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THE ECONOMIC IMPACT OF BREXIT

Nicholas Bloom
Stanford University and NBER

Pawel Smietanka
Deutsche Bundesbank Research Centre

Paul Mizen
King's College London

Philip Bunn
Bank of England

Gregory Thwaites
University of Nottingham

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Nicholas Bloom, Philip Bunn, Paul Mizen, Pawel Smietanka, and Gregory Thwaites
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ABSTRACT

This paper examines the impact of the UK's decision to leave the European Union (Brexit) in 2016. Using almost a decade of data since the referendum, we combine simulations based on macro data with estimates derived from micro data collected through our Decision Maker Panel survey. These estimates suggest that by 2025, Brexit had reduced UK GDP by 6% to 8%, with the impact accumulating gradually over time. We estimate that investment was reduced by between 12% and 18%, employment by 3% to 4% and productivity by 3% to 4%. These large negative impacts reflect a combination of elevated uncertainty, reduced demand, diverted management time, and increased misallocation of resources from a protracted Brexit process. Comparing these with contemporary forecasts – providing a rare macro example to complement the burgeoning micro-literature of social science predictions – shows that these forecasts were accurate over a 5-year horizon, but they underestimated the impact over a decade.

Nicholas Bloom
Stanford University
Department of Economics
and NBER
nbloom@stanford.edu

Philip Bunn
Bank of England
Philip.Bunn@bankofengland.co.uk

Paul Mizen
King's College London
Department of Economics
Paul.Mizen@kcl.ac.uk

Pawel Smietanka
Deutsche Bundesbank
Research Centre
pawel.smietanka@bundesbank.de

Gregory Thwaites
University of Nottingham
Department of Economics
gregorythwaites@gmail.com

1 INTRODUCTION

This paper uses almost a decade of data to study the impact of the UK's decision to leave the European Union (Brexit). The Brexit process started when the "Leave" campaign won the June 2016 UK EU Membership Referendum by 51.9% to 48.1%. But the complexity of the Brexit process meant that it was not until 31 January 2020 that the UK formally left the EU, with a transition period running until 31 December 2020, and negotiations on Northern Ireland stretching into 2023. As such, it was not until 2024 that the Brexit process was close to completion, necessitating our analysis of nearly 10 years of data.

We estimate that by 2025, the Brexit process had reduced UK GDP by 6% to 8%, investment by 12% to 18%, employment by 3% to 4%, and productivity by 3% to 4%. These effects accumulated gradually over time. We identify four main channels through which Brexit has affected the UK economy. First, the UK's decision to leave the EU generated a persistent increase in uncertainty, weighing on investment, in particular. Second, investment and employment growth were affected by lower expected demand for goods and services. Third, productivity growth *within firms* was affected by lower innovation and IT investment, and by management time and resources being used to prepare for Brexit. Finally, productivity growth *between-firms* was reduced as the more productive, internationally exposed, firms were more negatively impacted.

The identification strategy for estimating the impact of Brexit exploits the fact that the vote for Brexit was a largely unexpected event. The betting markets put the odds on the UK voting to leave the EU at around 30% in the months before the vote.[1] Using this discrete event, we employ both a macro and a micro identification strategy.

The macro-level estimation compares the UK's performance after 2016 to a set of up to 33 comparable countries. The approach matches UK performance to these countries in a ten-year pre-referendum control period and then simulates the next ten years after the referendum to forecast

[1] For example, see Bell (2016). Financial markets similarly did not seem to expect Brexit. Davies and Studnicka (2018) show that, in the two trading days following the EU referendum, companies that rely more heavily on European global value chains reported more negative returns.

the UK economy in the absence of Brexit. There is no single best way to weight the comparator countries together, so we consider the average of five different approaches: a synthetic control estimator, a simple unweighted average, a GDP weighted average, a gravity weighted average and a trade weighted average. We show that the UK has performed materially worse than other countries since 2016 across all these different approaches.

The micro-level analysis uses firm-level data to estimate a set of classic difference-in-differences regressions. Brexit had a heterogeneous impact on businesses according to their pre-referendum exposure to the EU, providing variation across firms to help identify the effects. We draw on data from the Decision Maker Panel (DMP), which is a major new survey of over 2,000 UK firms a month that we set up to help evaluate the impact of Brexit. The DMP is combined with data from firm accounts. Our Brexit exposure measure averages across six different individual pre-2016 firm-level exposure metrics: EU export share, EU import share, EU migrant labor share, EU regulatory exposure, EU directors share and EU firm ownership.

Our macro-based estimates of the impact of Brexit are typically larger than the micro-estimates. One source of the difference is likely to be negative spillover effects via demand and supply chains. In the micro estimation, firms with no direct prior exposure to the EU were nonetheless likely to still be negatively impacted by the Brexit process, which would lower the size of the estimated treatment impact. As such, the stable unit treatment variable assumption is likely violated. However, we prefer using both micro and macro estimation strategies as the macro approach cannot entirely separate out the Covid-19 pandemic which impacted the UK in 2020-2021, in the middle of the Brexit process. It differentially impacted countries and there were distinct policy responses in each country, including the UK's generous employment support scheme, which clouded the macro picture at this point. But micro evidence shows that firms heavily impacted by Brexit were not the same as those impacted by Covid, and our micro estimates include a set of controls for the pandemic. On balance we believe that the range of micro and macro estimates gives the most reliable assessment of the economic impact of Brexit. Reassuringly, both yield relatively similar time profiles and magnitudes of estimated impacts.

We also compare our results to the predictions surveyed in IMF (2016a), which covers estimates of the impact of Brexit on GDP made by a set of academic and professional economists around the time of the referendum. They forecast, on average, a negative hit of around 4% to GDP over the longer term, which is close to the 4% to 6% impact we estimate for 2021 (5-years after the 2016 vote). However, we note that our longer-run estimate of the impact of Brexit on GDP is more negative at 6% to 8%. At least in part, this could be due to the protracted nature of the Brexit process, which was not necessarily expected when the initial predictions were made. This highlights the political challenges in leaving a large trading block, and the need for political considerations in forecasting.

We see three motivations for this paper. First, the UK's exit from the European Union is a major economic and political event and worth studying directly. The UK is the world's sixth largest economy and the European Union the world's largest trading block; no other country has attempted to exit the EU trading bloc. Second, the UK's experience of Brexit has some parallels with the recent implementation of tariffs and immigration controls in the United States. These have both disrupted trade and migration and increased economic policy uncertainty. Finally, the recent expansion in the micro-literature of social science predictions (DellaVigna and Pope, 2018) has few parallels in macroeconomics, but the impact of Brexit provides a novel case study, since its impacts were widely predicted by the economics profession on the eve of the vote in May and June 2016, and those forecasts can be benchmarked against their realizations a decade later.

This paper links to three strands of literature.

First is the literature on the impact of Brexit. Several papers tried to assess the potential impacts of Brexit either prior to the referendum or shortly afterwards, including HM Treasury (2016), IMF (2016), Van Reenen (2016), Dhingra et al. (2017) and Sampson (2017). Brexit was typically assumed to lead to an increase in trade barriers that would lower future trade and productivity. Other papers have used post-referendum data to try and estimate the effects of Brexit, typically finding negative impacts on variables such as GDP, employment and investment, including Born et al (2019), Fetzer and Wang (2020), Dhingra and Sampson (2022), Springford (2022), Haskel and Martin (2023) and Alabrese et al. (2024).

Relatedly, Freeman et al. (2024), estimate that the move to a new trading arrangement with the EU in 2021 led to an immediate, sharp drop in both UK exports of goods to the EU and imports of goods into the UK from the EU. Crowley et al. (2020) show how uncertainty about future market access reduced the entry of UK firms into trading partner's markets. Keiller (2024) uses firm-level investment and administrative trade data to estimate that Brexit reduced manufacturing sector investment by 7%. Other papers consider the effects of Brexit on foreign direct investment (Breinlich et al, 2020; McGrattan and Waddle, 2020), global value chains (Vandenbussche et al., 2022), labor market outcomes, (Costa et al., 2019), prices (Breinlich et al., 2022, Di Pace and Masalo, 2025) and stock markets (Breinlich et al., 2018, Davies and Studnicka, 2018). Broadbent et al. (2024) model Brexit as a shock to future productivity in the tradable sector, which is offset in the short run by depreciation in the exchange rate.

We contribute to the literature on the impact of Brexit in two ways. First, by collecting our own panel microdata in the Decision Maker Panel (DMP) to directly measure firm-by-firm Brexit exposure and impacts. The DMP is one of the largest monthly business surveys in the UK, surveying thousands of firms from a range of industrial sectors and geographies every month. The sample of around 7,000 firms that we use in this paper accounts for around 10% of UK private sector employment. With this data we are able to observe immediate responses, expected changes, the dispersion of firms' expected responses and answers to Brexit-specific questions such as the amount of senior executives' time diverted to deal with Brexit. Second, we bring together the macro and micro-type approaches with a comprehensive study that assesses the overall impact on the UK economy, not just one particular aspect.

The second related literature our paper links to is the broader literature on trade reforms, including for example papers like Harrison (1994), Pavcnik (2002), Melitz (2003), Amiti and Konings (2007), Goldberg et al. (2009), Topalova and Khandelwal (2011), Bloom et al. (2016), Limão and Maggi (2015), De Loecker et al (2016), Goldberg and Pavcnik (2016), Handley and Limão (2017), Crowley et al (2018) and Dhingra et al (2022). These generally show that freer trade has a positive impact on growth – from a combination of higher productivity, improved reallocation, higher quality inputs and higher levels of innovation. When trade reforms reduce uncertainty – for example, by making temporary agreements permanent – additional positive investment and

employment impacts are usually observed. The withdrawal of the UK from the EU single market and customs union can be seen as a "reverse" trade reform – increasing trade barriers and generating uncertainty. There are few examples of this type of trade fragmentation, and therefore we add to the literature by studying this.

Third, our paper relates to is the literature on effects of uncertainty more generally, for example, Bernanke (1983), Dixit and Pindyck (1994) and Fernandez-Villaverde et al. (2011). The long-lasting nature of the Brexit uncertainty shock makes it different to most uncertainty shocks, which tend to be short-lived. Studying Brexit's impact can show how firms respond to persistent uncertainty over the best part of a decade. Hassan et al. (2024) use data from earnings calls to measure Brexit uncertainty and show how that led to lower hiring and investment in listed firms across the world. Graziano et al. (2021) consider the effects of Brexit induced trade policy uncertainty on trade in goods. Ahmad et al. (2023) extend this to services. Faccini and Palombo (2021) show the longer-term nature of the uncertainty created by Brexit may have induced a gradual and persistent economic impact.

The structure of this article is as follows. Section 2 provides a timeline of the key events in the Brexit process. Section 3 sets out our macro estimates of the impact of Brexit. Section 4 focusses on the micro estimates. It first provides overview of the Decision Maker Panel survey that we draw on, sets out the methodology and then presents the micro results. Section 5 compares the macro and micro results, before Section 6 concludes.

2 BACKGROUND ON THE BREXIT PROCESS

The Brexit process was long, legislatively complex and uncertain as to the outcome. We provide a brief overview of this as background to the paper and our identification strategy.

In January 2013, Prime Minister David Cameron promised to hold a referendum on the UK's membership if his Conservative Party won the 2015 General Election. They subsequently won the May 2015 election, and in February 2016, set the date for a referendum that was held on 23 June 2016. The UK voted to leave the EU by 51.9% to 48.1%, despite betting markets implying that

there was only around a 30% chance the UK would vote to leave in the days immediately beforehand. Following the referendum, there was a sharp depreciation in the sterling exchange rate and monetary policy in the UK was eased.

David Cameron resigned immediately after the Brexit referendum and was succeeded as Prime Minister by Theresa May. In March 2017, Article 50 was triggered, which formally began the process for the UK leaving the EU. This allowed two years for negotiations around the UK's future relationship with the EU, but the process was complex. At the Salzburg Summit in September 2018, EU leaders rejected Theresa May's 'Chequers proposals' as the two sides struggled to agree a deal that would allow the UK to leave the customs union and avoid a hard border between Northern Ireland and the Republic of Ireland. In November 2018, a draft withdrawal agreement was eventually reached, but this was rejected six times by the UK Parliament in early 2019. This led to the resignation of Theresa May, and Article 50 was temporarily extended.

Boris Johnson replaced Theresa May as Prime Minister in December 2019. A renegotiated withdrawal agreement was passed soon after by the UK Parliament, and the UK formally left the EU on 31 January 2020, with a transition period running until the end of 2020. During this transition period, the UK remained a member of the single market and customs union. The withdrawal agreement set out the broad terms on which the UK would leave the EU, but not the details of the future trading arrangements.

The new TCA (Trade and Cooperation Agreement) setting out the post-Brexit trade arrangements between the UK and the EU was finally agreed on 24 December 2020, only a week before the end of the transition period, and it came into effect on 1 January 2021. However, there was still a phased implementation of some aspects, including the Northern Ireland protocol, with further changes agreed in February 2023 as part of the Windsor Framework. Under the TCA, there were no tariffs or quotas on trade between the UK and EU, but the UK was no longer part of the EU single market or customs union. There are also ongoing parts of the Brexit process still being discussed in 2025, including issues related to fishing rights, farming exports, defense and energy policy.

3 MACRO ESTIMATES

3.1 Macro-level methodology for evaluating the impact of Brexit

Our macro analysis is based around comparing the aggregate performance of the UK economy to a set of comparable countries in the period before the Brexit referendum versus the period afterwards. The aim of this is to try and estimate what the UK economy might have looked like in the absence of Brexit. We compare the UK to a set of 33 comparator countries: the EU-27, the US, Canada, Japan, Iceland, Norway and Switzerland. Our data were collected from the OECD, World Bank and national statistical offices. They cover the period from 2006 Q1 to 2025 Q1. We carry out this analysis for GDP per capita, business investment, employment and labor productivity.

There is no single best way to weight the comparator countries together, and so we consider different approaches to show that our results are generally robust to the choice of weighting methodology. The five different approaches we consider are: (i) GDP weighted; (ii) GDP/air distance (gravity) weighted; (iii) UK trade weights; (iv) a formal synthetic control; and (v) simple unweighted. To generate a distribution, we also carry out a bootstrapping exercise using the unweighted data, in which we randomly draw 1,000 samples of 33 countries with replacement. This type of sensitivity analysis helps to show that our results are not dependent on a specific choice of comparator countries.

Perhaps the most commonly used weighting methodology in this type of analysis is a synthetic control, as proposed by Abadie and Gardeazabal (2003). Using this approach, Born et al. (2019) calculated that the Brexit vote has caused a UK output loss of 1.7% to 2.5% by 2018. Springford (2022) estimated that Brexit had lowered UK GDP by 5.5% by mid-2022. Alabrese et al. (2024) estimate that output losses from Brexit ranged from 5% to 10% by 2022. These ‘doppelganger type’ exercises work by trying to match, in this case, UK GDP growth to that of other countries in a pre-referendum control period. Countries (or other geographic areas) whose economic performance has the closest statistical relationship with the UK are assigned the highest weight, and those weights are then fixed over the post-referendum period to create a comparator country metric. However, the weights assigned to individual countries can often be sensitive to the control

period used and the exact assumptions made. A small number of countries are often assigned a large share of the weight, and in some cases, these countries can be economically small. By considering a wider range of weighting methodologies, our macro results are less dependent on the precise assumptions used to estimate our synthetic control.

In the construction of our synthetic control estimate, we use pre-referendum data from 2006 Q1 to 2016 Q1 (41 periods), to obtain optimal weights that minimize the prediction error in the pre-referendum period. To predict UK output per head in the pre-referendum period, we use GDP per head, trade openness, investment ratio, educational attainment, and industry share in value-added.[2]

One limitation of this macro-based approach of comparing the UK to a weighted average of similar countries is that factors other than Brexit could also be important in explaining why the economic performance of the UK has deviated from that of other countries. In particular, our sample period contains the Covid-19 pandemic. This will have had different effects on different countries. If the UK were more affected than other countries, that could incorrectly be attributed to Brexit. In some of our analysis we smooth through 2020, the height of the pandemic, and we focus on where the UK lies at the end of the sample period, when only differences in the long-term effects of the pandemic would be relevant. However, other factors such as differences in fiscal policies, could also contribute to cross-country differences in economic performance. This is why it is important to consider these macroeconomic estimates alongside other evidence from firm-level data.

A second caveat to this approach of comparing the UK to other countries is that Brexit may have had an impact on those comparator countries, not just the UK. This could particularly be the case for other countries in the EU, which face higher barriers to trading with the UK after Brexit. This would violate the stable unit treatment value assumption (SUTVA) which is necessary for making causal inferences. It is likely that the impact on other countries was negative on average (IMF, 2016b), which would help to understate the true impact of Brexit on UK output growth. This highlights the value of taking multiple approaches, including our micro-based approach, where identification of the Brexit effects should be stronger, before drawing conclusions.

[2] The weights assigned to different countries in our GDP synthetic control exercise are USA: 61.4%, Estonia: 10.9%, Greece: 9.5%, Italy: 6.7%, Ireland: 4.4%, Latvia: 3.4%, Iceland: 3% and Hungary 0.7%.

3.2 Macro results

Figure 1 shows UK GDP compared to that of other countries since the Brexit referendum. Our analysis focuses on GDP per capita. This helps to account for any differences in population growth trends across countries. It illustrates that UK GDP was growing at a similar rate to other comparable countries in the period prior to the Brexit referendum, regardless of how those other countries are weighted together.

Since the vote for Brexit in 2016 Q2, UK GDP has grown by less than other comparable countries. That is estimated to be the case across all of our different metrics for weighting other countries together, and it places the UK close to the bottom of the distribution we draw around the unweighted average, at around the 10th percentile.[3] Depending on which comparator metric is used, UK GDP per capita is estimated to have grown by between 6% and 10% less than other similar countries between the Brexit referendum and the year to 2025 Q1, and it only rose by 4% in absolute terms. The smallest implied impact is from GDP/air distance weighting the comparator countries, which places a heavy weight on large, nearby Northern European countries that experienced relatively slow growth post 2016. In part, this could have been due to Brexit spillovers. The largest estimated impacts are from the synthetic control and unweighted estimates, as these place more weight on faster growing countries, in particular the US for the synthetic control. Taking the simple average across our five weighting approaches, UK GDP is estimated to have been 8% lower than other similar countries over the year to 2025 Q1. We use this average as our central estimate of the effect of Brexit from macroeconomic data.

UK investment, employment and labor productivity are all estimated to have grown by less than in other comparable countries since 2016. Figures 2, 3 and 4 plot similar comparisons for the UK relative to other countries for business investment, employment and labor productivity respectively. UK business investment is estimated to have been, on average, 18% lower than that of comparable countries, with a range of 13% to 26% across the five weighting metrics. The largest estimate comes from the synthetic control, with the other four measures more closely grouped at around 15%. This again highlights the sensitivity of this approach, which again places a large weight on

[3] Figure A1 in the Appendix shows the UK relative to all 33 comparator countries individually.

the US. UK employment is estimated to have been, on average, 4% lower than other similar countries over the year to 2025 Q1, with the individual estimates ranging from 3% to 5%. For labor productivity, the average difference is -4%, with a range between -2% and -6%. The differences for employment and labor productivity are therefore smaller than for investment, but have grown steadily larger over our sample period.

To test the robustness of our estimates, we carry out a permutation test where we use the same synthetic control method for each individual country in our sample as if they had instead been the one affected by a large and unexpected event in 2016 Q2 (Figure A2). The UK lies at the bottom of the range of estimates for GDP and investment, although less so for employment and productivity.

In summary, our analysis of cross-country macroeconomic data shows that the UK has performed materially worse than other countries since 2016, which it seems reasonable to assume is mostly a Brexit effect. This helps to motivate our firm-level analysis, where we can more clearly identify the causal effects of Brexit, and which we turn to in the next section.

4 MICRO ESTIMATES

This part of the paper starts by setting out our firm-level panel data methodology for evaluating the impact of Brexit in section 4.1. Our analysis makes use of data from the Decision Maker Panel (DMP) survey, a major new survey of firms that we set up to help study the Brexit process. Section 4.2 provides an overview of this survey; section 4.3 summarizes our data on firms' prior exposure to the EU; and section 4.4 describes DMP data on how firms viewed the impact of Brexit and on uncertainty. Section 4.5 presents our micro-econometric results on the impact of Brexit on investment and employment, while section 4.6 covers the results on productivity.

4.1 Micro-level methodology for evaluating the impact of Brexit

To estimate the causal impact of Brexit using firm-level data, we use a classic difference-in-differences approach. This exploits two important factors. First, that the vote for Brexit was a surprise, with betting odds giving Brexit about a 30% chance of success through the six months period prior to the June 2016 vote. With little pre-referendum anticipation effect, the changes between more and less EU-exposed firms after 2016 should primarily reflect the impact of the Brexit vote and subsequent process of the UK leaving the EU. Second, Brexit is likely to have had a heterogeneous impact on UK firms according to their pre-referendum exposure to the EU, providing important variation across firms to help identify its effects.

Our difference-in-differences estimates test for changes in trends after the Brexit referendum that are correlated with prior EU exposure. The equations that we estimate take for the form of equation (1) below:

$$Y_{it} = \beta\, E_i \text{ x } Post_t + f_i + m_t + e_{it} \quad (1)$$

Where Y_{it} is an outcome variable (e.g. investment, employment or TFP growth); E_i is EU exposure of firm i; $Post_t$ is a dummy variable that takes the value of zero before the Brexit referendum and one afterwards; f_i are firm fixed effects and m_t are time fixed effects.[4] Standard errors are also clustered at the firm level.

EU exposure is based on six different firm-level metrics. These capture different dimensions of firms' exposure to the EU immediately *prior* to the 2016 referendum. The six variables we use are: (i) percentage of sales that were exports to the EU; (ii) percentage of costs that were imports from the EU; (iii) percentage of the workforce who were migrants from the EU; (iv) percentage of sales covered by EU regulations; (v) percentage of directors who were EU nationals; (vi) whether the firm was EU owned. Data on the first four exposure metrics were collected in the DMP survey and

[4] We focus on estimates in *growth* space because we find evidence of significant differences in the growth rates of our outcome variables in the pre-referendum period between firms with high and low levels of exposure to the EU.

refer to 2016 Q1.[5] The last two exposure measures are based on data from the Bureau van Dijk FAME database and are for 2015 (these data are only available annually).[6]

We take the simple average of the six EU exposure metrics as our preferred measure of pre-referendum exposure to the EU.[7] Each of the six measures is defined on a 0 to 1 scale. The Brexit process was complex and likely to have affected firms in many different ways. So, by using a broad measure of exposure, we aim to capture these different impacts as comprehensively as possible. Using this combined metric yields stronger results than any single individual exposure measure. This is one of the advantages of our primary data collection: we are able to capture this full range of exposure to the EU, which would not be possible in other datasets that only capture exposure along one or two dimensions. As we show in Section 4.3 below, these data also match up well against other sources, indicating that the data collected in the DMP survey are of high quality.

To try and help understand the channels through which Brexit affected firm outcomes, we also run another set of regressions that replace pre-referendum EU exposure with proxies for the first and second moment impacts of Brexit. These data were also collected in the DMP survey. Firms were asked about both the expected eventual impact of Brexit on their sales and about the importance of Brexit as a source of uncertainty. More details on these data are provided in Section 4.4. Instead of using prior EU exposure, we include both the expected long-run impact of Brexit on sales and

[5] The exact questions asked were: 'Approximately what percentage of your total sales revenue was accounted for by exports of goods and services from the United Kingdom to EU and non-EU countries immediately prior to the EU referendum (2016 Q1)?'; 'Approximately what percentage of your total costs (including labor costs) was accounted for by goods and services imported from EU and non-EU countries immediately prior to the EU referendum (2016 Q1)?'; 'Approximately what percentage of your employees were immigrants from the rest of the EU immediately prior to the EU referendum (2016 Q1); and 'Approximately what percentage of your sales was affected by EU regulations immediately prior to the EU referendum (2016 Q1)?. For the export and import questions, firms were asked to provide a number between 0 and 100. For the EU migrants' question, respondents were asked to select from: (i) Less than 1%; (ii) 1% to 5%; (iii) 6% to 10%; (iv) 11% to 20%; (v) 21% to 50%; (vi) More than 50%; (vii) Don't know. For the EU regulation question, respondents were asked to select from: (i) None; (ii) 1-10%; (iii) 11-50%; (iv) More than 50%; (v) Don't know. For questions where firms were asked to select a range, midpoints were used to assign a numerical value to these responses. These questions were initially asked to all firms in the panel in 2017 and were subsequently asked a number of times to collect data from firms who joined the panel at a later data or who did not originally respond. If firms responded more than once to any of these questions, their first response is used.

[6] FAME is provided by Bureau Van Dijk (BVD) using data on the population of UK firms from the UK Companies House. FAME itself is part of the global AMADEUS database.

[7] We also show in the Appendix that our results are robust to taking the first principal component of the six exposure measures rather than the simple average. We also show that our results are not dependent on any one single exposure measure.

average uncertainty in a set of regressions, both interacted with a pre-referendum dummy, to try and assess the relative importance of these two channels. However, we focus on the prior EU exposure approach in our main set of results because these metrics are more likely to be exogenous to subsequent firm performance and therefore offer a more robust methodology.[8]

In our micro analysis, we focus on understanding the impact on investment, employment and productivity. We also assess the implications for overall GDP by combining the impacts on these different variables together. We take the data for each of the outcome variables from company accounts data, provided by Bureau van Dijk FAME, where it is available, and the DMP survey if not.[9] DMP data are matched to accounting data using Companies House registration numbers. All firm-level data are organized in financial years.[10] In our micro analysis, we define the pre-referendum period as financial years 2011/12 to 2015/16.[11] The post-referendum period is defined as 2017/18 to 2023/24. We exclude 2016/17, as this contains a mix of pre and post referendum data, which varies depending on when firms' accounting years ends. In an extension to try and understand the channels behind the impacts on productivity, we also consider the effects of Brexit on the propensity of firms to apply for patents, using data from PATSTAT database. PATSTAT is a comprehensive, statistical database of patent information, primarily maintained by the European Patent Office.[12]

As well as being able to better identify the causal effects of Brexit, another advantage of our micro approach is that it is also possible to include controls for the Covid pandemic. This is another big event that affected the UK economy within our sample period. The DMP survey asked firms to estimate the impact of Covid on a number of different aspects of their business, such as sales,

[8] For example, there is at least a risk firms who have performed less well in the post-referendum period for reasons other than Brexit may report greater Brexit impacts subsequently in their survey responses.
[9] Quarterly DMP data are converted to annual data in order to combine them with annual accounts data. DMP data are only used for investment and employment, and they only account for around 5% of observations. All productivity data are taken from firm accounts.
[10] Firms are allocated to financial years according to when their accounting year ends. Years are defined from July to June in next calendar year, so for example, 2017/18 would cover firms with a financial year end between July 2017 and June 2018.
[11] We do not extend this back further to avoid having the 2008-10 financial crisis as part of our control period. We only estimate our regressions up to 2023/24 because of lags in the availability of accounting data.
[12] We thank Ralf Martin (Imperial), Arjun Shah (King's College London), Anna Valero (LSE) and Dennis Verhoeven (KU Leuven) for their assistance with enabling the data on patents to be linked to the DMP. See Dechezleprêtre (2023) for more detail on the PATSTAT data.

employment and investment, in different periods. We include these firm-level data on the impact of Covid as controls in our regressions, and these are summarised in Figure A3 in the Appendix.

4.2 Overview of the Decision Maker Panel (DMP) survey

We draw heavily on data from the Decision Maker Panel in our micro analysis. The DMP is a large and representative monthly online panel survey of UK businesses that we set up in 2016. It is run by the Bank of England in partnership with King's College London and the University of Nottingham and is supported by funding from the Economic and Social Research Council. It is similar in style to the Survey of Business Uncertainty run in the United States by the Federal Reserve Bank of Atlanta (Altig et al., 2022). Bunn et al. (2024a) provides a detailed overview of the DMP survey and further information on the survey methodology. More information, including aggregated data, is available on the survey website: www.decisionmakerpanel.co.uk. Below we summarize the information about the survey that is most relevant to our study.

The initial motivation for starting the DMP survey was to help assess the impact of Brexit on UK firms. Since then, it has been used to study the effects of other key events that have had significant economic impacts, such as the Covid-19 pandemic (Altig et al., 2020; Bloom et al., 2025), and the subsequent increase in inflation (Bunn et al., 2024b, Yotzov et al., 2025). The timely and quantitative nature of the survey data have helped to make the survey data useful for both informing policy decisions and creating opportunities for high-quality research.

The survey contains regular questions about recent developments in business conditions and about firms' expectations for how those conditions will evolve over the next year. The expectations questions ask firms about the distribution of their expectations, not just the single most likely outcome. This allows an assessment of the uncertainty surrounding those expectations. The regular questions cover sales, prices, employment, wages and investment.[13]

[13] The surveys have a rotating three-panel structure – each member is randomized at entry into one of the three panels (A, B or C). Each panel is given one third of the questions in any given month, so that within each quarter all firms rotate through all questions. This helps to keep the survey short for respondents whilst yielding a regular monthly flow of data. There is also an introductory survey on firm characteristics that firms are given for their first survey before they enter the regular panel. Most firms take between 5 and 10 minutes to complete the monthly surveys with a median completion time of just under 8 minutes.

Each survey also includes some special questions on topical issues. Some special questions are asked only once, others may be asked a number of times. This paper primarily makes use of the special questions relating to Brexit. The key special questions that we use are about pre-referendum exposure to the EU (through exports, imports, use of migrant labor and importance of EU regulation) and questions on Brexit uncertainty and the expected impact of Brexit on sales.

