# Trade Disintegration and Labour Markets: Evidence from Brexit

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We study the labour-market consequences of the largest episode of deep trade disintegration in recent history: Brexit, the United Kingdom's withdrawal from the European Union (EU). We develop a unified framework that jointly captures exposure to EU inputs, exports, and import competition. To estimate the effects of each of these three channels on labour market outcomes, we leverage rich administrative data on firm trade, employment, and worker wages in an exposure event study design with regional variation. We find that Brexit non-tariff barriers reduced wages by 2%, driven primarily by input exposure, while we detect little change in average regional employment. The adverse effects associated with export exposure were largely mitigated by firms reorienting sales towards domestic and non-EU markets. By contrast, we find little evidence that reduced import competition benefited workers. Decomposing regional effects into their firm-level components, we show that, despite limited regional employment effects, firms with greater input exposure experienced substantial employment declines. These contrasting results are categorised by worker reallocation toward less productive firms.

**Keywords**: Brexit, Non-Tariff Barriers, Labour Markets, Wages, Employment, Firms
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# 1 Introduction

The past decade has witnessed a dramatic return of protectionist trade policy, beginning with the tariff increases of the first Trump administration and the ensuing US–China trade war, and accelerating through the 2020s, most recently with the 2025 US "Liberation Day" tariffs. This retreat from trade integration has sparked a broad debate over the economic consequences of trade disintegration—the imposition of barriers that restrict the international flow of goods and services—with much of the existing evidence centred on production, trade, and prices (Fajgelbaum et al., 2020; Flaaen & Pierce, 2026; Flaaen et al., 2020). We bring workers to the centre of this debate and ask how trade disintegration reshapes wages and employment. The question is fundamental because trade integration imposed persistent losses on some workers and regions (Autor et al., 2013; Pierce & Schott, 2016), fuelling support for nationalist and protectionist politics (Antràs, 2020; Colantone & Stanig, 2018; Rodrik, 2021), while benefiting others (Dauth et al., 2014). If trade integration created both winners and losers, how does disintegration impact labour-market outcomes?

We answer this question in the context of Brexit, the United Kingdom's (UK) exit from the European Union (EU), which is the largest episode of deep trade disintegration in recent history. Our unique combination of rich administrative firm balance sheet, trade, and linked employer-employee data allows us to span the full Brexit period, from the exit vote in June 2016, through years of intense debate and uncertainty, until after the UK's departure from the EU single market in January 2021. In its place, the UK and EU entered the Trade and Cooperation Agreement (TCA), which preserved tariff- and quota-free trade in goods but introduced substantial non-tariff barriers (NTBs), including customs formalities, diverging product standards, and rules-of-origin requirements. This long transition from referendum to implementation allows us to distinguish how outcomes respond to the anticipation of trade disintegration from how they respond once new trade barriers actually take effect.

We identify three distinct channels which simultaneously impact workers in contrasting

ways. First, we consider an *input exposure* channel: regions that source inputs from the EU face higher costs after Brexit, potentially reducing production, employment, and wages. We capture this exposure using EU share of imports. Second, we consider an *export exposure* channel: UK regions exposed to EU exports face lower EU demand as prices increase to cover higher trade costs. We analogously measure exposure using the EU share of exports. Finally, we consider an *import competition* channel: by raising barriers for EU imports, UK markets are more shielded from foreign competition after Brexit, which may allow them to expand production, employment, and wages. We measure this exposure at the industry level as EU imports relative to total domestic sales and imports, which we then translate to regions using within-region industrial composition. Taken together, these channels capture the central forces through which bilateral trade disintegration reshape production decisions and, ultimately, workers, and are readily generalisable to other settings.

We develop a unified event-study framework that jointly captures exposure to all three channels at the regional level, allowing us to estimate the overall effect of Brexit's trade barriers – anticipated as well as implemented – on wages and employment. This approach has three advantages. First, it moves beyond existing estimates of Brexit's aggregate effects on firms, such as Bloom et al. (2019, 2025) and Do et al. (2025), by decomposing the shock into its constituent trade channels and tracing the mechanisms through which it affects workers. Second, because these channels are correlated, estimating them jointly is essential for isolating their individual effects. Third, these channels form the bedrock of the public debate surrounding trade disintegration, allowing us to quantify their relative importance through a horse race and assess the leading mechanisms shaping public perceptions of trade integration.

Our region-level results show that the labour market consequences of trade disintegration operate primarily through wage adjustments rather than changes in employment. Considering each of our three measures of exposure to Brexit, we find that wage losses arise predominantly through the input exposure channel. A one-standard-deviation increase in regional EU input exposure is associated with a 3.9% decline in real wages between

2015 and 2024, with most of this effect materialising following the introduction of bilateral non-tariff trade barriers under the TCA. Greater EU export exposure had limited effects on employment and wages, and we find little evidence that reduced competition from EU imports created new opportunities in domestic labour markets. A back-of-the-envelope calculation assuming that regions with no exposure to Brexit realised no wage losses suggests that workers lost, on average, 2% after the introduction of the TCA.

Exploiting our administrative firm-level data, we develop a framework that links regional treatment effects to their underlying firm-level adjustments within regions. We show that regional wage losses are concentrated among firms with greater EU input exposure, consistent with the presence of firm-level wage-setting power in local labour markets.

Turning to employment, we find that firms within regions with greater EU input exposure experienced significant employment losses: a one-standard-deviation increase in exposure is associated with a 6.8% reduction in employment between 2015 and 2024. We reconcile the contrast between regional and firm-level employment using linked employer-employee data, showing that workers in exposed firms are disproportionately likely to make firm to firm transitions within regions rather than transition into non-employment. Importantly, these transitions are categorised by movements toward less productive firms, suggesting that the resilience of aggregate employment across regions may conceal an important allocative cost of trade disintegration.

At both the regional and firm levels, exposure to EU export markets is associated with relatively limited changes in employment and wages. To understand this finding, we examine how firms adjust their sales across destination markets in response to Brexit. We find that firms with greater exposure to EU export markets redirect sales away from the European Union towards domestic and rest-of-world markets, consistent with the venting-out mechanism documented by Almunia et al. (2021). This reallocation of sales suggests that firms were able to offset reduced access to European markets by expanding into alternative destinations, thereby mitigating the adverse consequences for domestic employment and wages.

Finally, to understand why reduced competition from EU imports did not translate into gains for domestic workers, we examine changes in the composition of imports across industries. We find that while the market share of EU producers declined, this was largely offset by an increase in the market share of producers from the rest of the world, rather than by domestic firms. Consequently, the reduction in EU import competition provided little relief from foreign competitive pressure, limiting the potential benefits of trade disintegration for domestic workers.

To rationalise our results, we develop a conceptual model that links Brexit-related trade frictions to firm-level employment reallocation through heterogeneous EU input and export exposure. UK firms produce differentiated goods with a predetermined stock of capital, while labour and imported intermediate inputs adjust freely in response to trade shocks. Brexit affects firms first through uncertainty over future trade costs and subsequently through the realisation of higher non-tariff barriers. An important feature of the framework is increasing marginal costs due to predetermined capital, which dampens the effect of export shocks by redirecting sales towards non-EU markets. The model predicts that higher export barriers and import barriers for intermediate inputs reduce labour demand, whereas weaker import competition raises it. With firms operating in local labour markets in which labour supply is inelastic, wage adjustments in equilibrium leads to reallocation in employment across firms according to their exposure relative to the local economy-wide average, while leaving aggregate employment unchanged.

Taken together, our findings surrounding the differential margins of the UK's adjustment both before and after the implementation of the TCA not only shed light on one of the largest policy debates in UK history, but also provide key academic insights regarding the dynamic decision-making of firms in response to disintegrating shocks and the subsequent consequences for workers.

This paper ties together three strands of literature. First, we contribute to the emerging literature on the labour-market consequences of trade disintegration. Expanding in the wake of the 2018–19 US–China trade war, this literature has shown that deglobalisation

is more nuanced than simply reversing the well-documented effects of trade integration (Autor et al., 2013, 2014; Dix-Carneiro, 2014; Dix-Carneiro & Kovak, 2017; Felix, 2026), because higher trade barriers can simultaneously protect import-competing producers, raise the cost of imported intermediates, and reduce exporters' access to foreign markets through direct barriers or retaliation (Fajgelbaum & Khandelwal, 2022). Flaaen and Pierce (2026) is the closest in spirit to our study, providing an important precedent for our econometric approach by distinguishing between these three channels within a unified framework. Whereas their analysis focuses primarily on aggregate industry-level outcomes, including output, prices, and employment, we study local labour markets in order to capture the incidence of trade disintegration from the perspective of workers. Our micro-founded exposure measures also allow us to go beyond the local labour-market effects and examine the firm-level mechanisms underlying them.

Second, by drawing on firm-level data, we speak to the literature on the pass-through of trade shocks onto workers. We extend this literature by studying the direct consequences for workers of an NTB shock. Our results most closely mirror, in reverse, Amiti and Davis (2012), who show that trade liberalisation creates gains for workers in firms whose production and sales are more dependent on the international market. Garin and Silvério (2024) distinguish between idiosyncratic firm- and market-level export-demand shocks and show that in both cases part of the resulting change in labour demand is passed through to wages, while Hummels et al. (2014) show that offshoring raises wages for high-skilled workers at the expense of low-skilled workers. Related work asks whether such wage changes reflect genuine shifts in firm wage premia or worker composition. Verhoogen (2008) shows that improved export market access induces more productive firms to upgrade quality and raise wages, while Frías et al. (2024) show that these gains operate primarily through higher firm wage premia. By contrast, Krishna et al. (2014) find that much of the apparent wage advantage of exporters following trade liberalisation can be explained by changes in worker–firm matching.

Third, we contribute to the burgeoning literature on the economic consequences of Brexit. Existing work has largely centred on trade flows (Bhalotia et al., 2025; Broadbent et al.,

2024; Conconi et al., 2026; Dhingra et al., 2023; Fernandes & Winters, 2021; Freeman et al., 2025; Kren & Lawless, 2024), prices (Bakker et al., 2022; Breinlich et al., 2020; Graziano et al., 2024), and broader macroeconomic outcomes including GDP, investment, and output (Bloom et al., 2025; Breinlich et al., 2018, 2020). We instead place labour markets front and centre.[0] Building on previous analyses of employment (Bloom et al., 2025; Do et al., 2025), our unified framework moves beyond the aggregate Brexit shock to disentangle the distinct trade mechanisms through which disintegration affects workers.

We are also among the first to examine the wage effects of Brexit both before and after the implementation of the TCA. Despite the clear policy relevance of these outcomes, evidence remains relatively limited. A contemporaneous paper by Breinlich et al. (2026) studies the wage effects of supply chain barriers across trade in goods and services, while we instead focus on firms predominantly exposed through goods trade and provide a complete decomposition of disintegration along that dimension. Our analysis also complements Costa et al. (2024), who study the labour-market consequences of Brexit through another key margin, the depreciation of sterling. Finally, alongside Javorcik et al. (2026), who examine vacancy posting in response to Brexit, we provide some of the first evidence that labour markets respond not only to the implementation of new trade barriers, but also to the threat and uncertainty surrounding them, complementing work on the effects of Brexit uncertainty on trade and growth (Ahmad et al., 2023; Born et al., 2019; Graziano et al., 2021).

The paper proceeds as follows. Section 2 outlines the trade-disintegration context of Brexit, section 3 develops the conceptual framework that guides our analysis. Section 4 describes the administrative data sources, and section 5 sets out our identification strategy. We then present the core results in two parts: Section 6 estimates the effects using regional treatments, while section 7 uses firm-level treatments to uncover the mechanisms underlying these regional effects. Section 8 concludes.

[0]See Dhingra and Sampson (2022) for an excellent review of the impact of Brexit after the 2016 vote.

# 2 Brexit as a Disintegrating Shock

The process leading to the UK's withdrawal from the European Union began with the Conservative Party's 2015 general election manifesto, which committed to renegotiating the terms of EU membership and holding an in-or-out referendum by the end of 2017 (Conservative Party, 2015). Following the Conservatives' electoral victory, a referendum was held on 23 June 2016. Despite Prime Minister David Cameron campaigning in favour of remaining in the EU, and betting markets assigning just a 12% probability to a Leave victory on the day of the referendum (Crowley et al., 2018), the referendum resulted in a narrow majority in favour of withdrawal. Leave received 51.9% of the vote, compared with 48.1% for Remain, a margin of just 3.8 percentage points (Electoral Commission, 2016). The unexpected outcome initiated the process of withdrawal, with the UK formally notifying the European Council of its intention to leave under Article 50 of the Treaty on European Union on 29 March 2017 (European Commission, 2017).

The referendum outcome did not, however, determine the nature of the UK's eventual relationship with the EU. Cameron resigned following the vote and was succeeded by Theresa May in July 2016, initiating a prolonged period of political uncertainty over both the timing and the form of withdrawal. At one end of the spectrum, a relatively "soft" Brexit could have involved continued participation in the EU single market or a customs union, limiting some of the frictions associated with separation. At the other, departure without a preferential trade agreement would have meant trading under the most-favoured nation principle, exposing bilateral trade to tariffs as well as non-tariff barriers. An intermediate possibility was a free trade agreement that preserved tariff preferences while introducing new regulatory, administrative and customs frictions (Rutter et al., 2017). The range of possible outcomes therefore implied considerable uncertainty about future costs of trade with the EU.

The uncertainty was both substantial and persistent.[1] Using data from the Bank of England's Decision Maker Panel, Bloom et al. (2018) find that approximately 40% of

[1] Appendix Figure A.1 plots the evolution of Brexit-related business uncertainty over time.

UK businesses ranked Brexit among their three largest sources of uncertainty during the two years following the referendum, with this proportion increasing further in autumn 2018. Brexit-related uncertainty was particularly pronounced in industries more dependent on EU trade and EU migrant labour, suggesting that firms' exposure to the prospective change in economic arrangements shaped their expectations well before the new arrangements took effect. This evidence is consistent with the possibility of anticipatory adjustment in investment, supply relationships and trading decisions, although uncertainty alone does not identify the effect of the eventual trade barriers.

Political developments prolonged this period of uncertainty. Theresa May's proposed Withdrawal Agreement was repeatedly rejected by Parliament, and the original March 2019 withdrawal deadline was extended. After May resigned, Boris Johnson became Prime Minister in July 2019, renegotiated the Withdrawal Agreement and secured a further extension to the withdrawal deadline. The UK formally left the EU on 31 January 2020, but continued to participate in the single market and customs union during a transition period ending on 31 December 2020 (Walker, 2021). The terms of the future trading relationship therefore remained unresolved for much of 2020. Agreement on the EU–UK Trade and Cooperation Agreement (TCA) was reached only on 24 December 2020, shortly before its provisional application began on 1 January 2021 (European Commission, 2020).

The TCA established preferential arrangements for bilateral trade in goods, including zero tariffs and zero quotas for products satisfying the rules of origin. It did not, however, preserve the frictionless trade associated with EU membership. The UK exited the EU single market and customs union, introducing customs declarations, rules-of-origin requirements, and other regulatory and administrative procedures for cross-border trade. These non-tariff barriers increased the costs of importing intermediate inputs from the EU and exporting goods to EU customers. Conversely, higher barriers on EU imports could also reduce competitive pressure on UK producers serving domestic markets. The resulting economic effects could therefore operate through distinct, potentially offsetting channels: input exposure, export exposure, and import competition (Cabinet Office, 2020;

European Commission, 2020).[2]

Implementation of the new border arrangements was not fully symmetric or simultaneous. EU customs formalities for goods arriving from Great Britain applied from January 2021, whereas the UK phased in important import requirements over a longer period, including subsequent changes under the Border Target Operating Model (Cabinet Office, 2020, 2023). These differences in the timing and intensity of border frictions are relevant when interpreting the evolution of bilateral trade and the effects on UK firms. More generally, the institutional change at the end of the transition period marks a distinct implementation shock following several years during which firms could already anticipate, but could not know with certainty, the trading arrangements that would emerge.

Figure 1 plots the EU share of total UK goods trade.[3] The share was broadly stable around 55–56% before the referendum but began to decline during 2018–2020, when considerable uncertainty remained over the UK's future trading relationship with the EU. This pre-implementation decline is consistent with firms adjusting their trading relationships in anticipation of Brexit and in response to Brexit-related uncertainty, rather than only after new trade barriers came into force. The series then falls particularly sharply around January 2021, coinciding with the end of the transition period and the introduction of the TCA trading arrangements. Although the EU share subsequently recovers, these movements are descriptive and should not be interpreted as a causal estimate of Brexit's effect: contemporaneous pandemic disruptions, stockpiling, shifts in trade with non-EU partners and changes in recording practices may also have contributed to the pattern. This aggregate pattern conceals considerable heterogeneity across products. Appendix Figure A.3 documents changes in EU trade shares separately for imports and exports, revealing particularly widespread declines in EU export shares among products initially more dependent on EU markets, alongside more heterogeneous adjustments in import

[2]In Appendix D, we examine which product groups experienced the largest implied increases in trade costs following the implementation of the TCA. For both imports and exports, implied trade costs rose substantially for textiles and clothing, which often use raw materials imported from third countries. This pattern is suggestive of a role for rules-of-origin requirements in reshaping trade.

[3]The corresponding EU shares of total goods imports and total goods exports are shown separately in Appendix Figure A.2.

sourcing.

Figure 2 illustrates how exposure to Brexit varies across local labour markets, reflecting differences in industrial composition and EU input exposure, export exposure and import competition (formally defined in 5). Input exposure is concentrated in the Scottish Central Belt, northern England and parts of the Midlands and Wales. Export exposure follows a similar geographical pattern, while import competition exposure is more dispersed across Scotland, Wales and western and northern England. These patterns are reflected in the correlations across regions: input and export exposure are strongly correlated (0.71), whereas import competition is only weakly correlated with input exposure (0.17) and export exposure (0.22). Thus, regions vulnerable to increased trade costs along the input and export exposure margins often coincide, while those potentially benefiting from reduced EU import competition are more geographically distinct. The following section describes how these exposure measures are constructed.

# 3 Theoretical Framework

In this section, we present a tractable model of firms that face non-tariff trade barriers and uncertainty that change access to foreign supply chains and export markets, as well as import competition in the domestic market. We then derive theoretical predictions from the model, which we test in the data.

## 3.1 Environment

**Consumers**: In each destination country $d \in \mathcal{D}$, there is a representative agent that supplies labour $L_d$ inelastically to firms. Each agent derives utility by consuming a continuum of goods $f$ according to the constant elasticity of substitution (CES) aggregator

$$U_d = \left( \int_f q_{df}^{\frac{\sigma-1}{\sigma}} df \right)^{\frac{\sigma}{\sigma-1}} \tag{1}$$

where $\sigma$ is the elasticity of substitution between goods. Furthermore, we assume each good $f$ is a CES aggregate over origin countries $o \in \mathcal{O}$

$$q_{df} = \left( \sum_{o \in \mathcal{O}} q_{dof}^{\frac{\theta_f - 1}{\theta_f}} \right)^{\frac{\theta_f}{\theta_f - 1}} \tag{2}$$

where $\theta_f$ is the elasticity of substitution of good $f$ across origin countries.

**Final good producers**: Since we focus on UK producers, we drop the country subscript for final good producers. We assume that there is a fixed unit mass of firms with no entry or exit. Each firm produces a unique tradeable final good $f$ by combining labour ($l_f$), intermediate inputs ($m_f$), and capital ($k_f$) according to the following Cobb-Douglas production function

$$y_f = k_f^{\gamma} l_f^{\beta} m_f^{1-\beta-\gamma} \tag{3}$$

where $\gamma$ and $\beta$ are the output elasticities of capital and labour, respectively. We further assume that intermediate inputs are a CES aggregate over country varieties

$$m_f = \left( \sum_{o \in \mathcal{O}} m_{of}^{\frac{\alpha - 1}{\alpha}} \right)^{\frac{\alpha}{\alpha - 1}} \tag{4}$$

where $\alpha$ is the intermediate input elasticity of substitution across country varieties. In addition, we assume that the amount of labour and intermediate inputs can be freely adjusted in response to a shock, whereas the stock of capital cannot. This assumption is important for matching the model to our empirical findings on how firm sales adjust in response to Brexit and its implications for employment and wages. Finally, we assume that firms compete under monopolistic competition in each destination market.

**Workers and the Labour Market**: We assume that there is a continuum of homogeneous workers in the economy. Using a simplified version of discrete worker choice in

Berger et al. (2022), the residual labour supplied to each $f$ is

$$l_f^S = L\chi_f \left(\frac{w_f}{w}\right)^{\epsilon} \tag{5}$$

where $L$ is the aggregate amount of labour in the economy, $\chi_f$ is the firm-specific taste shifter of the worker, $w_f$ is the firm wage, $w$ is the wage index, and $\epsilon$ is the worker's elasticity of substitution across firms. We assume that regional labour supply is fixed and perfectly inelastic. Furthermore, labour is immobile across regions, meaning that the economy can be considered a single region. Finally, firms compete with one another to hire workers under monopsonistic competition. This assumption allows for differences in wages and employment across regions and firms within a region.

Next, we formalise how the costs of trade disintegration are modelled.

**Trade Costs – NTBs**: We assume that Brexit-induced trade costs consist of tariff-equivalent NTBs.[4] For the case of a UK firm importing intermediate inputs, the total cost of importing from origin $o$ is

$$c_o = \bar{c}_o(1 + \phi_o^M) \tag{6}$$

where $\bar{c}_o$ is the factory price of an intermediate input from origin $o$ and $\phi_o^M$ is the associated ad-valorem NTB on imports from origin $o$.[5] Similarly, the total price faced in destination $d$ for good $f$ from origin $o$ is

$$p_{dof} = \bar{p}_{dof}(1 + \phi_{dof}^X) \tag{7}$$

where $\bar{p}_{dof}$ is the factory price of good $f$ from origin $o$ in destination $d$ and $\phi_{dof}^X$ is the associated ad-valorem NTB. We are explicit in the notation here, as this applies both when UK final-good producers export to the EU ($o = UK$) and when EU final-good

[4] We abstract away from tariffs since they were unchanged between the UK and EU post-TCA.

[5] For tractability purposes, we assume that the costs of higher NTBs and uncertainty enter as variable costs for firms and consumers. Freeman et al. (2025) and Handley and Limão (2017) note uncertainty and NTBs also have a fixed cost component, respectively.

producers export to UK consumers ($d = UK$).

**Trade Costs – Uncertainty**: In the case of trade policy uncertainty, trade costs ($T$) are random variables. We take a reduced-form approach, where firms and consumers consider both the expected trade cost and its variance, such that the associated cost they factor into their decision-making ($\hat{T}$) takes the following form.

$$\ln \hat{T} = \mathbb{E}[\ln T] + \frac{\lambda}{2} Var[\ln T] \tag{8}$$

This assumes that both consumers and firms are risk averse, since they also consider the dispersion of trade costs. The degree of risk-aversion exhibited is governed by the parameter $\lambda > 0$.

Therefore, the total cost of a UK firm importing intermediate inputs from origin $o$ is

$$c_o = \bar{c}_o \hat{T}_o^M \tag{9}$$

and the total price in destination $d$ for good $f$ from origin $o$ is

$$p_{dof} = \bar{p}_{dof} \hat{T}_{dof}^X \tag{10}$$

where $\hat{T}_o^M$ and $\hat{T}_{dof}^X$ are the associated trade costs of intermediate inputs and final goods from equation (8), respectively.

## 3.2 Firm Decisions

The firm's problem consists of two stages. In the first stage, the firm faces uncertainty over trade costs. Under uncertainty, it must choose the amount of labour and intermediate inputs to employ and the price and quantity to sell to each destination country. In the second stage, the shocks are realised, and the firm repeats the same set of decisions as in stage one. We can consider the two stages separately, as they are independent of each other.

In both stages, destination $d$'s demand for good $f$ is

$$q_{df} = E_{df} p_{df}^{-\theta_f} \tag{11}$$

where $E_{df}$ is the demand shifter of destination $d$ for good $f$. Since firms compete under monopolistic competition and takes aggregate price indices as given, each firm optimally sets its factory price as a constant mark-up over marginal cost that is constant across destination markets.

$$\bar{p}_{df} = \bar{p}_f = \frac{\theta_f}{\theta_f - 1} mc_f(q_f, k_f) \tag{12}$$

where $mc_f(q_f, k_f)$ is the marginal cost function, expressed as

$$mc_f(q_f, k_f) = \left(\frac{1}{k_f^{\gamma}}\right)^{\frac{1}{1-\gamma}} \left(\frac{1+\epsilon}{\epsilon\beta} w_f\right)^{\frac{\beta}{1-\gamma}} \left(\frac{1}{1-\beta-\gamma} c_f\right)^{\frac{1-\beta-\gamma}{1-\gamma}} q_f^{\frac{\gamma}{1-\gamma}} \tag{13}$$

where $q_f$ is total output, $w_f$ is the wage, and $c_f$ is the index of firm $f$'s intermediate-input costs. Notice that, because firms are capital constrained, marginal costs and prices are increasing with output. This will play a key role in how labour demand adjusts to shocks in the model in order to match our empirical findings.

Finally, since firms compete under monopsonistic competition in hiring workers, firms optimally set their wages as a mark-down over marginal revenue with respect to labour, expressed as

$$w_f = \frac{\epsilon}{1+\epsilon} \frac{\partial R_f}{\partial l_f} \tag{14}$$

Inverting equation (14) yields the firm's (conditional) labour demand function below

$$l_f = \frac{\beta\epsilon}{1+\epsilon} mc_f q_f \frac{1}{w_f} \tag{15}$$

## 3.3 Theoretical Predictions

The set-up of the model delivers clear theoretical predictions on how uncertainty and changes in NTBs affect employment and wages through the three channels we consider. In addition, since firms hold monopsony power in the labour market, the model delivers variation in wages across *both* regions and firms. We first present how changes in NTBs (stage two) affect employment and wages. We then conduct a similar exercise for the case of uncertainty (stage one). For additional notation, denote $M$ as the value of input, $X$ as the value of output, and $\omega_f^o$ as the share of domestic consumption of final good $f$ originating from country $o$.

