The links between sectoral and regional investment and sectoral, regional, and aggregate productivity in the United Kingdom

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Abstract

We document significant regional and sectoral productivity disparities in the United Kingdom, particularly between London and other regions, with important implications for aggregate productivity and living standards. These differences are driven by sectoral trade imbalances, notably in intermediate services, where London serves as the primary supplier. We explore how productivity shocks propagate through regional and sectoral linkages, using a quantitative spatial model of the U.K. economy to assess their local and aggregate impact. Using data for the 12 ITL1 regions and 9 broad goods and services sectors, we incorporate regional migration, input-output linkages, capital dynamics, and other local factors. We find that productivity shocks have heterogeneous aggregate impacts depending on the originating regions and sectors. London and the Southern regions exhibit the largest influence on aggregate GDP, while the services sectors yield the highest aggregate total factor productivity (TFP) and GDP elasticities. We identify regions where increases in their capital stock would contribute most to aggregate outcomes, while also emphasising the need for targeted regional and sectoral policies that promote tradability across regions to mitigate disparities and improve national productivity.

1 Introduction

The United Kingdom exhibits large regional differences in productivity, mainly between London and most other regions. This disparity has significant implications for aggregate productivity and welfare, resulting in substantial regional differences in living standards across the country. Trade imbalances between regions differ by sector. Most regions tend to trade a relatively even proportion of intermediate goods; however, there is a large imbalance in intermediate services flows, with London acting as the main supplier to all UK regions. The prominence of specific industries in shaping these differences—such as the financial and business services sectors in London—underscores the importance of incorporating the sectoral composition of regions, particularly in terms of welfare and labour mobility.

Recent literature has examined the uneven role of London in shaping the UK's regional imbalances. For example, Gal and Egeland (2018) point to the capital's higher productivity as driving the North-South divide by attracting labour and capital resources. Although there is a growing literature linking regional productivity to aggregate productivity, the propagation of shocks in UK production networks has not been fully investigated from a regional perspective. In this study, we aim to contribute to this literature by using a quantitative model of the UK economy to measure the local and aggregate impact of changes in regional and sectoral productivity and infrastructure. We develop a static model that accounts for regional migration, input-output linkages between sectors, and local factors such as amenities and capital structures. The interplay of these components translates the disaggregated productivity changes into aggregate outcomes. We consider the large observed regional trade imbalances, including trade in services, and we use this model to propose policy options aimed at improving productivity at the sectoral, regional, and aggregate levels. Our contribution is twofold. First, we quantify how productivity and infrastructure shocks transmit through the United Kingdom's interregional input-output network when trade in inter-mediate services inputs is explicitly incorporated, an aspect that is often abstracted from in quan-titative sectoral applications, due to measurement constraints. Second, we provide UK-specific evidence by combining International Territorial Level 1 (ITL1) regional data with multi-sector interregional trade flows and by estimating sectoral trade elasticities that discipline the strength of propagation mechanisms across sectors and regions. This allows us to rank regions and sectors by their impact on the national aggregates, and to identify which region pairs deliver the largest aggregate gains from reductions in trade costs.

We use a rich dataset of 12 regions, covering the ITL1 regions in the United Kingdom. We employ bilateral trade flow data as estimated in the PBL EUREGIO database to calibrate the regional trade imbalances across regions and industries within the United Kingdom, in an open economy framework[1]. The labour input is constructed from a range of the Office for National Statistics (ONS) datasets, as well as information on gross value added.

Our framework builds on conventional specifications of the literature on trade and spatial economics, particularly Caliendo et al. (2018). We assume an open economy, multiple sector model, covering nine tradable goods and services sectors, that combine intermediate inputs from a set of varieties that can be purchased from other regions. Each variety is produced using labour, capital and intermediate goods, and is subject to idiosyncratic productivity levels, which are region- and

[1] See Thissen et al. (2018) and European Commission, Joint Research Centre (JRC) (2020) for specifics on the estimation and modelling of this database.

sector-specific. As in Moll (2014), final goods are consumed locally by two types of agents: workers and landlords. Workers have free mobility, but landlords are immobile and own the local capital infrastructure. This leads to a distribution of regional endowments that affect local productivity and influence the allocation of the labour input across regions.

Using this framework, we perform several counterfactuals, which allow comparisons with a baseline scenario where the outcomes should therefore be read as short-run under fixed local capital infrastructure and frictionless mobility of workers. In the long run, allowing for capital accumulation, capital adjustment costs, housing constraints, and gradual migration would alter the magnitude of regional and sectoral effects: capital deepening and migration can amplify gains where complementarities are strong, but adjustment frictions can dampen the reallocation mechanisms that drive propagation in the model.

Our preliminary findings suggest that disaggregated productivity changes can have different aggregate implications depending on the regions and sectors affected. These productivity changes are propagated across regions via regional trade linkages, and their sectoral structure determines their ultimate impact. We use elasticities to compare these effects across regional and sectoral shocks. Our quantitative exercises reveal stark heterogeneities in the aggregate impact of productivity shocks. A 1% positive productivity shock to all sectors in London increases national GDP by 1.27%, the largest of any region, compared to an impact of less than 1% for the devolved nations, even with normalised controls[2]. These differential impacts are quantitatively guided by our estimated sectoral trade elasticities, which range from 1.36 in manufacturing to 2.04 in non-market services, determining how cost shocks propagate through regional supply chains.

From a sectoral perspective, our results point towards a differential effect depending on the sector experiencing the productivity shock. This arises from costly regional trade on intermediate inputs, leading to the accumulation of production factors and the subsequent regional concentration of sectoral activity. A uniform 1% productivity improvement across all regions in a given sector shows that manufacturing and construction shocks have the smallest aggregate GDP impact (0.74–0.78%), despite their higher tradability. In contrast, shocks to agriculture, mining and energy, and financial intermediation have the largest effects, boosting aggregate GDP by 1.3-1.4%. Conversely, aggregate UK total factor productivity (TFP) is most responsive to positive shocks in services sectors, particularly real estate and business activities, which yield a 0.69% increase for a 1% positive productivity shock.

These results provide a numerical basis for targeted policies. We quantify that a 1% increase in a region's capital stock has a maximum national GDP elasticity of 0.2%, with the highest returns from investment in London and the South. Furthermore, strategically reducing trade costs between specific regional pairs offers highly cost-effective gains: a 1% reduction in estimated trade costs between the West Midlands and Wales, for instance, increases national GDP by 0.1%. Over-

[2]The overall effect of these shocks are reported in terms of elasticities, so to make comparisons across regions and sectors. The aggregate elasticities show the total impact on the UK economy resulting from the shocked sectors or regions. We multiply the size of the variable change (which is 1% in all counterfactuals) by the share of the region or sector where the shock originated. This approach controls for economic size of larger regions and sectors, normalising results so they have a constant national magnitude.

all, our findings demonstrate that the dual levers of strategic capital investment and infrastructure improvements,S and targeted trade cost reduction can significantly mitigate regional disparities, with the precise optimal mix depending on the specific regional and sectoral context.

Related literature

Our study relates to different lines of research. In particular, our work engages with the literature on quantitative spatial economics, see Redding and Rossi-Hansberg (2017) for a recent survey. Like many studies in this field, we analyse spatial economic patterns, while focusing on the transmission of shocks across several linkages. On the one hand, at a multisector scale, the transmission of sectoral shocks along production networks can have heterogenous impacts on aggregate economic variables, as explored in Long Jr and Plosser (1983), Horvath (2000), Acemoglu et al. (2012) and De Graeve and Schneider (2023). Given a region's economic structure, these sectoral shocks tend to influence as well the concentration of activity in specific regions through input-output relationships. The allocation of production factors influences as well the intensity of these shocks, as it will result in changes in the flows of migration and capital across regions and sectors, as explored recently in Caliendo et al. (2018), Caliendo et al. (2019), Cai et al. (2022) and Kleinman et al. (2023). We apply a framework based on these studies to determine the channels through which some regions and sectors in the United Kingdom take a more pronounced role in influencing their aggregate economic outcomes.

This strand of the literature considers international trade in static, multi-sector, multi-country quantitative models mostly based on the Ricardian model developed by Eaton and Kortum (2002). We follow mainly Caliendo et al. (2018) to assess the extent to which interregional trade, labour mobility, local fixed factors, and heterogeneous productivities affect national aggregate TFP and GDP. The interaction between internal trade and migration has been explored, among others, in Allen and Arkolakis (2014) and Redding (2016). A key aspect in Ricardian models is the estimation of trade elasticities. In Eaton and Kortum (2002), these determine the variation of the prices of traded goods to different shocks, and studies such as Simonovska and Waugh (2014) and Caliendo and Parro (2015) produce sectoral estimates for the United States based on international trade data. We contribute to the interregional trade literature by estimating trade elasticities for the United Kingdom, based on the intersectoral and interregional exchange of intermediate inputs and trade costs given by a generalised trade cost index. In addition, these measures are often calculated based on trade in goods. More recently, services trade data has been more available and alongside it, the complexities of measuring them, as well as their different idiosyncrasies when considering quantitative models. Miroudot et al. (2013), Gervais and Jensen (2019) and Nakano and Nishimura (2025) discuss in more detail the tradability of services and their measurement, while the importance of the trade in services in shaping regional production specialization in the United States has been studied by Rossi-Hansberg et al. (2019) and Hsieh and Rossi-Hansberg (2023), and Han et al. (2023) in Canada, based on available data. We contribute to this literature by acknowledging the relevance of the trade in services intermediate inputs, incorporating them in our analysis.

Finally, we contribute to the literature on regional disparities in the United Kingdom. Gal and Egeland (2018) note a significant sectoral impact from financial and business services, as manufacturing, construction, government, and distribution services have smaller regional differences. Rice and Venables (2022) indicate that these regional differences stem from the locational persistence of highly tradable sectors, tending to concentrate in specific regions and not develop in less competitive areas. Coyle and Mei (2023) focus on the sectoral composition of the United Kingdom, showing that the aggregate productivity slowdown stems from specific industries (primarily transport equipment and pharmaceuticals), rather than the relocation of factors towards less productive sectors.

In turn, as discussed in Kenny et al. (2023), this spatial inequality is characterised by a concentration of economic activity, migration and capital flows towards the capital of London, a pattern consistent with core-periphery models in spatial economics. In contrast, we employ a Ricardian trade model in order to assess the interactions not just with the periphery and London, but also among regions within the periphery itself. This approach allows us to shed light on why certain peripheral areas experience persistent underdevelopment despite proximity to growth centers, how interregional specialization shapes inequality, and whether policy interventions could rebalance economic opportunities more effectively across the United Kingdom. By moving beyond the simple core-periphery dichotomy, our model provides new insights into the granular dynamics of regional divergence and the potential for more targeted place-based policies. We draw conclusions in the lines mentioned by the above-mentioned studies: Rice and Venables (2022) on the local concentration of tradable sectors, Coyle and Mei (2023) on specific industries dragging down aggregate productivity, and on the prominence of the North-South divide (Gal and Egeland (2018), Gardiner et al. (2020), McCann and Yuan (2022)).

The rest of the paper is structured as follows. Section 2 describes the regional and sectoral composition of economic activity in the United Kingdom. In sections 3 and 4 we develop our static spatial model and we characterize the equilibrium properties of the model. Section 5 describes how we take the model to the data. This section discusses data measurement and the data sources used to take the model to the UK context, as well as our estimation strategy of the relevant trade elasticities. Section 6 presents our quantitative results, while Section 7 concludes. We relegate all proofs, theoretical derivations, and detailed data descriptions to the appendix.

2 Sectoral and regional linkages in the U.K. economy

The regional dimension of this paper is defined by the twelve ITL1 regions of the United Kingdom, with an additional Rest of the World (RoW) region. We consider nine sectoral groups as described in Table 1. The sectoral groups are informed by data availability in the 2010 vintage of the EUREGIO database (Thissen et al., 2018), which we use as our benchmark dataset for calibration. We aggregate sectors according to convention where applicable.