The panel grew quickly after its launch and it now regularly receives between 2,000 and 2,500 monthly responses, making it one of the largest regular business surveys in the UK (Figure A4 shows the sample size over time). The response rate is in the region of 50-55% for active respondents, defined as those who have responded to at least one survey in the last twelve months. The DMP currently covers around 4% of total UK private sector employment in each monthly survey, rising to about 6% for employees in private sector businesses that have more than 10 employees. Around 15,000 unique firms had responded to at least one of the monthly online surveys by September 2025, with the average firm responding 16 times. In this paper, we focus on the sub-sample of just over 7,000 firms who have answered all of the key special questions on Brexit exposure. This provides a large and representative sample for our analysis: these firms account for around 2.7 million employees, which is approximately 10% of UK private sector jobs.

The sampling frame for the DMP consists of active UK businesses with ten or more employees, as listed in the Bureau van Dijk FAME database. As of September 2025, the sampling frame contained approximately 79,000 firms. Firms are randomly selected from this sampling frame and invited by telephone to join the panel by a recruitment team based at the University of Nottingham. This approach helps to ensure that the survey provides a representative view of the UK economy. When the DMP recruitment team initially contacts firms, they request to speak with the Chief Financial Officer (CFO) and, if unavailable, the CEO. Consequently, an average of 79% of respondents hold these senior positions (66% are CFOs and 13% are CEOs). Given that the median firm in the survey employs about 70 people, these CEOs and CFOs will generally have a very good understanding of the overall direction and performance of the business. The recruitment team also follow up with firms who stop responding to try and re-recruit them back into the survey to improve the length of the panel time series.

The DMP survey covers all industrial sectors of the UK economy and all regions. It also covers large, medium-sized and small businesses; only firms with less than ten employees are not covered. As well as private businesses, the survey also includes charities and other not-for-profit organizations. Aggregated survey data are weighted using employment data to match the UK Interdepartmental Business Register by industry and firm size. Even on an unweighted basis, the DMP survey matches the industrial composition of the UK economy well (Figure A5). The DMP sample contains a more significant share of large firms than the Business Register (Figure A5). This is primarily because smaller firms are less likely to meet the DMP sampling frame criteria, since, for example, they typically lack the necessary basic accounting data. However, larger firms are also more influential in shaping UK economic outcomes, and the survey does still contain a good number of smaller businesses. Table A1 provides some descriptive statistics on the firms in the DMP survey.

Bunn et al. (2024a) provide a detailed evaluation of the quality of the DMP survey data. But in summary, aggregated data from the DMP survey match up well with comparable official statistics. Expectations data from the survey line up well with subsequent realizations, and for variables such as sales and employment, the DMP data align closely with accounts data in terms of both levels and growth rates (see Figure A6 for a comparison).

An important consideration for our study is whether the Brexit referendum itself had an impact on the type of firms that responded to the DMP survey. The linear response regressions in Table A2 show that whether a firm in the sampling frame has ever responded to a DMP survey is independent of the percentage of people voting to leave the EU in the local authority where that firm has its headquarters. Figure A7 confirms this lack of correlation; the scatter plot reveals no discernible pattern between response rates and local Brexit vote share.[14] The response rate analysis also shows that larger firms are more likely to respond to the DMP survey, although the magnitudes of these effects are not substantial.

[14] The DMP recruitment team are located in Nottingham, a Brexit supporting region, which offsets the involvement of the Bank of England and King's College in London, which are both based in London, a Remain supporting region.

A second check we carry out is to look at whether DMP respondents' personal views on Brexit are biased in one direction or the other. In the DMP survey, only 24% of panel members had a positive personal view of Brexit at the time of the referendum (Figure A7). This is clearly much lower than the 52% of the population who voted to leave the EU in the referendum. However, this figure of 24% closely aligns with data from the British Election Survey (BES), where 23% of respondents with CFO characteristics (managers with a degree and income over £50,000 a year) reported that they had voted for Brexit. CFOs responding to the DMP survey therefore appear to share similar views on Brexit with the wider population of CFOs who were less in favor of the UK leaving the EU than the country overall. Thus, in summary, we do not find any strong evidence of a Brexit-related bias in the firms who have responded to the DMP survey.

4.3 Firms' exposure to the EU

Our micro analysis centers around a broad measure of pre-referendum exposure to the EU, which takes the average of six different firm-level metrics covering the importance of EU exports, imports, migrant labor, EU regulation, directors who are EU nationals and firm ownership. The first four of these variables are data from the DMP survey, with the last two coming from Bureau van Dijk.

In the DMP survey, businesses reported that exports to the EU made up around 7% of their sales in 2016 Q1, imports from the EU accounted for 9% of costs, 9% of employees were nationals of other EU countries and 13% of sales were affected by EU regulation. On average, 7% of directors of firms in our sample were EU nationals in 2015, and 4% of firms were EU owned. Figure A8 plots the distribution of each of these individual exposure metrics, and Table A1 includes some descriptive statistics.

DMP export and import data can be benchmarked against Office for National Statistics (ONS) data from the input-output tables. These match up well (Figure 5). Data on EU exports are closely aligned, with both sources pointing to EU exports accounting for around 7% of sales just prior to the referendum.[15] For EU imports as a percentage of costs, the DMP data are around 2 percentage

[15] DMP data are for 2016 Q1 and ONS input-output data are for 2015 and are for the market sector.

points higher than the estimate from ONS data. This discrepancy is almost entirely accounted for by the wholesale and retail industry, where ONS data only include imports used in the provision of wholesale and retail services, whereas survey respondents presumably also include the cost of imported goods sold in their shops. Breaking the DMP versus ONS data down by industry, Figure 5 shows that they are well correlated, again aside from imports in wholesale and retail. The proportion of workers who were EU migrants in 2016 Q1 in the DMP survey also matched up well with estimates for 2015 from the ONS Labour Force Survey (9% vs 8%), and again, there is a strong correlation at the industry level.[16]

Combining the six individual metrics together, Figure 6 shows a wide spread in the distribution of firms' pre-referendum exposure to the EU. Just under 20% of firms had no direct exposure to the EU across any of the dimensions, while the other 80% had exposure across one or several of the aspects. This heterogeneity in exposure provides an important source of variation to help identify the effects of Brexit in our micro-level analysis. Taking all the measures together, the industries that are estimated to have had the highest prior exposure to the EU are manufacturing/production, wholesale and retail, and finance and insurance (Figure 6) – all relatively tradeable goods and services. The least exposed industries are more concentrated in non-tradables, including recreational services, health and other services (which is mainly personal services, for example, haircuts).

4.4 Survey data on the first and second moment impact of Brexit

One of the initial motivations for setting up the DMP survey was to collect data on the uncertainty that was created by the UK's decision to leave the EU. There were many different aspects to this uncertainty. In addition to uncertainty around what the UK's eventual relationship with the EU would look like, there was also uncertainty about future market access, the availability of migrant labor and product regulation, the speed of transition, and whether the UK would leave the EU at all. The uncertainty created by Brexit was also much more long-lasting than most typical uncertainty shocks.

[16] There is no comparable data available from other sources on the importance of EU regulation, the share of directors who are EU nationals and on EU ownership.

To monitor the uncertainty generated by Brexit, we created a Brexit uncertainty index (BUI). We define this as the percentage of firms who reported Brexit as one of the top three sources of uncertainty for their business in each period.[17] This BUI is plotted in Figure 7. This also correlates strongly with a Brexit media index, which captures the percentage of stories in UK newspapers that mention Brexit, and which is also shown in Figure 7.

The vote for Brexit generated a large, broad and long-lasting increase in uncertainty. After the June 2016 vote, just under 40% of firms rated Brexit as one of the three main drivers of uncertainty (Figure 7). This rose even higher after the September 2018 Salzburg summit when the EU did not accept the UK's Brexit proposal, which increased the chance of a no-deal Brexit. It remained at around 55% in the first quarter of 2019 as the UK Parliament rejected the proposed withdrawal agreement in the run-up to the initial end March 2019 deadline for the UK leaving the EU. Uncertainty then remained high throughout 2019 as the UK's exit from the EU was delayed, and it only started to fall after the election victory of Boris Johnson in December 2019, which paved the way for the UK to leave the EU in January 2020. However, the share of firms reporting that Brexit was an important source of uncertainty did not fall consistently below 40% until the second quarter of 2021, after the new trade agreement had come into effect. This was almost five years after the original referendum. After 2021, Brexit related uncertainty gradually declined, although in September 2025, Brexit was still an important source of uncertainty for around 16% of firms. Media coverage of Brexit also followed a similar pattern around these key Brexit events and has continued to decline gradually into 2025.

At the firm-level, Brexit uncertainty was highly correlated with prior exposure to the EU. Figure A9 shows this in descriptive form. Table 1 reports some simple regressions looking at the relationship between each of our six EU exposure measures and average Brexit uncertainty per

[17] Firms were asked 'How much has the result of the EU referendum affected the level of uncertainty affecting your business?' with four possible responses: (i) 'Not important', (ii) 'One of many drivers of uncertainty', (iii) 'One of the top two or three drivers of uncertainty', and (iv) 'The largest current source of uncertainty'. Our Brexit Uncertainty Index (BUI) is defined as the share of firms which choose options (iii) or (iv) – that is rating Brexit as, at the least, one of the three most important sources of uncertainty for their business. In our regression analysis, we define Brexit uncertainty on a 0 to 3 scale to make use of the additional granularity in these data. This variable is defined as 0 for those who answered, 'Not important', 1, for 'One of many drivers of uncertainty', 2, for 'One of the top two or three drivers of uncertainty', and 3, for 'The largest current source of uncertainty'. This measure is very highly correlated with the simpler metric of just focusing on Brexit being in the top 3 sources of uncertainty.

firm. All six measures are statistically significant when included individually, and when combined, five of the six still have a coefficient that is significant. The R^2 when including our six-measure average of EU exposure measures (column 8) is almost double that of any regression with only a single metric. This highlights the broad nature of the uncertainty created by Brexit, and the value of using multiple exposure measures rather just focusing on one dimension of EU exposure or just on trade.

As well as data on uncertainty, the DMP survey has also collected information on how firms view the long-term impact on their sales. They were repeatedly asked to assign probabilities to the likelihood of Brexit having a large (greater than 10%) or small (up to 10%) positive or negative impact on long run sales, or no impact at all.[18] Figure A10 summarizes the responses for selected quarters. On average, firms attached a probability of just under 15% to large negative impacts, just under 25% to small negative effects, around 50% to no impact and 12% to a positive impact. These responses were more stable than the uncertainty impacts over time. Assigning some simple midpoints to these responses implies that firms thought Brexit would lower their long-term sales by about 2.5% on average. Firms were not directly asked about the expected impacts on GDP, but it is possible that this would have been greater than firms' estimated sales impacts. In a separate question, they estimated that Brexit had also raised their unit costs by around 4%. This would likely have raised their nominal sales values if higher costs were passed on into higher prices, or reduced value-added if these additional costs were absorbed via lower profit margins.

DMP data on the long run expected impact of Brexit on sales are also well correlated with our EU exposure metrics (Table A3) and with Brexit uncertainty (Figure A11). This highlights the difficulty of disentangling the first and second moment effects of Brexit. Our approach of using a single measure of EU exposure will capture the joint impact of both channels.

[18] The exact question wording was: 'How do you expect the eventual Brexit agreement to affect your sales once the UK has left the EU, compared to what would have been the case had the UK remained a member of the EU? What is the percentage likelihood (probability) that it will: (i) Have a large positive effect on sales at home and abroad, adding 10% or more to sales ; (ii) Have a modest positive effect on sales at home and abroad, adding less than 10% to sales; (iii) make little difference; (iv) Have a modest negative effect on sales at home and abroad, subtracting less than 10% from sales; (v) Have a large negative effect on sales at home and abroad, subtracting more than 10% from sales.' Responses across the five categories had to sum to 100%. In calculating a continuous variable for the expected long-run sales impact we assume that an impact of less than 10% corresponds to 5%, on average, and more than 10% equates to an average impact of 20%.

4.5 Micro results on investment and employment

As explained in Section 4.1, we estimate the impact of Brexit at the micro level using firm-level data and a difference-in-differences type approach. This tests whether firms that were more exposed to the EU did worse after 2016, relative to the five years before, while also controlling for time and firm fixed effects. Table 2 reports the results for investment and employment. The results imply that, after the vote for Brexit, investment and employment in UK firms were both lower for firms more exposed to the EU.

Column (1) of Table 2 shows that firms with a higher level of pre-referendum exposure to the EU (based on our six-measure average) experienced higher investment growth than less exposed firms in the pre-referendum period between 2011 and 2015. But after 2016, investment growth was lower for these more exposed firms.[19] The equation in column (1) includes time fixed effects to capture other macro factors that affect all firms, but it does not include firm fixed effects. The result that firms more exposed to the EU had faster investment growth pre-referendum reflects the fact that these are typically larger and faster growing firms that were more integrated with Europe. This explains why our preferred regression specifications are in growth rather than levels terms.

In column (2), we add firm fixed effects. The coefficient on the post-referendum exposure interaction is then interpreted as showing the change relative to the pre-referendum period, which is equivalent to the difference between the coefficients in column (1). This interaction has a negative and highly significant coefficient. It implies that a firm with an EU exposure index of 0.1 (the mean) rather than 0 experienced investment growth that was 1.7 percentage points lower in each year between 2017 and 2023 than would have otherwise been the case. In column 3, we add a control for firms' estimate of the impact of Covid-19 on their investment growth. The coefficient on this variable is highly significant, but it makes very little difference to the Brexit effect because Covid and Brexit exposure have relatively little correlation across firms.

To estimate the impact of Brexit on aggregate investment from our micro results, we use the regression in Table 2 to calculate how different investment growth would have been in each year

[19] See Figure A12 in the Appendix for a descriptive chart that also shows this result.

if all firms were assumed to have zero EU exposure. The growth impacts are then cumulated to estimate the impact on the level of investment. The results imply that business investment was 12% lower by financial year 2023/24. The coefficients from Table 2 represent an average effect on growth. In Table A4 of the Appendix we also report the effects estimated separately for each individual year after 2016. The implied aggregate effects in levels terms are also plotted on Figure 8. Whilst there is some volatility from year to year, the effect on investment builds up gradually over time, rather than there being a sharp fall immediately after the referendum with most of the effect coming through very quickly.

In Table 3, we try to unpack whether the first moment effects of lower demand or the second moment effects of higher uncertainty were relatively more important for firms' investment responses. Instead of including EU exposure interacted with a post-Brexit time dummy, we include the expected impact of Brexit on long-run sales and average Brexit uncertainty. There is a strong correlation between the first and second moment metrics. Individually, both are associated with lower investment growth after the referendum. But when included together in column (1), the uncertainty term explains the majority of the overall impact, implying that higher uncertainty was relatively more important than lower expected future demand in explaining the fall in investment.[20] Again, these uncertainty effects are estimated to have accumulated gradually over time if allowed to vary by year.

Tables A5 and A6 report a set of further robustness checks around our investment results. Table A5 shows how our results are robust to taking the first principal component of our six EU exposure measures rather than a simple average. It also shows that our investment results are robust to leaving out any one of the six EU exposure metrics and are therefore not reliant on any single measure. This also provides further support to our approach of combining information from a range of metrics - no individual measure can capture all aspects of Brexit. Looking at how the Brexit effects vary across different types of firms (Table A6), for a given level of exposure, the point estimates are larger for firms that were more constrained by lower cashflow, larger firms, and firms

[20] The regression in column (2) of Table 3, which includes only Brexit uncertainty implies that investment was 15% lower by 2023, compared to 12% using our EU exposure metric in Table 2. We place most weight on the estimate that uses EU exposure given the potential endogeneity of the self-reported survey responses on uncertainty. Nevertheless, this is still a useful robustness check and is still useful in helping to investigate the channels that lowered investment.

in manufacturing, retail and finance (industries with the highest level of prior EU exposure and whose goods and services are most tradable). However, these differences in the point estimates are generally not statistically significant between the different subsamples.

Turning to employment, we find that employment growth was significantly lower in firms with higher exposure to the EU after the Brexit referendum. Column (4) of Table 2 illustrates how firms with higher EU exposure had faster employment growth between 2011 and 2015, but lower growth after 2016. This still holds after including firm fixed effects and a control for the effects of the Covid pandemic, as shown in columns (5) and (6). The results imply that a firm with Brexit exposure of 0.1 rather than zero (0.1 is the mean), experienced average employment growth that was around 0.5 percentage points a year less than it would have otherwise done after 2016. This translates into an impact of around 3.5% on the level of private sector employment by 2023, and 3% in whole economy space (assuming no impact on public sector employment which is not covered by our firm-level data).

As with investment, the Brexit effects on employment are estimated to have accumulated gradually over time since the referendum. Table A4 shows that Brexit is estimated to have had a persistently negative impact on employment growth even when the coefficients on EU exposure are allowed to vary by year. Figure 8 illustrates how the effects on employment have grown over time. But in contrast to investment, the effects of Brexit on employment appear most strongly associated with expectations of lower future demand rather than with Brexit uncertainty (see Table 3, columns (3) and (4)). Lower sales demand ought to translate into lower labor demand too. But lower labor supply may also have played a role. Inward migration to the EU fell notably after the Brexit referendum (shows in Figure A13), and of our six individual EU exposure measures, prior use of EU migrant labor has the strongest relationship with subsequent lower employment growth.

4.6 Micro results on productivity

The vote to leave the EU could have affected aggregate productivity through effects on productivity *within* individual firms, or because output was reallocated *between* firms with varying levels of productivity. In this section, we examine both effects, although we focus more on the within-firm effects, where we find that the Brexit effects have been largest. We follow the framework of Baily et al. (1992) to separate out these different channels:

$$\Delta\Pi_t = \sum_{\text{i}\in\text{Surv}} \bar{\varphi}_i \Delta\pi_{\text{i,t}} \qquad \text{… within firms} \tag{1}$$

$$+ \sum_{i\in Surv} \Delta\varphi_{i,t}(\bar{\pi}_{\text{i}} - \bar{\Pi}) \qquad \text{… reallocation between surviving firms} \tag{2}$$

$$+ \sum_{i\in\Delta Entry} \varphi_{i,t}(\bar{\pi}_{\text{i}} - \bar{\Pi}) \qquad \text{…. reallocation to new firms} \tag{3}$$

$$- \sum_{i\in\Delta Exit} \Delta\varphi_{i,t-1}\left(\pi_{i,t-1} - \bar{\Pi}\right) \qquad \text{…. reallocation from exiting firms} \tag{4}$$

Here $\pi_{i,t}$ is productivity in firm *i* at time *t,* Π_t is aggregate productivity at time *t,* $\varphi_{i,t}$ is the employment share of firm *i* at time *t* and a bar over a variable indicates the average of the variables across times *t*-1 and *t*. Δ is the change that is due to the vote for Brexit. Δ*Entry* and Δ*Exit* denote changes in firm entry and exit that are associated with Brexit. We first consider the effects of Brexit on within-firm productivity, before moving on to the between-firm effects.

In Table 4, we report our micro estimates of the impact of Brexit on TFP, our preferred measure of firm-level productivity, *within firms*. Column (1) shows that firms with higher pre-referendum exposure to the EU had faster TFP growth prior to the referendum, but lower TFP growth afterwards. This is also shown in Figure A12. Adding in firm-fixed effects in columns (2) and (3) again changes the interpretation of the coefficient on the exposure/post-referendum variable to be the change in the relationship after 2016. This confirms that firms with higher exposure to the EU experienced significantly lower growth in TFP after the referendum. In both cases, the results

imply that a firm with an EU exposure index of 0.1 (the approximate mean), rather than zero, experienced productivity growth of around 0.5 percentage points a year less after 2016 than it would have otherwise done. This translates into an overall within-firm Brexit impact of around 3.5% off the level of private sector TFP by 2023. The inclusion of the Covid control again makes little difference to the estimated Brexit impact.

Looking at the effects on TFP within firms by year (Table A4 and Figure 8), the impacts are estimated to have accumulated gradually over time, although the largest impacts are estimated to have come through between 2018 and 2020, before the new Free Trade Agreement with the EU took effect. The effects of Brexit on TFP also appear to be more strongly associated with the DMP proxy for Brexit uncertainty rather than the first moment effects on sales (Table 3, columns (5) and (6)).

Although we find clear micro-level evidence that Brexit lowered within-firm TFP growth, the evidence on sales growth and labor productivity is more mixed. Columns (4), (5) and (6) of Table 4 show that we do not find a significant effect on sales growth for firms with higher EU exposure after 2016. However, there is still a strong positive correlation between what firms expected for the long-run impact of Brexit on their sales and realised sales growth after the Brexit referendum (columns (7) and (8) of Table 3). The effects of Brexit on nominal sales will also be affected by what happened to firms' prices as well as their sales volumes. If Brexit pushed up prices, for example by increasing costs, then the effects on sales volumes would be larger than the impacts on sales values. Similarly, for labor productivity, we do not find a significant relationship with Brexit exposure after the referendum, although there is a significant correlation with Brexit uncertainty (Table A7 in the Appendix). Conceptually, TFP should be the best metric to look at, as it accounts for differences in capital as well as labor input, and because it is normalized by industry in each year, that may help to better understand changes in productivity within and across industries.

There are a number of potential channels through which the vote for Brexit could have lowered productivity within firms. These include elevated uncertainty, reduced innovation, lower trade, increased stock levels and management time being diverted from other activities, as well as

lower trade. Below, we consider the evidence for these different channels in more detail. We find that all of them may have played some role, although it is difficult to precisely quantify each of them. The composition of the channels may also have changed over time.

Elevated uncertainty could have lowered productivity by reducing spending on intangibles that can boost productivity. When respondents to the DMP survey were asked which types of investment they had reduced in response to Brexit, the most common response was spending less on machinery, equipment and building. But a number also reported investing less in research and development, software and training (Figure A14). If the coefficients on Brexit exposure are allowed to vary by industry in our main micro regressions, we find a clear positive correlation between the investment and TFP coefficients in each industry (Figure A15). That would also be consistent with some spillover from lower investment to lower TFP.

We also investigate whether firms that had a higher exposure to the EU became less likely to register patents after the vote for Brexit, using this as a proxy for innovation. We do this using data from the PATSTAT database, matched to our EU firm exposure measure. Firms with a higher level of exposure to the EU were much more likely to register patents prior to the referendum (Figure A16), being typically larger and more internationally exposed. The regression results reported in Table 5 find tentative evidence that firms more exposed to the EU became relatively less likely to apply for patents after 2016. This coefficient is only significant at the 10% level, but the data we use only go up to 2020, and given that the process of developing new innovations takes time, it is plausible that these results could become stronger as more data become available.

A second channel which may have led to lower productivity is the costs associated with preparing for Brexit. One aspect of this is the time spent by senior management time on Brexit preparations. Firms in the DMP survey were asked about this a number of times between 2017 and 2020. Figure A17 summarizes the results. On average, nearly 10% of CFOs were spending six hours or more per week on preparing for Brexit over this period, with a quarter spending between one and five hours a week. Around three-quarters reported spending at least some time planning for Brexit.

We find that time spent planning for Brexit by senior management is directly correlated with lower productivity growth in the post referendum period before the UK formally left the EU. Column (1) of Table 6 shows that average CFO hours spent on Brexit planning are, unsurprisingly, well correlated with firms' prior EU exposure. In column (2), we interact average CFO hours spent on Brexit with a post-referendum dummy in a regression with TFP growth as the dependent variable. This coefficient is significant at the 10% level. But only estimating this equation covering the period before the UK formally left the EU (column 3), the coefficient is larger and more strongly significant in those earlier years when the preparations for Brexit would have been taking place. While this does not prove causality, it is at least consistent with the time and cost of preparing for Brexit being a factor that contributed to lower productivity growth.

Related to time spent on Brexit planning, many firms increased their stock levels in preparation for the UK leaving the EU (Figure A17). For some firms, this was expected to be a temporary measure, but others expected to hold more stock on a permanent basis to help mitigate the extra barriers to trading with the EU. This may have also lowered measured productivity by increasing a firms' input costs while not raising their sales, at least temporarily. Column (4) of Table 6 shows in regression form, that firms more exposed to the EU did increase their stocks-to-total-assets ratio after 2016. Column (5) helps to confirm that this build-up of stocks largely took place prior to the UK actually leaving the EU.

Over the longer term, the productivity implications of Brexit may be more associated with lower trade and less specialization, rather than with the costs of transition and heightened uncertainty. Freeman et al. (2024), who analyze administrative data on trade in goods, find that exports and imports to the EU only fell once the new TCA came into effect in 2021, with no significant impact before that. Lower trade itself is therefore unlikely to have been a significant contributor to lower productivity before 2021. As argued by Broadbent (2024), in the short-run, firms who exported to the EU may have temporarily benefited from the depreciation of the exchange rate after the referendum because it took almost five years after that before the new rules for trading with the EU took effect.

Although the largest effects of Brexit on productivity are estimated to have been within-firms, the vote to leave the EU also had an impact on aggregate productivity through reallocation *between* firms. Figure 9 shows that there was a positive correlation between pre-referendum EU exposure and labor productivity.[21] It also shows that more productive firms expected more of a reduction in sales from Brexit over the long term. If high productivity firms were more adversely affected by Brexit and therefore made up a relatively smaller share of the UK economy than was previously the case, that would also have lowered aggregate productivity. To try and quantify the effect among surviving firms, we compare the average level of actual labor productivity in each year, weighted by actual employment, to a counterfactual using alternative employment weights that are based on what employment in each firm might have been in the absence of Brexit. These alternative employment weights are constructed using the coefficients from the employment regressions in Table 2.

Our estimates imply that reallocation-type effects among surviving firms have been small relative to the within-firm effects. These between-firm effects are estimated to have lowered aggregate productivity by 0.4% in 2023/24. These effects are estimated to have accumulated gradually over time, in line with the increasing impacts of Brexit on employment.

As well as between-firm effects among surviving firms, firm entry and exit can also have similar reallocation type implications for aggregate productivity. To assess this, we use two-digit industry data on firm birth and death rates from the ONS as dependent variables in a set of difference-in-differences regressions. These regressions include industry-level measures of pre-referendum exposure to the EU that are constructed from our firm-level data, again using the six-measure average. These regressions are reported in Table A8. The coefficients on EU exposure are not statistically significant, implying that changes in firm entry and exit associated with Brexit are unlikely to have had a large impact on aggregate productivity.

[21] Here we use labor productivity rather than TFP because it is not possible to easily compare the level of TFP across industries given the way it is normalised.

5 COMPARING MACRO AND MICRO ESTIMATES

Bringing together our macro and micro-based estimates of the impact of Brexit, both approaches indicate that the vote to leave the EU had a significant impact on the UK economy. However, the macro estimates are generally larger than the micro estimates. Table 7 summarizes the impacts. The macro estimates reported are for the year to 2025 Q1. The micro estimates are less timely and only available up to financial year 2023/24, representing a lag of around one year. The comparisons below assume that the micro estimates have not changed in the latest year and may therefore represent more of a lower bound. Using the macro approach, the level of GDP is estimated to have been 8% lower than it would have otherwise been, compared to 6% using the micro approach. In order to generate a GDP impact from the micro-estimates, we combine our estimates of the impact of Brexit on investment and capital, employment and productivity.[22]

Both micro and macro approaches imply Brexit impacts on employment and productivity of around 3% to 4%. The largest differences are in business investment, which is estimated to have been around 18% lower than it otherwise would have been using the macro approach, compared to 12% under the micro approach.[23]

Looking at the macro and micro-based impacts through time (Figure 8), they both have relatively similar profiles.[24] The effects on GDP and other variables are estimated to have grown gradually over time since the referendum, according to both approaches. The most notable differences are in business investment, where the macro estimates imply an earlier and larger fall in investment. Differences for other variables are smaller. In the most recent data, the estimated macro investment and employment impacts have shown signs of flattening off, but the GDP and productivity impacts have continued to grow.

[22] In our micro analysis, we estimate the effects on employment and TFP at the private sector level, but scale by their share in the whole economy to translate these into GDP space. We assume that there was no Brexit impact on the public sector. We also use labor productivity in our macro analysis for productivity even though TFP is a conceptually better measure to use, more comparable cross-country data are available for labor productivity. We use our micro-level TFP impacts when calculating the implied GDP impact from our micro-estimates.

[23] These investment impacts translate into impacts on capital of around 6% macro and 2% micro, assuming a depreciation rate of 4% and that annual investment equivalent to 6% of the capital stock.

[24] The macro impacts shown in Figure 8 smooth through the effects of the Covid pandemic for 2020, which otherwise adds significant volatility.

The main reason why the macro and micro estimates could differ is because of general equilibrium effects. The micro estimates assume that there was no Brexit impact on UK firms that had no direct exposure to the EU. But there could have been some effect on firms with no EU exposure if, for example, increased uncertainty and reduced consumer confidence also lowered demand for domestically produced goods and services. These general equilibrium effects need not necessarily be all negative for all firms. For example, lower demand for labor will reduce wages, and that may have benefited firms with no EU exposure. Similarly, the cut in interest rates that followed as part of the policy response to the referendum would have helped some firms.

General equilibrium effects that impact all firms would only be picked up in the macro estimates, not the micro-estimates. As discussed earlier, the macro estimates could also capture factors driving cross-country differences in growth other than Brexit, such as the effects of the Covid pandemic or government policies. The micro-based estimates are more likely to be causal because they are directly related to Brexit exposure, but they miss the general equilibrium implications. In the future work, we plan to develop a general equilibrium model to highlight which types of GE channels are likely to have been important. This should help reconcile the differences between our macro and micro estimates and help understand the extent to which we might expect these GE channels to lead the macro effects to be larger.