### 3.3.1 Non-Tariff Barriers

First, we look at the effects of higher input costs through higher import NTBs. Looking at regional wages, result 1 states that regional wages decline in response to higher import NTBs and that the decline is greater for regions that are more exposed. Since it is more costly for firms to import intermediate inputs, marginal costs increase, resulting in an increase in prices and lower output demand. Therefore, in the aggregate, lower output demand leads to lower labour demand and regional wages.

**Result 1** *Regional wages decline in response to an increase in import NTBs, and the decline is larger for more exposed regions (see proof in Appendix C).*

$$d\ln w = -\frac{1}{\zeta}\left[\sum_f \frac{(\theta_f - 1)(1-\beta-\gamma)}{\Omega_f}\frac{l_f}{L}\left(\frac{M_{of}}{M_f}\right) d\ln(1+\phi_o^M)\right] \leq 0$$

Variation in exposure to import NTBs can also arise among firms within regions, resulting in differential changes in firm-level wages. Result 2 states that firms that are more exposed to import NTBs, due to a larger share of intermediate-input purchases from origin $o$, set lower wages than those that are less exposed ($\frac{M_{of}}{M_f}$).

**Result 2** *The decline in firm wages (within a region) in response to an increase in import NTBs is larger for more exposed firms (see proof in Appendix C).*

$$d\ln w_f = -\frac{1}{\Omega_f}\left[(\theta_f - 1)(1-\beta-\gamma)\left(\frac{M_{of}}{M_f}\right) d\ln(1+\phi_o^M) - \varepsilon[1+\gamma(\theta_f-1)]d\ln w\right] \leq 0$$

With heterogeneous changes in firm wages, result 3 states that there will be a reallocation of labour within a region. Higher import NTBs push up firms' marginal costs of production, resulting in higher factory prices. The increase in prices reduces output demand and labour demand, resulting in lower firm wages. However, since the shock occurs for all firms, aggregate regional wages fall, which has a positive effect on firm labour demand. Therefore, the net effect on firm employment depends on whether the negative direct effect of the import NTB shock or the positive indirect effect of lower regional wages dominates. The former dominates for firms that are more exposed to the import NTB shock, and vice versa for less-exposed firms. Since aggregate labour supply is fixed, some workers move to seek employment in relatively higher-paying firms by moving from the most- to the least-exposed firms in the region.

**Result 3** *Firms that are more exposed to import NTBs see employment declines, whilst firms that are less exposed see employment increases (see proof in Appendix C).*

$$d\ln l_f = -\frac{\epsilon}{\Omega_f}\left[\overbrace{(\theta_f - 1)(1-\beta-\gamma)\left(\frac{M_{of}}{M_f}\right) d\ln(1+\phi_o^M)}^{Direct\ effect} - \underbrace{[1+(\beta+\gamma)(\theta_f-1)]d\ln w}_{Indirect\ effect}\right]$$

Second, we look at export NTBs to the EU. At the regional level, result 4 states that an

increase in export NTBs leads to a decline in regional wages. This occurs since higher export NTBs reduce aggregate output demand, which, in turn, lowers aggregate labour demand and wages. Furthermore, the decline is larger for regions that are more exposed due to a greater decline in aggregate output.

**Result 4** *Regional wages decline in response to an increase in export NTBs, and the decline is larger for more exposed regions (see proof in Appendix C).*[6]

$$d\ln w = -\frac{1}{\zeta}\left[\sum_f \frac{\theta_f}{\Omega_f}\frac{l_f}{L}\frac{X_{df}}{X_f} d\ln(1+\phi_{df}^X)\right] \leq 0$$

Similar to the case of import NTBs, variation in exposure to export NTBs can arise ($\frac{X_{df}}{X_f}$), resulting in heterogeneous changes in firm wages. Result 5 states that the fall in firm wages in response to higher export NTBs is larger for firms that are more exposed to Brexit in terms of their output.

**Result 5** *The decline in firm wages (within a region) in response to an increase in export NTBs is larger for more exposed firms (see proof in Appendix C).*

$$d\ln w_f = -\frac{1}{\Omega_f}\left[\theta_f \frac{X_{df}}{X_f} d\ln(1+\phi_{df}^X) - \epsilon[1+\gamma(\theta_f-1)] d\ln w\right] \leq 0$$

These heterogeneous wage responses translate into a reallocation of labour within the region, as formalised in result 6. Firm labour demand declines because of lower output demand from higher export NTBs, resulting in lower firm wages. However, there is an indirect effect from the fall in the regional wage, which attracts workers since the relative firm wage is higher. Therefore, the net effect depends on whether

[6] $\zeta = \sum_f \frac{l_f}{L}\frac{1+(\beta+\gamma)(\theta_f-1)}{\Omega_f}$ and $\Omega_f = \epsilon[1+\gamma(\theta_f-1)] + 1 + (\beta+\gamma)(\theta_f-1)$

the direct effect of export NTBs on firm wages or the indirect effect of lower regional wages dominates. This will depend on how exposed the firm is relative to the regional average. As a result, firm wages relative to the regional wage increase for the least-exposed firms and decrease for the most-exposed firms. As a result, labour is reallocated from the most- to the least-exposed firms in response to an increase in export NTBs.

**Result 6** *Firms that are more exposed to export NTBs see employment declines, whilst firms that are less exposed see employment increases (see proof in Appendix C).*

$$d\ln l_f = -\frac{\epsilon}{\Omega_f}\left[\overbrace{\theta_f \frac{X_{df}}{X_f} d\ln(1+\phi_{df}^X)}^{Direct\ effect} - \underbrace{[1+(\beta+\gamma)(\theta_f-1)]d\ln w}_{Indirect\ effect}\right]$$

It is important to note that, since firms are capital constrained, the effects on wages and employment are muted. When firms are capital constrained, output to each destination is restricted to below the unconstrained optimum due to increasing marginal costs. As a result, when a firm faces an increase in export NTBs to destination $d$, the fall in demand lowers the factory price, which increases output to other destinations (see appendix C).

Thirdly, we look at the effects of lower import competition from greater UK import NTBs on final goods from origin $o$ ($\phi^X_{UK,of}$). In comparison to the other two channels, result 7 states that when NTBs increase for imported final goods from foreign origin $o$, regional wages rise. This occurs since consumers switch to relatively cheaper domestic varieties, which increases aggregate demand for labour and wages in the domestic economy. In addition, the increase in regional wages is larger for regions that are more exposed to import competition from origin $o$ ($\omega^o_f$).

**Result 7** *Regional wages increase in response to higher import NTBs for final goods from*

*origin $o$ (lower import competition), and the increase is greater for more exposed regions (see proof in Appendix C).*[7]

$$d\ln w = \frac{1}{\Gamma}\left[\sum_f \frac{(\theta_f - 1)}{\Theta_f}\frac{l_f}{L}\omega_f^o d\ln(1+\phi_{UK,of}^X)\right] \geq 0$$

In response to lower import competition, there is an increase in wages set by all firms. However, the increase is heterogeneous across firms. Result 8 states that all firms set higher wages in response to lower import competition, due to greater demand, but the increase is greater for firms that are initially more exposed to import competition from origin $o$.

**Result 8** *The increase in firm wages (within a region) in response to higher import NTBs for final goods is larger for more exposed firms (see proof in Appendix C).*

$$d\ln w_f = \frac{1}{\Theta_f}\left[(\theta_f - 1)\omega_f^o d\ln(1+\phi_{UK,of}^X) + \epsilon[1+\gamma(\theta_f-1)(1-\omega_f^{UK})]d\ln w\right] \geq 0$$

Like in the other two channels, the increase in regional and firm wages has opposing effects on firm employment. When there is a decrease in import competition, domestic firm output increases, which leads to greater labour demand. Firms attract more labour by setting higher wages. However, since this is true for all firms, the regional wage increases, which makes the firm wage less attractive compared to the average regional wage. As a result, firms that are more exposed to import competition and are able to set higher relative wages employ more labour which comes at the expense of less exposed firms reducing the number of workers they employ (result 9).

**Result 9** *Firms that are more exposed to import NTBs in final goods employ more labour,*

[7] $\Gamma = \sum_f \frac{1}{\Theta_f}\frac{l_f}{L}[1+(\beta+\gamma)(\theta_f-1)(1-\omega_f^{UK})]$ and $\Theta_f = \epsilon[1+\gamma(\theta_f-1)(1-\omega_f^{UK})]+1+(\beta+\gamma)(\theta_f-1)(1-\omega_f^{UK})$

*whilst firms that are less exposed employ less labour (see proof in Appendix C).*

$$d\ln l_f = \frac{\epsilon}{\Theta_f}\left[\overbrace{(\theta_f - 1)\omega_f^o d\ln(1+\phi^X_{UK,of})}^{Direct\ effect} - \underbrace{[1+(\beta+\gamma)(\theta_f-1)(1-\omega_f^{UK})]d\ln w}_{Indirect\ effect}\right]$$

### 3.3.2 Uncertainty

We now look at how uncertainty through the three channels affects wages and employment. The results are analytically similar to the case of NTBs. As a result, we only list the results for the case of uncertainty in importing intermediate inputs and leave the remaining results to the appendix B.

10 states that regional wages decline in response to greater uncertainty in importing intermediate inputs and that the decline is greater for regions that are more exposed. Since it is more costly for firms to import intermediate inputs, marginal costs increase, resulting in an increase in prices and lower output demand. Therefore, in the aggregate, lower output demand leads to lower labour demand and regional wages.

**Result 10** *Regional wages decline in response to an increase in import uncertainty, and the decline is larger for more exposed regions (see proof in Appendix C).*

Variation in exposure to import uncertainty can also arise among firms within regions, resulting in differential changes in firm-level wages. Result 11 states that firms that are more exposed to uncertainty set lower wages than those that are less exposed.

**Result 11** *The decline in firm wages (within a region) in response to an increase in import uncertainty is larger for more exposed firms (see proof in Appendix C).*

Import uncertainty generates a similar link between heterogeneous firm-level wage responses and labour reallocation within the region, as formalised in result 12. Higher import uncertainty pushes up firms' marginal costs of production, resulting in higher fac-

tory prices. The increase in prices reduces output demand and labour demand, resulting in lower firm wages. However, since all firms face uncertainty, aggregate regional wages fall, which has a positive effect on firm labour demand. Therefore, the net effect on firm employment depends on whether the negative direct effect of uncertainty or the positive indirect effect of lower regional wages dominates. The former dominates for firms that are more exposed to import uncertainty, and vice versa for less-exposed firms. As a result, labour is reallocated from the most- to the least-exposed firms in response to an increase in import uncertainty.

**Result 12** *Firms that are more exposed to import uncertainty see employment declines, whilst firms that are less exposed see employment increases (see proof in Appendix C).*

# 4 Data

Our analysis draws on three core administrative datasets covering firm-level trade patterns, sales, and employment, and linked employer–employee records. This section describes each dataset in turn, alongside two auxiliary surveys that we use to construct important controls and secondary outcomes. A full description of the data, including detailed cleaning and sample construction steps, is provided in Appendix E.

## 4.1 Administrative & Linked Employer-Employee Data

**Annual Survey of Hours and Earnings (ASHE)**: Our primary source of worker data, ASHE, is a legally mandated employer survey covering a 1% random sample of employees selected according to their National Insurance number (the UK equivalent of a US Social Security number) between 2011 and 2024.[8] ASHE is the foremost source of linkable earnings data in the UK and serves as the basis for the Office for National Statistics' (ONS) official earnings statistics and allows us to follow workers throughout their labour market histories. Our primary outcome is gross hourly pay, calculated as gross weekly earnings, including overtime, divided by total hours worked during the survey reference

[8]The response rate of the survey sits at 80%, which is considerably higher than alternative sources such as the Labour Force Survey (LFS).

week. ASHE also records a rich set of individual characteristics, including hours worked, age, occupation, and sex. Importantly for our local labour market analysis, we observe workers' home addresses annually, which we map to consistent 2011 Travel to Work Areas. ASHE does not cover all types of workers, most notably excluding sole traders and workers with very low weekly earnings; we discuss these coverage restrictions in Appendix E.

**Business Structure Database (BSD)**: The BSD provides core firm-level information for the universe of enterprises registered on the IDBR between 2011 and 2024, which we refer to synonymously as firms. These records can be linked directly to firm identifiers in ASHE, allowing the BSD to form the bridge between workers, firms, and the trade data described below. For our purposes, the BSD provides two key outcomes: sales and employment. We use employment from the BSD rather than ASHE because the smaller ASHE sample introduces additional sampling noise into estimates of regional employment stocks.

We impose two main sample restrictions. First, we exclude public sector enterprises, which largely capture local government units such as councils and hospitals. Second, because sales and employment are reported at the enterprise level rather than separately for each reporting unit, we restrict the sample to firms with a single reporting unit. This avoids measurement error when enterprise-level outcomes are assigned to the location of the firm's headquarters despite activity being distributed across multiple locations. For example, a firm headquartered in London could record a decline in employment driven entirely by a reporting unit in Liverpool.

**HMRC Trade in Goods Database (TiG)**: We utilise the TiG database to construct our measures of exposure to Brexit. It includes detailed information on the import and export transactions of UK firms at the firm–product–partner-country level between 2011 and 2022. Transactions are recorded monthly and valued in pounds sterling, which we aggregate to the annual level to match the frequency of the ASHE and BSD data. We further aggregate trade flows into EU and rest-of-world (RoW) totals for each firm, separately for imports and exports. These data form the basis of the three measures of Brexit

exposure introduced in the following section and are linked to the BSD through a common firm identifier.

One complication is that the measurement of EU trade changes over our sample period. Prior to 2021, EU trade is recorded through Intrastat, while from January 2021 onward for exports and 2022 for imports it is recorded through customs declarations; non-EU trade is observed through customs declarations throughout. The change in reporting regime generates a modest upward shift in recorded trade around the introduction of the TCA. This does not affect the construction of our Brexit exposure measures, which are fixed using pre-Brexit trade shares, but may mechanically affect realised trade outcomes used in our first-stage analysis. To ensure comparability across reporting regimes, we follow Freeman et al., 2025 and impose a common minimum transaction value of £2,500 and restrict the sample throughout to firms exceeding the pre-2021 Intrastat reporting thresholds of £250,000 in annual EU exports and £1.5 million in annual EU imports.

# 5 Empirical Strategy

Our dual empirical strategies use granular administrative data to estimate how region- and firm-level exposure to Brexit affects worker outcomes, capturing broader local labour-market equilibrium effects and direct firm-level responses, respectively. Taken together, the regional estimates capture differences in outcomes between local labour markets, while the firm-level estimates use within-region variation to identify the firm-level adjustments underlying these regional effects.[9] We begin by explaining how our firm-level treatments are constructed from underlying administrative trade data, before showing how these exposures are aggregated to the regional level and discussing the resulting sample restrictions. We then set out the event-study specifications in detail, clarify the parameters identified by each design, and state the assumptions required for identification.

[9] Appendix F describes how the regional- and firm-level specifications are related.

## 5.1 Three Measures of Exposure

Grounded in our conceptual framework, we identify three channels through which exposure to Brexit may affect firms, with corresponding consequences for their workers. We consider each in turn.

**Input exposure**: To capture firms' reliance on the EU as a source of imports, we follow Bernard et al. (2006) and Bloom et al. (2016) and construct an EU "value share", defined as the share of a firm's total imports originating from the EU. For firm $f$ in year $t$, this is given by

$$EXP^{M}_{f,t} = \frac{M^{EU}_{f,t}}{M^{EU}_{f,t} + M^{RoW}_{f,t}}, \tag{16}$$

where $M^{c}_{f,t}$ denotes imports by firm $f$ from partner region $c \in \{EU, RoW\}$ in year $t$. This measure captures the geographical composition of a firm's imports: firms with larger values are more reliant on the EU, rather than the rest of the world, as a source of imported goods.

Because firms may adjust their sourcing patterns in anticipation of Brexit, we fix exposure using information from the pre-referendum period. Specifically, our treatment is the average firm-level EU import share between 2011 and 2015. Averaging across these years reduces the influence of transitory fluctuations in bilateral sourcing patterns and ensures that treatment is not determined by an idiosyncratic pre-referendum year. This construction restricts the analysis to firms with an established importing relationship during the pre-period, with identifying variation arising from differences in the geographical composition of their imports prior to Brexit.

Importantly, $EXP^{M}_{f,t}$ captures reliance on the EU *conditional on importing*; it does not measure the overall importance of imports to the firm. Two firms can therefore have the same EU import share while differing substantially in their dependence on imported goods.

An alternative treatment, as in Freeman et al. (2025), would measure EU imports as a

share of total costs. However, information on input costs is not available in the version of the TiG data that can be linked to ASHE. We conduct two validation exercises to assess how closely our treatment is related to this alternative. First, we compare our treatment with a proxy that measures EU imports as a share of firm revenue. At the firm level, the correlation is 0.82. Second, for a small sample of firms observed in the Annual Business Survey, we can measure EU imports as a share of total costs; in this case, the correlation is 0.55.

**Export Exposure**: We construct our second exposure measure analogously to input exposure but using exports instead of imports. Our primary treatment captures firms' reliance on the EU as an export market, defined as the share of total exports directed to EU countries:

$$EXP^X_{f,t} = \frac{X^{EU}_{f,t}}{X^{EU}_{f,t} + X^{RoW}_{f,t}}, \tag{17}$$

where $X^c_{f,t}$ denotes exports by firm $f$ to destination region $c$ in year $t$. As above, we average this measure over 2011–2015. Like the input exposure measure, export exposure captures the geographical composition of trade conditional on the firm exporting. While EU exports as a share of total revenue are observed for all firms, we prefer our exposure measure for comparability across the import and export margins. The two measures have a correlation of 0.82.

**Import Competition**: Our final treatment captures firms' exposure to import competition from EU firms exporting to UK markets. Unlike our input exposure and export exposure treatments, measuring competition requires us to define the domestic market in which firms operate. We define this at the four-digit industry level – the finest level available in our data –, $s$, assigning each firm to a unique and time-invariant industry.[10] This implicitly assumes that four-digit industries provide a reasonable approximation to the relevant domestic product market.

[10]We use the 2007 UK Standard Industrial Classification, which contains 615 four-digit industries, and assume that each firm operates in a single domestic industry.

We first construct firm-level domestic sales, $R_{f,t}^{Dom}$, as total firm revenue, $R_{f,t}$, net of exports, $X_{f,t}$. We then use the underlying trade data to aggregate product-level imports from the EU and the rest of the world to the corresponding four-digit industry, yielding $M_{s,t}^{EU}$ and $M_{s,t}^{RoW}$. This mapping assumes that imported products are assigned to the domestic industries with which they compete. Domestic market size is consequently defined as domestic sales plus imports:

$$DOM_{s,t} = \sum_{f \in s} R_{f,t}^{Dom} + M_{s,t}^{EU} + M_{s,t}^{RoW}. \tag{18}$$

Our measure of exposure to import competition is then the EU import penetration of this market,

$$EXP_{s,t}^{D} = \frac{M_{s,t}^{EU}}{DOM_{s,t}}. \tag{19}$$

Higher values identify domestic industries facing greater pre-Brexit competition from EU imports and, correspondingly, greater potential protection as Brexit raises barriers to EU trade. This interpretation assumes that greater pre-Brexit EU import penetration translates into a larger relaxation of foreign competitive pressure following Brexit. As with our other treatments, we average exposure over 2011–2015 to fix the measure prior to the referendum.

## 5.2 Regional Treatments

To analyse the effects of Brexit across places, we exploit variation in exposure across travel-to-work areas (TTWAs), the ONS's official approximation of local labour markets, which partition England, Scotland, Wales and Northern Ireland into 228 distinct regions.[11] Although treatment varies at the regional level, we estimate the regressions using micro-level outcomes: hourly wages for individual workers observed in ASHE and employment for firms observed in the BSD. We retain outcomes at the micro level to keep the outcome

[11] Examples include London, Manchester, Edinburgh, Swansea and Belfast.

definitions and estimation samples consistent across the regional- and firm-level analyses.[12] We use the BSD rather than ASHE for employment because it provides substantially broader coverage of firms.

In our preferred specification, we aggregate our firm- and industry-level treatments to the region level using weights that reflect the economic importance of each exposure within the local economy. Regional input exposure is the import-weighted average of firm-level exposure, $EXP^{M}_{r,11\text{–}15} = \sum_{f \in r} \omega^{M}_{fr} EXP^{M}_{f,11\text{–}15}$,[13] while regional export exposure is defined analogously as $EXP^{X}_{r,11\text{–}15} = \sum_{f \in r} \omega^{X}_{fr} EXP^{X}_{f,11\text{–}15}$.[14] Finally, regional import competition exposure is the domestic sales-weighted average of industry-level exposure to EU import competition, $EXP^{D}_{r,11\text{–}15} = \sum_{s} \omega^{R}_{sr} EXP^{D}_{s,11\text{–}15}$.[15] Therefore, the resulting measures capture the extent to which local economic activity is concentrated in firms or industries exposed to each Brexit channel. In all cases, treatments are standardised to have mean zero and variance one.

We then estimate continuous-treatment event-study specifications that compare the differential evolution of labour-market outcomes across regions with higher versus lower pre-Brexit exposure to EU trade along each of our three channels. Our regional analysis asks whether workers and firms located in regions with greater pre-Brexit exposure to each trade-disintegration channel experienced different wage and employment trajectories following the referendum. We lean on the BSD for our employment outcomes owing to its coverage of the near universe of firms, while ASHE is restricted to a 1% sample. We exploit variation in exposure across local labour markets, estimating wage responses using individual-level observations from ASHE and employment responses using firm-level observations from the BSD. Both specifications include region and year fixed effects, absorbing time-invariant differences across local labour markets and common aggregate shocks. We jointly include exposure to each of the three Brexit channels, allowing their

[12] Because firm employment is observed only while a firm is active, our baseline estimates do not directly capture extensive-margin adjustment through firm entry and exit. Appendix Figure A.9 examines the importance of these margins.

[13] $\omega^{M}_{fr}$ denotes firm $f$'s share of total imports in region $r$.

[14] $\omega^{X}_{fr}$ denotes firm $f$'s share of total exports in region $r$.

[15] $\omega^{R}_{sr}$ denotes industry $s$'s share of total sales in region $r$.

effects to vary flexibly over time.

For wages, we estimate:

$$\log w_{irt} = \gamma_r + \gamma_t + \sum_{T \in \{M,X,D\}} \sum_{\substack{k=2011 \\ k \neq 2015}}^{2024} \beta_k^{T,w} EXP_{r,11-15}^{T} \times I_{t=k} + \sum_{\substack{k=2011 \\ k \neq 2015}}^{2024} \delta_k^{w\prime} Z_r \times I_{t=k} + \varepsilon_{irt}, \tag{20}$$

where $w_{irt}$ denotes the hourly wage of worker $i$ employed in region $r$ in year $t$. For employment, we estimate an analogous specification using firm-level observations:

$$\log E_{frt} = \gamma_r + \gamma_t + \sum_{T \in \{M,X,D\}} \sum_{\substack{k=2011 \\ k \neq 2015}}^{2024} \beta_k^{T,E} EXP_{r,11-15}^{T} \times I_{t=k} + \sum_{\substack{k=2011 \\ k \neq 2015}}^{2024} \delta_k^{E\prime} Z_r \times I_{t=k} + \varepsilon_{frt}, \tag{21}$$

where $E_{frt}$ denotes employment at firm $f$ in region $r$ and year $t$. In both specifications, $I_{t=k}$ is an indicator for year $k$, and $Z_r$ contains our regional controls for EU migrant shares, sterling depreciation exposure, and COVID-19 exposure. We interact these measures with year indicators to allow their associations with labour-market outcomes to vary flexibly over time. We omit 2015 as the reference year, so each $\beta_k^{T,w}$ and $\beta_k^{T,E}$ captures the differential evolution of wages and employment, respectively, between year $k$ and 2015 associated with greater pre-Brexit regional exposure to channel $T$, conditional on the remaining exposure measures and controls. Standard errors are clustered at the region level.

An important consideration for identification is that several macroeconomic developments between 2015 and 2024 may have differentially affected regions according to their pre-existing economic characteristics. To distinguish the labour-market effects associated with our three trade-disintegration channels from these other developments, our baseline specification accounts for regional differences in exposure to migration shocks, sterling depreciation, and the COVID-19 pandemic.

First, Brexit altered patterns of international migration by restricting the movement of

EU workers into the UK, contributing to a decline in net EU migration and potentially affecting regional labour supply. These adjustments may have been particularly important in regions with greater initial reliance on EU workers, whose exposure to our trade channels may also differ systematically.[16] We capture this heterogeneity using regional EU migrant shares, with their construction detailed in Appendix E.5.

Second, the referendum precipitated a substantial depreciation of sterling, altering the relative prices of internationally traded goods. By improving the price competitiveness of UK exports and raising the domestic cost of imports, exchange-rate movements may have affected regional wages and employment independently of the uncertainty and non-tariff barriers associated with Brexit. While year fixed effects absorb the common component of sterling depreciation, exchange-rate movements varied considerably across foreign currencies. Regions with different trade compositions may therefore have experienced different effective changes in exchange rates, potentially confounding the estimated effects of our exposure measures. To account for this variation, we construct regional exposure to sterling depreciation using granular administrative trade data, as outlined in Appendix E.6.[17]

Finally, the implementation of the TCA coincided with the COVID-19 pandemic, which disrupted international trade and domestic economic activity. The pandemic also affected labour-market outcomes through government support programmes, particularly the Coronavirus Job Retention Scheme (CJRS), which subsidised the wages of furloughed workers and helped firms retain employees during periods of reduced activity. Consequently, observed wage and employment adjustments may partly reflect regional differences in the severity of pandemic-related disruptions and the extent of government labour-market support. We measure regional COVID-19 exposure using the weighted share of workers furloughed under the CJRS in the 2020 ASHE. Further details on the construction of this measure are provided in Appendix E.7.

Identification follows the continuous-treatment difference-in-differences framework of Call-

[16] The decline in EU migration was offset by an influx of non-EU migrants. See Appendix Figure A.4 for details.

[17] Appendix Figure A.5 illustrates sterling's depreciation against the euro and US dollar around the referendum.

away et al. (2026). We require that, conditional on fixed effects, the other Brexit exposure channels, and the interacted regional controls, regions with different treatment intensities would have followed parallel counterfactual wage and employment trends absent the trade-disintegration shock. Interpreting the coefficients as causal responses to greater exposure requires additional restrictions: conditional on these covariates, exposure intensity must not select regions with systematically different treatment gains, and the conditional mean response must be adequately represented by the specified linear, additive function of the three exposure measures. Under these assumptions, $\beta_k^{T,w}$ and $\beta_k^{T,E}$ trace the differential wage and employment responses, respectively, to greater pre-Brexit regional exposure to channel $T$, relative to 2015. The 2011–2014 coefficients provide a diagnostic for differential pre-trends.