Table 1: Sectoral Groups

EUREGIO code(s)	Sector Name	SIC07 code(s)
ss1	Agriculture	A
ss2	Mining and Energy Supply	B,D,E
ss3 - ss8	Manufacturing	C
ss9	Construction	F
ss10,ss11	Distribution; Hotels and Restaurants	G,I
ss12	Transport and storage; Info and communication	H,J
sss13	Financial intermediation	K
ss14	Real estate, renting and business activities	L,M,N
ss15	Non-market services	O,P,Q,R,S,T

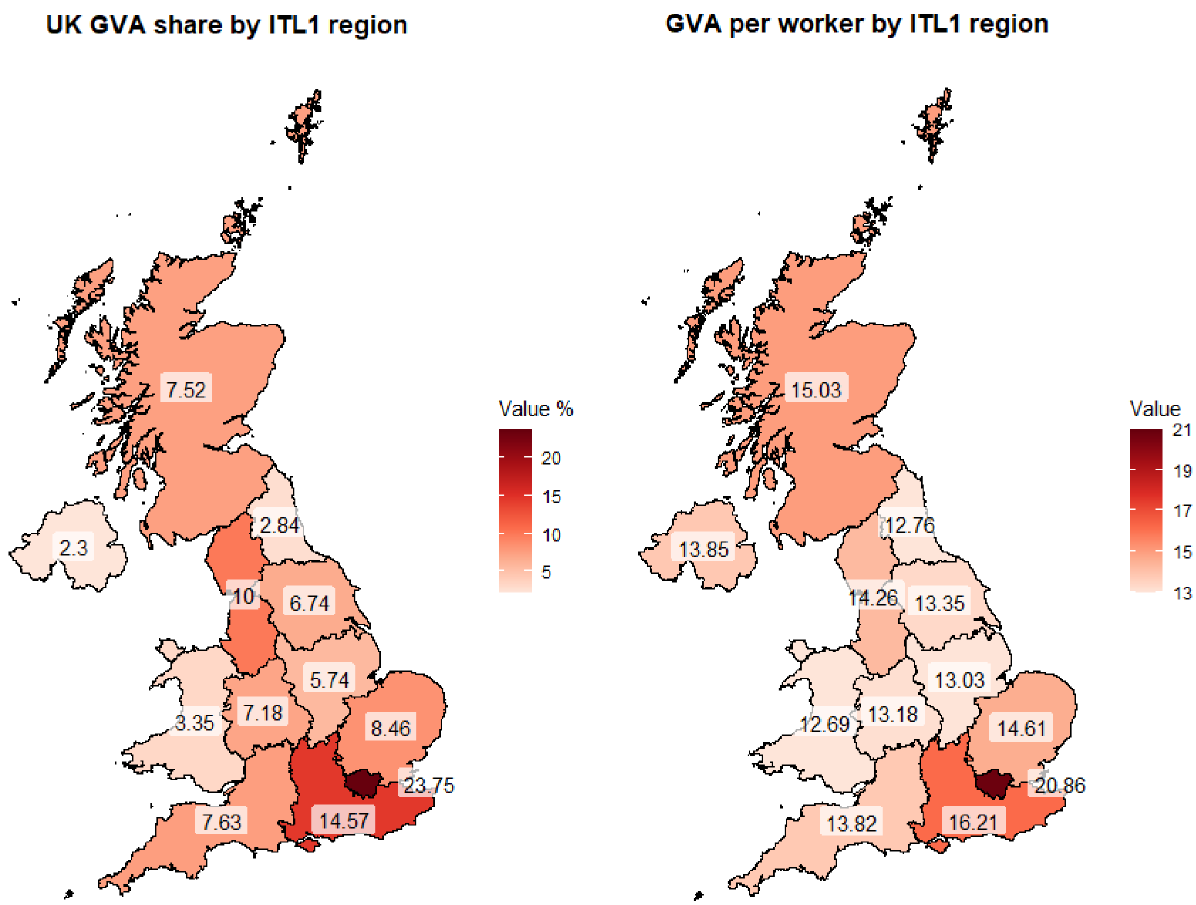
2.1 The Spatial Distribution of Economic Activity

Aggregate data for the UK economy masks considerable heterogeneity in economic circumstances across regions. Understanding regional variation in economic activity is important because it informs the aggregate impact of sector- and region-specific productivity shocks. The transmission of such shocks takes form in different channels, most prominently through migration flows altering employment shares, and trade in goods and services. In this paper we focus exclusively on trade in intermediate inputs, connecting the productive structures of each region and sector in the economy.

Figure 1 illustrates the average share of national GVA produced by each region. There is considerable variation in regional contributions to national GDP. For example, London contributes the most to UK GDP and accounted for 23.7 per cent of national output in 2023. The second-highest contributor to national output is the South East, which generates 14.6 per cent of UK output. Northern Ireland contributes the least, producing 2.30 per cent in 2023. This variation in output volumes across UK regions cannot be explained by geographic size. London has the smallest land area of the UK ITL1 regions; it is almost nine times smaller than Northern Ireland and some fifty times smaller than Scotland. The supply of labour across regions also cannot explain the entirety of the variation in regional output. Figure 1 shows that London exhibits the highest labour productivity of any UK region. Output per job in London is 28.7 per cent higher than in the South East, the second most productive ITL1 region, and 64.4 per cent higher than in Wales, the least productive region.

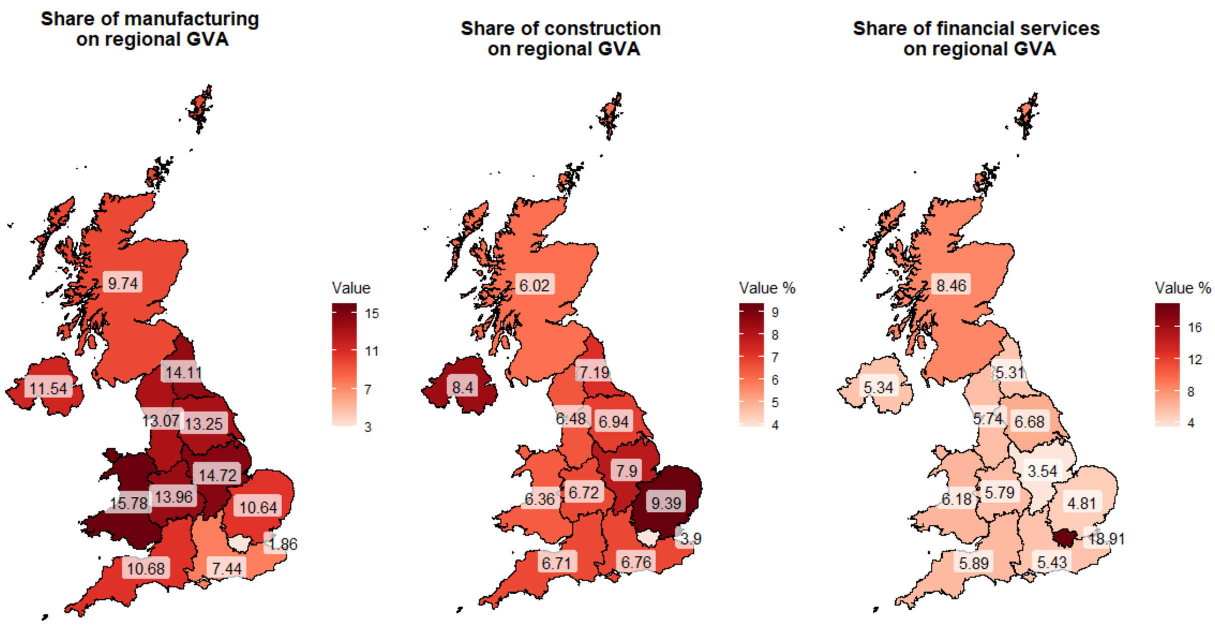
Regional disparities in economic activity are underpinned by substantial variation in the spatial distribution of sectoral activity. Figure 2 shows the GVA share of a selection of sectors for a given region's total output. Wales is the most manufacturing-intensive region, with manufacturing accounting for 15.8 per cent of its GVA, whereas London is 8.5 times less manufacturing-intensive, at only 1.86 per cent. Construction shares exhibit a narrower range: regional GVA shares span from 2.9 per cent in London to 9.4 per cent in the East of England, meaning London is roughly 2.4 times less construction-intensive than the East of England. Financial services shares range from 3.5 per cent of GVA in the East Midlands to 18.9 per cent in London. This implies that the East Midlands is about 5.3 times less finance-intensive than London. More generally, the economic composition of

Figure 1: U.K. Output Shares and Productivity by Region, 2023



London drives much of the spatial variation in sectoral concentration across the United Kingdom.

Figure 2: Spatial distribution of sectoral activity (value added shares, 2023)



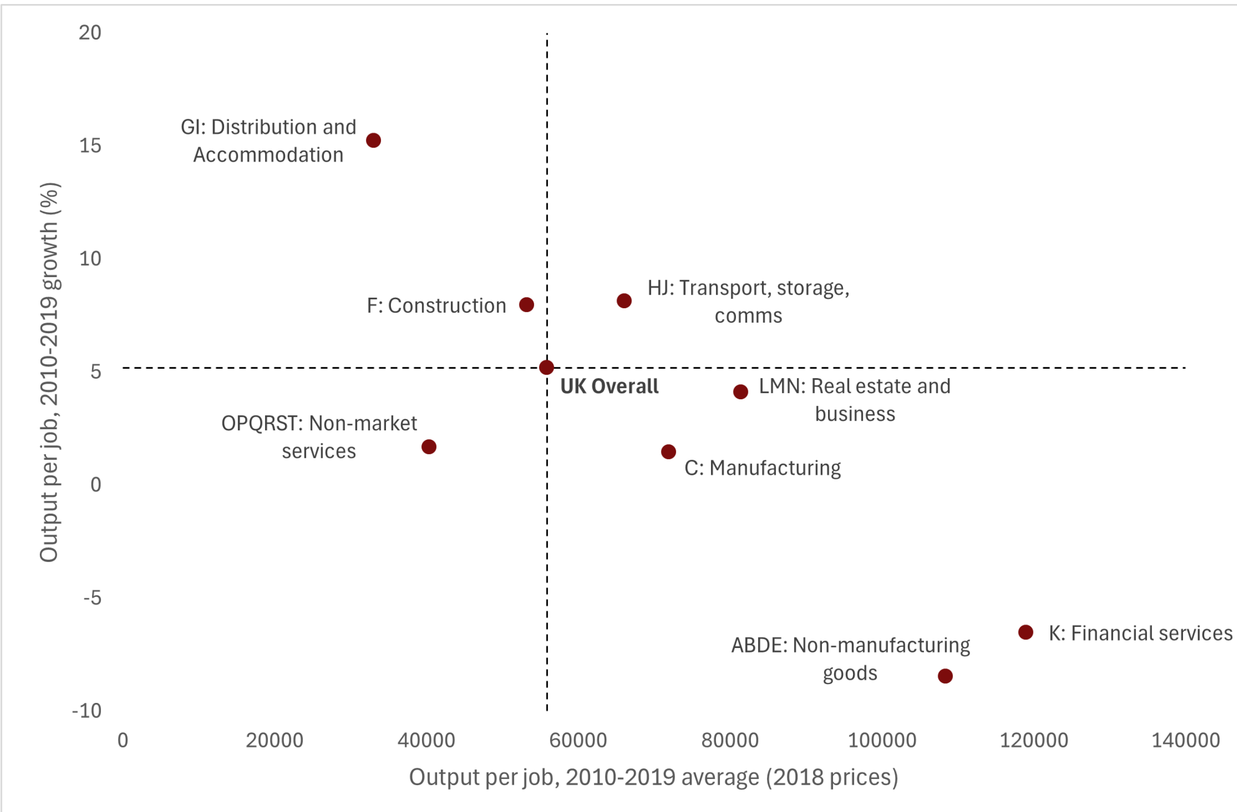
The spatial distribution of sectoral activity is important because sectors are not equally productive. Sectoral productivity differentials therefore directly inform regional differences in productivity levels and productivity growth. Figure 3 plots output per job in levels against output per job growth over the 2010–2019 period. The most productive sectors are non-manufacturing goods and financial services, while the least productive sectors are distribution and accommodation and non-market services. Figure 3 also shows that low productivity sectors tend to realise higher rates of productivity growth, with productivity actually falling for non-manufacturing goods sectors and financial services over the period 2010 to 2019.