Our estimates of the impact of Brexit on GDP using both approaches are a larger than economists had predicted prior to the referendum. IMF (2016a) provide details of the estimates of the long-run impact of Brexit that were made at the time of the referendum, which are also summarized in Figure A18. The average GDP impact in these studies was a loss of around 4%. These initial assessments were correct in estimating that leaving the EU would lower UK GDP per capita in the long run. By 2021, five years after the referendum, our estimated GDP impacts were very close to these initial predictions at between 4% and 6%. However, the effects have since continued to grow over a longer horizon. One reason the magnitude of these initial estimates may have been too low is because they were made without including the additional costs of uncertainty.

6 CONCLUSION

This paper presents a comprehensive economic analysis of the UK's decision to leave the European Union. We employ both macro and micro approaches to evaluate the implications for GDP, investment, employment, and productivity. Our macro analysis is based on comparing the UK's economic performance against a set of comparable countries, using a range of different weighting methods to estimate what the UK economy might have looked like without Brexit. Our micro approach employs a difference-in-differences estimation using firm-level data from the Decision Maker Panel survey, matched with firm accounts. The micro approach is likely to better capture the causal impact of Brexit, but it may miss the impact of general equilibrium spillovers.

We estimate that by the start of 2025, the UK economy was approximately 8% smaller than it would have been without Brexit, based on macro data, and 6% smaller using firm-level micro data. Investment is estimated to have been 12-18% lower, employment 3-4% lower and productivity also 3-4% lower than it would have been if the UK had not voted to the leave the EU.

We show that Brexit generated a large, broad and long-lasting increase in uncertainty. This contributed to lower business investment, in particular, but it also may have reduced productivity too by restraining innovation and spending on potentially productivity enhancing forms of capital expenditure. We also show how the time and resources firms devoted to preparing for Brexit were strongly correlated with lower productivity. These channels have potentially been more important than the effects of reduced trade with the EU, at least initially, although the ways in which Brexit affects productivity will change over time and the trade effects may well become more important.

The UK’s experience of Brexit also has some parallels with the recent implementation of new tariffs on goods entering the United States in 2025. There are few other examples of increases in trade barriers between major developed countries, and like Brexit, announcements on tariffs have created uncertainty about what future trading arrangements could be and what the process towards a long-term solution might look like. In the case of Brexit, there was a substantial economic impact on the United Kingdom.

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Table 1: EU exposure and Brexit uncertainty

Dependent variable: Brexit uncertainty (0-3 scale)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Share of sales to EU	0.838***						0.321***	
	(0.058)						(0.059)	
Share of costs from EU imports		0.871***					0.524***	
		(0.049)					(0.051)	
Share of EU migrants in workforce			0.792***				0.665***	
			(0.037)				(0.037)	
Share of sales covered by EU regulations				0.579***			0.396***	
				(0.027)			(0.028)	
Share of directors who are EU nationals					0.491***		0.141***	
					(0.042)		(0.045)	
Dummy for being EU owned						0.303***	0.021	
						(0.043)	(0.047)	
EU exposure (6 measure average)								2.146***
								(0.071)
Observations	7,035	7,035	7,035	7,035	7,035	7,035	7,035	7,035
R-squared	0.037	0.050	0.068	0.064	0.019	0.006	0.151	0.128

Notes: DMP data for all variables, except share of directors who are EU nationals and ownership which are from the Bureau Van Dijk FAME database. EU exposure measures are for 2016 Q1, just before the Brexit referendum, except for directors and ownership data which are for 2015. Dependent variable is average Brexit uncertainty per firm, as collected in DMP surveys between August 2016 and April 2024. Brexit uncertainty is based on responses to the question: 'How much has the result of the EU referendum affected the level of uncertainty affecting your business?' Brexit uncertainty is defined as 0 for those who answered, 'Not important', 1, for 'One of many drivers of uncertainty', 2, for 'One of the top two or three drivers of uncertainty', and 3, for 'The largest current source of uncertainty'. Missing values for uncertainty for an individual firm in a given period are imputed from a regression using time and firm fixed effects. All equations are estimated by OLS with robust standard errors. *** p<0.01, ** p<0.05, * p<0.1.

Table 2: EU exposure and outcomes for investment and employment

Dependent variable (all in growth rates):	Investment			Employment		
All equations estimated 2011-2023 (financial years)	(1)	(2)	(3)	(4)	(5)	(6)
EU exposure (6 measure average)*pre-referendum	8.794**			4.611***		
	(3.850)			(1.466)		
EU exposure (6 measure average)*post-referendum	-6.700**	-16.505***	-17.043***	-2.193**	-4.737***	-5.057***
	(2.751)	(5.375)	(5.359)	(1.054)	(1.792)	(1.792)
Covid-19 impact on investment growth			0.728***			
			(0.046)			
Covid-19 impact on employment growth						0.260***
						(0.026)
Time fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Firm fixed effects	No	Yes	Yes	No	Yes	Yes
Observations	53,630	53,630	53,630	63,822	63,822	63,822
Test exposure coefficients are equal pre and post referendum (p-value):	0.0012			0.0001		
Implied impact of Brexit on levels in 2023 (%):						
- Private sector			-11.6			-3.4
- Whole economy						-2.8

Notes: EU exposure is the average of the following 6 exposure measures: share of sales to EU; share of costs from EU imports; share of EU migrants in workforce; share of sales covered by EU regulations; share of directors who are EU nationals; and a dummy for being EU owned. All are on a 0-1 scale. DMP data for all exposure variables, except share of directors who are EU nationals and ownership which are from the Bureau Van Dijk FAME database. EU exposure measures are for 2016 Q1, just before the Brexit referendum, except for directors and ownership data which are for 2015. Regressions use company accounts data from the Bureau Van Dijk FAME database for investment and employment where available and DMP data where accounts data are missing. Data used are from financial years 2011 to 2023, but 2016 is excluded (years are defined from Q3 to Q2 in next calendar year, so 2017 represents 2017/18 and would cover firms with a financial year end between 2017 Q3 and 2018 Q2). Covid-19 impact variables are from the DMP survey and are impacts on the firm estimated by survey respondents (see Appendix for more details on these). These Covid controls are interacted with separate year dummies where data are missing. Standard errors are clustered at the firm level. *** p<0.01, ** p<0.05, * p<0.1.

Memo: The mean of the Brexit exposure measure is 0.1.

Table 3: First and second moment impact of Brexit

Dependent variable (all in growth rates):	Investment		Employment		TFP		Sales	
All equations estimated 2011-2023 (financial years)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Brexit uncertainty*post-referendum	-1.564*	-1.740**	0.100		-0.584	-0.775**	0.188	
	(0.919)	(0.774)	(0.308)		(0.361)	(0.315)	(0.340)	
Expected long-run reduction in sales from Brexit*post-referendum	-0.057		-0.180***	-0.171***	-0.064		-0.262***	-0.244***
	(0.161)		(0.056)	(0.047)	(0.064)		(0.061)	(0.053)
Covid controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	87,710	87,710	105,491	105,491	74,290	74,290	91,333	91,333
Implied impact of Brexit on levels in 2023 (%):								
- Private sector		-15.2		-3.0		-6.8		-4.3
- Whole economy				-2.5		-5.6		

Notes: Brexit uncertainty is based on responses to a DMP question on the importance of Brexit as a source of uncertainty and is measured on a scale of 0 to 3. Expected long-run reduction in sales from Brexit is also based on a DMP question and is in percentage terms. Uncertainty data were collected in surveys between August 2016 and April 2024. Sales impact data were collected between February 2017 and April 2024. Missing values for both variables in a given survey year are imputed from a regression using time and firm fixed effects. Regressions in this table use company accounts data from the Bureau Van Dijk FAME database for investment, employment, sales and TFP growth where available and DMP data where accounts data are missing for investment, employment and sales. Data used are from financial years 2011 to 2023, but 2016 is excluded (years are defined from Q3 to Q2 in next calendar year, so 2017 represents 2017/18 and would cover firms with a financial year end between 2017 Q3 and 2018 Q2). TFP is calculated as the residual from a production function $\ln(Yit) = 0.63\ln(L_{it})+0.37\ln(K_{it})$ where Y_{it} is real value-added of firm i in year t, L is labour input (total real labour costs) and K is capital (total real fixed assets), nominal values from accounting data are deflated using the GDP deflator. TFP data are normalised by 4-digit industry (using data for the full DMP sampling frame) within each year. Real value-added is defined as operating profits plus total labour costs divided by the aggregate GDP deflator. Covid controls are variables for the impact of Covid-19 on investment growth for the investment equations, Covid-19 impact on employment growth in the employment equations, Covid-19 impact on sales growth in the sales equations and Covid-19 impact on sales per employee growth in the TFP equations. Covid-19 impact variables are from the DMP survey and are impacts on the firm estimated by survey respondents (see Appendix for more details on these). These Covid controls are interacted with separate year dummies where data are missing. Standard errors are clustered at the firm level. *** p<0.01, ** p<0.05, * p<0.1.

Memo: The mean of Brexit uncertainty is 1.25 and the expected long-run reduction in sales is 2.5%.

Table 4: EU exposure and outcomes for TFP and sales

Dependent variable (all in growth rates):	TFP			Sales		
Equations estimated 2011-2023 (financial years)	(1)	(2)	(3)	(4)	(5)	(6)
EU exposure (6 measure average)*pre-referendum	2.810*			1.252		
	(1.521)			(1.700)		
EU exposure (6 measure average)*post-referendum	-1.842	-5.107**	-4.953**	-0.104	-1.727	-2.119
	(1.285)	(2.244)	(2.252)	(1.324)	(2.128)	(2.131)
Covid-19 impact on sales growth per employee			0.321***			
			(0.036)			
Covid-19 impact on sales growth						0.698***
						(0.030)
Time fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Firm fixed effects	No	Yes	Yes	No	Yes	Yes
Observations	43,283	43,283	43,283	54,310	54,310	54,310
Test exposure coefficients are equal pre and post referendum (p-value):	0.0254			0.5134		
Implied impact of Brexit on levels in 2023, within firm only (%):						
- Private sector			-3.4			
- Whole economy			-2.8			

Notes: EU exposure is the average of the following 6 exposure measures: share of sales to EU; share of costs from EU imports; share of EU migrants in workforce; share of sales covered by EU regulations; share of directors who are EU nationals; and a dummy for being EU owned. All are on a 0-1 scale. DMP data for all exposure variables, except share of directors who are EU nationals and ownership which are from the Bureau Van Dijk FAME database. EU exposure measures are for 2016 Q1, just before the Brexit referendum, except for directors and ownership data which are for 2015. Regressions use company accounts data from the Bureau Van Dijk FAME database for sales and TFP growth where available and DMP data where accounts data are missing for sales. Data used are from financial years 2011 to 2023, but 2016 is excluded (years are defined from Q3 to Q2 in next calendar year, so 2017 represents 2017/18 and would cover firms with a financial year end between 2017 Q3 and 2018 Q2). TFP is calculated as the residual from a production function $\ln(Y_{it}) = 0.63\ln(L_{it})+0.37\ln(K_{it})$ where Y_{it} is real value-added of firm i in year t, L is labour input (total real labour costs) and K is capital (total real fixed assets), nominal values from accounting data are deflated using the GDP deflator. TFP data are normalised by 4-digit industry (using data for the full DMP sampling frame) within each year. Real value-added is defined as operating profits plus total labour costs divided by the aggregate GDP deflator. Covid-19 impact variables are from the DMP survey and are impacts on the firm estimated by survey respondents (see Appendix for more details on these). These Covid controls are interacted with separate year dummies where data are missing. Standard errors are clustered at the firm level. *** p<0.01, ** p<0.05, * p<0.1.

Memo: The mean of the Brexit exposure measure is 0.1.

Table 5: EU exposure and patent applications

Dependent variable: Probability of applying for at least one patent All equations estimated 2012-2020	All regions	UK	US	Top 5 non-Europe	EU	World Patent Office
	(1)	(2)	(3)	(4)	(5)	(6)
EU exposure (6 measure average)*post referendum	-2.011*	-1.223	-0.548	-1.389*	-0.429	-0.755
	(1.089)	(0.978)	(0.635)	(0.730)	(0.788)	(0.750)
Time fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Firm fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	52,244	52,244	52,244	52,244	52,244	52,244

Notes: EU exposure is the average of the following 6 exposure measures: share of sales to EU; share of costs from EU imports; share of EU migrants in workforce; share of sales covered by EU regulations; share of directors who are EU nationals; and a dummy for being EU owned. All are on a 0-1 scale. DMP data for all exposure variables, except share of directors who are EU nationals and ownership which are from the Bureau Van Dijk FAME database. EU exposure measures are for 2016 Q1, just before the Brexit referendum, except for directors and ownership data which are for 2015. Patents data are from World Patent Statistical Database and are for calendar years. We thank Ralf Martin (Imperial), Arjun Shah (King's College London), Anna Valero (LSE) and Dennis Verhoeven (KU Leuven) for their assistance with enabling the data on patents to be linked to the DMP.

Table 6: Impact of preparing for Brexit

Dependent variable:	CFO weekly hours Brexit planning	TFP growth		ΔStocks/total assets	
Time period	2017-20 average	2011-23	2011-19	2011-23	2011-19
	(1)	(2)	(3)	(4)	(5)
EU exposure (6 measure average)	4.012***				
	(0.303)				
CFO weekly hours Brexit planning*post-referendum		-0.264*	-0.413**		
		(0.153)	(0.197)		
EU exposure (6 measure average)*post-referendum				0.616**	1.033***
				(0.261)	(0.317)
Covid-19 impact on sales growth per employee		0.361***			
		(0.040)			
Time fixed effects	No	Yes	Yes	Yes	Yes
Firm fixed effects	No	Yes	Yes	Yes	Yes
Observations	2,819	36,985	25,379	42,591	28,682

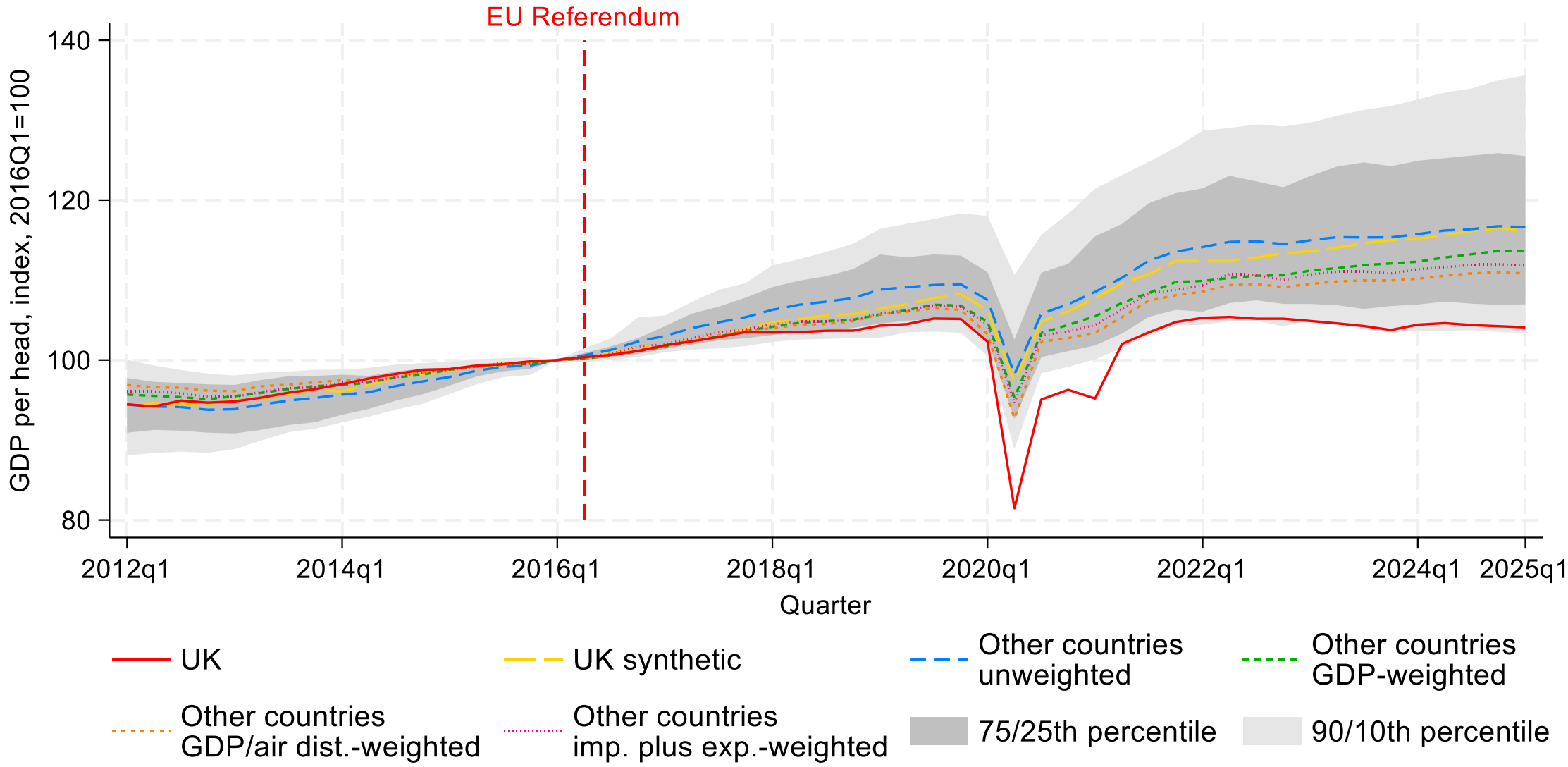
Notes: EU exposure is the average of the following 6 exposure measures: share of sales to EU; share of costs from EU imports; share of EU migrants in workforce; share of sales covered by EU regulations; share of directors who are EU nationals; and a dummy for being EU owned. All are on a 0-1 scale. DMP data for all exposure variables, except share of directors who are EU nationals and ownership which are from the Bureau Van Dijk FAME database. EU exposure measures are for 2016 Q1, just before the Brexit referendum, except for directors and ownership data which are for 2015. Data on CFO hours spent planning for Brexit are averages of data collected between November 2017 and March 2020. They are based on the question 'On average, how many hours a week are the CEO and CFO of your business spending on preparing for Brexit at the moment?' Please select one option for each for CEO and CFO: (i) None; (ii) Up to 1 hour; (iii) 1 to 5 hours; (iii) 6 to 10 hours; (iv) More than 10 hours; (v) Don't know'. Midpoints are assigned to responses in each category. TFP growth data are based on company accounts data from Bureau Van Dijk FAME and are calculated using the approach explained in the footnote to Table 4. Data from on stocks/total assets are company accounts data from Bureau Van Dijk FAME

Table 7: Summary of estimated Brexit impacts

	Macro estimates (year to 2025 Q1)	Micro estimates (financial year 2023/24)
Business investment	-18%	-12%
Whole economy employment	-4%	-3%
Whole economy productivity	-4%	-3%
GDP	-8%	-6%

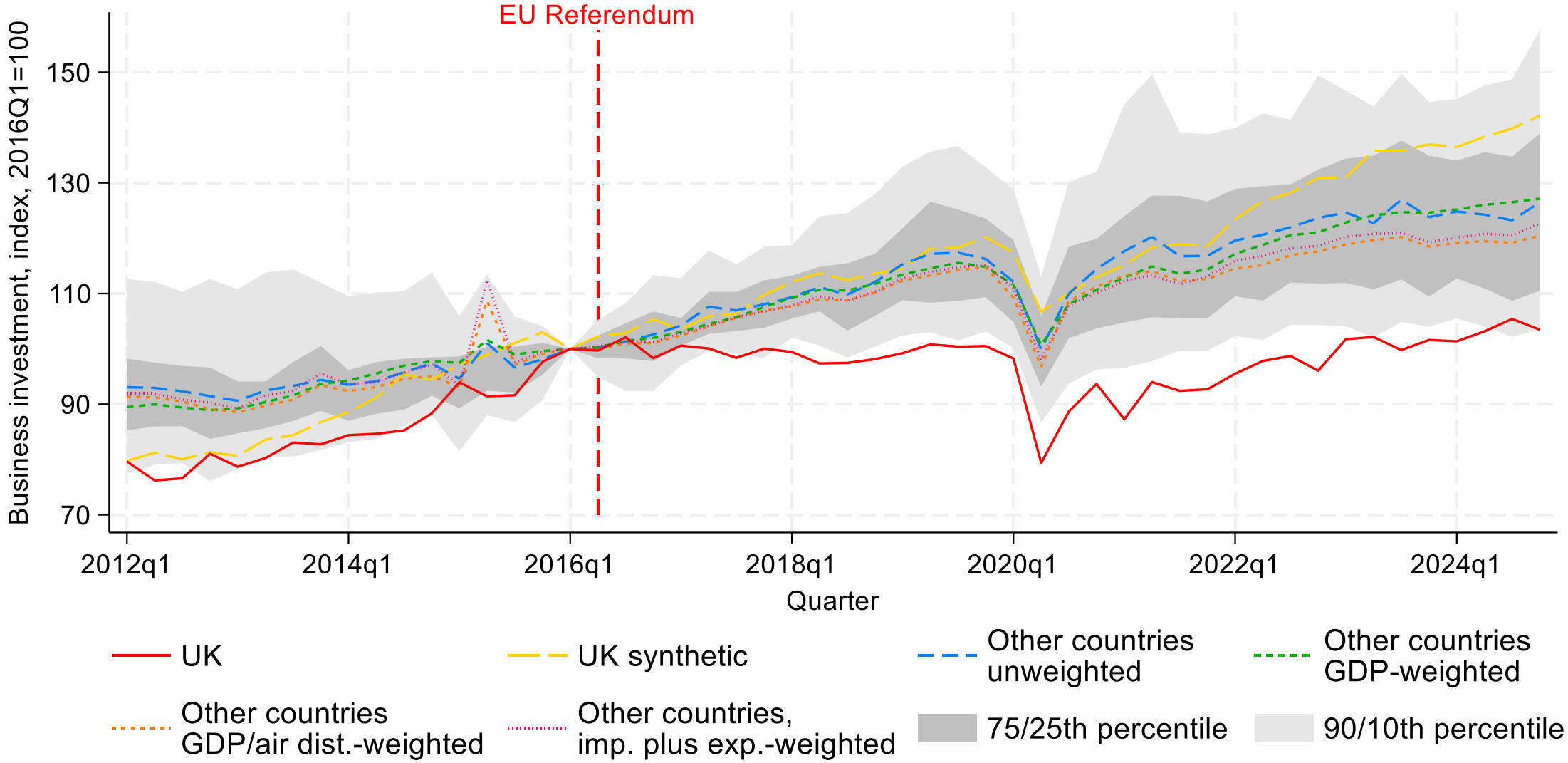
Notes: Estimates for employment, productivity and GDP are for the whole economy. Whole economy micro estimates for employment and productivity are constructed by scaling private sector estimates by their share in whole economy employment. Productivity impacts are based on TFP estimates for the micro estimates and labour productivity for the macro estimates. GDP micro-based estimates are constructed by combining TFP, employment and capital impact estimates. Capital impacts are estimated from investment impacts by assuming that annual investment is equivalent to 6% of the capital stock and a depreciation rate of 4%, in line with official data. The macro estimates represent the average of the UK relative to 5 different comparator country metrics: GDP weighted; GDP/air distance weighted; UK trade weighted; formal synthetic control; and simple unweighted. Investment macro impacts are for 2024 Q2 to 2024 Q4 rather than 2024 Q2 to 2025 Q1.

Figure 1: GDP per capita cross-country comparison



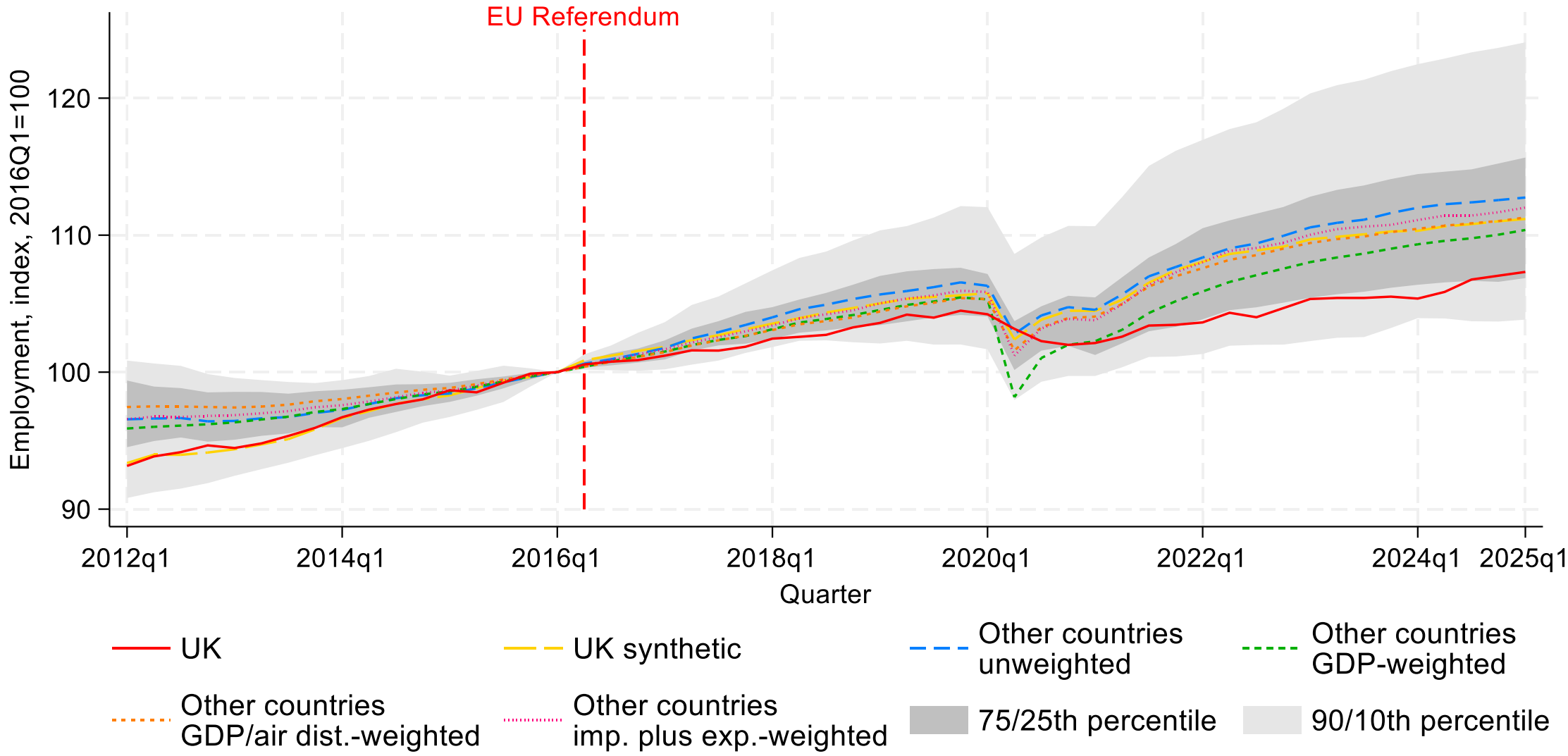
Notes: The figure uses data on real gross domestic product per person in the population. Comparator countries are US, Canada, EU-27 countries, Iceland, Norway, Switzerland, and Japan. All series used in the calculations have been seasonally adjusted. The synthetic control method estimates the effect of the EU referendum on the UK's economy by comparing the evolution of GDP per capita for the UK to the evolution of GDP per capita for a synthetic control group. We use data starting from 2006Q1 up to the EU referendum (2016Q2, 41 periods) to obtain optimal weights that minimize the prediction error in the pre-referendum period. To predict UK GDP per capita in the pre-referendum period we used GDP per capita, trade openess, investment ratio, educational attainment, and industry share in value added. Due to highly volatile time series we excluded Cyprus and Malta. For Ireland we use a measure of modified domestic demand rather than GDP because of distortons in the headline GDP data. The country weights are: US: 0.614, EST: 0.109, GRE: 0.095, ITA: 0.067, IRE: 0.044, LAT: 0.034, ICE: 0.03, HUN: 0.007. Percentiles were estimated using the bootstrapping method. Sources: OECD, Irish Central Statistics Office and World Bank.