As in Freeman et al. (2025), we index treatment to 2015 rather than, for example, the introduction of the TCA in 2021. Doing so allows us to exploit the plausibly unanticipated nature of the Leave victory: polling favoured Remain throughout much of the campaign period (Bloom et al., 2018), limiting the scope for firms and workers to adjust in advance of the referendum result. Indexing exposure to the final pre-referendum year therefore provides a cleaner benchmark from which to trace the labour-market effects of the subsequent trade disintegration shock.

## 5.3 Firm-Level Treatments

To explore the mechanisms underlying the regional labour-market effects of Brexit, we exploit variation in firms' pre-referendum exposure to EU trade through two channels: input and export exposure. We use these treatments in separate firm- and worker-level event-study specifications, comparing firms according to their reliance on the EU as a source of imports and an export destination, respectively. We exclude the import competition channel, as exposure to import competition is defined at the industry level rather than the individual firm level.

We estimate a continuous-treatment event-study specification analogous to equation (20),

replacing regional exposures with their firm-level counterparts. We include firm fixed effects alongside region-by-year and industry-by-year fixed effects, allowing us to compare employment trajectories across firms with different pre-Brexit exposure while absorbing local and industry-specific shocks. As before, we control for sterling depreciation and COVID-19 exposure, each interacted with year indicators.[18] Specifically, we estimate:

$$\log E_{ft} = \gamma_f + \gamma_{rt} + \gamma_{st} + \sum_{T \in \{M,X\}} \sum_{\substack{k=2011 \\ k \neq 2015}}^{2024} \beta_k^T EXP_{f,11-15}^T \times I_{t=k} + \sum_{\substack{k=2011 \\ k \neq 2015}}^{2024} \delta_k' Z_f \times I_{t=k} + \varepsilon_{ft}, \tag{22}$$

As in the regional analysis, identification requires conditional parallel trends: absent Brexit, firms with different pre-referendum exposure would have followed parallel employment trajectories, conditional on the fixed effects and controls. Under this assumption, the coefficients $\beta_k^T$ identify the differential employment response to Brexit associated with greater exposure to channel $T$, relative to 2015.

We next examine whether workers employed at firms with greater pre-referendum exposure to Brexit experienced different wage growth from those at less exposed firms. We use linked employer-employee data from ASHE, with log hourly wages measured at the individual level as our outcome.

We estimate a specification analogous to the firm-level employment regression, retaining the same fixed effects and controls but additionally including individual fixed effects. These allow us to examine wage changes within workers over time, absorbing persistent

[18] We omit EU migrant shares from this analysis since they are calculated at the regional level and are perfectly collinear with region-by-year fixed effects.

differences in individual earnings. Specifically, we estimate:

$$\begin{aligned}\log w_{ift} =& \alpha_i + \gamma_f + \gamma_{r(f)t} + \gamma_{s(f)t} \\ &+ \sum_{T\in\{M,X\}} \sum_{\substack{k=2011 \\ k\neq 2015}}^{2024} \beta_k^T EXP^T_{f(i,2015),11\text{–}15} \times I_{t=k} \\ &+ \sum_{\substack{k=2011 \\ k\neq 2015}}^{2024} \delta_k' Z_{f(i,2015)} \times I_{t=k} + \varepsilon_{ift},\end{aligned} \tag{23}$$

where $EXP^T_{f(i,2015),11-15}$ is the pre-Brexit exposure to channel $T$ of worker $i$'s last pre-Brexit-referendum employer $f(i, 2015)$. This allows us to capture the effects of each channel on workers' wages both within the same job spell as well as wage changes due to endogenous mobility responses. As in the firm-level employment analysis, identification requires conditional parallel trends: absent Brexit, workers at firms with different pre-referendum exposure would have experienced parallel wage trajectories, conditional on the fixed effects and controls.

## 5.4 Industry-Level Import Competition

Finally, we examine the effects of Brexit on import competition from EU producers within UK markets. We aggregate firm-level outcomes and pre-referendum exposure to import competition to the industry level, following the same aggregation approach as in our regional analysis.

We first investigate whether industries with greater exposure to EU import competition experienced changes in the market shares of domestic producers, EU competitors, and rest-of-world competitors. We additionally examine whether protection from EU import competition altered the ownership composition of domestic production by calculating the shares of domestic sales accounted for by UK-owned, EU-owned, and rest-of-world-owned firms. We construct industry-level measures of EU and rest-of-world competition by mapping product-level imports to industries.

For both sets of outcomes, we estimate a continuous-treatment event-study specification

analogous to our preceding regressions and jointly include all three channels of Brexit exposure. We include industry and year fixed effects, with 2015 as the reference year. Specifically, we estimate:

$$Y_{st} = \gamma_s + \gamma_t + \sum_{T \in \{M,X,D\}} \sum_{\substack{k=2011 \\ k \neq 2015}}^{2024} \beta_k^{T,c} EXP_{s,11\text{–}15}^{T} I_{t=k} + \varepsilon_{st}^{c}, \tag{24}$$

where $Y_{st}$ denotes the outcome in industry $s$ and year $t$, while $T$ indexes the three exposure channels: input exposure ($M$), export exposure ($X$), and import competition ($D$). Our primary interest is in the coefficients $\beta_k^{D,c}$, which capture differential changes in market shares across industries with greater pre-referendum exposure to import competition, conditional on the other exposure channels.

Identification requires conditional parallel trends: absent Brexit, industries with different pre-referendum import competition exposure would have parallel changes in market shares, conditional on the fixed effects and other exposure channels.

# 6 Consequences of Brexit for Local Labour Markets

We divide our results into two sections. We begin by examining the regional consequences of Brexit, focusing on wages and employment as outcomes and distinguishing between our three channels. We then use these coefficients to calculate a back-of-the-envelope earnings effect of Brexit in terms of workers' total labour income. In the second section, we investigate the mechanisms underlying these regional results.

Figure 3 summarises our main regional estimates. The left-hand column (panels a–c) reports the effects on real hourly wages, and the right-hand column (panels d–f) reports the effects on employment. Within each column, the rows correspond to the input exposure, export exposure and import competition channels, respectively.

## 6.1 Wages

Beginning with the input exposure channel in Figure 3, panel a, we observe very little wage adjustment over the 2011–2015 period, lending credibility to our identifying assumption. Following the Brexit referendum in 2016, however, we observe an immediate decline in real wages that reaches approximately 3.9% by 2017.[19] This initial decline is transitory, with wages recovering almost fully by the 2019–2020 period.

Following the introduction of the Trade and Cooperation Agreement (TCA) in 2020–2021, we observe a second, "double-dip" decline in wages. This decline is particularly pronounced, with wages falling rapidly to approximately 4.9% below their 2015 benchmark by 2023. Although there are signs of a modest recovery in 2024, the overall effect of the input exposure channel over this post-TCA period amounts to a 3.9% reduction in workers' hourly wages across regions. These effects persist after controlling for industry-by-year fixed effects, indicating that they are not explained by exposed regions' concentration in industries experiencing different national wage trends.

The remaining two channels display quite different patterns. Along the export exposure channel in Figure 3, panel b, wages surprisingly increase modestly between 2021 and 2024, rising by 1.8% on average and reaching 3.0% above their 2015 benchmark by 2024. By contrast, we observe no statistically significant wage effects along the import competition channel in Figure 3, panel c, throughout the period. Wages begin to increase marginally following the introduction of the TCA, reaching at most 2.0% above their baseline level by 2024, but this increase remains statistically insignificant.

Taken together, these three margins of adjustment suggest that the wage effects of economic disintegration in the context of Brexit were primarily realised through the input exposure channel: firms face higher prices for imported intermediate inputs, with direct consequences for workers' wages.

[19] Throughout the paper, coefficients from specifications with outcomes in logs are converted from log points to percentage changes using $100[\exp(\beta) - 1]$.

## 6.2 Employment

We next turn to the effects of Brexit on employment, presented in the right-hand column of Figure 3 (panels d–f). Considering again our three channels, we observe markedly different results compared with wages. Along the input exposure margin (Figure 3, panel d), we find noisily estimated null effects on employment throughout the pre-Brexit period, the subsequent uncertainty period following the referendum, and the period following the implementation of the TCA. Similar patterns emerge along both the export exposure and import competition channels (Figure 3, panels e and f), with no statistically significant employment adjustments observed throughout the period. Taken together, these results suggest that employment adjustments in our sample were negligible and that the burden of adjustment to Brexit borne by workers was primarily along the wage margin.

## 6.3 Overall Wage and Earnings Losses

We approximate an overall effect of Brexit following Autor et al. (2013) by assuming that regions with no exposure to Brexit experienced no changes in labour market outcomes. By averaging our coefficients between 2021–2024, scaling the wage results from Figure 3 by average regional exposure, and averaging the effects across regions (weighted by regional employment), we estimate that the average worker experienced a reduction of approximately 2.0% in hourly labour income as a consequence of Brexit. Given a median hourly wage in the UK of £20.88 in 2024, this implies a loss of approximately £0.41 over the 2021–2024 period. Applied to median annual earnings of £32,890 in 2024, the same reduction corresponds to approximately £658 per year.

As shown in Figure A.8, hourly wage effects vary across regions. Dividing regions into the South of England, which covers London and the lower part of England, other areas of the UK, including Scotland, Wales, northern England, and most of the Midlands, we find that Brexit increased hourly wage inequality by 0.47pp (5.9%).

# 7 Mechanisms and Firm-level Evidence

Our regional results point to declining wages through the input exposure channel and null employment effects. However, what drives these results within regions? Do wages decline across all firms, or are these effects concentrated among firms exposed to Brexit? Likewise, were there no employment effects of Brexit, or do the results mask an underlying reallocation of workers between firms? To answer these questions, we leverage our granular administrative microdata to explore how labour market outcomes responded to firm-specific exposure to Brexit. Consequently, in this section, we focus exclusively on the input exposure and export exposure channels.

## 7.1 Firm-level Wage Setting Power

Beginning with the wage effects in Figure 4, panel a, we first examine the input exposure channel. A similar pattern emerges to that observed at the regional level. Wages remain approximately flat during the pre-Brexit period, before declining by approximately 2.0% by 2018 and subsequently recovering to their pre-Brexit levels just before the TCA was signed in 2020. From 2021 onwards, we observe a substantial decline in wages, reaching approximately 3.7% below their pre-Brexit levels in 2023, before recovering slightly in 2024.

The decline in wages at both the firm and regional levels suggests that wage adjustments within regions were predominantly driven by firms directly exposed to Brexit, rather than less-exposed firms operating in the same regions. This finding suggests that firms possess individual wage-setting power.[20] However, in the post-TCA period, firm-level wage declines are approximately one percentage point smaller than the corresponding regional wage declines, suggesting the presence of negative wage spillovers to domestic firms that are not directly exposed to Brexit.

Turning to the export exposure margin in Figure 4, panel b, we observe a similar corre-

[20] In a perfectly competitive labour market, wages would be determined entirely at the market level, implying that firm-level exposure to Brexit would have no independent effect on wages once market-level conditions are accounted for.

spondence between the regional and firm-level results. Prior to the Brexit shock, wages remain unchanged at both levels, a pattern that continues throughout the uncertainty period following the referendum. In the post-TCA period, however, wages increase modestly, reaching a maximum of 1.7% above their pre-Brexit levels in 2024.[21]

## 7.2 Firm-Level Employment Declines

We next examine employment adjustment at the firm level, where the effects of Brexit differ substantially from those observed across local labour markets. Figure 5, panel a, shows that firms more exposed to EU input exposure experienced significant employment contractions following the Brexit referendum, with little evidence of differential trends beforehand. By 2020, firms with a one-standard-deviation higher exposure to the input exposure channel experienced a 3.9% reduction in firm employment relative to 2015. These losses deepened following the implementation of the TCA, reaching 6.8% by 2024. In contrast, we find little evidence of employment adjustment along the export exposure margin. Figure 5, panel b, shows no statistically significant employment responses among firms more exposed to greater EU export exposure, either following the referendum or after the implementation of the TCA. This finding is consistent with the regional results, suggesting that employment adjustment was concentrated along the input exposure margin.

## 7.3 Worker Reallocation to Less Productive Firms

The divergence between the firm-level and regional results along the input exposure margin reveals an important dimension of labour market adjustment to Brexit. Despite substantial employment losses among firms exposed to EU input exposure, we find little evidence of corresponding employment declines at the regional level. Given the consistent underlying sample and aggregation of exposure measures across the two levels of analysis (see Appendix F for the relationship between the regional and firm-level specifications),

[21] We find no corresponding adjustment in weekly hours, suggesting that firms did not respond to either channel by adjusting labour input along the intensive margin (Appendix Figure A.6).

these findings are consistent with substantial reallocation of employment across firms within local labour markets. In particular, employment contractions among more-exposed firms appear to have been offset by relatively stronger employment outcomes elsewhere in the region. We subsequently examine individual worker transitions to investigate whether these changes reflect movements of workers between employers.

To examine the nature of this reallocation, we begin by comparing the characteristics of firms with different levels of EU input exposure. Table 1 shows that more-exposed firms are, on average, larger in terms of both employment and sales, and exhibit higher sales per worker, our proxy for labour productivity. Combined with the employment responses documented above, these differences raise the possibility that Brexit induced a reallocation of employment away from more productive firms towards less productive firms within local labour markets.

We test this formally by examining year-on-year worker transitions as outcomes in equation (23). For simplicity, we replace our event-study specification with a two-period difference-in-differences approach, where the pre-period is defined as 2011–2015 and the post-period as 2016 onwards. In Table 2, we show that workers in Brexit-exposed firms do not experience a higher probability of transitioning into non-employment, consistent with our model of inelastic labour supply, or of moving to an employer in a different region, supporting our assumption of regional immobility. However, workers in firms exposed to EU input exposure are more likely to make firm-to-firm transitions.

We quantify the nature of these transitions by examining the characteristics of the destination firms. We begin by considering changes in firm size, measured by employment. We define two binary variables: one that takes a value of one if a worker transitions to a larger firm, and another that takes a value of one if a worker transitions to a smaller firm. Both variables are defined to be zero if the worker does not make a transition in that period. Finally, we consider the net probability of moving to a larger rather than a smaller firm, defined as the difference between these two variables. Workers exposed along the input exposure margin are marginally less likely to move to larger firms and considerably

more likely to move to smaller firms, leading to a 1.0 percentage point decline in the net probability of moving to a larger rather than a smaller firm. The same relationship holds when we define these variables in terms of firm revenue or sales per worker. Together, these findings provide direct evidence of worker movements contributing to the firm-level employment adjustments, reinforcing the conclusion that Brexit induced a reallocation of labour away from relatively productive firms towards less productive firms within local labour markets.

## 7.4 Revenue Persistence Among Exporters

We next examine firm-level revenue responses to rationalise the differing wage and employment effects we observe across the supply chain and export-opportunities margins. A contraction in firm sales may induce firms to reduce employment or wages, whereas firms that maintain their revenue face less pressure to adjust along either margin. We therefore examine how total firm revenue responds to Brexit across the two exposure channels.

Beginning with the supply chain margin, Figure 6, Panel A, shows that firms more exposed to EU supply chain disruption experienced substantial reductions in sales following the Brexit referendum, with little evidence of differential trends beforehand. By 2020, a one-standard-deviation increase in supply chain exposure was associated with a 6% reduction in firm revenue relative to 2015. Sales continued to decline following the implementation of the TCA, with a particularly pronounced contraction between 2022 and 2023, when revenue fell by a further eighteen percentage points, an effect mirrored in domestic sales in panel C. This pattern is consistent with the gradual implementation of Brexit-related import barriers, which progressively increased the costs of trading with the EU, and echos Bakker et al. (2022), who find that the prices of final good imports increased significantly after the TCA. Revenue losses along the supply chain margin intensified as trade frictions accumulated, which aligns with the earlier employment and wage results.

In contrast, we find little evidence of revenue adjustment along the export market access margin. Figure 6, Panel B, shows no statistically significant reductions in revenue among

firms more exposed to EU export barriers, either during the uncertainty period following the referendum or after implementation of the TCA. This aligns with the earlier null effects for wages and employment. Despite reduced access to EU markets, more-exposed firms appear to have preserved their overall sales. This effect is more pronounced when we consider domestic sales in panel D: between 2020 and 2021 firms experience a 5% increase in sales, although this is only marginally significant. In line, we find null effects on firm activity or probability of trading, confirming that our results are likely not driven by selective firm-survival (see Figure A.9).

We subject our sales results to five additional robustness checks, finding that our results are robust throughout (see Figures (A.10) and (A.11)). First, we control for pre-referendum exposure to North American trade to account for potential confounding effects of the US–China trade war, which disrupted global trade flows from 2018 onwards. Second, we use input–output matrices to account for indirect exposure to Brexit through domestic supply chains. For example, a UK car manufacturer may purchase components from a domestic parts supplier that relies on EU imports, exposing the manufacturer indirectly to Brexit-related trade frictions. Details of this construction are provided in Appendix E. Third, we refine our supply chain treatment to capture EU exposure through intermediate imports rather than all imported goods, distinguishing reliance on imported production inputs from imports of final goods for resale. Fourth, we restrict the sample to UK-owned firms to reduce the influence of multinational firms' ability to reallocate production and employment across borders. Finally, we restrict the sample to firms operating in 2020 to assess whether pre-TCA adjustments reflect changes in firm composition through entry and exit, rather than adjustments among continuing firms.

## 7.5 Trade Reallocation away from the EU

To investigate the mechanisms underlying these contrasting revenue responses, we examine how firms adjusted the geographical composition of their international trade following Brexit. In particular, we distinguish between trade with the EU and the rest of the world, allowing us to assess whether firms responded to new trade barriers by substituting to-

wards alternative suppliers and export destinations.

Turning to the export exposure margin, we investigate whether the stability of total firm revenue masks changes in the geographical composition of sales. Figure 8, panels a–c, shows that firms more exposed to EU export barriers experienced substantial reductions in exports to the EU following Brexit. By 2022, a one-standard-deviation higher exposure to EU export markets was associated with a 23.7% decline in EU exports relative to 2015. However, this contraction was accompanied by a significant expansion of exports to the rest of the world, which increased by 23.4% over the same period. These findings suggest that firms responded to reduced access to EU markets by redirecting sales towards alternative export destinations.

These findings are consistent with the venting-out mechanism discussed earlier (Almunia et al., 2021), operating in the opposite direction. By reallocating sales towards alternative international and domestic markets, firms appear to have mitigated the effects of reduced EU market access, helping to explain the limited adjustment in firm revenue, wages and employment along the export exposure margin.

Turning to the input exposure margin, Figure 8, panels d–f, reveals a similar pattern of geographical reallocation on the import side. Firms more exposed to EU input exposure reduced their imports from the EU while increasing imports from the rest of the world. These adjustments were relatively modest during the uncertainty period following the referendum but became substantially more pronounced after the implementation of the TCA. By 2024, a one-standard-deviation increase in input exposure was associated with a 41.1% reduction in EU imports and an 18.5% increase in rest-of-world imports, relative to 2015.[22]

Taken together, these findings reveal an asymmetry in firms' responses to Brexit-related trade barriers. Along the export margin, geographical reallocation coincides with stable revenue, wages and employment. Along the input exposure margin, firms also reallocate their imports, particularly following the implementation of the TCA, yet revenue and

[22] Appendix Figure A.12 reports the corresponding placebo regressions for firm-level exports and imports using exposure to non-EU trading partners.

labour market outcomes deteriorate. Geographical reallocation therefore appears more effective at insulating firms from export barriers than from input barriers.[23]

## 7.6 Anatomy of the Export Reallocation

To further understand how firms adjusted to reduced EU market access, we examine changes in their export relationships and product composition, with additional evidence on trading partners, export prices, and product-destination concentration in Appendix Figures A.13, A.14, and A.15. We find substantial restructuring of firms' export networks following Brexit. Firms more exposed to EU export barriers experienced a pronounced decline in the number of EU trading partners, accompanied by an increase in relationships with the rest of the world. This geographical reallocation also occurred within existing product portfolios. In particular, firms became substantially less likely to export their pre-Brexit core products to the EU, while becoming more likely to export these same products to non-EU destinations. In Appendix H we show that declines in EU trade were primarily driven by extensive margin termination of trade agreements, rather than intensive margin reductions in continuing trade relationships or a decreased rate at which new relationships were struck. Export concentration also declined (Appendix Figure A.15), suggesting that adjustment involved both the geographical diversification of trading relationships and changes in the composition of exported products.

We additionally examine whether this reallocation was accompanied by changes in export prices (Appendix Figure A.14). Following implementation of the TCA, more-exposed firms experienced an increase in EU export unit values, while unit values for exports to the rest of the world remained relatively stable. Although unit values may also reflect changes in product composition and quality, these findings provide little evidence that firms expanded into alternative export markets by accepting lower prices. Taken together, the results suggest that firms adjusted to reduced EU market access through substantial

[23] One possible explanation is that exported goods are more substitutable than imported goods, making export reorientation comparatively less costly. Consistent with this interpretation, the trade-weighted average elasticity of substitution is higher for exports than for imports, although the difference is not statistically significant at conventional levels; see Appendix G.

reorganisation of their export activities, without corresponding reductions in non-EU export unit values. This adjustment is consistent with the relative stability of firm revenue, wages and employment along the export exposure margin.

## 7.7 Unpacking Import Competition

The regional results provide little evidence that reduced EU import competition improved labour market outcomes for domestic workers. Why, then, did the protection afforded by Brexit fail to generate these gains? To investigate this question, we return to the industry-level regressions, examining competitive adjustment at the level at which import protection is defined. Specifically, we trace how domestic market shares of UK, EU, and rest-of-world producers evolved before and after Brexit.

Figure 9, panels a–c, shows that Brexit substantially altered the composition of import competition in UK markets. Industries more exposed to EU import competition experienced a pronounced decline in the market share of EU producers following implementation of the TCA. However, this decline did not translate into increased market share for domestic producers. Instead, the reduction in EU competition was offset almost entirely by an expansion in the market share of producers from the rest of the world. Thus, rather than protecting domestic production, Brexit primarily induced a change in the geographical composition of import competition. Importantly, changes in market shares need not imply equivalent changes in sales levels: Appendix Figure A.16, which reports revenue responses for domestic, EU and rest-of-world suppliers, indicates that the declining EU share reflects a contraction in EU market activity rather than perfect substitution towards rest-of-world suppliers.

The pattern persisted within the domestic market as well. Figure 9, panels d–f, shows that EU-owned firms within the UK lost domestic market share after Brexit. But that loss was absorbed primarily by firms under rest-of-world ownership rather than domestically owned firms. Taken together, this evidence suggests that Brexit altered the composition of competition within UK markets without meaningfully benefiting domestic producers,

helping to rationalise the absence of positive wage and employment effects along the import-competition margin.

# 8 Conclusion

How do labour markets adjust when deep economic integration across national borders is upended by the introduction of a comprehensive set of non-tariff barriers? This paper examines this question in the context of Brexit, studying both the period of uncertainty following the 2016 referendum and the subsequent introduction of bilateral non-tariff trade barriers under the TCA, which took effect in 2021.

We develop a novel unified framework designed to capture the principal economic forces through which trade disintegration affects labour markets. On the one hand, domestic producers may benefit from reduced import competition. On the other, trade disintegration can impose costs through diminished access to inputs via international supply chains as well as to export markets. To examine these competing forces, we utilise detailed administrative trade data and linked employer–employee records to apply an exposure event study design comparing regions and firms that are more or less exposed to Brexit-induced trade disintegration.

Across local labour markets, we find that labour market adjustments operate predominantly through reductions in wages rather than employment, leading to a 2.0% real wage loss that was driven primarily by EU input exposure. These wage effects emerge following the uncertainty period and become more pronounced after the implementation of the TCA, with regions exhibiting a one-standard-deviation higher EU input exposure experiencing a relative wage decline of approximately 3.9% between 2015 and 2024.

Turning to export exposure, the adverse consequences of restricted access to EU markets were mitigated by firms reallocating sales away from the European Union towards domestic and rest-of-the-world markets, in a pattern reminiscent of the venting-out mechanism studied by Almunia et al. (2021). We find limited evidence that reduced import competition benefited regions. Instead, pressure from EU producers was largely replaced

by that from the rest of the world, leaving domestic firms with little relief from foreign competitors.

To unpack the mechanisms underlying our regional results, we exploit firm-level variation in exposure within regions using this framework. Mapping firm-level variation to worker outcomes shows that wage losses are concentrated among workers in firms directly exposed to Brexit, consistent with firm-level wage-setting power within regions.

We also find that the absence of regional employment effects masks substantial adjustment across firms, particularly along the input exposure margin. A one-standard-deviation increase in firm-level EU input exposure is associated with a 6.8% decline in employment. Set against the stability of regional employment, this pattern suggests that employment losses at exposed firms were at least partly offset by stronger employment outcomes elsewhere within the same local labour markets. Evidence from worker transitions shows that this was partly driven by workers in productive exposed firms moving to less productive alternatives. The resilience of aggregate employment may therefore conceal an important allocative cost of Brexit, with potentially adverse consequences for aggregate labour productivity.