2.2 Regional Trade Linkages

Given substantial variation in economic circumstances across regions, interregional trade linkages could play a key role in the propagation and amplification of sectoral and regional productivity shocks.

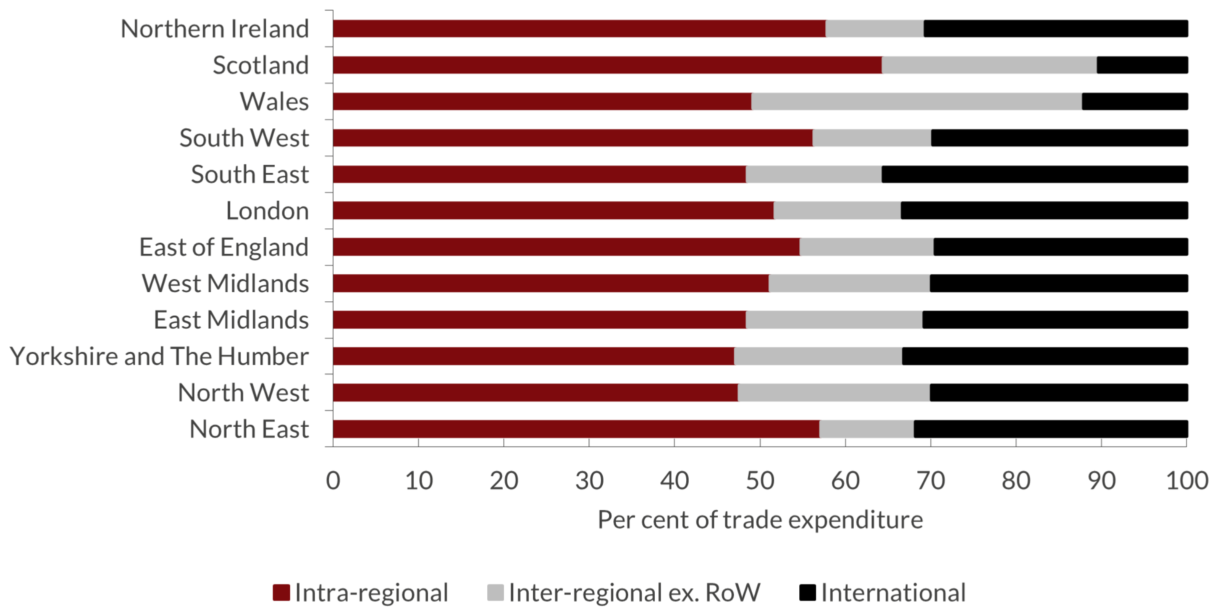
Every UK region relies heavily on intraregional trade (Figure 4) with the most autarkic region being Scotland where 64.4 per cent of trade expenditure is intraregional. The least autarkic regions are the North West and Yorkshire and The Humber, which exhibit intraregional trade expenditure shares of 47.5 per cent and 47.2 per cent, respectively. Interregional trade within the United Kingdom occupies a particularly large share of trade expenditure for Wales (38.7 per cent) and Scotland (25.2 per cent). It is perhaps surprising that interregional trade only accounts for 11.1

Figure 3: Sectoral productivity performance, output per job, 2010-2019



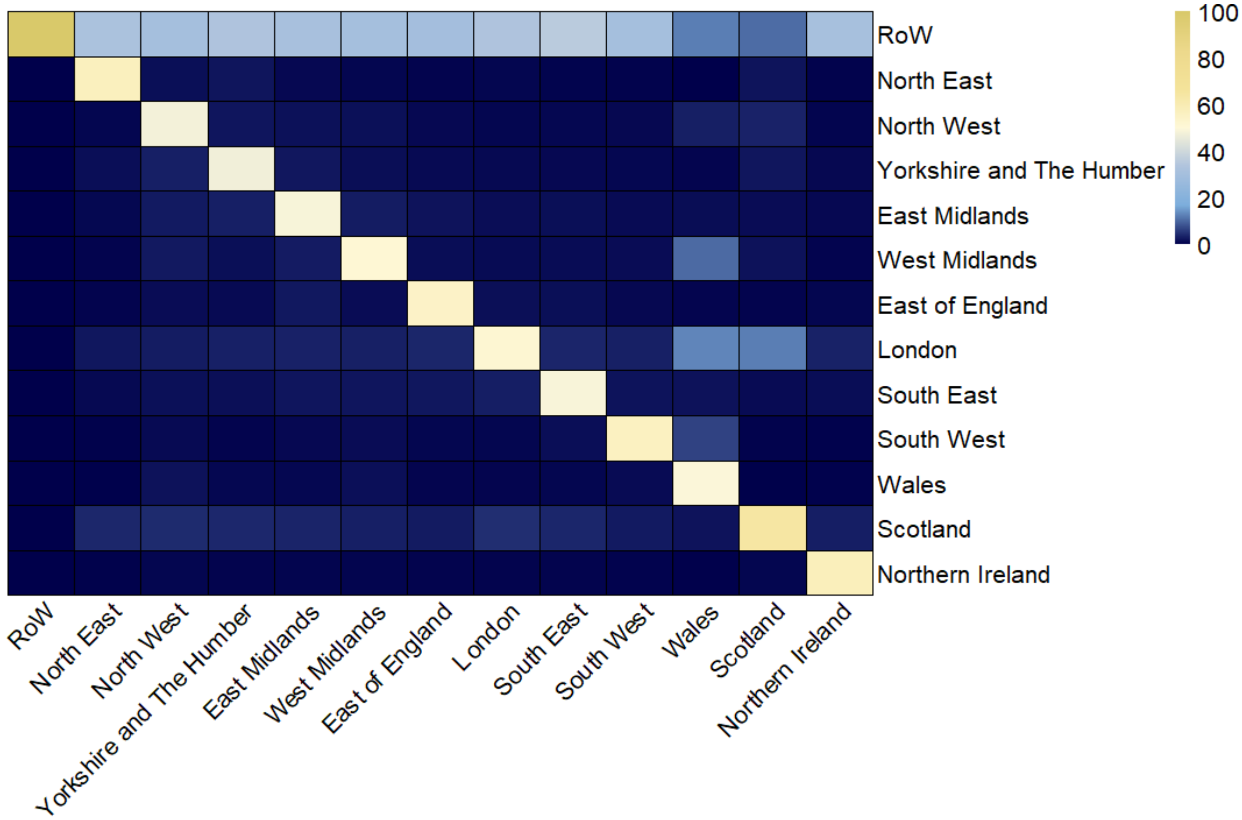
per cent of trade expenditure on the North East but 22.2 per cent in the North West. Note that most of this discrepancy cannot be explained by differences in reliance on imports from abroad but, instead, is largely explained by a much greater reliance on intraregional trade in the North East. As a relatively small open economy, each UK region relies heavily on imports from abroad. Global trade accounts for 27.8 per cent of total UK trade expenditure. The international share of trade expenditure is notably lower for Scotland (10.4 per cent) and Wales (12.1 per cent).

Figure 4: Trade expenditure shares by trade partner, 2010



To obtain a more granular picture of trade linkages, Figure 5 presents a heatmap of interregional trade expenditure shares. The UK's input-output network is sparse; for any given region, the majority of intermediates are purchased from a small set of regions. Naturally, the share of RoW expenditure on products from individual UK regions is small. Of the UK regions, London occupies the largest share of RoW expenditure at 0.048 per cent. The North East and Wales have the smallest shares of RoW expenditure at 0.009 per cent each. London and Scotland are key suppliers of traded intermediates for other UK regions, as indicated by the rows in Figure 5. London's share of total UK trade expenditure is 11 per cent while Scotland's is 13.3 per cent. By comparison, the UK trade expenditure shares of the other devolved nations of Wales and Northern Ireland are 2.2 and 2.4 per cent, respectively. London occupies a particularly large share of trade expenditure in Scotland and Wales. The converse is not true, highlighting that London plays a central role in supplying intermediates to Wales and Scotland but is not particularly reliant on imports from these regions. The trade linkages of Wales are particularly regionally concentrated, with intermediates predominantly supplied from abroad, London, the West Midlands, and South West. In contrast to the other devolved nations, Northern Ireland is not particularly reliant on imports from London, rather allocating most trade expenditure either internationally or intra-regionally.

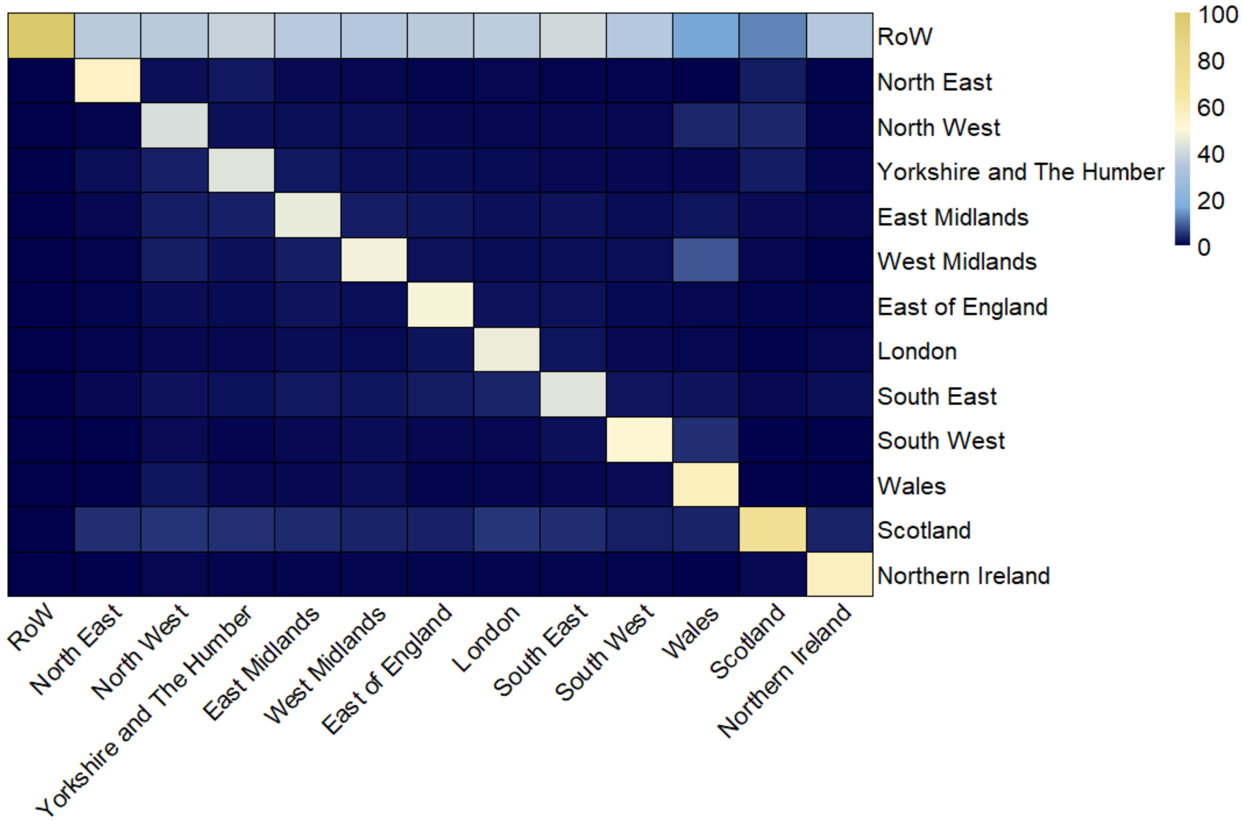
Figure 5: Heatmap of interregional trade expenditure shares, 2010



Source: EUREGIO Database, author's calculations.
Notes: Each (i, j) element in the matrix shows the percentage of total expenditure by region i (columns) coming from producing region j (rows).

Figures 6 and 7 display heatmaps of interregional goods and services trade expenditure shares, respectively. In line with the consensus on sectoral trade, regions are generally more autarkic with respect to services than goods as indicated by the brighter diagonal cells in Figure 7 compared to Figure 6. Expanding on the aforementioned importance of London and Scotland as domestic suppliers of intermediates, Figures 6 and 7 reveal that other UK regions rely on London as a supplier of tradable services while Scotland is a supplier of traded goods. The sectoral heatmaps also reveal that Wales predominantly purchases tradable services from other UK regions, relying more heavily on foreign imports (and the West Midlands) for the supply of intermediate goods. The international share of trade expenditure for both goods and services is lower in Scotland and Wales compared to other UK regions.