Figure 2: Business investment cross-country comparison



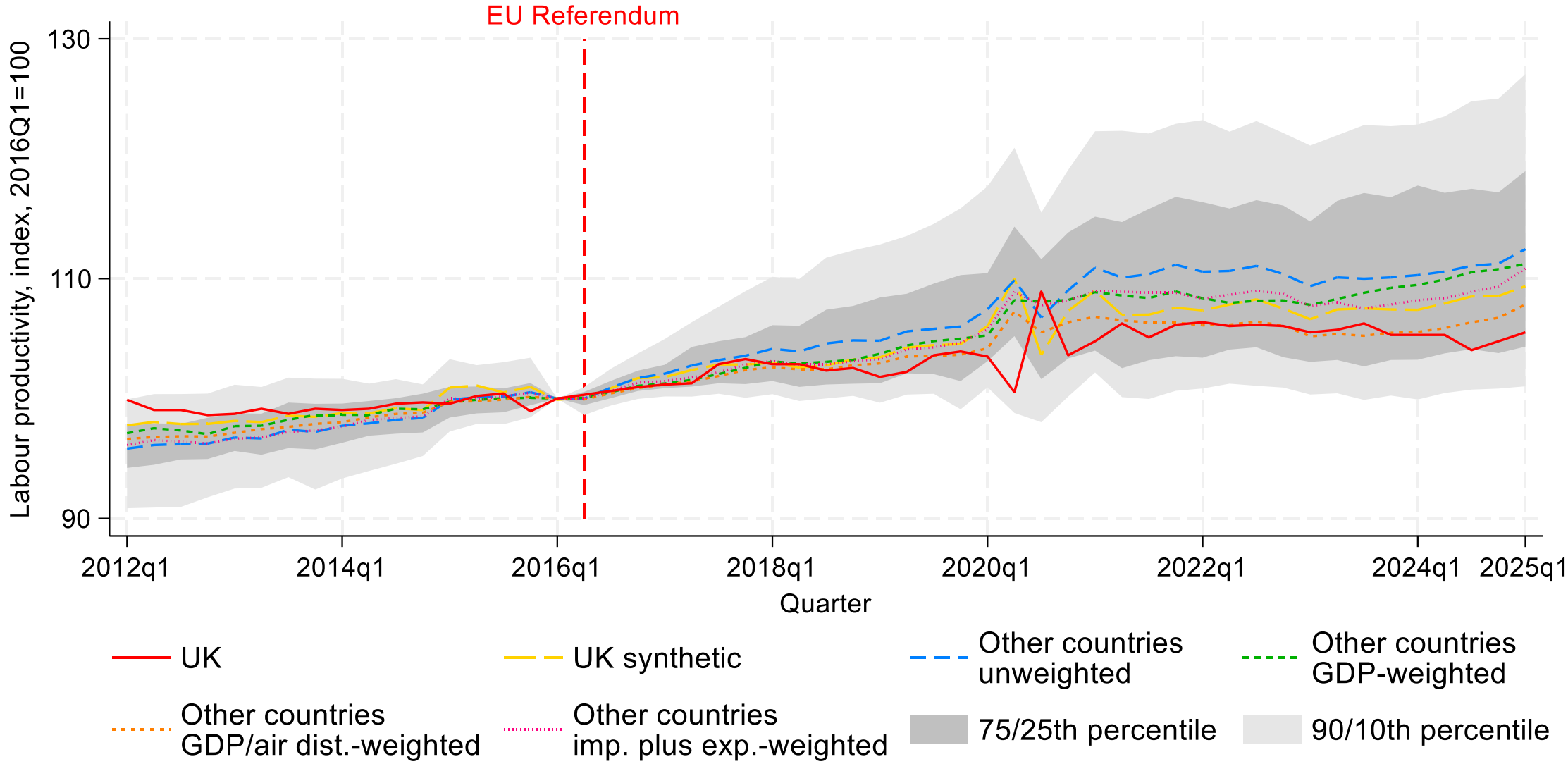
Notes: Investment is defined as business non-residential gross fixed capital formation. Comparator countries are US, Canada, EU-27 countries, Iceland, Norway, Switzerland, and Japan. All series used in the calculations have been seasonally adjusted. The synthetic control method estimates the effect of the EU referendum on the UK's economy by comparing the evolution of UK investment to the evolution of investment for a synthetic control group. We use data starting from 2006Q1 up to the EU referendum (2016Q2, 41 periods) to obtain optimal weights that minimize the prediction error in the pre-referendum period. To predict business invesment in the UK in the pre-referendum period we used the values of business investment in other countries in that period. Not included in the estimation were Cyprus, Estonia, Ireland, and Malta due to highly volatile data. For Belgium the series used includes residential investment. The country weights were: USA: 0.66, LTU: 0.25, POL: 0.09. Percentiles were estimated using the bootstrapping method. Sources: ONS, U.S. Bureau of Economic Analysis, Statistics Canada, Eurostat and OECD.

Figure 3: Employment cross-country comparison



Notes: Employment is the number of the employed people in the population aged 15 and over. Comparator countries are US, Canada, EU-27 countries, Iceland, Norway, Switzerland, and Japan. All series used in the calculations have been seasonally adjusted. The synthetic control method estimates the effect of the EU referendum on the UK's economy by comparing the evolution of UK employment to the evolution of employment for a synthetic control group. We use data starting from 2006Q1 up to the EU referendum (2016Q2, 41 periods) to obtain optimal weights that minimize the prediction error in the pre-referendum period. To predict employmentin the UK in the pre-referendum period we used employment in other countries in that period. The country weights were: US: 0.006, CAN: 0.011, AUS: 0.01, BEL: 0.009, BUL: 0.008, CRO: 0.014, CYP: 0.004, CZE: 0.01, DEN: 0.007, EST: 0.003, FIN: 0.008, FRA: 0.009, GER: 0.011, GRE: 0.01, HUN: 0.408, IRE: 0.014, ITA: 0.006, LAT: 0.003, LIT: 0.004, LUX: 0.031, MAL: 0.028, NET: 0.008, POL: 0.016, POR: 0.006, ROM: 0.005, SLK: 0.009, SLO: 0.008, SPA: 0.005, SWE: 0.011, ICE: 0.007, NOR: 0.285, CHE: 0.014, JAP: 0.008. Percentiles were estimated using the bootstrapping method. Sources: U.S. Bureau of Labor Statistics, OECD, Eurostat and Swiss Federal Statistical Office. .

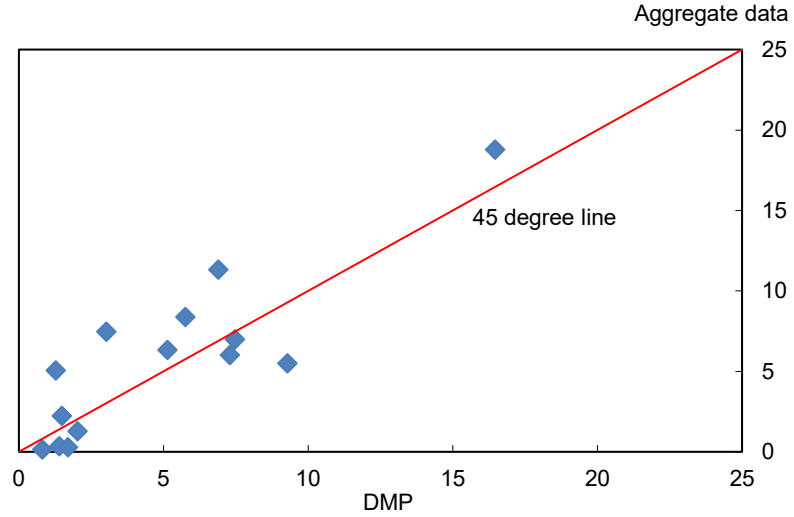
Figure 4: Labor productivity cross-country comparison



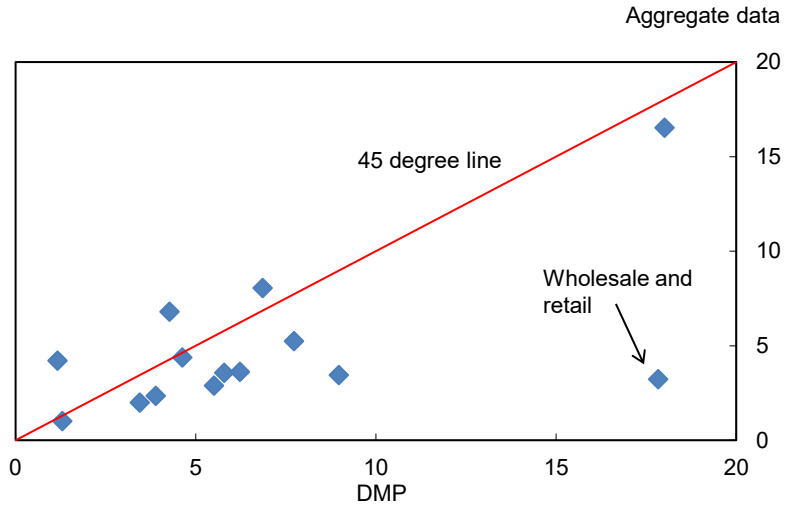
Notes: Labour productivity defined as real output per hour worked. Comparator countries are US, Canada, EU-27 countries, Iceland, Norway, Switzerland, and Japan. All series used in the calculations have been seasonally adjusted and some series have been calendar adjusted too. The series for Canada measures business sector labour productivity. The series for Japan was constructed using measures of productivity in services, manufacturing, construction and mining sectors weighted by the size of each sector in terms of their contributions to GDP. The synthetic control method estimates the effect of the EU referendum on the UK's economy by comparing the evolution of UK labor productivity to the evolution of labor productivity for a synthetic control group. We use data starting from 2006Q1 up to the EU referendum (2016Q2, 41 periods) to obtain optimal weights that minimize the prediction error in the pre-referendum period. To predict labor productivity in the UK in the pre-referendum period we used labor productivity in other countries in that period. The country weights were: US: 0.023, CAN: 0.028, AUS: 0.026, BEL: 0.03, BUL: 0.017, CRO: 0.025, CYP: 0.03, CZE: 0.025, DEN: 0.026, EST: 0.02, FIN: 0.031, FRA: 0.028, GER: 0.027, GRE: 0.191, HUN: 0.031, IRE: 0.012, ITA: 0.034, LAT: 0.014, LIT: 0.02, LUX: 0.035, MAL: 0.017, NET: 0.029, POL: 0.016, POR: 0.029, ROM: 0.012, SLK: 0.017, SLO: 0.028, SPA: 0.023, SWE: 0.029, ICE: 0.029, NOR: 0.033, CHE: 0.028, JAP: 0.036. Percentiles were estimated using the bootstrapping method. Sources: Eurostat, OECD, ONS, Statistics Canada, Japan Productivity Center.

Figure 5: Measures of pre-referendum exposure to the EU

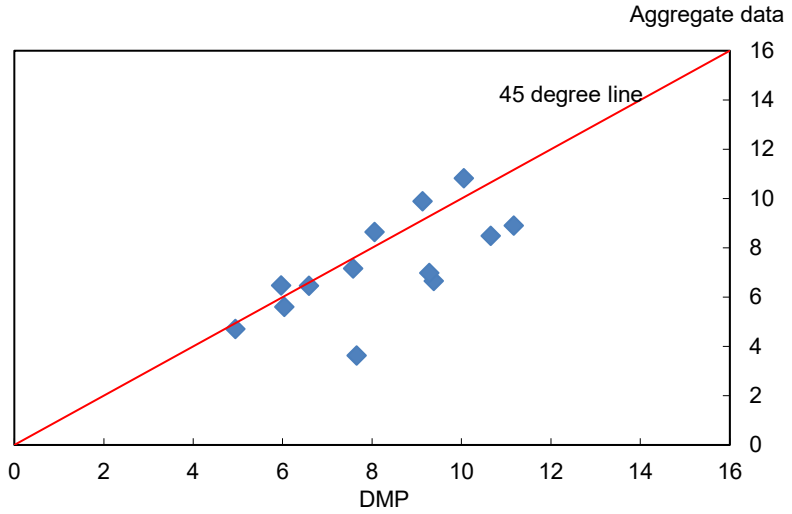
Percentage of sales that were exports to the EU, by industry



Percentage of costs that were imports from the EU, by industry



Percentage of EU migrants in workforce, by industry

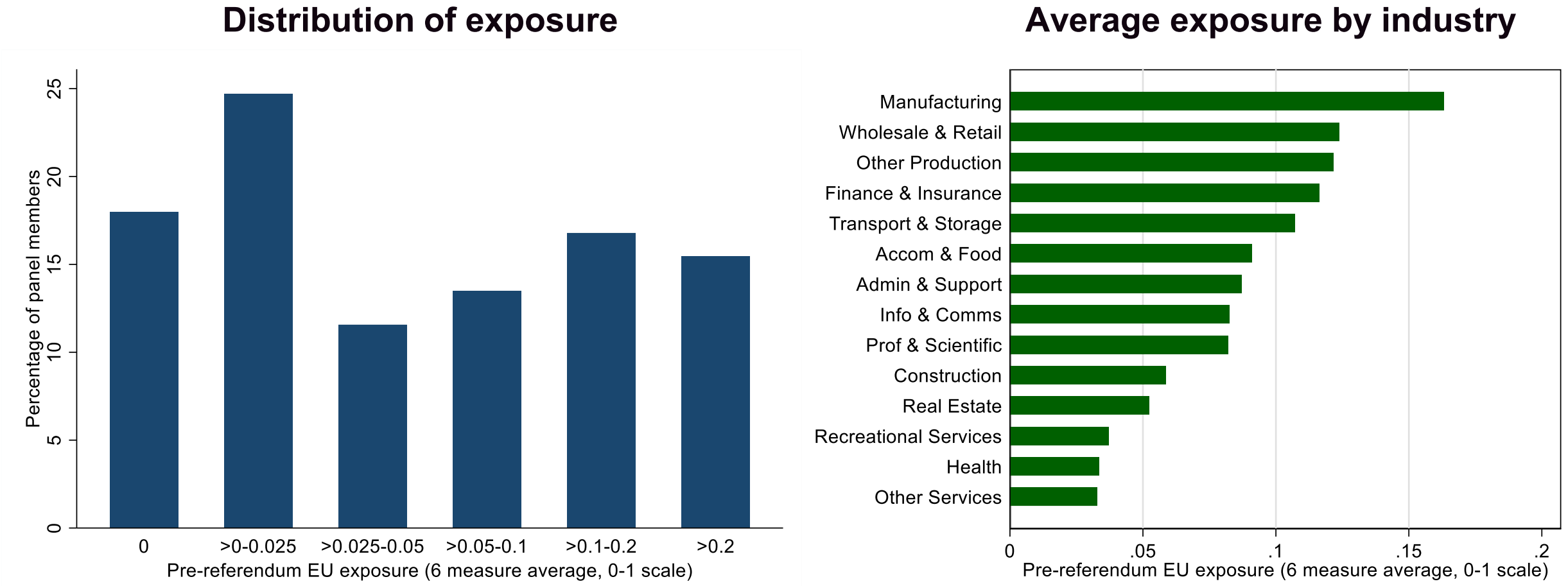


Aggregate statistics

	DMP	Aggregate data
Percentage of sales that were exports to EU	6.9%	7.4%
Percentage of costs that were imports from EU	8.9%	6.9%
- Excluding wholesale and retail	7.7%	7.4%
Percentage of EU migrants in workforce	9.1%	8.1%

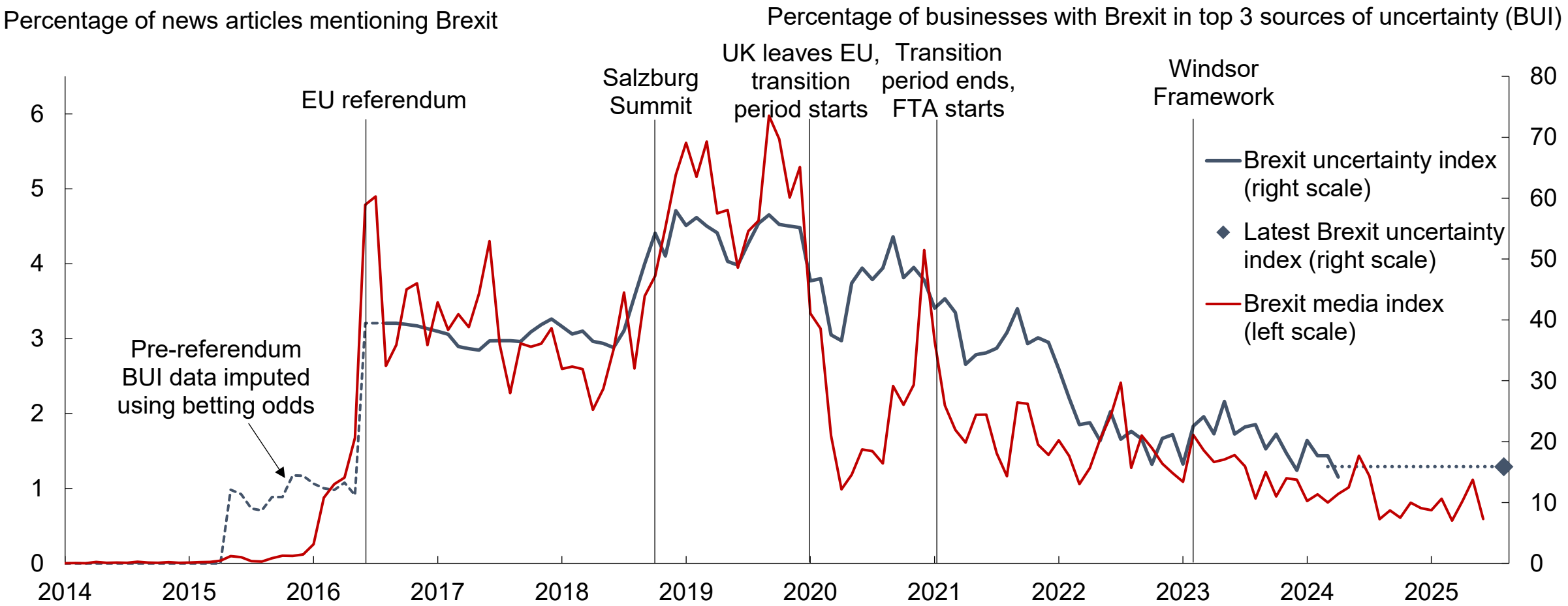
Notes: DMP data on the percentage of sales that were exports to the EU, percentage of costs that were imports from the EU and percentage of employees who were EU migrants are for 2016 Q1. Aggregate data on the percentage of sales that were exports to the EU and the percentage of costs that were imports from the EU are for 2015. They are calculated from the ONS 2015 Input-Output tables and are for the market sector. Imports as a percentage of costs are imports that are used for intermediate consumption. The share of imports used for intermediate consumption that are from the EU in each industry is assumed to be the same as the share of EU imports in total imports in that industry. Aggregate data on the percentage of employees who were EU migrants are for 2016 H1. They are calculated from the ONS Labour Force Survey and are the percentage of employees who report working in the private sector who were born in the EU. Sources: Decision Maker Panel and ONS.

Figure 6: Pre-referendum exposure to the EU



Notes: EU exposure is the average of the following 6 exposure measures: share of sales to EU; share of costs from EU imports; share of EU migrants in workforce; share of sales covered by EU regulations; share of directors who are EU nationals; and a dummy for being EU owned. All are on a 0-1 scale. DMP data for all exposure variables, except share of directors who are EU nationals and ownership which are from the Bureau Van Dijk FAME database. EU exposure measures are for 2016 Q1, just before the Brexit referendum, except for directors and ownership data which are for 2015.

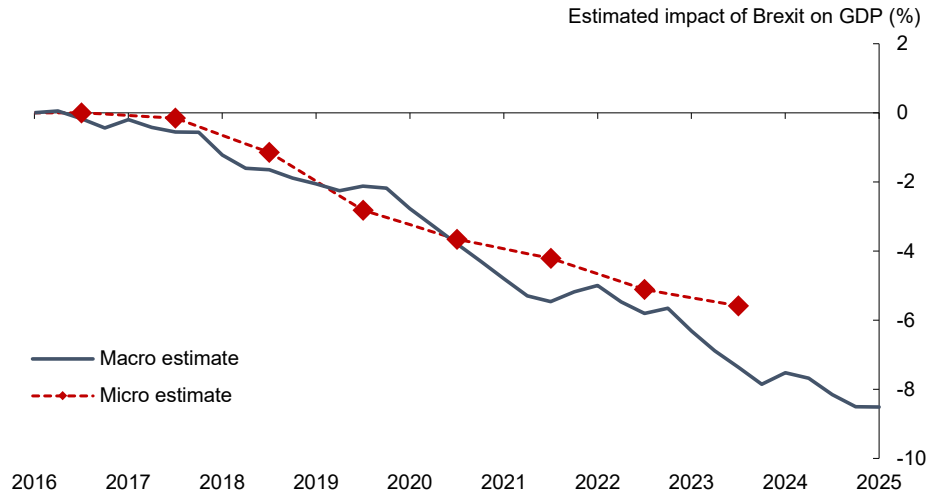
Figure 7: Brexit uncertainty index and Brexit media index



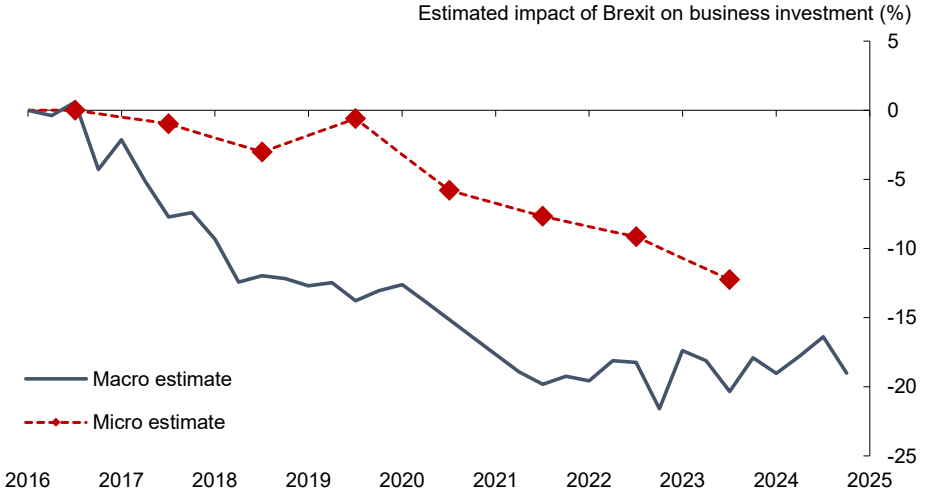
Notes: Brexit uncertainty index shows the percentage of DMP survey respondents who view Brexit as their "top" or "one of their top three" sources of uncertainty in response to the question 'How much has the result of the EU referendum affected the level of uncertainty affecting your business?'. Values are interpolated for some months before August 2018 when the question was not asked. Final diamond is for August and September 2025. The Brexit uncertainty question was not asked between April 2024 and July 2025. Brexit media index is the percentage of articles in British newspapers which mention the term 'Brexit'. Sources: Access World News' News-Bank and Decision Maker Panel.

Figure 8: Estimated impact of Brexit

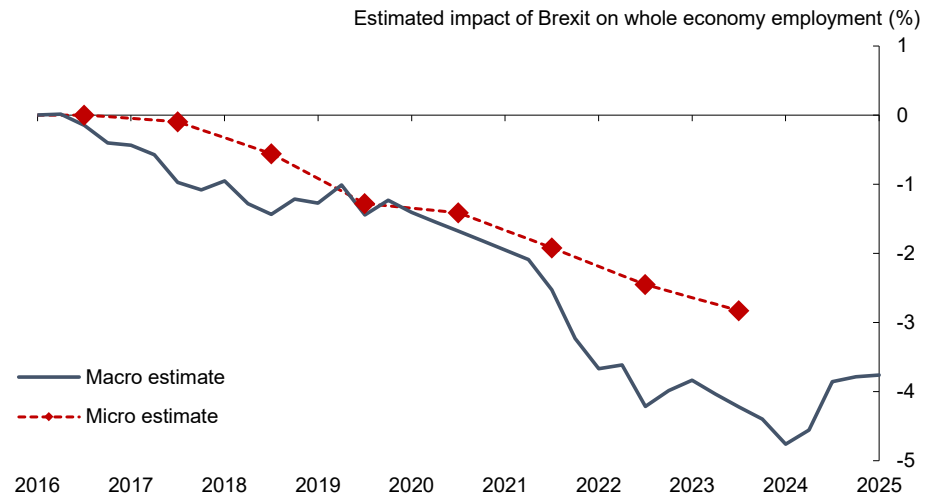
GDP



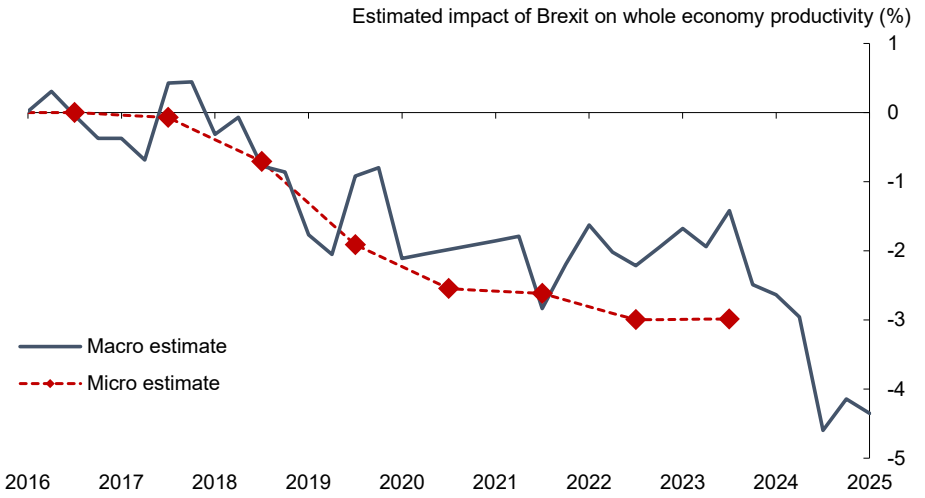
Business investment



Whole economy employment

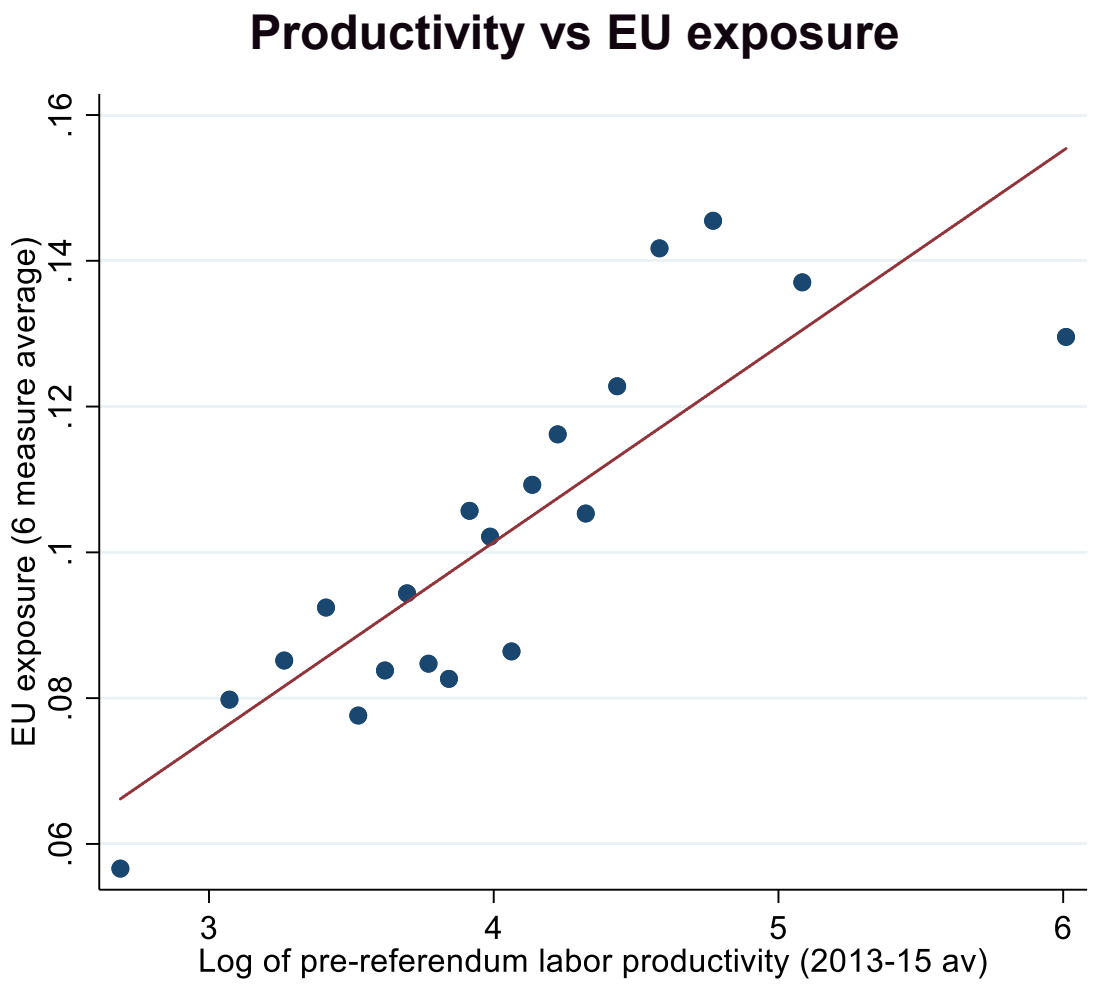


Whole economy productivity



Notes: Estimates for employment, productivity and GDP are for the whole economy. Whole economy micro estimates for employment and productivity are constructed by scaling private sector estimates by their share in whole economy employment. Productivity impacts are based on TFP estimates for the micro estimates and labor productivity for the macro estimates. GDP micro-based estimates are constructed by combining TFP, employment and capital impact estimates. Capital impacts are estimated from investment impacts by assuming that annual investment is equivalent to 6% of the capital stock and using a depreciation rate of 4%. Micro estimates are annual and are for financial years (shown as red diamonds which are plotted for Q3). Macro estimates are quarterly. The macro estimates represent the average of the UK relative to 5 different comparator country metrics: GDP weighted; GDP/air distance weighted; UK trade weighted; formal synthetic control; and simple unweighted. Macro estimates for 2020 Q2 to 2021 Q1 are calculated by interpolating between estimates for 2020 Q1 and 2021 Q2 to smooth through the impact of the Covid-19 pandemic.