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# Figures

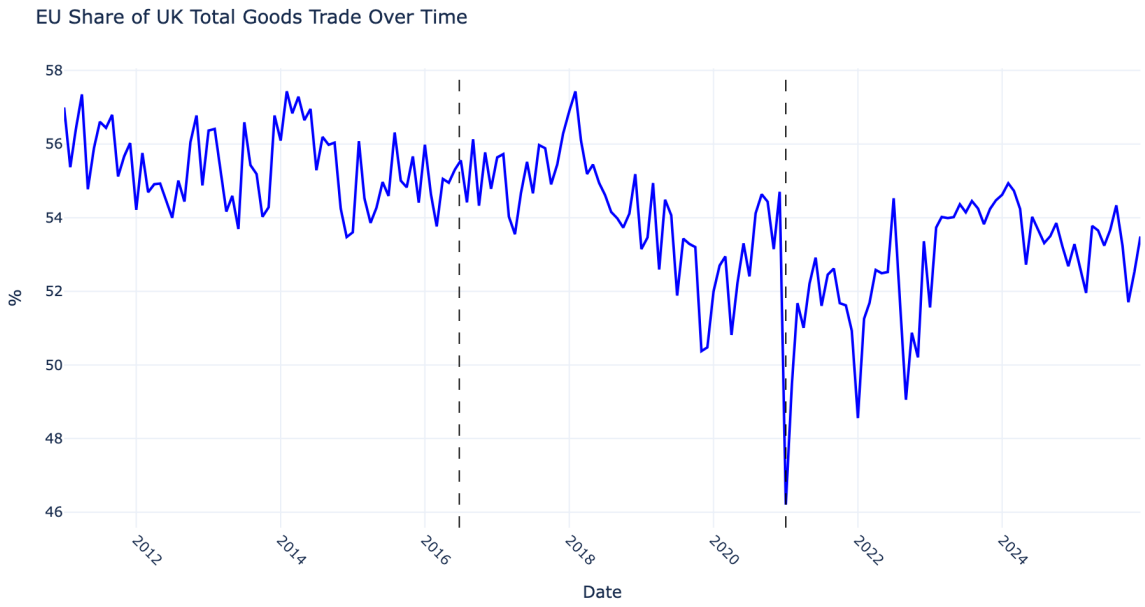



Figure 1: EU Share of UK Goods Trade

*Notes:* The figure shows the EU share of total UK goods trade over time, calculated as the value of UK goods imports from and exports to the EU divided by total UK goods trade with all countries. The dashed vertical lines mark the June 2016 EU referendum and the January 2021 implementation of the Trade and Cooperation Agreement. *Source:* HMRC official trade statistics.

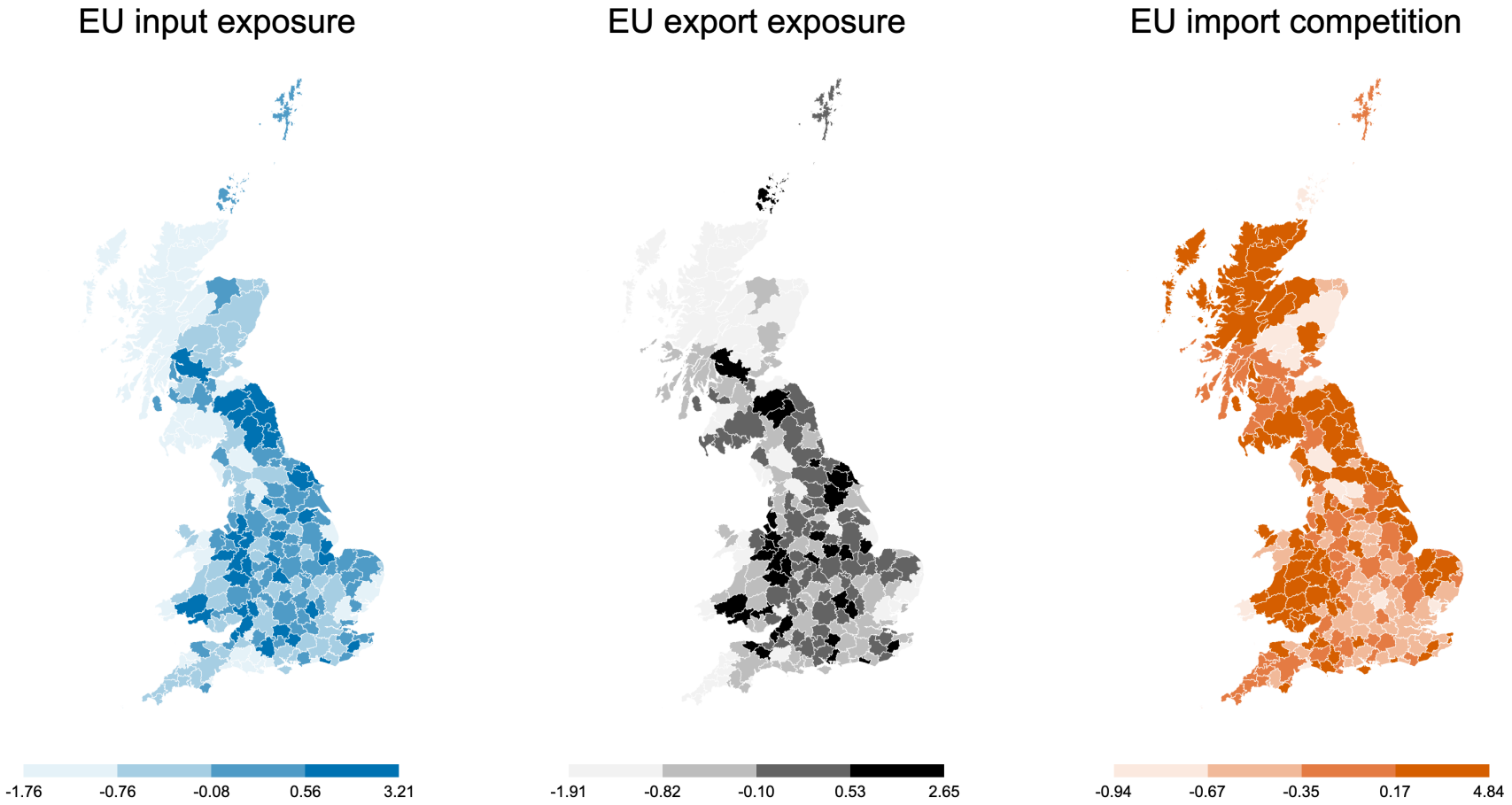
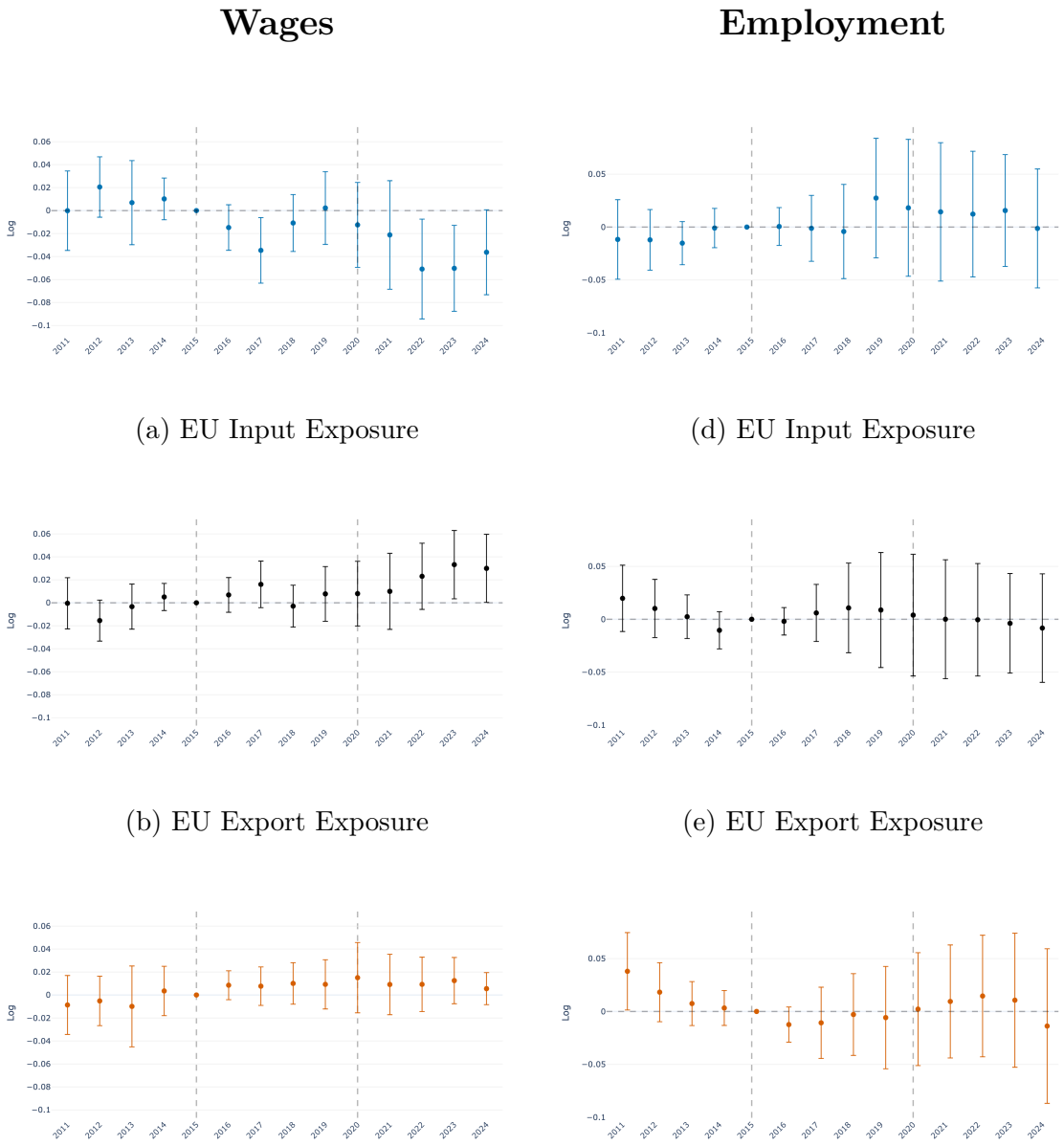



Figure 2: Regional Exposure to Brexit

*Notes:* The maps show standardised regional exposure to Brexit across Travel to Work Areas. From left to right, the panels report exposure EU input exposure, EU export exposure and EU import competition, constructed as described in Section 5.2. Darker shading indicates greater exposure within each channel. *Sources:* BSD and TiG.




(a) EU Input Exposure

(d) EU Input Exposure

(b) EU Export Exposure

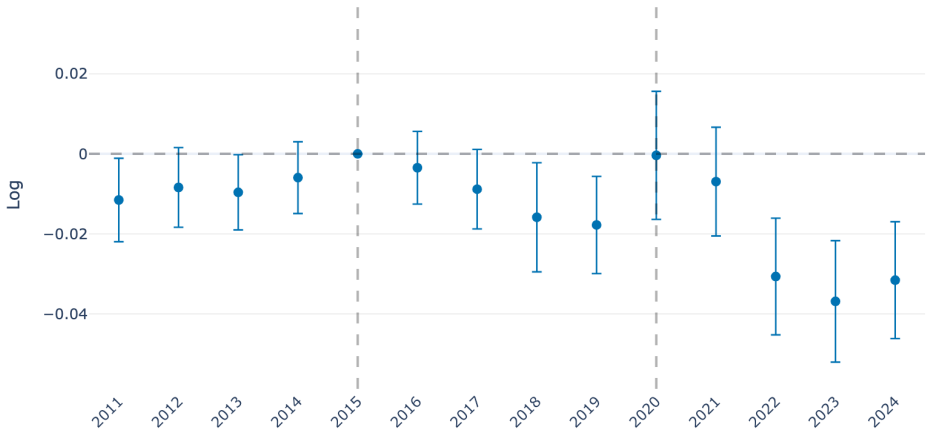
(e) EU Export Exposure

(c) EU Import Competition

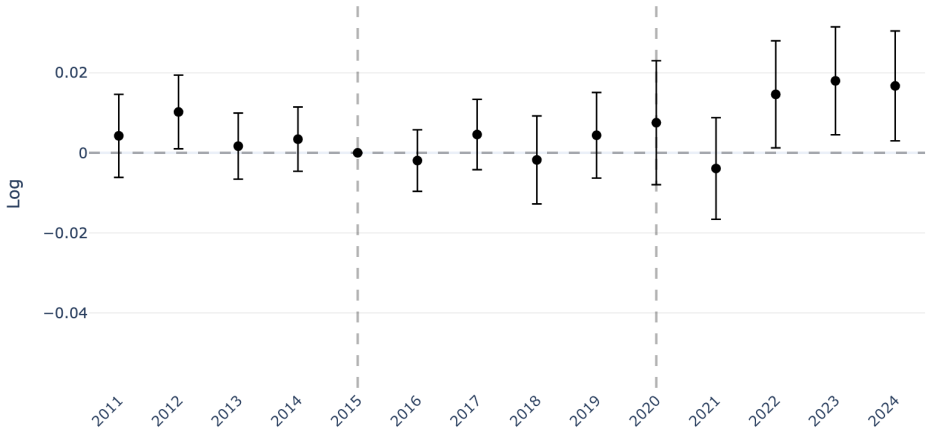
(f) EU Import Competition

Figure 3: Regional Wage and Employment Responses to Brexit Exposure

*Notes:* Panels (a)–(c) show annual responses of log real hourly wages to regional Brexit exposure, while panels (d)–(f) show responses of log employment. The rows distinguish exposure EU input exposure, export exposure and import competition. Coefficients represent the effect of a one-standard-deviation increase in regional exposure relative to 2015; bars show 95 per cent confidence intervals. Estimates follow equations (20) and (21), jointly include all three channels, and control for region and year fixed effects and the time-varying effects of EU migration, sterling depreciation and COVID-19 exposure. Standard errors are clustered by region. *Sources:* ASHE, BSD and TiG.



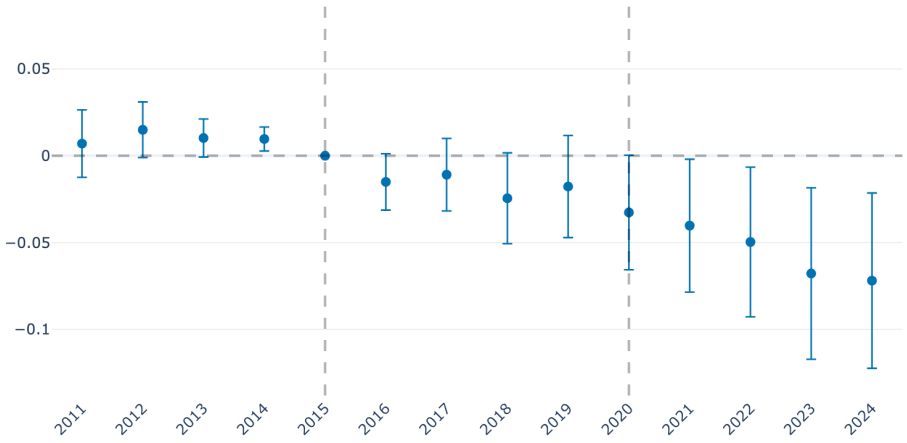

(a) EU Input Exposure



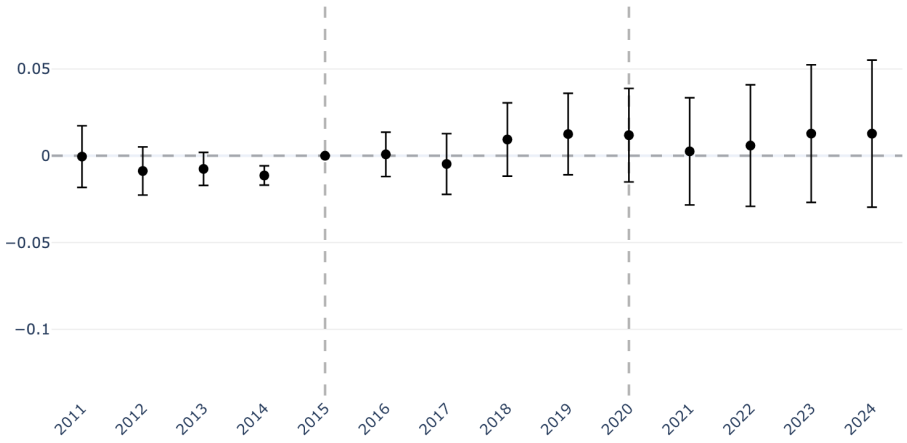

(b) EU Export Exposure

Figure 4: Worker Wage Responses to Firm-Level Brexit Exposure

*Notes:* The figure shows annual responses of workers' log real hourly wages to firm-level Brexit exposure, measured using their last pre-referendum employer. Panels (a) and (b) report exposure EU input exposure and EU export exposure, respectively. Coefficients represent the effect of a one-standard-deviation increase in firm-level exposure relative to 2015; bars show 95 per cent confidence intervals. Estimates follow equation (23), jointly include both channels, and control for worker and firm fixed effects, region-by-year and industry-by-year fixed effects, and the time-varying effects of sterling depreciation and COVID-19 exposure. Standard errors are clustered by firm. *Sources:* ASHE, BSD and TiG.



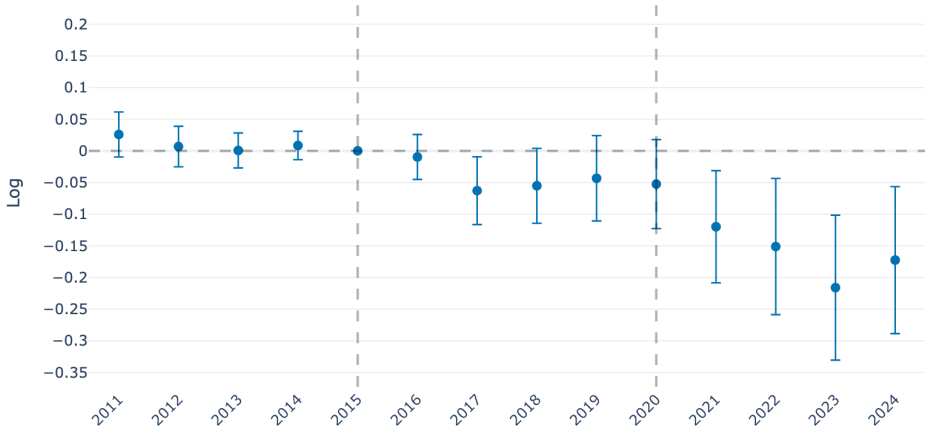

(a) EU Input Exposure



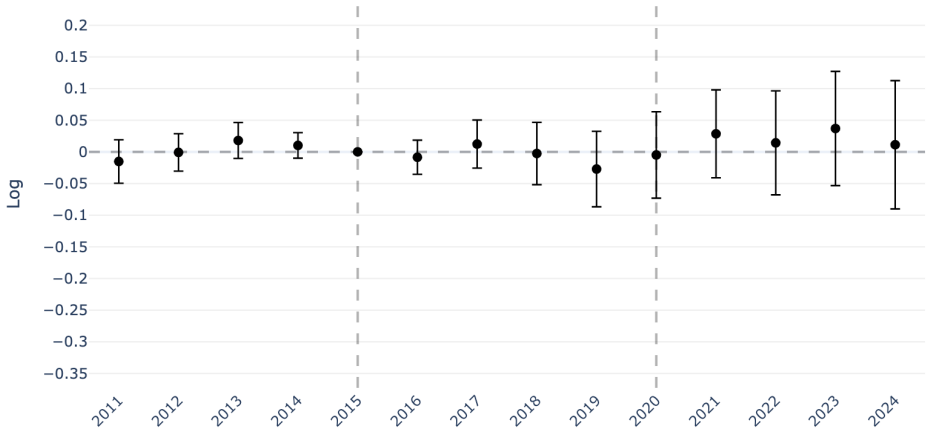

(b) EU Export Exposure

Figure 5: Firm Employment Responses to Firm-Level Brexit Exposure

*Notes:* The figure shows annual responses of log employment to firm-level Brexit exposure. Panels (a) and (b) report the overall responses to EU input exposure and EU export exposure, respectively. Coefficients represent the effect of a one-standard-deviation increase in firm-level exposure relative to 2015; bars show 95 per cent confidence intervals. Estimates follow equation (22), jointly include both channels, and control for firm fixed effects, region-by-year and industry-by-year fixed effects, and the time-varying effects of sterling depreciation and COVID-19 exposure. Standard errors are clustered by firm. *Sources:* BSD and TiG.




(a) Total Sales: EU Input Exposure




(b) Total Sales: EU Export Exposure

Figure 6: Firm Sales Responses to Firm-Level Brexit Exposure

*Notes:* The figure shows annual responses of log total sales to firm-level Brexit exposure. Panels (a) and (b) report exposure EU input exposure and EU export exposure, respectively. Coefficients represent the effect of a one-standard-deviation increase in firm-level exposure relative to 2015; bars show 95 per cent confidence intervals. Estimates follow equation (22), jointly include both channels, and control for firm fixed effects, region-by-year and industry-by-year fixed effects, and the time-varying effects of sterling depreciation and COVID-19 exposure. Standard errors are clustered by firm. *Sources:* BSD and TiG.

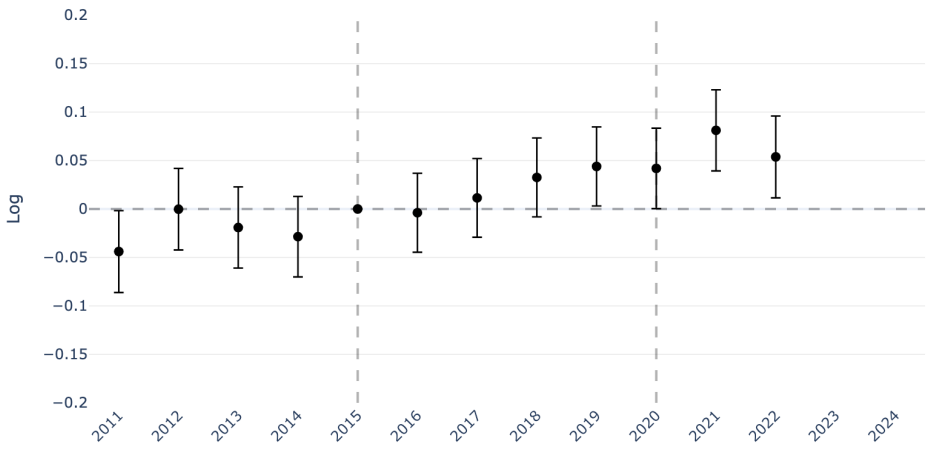
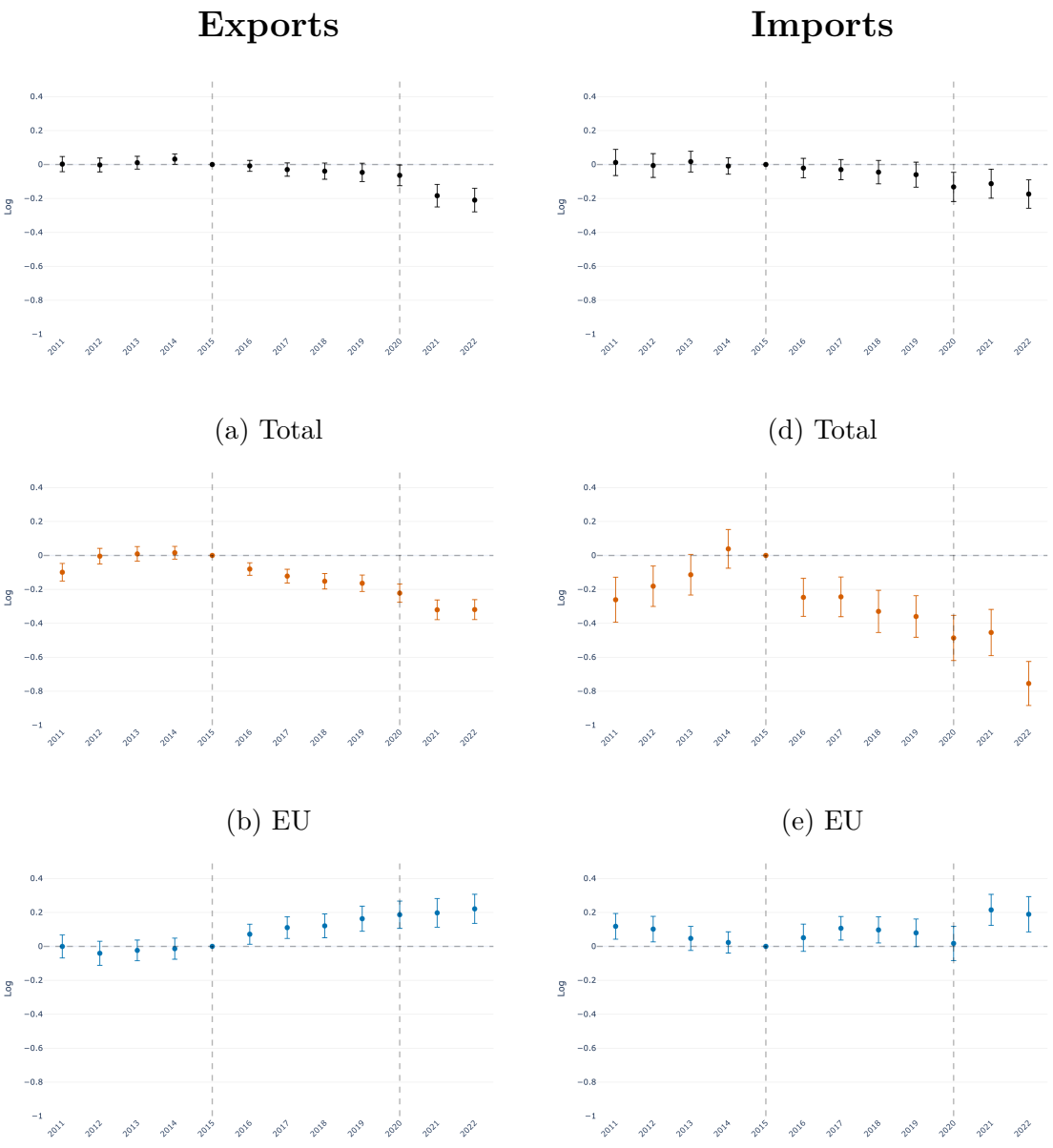



Figure 7: Domestic Sales Response to Firm-Level EU Export Exposure

*Notes:* The figure shows annual responses of log domestic sales to firm-level EU export exposure, conditional on positive exposure to the EU. Coefficients represent the effect of a one-standard-deviation increase in firm-level exposure relative to 2015; bars show 95 per cent confidence intervals. The specification follows equation (22) and controls for firm fixed effects, region-by-year and industry-by-year fixed effects, and the time-varying effects of sterling depreciation and COVID-19 exposure. Standard errors are clustered by firm. Series ends with the trade data in 2022. *Sources:* BSD and TiG.