Figure 6: Heatmap of interregional goods trade expenditure shares, 2010



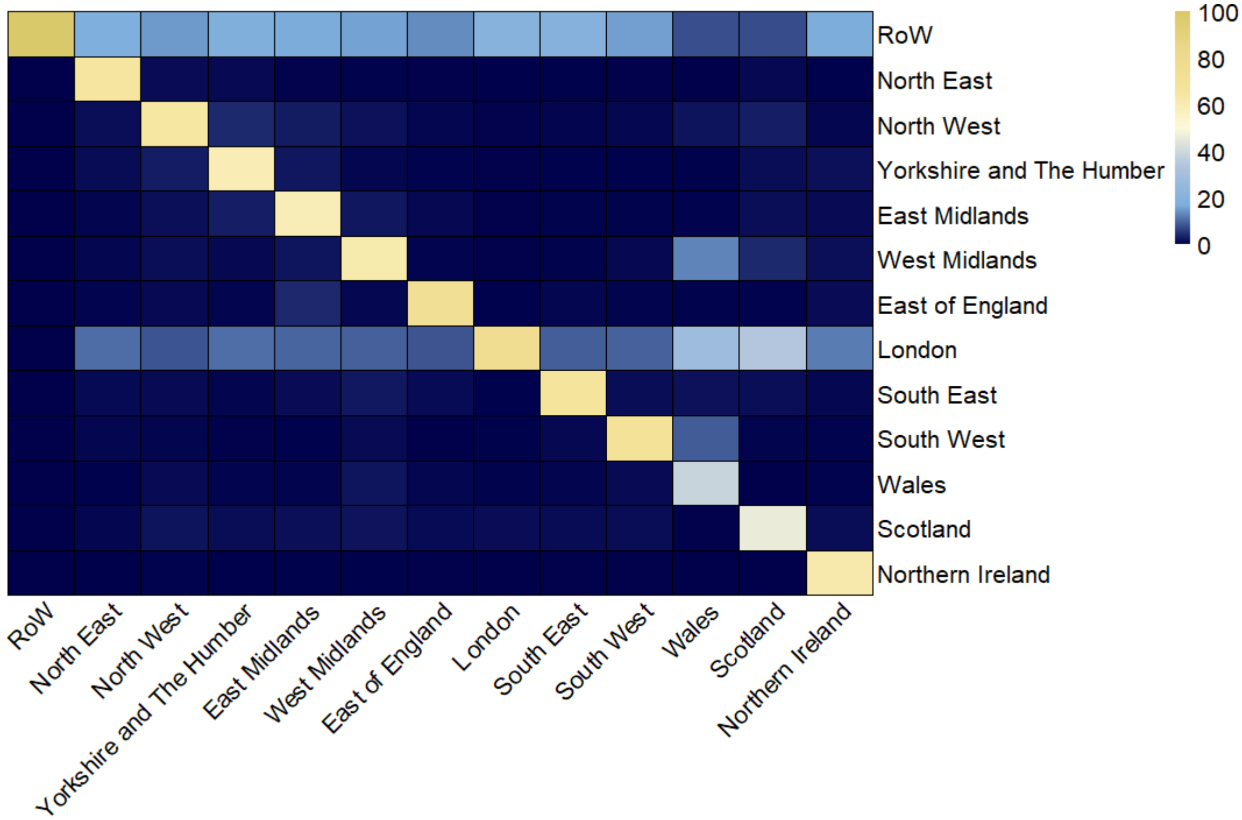
Source: EUREGIO Database, author's calculations.
Notes: Each (i, j) element in the matrix shows the percentage of total expenditure by region i (columns) coming from producing region j (rows). Figure excludes trade with construction sector.

2.3 The Sectoral-Regional Intersection

We have presented evidence of substantial heterogeneity in economic circumstances across UK regions, which influences the propagation and amplification of sector-specific or region-specific shocks. These are subject to a sparse network of trade linkages with particular reliance on supply of intermediates from international markets, London, and Scotland. We should expect regional comparative advantages and trade networks to inform the degree to which sectoral activity clusters in these specific regions.

Following Rice and Venables (2022), we create a summary statistic of sectoral clustering across regions, i.e., "sector sparsity". We first calculate region i's share of total workforce jobs in sector s: $S_{is} = L_{is}/\sum_i L_{is}$ where L_{is} denotes workforce jobs in region-sector pairing i, s. Next, we obtain region i's share of total UK workforce jobs: $X_i = \sum_s L_{is}/\sum_i \sum_s L_{is}$. Taking the ratio of these two statistics yields a measure of the importance of a region for a given sector relative to aggregate UK employment: $Q_{is} = S_{is}/X_i$. For each sector s, the shape of the distribution of Q_{is} across regions measures the sector sparsity; that is, the extent to which sectoral employment is concentrated in few regions. For each sector, we use the standard deviation σ_s to summarise the

Figure 7: Heatmap of interregional services trade expenditure shares, 2010

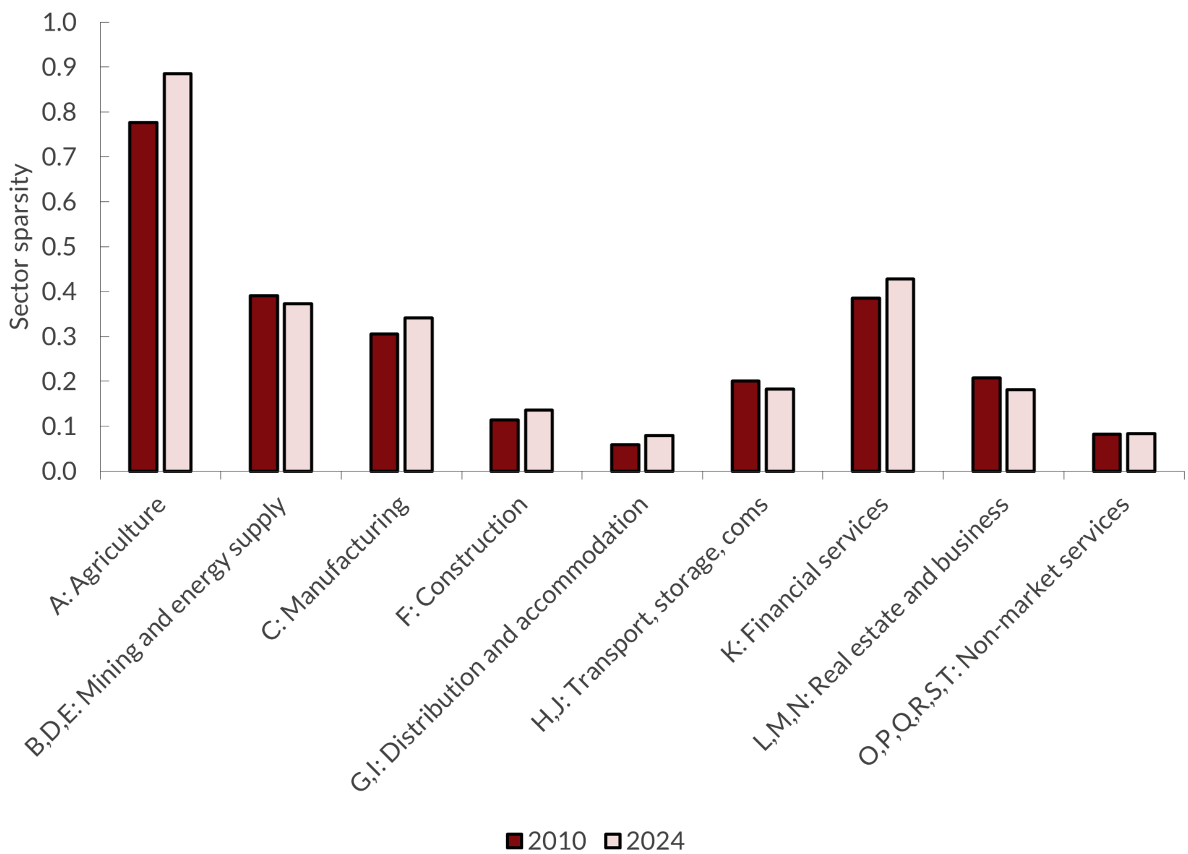


Source: EUREGIO Database, author's calculations.
Notes: Each (i, j) element in the matrix shows the percentage of total expenditure by region i (columns) coming from producing region j (rows). Figure excludes trade with construction sector.

shape of the distribution of Q_{is}. Sector sparsity increases with σ_s, meaning that for "ubiquitous" sectors (located everywhere in proportion to total employment), the distribution of Q_{is} is clustered around zero (Rice and Venables, 2022).

Figure 8 plots σ_s for each of our nine sector groups. Generally, intermediate goods producing sectors are sparser than services. This is consistent with the sectoral trade literature, which identifies a positive relationship between sparsity and sectoral tradability (Rice and Venables, 2022) and often characterises services as non-tradable (Caliendo et al., 2018; Cai et al., 2022). Financial services are particularly sparse relative to other services sectors. This is consistent with the fact that intermediate financial services tend to be traded outwards from London (see Figures 2 and 7). Also consistent with Figure 2, manufacturing is sparse relative to other sectors while construction is a comparatively ubiquitous sector. It is also promising that sparsity across sectors has remained broadly stable between 2010 and 2024, suggesting that using trade flow data from 2010 should not compromise the validity of our analysis of current trade linkages.

Figure 8: Sector sparsity across U.K. ITL1 regions in 2010 and 2024



3 Model

We build on Caliendo et al. (2018) for the overall structure of the sectoral and regional model, introducing international trade and assuming that services are fully tradable. Our objective is to analyse the role of domestic trade in goods and services in shaping the United Kingdom's industrial structure. We consider an open economy in which there is within-country and international trade between the 12 ITL1 regions. In each region, there are nine goods and services sectors. Firms use labour, capital and intermediate inputs as factors of production.

We assume that the representative firm in each sector and region exports and imports goods and services in the form of intermediate inputs with other regions. We model trade costs through the existence of iceberg costs. Following Eaton and Kortum (2002), producers differ in their productivity and the trade costs associated with different regions. Workers are freely mobile across regions and sectors, while capital stock is fixed locally. Agents consume a composite final good of all local sectors, such that there is no inter-regional trade in final goods.

3.1 Intermediate inputs

In region $i \in \{1, ..., N\}$ and sector j there is a continuum of producers $z \in [0, 1]$, whose production technology is given by

$$q_i^j(z) = Z_i^j(z) \left[T_i^j (L_i^j(z))^{1-\beta^j} (K_i^j(z))^{\beta^j}\right]^{\gamma^j} \left[\prod_{h=1}^{J} \left(M_i^{jh}(z)\right)^{\lambda_n^{jh}}\right]^{1-\gamma^j} \quad (1)$$

where q_i^j is the variety of output produced by sector j in region i in time period t; Z_i^j denotes the variety-specific component of gross output productivity, and L_i^j and K_i^j denote the firm demand for labour and capital, respectively. M_i^{jh} is sector h's output used as an intermediate input in sector j's production. All these terms are sector-region specific. T_i^j is the fundamental exogenous component of measured value-added productivity, and scales value-added and not gross output. γ^j is the share of sector j income spent on value added, β^j is the income share of capital infrastructures on value added, and λ_n^{jh} is the share of sector j spent on intermediate inputs from each sector h. We assume the production function has constant returns to scale, such that $\sum_{h=1}^{H} \lambda_n^{jh} = 1$.

3.2 Final goods

The quantity of final goods in (i, j) is denoted by Q_i^j, while the demand of intermediate input is given by $\widetilde{q}_{i,t}^j$.

$$Q_i^j = \left[\int \widetilde{q}_i^j(Z^j)^{1-1/\eta} \phi^j(Z^j) dZ^j\right]^{\eta/(\eta-1)} \quad (2)$$

As in Eaton and Kortum (2002), we assume that, in every period, gross output productivity Z_i^j is a random draw from a Fréchet distribution with shape parameter θ^j that varies across sectors, such as $F(Z) = e^{-Z^{-\theta^j}}$, and where $\phi^j(Z^j)$ is the probability density function of the distribution. All draws are assumed to be independent across sectors and regions. For a given intermediate variety, the particular vector of productivity draws received by the different n regions is $Z^j = (Z_1^J, Z_2^J, ...Z_N^J)$. Measured gross productivity is calculated as the resulting composite $A_i^j = Z_i^j T_i^{j\gamma^j}$.