Figure 9: Pre-referendum labor productivity and EU exposure



Notes: EU exposure is the average of the following 6 exposure measures: share of sales to EU; share of costs from EU imports; share of EU migrants in workforce; share of sales covered by EU regulations; share of directors who are EU nationals; and a dummy for being EU owned. All are on a 0-1 scale. DMP data for all exposure variables, except share of directors who are EU nationals and ownership which are from the Bureau Van Dijk FAME database. EU exposure measures are for 2016 Q1, just before the Brexit referendum, except for directors and ownership data which are for 2015. Brexit sales impact the is average expected long-run reduction in sales from Brexit, per firm, as collected in DMP surveys between February 2017 and April 2024. Missing values for Brexit sales impact in a given survey year are imputed from a regression using time and firm fixed effects. Pre-referendum labor productivity defined as the annual real value-added per employee in £ thousands (2013-2015 average) and is calculated using accounts data from the Bureau van Dijk FAME dataset. The figure shows binscatter plots which split responses into 25 groups according to average pre-referendum labor productivity. Sources: Bureau van Dijk FAME and Decision Maker Panel.

Appendix

Table A1: Descriptive statistics

	Mean (weighted)	Mean (unweighted)	Standard deviation	10th percentile	25th percentile	Median	75th percentile	90th percentile
Accounts data (2015)								
Employment	927	396	4894	13	26	67	157	405
Sales (£, 000)	177465	86903	1035985	1928	5467	12279	28081	83099
Investment (£,000)	8200	3645	92397	0	10	81	458	2206
Percentage of publically listed firms	4%	2%	-	-	-	-	-	-
First and second moment Brexit impacts								
Expected long-run impact on sales from Brexit (%)	-2.5	-2.7	4.1	-9.5	-4.9	-1.0	0.0	0.4
Average Brexit uncertainty (0-3 scale)	1.3	1.2	0.8	0.0	0.7	1.1	1.8	2.2
Pre-referendum EU exposure								
Share of sales to EU	0.07	0.07	0.17	0	0	0	0.05	0.25
Share of costs from EU imports	0.09	0.09	0.19	0	0	0	0.08	0.30
Share of EU migrants in workforce	0.14	0.14	0.24	0	0	0.03	0.12	0.58
Share of sales covered by EU regulations	0.17	0.15	0.32	0	0	0	0.07	1
Share of directors who are EU nationals	0.07	0.07	0.20	0	0	0	0	0.33
Dummy for being EU owned	0.04	0.04	0.19	0	0	0	0	0
EU exposure (6 measure average)	0.10	0.09	0.12	0	0.01	0.04	0.15	0.26

Notes: Data for the 7035 firms who have data on all six pre-referendum EU exposure measures. Accounts data are from the Bureau van Djik FAME database. DMP data for all EU exposure variables, except share of directors who are EU nationals and ownership which are from the Bureau Van Dijk. First and second moment impacts of Brexit are from DMP survey. Weighted data are weighted together using pre-referendum employment with weights capped at 250 employees for larger firms.

Table A2: Linear probability models for propensity to respond to DMP survey

Dependent variable: Ever responded to a survey if in sampling frame	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Leave vote share	-0.001	0.008	-0.013	-0.012	-0.008	-0.012	-0.010
	(0.013)	(0.013)	(0.013)	(0.013)	(0.013)	(0.013)	(0.013)
Log of employment			0.026***	0.011***	0.009***	0.009***	0.013***
			(0.001)	(0.002)	(0.002)	(0.002)	(0.002)
Log of sales				0.010***	0.006***	0.008***	0.002
				(0.002)	(0.002)	(0.002)	(0.002)
Log of assets					0.005***	0.003***	0.002**
					(0.001)	(0.001)	(0.001)
Log of firm age						0.021***	0.020***
						(0.002)	(0.002)
Log of labour productivity							0.011***
							(0.004)
1 digit industry dummies	No	Yes	Yes	Yes	Yes	Yes	Yes
Observations	62,654	62,654	62,654	62,654	62,654	62,654	62,654
R-squared	0.000	0.006	0.029	0.033	0.034	0.035	0.036
F-test for joint significance of industry dummies (p-value)	-	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

Notes: Linear probability model for whether a firm is in the DMP sampling frame and has ever responded to a DMP survey between September 2016 and June 2025 (1=responded to DMP, 0=Not responded). Only includes firms that were incorporated and had a set of published accounts for 2015 or earlier. Firm characteristics are pre-referendum accounts data from the Bureau Van Dijk FAME database (2015 data for most firms, earlier data if 2015 data were not available). Regressions also include dummy variables (coefficients not reported) for missing employment, sales or labour productivity data. 'Leave vote share' is Electoral Commission data on the share of the vote for leaving the EU in the local authority that a firm is headquartered in. Robust standard errors are used. *** p<0.01, ** p<0.05, * p<0.1.

Table A3: EU exposure and expected long-run impact of Brexit on sales

Dependent variable: Expected long-run reduction in sales from Brexit (%)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Share of sales to EU	4.896***						2.928***	
	(0.367)						(0.378)	
Share of costs from EU imports		3.206***					1.453***	
		(0.299)					(0.322)	
Share of EU migrants in workforce			3.300***				2.666***	
			(0.242)				(0.241)	
Share of sales covered by EU regulations				2.679***			1.807***	
				(0.173)			(0.182)	
Share of directors who are EU nationals					1.834***		0.429	
					(0.262)		(0.275)	
Dummy for being EU owned						0.934***	-0.129	
						(0.266)	(0.283)	
EU exposure (6 measure average)								9.289***
								(0.444)
Observations	7,035	7,035	7,035	7,035	7,035	7,035	7,035	7,035
R-squared	0.039	0.021	0.037	0.043	0.008	0.002	0.093	0.075

Notes: DMP data for all variables, except share of directors who are EU nationals and ownership which are from the Bureau Van Dijk FAME database. EU exposure measures are for 2016 Q1, just before the Brexit referendum, except for directors and ownership data which are for 2015. Dependent variable is average expected long-run reduction in sales from Brexit, per firm, as collected in DMP surveys between February 2017 and April 2024. Missing values for Brexit sales impact in a given survey year are imputed from a regression using time and firm fixed effects. All equations are estimated by OLS with robust standard errors. *** p<0.01, ** p<0.05, * p<0.1.

Table A4: EU exposure and firm outcomes, by year

Dependent variable (all in growth rates):	Investment	Employment	TFP	Sales
All equations estimated 2011-2023 (financial years)	(1)	(2)	(3)	(4)
EU exposure (6 measure average)*2017	-10.069	-1.220	-0.755	9.610***
	(12.089)	(2.753)	(4.372)	(3.407)
EU expoure (6 measure average)*2018	-20.917*	-5.796**	-7.228	-3.619
	(11.789)	(2.724)	(4.485)	(3.593)
EU exposure (6 measure average)*2019	24.758**	-9.031***	-13.870***	-2.188
	(12.350)	(2.972)	(4.726)	(3.579)
EU exposure (6 measure average)*2020	-53.345***	-1.685	-7.740	-12.401***
	(12.310)	(2.999)	(5.405)	(4.529)
EU exposure (6 measure average)*2021	-19.322	-6.371**	-0.140	-3.791
	(12.818)	(3.057)	(5.528)	(4.754)
EU exposure (6 measure average)*2022	-15.241	-6.681**	-4.002	-0.621
	(12.031)	(3.218)	(5.440)	(3.928)
EU exposure (6 measure average)*2023	-31.869**	-4.705*	0.746	-2.078
	(13.232)	(2.725)	(5.414)	(3.825)
Covid controls	Yes	Yes	Yes	Yes
Time fixed effects	Yes	Yes	Yes	Yes
Firm fixed effects	Yes	Yes	Yes	Yes
Observations	53,630	63,822	43,283	54,310

Notes: EU exposure is the average of the following 6 exposure measures: share of sales to EU; share of costs from EU imports; share of EU migrants in workforce; share of sales covered by EU regulations; share of directors who are EU nationals; and a dummy for being EU owned. All are on a 0-1 scale. DMP data for all exposure variables, except share of directors who are EU nationals and ownership which are from the Bureau Van Dijk FAME database. EU exposure measures are for 2016 Q1, just before the Brexit referendum, except for directors and ownership data which are for 2015. Regressions in this table use company accounts data from the Bureau Van Dijk FAME database for investment, employment, sales and TFP growth where available and DMP data where accounts data are missing for investment, employment and sales. Data used are from financial years 2011 to 2023, but 2016 is excluded (years are defined from Q3 to Q2 in next calendar year, so 2017 represents 2017/18 and would cover firms with a financial year end between 2017 Q3 and 2018 Q2). Covid-19 impact variables are from the DMP survey and are impacts on the firm estimated by survey respondents (see Appendix for more details on these). These Covid controls are interacted with separate year dummies where data are missing. Standard errors are clustered at the firm level. *** p<0.01, ** p<0.05, * p<0.1.

Table A5: Investment robustness

Dependent variable: Investment growth	(1)	(2) (Accounts data only)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
EU exposure (6 measure average)*post-referendum	-17.043***	-12.153**							
	(5.359)	(5.578)							
Principal component EU exposure (6 measure average)*post-referendum			-1.157**						
			(0.459)						
EU exposure (5 measure average, excluding share of sales to EU)*post-referendum				-16.228***					
				(4.859)					
EU exposure (5 measure average, excluding share of costs from EU imports)*post-referendum					-14.864***				
					(5.165)				
EU exposure (5 measure average, excluding EU migrant worker share)*post-referendum						-11.618**			
						(4.805)			
EU exposure (5 measure average, excluding importance of EU regulations)*post-referendum							-13.814**		
							(5.711)		
EU exposure (5 measure average, excluding EU directors share)*post-referendum								-17.919***	
								(5.146)	
EU exposure (5 measure average, excluding Dummy for EU owned)*post-referendum									-19.098***
									(5.170)
Covid-19 impact on investment growth	0.728***	0.731***	0.728***	0.728***	0.728***	0.728***	0.728***	0.728***	0.729***
	(0.046)	(0.055)	(0.046)	(0.046)	(0.046)	(0.046)	(0.046)	(0.046)	(0.046)
Time fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	53,630	49,200	53,630	53,630	53,630	53,630	53,630	53,630	53,630

Notes: EU exposure is the average of the following 6 exposure measures: share of sales to EU; share of costs from EU imports; share of EU migrants in workforce; share of sales covered by EU regulations; share of directors who are EU nationals; and a dummy for being EU owned. All are on a 0-1 scale. DMP data for all exposure variables, except share of directors who are EU nationals and ownership which are from the Bureau Van Dijk FAME database. EU exposure measures are for 2016 Q1, just before the Brexit referendum, except for directors and ownership data which are for 2015. Regressions in this table use company accounts data from the Bureau Van Dijk FAME database for investment, where available and DMP data where accounts data are missing. Data used are from financial years 2011 to 2023, but 2016 is excluded (years are defined from Q3 to Q2 in next calendar year, so 2017 represents 2017/18 and would cover firms with a financial year end between 2017 Q3 and 2018 Q2). Covid-19 impact variables are from the DMP survey and are impacts on the firm estimated by survey respondents (see Appendix for more details on these). These Covid controls are interacted with separate year dummies where data are missing. Standard errors are clustered at the firm level. *** p<0.01, ** p<0.05, * p<0.1.

Table A6: Investment robustness

Dependent variable: Investment growth	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
All equations estimated 2011-2023 (financial years)	All firms	Below average profit margin in 2013-15	Above average profit margin in 2013-15	Smaller firms (<100 employees in 2013-15)	Larger firms (100+ employees in 2013-15)	Younger firms (born 2000+)	Older firms (born pre-2000)	Manufacturing, retail & finance	Other industries
EU exposure (6 measure average)*post-referendum	-17.043***	-17.816**	-5.232	-11.288	-21.507***	-27.303***	-11.321*	-21.655***	-13.608
	(5.359)	(8.428)	(7.368)	(7.463)	(7.657)	(9.843)	(6.263)	(7.097)	(9.398)
Covid-19 impact on investment growth	0.728***	0.744***	0.766***	0.734***	0.677***	0.703***	0.746***	0.827***	0.660***
	(0.046)	(0.075)	(0.070)	(0.065)	(0.071)	(0.070)	(0.062)	(0.070)	(0.061)
Time fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	53,630	19,491	20,061	27,881	18,736	24,942	28,688	21,155	32,475
Test that exposure coefficients are equal:			(2) vs (3)		(4) vs (5)		(6) vs (7)		(8) vs (9)
- p value			0.26		0.34		0.17		0.49

Notes: EU exposure is the average of the following 6 exposure measures: share of sales to EU; share of costs from EU imports; share of EU migrants in workforce; share of sales covered by EU regulations; share of directors who are EU nationals; and a dummy for being EU owned. All are on a 0-1 scale. DMP data for all exposure variables, except share of directors who are EU nationals and ownership which are from the Bureau Van Dijk FAME database. EU exposure measures are for 2016 Q1, just before the Brexit referendum, except for directors and ownership data which are for 2015. Regressions in this table use company accounts data from the Bureau Van Dijk FAME database for investment, where available and DMP data where accounts data are missing. Data used are from financial years 2011 to 2023, but 2016 is excluded (years are defined from Q3 to Q2 in next calendar year, so 2017 represents 2017/18 and would cover firms with a financial year end between 2017 Q3 and 2018 Q2). Covid-19 impact variables are from the DMP survey and are impacts on the firm estimated by survey respondents (see Appendix for more details on these). These Covid controls are interacted with separate year dummies where data are missing. Standard errors are clustered at the firm level. *** p<0.01, ** p<0.05, * p<0.1.

Table A7: EU exposure and GVA/labor productivity growth

Dependent variable (all in growth rates):	Value-added			Labor productivity		
All equations estimated 2011-2023 (financial years)	(1)	(2)	(3)	(4)	(5)	(6)
EU exposure (6 measure average)*post-referendum	-4.145			-0.601		
	(2.576)			(2.052)		
Brexit uncertainty*post-referendum		-0.786*			-0.497	-0.674**
		(0.406)			(0.347)	(0.298)
Expected long-run reduction in sales from Brexit*post-referendum		-0.166**	-0.241***		-0.060	
		(0.073)	(0.063)		(0.061)	
Covid-19 impact on sales growth	0.598***	0.599***	0.599***			
	(0.043)	(0.036)	(0.036)			
Covid-19 impact on sales growth per employee				0.425***	0.427***	0.427***
				(0.038)	(0.033)	(0.033)
Time fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Firm fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	44,010	75,492	75,492	43,677	74,988	74,988
Implied impact of Brexit on levels in 2023 (%):						
- Private sector	-2.8		-3.8	-0.4		-5.8
- Whole economy	-2.3		-3.1	-0.3		-4.7

Notes: EU exposure is the average of the following 6 exposure measures: share of sales to EU; share of costs from EU imports; share of EU migrants in workforce; share of sales covered by EU regulations; share of directors who are EU nationals; and a dummy for being EU owned. All are on a 0-1 scale. DMP data for all exposure variables, except share of directors who are EU nationals and ownership which are from the Bureau Van Dijk FAME database. EU exposure measures are for 2016 Q1, just before the Brexit referendum, except for directors and ownership data which are for 2015. Regressions in this table use company accounts data from the Bureau Van Dijk FAME database. Real value-added is defined as operating profits plus total labour costs divided by the aggregate GDP deflator. Labor productivity is defined as annual real value-added per employee. Data used are from financial years 2011 to 2023, but 2016 is excluded (years are defined from Q3 to Q2 in next calendar year, so 2017 represents 2017/18 and would cover firms with a financial year end between 2017 Q3 and 2018 Q2). Covid-19 impact variables are from the DMP survey and are impacts on the firm estimated by survey respondents (see Appendix for more details on these). These Covid controls are interacted with separate year dummies where data are missing. Standard errors are clustered at the firm level. *** p<0.01, ** p<0.05, * p<0.1.

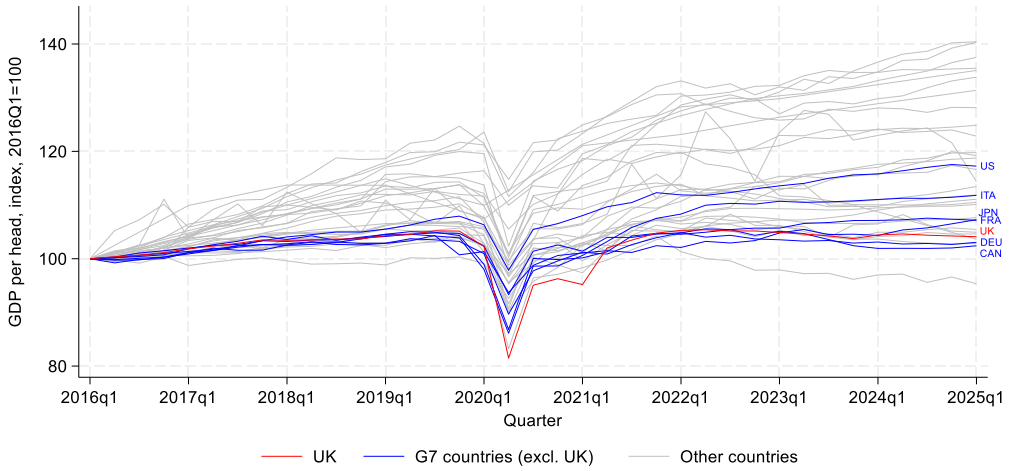
Table A8: Firm entry and exit regressions

Dependent variable:	Industry level data (2011-2023)			
	Net entry rate	Net entry rate	Entry rate	Exit rate
	(1)	(2)	(3)	(4)
EU exposure (6 measure average)*post-referendum	0.652	-2.938	-1.947	0.581
	(3.660)	(7.169)	(7.555)	(3.083)
2 digit industry dummies	No	Yes	Yes	Yes
Year dummies	Yes	Yes	Yes	Yes
Observations	940	940	940	940
R-squared	0.108	0.380	0.588	0.724

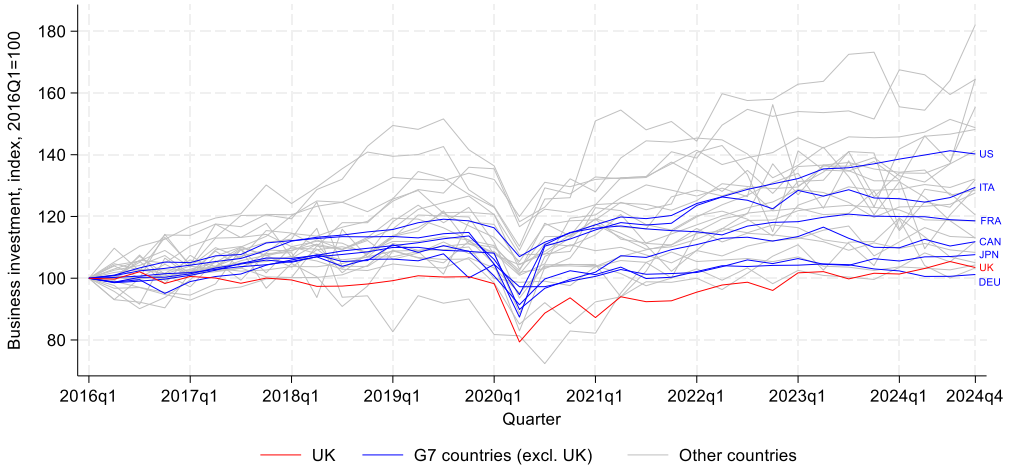
Notes: EU exposure is the average of the following 6 exposure measures: share of sales to EU; share of costs from EU imports; share of EU migrants in workforce; share of sales covered by EU regulations; share of directors who are EU nationals; and a dummy for being EU owned. All are on a 0-1 scale. DMP data for all exposure variables, except share of directors who are EU nationals and ownership which are from the Bureau Van Dijk FAME database. EU exposure measures are for 2016 Q1, just before the Brexit referendum, except for directors and ownership data which are for 2015. Two-digit industry data on firm birth and rates by year are from the Office for National Statistics. Two-digit industry data on exposure to the EU are constructed by collapsing the firm level data down to industry level. *** p<0.01, ** p<0.05, * p<0.1.

Figure A1: Comparison of UK versus other individual countries

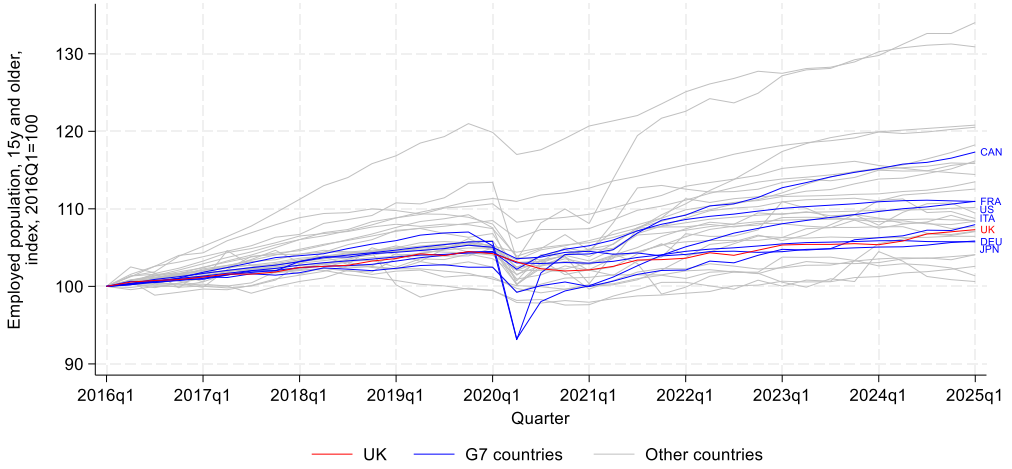
GDP per capita



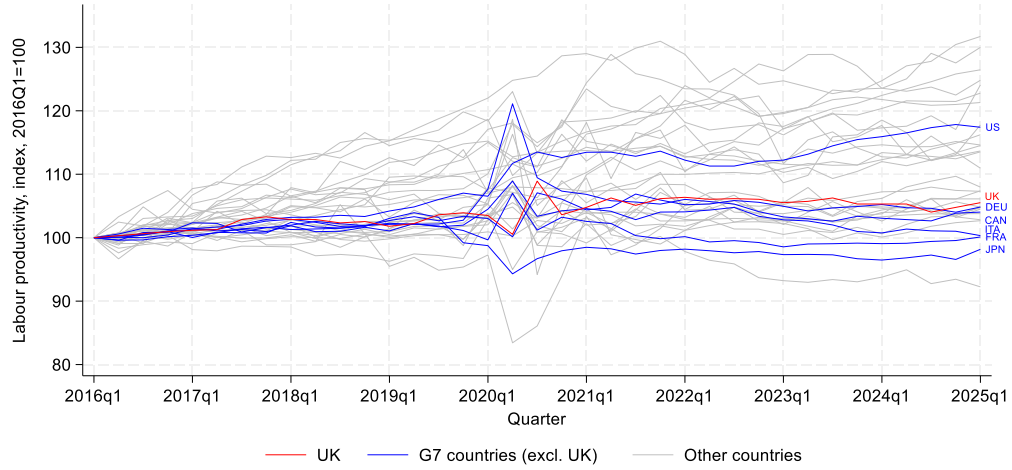
Business investment



Employment

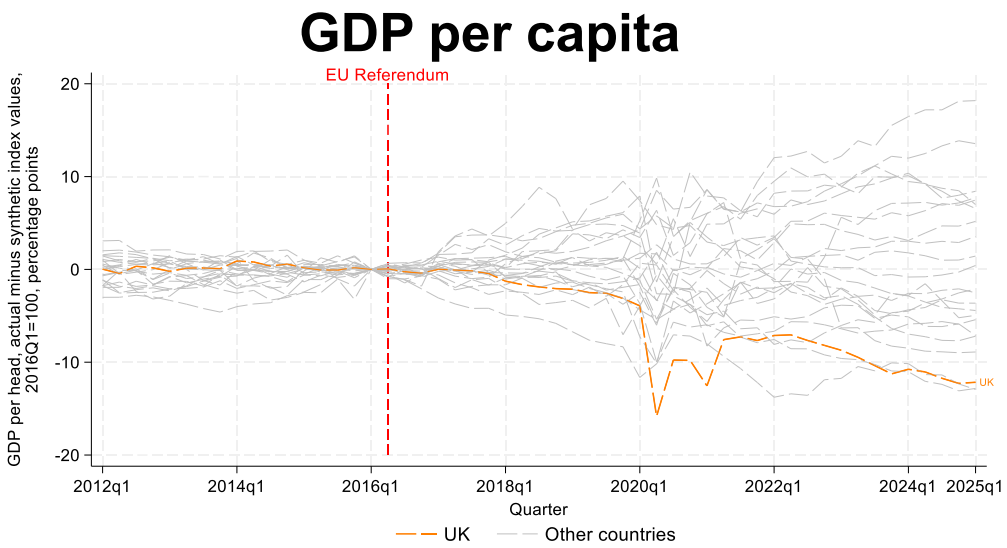


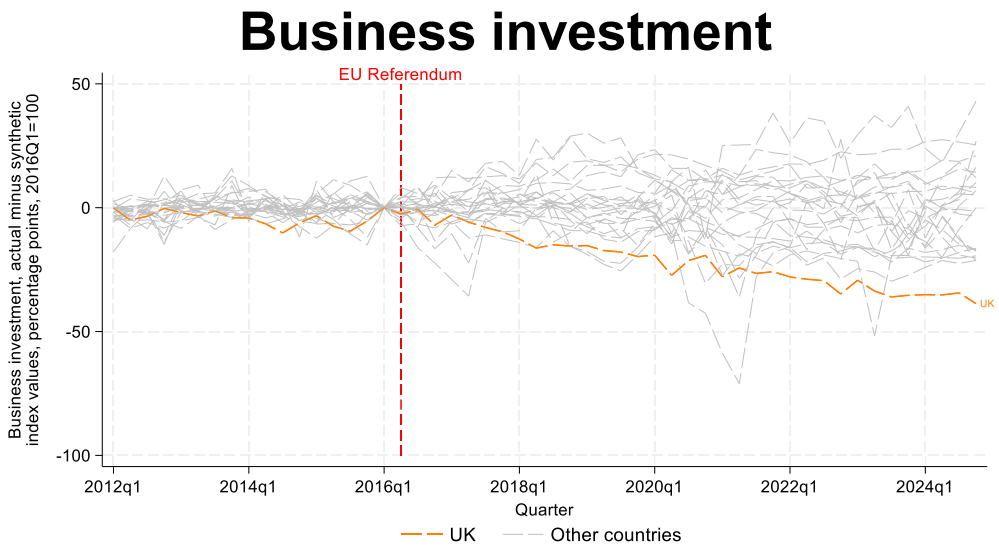
Labor productivity

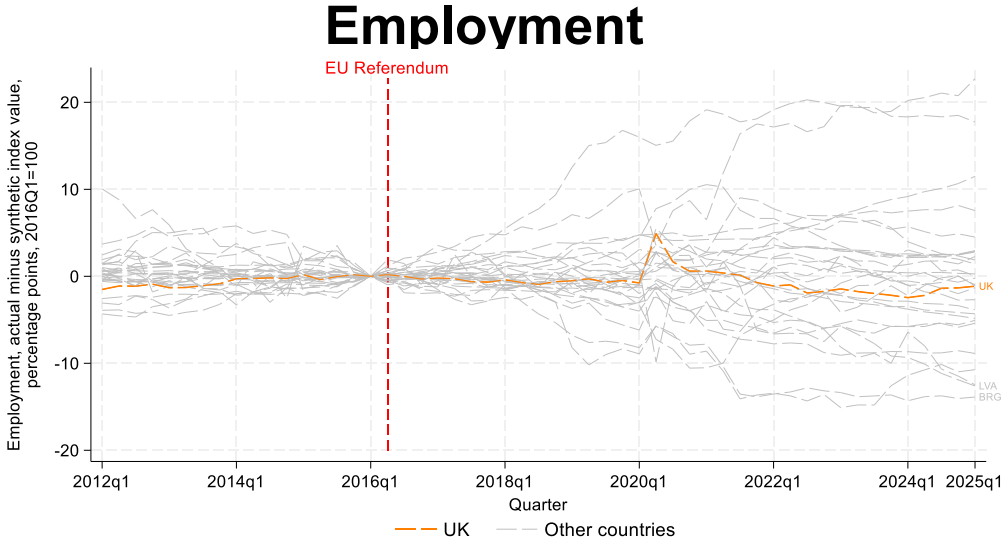


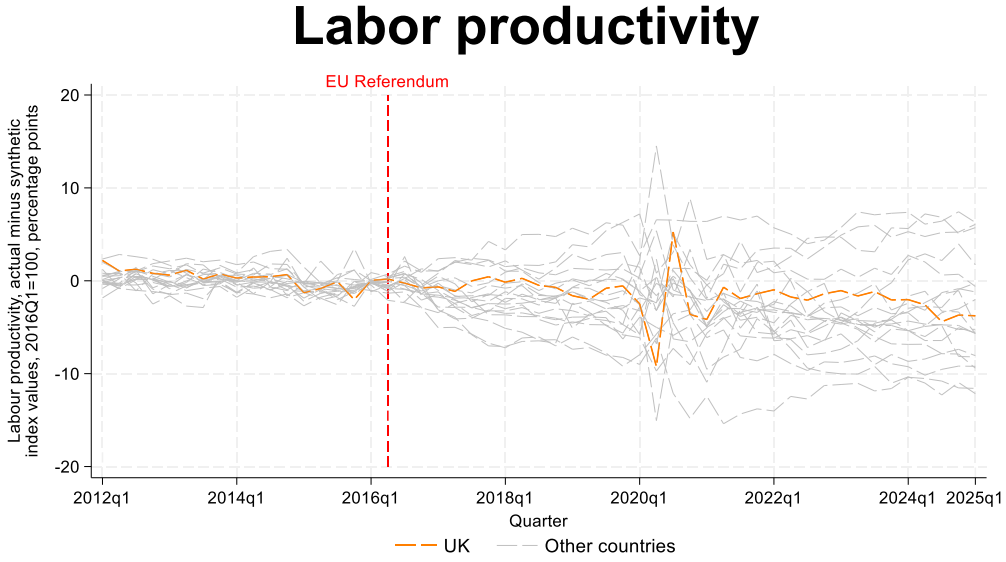
Notes: Other countries include US, Canada, EU-27 countries, Iceland, Norway, Switzerland, and Japan. Sources: ONS, U.S. Bureau of Economic Analysis, Statistics Canada, Eurostat, OECD.