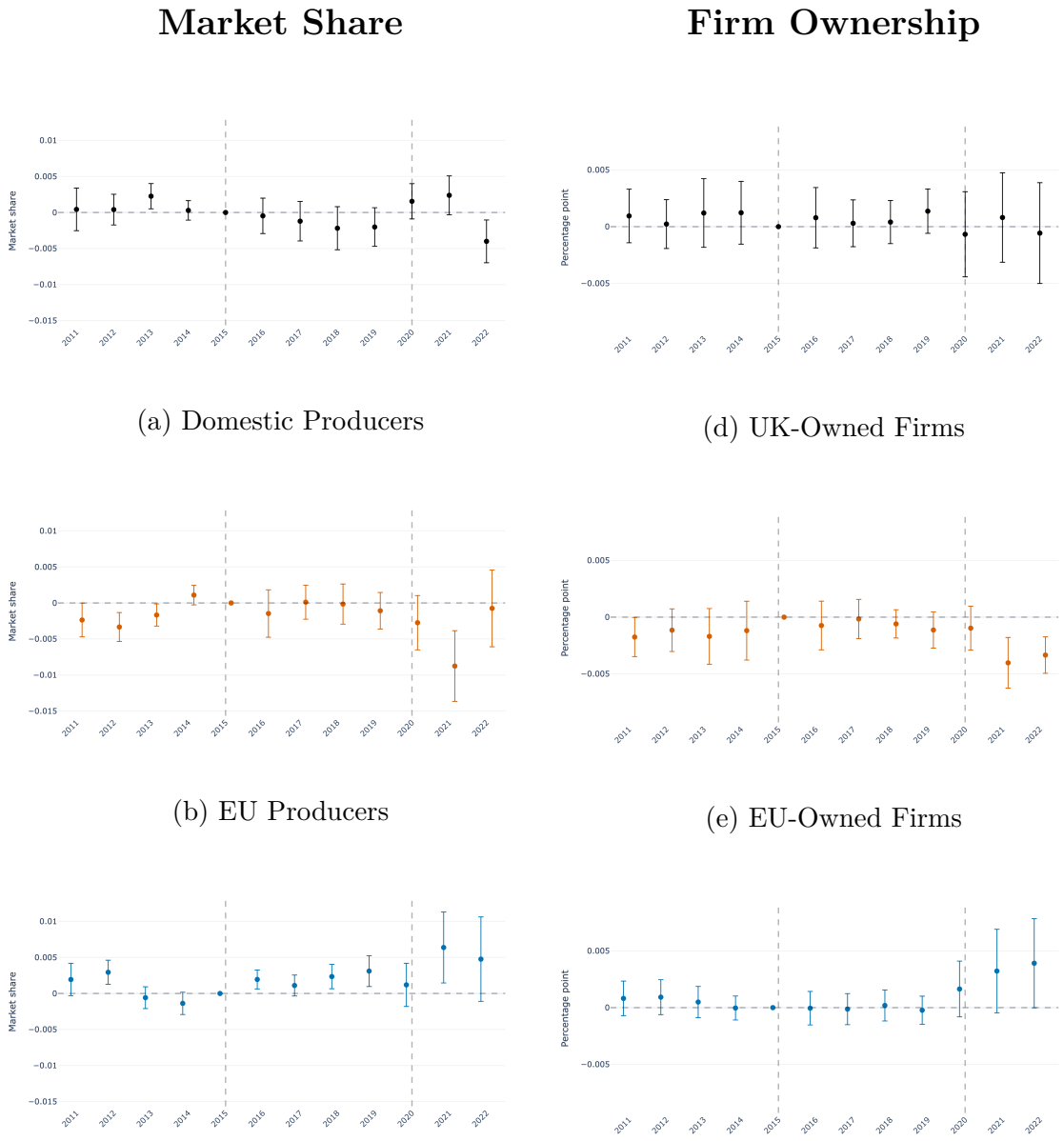

(a) Total (d) Total

(b) EU (e) EU

(c) Rest of the World (f) Rest of the World

Figure 8: Firm-Level Trade Reallocation in Response to Brexit Exposure

*Notes:* The figure shows annual responses of firm-level trade flows to Brexit exposure. Panels (a)–(c) report total, EU and rest-of-world exports in response to EU export exposure, while panels (d)–(f) report total, EU and rest-of-world imports in response to EU input exposure. Outcomes are measured in logs. Coefficients represent the effect of a one-standard-deviation increase in firm-level exposure relative to 2015; bars show 95 per cent confidence intervals. Estimates follow equation (22), jointly include both channels, and control for firm fixed effects, region-by-year and industry-by-year fixed effects, and the time-varying effects of sterling depreciation and COVID-19 exposure. Standard errors are clustered by firm. *Sources:* BSD and TiG.




(a) Domestic Producers

(d) UK-Owned Firms

(b) EU Producers

(e) EU-Owned Firms

(c) Rest-of-World Producers

(f) Rest-of-World-Owned Firms

Figure 9: Industry Market-Share and Ownership Responses to EU Import Competition

*Notes:* The figure shows annual responses to industry-level exposure to EU import competition. Panels (a)–(c) report the domestic, EU and rest-of-world shares of the UK market, while panels (d)–(f) report the shares of domestic sales accounted for by UK-, EU- and rest-of-world-owned firms. Coefficients represent the effect of a one-standard-deviation increase in industry-level exposure relative to 2015; bars show 95 per cent confidence intervals. Estimates follow equation (24), jointly include all three exposure channels, and control for industry and year fixed effects. Standard errors are clustered by industry. *Sources:* BSD and TiG.

# Tables

Table 1: Summary statistics by EU export and import exposure in 2015

| | EU export exposure | | | EU import exposure | | |
|---|---|---|---|---|---|---|
| Variable | Non-EU trader | Low exposure | High exposure | Non-EU trader | Low exposure | High exposure |
| EU export share | 0 | 0.229<br>(0.0032) | 0.802<br>(0.00394) | – | – | – |
| EU import share | – | – | – | 0 | 0.169<br>(0.00385) | 0.804<br>(0.00501) |
| Imports (£000) | 277.8<br>(24.07) | 4482.6<br>(864.5) | 12318<br>(2097) | 371.3<br>(11.98) | 7830.8<br>(1180.4) | 13383.4<br>(1809.7) |
| Exports (£000) | 264<br>(12.84) | 4751.8<br>(386.7) | 6553.5<br>(362.3) | 396.9<br>(15.01) | 10592.4<br>(889.6) | 14984.6<br>(3053.9) |
| Total sales (£000) | 5846.6<br>(554.1) | 25792.1<br>(2718.8) | 41409.4<br>(3351.6) | 5465.4<br>(507.5) | 52312.1<br>(7526.3) | 58947.1<br>(6213.7) |
| Employment | 32.25<br>(1.661) | 110.5<br>(8.58) | 155.6<br>(9.863) | 30.72<br>(0.963) | 214.8<br>(21.43) | 194.1<br>(9.44) |
| Sales per worker | 234.7<br>(33.29) | 296<br>(23.58) | 515.7<br>(68.56) | 207.8<br>(9.624) | 362.8<br>(26.75) | 542<br>(72.86) |
| Capital stock$^{+}$ | 2403.5<br>(1154.8) | 13812.8<br>(4638.8) | 19852.1<br>(10465.1) | 1069.9<br>(49.01) | 32315.2<br>(12755.8) | 30407.6<br>(14987.4) |
| Capital expenditure$^{+}$ | 266.5<br>(83.19) | 1362<br>(481.2) | 1676.8<br>(720.9) | 177.1<br>(12.71) | 3506.5<br>(1419.3) | 3114.6<br>(1171.6) |
| Firm age | 23.38<br>(0.127) | 26.73<br>(0.27) | 28.05<br>(0.261) | 20.68<br>(0.101) | 27.86<br>(0.307) | 28.84<br>(0.307) |
| Observations | 8194 | 1740 | 1741 | 12778 | 1211 | 1217 |

*Notes:* The table compares firm characteristics in 2015 across firms with different EU export exposure (columns 1–3) and EU import exposure (columns 4–6). Non-EU traders trade only with countries outside the EU; firms with positive EU exposure are classified as low or high exposure using the median of the relevant exposure distribution. Cells report means, with standard errors in parentheses. Monetary values are expressed in thousands of pounds, and a dash indicates that a measure is not applicable. Firms are classified separately for exports and imports, so samples and observation counts differ across the two column groups. The superscript + identifies variables obtained from the Annual Respondents Database (ARD). *Sources:* BSD, TiG and ARD.

Table 2: Worker Transition Regressions

| | Input Exposure | | Export Exposure | | Observations |
|---|---|---|---|---|---|
| *Panel A. Worker transitions* | | | | | |
| Employment to non-employment | 0.18 | (0.41) | 0.02 | (0.47) | 359,128 |
| Regional transition | −0.21 | (0.25) | 0.007 | (0.28) | 388,221 |
| Firm-to-firm transition | 0.64*** | (0.25) | 0.14 | (0.30) | 359,128 |
| *Panel B. Reallocation by employment* | | | | | |
| Transition to larger employer | −0.29 | (0.28) | 0.22 | (0.29) | 352,146 |
| Transition to smaller employer | 0.71*** | (0.18) | 0.05 | (0.21) | 352,146 |
| Net transition to larger employer | −1.00*** | (0.35) | 0.27 | (0.36) | 352,146 |
| *Panel C. Reallocation by turnover* | | | | | |
| Transition to higher-turnover firm | −0.27 | (0.28) | 0.00 | (0.29) | 352,146 |
| Transition to lower-turnover firm | 0.67*** | (0.15) | 0.18 | (0.20) | 352,146 |
| Net transition to higher-turnover firm | −0.95*** | (0.32) | −0.18 | (0.38) | 352,146 |
| *Panel D. Reallocation by productivity (sales per worker)* | | | | | |
| Transition to more productive firm | −0.23 | (0.26) | 0.09 | (0.28) | 352,146 |
| Transition to less productive firm | 0.65*** | (0.22) | 0.29 | (0.27) | 352,146 |
| Net transition to more productive firm | −0.88*** | (0.32) | −0.38 | (0.34) | 352,146 |

*Notes:* The table reports two-period difference-in-differences estimates of annual worker transitions, replacing log hourly wages in equation (23) with the indicated outcome. Coefficients represent the effect of a one-standard-deviation increase in exposure assigned using the worker's last pre-referendum employer, comparing 2016–2024 with 2011–2015; both channels are included jointly. Coefficients are scaled by 100 to represent percentage point changes. Panel A reports year-on-year worker transitions, while Panels B–D classify firm-to-firm transitions by differences in employment, turnover and sales per worker between origin and destination firms; net outcomes equal upward minus downward transition probabilities. Estimates include worker and firm fixed effects, region-by-year and industry-by-year fixed effects, and the time-varying effects of sterling depreciation and COVID-19 exposure. Standard errors are clustered by firm. *Sources:* ASHE, BSD and TiG. $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.10$.

# A Appendix Figures

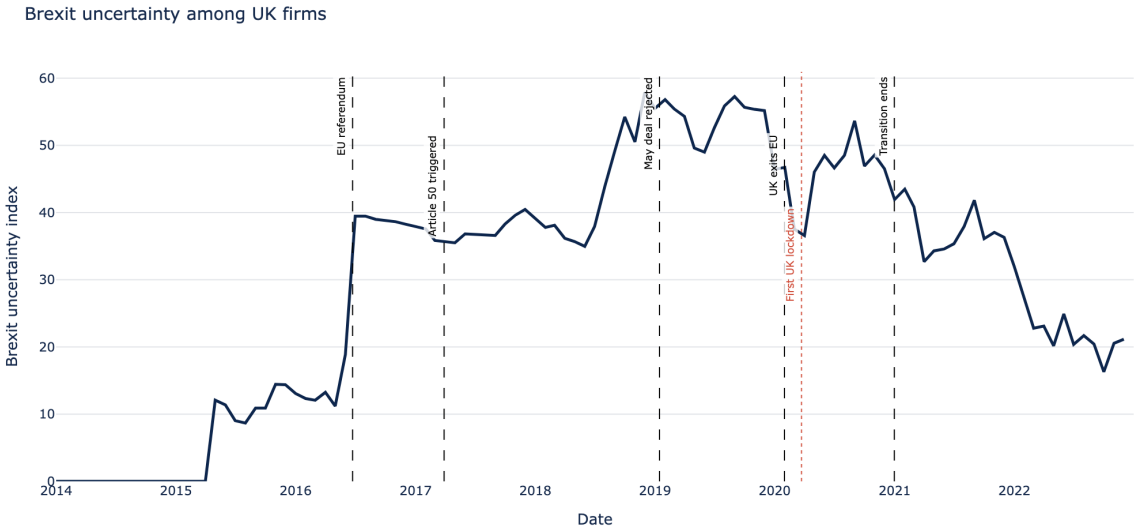
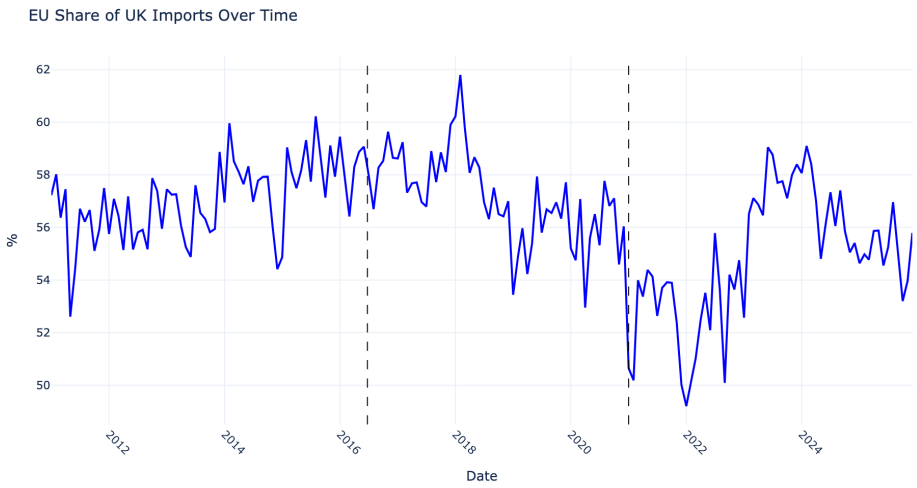
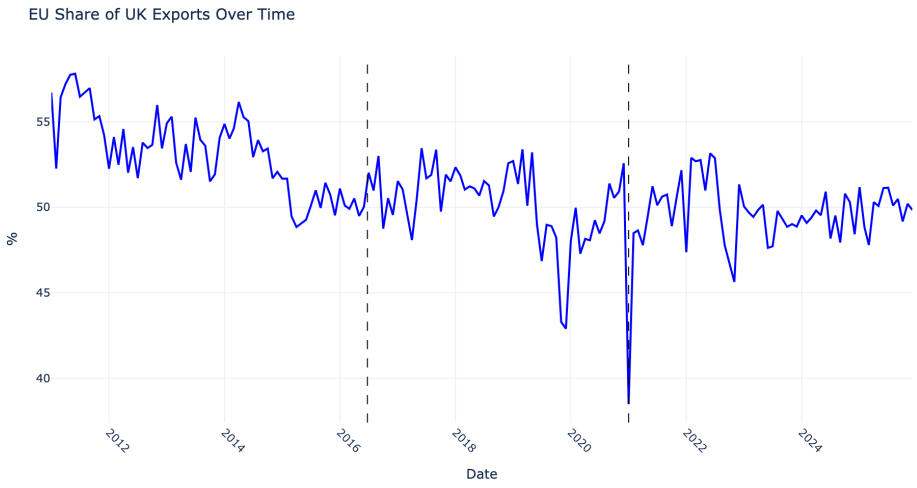



Figure A.1: Brexit-Related Business Uncertainty

*Notes:* The figure shows the monthly Brexit Uncertainty Index from January 2014 to December 2022, measured as the weighted percentage of firms identifying Brexit as one of their three greatest sources of uncertainty. Values between May 2015 and August 2016 are imputed using betting-market odds, while earlier values are set to zero. The vertical lines mark key Brexit events and the first UK COVID-19 lockdown. *Source:* Bank of England Decision Maker Panel.



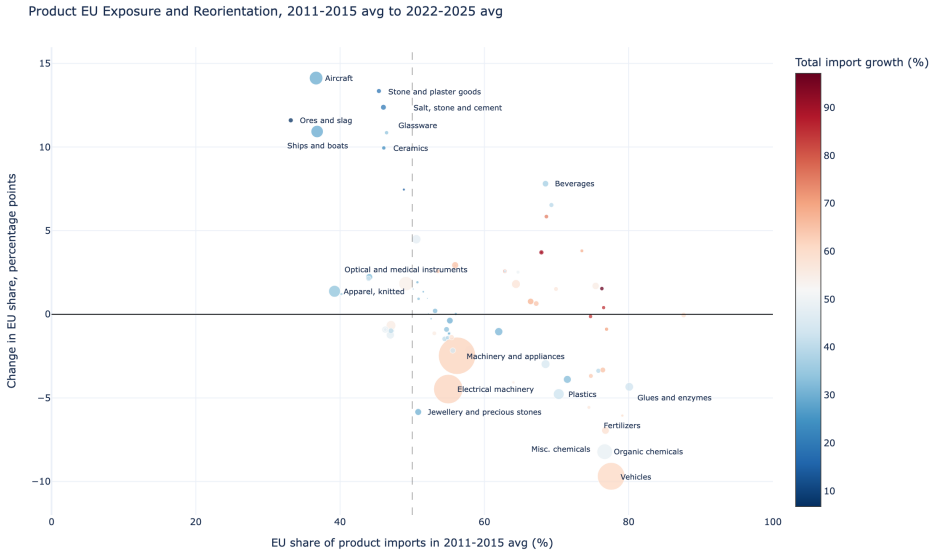

**(a) Imports**



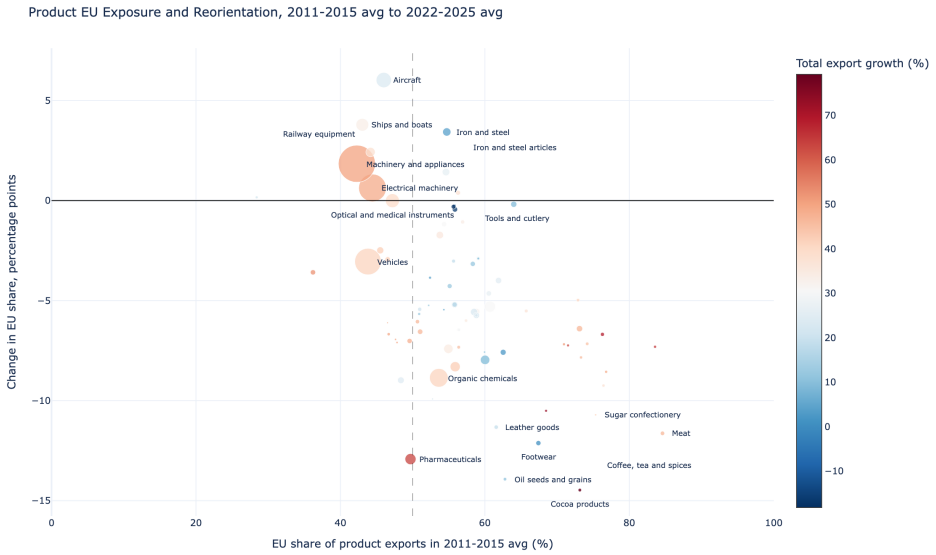

**(b) Exports**

Figure A.2: EU Shares of UK Goods Imports and Exports

*Notes:* The figure shows the EU share of UK goods trade over time, separately for imports in panel (a) and exports in panel (b). Each share is calculated as the value of UK goods imports from or exports to the EU divided by the corresponding total with all countries. The dashed vertical lines mark the June 2016 EU referendum and the January 2021 implementation of the Trade and Cooperation Agreement. *Source:* HMRC official trade statistics.




(a) Imports




(b) Exports

Figure A.3: Product-Level Reorientation of UK Goods Trade

*Notes:* The figure compares changes in the geographical composition of UK goods trade across two-digit HS product groups, separately for imports in panel (a) and exports in panel (b). The horizontal axis reports each product group's average EU trade share in 2011–15, while the vertical axis reports its percentage-point change between 2011–15 and 2022–25. Bubble size represents total product-level trade in 2011–15, and colour represents the percentage change in total trade between the two periods. The horizontal line marks no change in the EU share, and the dashed vertical line marks an initial EU share of 50 per cent. *Source:* HMRC official trade statistics.

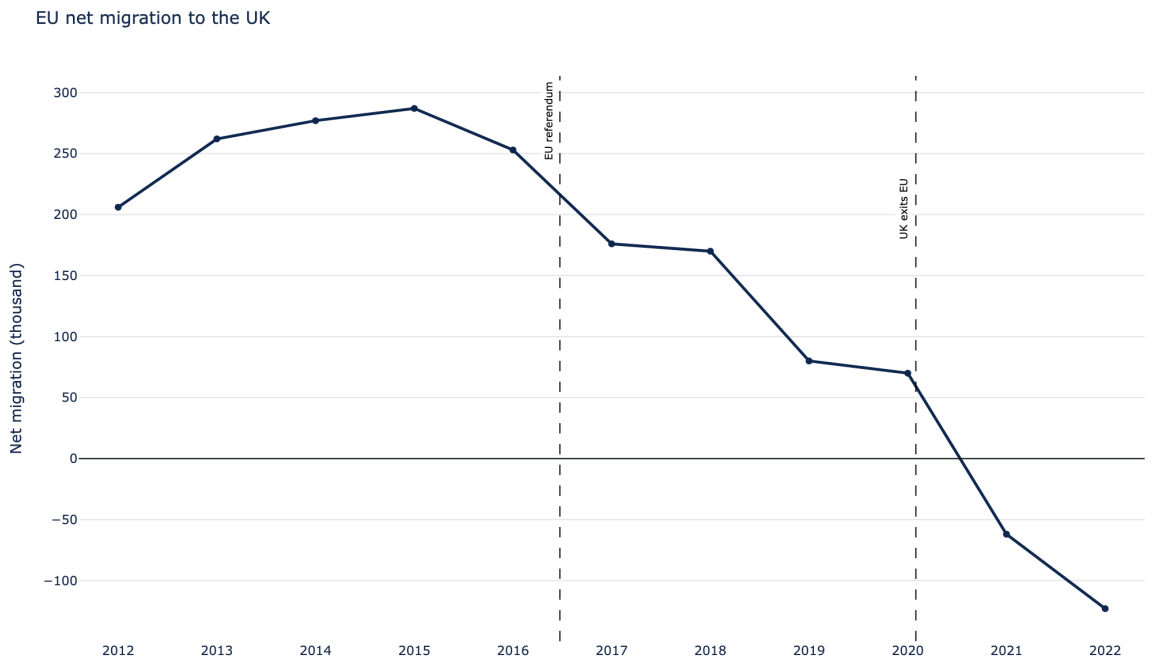



Figure A.4: EU Net Migration to the UK

*Notes:* The figure shows annual long-term net migration of EU nationals to the UK from 2012 to 2022, calculated as immigration minus emigration and expressed in thousands. Observations refer to years ending in December. The dashed vertical lines mark the June 2016 EU referendum and the UK's formal departure from the EU in January 2020. *Source:* Home Office official statistics.

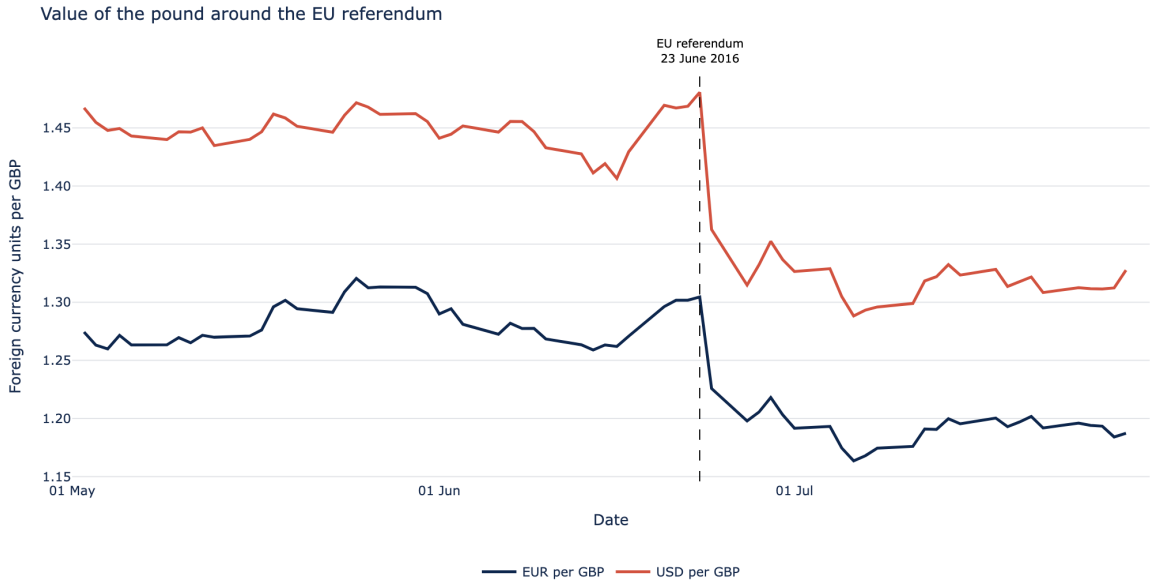
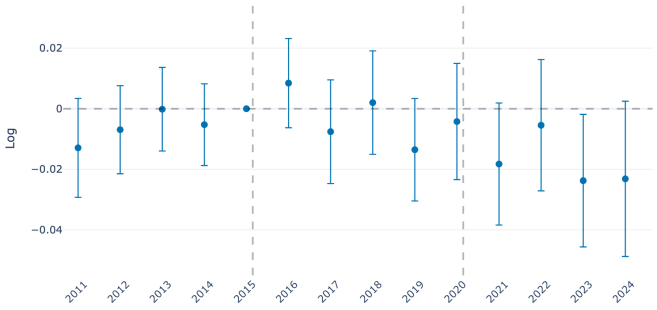
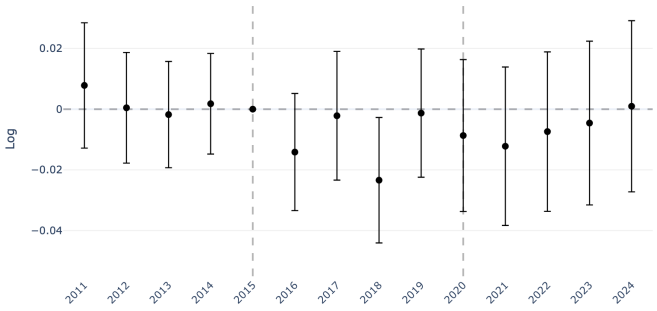



Figure A.5: Sterling Exchange Rates Around the EU Referendum

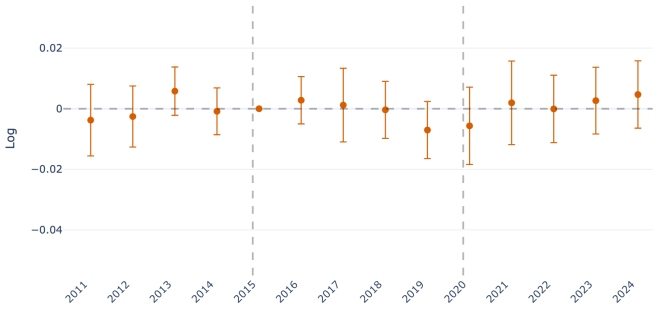
*Notes:* The figure shows daily sterling exchange rates between 1 May and 31 July 2016, expressed as euros and US dollars per pound sterling. The dashed vertical line marks the EU referendum on 23 June 2016. *Source:* IMF.