We adopt the continuum-of-varieties framework for two key reasons. First, it allows us to capture realistic within-sector heterogeneity in firm productivity without requiring firm-level data for each UK region—a practical necessity given data limitations at the ITL1 level. Second, this approach generates smooth, gravity-type trade flows between regions that are consistent with empirical estimates of trade elasticities. The Fréchet distribution yields closed-form solutions for regional trade shares, making the model tractable while still capturing how domestic trade costs shape the selection of producers into different markets. This is particularly important for analysing the United Kingdom's industrial structure, as heterogeneity in firm productivity fundamentally determines which regions specialise in which activities and how they integrate into domestic and international value chains.

3.3 Prices and factor payments

Final goods are non-tradable and are consumed by local agents in the same location i where they are produced. Firms in each region and sector (i, j) purchase intermediate inputs from other regions and sectors (n, h). Intermediate inputs are costly to trade. We assume that there exist iceberg costs that reduce trade of intermediate inputs across regions. These trade costs include transportation costs and other barriers to trade. These iceberg costs $\tau_{in} \geq 1$ affect the shipping of intermediate goods from region i to region n. As is standard in the literature, we assume that there are no trade costs within a region ($\tau_{ii} = 1$). Note that trade costs do not vary with sector j.

Markets are competitive: from the firms' cost minimisation problem, subject to technology 1, the unit cost of input bundle is given by

$$x_i^j = \Omega^{jh} \left[\left(w_i^j \right)^{1-\beta^j} \left(r_i^j \right)^{\beta^j} \right]^{\gamma^j} \left(\prod_{h=1} (p_{ni}^h)^{\lambda_n^{jh}} \right)^{1-\gamma^j} \tag{3}$$

where $\Omega^{jh} = \left((\beta^j)\gamma^j \right)^{-\gamma^j} \left(\frac{1-\beta^j}{1-\beta^j} \right)^{-\gamma^j \beta^j} \left(\frac{\prod_{h=1} \lambda_n^{jh - \lambda_n^{jh}}}{1-\gamma^j} \right)$ is a constant term, w_i^j and r_i^j are the wage and rental rates of labour and capital respectively, and p_i^h is the price of sector-h's input from region n purchased by either sector in region i. The price of shipping produced goods from sector j in region n to location i depends on the iceberg trade costs and the input marginal costs:

$$p_{in}^j = \frac{\tau_{in} x_n^j}{Z_n^j (T_n^j)^{\gamma^j}} \tag{4}$$

The price paid for a particular variety whose vector of productivity draws is Z^j, $p_i^j(Z^j)$, is therefore given by the minimum of the unit costs across regions, adjusted by the transport costs

τ_{in}, i.e., competitive buyers purchase the variety from the supplier in either region that offers the lower price,

$$p_i^j(Z^j) = \min_i \left\{ \frac{\tau_{in} x_i^j}{Z_i^j (T_i^j)^{\gamma^j}} \right\} \tag{5}$$

Following Eaton and Kortum (2002), given the distribution of prices, the price of the composite sectoral final good j in region i may then be expressed as

$$P_i^j = \Gamma \left[\sum_{i=1}^{N} (\tau_{in} x_i^j)^{-\theta^j} (T_i^j)^{\theta^j \gamma^j} \right]^{-1/\theta^j} \tag{6}$$

where Γ is the Gamma function evaluated at $\left(1 - \frac{\eta-1}{\theta^j}\right)^{1/(1-\eta)}$. Regional and sectoral trade patterns in this model depend on the dispersion of productivities (comparative advantage) and trade barriers (geographic or economic). A lower value of θ^j generates more room for comparative advantage, rather than trade barriers, in driving trade patterns. As in Eaton and Kortum (2002), under the Fréchet distribution assumption, the share of region i's expenditure on sector-j goods from region n can be derived as

$$\pi_{in}^j = \frac{(\tau_{in} x_n^j)^{-\theta^j} (T_n^j)^{\theta^j \gamma^j}}{\sum_{n=1}^{N} (\tau_{in} x_n^j)^{-\theta^j} (T_n^j)^{\theta^j \gamma^j}} \tag{7}$$

Therefore, the probability of importing sector j goods from region n to region i depends on sector j's productivity in region n, the cost of the input bundle x_{it}^j, and the trade costs of shipping from region n to region i, τ_{in}.

3.4 Household consumption

Workers do not have access to an investment technology, and choose their consumption of varieties to maximise their utility in their location. The utility function of a worker in location i depends on the consumption index C_i defined over the varieties supplied by each location:

$$U_i = b_i C_i = b_i \prod_{j=1}^{J} (C_i^j)^{\psi^j}, \qquad \sum_{j=1}^{J} \psi^j = 1 \tag{8}$$

where amenities (b_i) capture characteristics of a location that make it a more attractive place to live regardless of the wage and cost of consumption goods, and we assume that they are exogenous. We incorporate Han et al. (2023) assumptions on regional and international trade to represent the regional differences in trade balances. The budget constraint of a representative household is

$$\sum_{j=1}^{J} P_i^j C_i^j + (\iota_i^{\text{Dom}} + \iota_i^{\text{Int}}) w_i L_i = w_i L_i + (\xi^{\text{Dom}} + \xi^{\text{Int}}) L_i \tag{9}$$

where ι_i^{Dom} and ι_i^{Int} are modeled as the ratio of domestic and international net exports to total value-added for region i in the baseline economy. The net returns $\iota_i^{\text{Dom}} w_i L_i - \xi^{\text{Dom}} L_i$ and $\iota_i^{\text{Int}} w_i L_i - \xi^{\text{Int}} L_i$ govern trade imbalances that emerge from interregional and international trade, which satisfy:

$$\sum_i \iota_i^{\text{Dom}} w_{i,t} L_{i,t} = \xi^{\text{Dom}} \sum_i L_{i,t}, \qquad \forall i \in \{1, \ldots, J\}; \tag{10}$$

$$\sum_i \iota_i^{\text{Int}} w_{i,t} L_{i,t} = \xi^{\text{Int}} \sum_i L_{i,t}, \qquad \forall i \in \{1, \ldots, J+1\}. \tag{11}$$

Given that net exports sum to zero, the lump-sum transfers ξ^{Dom} and ξ^{Int} will equal 0 in the benchmark.

Agents move freely across regions. In equilibrium, households are indifferent between living in any region ($U_i = \tilde{U}$, $\forall i$). Utility maximisation implies that goods consumption expenditure on each sector is a constant share of overall goods consumption expenditure in each region:

$$P_i^j C_i^j = \psi^j P_i C_i \tag{12}$$

where the expression for total expenditure is given by (9). The consumption goods price index (P_i) in location i depends on the consumption goods price index for each sector j in that location P_i^j, as given by the profit maximisation problem:

$$P_i = \prod_{j=1}^{J} \left(\frac{P_i^j}{\psi^j} \right)^{\psi^j} \tag{13}$$

3.5 Market Clearing

Labour and capital markets. From the profit maximisation problem and zero profits, payments for labour and capital in each sector are constant shares of revenue in that sector:

$$w_i^j L_i^j = \gamma^j (1 - \beta^j) q_i^j \tag{14}$$

$$r_i^j K_i^j = \gamma^j \beta^j q_i^j \tag{15}$$

The immobility of capital across sectors and regions once installed implies that the rate of return on capital does not need to be equalised across sectors and locations outside of steady state ($r_{it}^j \neq r_{nt}^h$). We choose the total labour income of all locations as our numeraire: $\sum_{i=1}^{N} \sum_{j=1}^{J} w_i^j L_i^j = 1$. Regional labour and capital market clearing require that

$$\sum_{j=1}^{J} \sum_{i=1}^{N} L_i^j = \sum_{i=1}^{N} L_i = \tilde{L} \qquad \& \qquad \sum_{j=1}^{J} \sum_{i=1}^{N} K_i^j = \sum_{i=1}^{N} K_i = \tilde{K} \tag{16}$$

Profit maximisation by the variety producers in each region i implies that

$$w_i^j L_i^j = \frac{1-\beta^j}{\beta^j} r_i^j K_i^j \tag{17}$$

In equilibrium, workers in either sector are indifferent between living in any region $U_i^j = U_{i'}^{j'}$, which implies the spatial arbitrage condition:

$$b_i \frac{w_i^j(1-\iota_i^{Dom}-\iota_i^{Int})+(\xi^{Dom}+\xi^{Int})}{P_i} = b_{i'} \frac{w_{i'}^{j'}(1-\iota_{i'}^{Dom}-\iota_{i'}^{Int})+(\xi^{Dom}+\xi^{Int})}{P_{i'}} \tag{18}$$

The above profit maximisation condition (17), together with the free mobility condition leads to

$$L_i = \left[\frac{\omega_i(1-\iota_i^{Dom}-\iota_i^{Int})}{\frac{P_i U}{b_i} - (\xi^{Dom}+\xi^{Int})}\right]^{\frac{1}{1-\beta^i}} K_i \tag{19}$$

where $\omega_i = \left(\frac{w_i^j}{\beta^j}\right)^{\beta^j}\left(\frac{r_i^j}{1-\beta^j}\right)^{1-\beta^j}$. Combining this with the labour market clearing condition, results in an expression for labour input in region i

$$L_i = \frac{\left[\frac{\omega_i(1-\iota_i^{Dom}-\iota_i^{Int})}{\frac{P_i U}{b_i} - (\xi^{Dom}+\xi^{Int})}\right]^{\frac{1}{1-\beta^i}} K_i}{\sum_{i=1}^N \left[\frac{\omega_i(1-\iota_i^{Dom}-\iota_i^{Int})}{\frac{P_i U}{b_i} - (\xi^{Dom}+\xi^{Int})}\right]^{\frac{1}{1-\beta^i}} K_i} \tilde{L} \tag{20}$$

This expression implies that the employment share in region i is increasing in its capital K_i and in the factor prices captured by ω_i. Conversely, employment in region i decreases with the relative size of the domestic and international trade surplus, as given by the ι_i^{dom} and ι_i^{dom}. Because the lump-sum transfers ξ^{dom} and ξ^{int} are homogenous across regions, an increase in the former implies larger contributions to the national and international portfolios, which decreases the income per capita available in region i, pushing workers away.

Goods market Goods market clearing implies that income in each location and sector y_i^j is equal to expenditure on the goods produced by that location and sector X_i^j:

$$y_i^j \equiv w_i^h L_i^h + r_i^h K_i^h = X_i^j, \qquad y_i = \sum_{j=1}^J y_i^j \tag{21}$$

Because of the zero profit assumption in the final goods sector, total revenue exhausts total expenditure on intermediates. This means that total expenditure is equivalent to the purchase of intermediate inputs by each sector. Using the share of region n's expenditure on sector j from region i π^j_{ni}, the above can be expressed as

$$y^j_i = \sum_{n=1}^{N+1} \pi^j_{ni} X^j_n \tag{22}$$

Regional market clearing in final goods implies that

$$X^j_i = \sum_{h=1}^{J} \lambda^{hj}_i \sum_{n=1}^{N} \pi^h_{ni} X^h_n + \psi^j y_i L_i \tag{23}$$

where X^j_i denotes total expenditures on final good j in region i, equivalent to total revenue. In equilibrium, in any region i, total expenditures on intermediate inputs purchased from other regions must equal total revenue from intermediates sold to other regions, such that

$$\sum_{j=1}^{J}\sum_{i=1}^{N} \pi^j_{ni} X^j_i + \underbrace{(\iota^{dom}_i w_i L_i - \xi^{dom} L_i)}_{\text{domestic surplus}} + \underbrace{(\iota^{int}_i w_i L_i - \xi^{int} L_i)}_{\text{intl. surplus}} = \sum_{j=1}^{J}\sum_{i=1}^{N} \pi^j_{in} X^j_n \tag{24}$$

3.6 General Equilibrium

The general equilibrium in each period is determined as in a standard static international trade model.