Figure A2: Permutation tests for synthetic control analysis



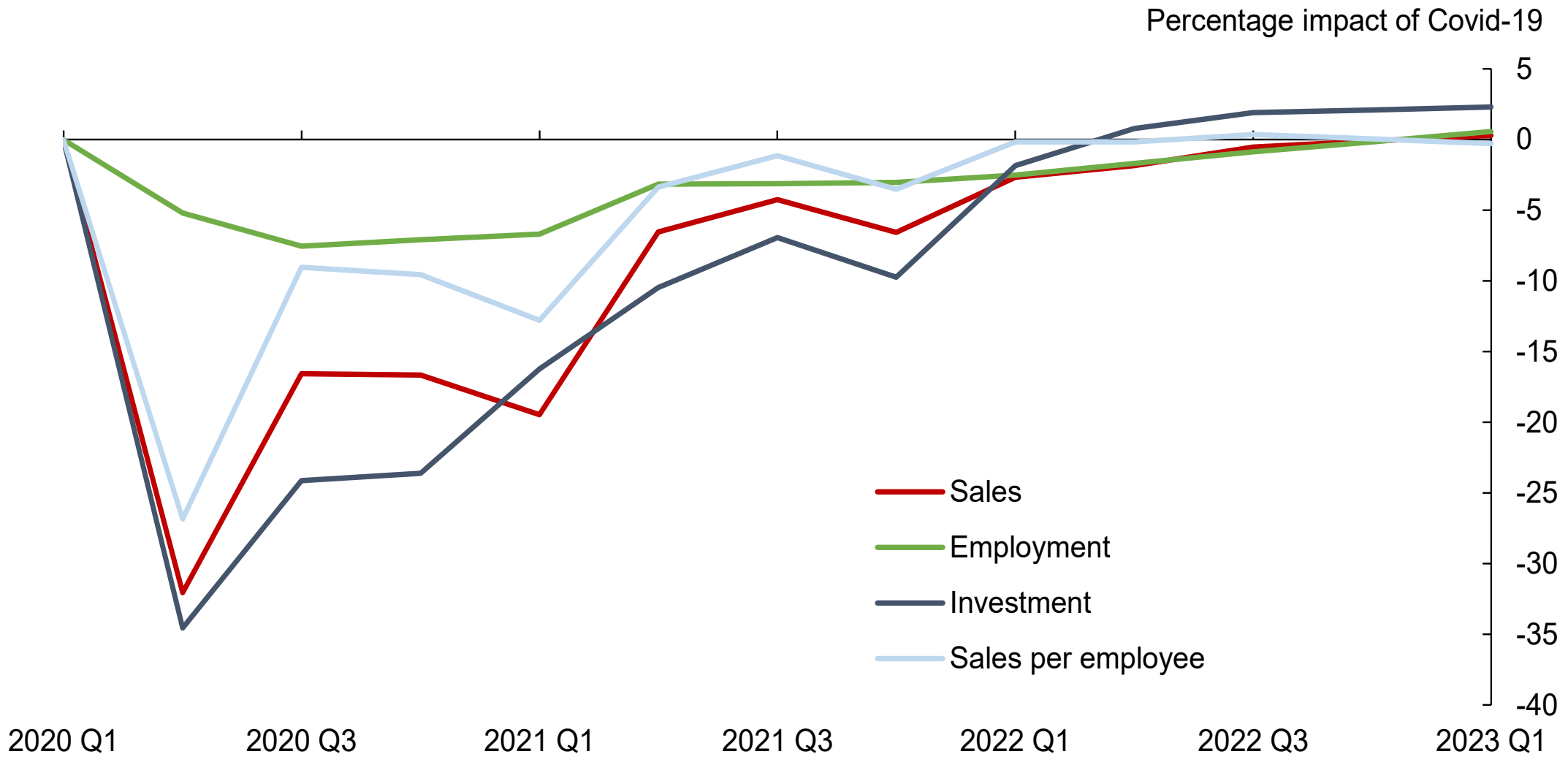






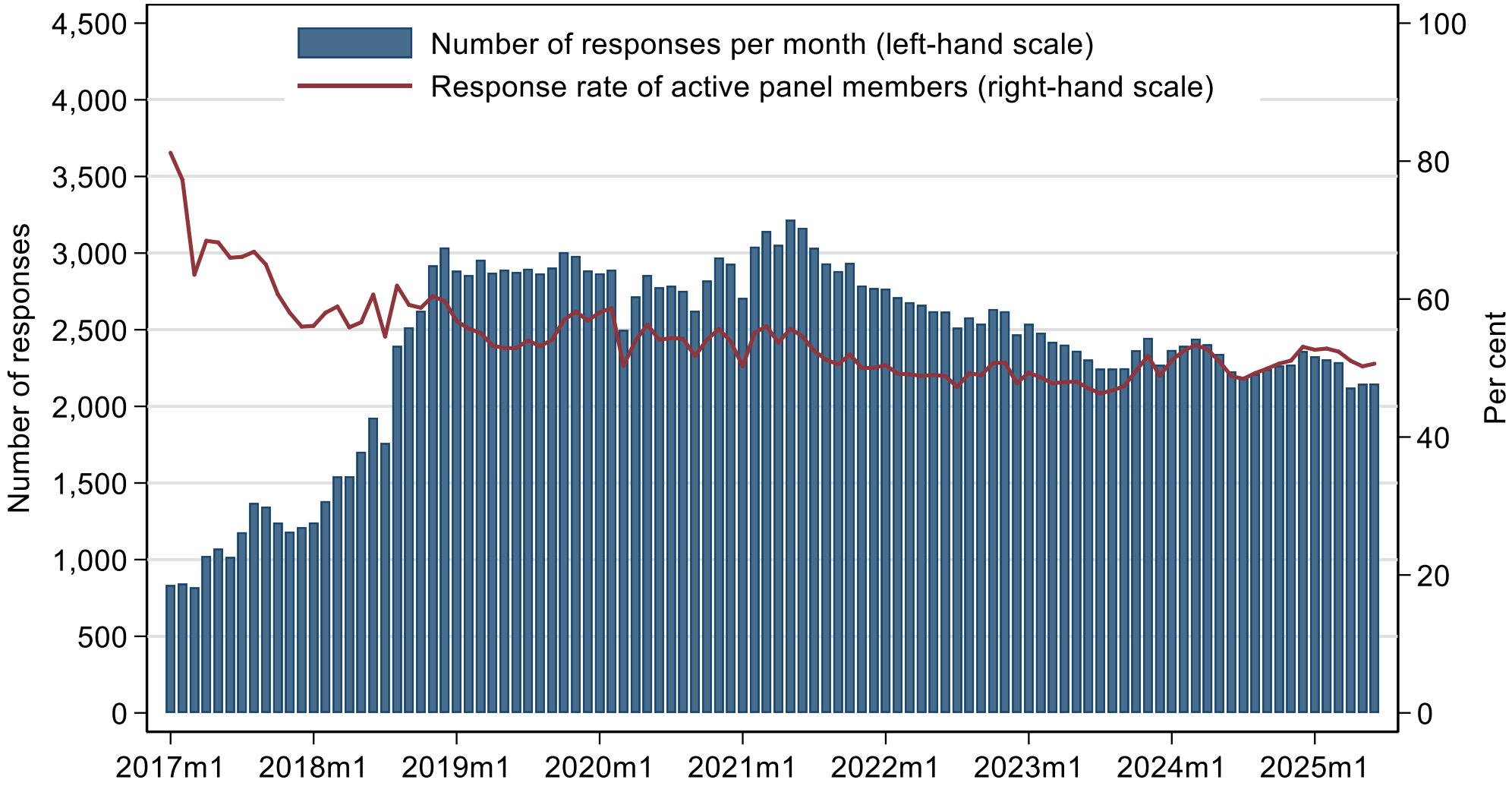
Notes: These charts show the difference between the synthetic values and the actual values calculated separately for every single country in the sample. Each line in this chart corresponds to a different country. Other countries include US, Canada, EU-27 countries, Iceland, Norway, Switzerland, and Japan. Sources: ONS, U.S. Bureau of Economic Analysis, Statistics Canada, Eurostat, OECD.

Figure A3: Impact of Covid-19 on businesses



Notes: The results are based on the questions: 'Relative to what would otherwise have happened, what is your best estimate for the impact of the spread of Covid-19 on the sales/employment/capital expenditure of your business in each of the following periods?' Impact on sales per employee is a calculated using responses to the questions on sales and employment questions. Data shown for 2023 Q1 are for 2023+. Source: Decision Maker Panel.

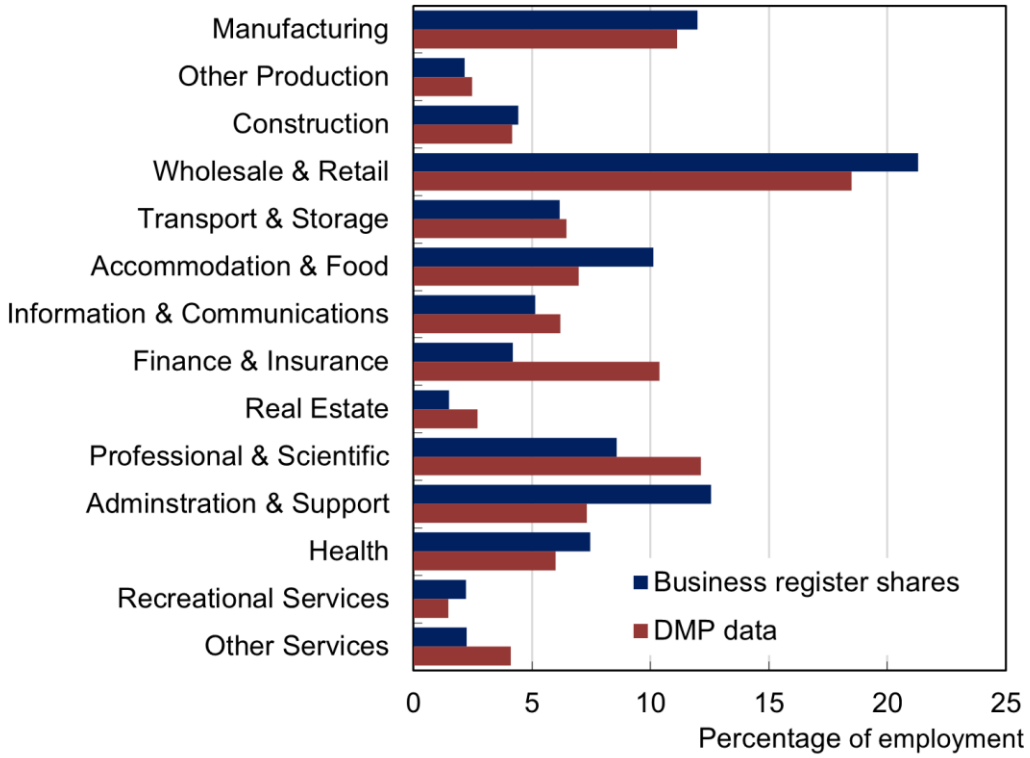
Figure A4: DMP sample size and response rate



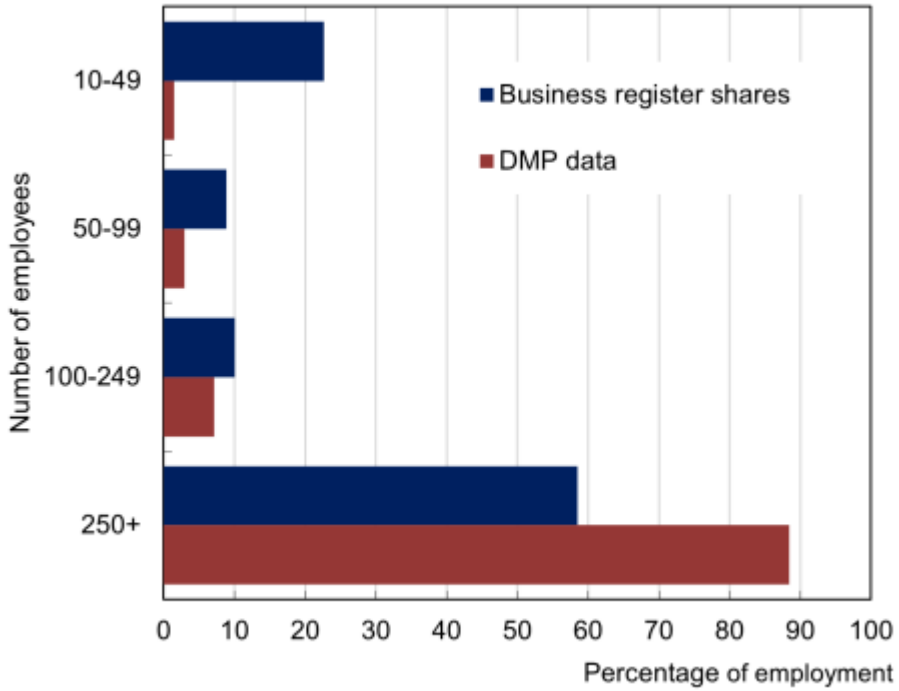
Notes: The response rate of active panel members is calculated as the response rate of panel members who had completed at least one survey over the last twelve months.

Figure A5: DMP sample versus Business Register

By industry

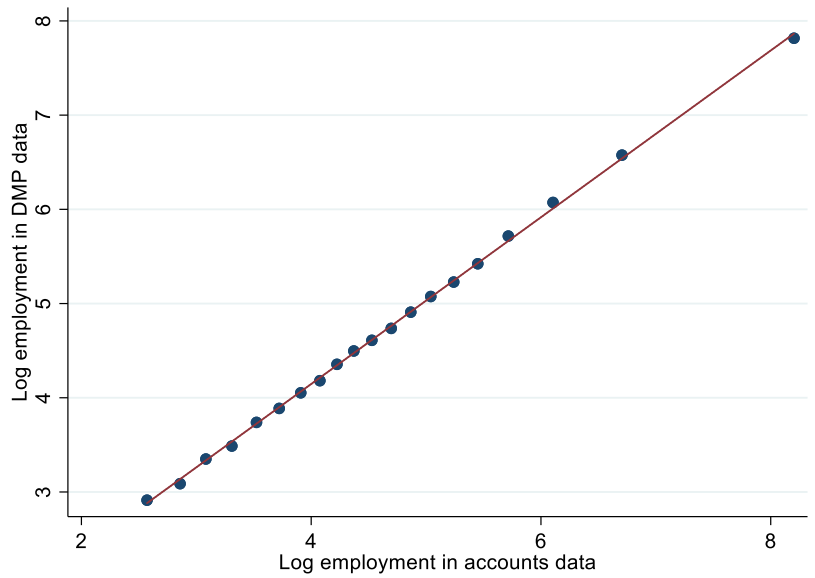


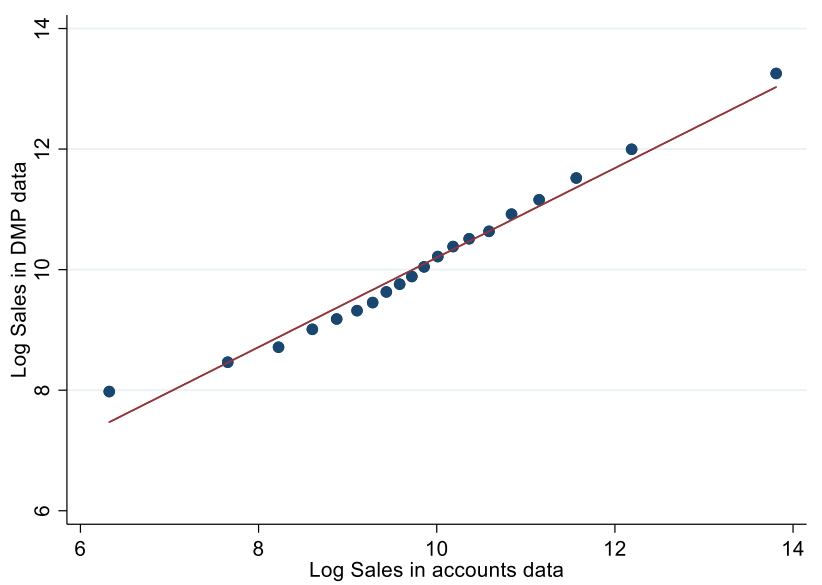
By firm size

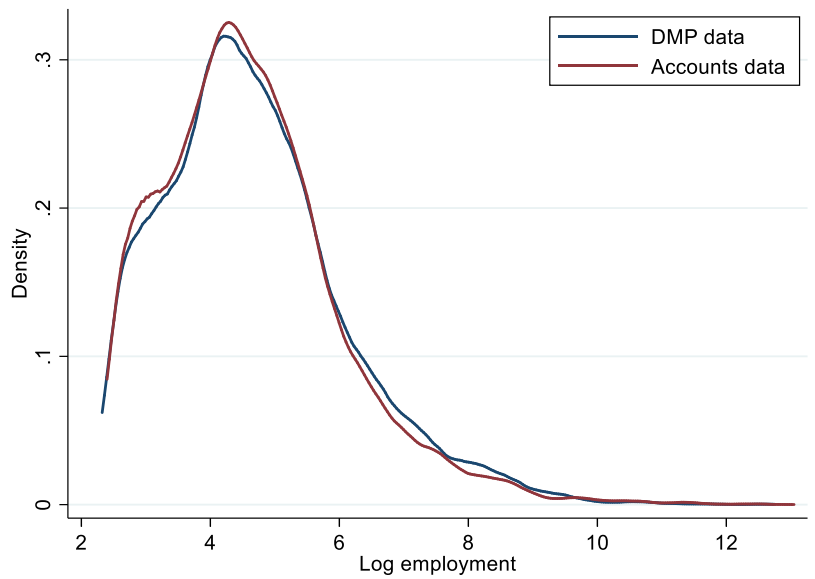


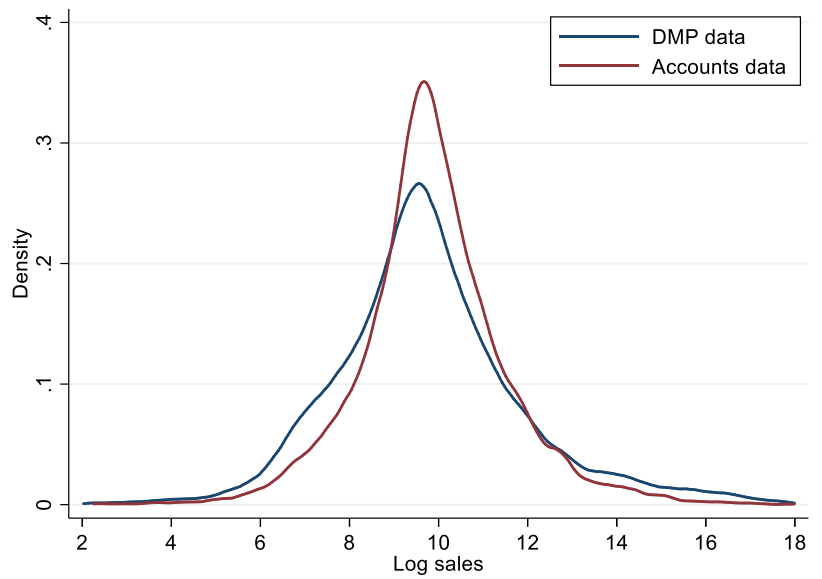
Notes: The results presented here are averages for 2017 to 2023. DMP data are unweighted. Sources: Department for Business, Energy and Industrial Strategy (BEIS) and Decision Maker Panel.

Figure A6: DMP data versus company accounts data





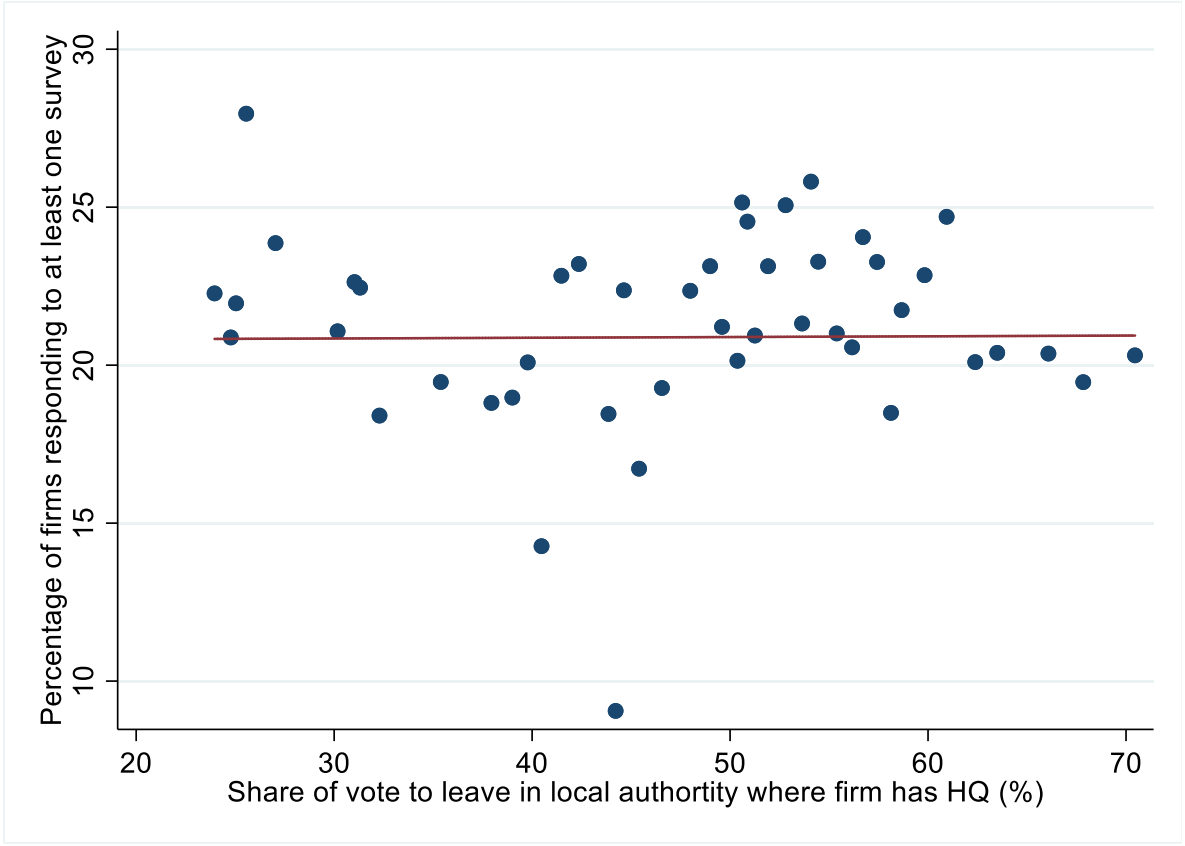




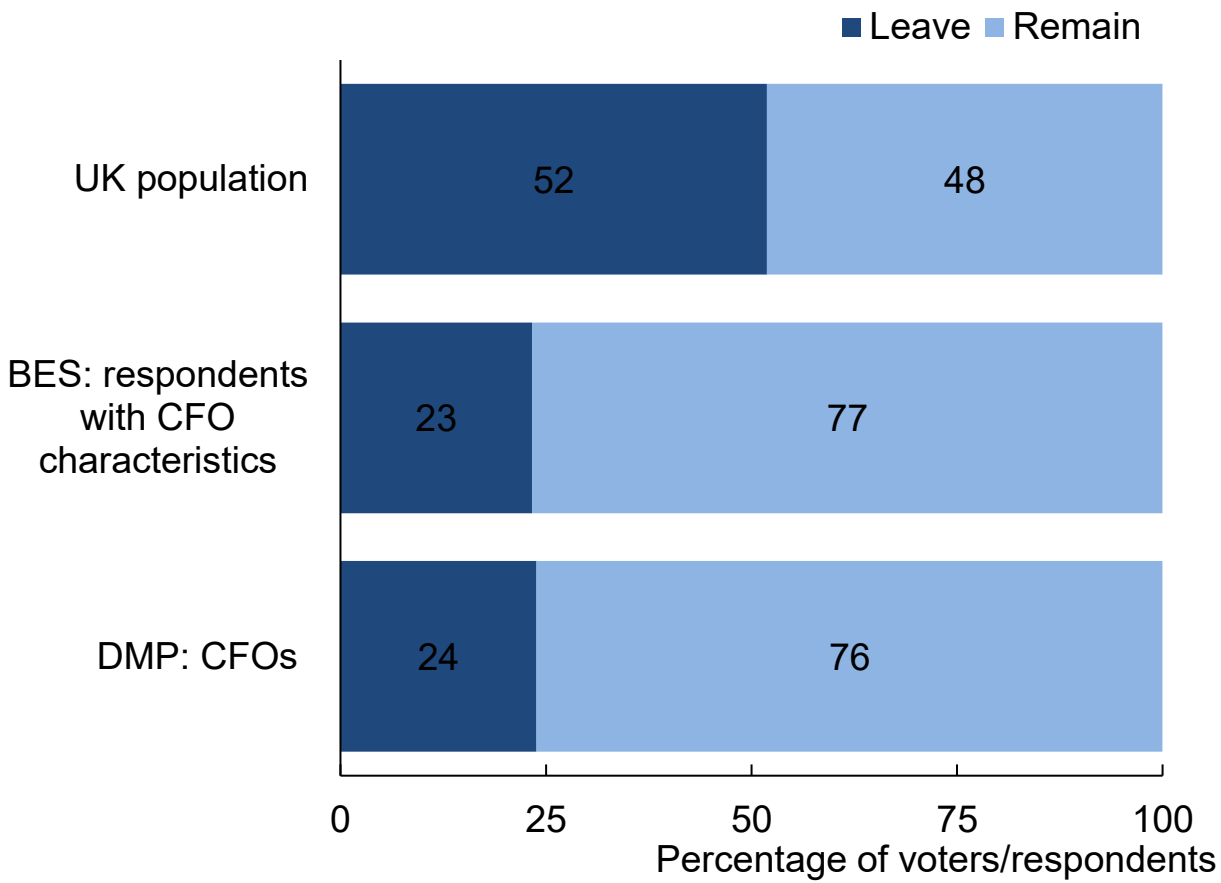
Notes: Sales values from the DMP survey are annualised average quarterly sales reported by businesses across the year. DMP employment data are averages across the year. DMP data are plotted against annual company accounts data from Bureau Van Dijk for the corresponding financial year. The dots on the top charts each represent 5% of observations, grouped by log employment/sales from accounts data. Charts are based on annual data between 2017 and 2023.

Figure A7: Characteristics of DMP survey respondents

Response rates and local Brexit vote shares



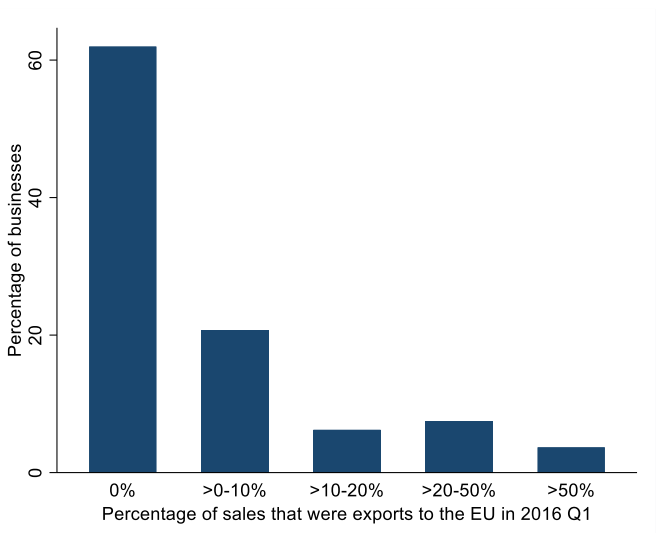
Personal views on Brexit



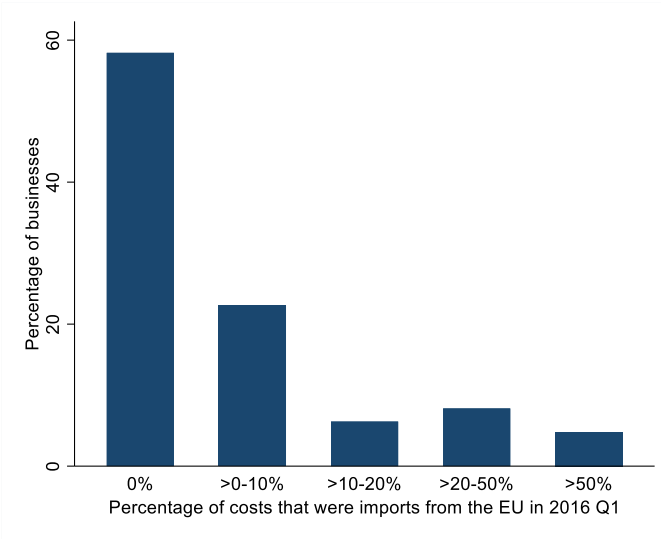
Notes: The left panel shows a binscatter plot which splits firms into 50 groups according to the share of the vote to leave the EU in the local authority where the firms has its headquarters. Personal views of DMP members on Brexit in the right panel are at the time of the June 2016 referendum and are taken from questions asked in the February to April 2018 surveys. Respondents who did not have a strong view either way (4 per cent) were excluded. The question asked respondents 'Taking everything into account, how do you personally view the UK voting to leave the European Union at the time of referendum? (i) Very positive; (ii) Somewhat positive; (iii) Neither positive nor negative; (iv) Somewhat negative; (v) Very negative; (vi) Prefer not to state; (vii) Don't know'. British Election Study data are self-reported referendum votes. Respondents with CFO characteristics are defined as managers/professionals by work type with a degree and annual income of over £50,000. Sources: Electoral Commission, British Election Study and Decision Maker Panel.