(a) EU Input Exposure



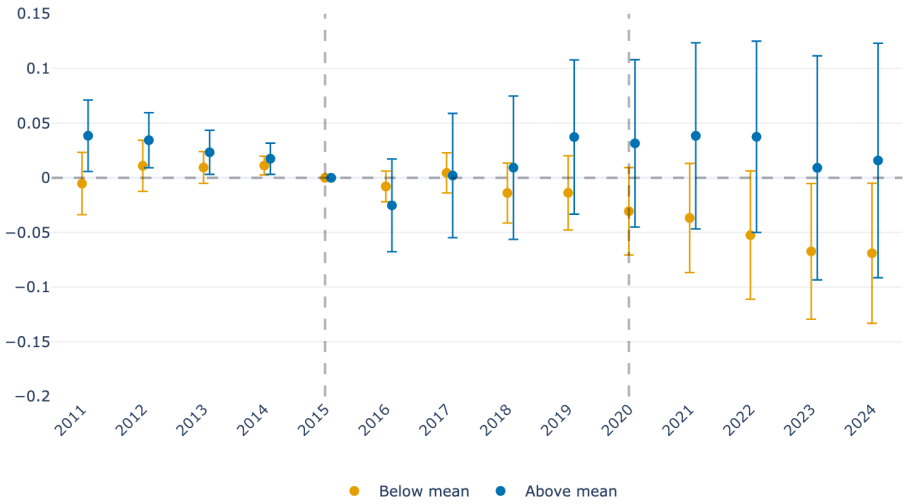

(b) EU Export Exposure



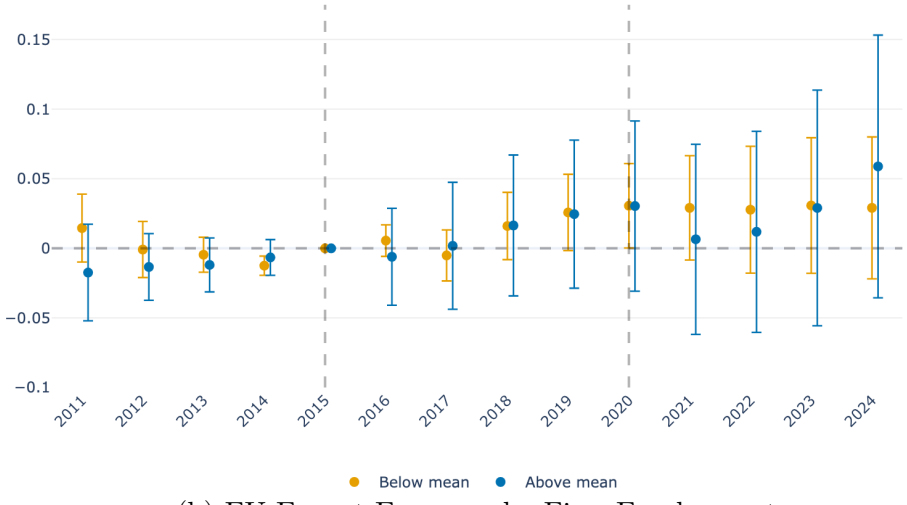

(c) EU Import Competition

Figure A.6: Worker Hours Responses to Firm-Level Brexit Exposure

*Notes:* The panels plot dynamic responses of worker wages to a one-standard-deviation increase in pre-referendum input and export exposure. Estimates are relative to 2015 and are obtained from the worker-level specification in equation (23), controlling for region and year fixed effects and the time-varying effects of sterling depreciation and COVID-19 exposure. *Sources:* ASHE and TiG.




(a) EU Input Exposure by Firm Employment




(b) EU Export Exposure by Firm Employment

Figure A.7: Firm Employment Responses by Firm Size

*Notes:* The figure shows heterogeneity in the annual responses of log employment to firm-level Brexit exposure by firms' pre-Brexit employment. Panels (a) and (b) report responses to EU input exposure and EU export exposure, respectively. Coefficients represent the effect of a one-standard-deviation increase in firm-level exposure relative to 2015; bars show 95 per cent confidence intervals. Estimates follow equation (22), jointly include both channels, and control for firm fixed effects, region-by-year and industry-by-year fixed effects, and the time-varying effects of sterling depreciation and COVID-19 exposure. Standard errors are clustered by firm. *Sources:* BSD and TiG.

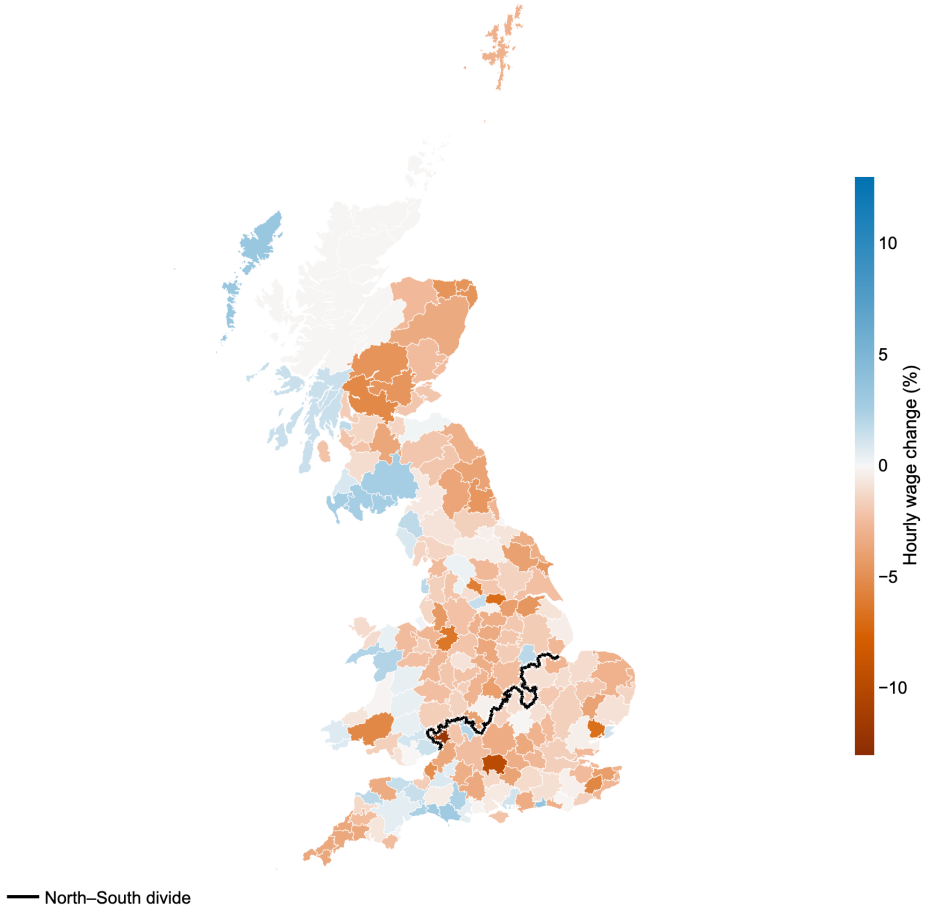
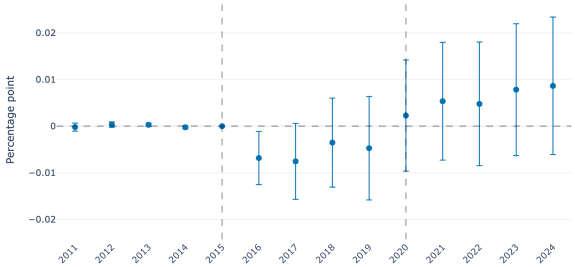
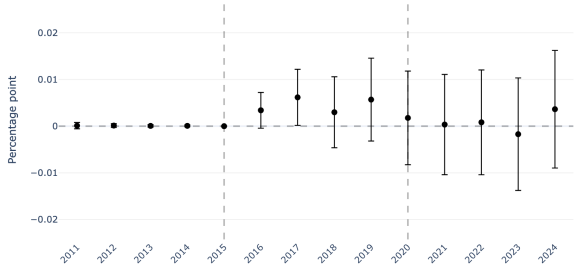



Figure A.8: Estimated Regional Wage Effects of Brexit

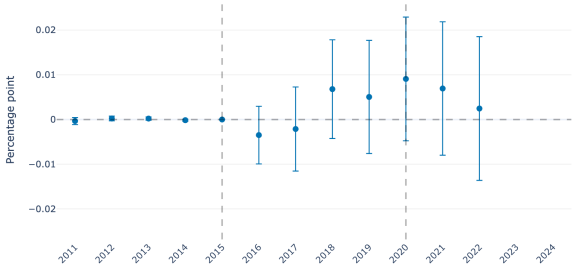
*Notes:* The map shows the estimated average percentage change in hourly wages attributable to regional Brexit exposure across Travel to Work Areas between 2021 and 2024. For each region, the measure is constructed by multiplying its exposure to each of the three channels by the corresponding average regional wage coefficient from Figure 3 and summing across channels, assuming no effect in the absence of exposure. The black line marks the North–South divide. *Sources:* ASHE, BSD and TiG.



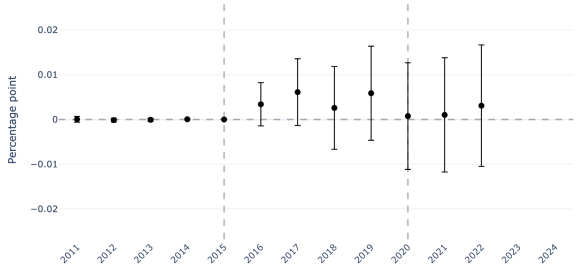

(a) Firm Activity: EU Input Exposure




(b) Firm Activity: EU Export Exposure



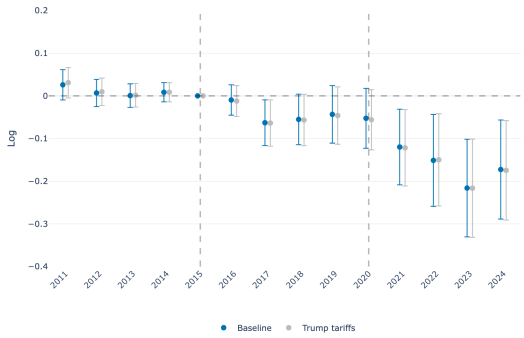

(c) Trading Status: EU Input Exposure



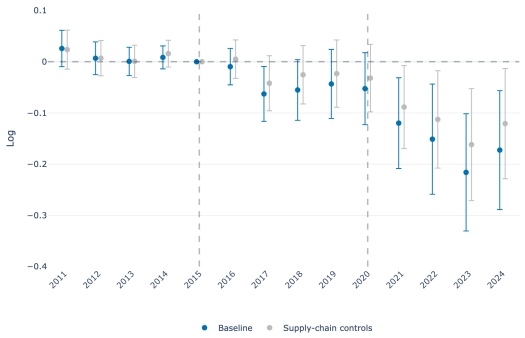

(d) Trading Status: EU Export Exposure

Figure A.9: Firm Activity and Trading Responses to Firm-Level Brexit Exposure

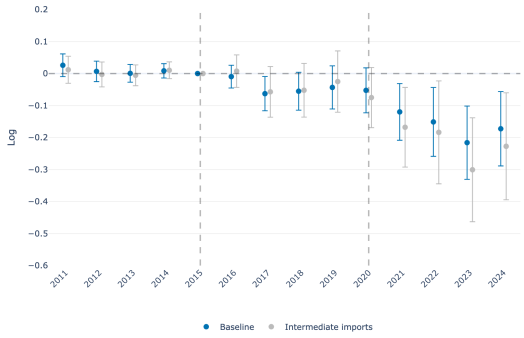
*Notes:* The figure shows annual responses of firm activity and trading status to firm-level Brexit exposure. The top row reports the probability that a firm is active in the BSD, while the bottom row reports the probability that it is observed trading in TiG. The left and right columns report exposure EU input exposure and EU export exposure, respectively. Coefficients represent the effect of a one-standard-deviation increase in firm-level exposure relative to 2015; bars show 95 per cent confidence intervals. Estimates follow equation (22), jointly include both channels, and include firm fixed effects, region-by-year and industry-by-year fixed effects, and the time-varying effects of sterling depreciation and COVID-19 exposure. Standard errors are clustered by firm. *Sources:* BSD and TiG.



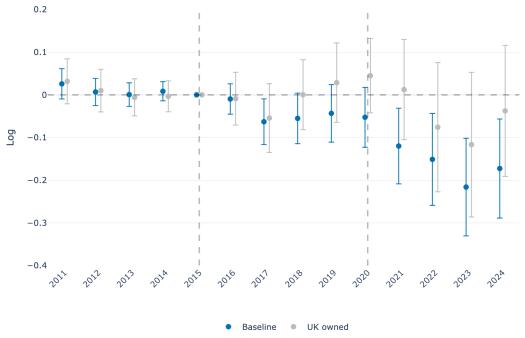

(a) North American Trade Exposure



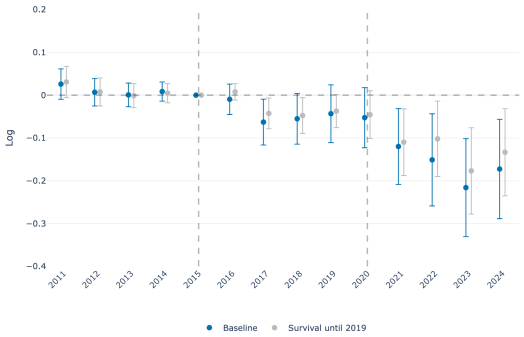

(b) Indirect Input Exposure




(c) Intermediate Imports Only



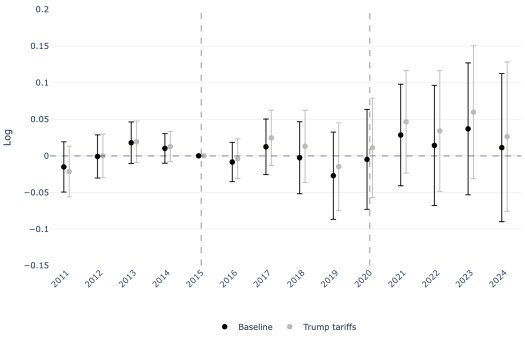

(d) UK-Owned Firms Only



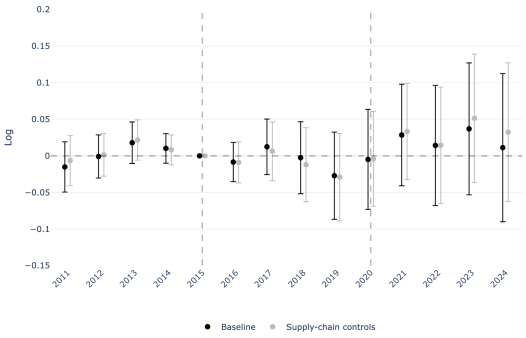

(e) Firms Surviving Until 2019

Figure A.10: Robustness of Firm Sales Responses to EU Input Exposure

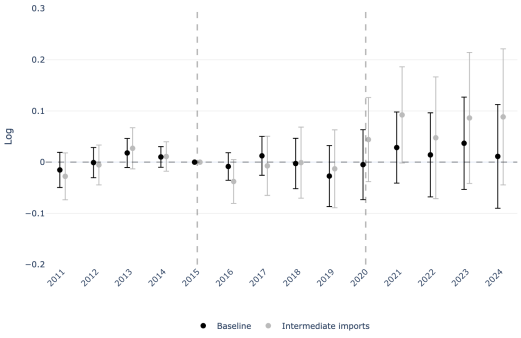
*Notes:* The figure compares baseline estimates of the annual response of log firm sales to firm-level EU input exposure with five robustness checks. The checks control for North American trade exposure, incorporate indirect domestic input exposure, restrict imports to intermediate goods, restrict the sample to UK-owned firms, and restrict the sample to firms surviving until 2019. Blue markers show baseline estimates and grey markers show the corresponding robustness estimates. Coefficients represent the effect of a one-standard-deviation increase in exposure relative to 2015; bars show 95 per cent confidence intervals. Estimates follow equation (22) and include firm fixed effects, region-by-year and industry-by-year fixed effects, and time-varying controls. The indirect-exposure specification omits industry-by-year fixed effects. Standard errors are clustered by firm. *Sources:* BSD and TiG.



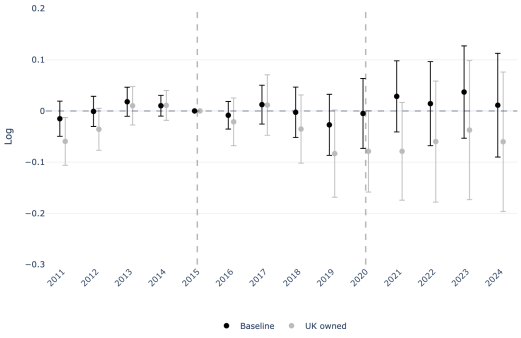

(a) North American Trade Exposure



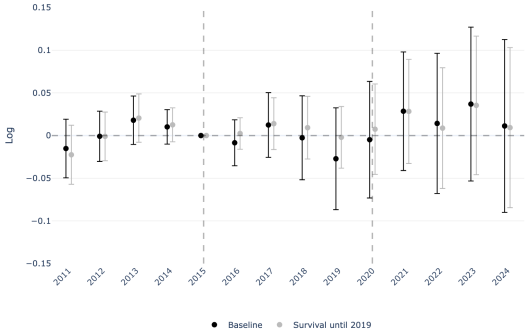

(b) Indirect Input Exposure




(c) Intermediate Imports Only



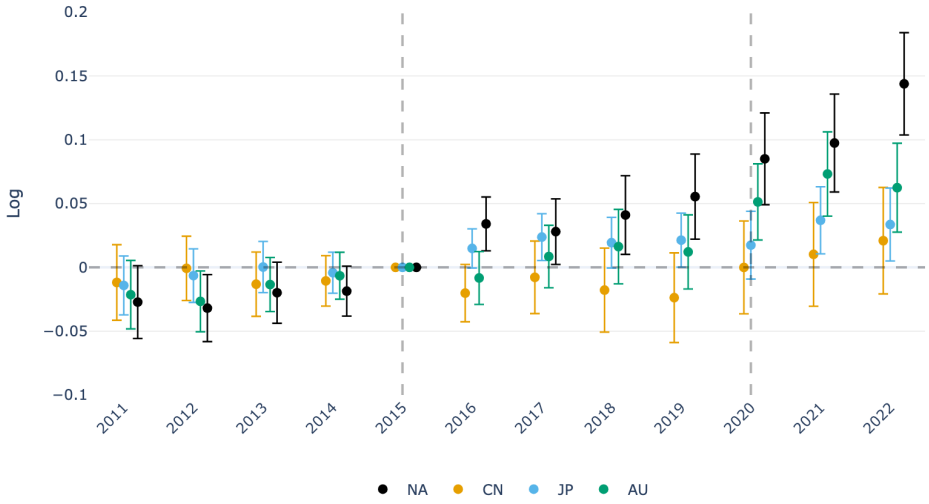

(d) UK-Owned Firms Only



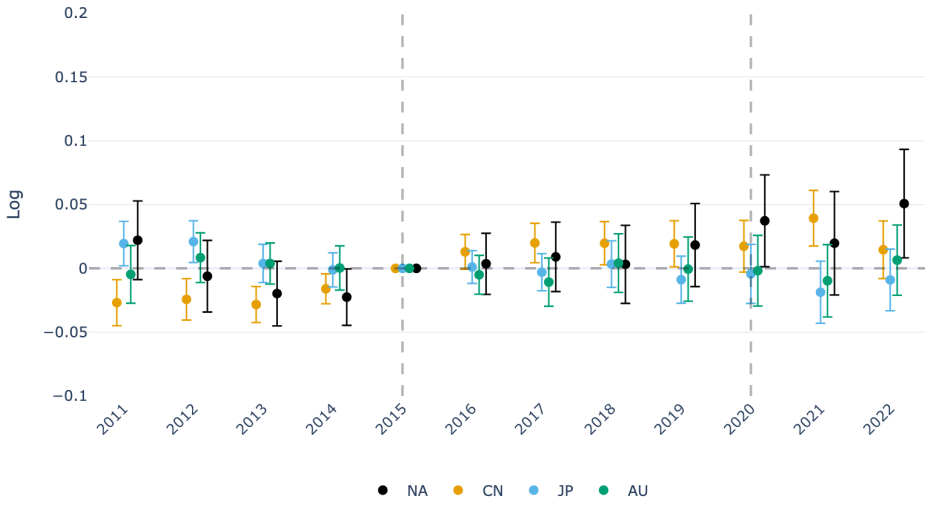

(e) Firms Surviving Until 2019

Figure A.11: Robustness of Firm Sales Responses to EU Export Exposure

*Notes:* The figure compares baseline estimates of the annual response of log firm sales to firm-level EU export exposure with five robustness checks. The checks control for North American trade exposure, indirect domestic input exposure and input exposure measured using intermediate imports, restrict the sample to UK-owned firms, and restrict the sample to firms surviving until 2019. Blue markers show baseline estimates and grey markers show the corresponding robustness estimates. Coefficients represent the effect of a one-standard-deviation increase in exposure relative to 2015; bars show 95 per cent confidence intervals. Estimates follow equation (22) and include firm fixed effects, region-by-year and industry-by-year fixed effects, and time-varying controls. The indirect-exposure specification omits industry-by-year fixed effects. Standard errors are clustered by firm. *Sources:* BSD and TiG.



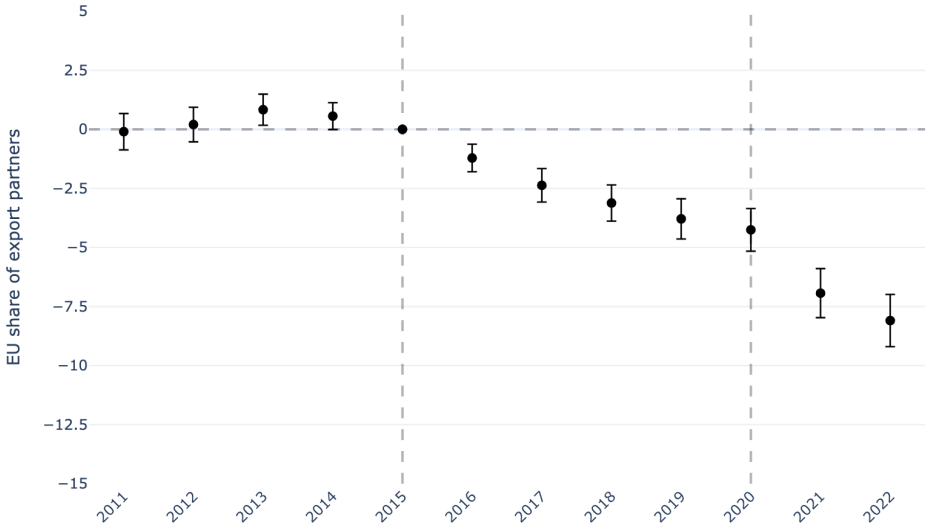

(a) Exports



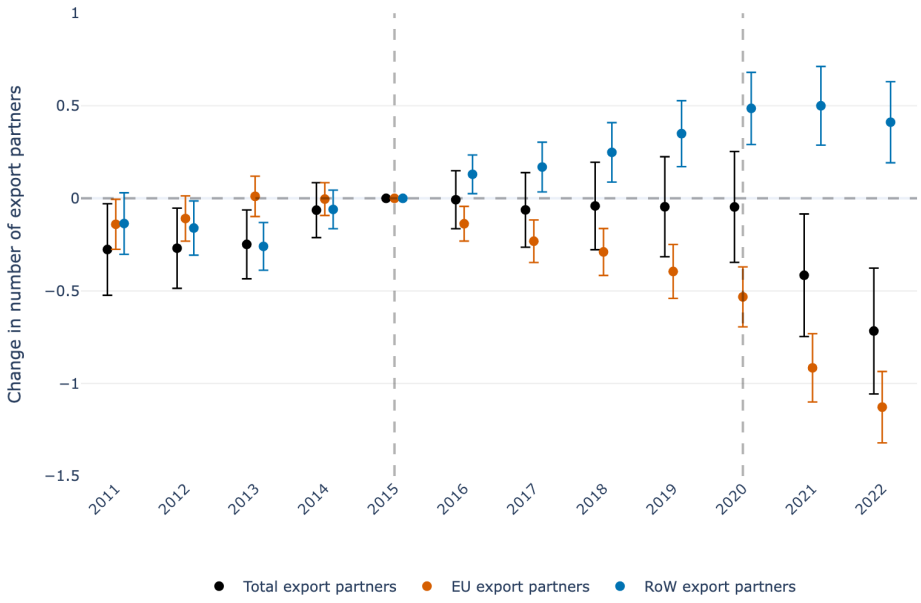

(b) Imports

Figure A.12: Placebo Estimates for Firm Export and Import Responses

*Notes:* The figure shows annual responses of firm-level trade flows to placebo exposure outside the EU. Panel (a) reports log total exports against pre-referendum export exposure to North America, China, Japan and Australia, while panel (b) reports log total imports against the corresponding import exposures. Coefficients represent the effect of a one-standard-deviation increase in the relevant firm-level exposure relative to 2015; bars show 95 per cent confidence intervals. Estimates follow equation (22) and include firm fixed effects, region-by-year and industry-by-year fixed effects, and time-varying controls. Standard errors are clustered by firm. *Sources:* BSD and TiG.