Definition 3.1. Equilibrium: Given region-specific labour and capital endowment $\{L^j_i, K^j_i\}^N_{i=1}$ in each location, trade costs $\{\tau_{in}\}$, productivity processes $\{T^j_i\}$, location fundamentals $\{b_i\}$, and structural parameters, an *equilibrium* is a stochastic process of wages, capital returns, mass of workers and stock of capital in each location and sector $\{w^j_i, r^j_i, L^j_i, K^j_i\}_{i \in N}$, measurable with respect to the fundamental shocks, such that, given prices, the allocations satisfy the equilibrium conditions determined by the bilateral trade shares (7), the equilibrium location prices (6), the labour and capital markets clearing condition (16), and the equilibrium in the goods market (23).

4 Aggregation and changes in measured TFP and GDP

The following section formalises the measurement of the aggregate variables within our framework. We define the aggregation rules for calculating TFP and GDP, based on the disaggregated equilibrium outcomes across regions and sectors, and consistent with UK industry and regional trade data.

4.1 Measured TFP

We follow Caliendo et al. (2018) and calculate measured sectoral total factor productivity in a region-sector pair (i, j) as

$$\ln A_i^j = \ln \frac{w_i^j L_i^j + r_i^j K_i^j + \sum_{h=1}^J P_i^h M_i^{jh}}{P_i^j} - (1-\beta_i)\gamma^j \ln L_i^j - \beta_i \gamma K_i^j - (1-\gamma^j)\sum_{h=1}^J \lambda_i^{jh} \ln M_i^{jh} \quad (25)$$

where the first term denotes gross output revenue over the sectoral price, which is equivalent to Y_i^j/P_i^j, while the last three terms denote the logs of the production factors.

From the equilibrium condition in the factor markets (14), $q_i^j = w_i^j L_i^j/\gamma^j(1-\beta^j)$, we substitute this into the production of intermediate goods as

$$q_i^j(z_i^j) = \frac{p_i^j(z_i^j) q_i^j(z_i^i)}{y_i^j} z_i^i \left[T_i^j (K_i^j)^{\beta^j} (L_j^n)^{1-\beta^j}\right]^{\gamma^j} \left[\prod_{h=1}^J (M_{jh}^n)^{\lambda^{jh}}\right]^{1-\gamma^j} \quad (26)$$

Given that $p_i^j(z_i^j) = x_i^j/z_i^j(T_i^j)^{\gamma^j}$, $A_i^j = x_i^j/P_i^j$, and using the gravity equation (7) (π_i^j), we can calculate changes in measured TFP $(\widehat{A}_i^j)$ using the ratio of the change in the cost of the input bundle to the change in the price of final goods, as

$$\ln \widehat{A}_i^j = \ln \frac{\widehat{x}_i^j}{\widehat{P}_i^j} = \ln \frac{(\widehat{T}_i^j)^{\gamma^j}}{(\widehat{\pi}_{ii}^j)^{1/\theta^j}} \quad (27)$$

Measured TFP at the level of a sector in a region is calculated based on gross output, so we use gross output revenue shares to aggregate these TFP measures into regional, sectoral, or national measures. Consider first the region-sector (i,j) that experiences a change or increase in fundamental productivity, T_i^j. The expression above implies that an increase in productivity increases its region and sector comparative advantage, increasing its reliance on self-produced, domestic inputs π_{ii}^j and reducing that of other regions, that purchase inputs from region i.

4.2 GDP

Real GDP is calculated by taking the difference between real gross output and expenditures on intermediates. Given the equilibrium factor demands of the intermediate good producers, as well as factor market equilibrium conditions, changes in real GDP may be written as

$$\ln \widehat{GDP}_i^j = \ln \widehat{w}_i^j + \ln \widehat{L}_i^j - \ln \widehat{P}_i^j \quad (28)$$

Using the gravity equation (7) (π_i^j), we can express changes in GDP resulting from changes in fundamental TFP as

$$\ln \widehat{GDP}_i^j = \ln \widehat{A}_i^j + \ln \widehat{L}_i^j + \ln \left(\frac{\widehat{w}_i^j}{\widehat{x}_i^j}\right) \quad (29)$$

Given that real GDP is a value-added measure, we use value-added shares in constant prices to aggregate changes in GDP. The impact on aggregate GDP is identical as that of measured TFP, but with two more effects. On the one hand, there is the impact of labour migration across regions and sectors. A positive productivity shock attracts workers to a given sector–region pair by means of higher marginal productivity and thus, higher wage rates, increasing GDP proportionally through $\widehat{L}_i^j$, as all production factors change in the same proportions and the production function of intermediates has constant returns to scale. On the other hand, through variations in factor prices, a productivity shock will alter the relative costs of capital and labour, which are embedded in x_i^j as in equation (3). As capital is fixed to a region, the relative price of capital falls more than wages, resulting in a decrease in GDP.

As we consider the aggregate economy-wide effects of a positive T_i^j, the end result for aggregate GDP may be larger or smaller than the original change. The overall impact will depend on whether the direct effect of migration dominates the strain on local resources in the region experiencing the change, i, as well as the intensity with which this fixed factor is used in the regions that workers migrate from.

5 Data and calibration

5.1 Regional Trade Flows

Our model requires the use of a multi-regional input-output framework disaggregated by sector. We use the most recently available 2010 data from the EUREGIO database, a time series of global input-output tables with regional detail for the European Union. For the United Kingdom, the database covers 37 NUTS2 regions and 14 economic sectors.

This database is constructed using several data sources, including the World Input-Output Database (WIOD) and the Eurostat regional economic accounts. Interregional trade estimates developed by PBL Netherlands Environmental Assessment Agency are then used to estimate the EUREGIO supply and use tables, while ensuring consistency of the regional tables with the national totals. The data used in the construction of EUREGIO are all survey data, with only non-behavioural assumptions made during estimation. This ensures that empirical analyses can measure the impact of changes in the behaviour of economic agents and in policies, without those behaviours being endogenously embedded in the model (Thissen et al., 2018).

To the best of our knowledge, the 2010 EUREGIO vintage is the most recent trade data publicly available for our purposes. We would ideally use more up-to-date estimates of interregional and intersectoral trade, especially given the United Kingdom's exit from the European Union and, most recently, a resurgence of protectionism following the announcement of widespread tariffs by the United States in April 2025. While Timmer et al. (2016) find that there was limited change in international trade fragmentation between 2000 and 2014, more recent innovations to trade policy could alter the degree to which our empirical analysis reflects current UK trade linkages. This is most relevant for the composition of input-output linkages, as higher barriers to trade with the European Union, for example, could alter the intraregional, interregional, and international composition of trade. Changes to trade barriers are less of a concern for the estimation of trade elasticities, since the spatial distribution of sectoral activity in our Ricardian framework is interpreted to reflect inherent sectoral characteristics rather than the prevailing structure of regional trade. Indeed, studies that analyse the effect of Brexit on trade in the United Kingdom use constant trade elasticities (Dhingra et al., 2017; Lewis and Tolva, 2024), supporting the intuition of our approach. To be sure, we find that our sectoral trade elasticity estimates are robust to excluding international trade flows, which tentatively suggests that recent changes in external trade costs are not consequential for our estimates.

5.2 Regional Trade Costs

The trade gravity equation framework requires a measure of bilateral trade costs τ_{in}. We use generalised transport cost data developed by Persyn et al. (2022), who estimate the total average cost of driving a representative 40-tonne articulated truck between the centroids of the ITL2 subregions using data on expected time taken and road distance travelled. The dataset covers the NUTS2 (equivalent to ITL2) regions of the United Kingdom and European Union. They assume that transport costs take the following functional form:

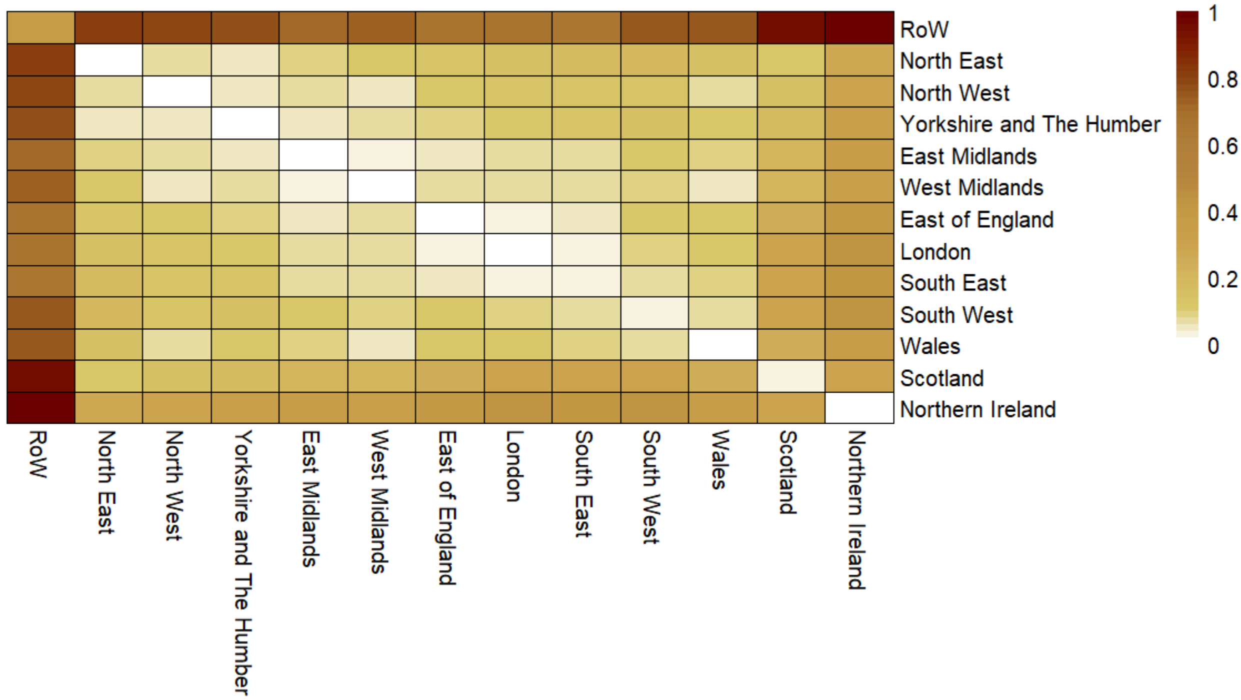
$$TC_{in} = \min_{p_{in} \in P_{in}} (D_{in} + T_{in}) + X_i + V_{in}$$

The total transport cost TC_{in} between a pair of regional centroids i, n is given by the cheapest path among the set of possible trips $p_{in} \in P_{in}$ and is a function of road distance D_{in}, travel time T_{in}, taxes X_i, and vignettes V_{in}. We use the harmonic averages of their estimates, since trade is more likely to occur between centroids in closer proximity to one another (Head and Mayer, 2010).

Since generalised transport costs are only available for the United Kingdom and the European Union, we estimate sectoral trade elasticities excluding trade flows from non-EU countries. We find that our trade elasticity estimates are robust when we incorporate non-EU trade flows using a trade cost approximation. We obtain ITL1-level transport costs for UK regions and generalised EU transport costs by taking the relevant harmonic averages of the more granular ITL2 data. It is worth noting that we do not calculate sector-specific transport costs. Since we estimate the trade elasticities of goods and services sectors, it is difficult to construct sector-specific transport costs in a way that preserves the interpretation of elasticities across sectors. This is likely to bias our elasticity estimates downwards, as shown by Zofío et al. (2025), who find that information regarding sector-specific trade costs drives variation between domestic and foreign substitution elasticities for goods-producing sectors. Despite this limitation, we find that our trade elasticity estimates without sector-specific costs remain interpretable across sectors, which is our primary objective in this exercise.

Figure 9 presents a heatmap of bilateral trade costs between UK ITL1 regions and the European Union derived from Persyn et al. (2022). Trade costs have been normalised against the range of bilateral costs across all region pairs. Unsurprisingly, intra-regional trade costs are the lowest for every region, since they reflect within-region trade. Northern Ireland and Scotland face particularly high domestic and international trade costs compared to other UK regions.