Figure A8: Pre-referendum exposure of DMP firms to the EU

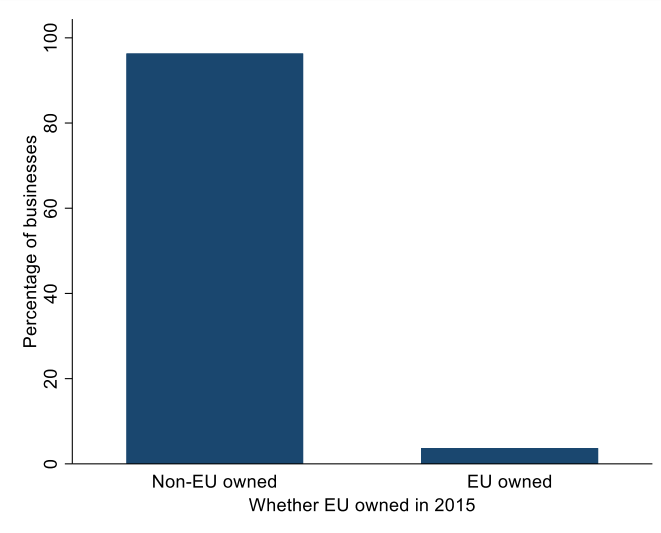
Percentage of sales that were exports to the EU



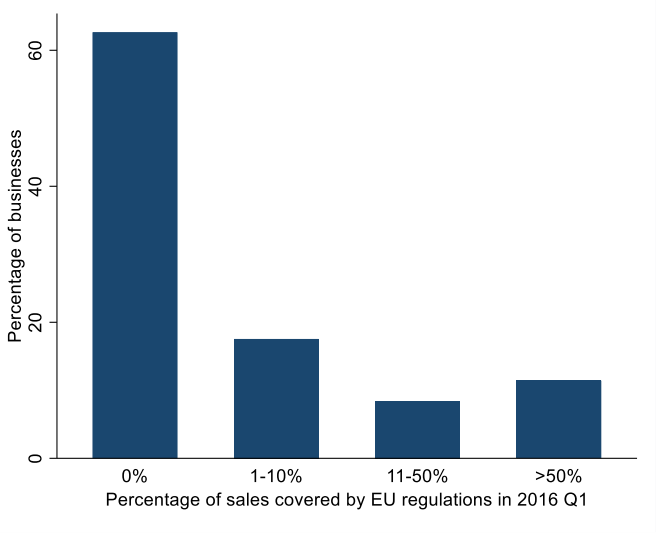
Percentage of costs that were imports from the EU



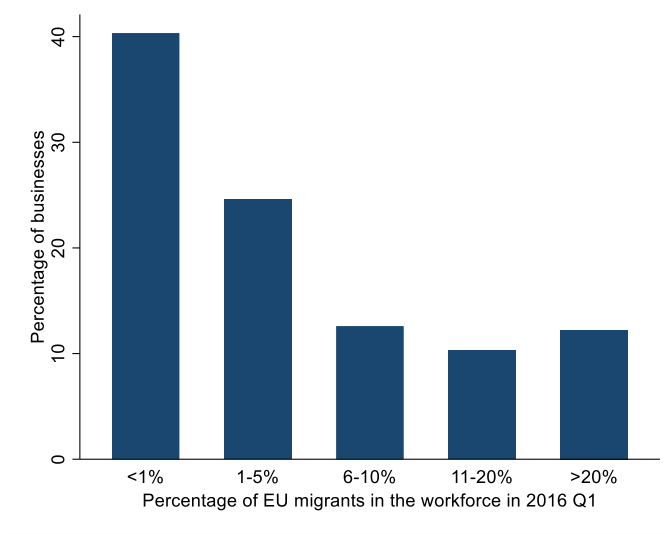
Whether EU owned



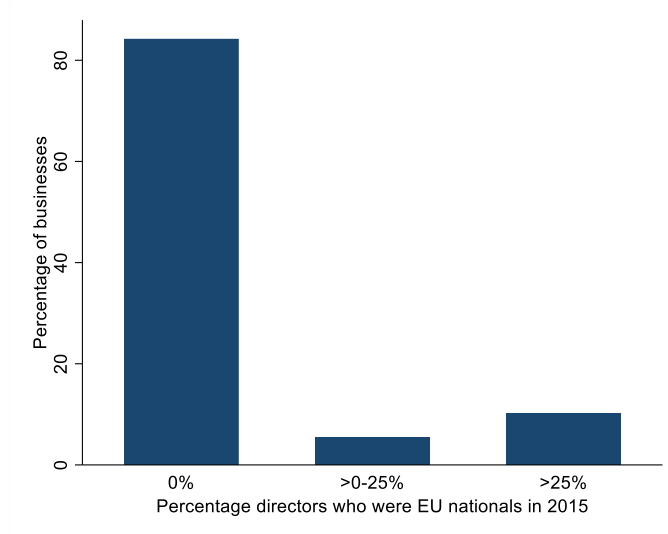
Percentage of sales covered by EU regulations



Percentage of workforce who were EU migrants



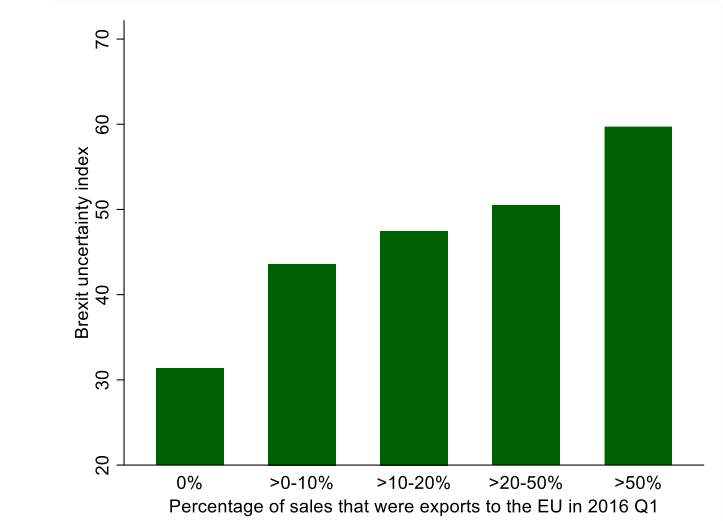
Percentage of directors who were EU nationals



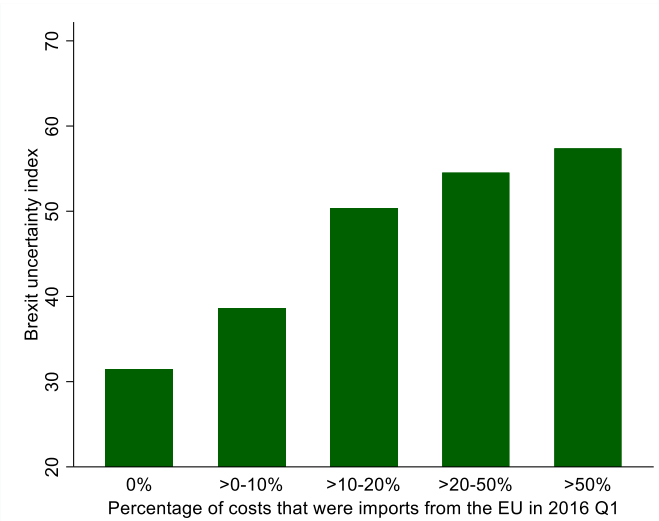
Notes: EU exports, EU imports, sales covered by EU regulations and EU migrant workers data are from the Decision Maker Panel. EU directors and ownership data are from Bureau Van Dijk FAME.

Figure A9: Brexit uncertainty and prior EU exposure

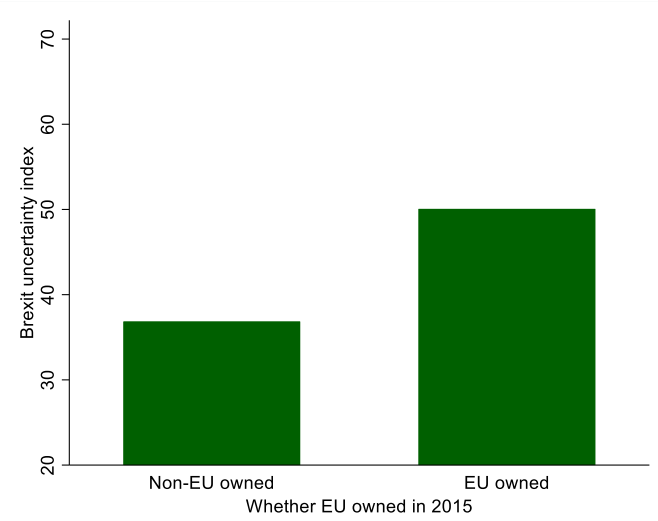
Percentage of sales that were exports to the EU



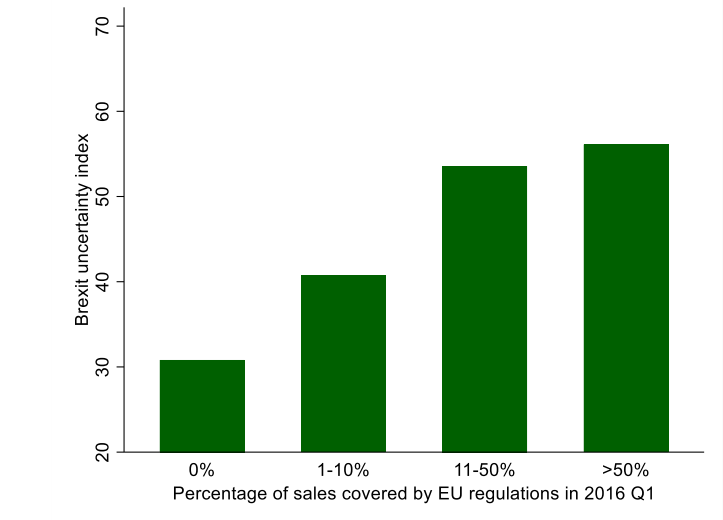
Percentage of costs that were imports from the EU



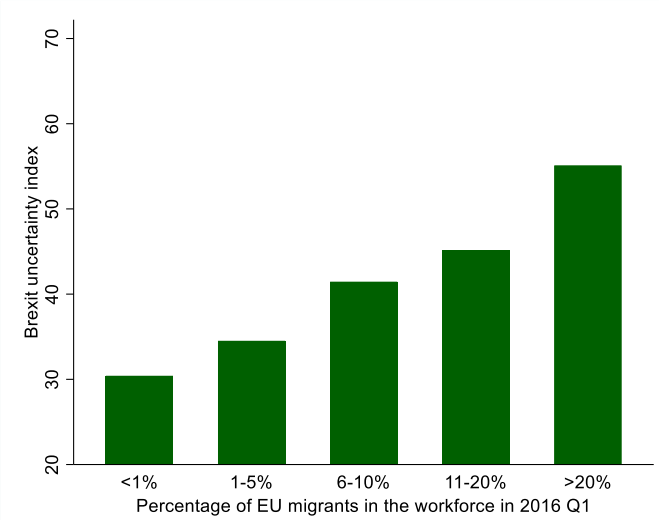
Whether EU owned



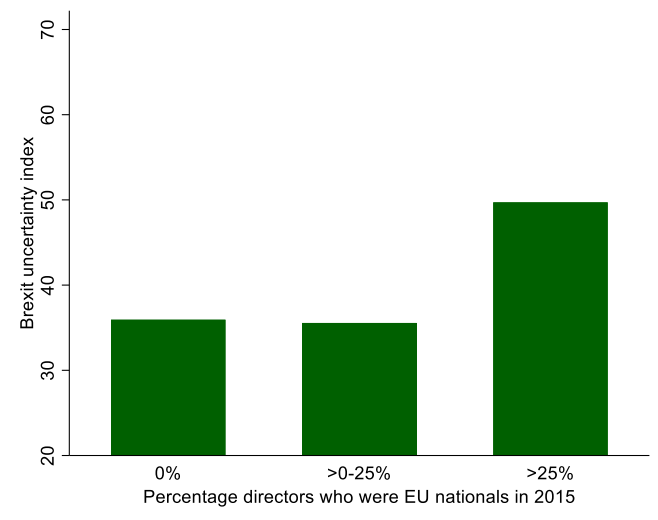
Percentage of sales covered by EU regulations



Percentage of workforce who were EU migrants

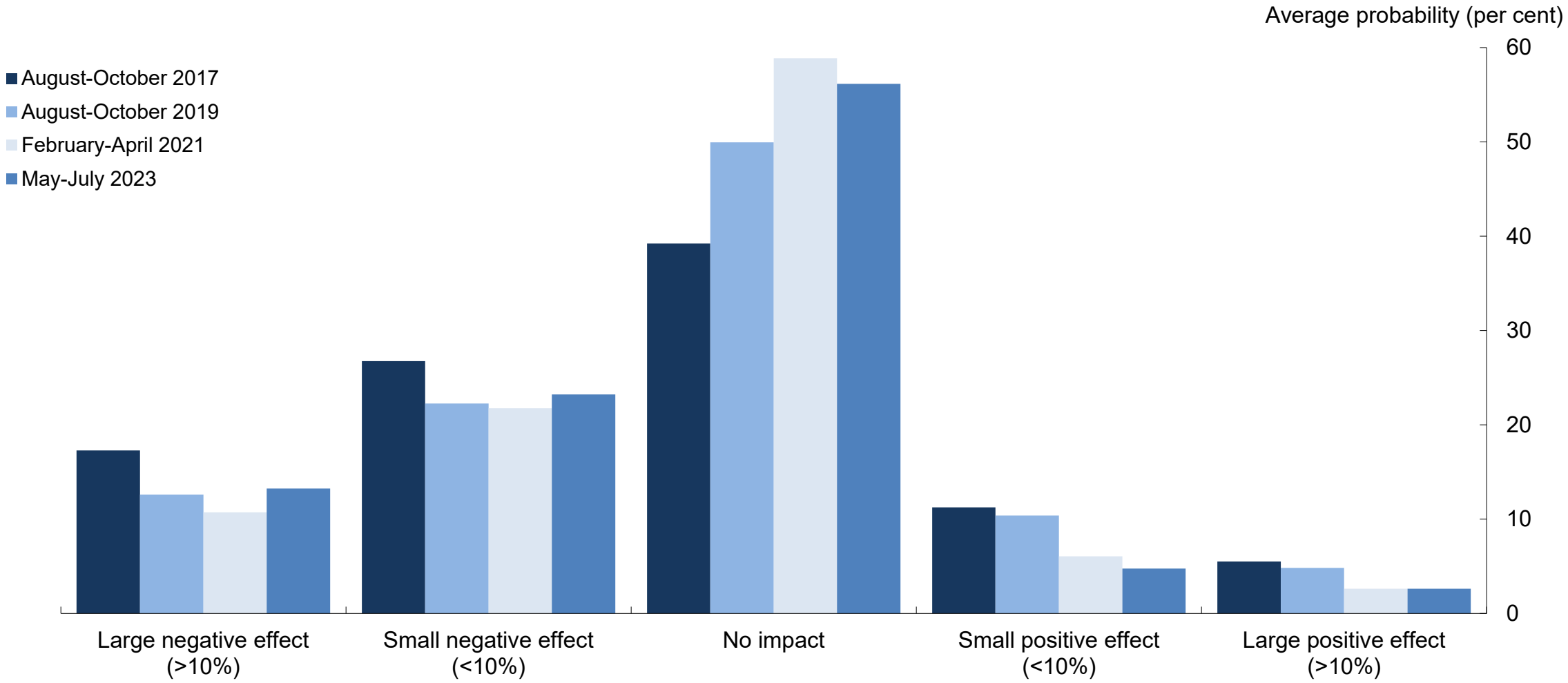


Percentage of directors who were EU nationals



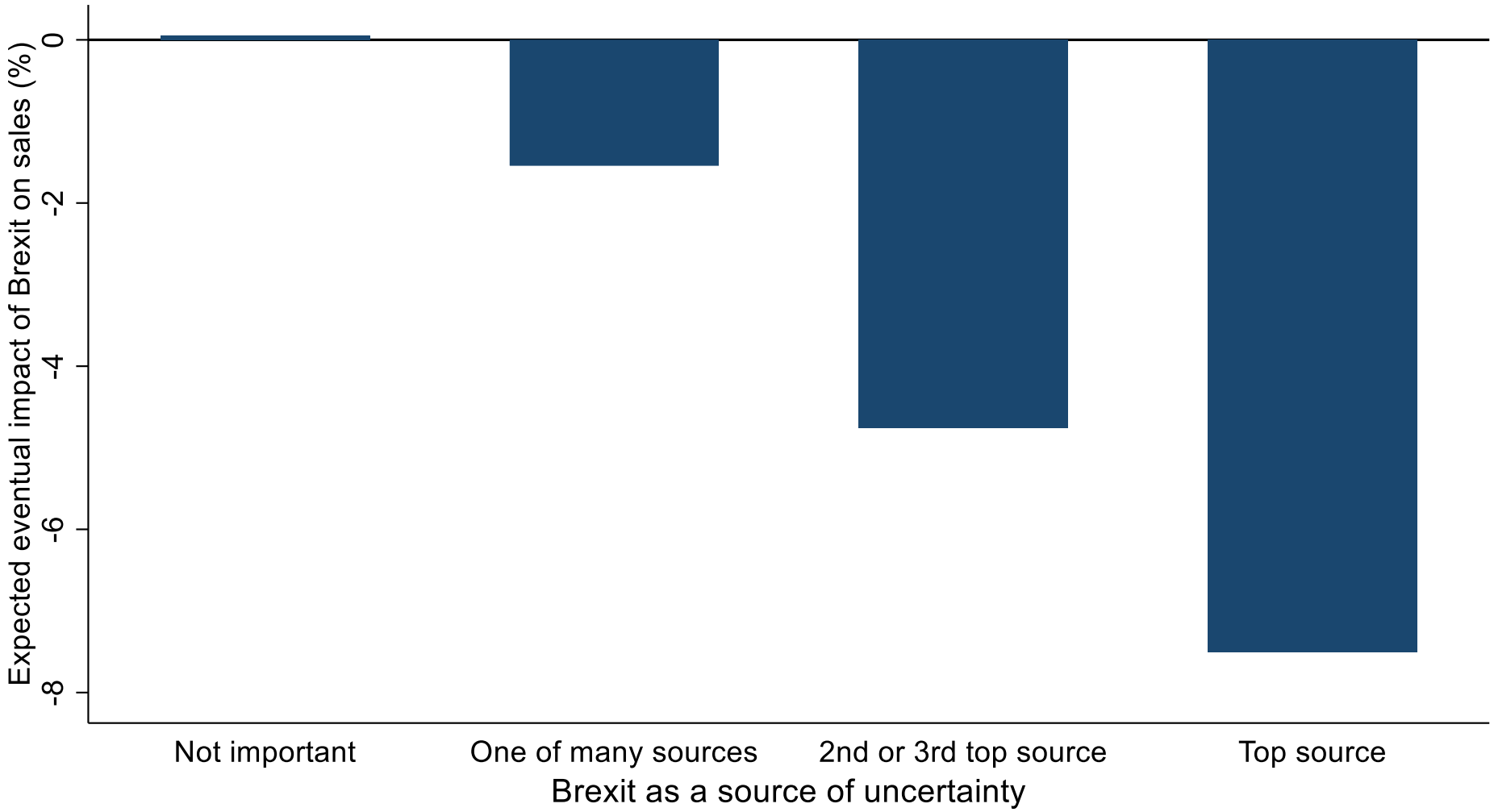
Notes: EU exports, EU imports, sales covered by EU regulations and EU migrant workers data are from the Decision Maker Panel. EU directors and ownership data are from Bureau Van Dijk FAME. Brexit uncertainty index shows the percentage of DMP survey respondents who view Brexit as their "top" or "one of their top three" sources of uncertainty in response to the question 'How much has the result of the EU referendum affected the level of uncertainty affecting your business?'. Brexit uncertainty data are averages for August 2016 to April 2024.

Figure A10: Expected eventual impact of Brexit on sales



Notes: Question: 'How do you expect the eventual Brexit agreement to affect your sales once the UK has left the EU, compared to what would have been the case had the UK remained a member of the EU? What is the percentage likelihood (probability) that it will: (i) Have a large positive effect on sales at home and abroad, adding 10% or more to sales; (ii) Have a modest positive effect on sales at home and abroad, adding less than 10% to sales; (iii) Make little difference; (iv) Have a modest negative effect on sales at home and abroad, subtracting less than 10% from sales; (v) Have a large negative effect on sales at home and abroad, subtracting more than 10% from sales'. Source: Decision Maker Panel.

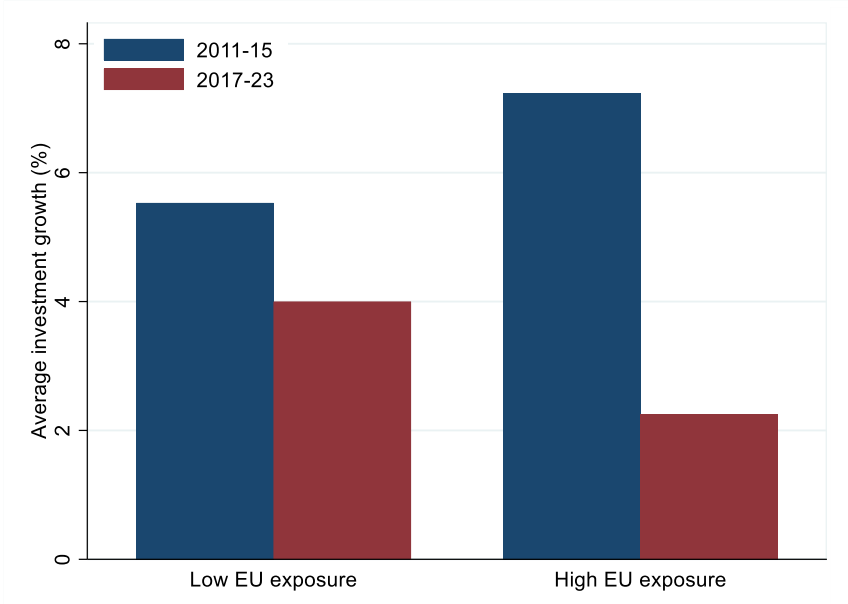
Figure A11: Correlation between first moment and second moment impact of Brexit



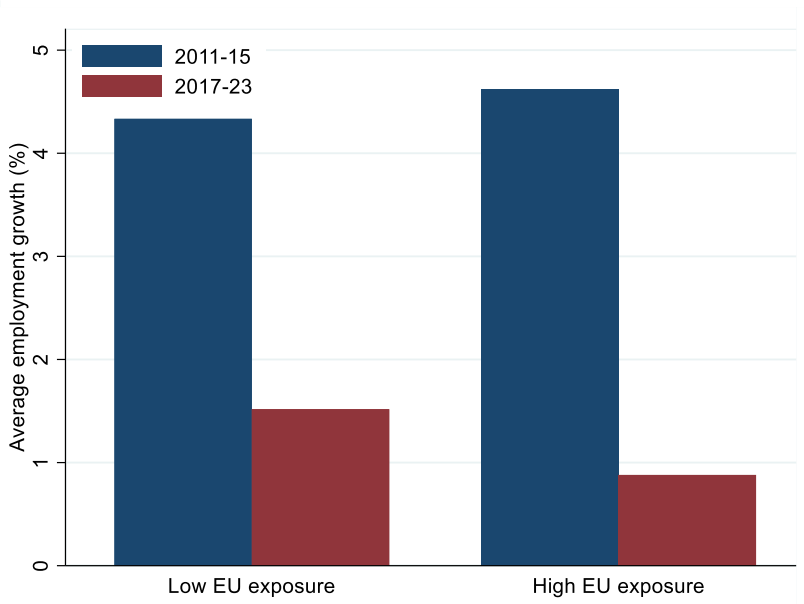
Notes: Based on DMP questions reported in the footnotes to Figure 7 and Figure A10. Figure is based on averages of data collected in DMP surveys between August 2016 and April 2024. Source: Decision Maker Panel.