(a) EU Share of Export Partners




(b) EU, Rest-of-World and Total Export Partner Counts

Figure A.13: Firm Export-Partner Responses to EU Export Exposure

*Notes:* The figure shows annual responses of firms' export relationships to firm-level EU export exposure. Panel (a) reports the EU share of export partners in percentage points, while panel (b) reports changes in the total number of export partners and the numbers located in the EU and the rest of the world. Coefficients represent the effect of a one-standard-deviation increase in firm-level exposure relative to 2015; bars show 95 per cent confidence intervals. Estimates follow equation (22), jointly include both exposure channels, and include firm fixed effects, region-by-year and industry-by-year fixed effects, and time-varying controls. Standard errors are clustered by firm. *Sources:* BSD and TiG.

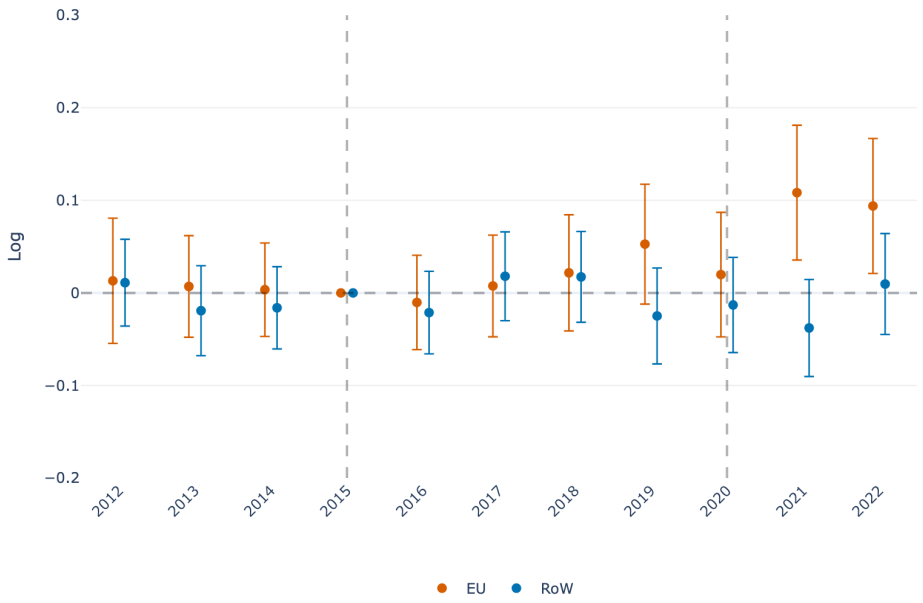



Figure A.14: Firm Export Unit-Value Responses to EU Export Exposure

*Notes:* The figure shows annual responses of firms' log export unit values to firm-level EU export exposure, separately for exports to the EU and the rest of the world. Coefficients represent the effect of a one-standard-deviation increase in firm-level exposure relative to 2015; bars show 95 per cent confidence intervals. Estimates follow equation (22), jointly include both exposure channels, and include firm fixed effects, region-by-year and industry-by-year fixed effects, and time-varying controls. Standard errors are clustered by firm. *Sources:* BSD and TiG.

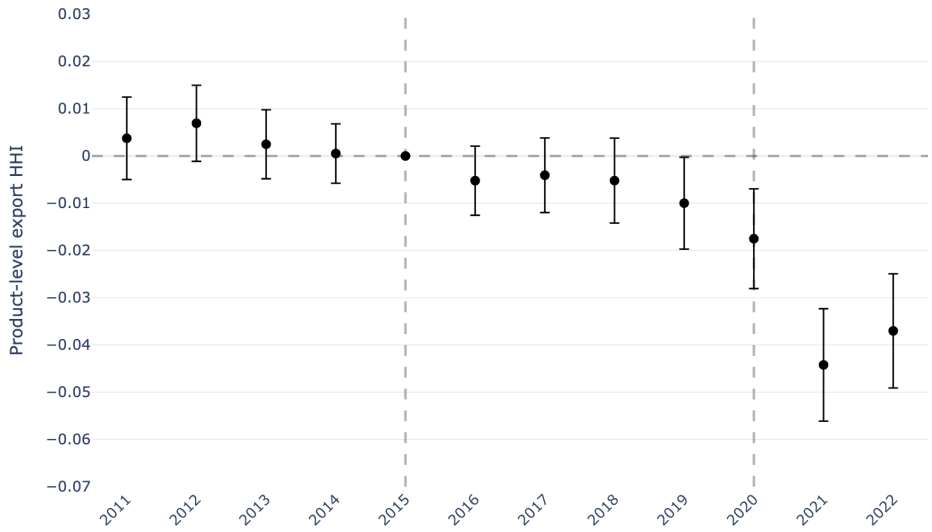
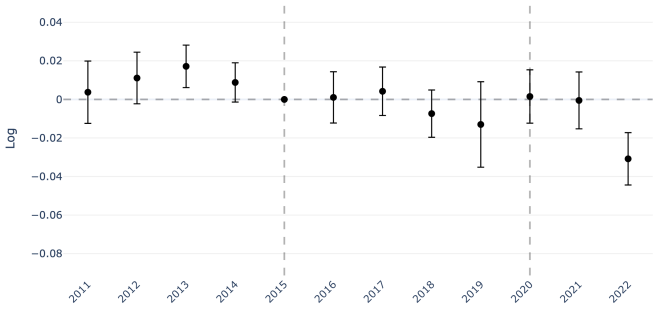
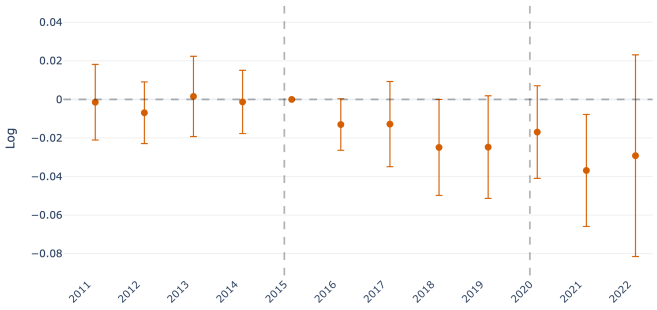



Figure A.15: Firm Export-Concentration Responses to EU Export Exposure

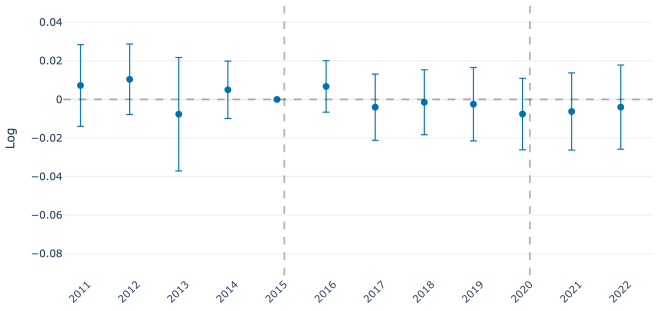
*Notes:* The figure shows annual responses of firms' export concentration to firm-level EU export exposure. Concentration is measured using a Herfindahl–Hirschman Index across each firm's product–destination export flows, with lower values indicating greater diversification. Coefficients represent the effect of a one-standard-deviation increase in firm-level exposure relative to 2015; bars show 95 per cent confidence intervals. Estimates follow equation (22), jointly include both exposure channels, and include firm fixed effects, region-by-year and industry-by-year fixed effects, and time-varying controls. Standard errors are clustered by firm. *Sources:* BSD and TiG.




(a) Domestic Suppliers




(b) EU Suppliers




(c) Rest-of-World Suppliers

Figure A.16: Industry Revenue Responses to EU Import Competition

*Notes:* The figure shows annual responses of revenue to industry-level exposure to EU import competition. Panels (a)–(c) report log revenue earned by domestic, EU and rest-of-world suppliers in the UK market, respectively. Coefficients represent the effect of a one-standard-deviation increase in industry-level exposure relative to 2015; bars show 95 per cent confidence intervals. Estimates follow equation (24), jointly include all three exposure channels, and control for industry and year fixed effects. Standard errors are clustered by industry. *Sources:* BSD and TiG.

# B Uncertainty results

This appendix completes the theoretical characterisation of trade-policy uncertainty introduced in Section 3. The main text presents the predictions for uncertainty affecting imported intermediate inputs; here, we state the corresponding results for uncertainty surrounding export conditions and competition from imported final goods. For each channel, we describe the implications for regional wages, firm-level wages and the allocation of employment across firms within a region. Formal proofs are provided in the following appendix.

**Result 13** *Regional wages decline in response to an increase in export uncertainty, and the decline is larger for more exposed regions (see proof in Appendix C).*

**Result 14** *The decline in firm wages (within a region) in response to an increase in export uncertainty is larger for more exposed firms (see proof in Appendix C).*

**Result 15** *Firms that are more exposed to export uncertainty see employment declines, whilst firms that are less exposed see employment increases (see proof in Appendix C).*

**Result 16** *Regional wages increase in response to higher import uncertainty for final goods from origin o (lower import competition), and the increase is greater for more exposed regions (see proof in Appendix C).*

**Result 17** *The increase in firm wages (within a region) in response to higher import uncertainty for final goods is larger for more exposed firms (see proof in Appendix C).*

**Result 18** *Firms that are more exposed to import uncertainty in final goods employ more labour, whilst firms that are less exposed employ less labour (see proof in Appendix C).*

# C Model Proofs

## Result 1, 2 and 3

First, we need to differentiate the conditional labour demand function of each firm (equation (15)) with respect to $(1+\phi_o^M)$

$$\begin{aligned}\frac{d\ln l_f}{d\ln(1+\phi_o^M)} &= \frac{d\ln mc_f}{d\ln(1+\phi_o^M)} + \frac{d\ln q_f}{d\ln(1+\phi_o^M)} - \frac{d\ln w_f}{d\ln(1+\phi_o^M)} \\ &= -\frac{(\theta_f-1)(1-\beta-\gamma)}{1+\gamma(\theta_f-1)}\left(\frac{M_{of}}{M_f}\right) - \frac{1+(\beta+\gamma)(\theta_f-1)}{1+\gamma(\theta_f-1)}\frac{d\ln w_f}{d\ln(1+\phi_{df}^X)} \end{aligned} \tag{B.1}$$

Equating this to the associated derivative of the labour supply function in equation (5) and solving for changes in firm-level wages, we obtain result 2.

$$d\ln w_f = -\frac{1}{\Omega_f}\left[(\theta_f-1)(1-\beta-\gamma)\left(\frac{M_{of}}{M_f}\right)d\ln(1+\phi_o^M) - \varepsilon[1+\gamma(\theta_f-1)]d\ln w\right]$$

Substituting the above back into the labour demand equation (B.1), we obtain result 3.

$$d\ln l_f = -\frac{\epsilon}{\Omega_f}\left[(\theta_f-1)(1-\beta-\gamma)\left(\frac{M_{of}}{M_f}\right)d\ln(1+\phi_{df}^X) + [1+(\beta+\gamma)(\theta_f-1)]d\ln w\right]$$

Finally, result 1 is obtained by imposing the regional labour market clearing condition and solving for regional wages.

$$\sum_f \frac{l_f}{L} d\ln l_f = 0$$

$$\Rightarrow d\ln w = -\frac{1}{\zeta}\left[\sum_f \frac{(\theta_f - 1)(1-\beta-\gamma)}{\Omega_f}\frac{l_{if}}{L}\left(\frac{M_{of}}{M_f}\right) d\ln(1+\phi_o^M)\right]$$

## Result 4, 5 and 6

First, we need to differentiate the conditional labour demand function of each firm (equation (15)) with respect to $(1+\phi_{df}^X)$

$$\begin{aligned}\frac{d\ln l_f}{d\ln(1+\phi_{df}^X)} &= \frac{d\ln mc_f}{d\ln(1+\phi_{df}^X)} + \frac{d\ln q_f}{d\ln(1+\phi_{df}^X)} - \frac{d\ln w_f}{d\ln(1+\phi_{df}^X)} \\ &= -\frac{\theta_f}{1+\gamma(\theta_f-1)}\frac{X_{df}}{X_f} - \frac{1+(\beta+\gamma)(\theta_f-1)}{1+\gamma(\theta)f-1}\frac{d\ln w_f}{d\ln(1+\phi_{df}^X)}\end{aligned} \tag{B.2}$$

Equating this to the associated derivative of the labour supply function in equation (5) and solving for changes in firm-level wages gives us result 5.

$$d\ln w_f = -\frac{1}{\Omega_f}\left[\theta_f\frac{X_{df}}{X_f}d\ln(1+\phi_{df}^X) - \varepsilon[1+\gamma(\theta_f-1)]d\ln w\right]$$

Substituting the above back into the labour demand equation (B.2), we obtain result 6

$$d\ln l_f = -\frac{\epsilon}{\Omega_f}\left[\theta_f\frac{X_{df}}{X_f}d\ln(1+\phi_{df}^X) + [1+(\beta+\gamma)(\theta_f-1)]d\ln w\right]$$

Finally, result 4 is obtained by imposing the regional labour market clearing condition and solving for regional wages

$$\sum_f \frac{l_f}{L}d\ln l_f = 0$$

$$\Rightarrow d\ln w = -\frac{1}{\zeta}\left[\sum_f \frac{\theta_f}{\Omega_f}\frac{l_{if}}{L}\frac{X_{df}}{X_f} d\ln(1+\phi_{df}^X)\right]$$

Now we show how the effects on employment and wages are muted due to the reallocation of sales. For an increase in export NTBs from destination $i$, the fall in output to destination $i$ is

$$d\ln q_{df} = -\theta_f d\ln(1+\phi_{df}^X) + \frac{\theta_f}{1+\gamma(\theta_f-1)}\left[\theta_f\gamma\frac{X_{df}}{X_f} d\ln(1+\phi_{df}^X) - \beta d\ln w\right] < 0$$

In comparison, the change in output to the rest of the world ($d = c$) is

$$\begin{aligned} d\ln q_{cf} &= -\theta_f d\ln \bar{p}_f \\ &= \frac{\theta_f}{1+\gamma(\theta_f-1)}\left[\theta_f\gamma\frac{X_{df}}{X_f} d\ln(1+\phi_{df}^X) - \beta d\ln w\right] > 0 \end{aligned}$$

The reduction in the factory price partially offsets the decline in output to destination $i$, resulting in a muted effect on wages and employment.

## Result 7, 8 and 9

First, we need to differentiate the conditional labour demand function of each firm (equation (15)) with respect to $(1+\phi_{UK,of}^X)$

$$\begin{aligned} \frac{d\ln l_f}{d\ln(1+\phi_{UK,of}^X)} &= \frac{d\ln mc_f}{d\ln(1+\phi_{UK,of}^X)} + \frac{d\ln q_f}{d\ln(1+\phi_{UK,of}^X)} - \frac{d\ln w_f}{d\ln(1+\phi_{UK,of}^X)} \\ &= \frac{(\theta_f-1)\omega_f^o}{1+\gamma(\theta_f-1)(1-\omega_f^{UK})} - \frac{1+(\beta+\gamma)(\theta_f-1)(1-\omega_f^{UK})}{1+\gamma(\theta_f-1)(1-\omega_f^{UK})}\frac{d\ln w_f}{d\ln(1+\phi_{UK,of}^X)} \end{aligned} \tag{B.3}$$

Equating this to the labour supply function in equation (5) and solving for changes in firm-level wages, we obtain result 8.

$$d\ln w_f = \frac{1}{\Theta_f}\left[(\theta_f - 1)\omega_f^o d\ln(1+\phi_{UK,of}^X) + \varepsilon[1+\gamma(\theta_f-1)(1-\omega_f^{UK})]d\ln w\right]$$

Substituting the above back into the labour demand equation (B.3), we obtain result 9

$$d\ln l_f = \frac{\epsilon}{\Theta_f}\left[(\theta_f - 1)\omega_f^o d\ln(1+\phi_{UK,of}^X) - [1+(\beta+\gamma)(\theta_f-1)(1-\omega_f^{UK})]d\ln w\right]$$

Finally, result 7 is obtained by imposing the regional labour market clearing condition and solving for regional wages

$$\sum_f \frac{l_f}{L} d\ln l_f = 0$$

$$\Rightarrow d\ln w = \frac{1}{\Gamma}\left[\sum_f \frac{(\theta_f - 1)}{\Theta_f}\frac{l_{if}}{L}\omega_f^o d\ln(1+\phi_{UK,of}^X)\right]$$

## Result 10, 11 and 12

The proof follows the same steps as in the proofs for results 1, 2, and 3, but with respect to $Var[\ln T_o^M]$.

## Result 13, 14 and 15

First, define effective market access to country $d$ as

$$\hat{B}_{df} = E_{df}(\hat{T}^X_{df})^{-\theta_f}$$

where $\hat{T}^X_{df}$ takes form in equation (8). Given that there is no uncertainty in country $c \neq i$, such that market access remains a $B_{cf}$, we then define total effective market access as

$$\hat{B}_f = \hat{B}_{df} + \sum_{c \neq i} B_{cf}$$

Given this, the remaining proof follows the same steps as in the proofs for results 4, 5, and 6, but with respect to $Var[\ln T^X_{df}]$.

## Result 16, 17 and 18

The proof follows the same steps as in the proofs for results 7, 8, and 9, but with respect to $Var[\ln T^X_{of,UK}]$.

# D Implied Changes in Trade Costs by Product

To provide descriptive evidence on the product incidence of the post-TCA trade shock, we infer changes in UK–EU bilateral trade costs from residual changes in trade flows. The purpose of this exercise is to identify the product groups in which implied trade-cost changes were concentrated, rather than to estimate the causal effect of particular non-tariff barriers or regulations. Annual trade values and quantities are averaged over a pre-TCA period (2017–2019) and a post-TCA period (2022–2024). We exclude 2020–2021 to avoid the transition to the new trading regime and the acute disruption associated with the COVID-19 pandemic. Crude oil and gas are also excluded. For trade direction $d \in \{X, M\}$, partner $j$, and product $k$, we estimate

$$\Delta \ln T_{jk}^{d} = \beta_d \Delta \ln P_{jk}^{d} + \gamma_d \Delta \ln A_{jk} + \alpha_j^{d} + \lambda_k^{d} + \varepsilon_{jk}^{d}, \tag{B.1}$$

where $T_{jk}^{d}$ is the average value of UK exports ($d = X$) or imports ($d = M$), $P_{jk}^{d}$ is the corresponding unit value, and $\alpha_j^{d}$ and $\lambda_k^{d}$ are partner and product fixed effects. The variable $A_{jk}$ denotes the destination country's total imports and is included only in the export specification, so that $\gamma_M = 0$. For any variable $Z$, $\Delta \ln Z$ is the difference between the logarithms of its post- and pre-period averages. The log specification restricts the estimation sample to partner–product cells with positive trade in both periods. The exercise therefore describes changes among continuing trade relationships and does not capture trade-cost changes operating through the entry or exit of partner–product relationships.

The residual $\widehat{\varepsilon}_{jk}^{d}$ captures the partner–product-specific change in trade that is not explained by unit values, common partner shocks, or common product shocks. Under a constant-elasticity trade-demand relationship, the residual is related to the change in the iceberg trade-cost wedge by

$$\widehat{\Delta \ln \tau_{EU,k}^{d}} = \frac{\widehat{\varepsilon}_{EU,k}^{d}}{1 - \bar{\theta}_k^{d}}, \tag{B.2}$$

where $\bar{\theta}_k^{d}$ is the pre-period trade-weighted elasticity for product group $k$. Equation (B.2) converts the unexplained change in UK–EU trade into an implied change in bilateral

trade costs. The resulting measure is a broad residual trade-cost wedge, not a causal estimate of the effect of a particular regulation. It may also capture unobserved changes in rules-of-origin costs, transport frictions, product composition, reporting practices, or other bilateral shocks. The corresponding ad valorem change is $\exp\left(\Delta \widehat{\ln \tau^{d}_{EU,k}}\right) - 1$.

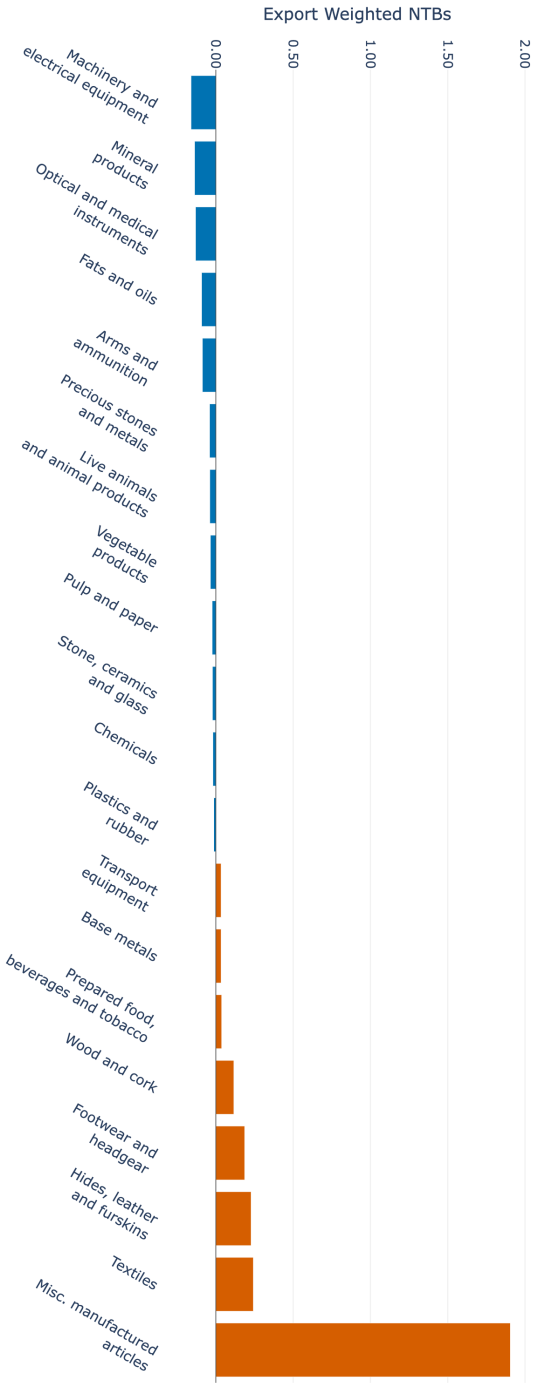



Figure D.1: Implied Export Trade-Cost Changes by Product Section

*Notes:* The figure reports implied changes in UK–EU export trade costs across broad HS product sections, weighted by pre-TCA export values. Positive bars indicate increases in the implied trade-cost wedge and negative bars indicate decreases. The changes are recovered from residual bilateral trade growth between the 2017–19 and 2022–24 averages using equations (B.1) and (B.2), controlling for changes in unit values, destination-country demand, and partner and product fixed effects. The estimates are descriptive residual trade-cost wedges and should not be interpreted as the causal effects of particular regulations. The sample includes partner–product cells with positive trade in both periods and excludes crude oil and gas. *Source:* HMRC official trade statistics.

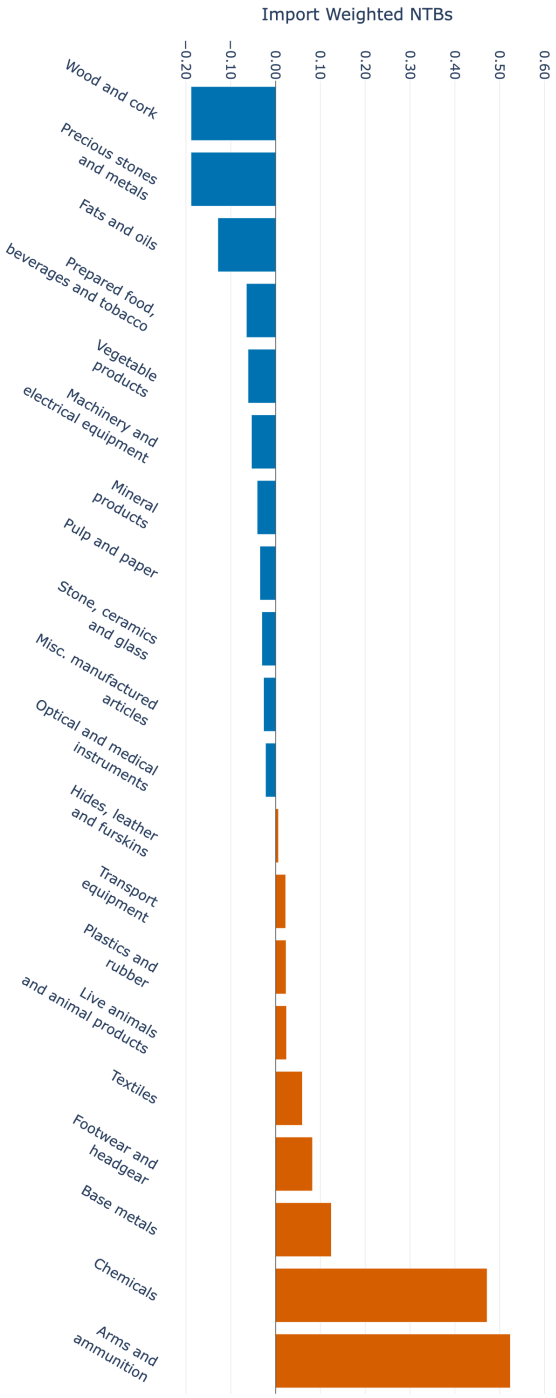



Figure D.2: Implied Import Trade-Cost Changes by Product Section

*Notes:* The figure reports implied changes in UK–EU import trade costs across broad HS product sections, weighted by pre-TCA import values. Positive bars indicate increases in the implied trade-cost wedge and negative bars indicate decreases. The changes are recovered from residual bilateral trade growth between the 2017–19 and 2022–24 averages using equations (B.1) and (B.2), controlling for changes in unit values and partner and product fixed effects. The estimates are descriptive residual trade-cost wedges and should not be interpreted as the causal effects of particular regulations. The sample includes partner–product cells with positive trade in both periods and excludes crude oil and gas. *Source:* HMRC official trade statistics.