Figure 9: Heatmap of normalised bilateral trade costs



5.3 Estimating Sectoral Trade Elasticities

Trade elasticities capture the responsiveness of trade flows to changes in bilateral trade costs. In our Ricardian framework, sectoral trade elasticities θ^j are key parameters in our model, as they also identify the shape parameter of the Fréchet distribution of idiosyncratic firm productivity z_n^j. The intuition behind this relationship is as follows. A low dispersion of productivity for a given sector (high θ^j) implies that regions are similar in their efficiency in producing output for sector j. A high dispersion of productivity (low θ^j) implies that a few regions dominate in their efficiency in sector j. In turn, when productivity dispersion is low, trade flows are highly sensitive to changes in trade costs (high θ^j) because even small changes to regional trade costs can be sufficiently large to incentivise switching trade partners. Conversely, when productivity dispersion is high, trade flows are inelastic to changes in trade costs (low θ^j) because a few regions are particularly productive in sector j and are therefore insulated from cost shocks that disrupt trade in sector j.

We extend the methodology of Eaton and Kortum (2002) to estimate the vector of sectoral trade elasticities. From the bilateral trade shares equation (7), we obtain:

$$\frac{\pi_{in}^j}{\pi_{nn}^j} = \frac{(\tau_{in} x_i^j)^{-\theta^j}}{(\tau_{nn} x_n^j)^{-\theta^j}} \tag{30}$$

Taking logs gives:

$$\log\left(\frac{\pi_{in}^j}{\pi_{nn}^j}\right) = -\theta^j \left[\log(x_i^j) - \log(x_n^j) + \log\left(\frac{\tau_{in}}{\tau_{nn}}\right)\right] \tag{31}$$

Exploiting the normalisation of intra-regional trade costs, $\tau_{nn} = 1$, and substituting-in notation for exporter and importer fixed effects leaves us with the following equation for estimation:

$$\log\left(\frac{\pi_{in}^j}{\pi_{nn}^j}\right) = S_i - S_n - \theta^j \log\left(\tau_{in}\right) \tag{32}$$

where τ_{in} denotes the bilateral trade cost, S_i gives exporter fixed-effects, and S_n importer fixed-effects. The object π_{in}^j denotes region n's expenditure on intermediates from sector j produced by region i, while π_{nn}^j represents sector-specific intra-regional trade as region n's expenditure on intermediates from sector j produced by region n. We estimate equation (32) using OLS with importer and exporter fixed effects separately for each sector j, and identify θ^j from the coefficient on bilateral trade costs.

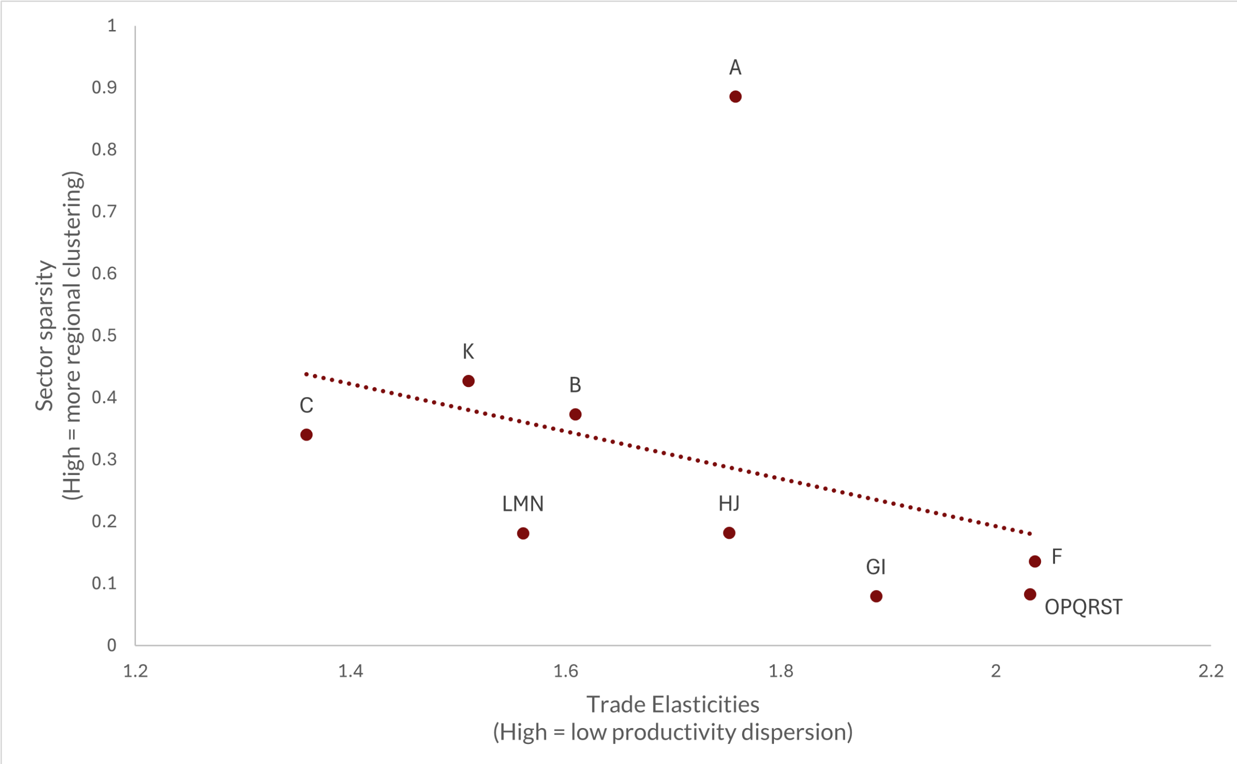
The sectoral trade elasticities estimated using equation (32) are shown in Table 2. Manufacturing exhibits the lowest elasticity (1.36) and construction the highest (2.04). Lower elasticities in manufacturing, finance, and professional services and higher elasticities in construction and non-market services are intuitive given the sparsity of these sectors across the United Kingdom. Recall that in our Ricardian framework a lower trade elasticity implies higher within-sector productivity dispersion, indicating that low-elasticity sectors compete on comparative advantage rather than trade costs on the margin. In turn, we should expect that sectors with high productivity dispersion (low θ^j) trade outwards from productive hubs as welfare gains from trade are larger. Figure 10 supports this intuition and illustrates a negative relationship between trade elasticities and sectoral sparsity.

Table 2: Sectoral Trade Elasticities

SIC07 code(s)	**Sector**	θ^j	Std. Error
A	Agriculture	1.76	0.165
BDE	Mining and energy supply	1.61	0.120
C	Manufacturing	1.36	0.100
F	Construction	2.04	0.159
GI	Distribution, hotels, and restaurants	1.89	0.140
HJ	Transport, storage, and communication	1.75	0.122
K	Financial intermediation	1.51	0.182
LMN	Real estate and business	1.56	0.200
OPQRST	Non-market services	2.03	0.157

Notes: Robust standard errors. All coefficients are significant at the 1% level.

Figure 10: Trade Elasticities and Sector Sparsity



The estimated sectoral elasticities are relatively small and narrowly dispersed compared with those commonly found in the Ricardian trade literature, which typically reports country-to-country elasticities at a higher level of sectoral disaggregation (Caliendo and Parro, 2015; Carrascal-Incera and Orea, 2024). This likely reflects, in part, our use of generalised trade costs that exclude sector-specific information and therefore may bias the estimates downward. However, it is also worth noting that the degree of industrial and regional aggregation matters for the calculation of these trade elasticities. Additionally, variation in industry-level elasticities will, by construction, not be captured by our higher-level sector-specific elasticities. We do not model country-to-country industrial trade but rather sectoral trade with a single foreign producer within a sparse interregional trade network.

Our sectoral trade elasticity estimates are closer to those in the scarcer literature on region-specific and country-specific trade linkages within the European Union, which typically use Armington-type trade models. Based on physical distance as a measure of generic transport costs, Zofío et al. (2025) find that domestic trade elasticities range from 0.96 to 1.64 for industries in the agriculture, mining and manufacturing sectors. Across these sectors, we obtain the range $[1.36, 1.76]$. Note that this is not their preferred specification, which instead uses sector-specific trade costs to obtain larger trade elasticities. Németh et al. (2011) estimate trade elasticities for energy-intensive goods sectors in Europe and obtain a range from 0.8 to 2.8. Bilgic et al. (2002) estimate Armington elasticities ranging from 0.3 to 2.87 for a selection of commodity groups. The plausibility of our trade elasticity estimates $[1.36, 2.04]$ is supported by the observation that Ricardian elasticities are typically smaller than Armington elasticities (Simonovska and Waugh, 2014).

Estimating and interpreting Ricardian trade elasticities for services is inherently more fragile than for goods, as measured trade flows and trade costs may imperfectly capture non-price frictions, quality differences, and the delivery modes of intermediate services (including cross-region sourcing within production networks). This concern is particularly relevant for non-market services, where observed trade and pricing are shaped by institutional arrangements and measurement conventions. More broadly, the services trade literature emphasises that services often enter value chains as intermediate inputs and that their traded component is harder to observe in conventional statistics, motivating input-output-based approaches and value-added accounting (e.g., Miroudot et al. (2009); Johnson and Noguera (2012); Miroudot et al. (2013)). Accordingly, we interpret the services sectors θ^j estimates as providing a useful calibration target for the model's propagation mechanisms and rankings, but we caution against over-interpreting them as precise structural objects.

5.4 Robustness of trade elasticities

To further validate our results, we perform three robustness checks. Following Zofío et al. (2025), we substitute our generalised transport cost measure for physical road distance. Given that both measures are sector-nonspecific, this comparison enables us to evaluate whether the generalised measure offers a more comprehensive representation of transport cost variation. We find that using physical road distance reduces the magnitude of elasticities across all sectors, although this is not statistically significant. The non-significance is unsurprising, given our relatively small sample size of 169 cross-sectional observations per sector, and the change in magnitude of the estimates suggests that generalised transport costs are more appropriate than simple road distances.

As a second check, we estimate sectoral trade elasticities using trade flows with both EU and non-EU countries. To construct a measure of non-EU trade costs, we first calculate the average distance between the United Kingdom and the European Union as well as the United Kingdom and the rest of the world. Next, we calculate the shares of EU and non-EU imports received by each UK ITL1 region. Finally, we weight the EU and non-EU trade distances from the United Kingdom according to the share of EU and non-EU imports of each UK region. This gives an approximation for trade costs with the rest of the world. We find that our trade elasticity estimates are robust to the incorporation of rest of the world trade.

For the third check, we estimate trade elasticities for a closed economy specification of UK trade. We find that trade elasticities are robust to this alteration, suggesting that recent innovations such as Brexit and US tariffs are unlikely to change our sectoral estimates. While the lack of distinction between foreign and domestic sensitivities may be an artefact of using sector-nonspecific trade costs, the key point is that the intuition behind the sectoral elasticities is preserved.

6 Counterfactual exercises

In this section we perform a series of counterfactuals to assess the relevance of sectoral linkages in shaping regional disparities in TFP, GDP and labour mobility. We consider shocks to fundamental productivity, local capital infrastructure, and trade costs between regions. We start the simulation with an initial guess on the price of the production factors. We compute sectoral price, input cost, intermediate input trade shares, income and gross output subsequently, updating the price of the production factors. A new general equilibrium is then solved with these new allocations.

We begin by analysing changes to all sectors in one region, which we refer to as regional changes. We then study changes to all regions in one sector, which we refer to as sectoral changes. Next, we examine specific sectoral-regional technology shocks. We continue with examining the impact of changes to variations in capital stock within a region. Finally, we reduce interregional trade costs to identify region pairs whose improved trade partnership would benefit national aggregate GDP the most. In all these exercises, we focus on the role of interregional trade in intermediate inputs, such that international trade is represented by the contribution of the international trade balance towards each region's income, as described in section 3.4. The set of all detailed tables of results can be found in the annex, section 8.2.

The magnitude of the changes we apply to target variables in the baseline equilibrium are of 1% shocks are designed to be small, local perturbations. These will generate different outcomes that we report in terms of percentage elasticities across regional, sectoral and aggregate variables. In practical policy terms, these objects map into bundles of interventions (e.g., skills and innovation policies that raise effective productivity; transport/digital infrastructure and regulatory frictions that lower effective trade costs; or place-based investment that expands the effective local capital stock). The required scale to achieve a 1% change is policy- and context-specific, so we interpret the results as informative about relative leverage across regions-sectors rather than as literal forecasts from a single programme[3].