Figure A12: Investment, employment and productivity growth by EU exposure

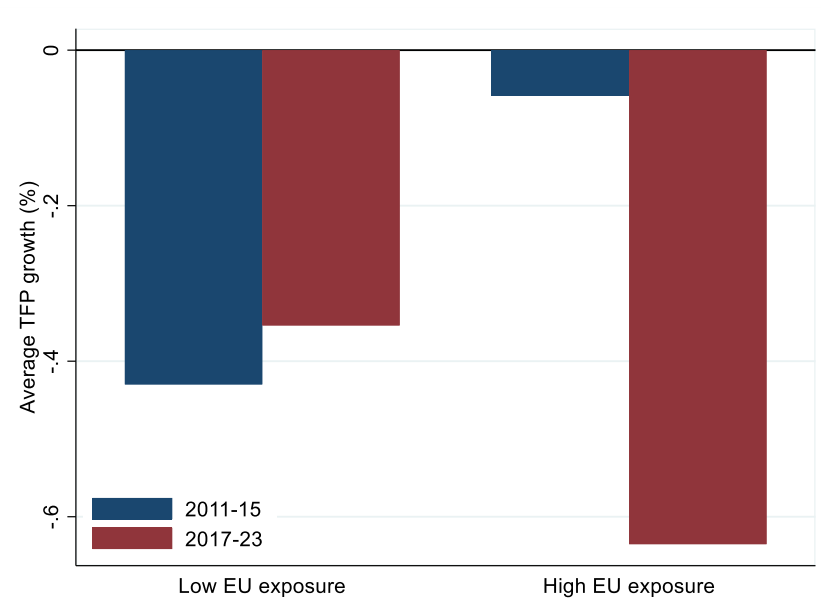
Investment growth



Employment growth

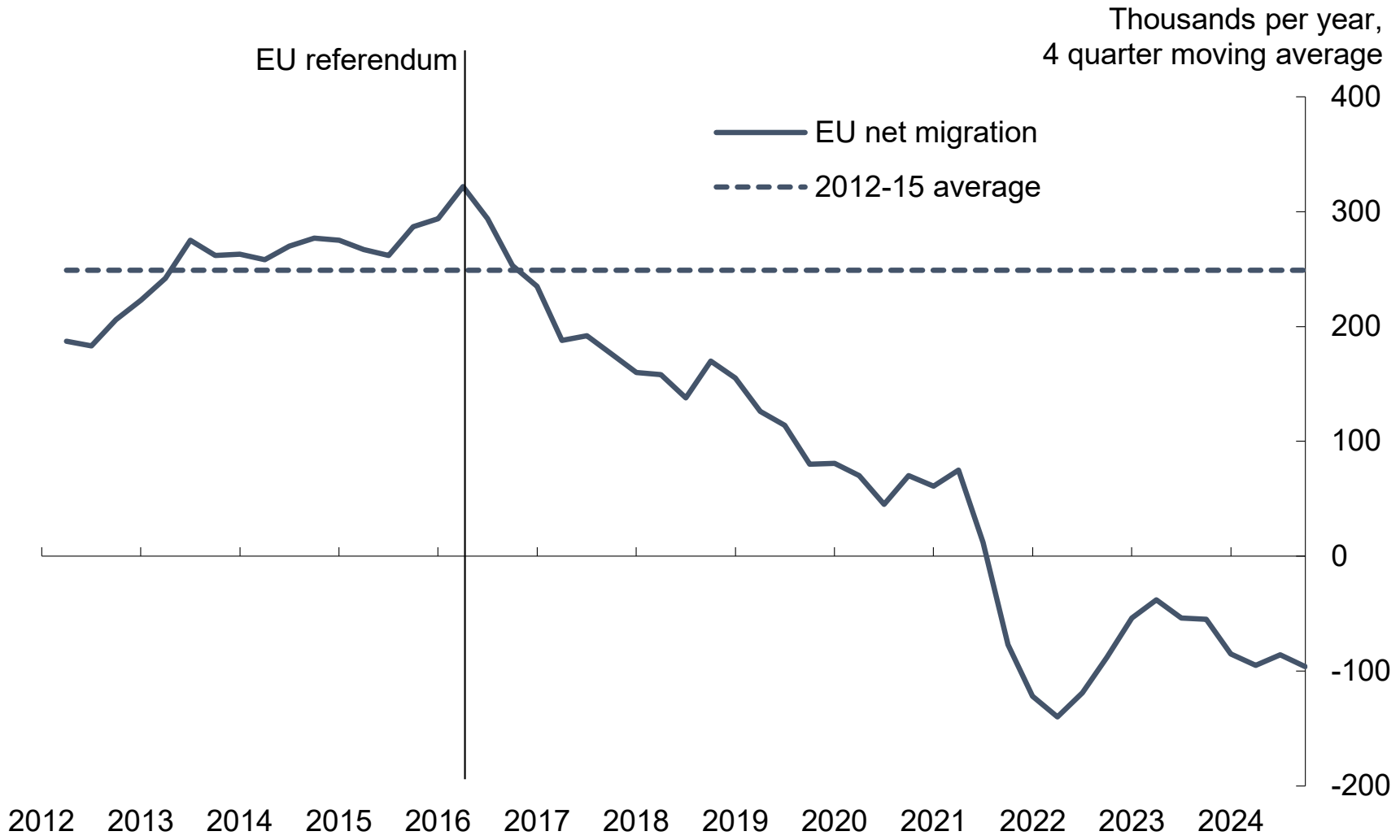


TFP growth



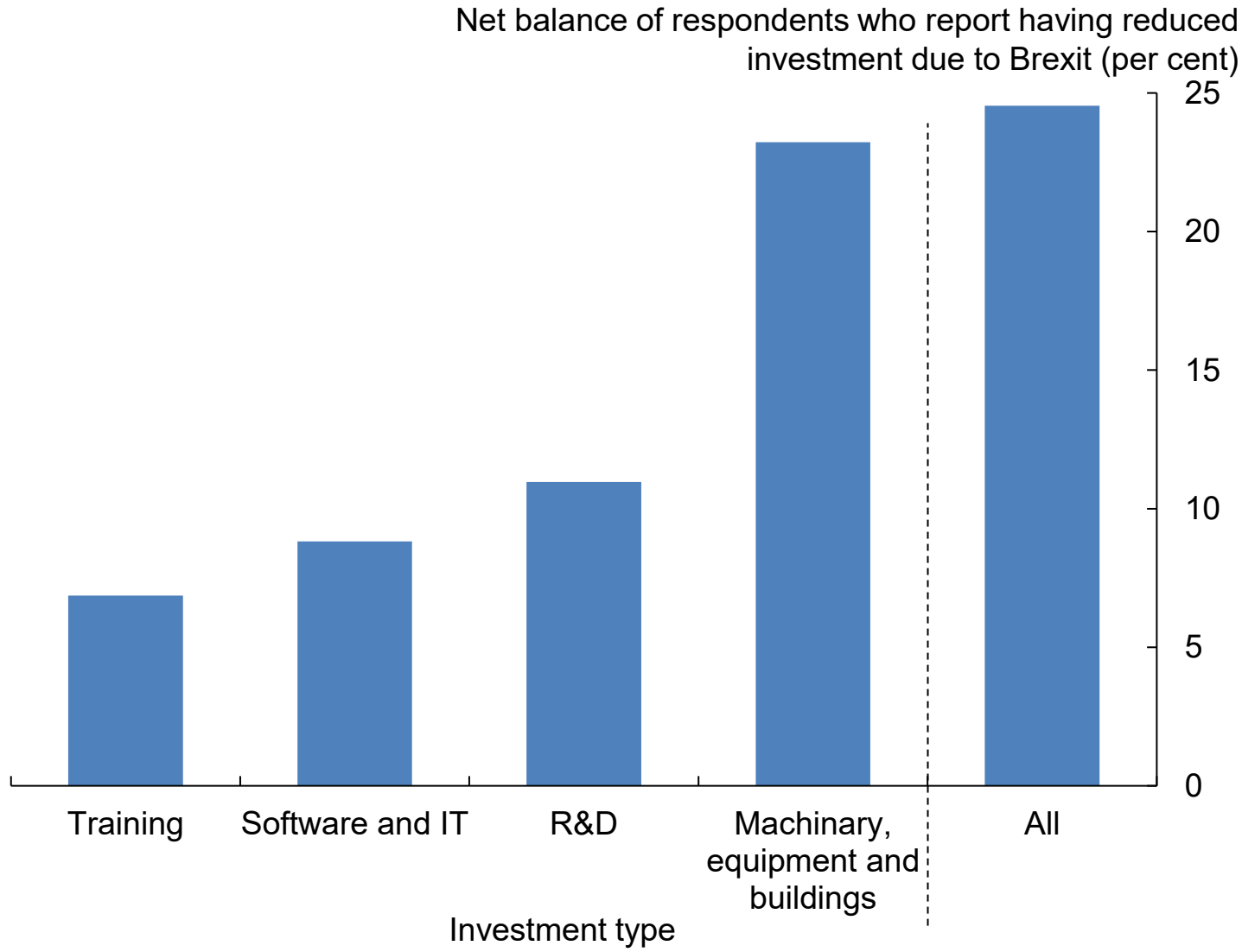
Notes: High EU exposure is defined as firms with above average pre-referendum exposure to the EU, based on the average of the following 6 exposure measures: share of sales to EU; share of costs from EU imports; share of EU migrants in workforce; share of sales covered by EU regulations; share of directors who are EU nationals; and a dummy for being EU owned. All are on a 0-1 scale. Low EU exposure is defined as firms with below average pre-referendum exposure on the same metric.

Figure A13: Net migration from the EU to the UK



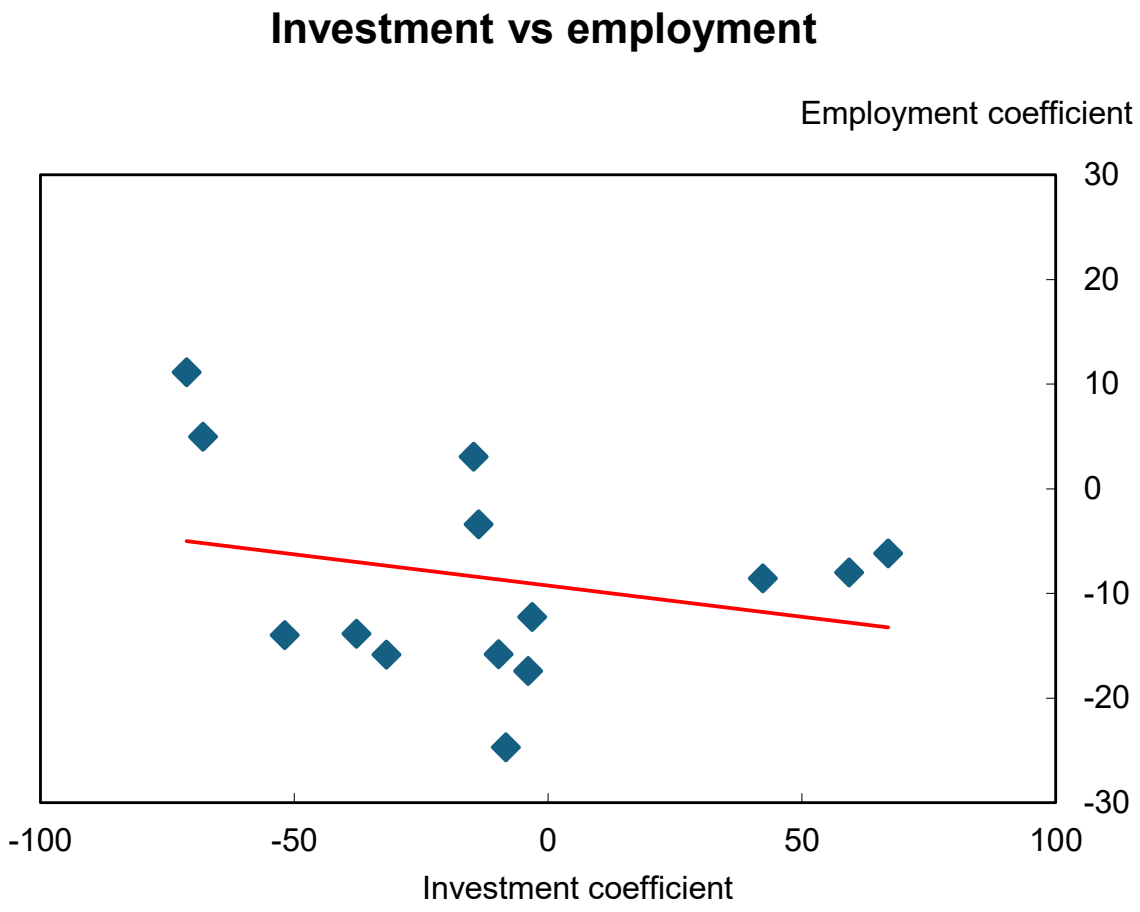
Source: ONS.

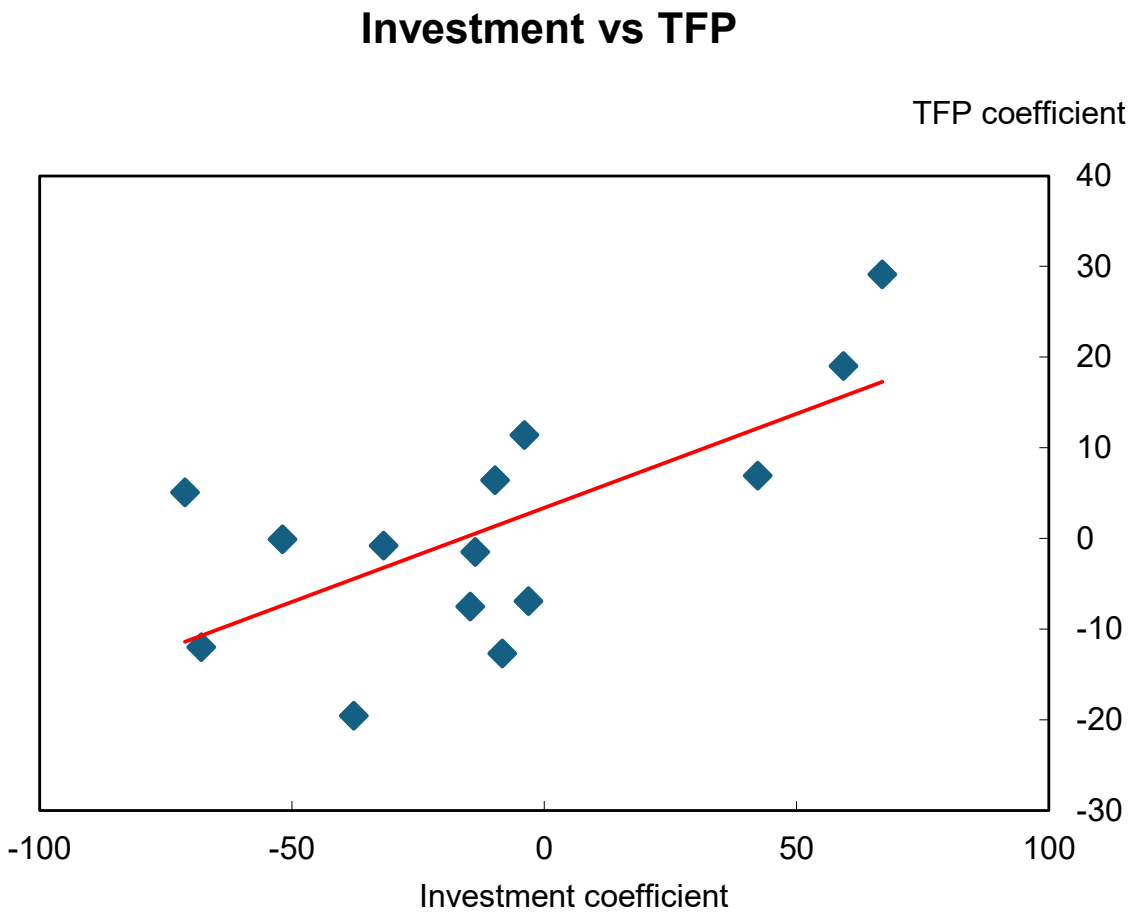
Figure A14: Impact of Brexit on different types of investment



Notes: The results are based on the question 'Could you say how the UK's decision to vote 'Leave' in the EU referendum has affected your capital expenditure since the referendum? Please select one option for each type of investment [Training of employees; Software, data, IT, website; Research and development; Machinery, equipment and buildings]: a large positive influence, adding 5% or more; a minor positive influence, adding less than 5%; no material impact; a minor negative influence, subtracting less than 5%; a large negative influence, subtracting 5% or more.' 'Net balance' is defined as the share who say that Brexit has reduced investment less the share saying it has increased investment. Data were collected between February and April 2019. Source: Decision Maker Panel.

Figure A15: Correlations between 1 digit industry level coefficients on EU exposure in firm outcome regressions

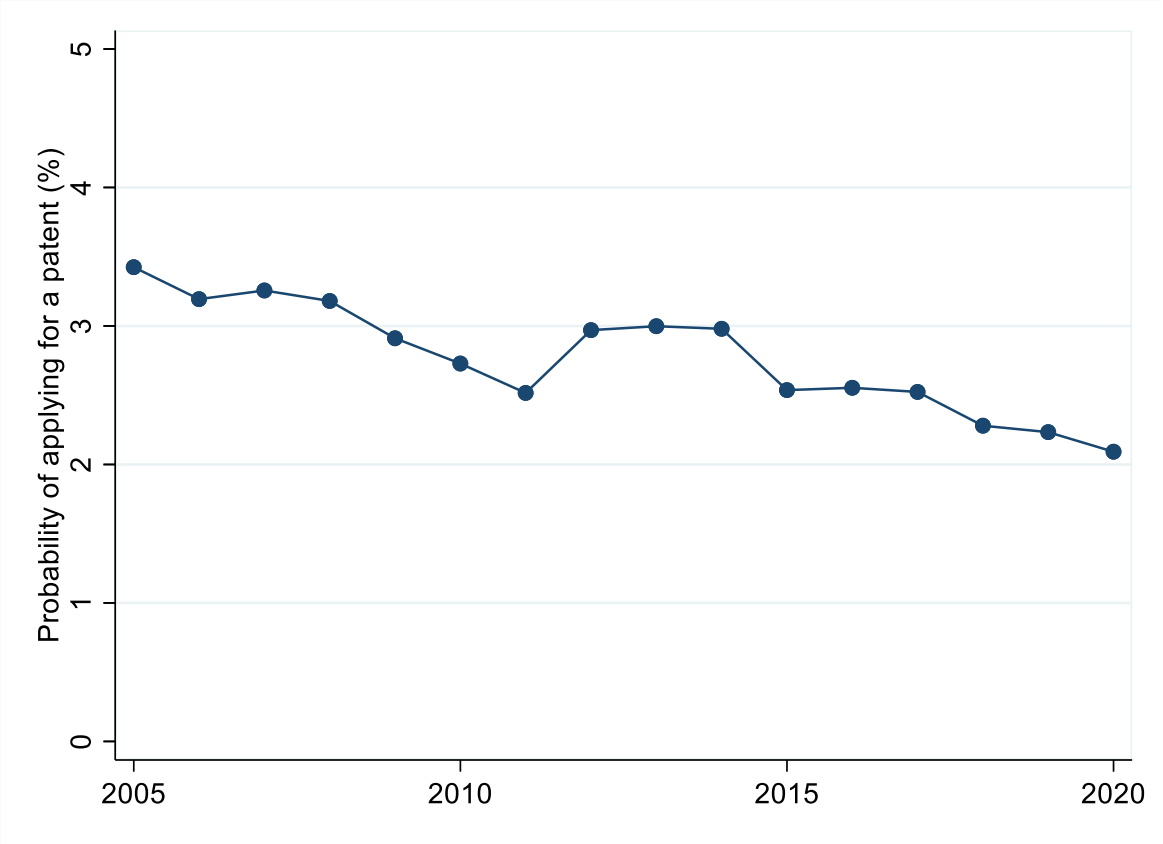




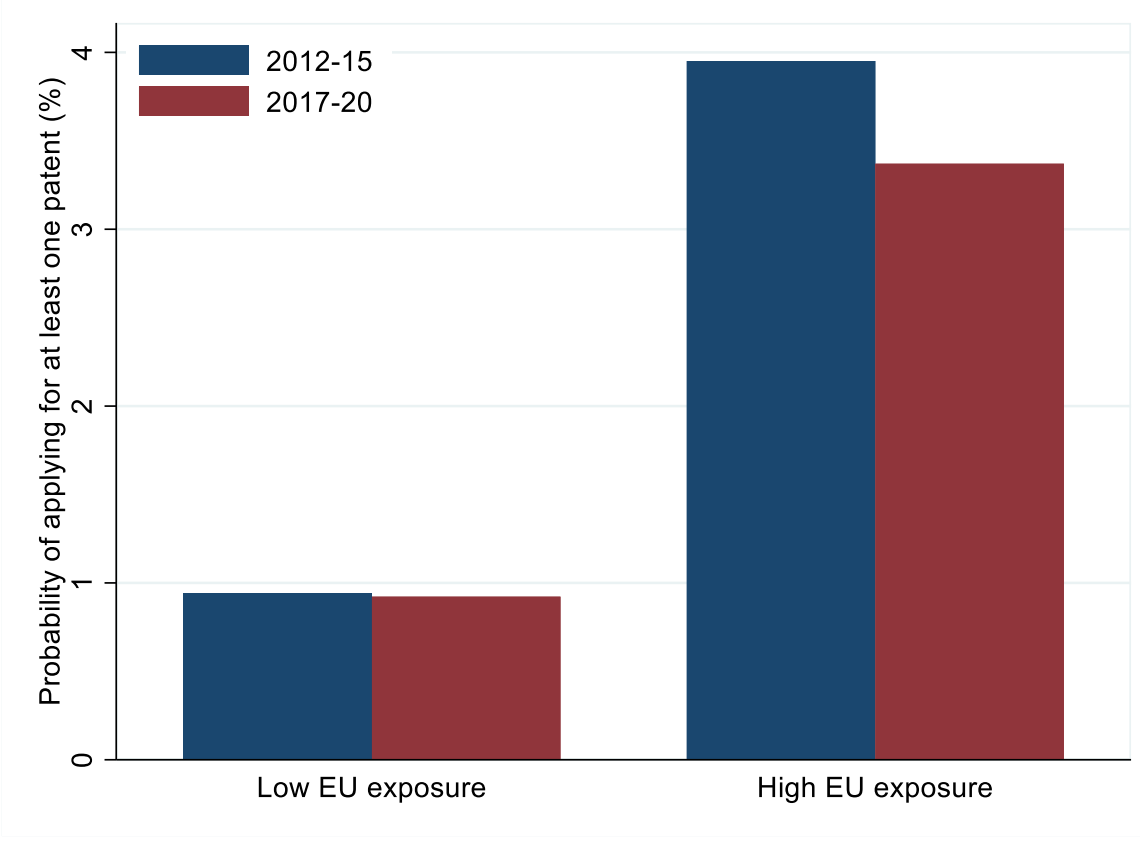
Notes: The figures show the correlation between the industry level coefficients on EU exposure*post referendum in regressions for investment growth vs regressions for employment/TFP growth where the coefficients on EU exposure*post referendum are allowed to vary by industry. These regressions are identical to those shown in Tables 2 and 4, other than that coefficients are allowed to vary by industry

Figure A16: Patents analysis

Probability of DMP firms applying for a patent



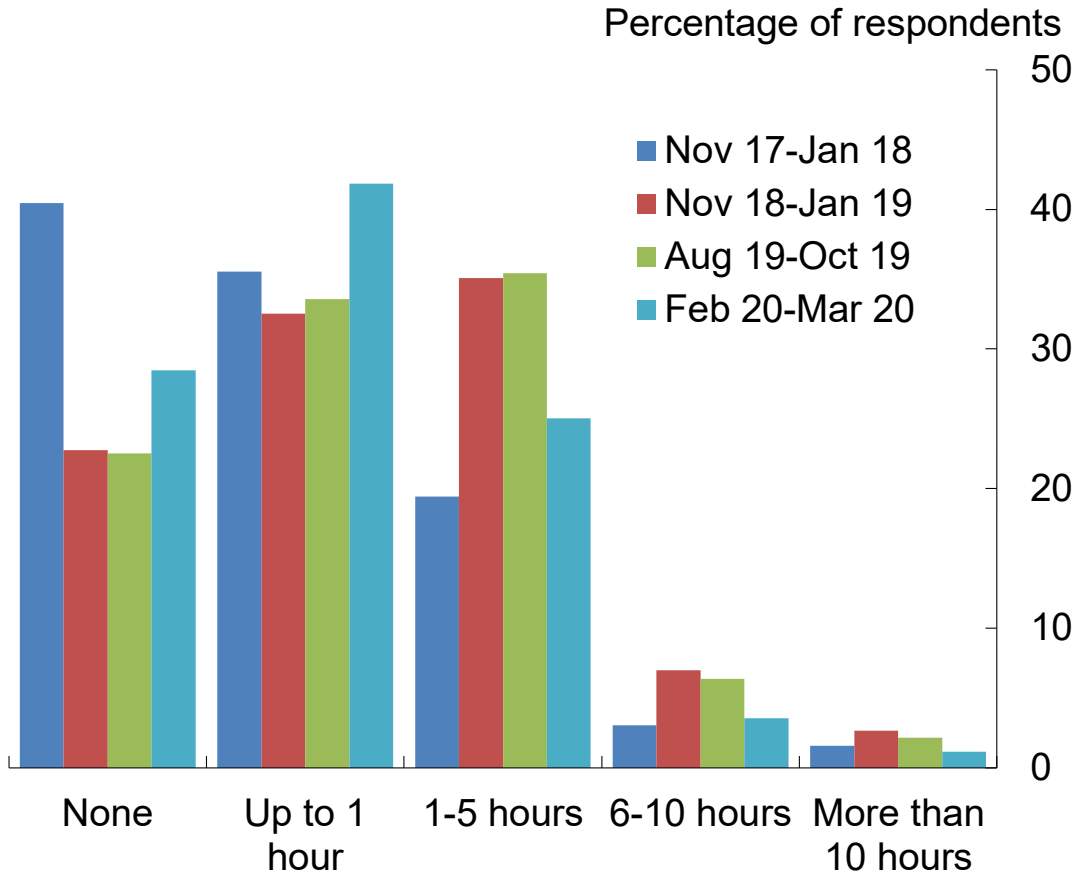
Split by EU exposure



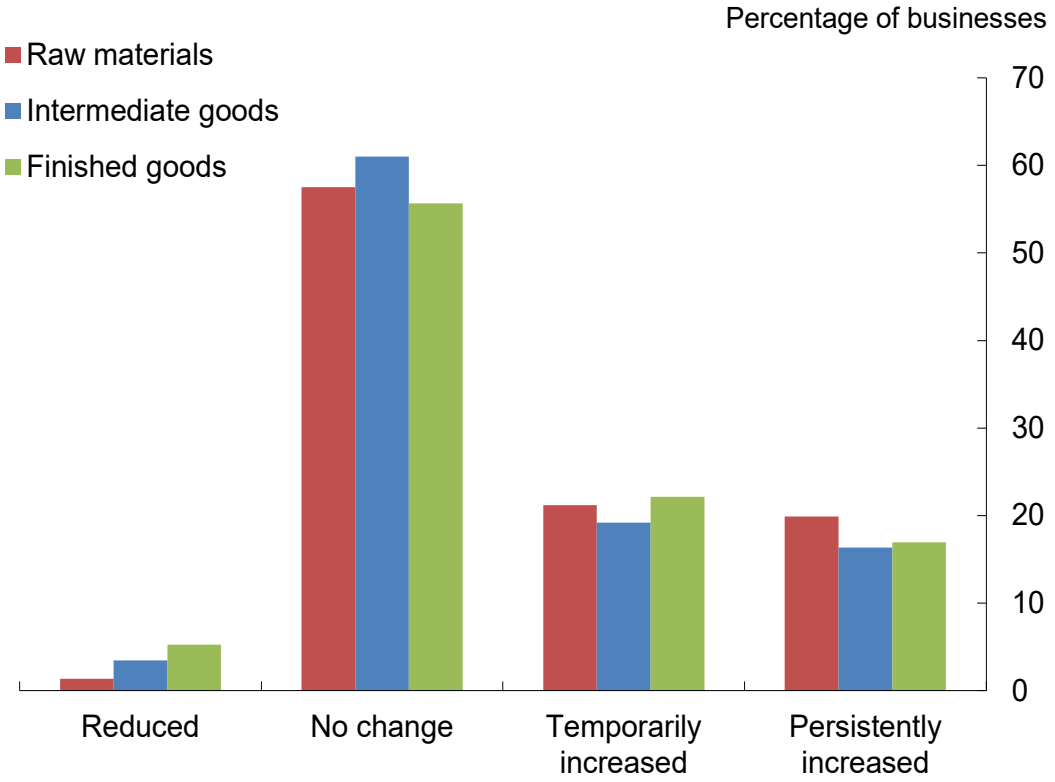
Notes: High EU exposure is defined as firms with above average pre-referendum exposure to the EU, based on the average of the following 6 exposure measures: share of sales to EU; share of costs from EU imports; share of EU migrants in workforce; share of sales covered by EU regulations; share of directors who are EU nationals; and a dummy for being EU owned. All are on a 0-1 scale. Low EU exposure is defined as firms with below average pre-referendum exposure on the same metric. Patents data are from World Patent Statistical Database. We thank Ralf Martin (Imperial), Arjun Shah (King's College London), Anna Valero (LSE) and Dennis Verhoeven (KU Leuven) for their assistance with enabling the data on patents to be linked to the DMP.

Figure A17: Time spent planning for Brexit and impact on stocks

Weekly CFO hours spent on Brexit planning

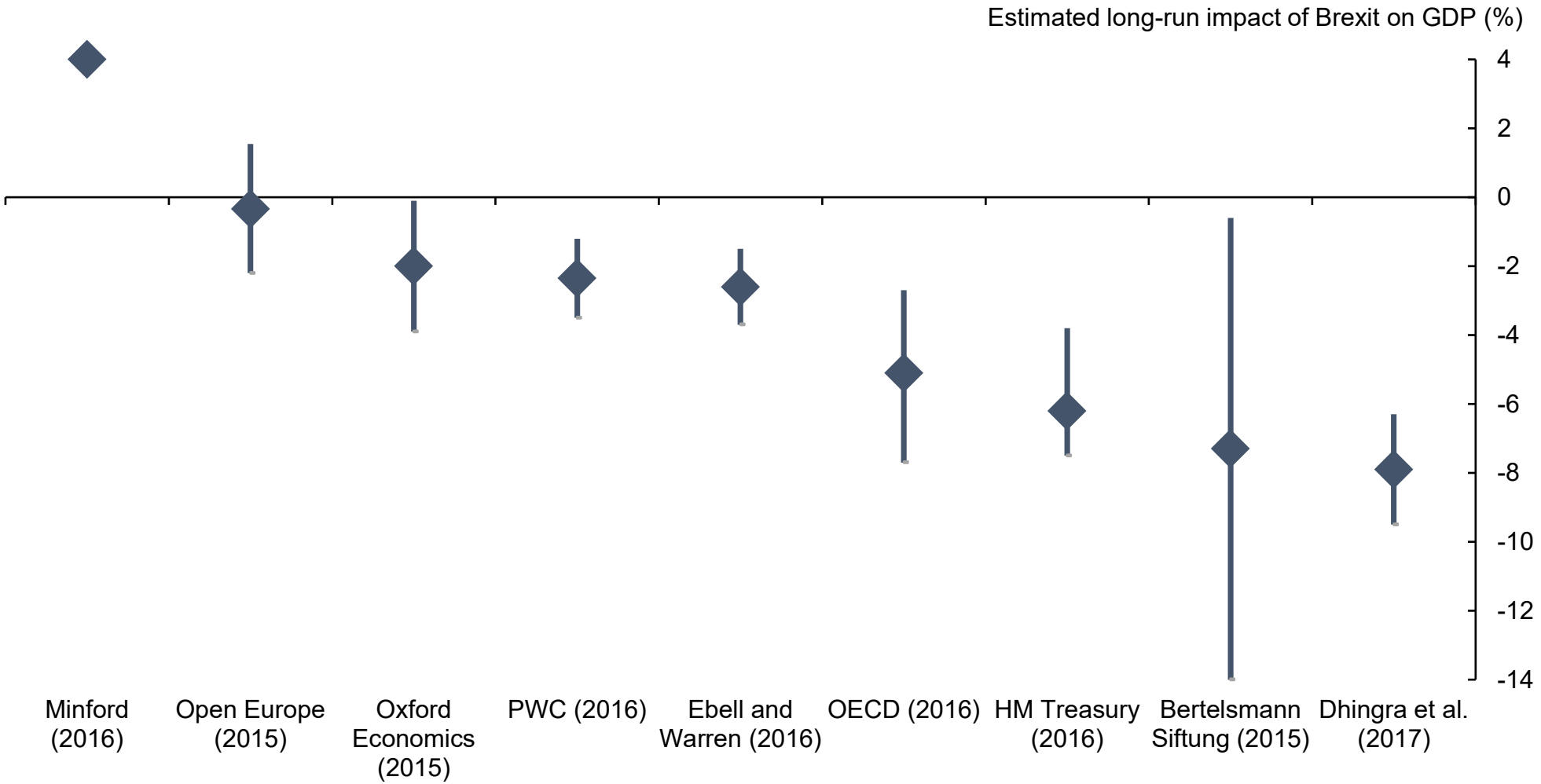


Impact of Brexit on stocks in 2019



***Notes**:* Charts are based on the questions 'On average, how many hours a week are the CEO and CFO of your business spending on preparing for Brexit at the moment?' and 'Which of the following statements best describes how the UK's decision to leave the EU has affected your stockbuilding decisions? (i) Stock levels have been increased, and expect to increase further; (ii) Stock levels have increased, expect to maintain higher level over medium term; (iii) Stock levels have been increased, expect to run down after 31 October 2019; (iv) Stock levels have been increased, expect to run down over next few months; (v) Stock levels had been increased, but have already been reduced to normal levels; (vi) Stock levels have been unchanged; vii) Stock levels have been reduced; viii) Not applicable, do not hold stocks ". The stocks question was asked between May and July 2019, and the figure excludes firms who do not hold stocks. Source: Decision Maker Panel.

Figure A18: Predictions of the long-term impact of Brexit on UK GDP



Source: These studies were originally summarised in IMF (2016a). The stalks show ranges. Diamonds denote midpoints or central estimates estimates.