# E Full Data Description

This appendix documents the principal processing decisions behind the firm, worker and trade data. It also describes the input–output construction of indirect input exposure and introduces the auxiliary sources used to construct regional migration shares, exposure to sterling depreciation and differential exposure to COVID-19.

## E.1 Administrative records and linkage

We combine the Annual Survey of Hours and Earnings (ASHE), the Business Structure Database (BSD), and HMRC's Trade in Goods (TiG) records. ASHE provides employee-level pay, hours, and employer identifiers; the BSD provides enterprise employment, turnover, industry and location; and TiG supplies goods-trade values by reporting trader, detailed product, partner country and month. Firm identifiers allow the employment and balance-sheet records to be linked to trading activity, and ASHE employer identifiers enable workers to be assigned to the firm-level measures. We use time-consistent 2016 Travel to Work Area boundaries throughout the regional analysis.

The ASHE and BSD data extend through 2024, while the HMRC Trade in Goods data extend through 2022. We use pre-referendum trade information to construct fixed Brexit exposure measures for firms observed in the administrative data through 2024, while our analysis of realised trade flows ends in 2022.

## E.2 Business Structure Database (BSD)

The Business Structure Database (BSD) provides annual information on UK enterprises, including employment (which we measure using BSD rather than ASHE because the BSD covers enterprises on the Inter-Departmental Business Register (IDBR), providing more complete coverage than the ASHE sample), turnover, industry classification and geographical location. We use the BSD to construct firm-level outcomes and assign enterprises to Travel to Work Areas (TTWAs), using consistent 2016 geographical boundaries throughout the analysis.

To address concerns about the geographical attribution of firm-level activity, we restrict our sample to enterprises comprising a single reporting unit. This restriction simplifies the assignment of enterprises to Travel to Work Areas.

## E.3 Annual Survey of Hours and Earnings (ASHE)

The Annual Survey of Hours and Earnings is an annual employer-based survey covering approximately one per cent of employee jobs, sampled using National Insurance identifiers from HMRC's Pay As You Earn (PAYE) records. Its longitudinal structure allows individuals to be observed across years. Our data extend through 2024, and our principal outcomes are hourly earnings, including overtime, and weekly hours worked. ASHE excludes self-employed workers, while coverage may be incomplete for employees at businesses outside the Inter-Departmental Business Register (IDBR) and for some low-paid employees not recorded in PAYE (Bell et al., 2022).

For our worker-level analysis, we link ASHE employer identifiers to enterprises in the Business Structure Database. This allows us to assign workers their employer's pre-referendum Brexit exposure measures. We assign observations to workers' Travel to Work Areas rather than their employers' Travel to Work Areas, using consistent 2016 geographical boundaries. Our wage outcome is hourly earnings, including overtime, while our hours outcome measures weekly hours worked. We restrict our sample to private-sector workers aged 18 to 65. This restriction reflects the fact that public-sector pay is largely determined through national pay-setting arrangements, making it less directly responsive to local labour-market conditions (Nibloe, 2025).

## E.4 Cleaning HMRC Trade in Goods records

**Raw transactions and trader identifiers.** Following the data treatment of Freeman et al. (2025), we start from the HMRC EU and Non-EU Trade Panel records, in which a trade observation is indexed by a trader identifier, Combined Nomenclature eight-digit (CN8) product, partner country and calendar month, separately for goods exports and imports. Values are expressed in pounds sterling. We link HMRC trader identifiers to

the enterprise data through the available trader–VAT–enterprise correspondence; where a VAT registration maps to multiple establishments, enterprise outcomes and location assignments are taken from the BSD linkage rather than inferred from the trading declaration. We retain the special-trade concept, which excludes goods moving into or out of customs warehouses and free zones without entering the corresponding domestic customs territory.

**Valid trade records and partner classification.** The cleaning protocol follows Freeman et al. in excluding non-monetary gold, Harmonised System Chapters 98 and 99, and observations with negative trade values after consolidation to the VAT–CN8–country–month level. These adjustments avoid including special or non-comparable product categories and negative correction entries in the exposure numerator or denominator. We classify partners consistently as EU or rest of world over time, using the composition of the EU relevant for the Brexit comparison. Following Freeman et al., Croatia is included with EU partners throughout the sample even though it joined in July 2013. The same fixed country grouping is used when constructing pre-referendum trade shares and post-referendum outcomes; this avoids changes in the group definition being mistaken for changes in firm trade.

**Changes from Intrastat to customs declarations.** Before Brexit, UK–EU trade was recorded through the Intrastat system, while trade with non-EU countries was recorded through customs declarations. The transition to customs declarations for EU exports occurred in January 2021, while the corresponding transition for EU imports took place in January 2022, following the phased introduction of UK border requirements. The change in reporting systems introduced differences in the coverage of transactions and traders, particularly because Intrastat operated with annual reporting thresholds that did not apply in the same way to customs declarations. Following Freeman et al. (2025), we harmonise the data across reporting regimes by excluding EU trade observations below £2,500 at the trader–product–country–month level and imposing common annual EU trade thresholds of £250,000 for exporters and £1.5 million for importers. These annual

thresholds are evaluated using traders' total EU exports and imports in each calendar year, with the two trade directions treated separately. We also exclude firms whose EU trade becomes observable only after the relevant transition to customs declarations, to avoid treating changes in reporting coverage as the entry of new traders.

**Annual aggregation and treatment construction.** Having applied the transaction-level and annual trader-level rules, we aggregate the remaining trade values to firm–year–EU and firm–year–rest-of-world totals, separately for imports and exports. The underlying country and product breakdowns are retained for the exchange-rate and import-penetration constructions. For treatment construction, we calculate the firm's EU share of total imports and exports in each observed pre-referendum year, then average the valid annual shares over 2011–2015 as set out in equations (16) and (17). Firms without the relevant positive denominator do not contribute an observed share for that direction of trade. Regional measures use the corresponding pre-referendum total-import, total-export or domestic-sales weights described in the main text.

## E.5 Regional EU migrant shares

The Annual Population Survey (APS) is a large repeated cross-sectional household survey covering roughly 320,000 respondents per year. Unlike ASHE, it provides detailed demographic information, including country of birth and migration status. For consistency with the ASHE data, we restrict the APS sample to private-sector employees. We assign respondents to Travel to Work Areas (TTWAs) using consistent 2016 boundaries. In each year, we apply the representative APS cross-sectional survey weights to calculate the number of employees born in an EU country as a fraction of total employees within the private-sector sample in each TTWA. We then average these annual shares over 2011–2015. Because it is based on the pre-referendum share of EU-born private-sector employees, this variable measures potential local-labour-supply exposure rather than actual post-Brexit migrant departures. It enters the regional wage robustness exercise as a fixed regional characteristic interacted with year indicators.

Let $\mathcal{I}_{rt}$ denote the private-sector employees sampled in TTWA $r$ in year $t$, let $w_{it}$ be the year-specific cross-sectional survey weight, and let $B_{it}$ equal one if employee $i$ was born in an EU country and zero otherwise. Our regional EU migrant-share control is defined as

$$EUShare_{r,11\text{–}15} = \frac{1}{5} \sum_{t=2011}^{2015} \frac{\sum_{i \in \mathcal{I}_{rt}} w_{it} B_{it}}{\sum_{i \in \mathcal{I}_{rt}} w_{it}}. \tag{B.1}$$

## E.6 Daily exchange rates and exposure to sterling depreciation

The sharp depreciation of sterling following the June 2016 referendum represents a distinct channel through which Brexit may have affected UK firms and workers, independently of the trade barriers introduced subsequently. To measure exposure to this shock, we follow the approach of Costa et al. (2024), using daily exchange-rate data obtained from the International Monetary Fund (IMF). For each trading-partner currency, we measure the change in sterling's value between the average exchange rate in May 2016 and the average exchange rate in July 2016. Since the magnitude of sterling depreciation varied across currencies, differences in firms' pre-referendum trading patterns generate variation in their exposure to the exchange-rate shock.

Let $e_{cd}$ denote the number of units of trading-partner currency $c$ that one pound sterling purchases on day $d$. Using daily exchange rates from the IMF, we calculate the arithmetic average of the available daily observations for each currency in May and July 2016. We define the depreciation of sterling against currency $c$ as

$$\Delta_c^{\text{GBP}} = \log \bar{e}_{c,\text{May 2016}} - \log \bar{e}_{c,\text{July 2016}}, \tag{B.2}$$

where $\bar{e}_{c,m}$ denotes the arithmetic average of the available daily exchange rates in month $m$. A positive value indicates sterling depreciation, as the pound purchases fewer units of foreign currency in July than in May.

We combine the country-specific exchange-rate shocks with firms' pre-referendum bilateral trade shares from the Trade in Goods (TiG) data. Let $s_{fc}^M$ denote country $c$'s share of firm $f$'s total goods imports during 2011–2015, and define $s_{fc}^X$ analogously for exports.

We construct separate firm-level measures of import and export exposure to sterling depreciation as

$$FX_f^M = \sum_c s_{fc}^M \Delta_c^{\text{GBP}}, \qquad FX_f^X = \sum_c s_{fc}^X \Delta_c^{\text{GBP}}, \tag{B.3}$$

where the bilateral trade shares sum to one for firms with positive pre-referendum imports or exports, respectively. These measures depend on the composition of firms' trading partners rather than their overall trade intensity.

We aggregate firm-level exchange-rate exposure to Travel to Work Areas (TTWAs) using each firm's share of regional imports or exports over 2011–2015 as weights. Regional import and export exposure are defined, respectively, as

$$FX_r^M = \sum_{f \in r} \omega_{fr}^M FX_f^M, \qquad FX_r^X = \sum_{f \in r} \omega_{fr}^X FX_f^X, \tag{B.4}$$

where

$$\omega_{fr}^M = \frac{M_{f,11\text{–}15}}{\sum_{f' \in r} M_{f',11\text{–}15}}, \qquad \omega_{fr}^X = \frac{X_{f,11\text{–}15}}{\sum_{f' \in r} X_{f',11\text{–}15}}. \tag{B.5}$$

Here, $M_{f,11\text{–}15}$ and $X_{f,11\text{–}15}$ denote firm $f$'s total imports and exports over 2011–2015, respectively.

## E.7 COVID-19 exposure measured by furlough participation

The COVID-19 pandemic overlapped with the final stages of Brexit negotiations and the introduction of the TCA. To account for differences in the economic disruption caused by the pandemic across local labour markets, we construct a measure of COVID-19 exposure using furlough participation in the 2020 Annual Survey of Hours and Earnings (ASHE). Specifically, we use an indicator identifying employees furloughed under the UK government's Coronavirus Job Retention Scheme (CJRS) at the ASHE reference date of 22 April 2020. The scheme allowed employers to retain employees on payroll while receiving government support for their wages. The 2020 furlough indicator is derived from HMRC administrative records linked to ASHE, whereas the corresponding 2021 indicator was collected through the ASHE questionnaire. We therefore use the 2020 indicator to

construct a single measure of exposure to the initial pandemic shock Office for National Statistics, 2021, pp. 3–4.

For each worker $i$ observed in ASHE in 2020, let $F_{i,2020}$ equal one if the HMRC-linked CJRS indicator records the worker as furloughed at the April 2020 reference date, and zero if the worker is recorded as not furloughed. We impute 0 values to workers who are not observed in 2020 in order to avoid subsetting our analyses to workers observed in 2020. At the worker level, we define COVID-19 exposure as $COVID_i = F_{i,2020}$. To construct firm- and regional-level exposure, we aggregate the indicator using the 2020 ASHE sampling weights. Let $w_{i,2020}$ denote worker $i$'s sampling weight, and let $\mathcal{I}_{f,2020}$ and $\mathcal{I}_{r,2020}$ denote, respectively, the sets of ASHE workers linked to firm $f$ and assigned to Travel to Work Area (TTWA) $r$ in 2020. Each set includes only observations with valid furlough indicators and sampling weights. We define the weighted share of furloughed workers at each level as

$$COVID_f = \frac{\sum_{i \in \mathcal{I}_{f,2020}} w_{i,2020} F_{i,2020}}{\sum_{i \in \mathcal{I}_{f,2020}} w_{i,2020}}, \qquad COVID_r = \frac{\sum_{i \in \mathcal{I}_{r,2020}} w_{i,2020} F_{i,2020}}{\sum_{i \in \mathcal{I}_{r,2020}} w_{i,2020}}. \tag{B.6}$$

## E.8 Indirect input exposure

Our baseline input-exposure measure captures a firm's direct reliance on imports from the EU, but firms may also be exposed indirectly through transactions with domestic suppliers and customers. To capture these linkages, we combine firms' pre-referendum input exposure with the most recent ONS input–output tables. We first calculate the average direct input exposure among firms in each industry. Let $\overline{EXP}^M_{s'}$ denote this average for industry $s'$, and let $Z_{s's}$ denote the value of intermediate inputs that industry $s$ purchases from industry $s'$ in the input–output table.

For each industry $s$, we define upstream exposure as the exposure of its domestic suppliers, weighted by their shares in the industry's intermediate-input purchases:

$$EXP^{M,\text{up}}_s = \sum_{s'} \frac{Z_{s's}}{\sum_{s''} Z_{s''s}} \overline{EXP}^M_{s'}. \tag{B.7}$$

This measure is high when an industry purchases a large share of its intermediate inputs from domestic industries whose firms are themselves highly reliant on EU imports.

We construct downstream exposure analogously. Let $Z_{ss'}$ denote intermediate sales from industry $s$ to industry $s'$. Downstream exposure is the exposure of an industry's domestic customers, weighted by their shares in its intermediate sales:

$$EXP_s^{M,\text{down}} = \sum_{s'} \frac{Z_{ss'}}{\sum_{s''} Z_{ss''}} \overline{EXP}_{s'}^{M}. \tag{B.8}$$

This measure is high when an industry sells a large share of its intermediate output to domestic industries with high direct reliance on EU imports. Both measures capture first-order domestic production linkages rather than higher-order connections obtained from a Leontief inverse. We assign the resulting upstream and downstream measures to firms according to their industry and standardise them over the estimation sample.

In the robustness specifications reported in Appendix Figures A.10 and A.11, we augment the baseline regression with the upstream and downstream exposure measures interacted with year indicators. The coefficient of interest therefore continues to capture the response to the relevant firm's direct Brexit exposure, conditional on indirect exposure through its domestic production network. Because the indirect measures vary at the industry level, these specifications omit industry-by-year fixed effects.

# F Linking Regional and Firm-level Regressions

This appendix sets out a framework linking our regional and firm-level event-study specifications. Both regressions are estimated using identical samples of firm-year observations and exploit complementary sources of variation in Brexit exposure. We focus on EU input exposure, although the argument extends to other exposure channels. For transparency, the framework below uses unweighted regional averages; our results are robust to constructing the regional treatments in this way.

Let $x_f$ denote pre-Brexit firm-level EU input exposure and $y_{frt} = \log Y_{frt}$ denote log firm employment. Let $\mathcal{F}_r$ denote the set of firms in region $r$ in the common estimation sample and let $N_r$ denote the number of such firms. Regional exposure is constructed as the unweighted average of firm exposure:

$$x_r = \frac{1}{N_r} \sum_{f \in \mathcal{F}_r} x_f. \tag{B.1}$$

Define regional average log employment analogously as $\bar{y}_{rt} = N_r^{-1} \sum_{f \in \mathcal{F}_r} y_{frt}$. Firm exposure and employment can then be decomposed into regional and within-region components:

$$\begin{aligned} x_f &= x_r + (x_f - x_r), \\ y_{frt} &= \bar{y}_{rt} + (y_{frt} - \bar{y}_{rt}). \end{aligned} \tag{B.2}$$

By construction, both within-region components have mean zero:

$$\frac{1}{N_r} \sum_{f \in \mathcal{F}_r} (x_f - x_r) = 0, \qquad \frac{1}{N_r} \sum_{f \in \mathcal{F}_r} (y_{frt} - \bar{y}_{rt}) = 0. \tag{B.3}$$

Consider our regional and firm-level event-study specifications, suppressing additional controls:

$$y_{frt} = \gamma_r + \gamma_t + \sum_{k \neq 2015} \beta_k^R x_r I_{t=k} + \varepsilon_{frt}, \tag{B.4}$$

$$y_{frt} = \gamma_f + \gamma_{rt} + \sum_{k \neq 2015} \beta_k^F x_f I_{t=k} + u_{frt}. \tag{B.5}$$

Because regional exposure and the fixed effects in equation (B.4) are constant across firms

within each region-year, the unweighted firm-level regional specification is equivalent to a regression of $\bar{y}_{rt}$ on regional exposure in which each region-year is weighted by its number of firm observations. It therefore identifies the relationship between regional exposure and changes in average log employment across regions.

In contrast, region-year fixed effects in equation (B.5) absorb both regional average employment and regional exposure interacted with time. The firm-level specification is consequently algebraically equivalent to

$$y_{frt} - \bar{y}_{rt} = \widetilde{\gamma}_f + \widetilde{\gamma}_{rt} + \sum_{k \neq 2015} \beta_k^F (x_f - x_r) I_{t=k} + u_{frt}. \tag{B.6}$$

Thus, the firm-level coefficient identifies the relationship between within-region deviations in exposure and employment, conditional on firm fixed effects.

The central implication is that the two specifications identify complementary margins of labour-market adjustment. The regional regression captures differences in average employment trajectories across regions with different EU exposure, whereas the firm-level regression captures differential employment adjustment among firms within the same region. Consequently, a small regional coefficient alongside a negative firm-level coefficient is consistent with adjustment taking place predominantly within regional labour markets, rather than through systematic differences in average employment growth across regions.

# G Elasticities of Substitution Between Products

One reason why UK firms may be better able to reallocate exports away from EU destination markets to the rest of the world than they are at substituting away from intermediate inputs from the EU might be that the UK export product basket may be made up of more substitutable goods than the import product basket. We test whether this is the case by taking the trade-weighted average elasticity of substitution separately for UK exports to the EU and imports from the EU. The results of this exercise are reported in Table 3. We find that goods exported from the UK to the EU before the Brexit referendum were indeed more substitutable than imports from the EU. However, the difference in the average elasticity of substitution of 0.91 is not statistically significant at conventional levels.

Table 3: Average trade elasticity of UK trade

| | Exports | Imports | Difference | Bootstrap SE | $p$-value |
|---|---|---|---|---|---|
| EU | 7.82 | 6.91 | 0.91 | 0.59 | 0.120 |
| RoW | 5.79 | 5.61 | 0.19 | 0.69 | 0.787 |

Notes: Trade-weighted average of $\theta_k = -\varepsilon_k$, the product-level trade elasticity in the authors' preferred version (1%-significant tariff elasticities kept, insignificant estimates set to zero, p1–p99 of the distribution kept). Weights are each HS6 product's share of average annual UK exports to (imports from) the partner bloc, 2011–2015. Difference = Exports − Imports. Standard errors come from a paired bootstrap over HS6 products (5,000 replications): products are resampled with replacement, each keeping its $\theta_k$ and both its export and import trade values, and both weighted averages are recomputed on every draw. The two-sided $p$-value uses the normal approximation Difference/SE. Source: BACI.

# H Tradeflow Decomposition

Trading networks evolve over time along three dimensions: new relationships form, existing relationships dissolve, and continuing relationships strengthen or weaken in value. The first two constitute the extensive margin, while the third represents the intensive margin.

To explore the reorientation of UK firms' exports away from the European Union and towards the rest of the world, we decompose changes in export values along these three dimensions. We first aggregate the value of exports across all products within each firm destination country-year pair. Taking 2015 as our baseline, we then classify trading relationships for each subsequent year $t$ into three groups: new relationships, where a firm exports to a destination in year $t$ but not in 2015; dissolved relationships, where a firm exported to a destination in 2015 but no longer does so in year $t$; and continuing relationships, where a firm exports to the same destination in both periods. We then sum export values within each group separately across EU and non-EU destination countries. This provides a firm-level decomposition of changes in exports into the contributions of newly formed relationships, dissolved relationships, and changes in the value of continuing relationships.

Formally, aggregating across firms $f$ and destination countries $c$, this can be written as:

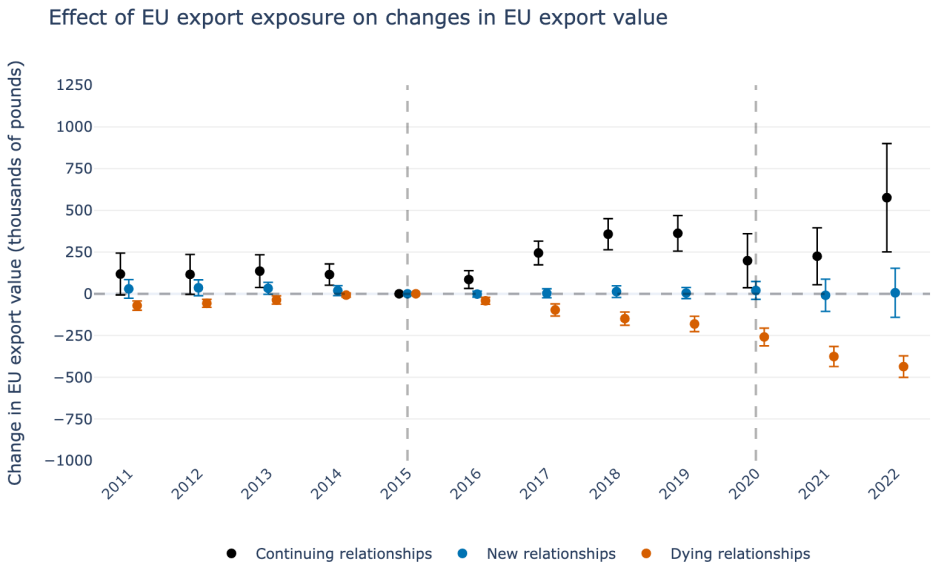
$$\begin{aligned}\Delta_g^X(t, 2015) = &\sum_{\substack{(f,c) \\ c \in g}} \Delta^X_{\text{New},fc}(t, 2015) \\ &+ \sum_{\substack{(f,c) \\ c \in g}} \Delta^X_{\text{Die},fc}(t, 2015) \\ &+ \sum_{\substack{(f,c) \\ c \in g}} \Delta^X_{\text{Cont},fc}(t, 2015),\end{aligned} \tag{B.1}$$

Here, $g$ identifies the destination group (EU versus RoW). The indices $f$ and $c$ denote firms and trading-partner countries, respectively, with the summation taken over all firm–country pairs for which country $c$ belongs to group $g$. The term $\Delta_g^X(t, 2015)$ represents

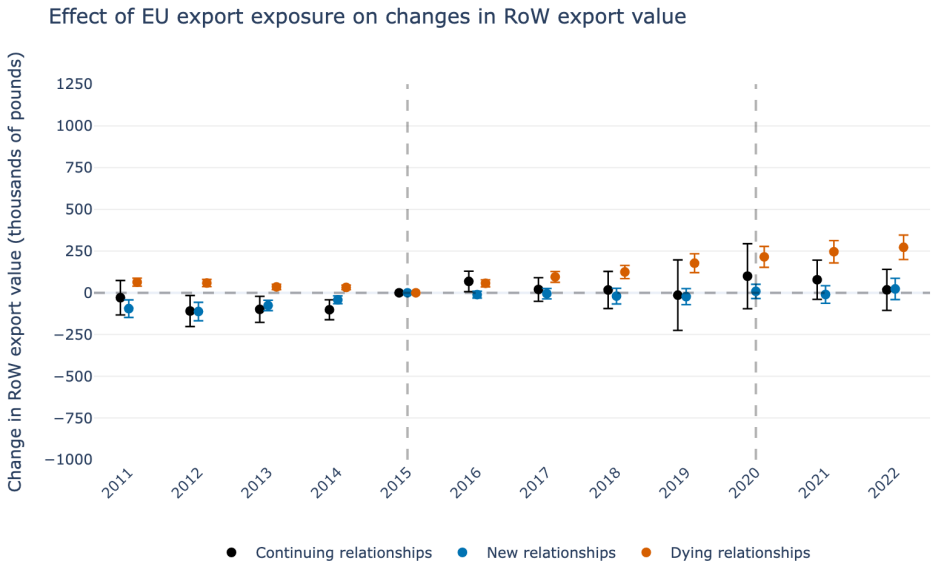
the change in the total value of exports to destination group $g$ between 2015 and year $t$.

On the right-hand side, $\Delta^{X}_{\text{New},fc}(t, 2015)$ captures the positive contribution from relationships that exist in year $t$ but not in 2015, while $\Delta^{X}_{\text{Die},fc}(t, 2015)$ captures the negative contribution from relationships that existed in 2015 but not in year $t$. Finally, $\Delta^{X}_{\text{Cont},fc}(t, 2015)$ measures the change in trade value among relationships that persist across both periods.

Figure H.1, panel a, explores how EU exports respond along each of these dimensions at the firm level in response to a one-standard-deviation increase in EU export exposure. We show that the majority of the decline in EU trade over this period was driven by dying EU relationships, while the value of existing relationships increased owing to a selection effect. Our results are necessarily estimated in levels because within-firm trade flows often remain constant over time (i.e. no dying or new relationships), so the magnitudes should be considered cautiously. In contrast, Figure H.1, panel b, shows that rest-of-world trade primarily increases because trade relationships dissolve less frequently and persist for longer.




(a) EU




(b) Rest of the World

Figure H.1: Firm Export-Value Responses by Relationship Status

*Notes:* The figure decomposes annual changes in firm-level export values associated with EU export exposure, separately for EU destinations in panel (a) and rest-of-world destinations in panel (b). Export relationships are defined at the firm–destination level relative to 2015: continuing relationships are observed in both years, new relationships are observed only in the comparison year, and dying relationships are observed only in 2015. Outcomes are expressed in thousands of pounds. Coefficients represent the effect of a one-standard-deviation increase in firm-level exposure relative to 2015; bars show 95 per cent confidence intervals. Estimates follow equation (22) and include firm fixed effects, region-by-year and industry-by-year fixed effects, and time-varying controls. Standard errors are clustered by firm. *Sources:* BSD and TiG.