6.1 Regional productivity changes

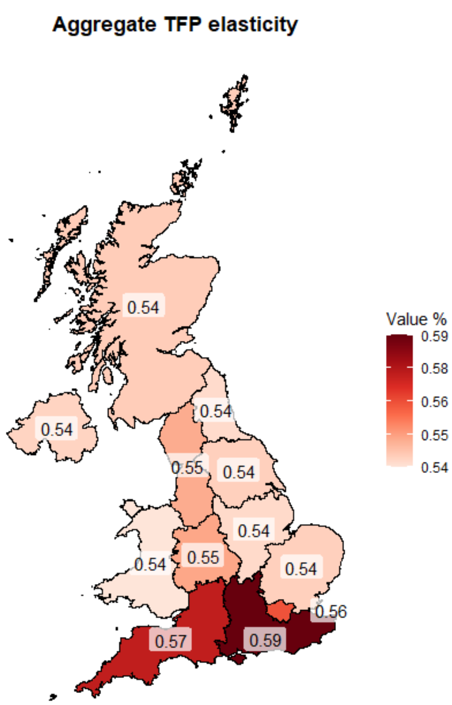
We let $\widehat{T}_i^j = 1.01$ for a set of industries J and regions N and let trade costs remain constant, as $\widehat{\tau_{in}}^j = 1$, for all j, n, i. In this particular counterfactual exercise, we assume that all sectors in a specific region face the same shock. The rationale is to show the relative importance of each region towards its contribution to aggregate TFP and GDP. We do this by calculating national aggregate TFP and GDP elasticities, so to ease comparison of results across regions and sectors. As in Caliendo et al. (2018), we take the variation of the aggregate variable, and we normalise it using the relative size of the region in which the shock was originated.

[3]Our benchmark calibration uses the EUREGIO interregional input-output data from 2010. This benchmark is well suited to capturing the structure of UK interregional production linkages in that period, but it predates major changes such as Brexit and COVID, as discussed in the previous section. Consequently, the quantitative magnitudes of the counterfactuals should be interpreted with caution when extrapolating to the current U.K. economy, and the results are best read as highlighting the mechanisms and the ranking of propagation channels under the 2010 production network.

As reflected in figure 11 for every single UK region, the TFP elasticity is lower than the magnitude of the productivity shock. This occurs because the shocks to fundamental productivity increase value-added, but measured TFP is based on gross output. The effect is attenuated by the share of intermediate inputs; the gains are effectively passed on as lower prices for goods and services along supply chains rather than being fully captured in the originating region's productivity. Although similar in magnitude, the results suggest that Southern regions have a higher impact on aggregate TFP than if the productivity shock originated in the North. Productivity gains in these regions are widely diffused as cheaper inputs for the rest of the UK economy.

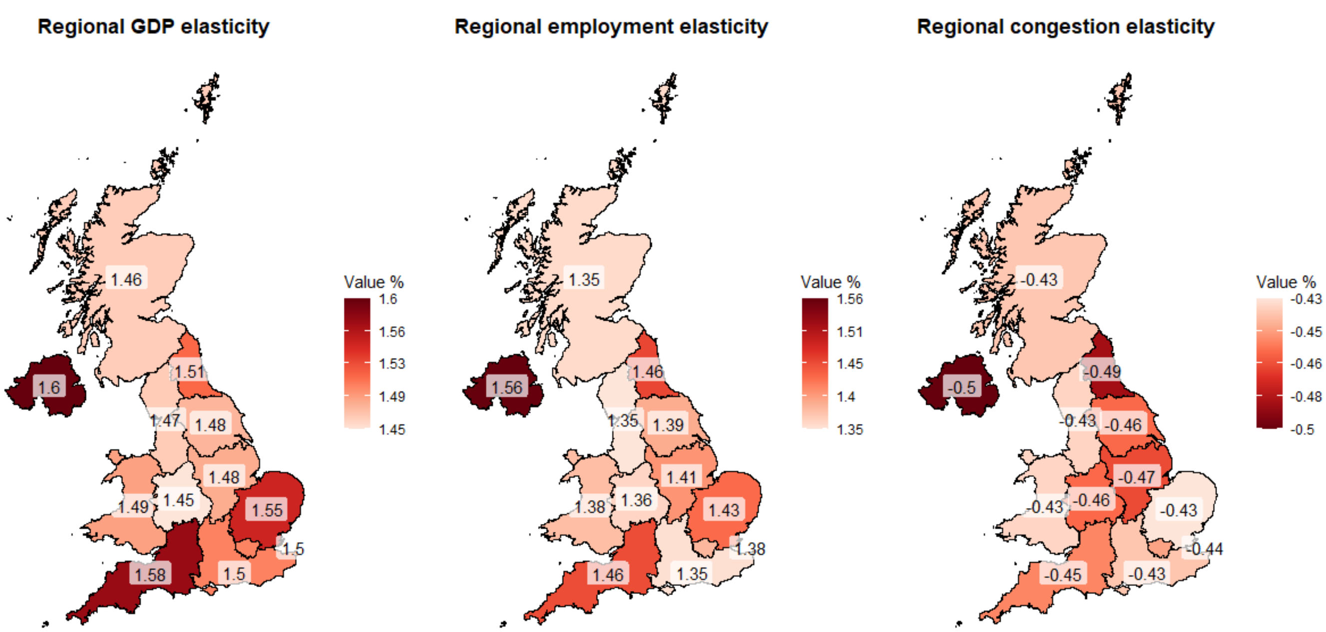
When examining the impact on aggregate GDP in panel b) of figure 11, which incorporates labour mobility and relative input cost, the results emphasise the regional disparities that highlight the UK's economic hierarchy. An increase of 1 per cent in the fundamental productivity of all sectors in London would increase national GDP by 1.27 per cent, in contrast with most other regions, where a similar shock would increase the UK's GDP by only slightly more than 1 per cent. A shock in one of the devolved nations would instead contribute less than 1 per cent. Note that despite the normalisation of these percentages using economic size, London and the Southern regions display the highest impacts on GDP, implying that these results are not just driven by their implied absolute variation.

Figure 11: Aggregate TFP and GDP elasticities



These impacts on aggregate national GDP can be measured in terms of the combined variation in each region's GDP, or through the channels described in equation (29). Panel a) in figure 12 displays the variation in regional GDP of the region in which the shock originates, showing that the impact is somewhat homogeneous. However, when we disaggregate the aggregate GDP elasticity using equation (29), we can compute the regional contributions of the TFP elasticity, labour mobility and the relative factor price effect. An increase in productivity in a region would provoke three effects that feed back to each other: first, it will directly increase regional GDP. Second, it will increase the marginal productivity of labour and hence the wage rate in the originating region, attracting workers from other regions. Panel b) in figure 12 shows that some regions would have a relatively stronger increase in their regional employment, specifically Northern Ireland (1.56 per cent), the North East and the South West (1.46 per cent). Third, these flows of workers will alter the relative allocation of labour and capital input. Assuming in a static equilibrium that regional capital infrastructure is fixed, the resulting capital-labour ratio will show regional differences in the regional wage-capital rent ratios, reflected in turn in the production costs. These congestion effects contribute negatively to aggregate GDP in the region that receives the flow of workers, as capital cannot reallocate regionally to balance this. As such, some regions show a stronger negative congestion effect, such as Northern Ireland and the North East, partially offsetting the stronger employment effect on GDP.

Figure 12: Regional GDP, employment and congestion elasticities



To test the relative strength of the sectoral tradability channel, we conduct two counterfactual exercises in which we homogenize the trade elasticity (θ^j) across all sectors. First, we assume that all sectors have the same trade elasticity as manufacturing ($\theta^j = 1.6, \forall j$). This implies that tradability of all sectors increases, although just slightly given their initial magnitude. The results in figure 11 barely change, although we notice a slight decrease in the variation of the regional GDP elasticity and employment. The aggregate GDP elasticity for most regions have a non-significant decrease, except for the devolved nations (Wales, Scotland, Northern Ireland), which show a higher impact.

In contrast, reducing sectoral tradability by setting $\theta^j = 8$ for all sectors, a value closer to the literature, increases regional GDP and employment across all regions. Consequently, trade flows become highly sensitive to trade costs, weakening comparative advantage and thereby weakening the mechanism that makes intermediate inputs produce regionally cheaper. The effect on aggregate GDP is mixed but, as with the first counterfactual, all deviations from the baseline are quantitatively small.

Furthermore, table 3 illustrates how trade and migration act as substitute mechanisms for distributing regional gains. A regional productivity shock implies that a region can produce goods and services cheaper, which implies first, that it will consume more of their domestically-produced intermediate inputs, decreasing their imports, and second, the other regions will consume more of these cheaper intermediate inputs, increasing the exports of the originating region. Given the relative size of each region and the heterogeneous intensity with which each region and sector employs inputs from other regions, there will be different impacts on the trade balances of each region.

Table 3: Regional trade balances and percent change (%) resulting from regional productivity shocks

Shock in →	Simulated initial	% Variation in trade balance											
Impact on ↓	trade balance	NE	NW	YH	EM	WM	EE	LDN	SE	SW	WL	SC	NI
North East	-1358.80	0.82	-0.90	-0.02	-0.01	0.01	-0.08	0.35	-0.23	0.04	-0.04	0.02	-0.05
North West	409.38	0.28	3.34	-3.36	0.06	-0.26	0.27	-2.49	1.19	0.23	0.82	-0.49	0.99
Yorkshire atH	-1097.31	-0.14	0.11	0.34	-0.47	0.05	-0.12	0.72	-0.40	-0.01	-0.13	0.09	-0.20
East Midlands	-1443.19	-0.11	0.06	-0.08	0.68	-0.66	-0.07	0.49	-0.30	0.01	-0.08	0.06	-0.11
West Midlands	-681.49	-0.19	0.25	-0.20	-0.03	0.16	-0.27	1.14	-0.62	-0.03	-0.50	0.32	-0.27
East of England	-2216.15	-0.11	0.06	-0.07	-0.04	0.05	0.58	-0.20	-0.29	0.02	-0.07	0.07	-0.14
London	6096.66	-0.04	-0.12	0.07	0.02	-0.02	0.00	1.26	-1.35	0.04	0.09	-0.04	0.10
South East	1193.84	0.08	-0.45	0.30	0.09	-0.10	0.10	-1.07	3.25	-2.54	0.35	-0.29	0.54
South West	1152.94	0.05	-0.37	0.23	0.05	-0.08	0.07	-0.80	0.38	2.54	-1.95	-0.38	0.43
Wales	-885.52	-0.18	0.13	-0.13	0.00	0.14	-0.26	0.89	-0.54	0.11	0.13	-0.26	-0.24
Scotland	590.30	0.14	-0.56	0.38	0.10	-0.16	0.22	-1.63	0.85	0.13	0.49	2.78	-2.40
Northern Ireland	-1760.65	-0.08	-0.04	0.01	0.00	0.01	-0.07	0.23	-0.19	0.04	-0.01	0.02	1.05

The first column in table 3 shows the calculated trade balance as given by the model equilibrium. London and the South keep a trade surplus from being the main suppliers of intermediate inputs to the other regions, while the North West and Scotland surplus comes from the supply of mining- and energy-related intermediates. The rest of the table shows how these trade balances change in percentage terms as a result of the productivity shock. Note that the diagonal in the matrix of trade variations is positive for all regions. This shows how an increase in fundamental productivity improves the trade balance for all regions: as intermediate inputs become cheaper, all regions would increase their demand of them. This effect is higher for regions that have a comparative advantage in certain industries: the North West in agriculture and mining, and London and the South East and West on services.

6.2 Sectoral productivity changes

Our framework also allows us to recover the aggregate impact on TFP and GDP of sectoral shocks. In this counterfactual, we assume there is a 1 per cent fundamental productivity shock to a specific industry in all regions. This allows us to identify not only which industries have a higher relevance in economic size terms, but also the channels through which their relevance operates. That is, whether their aggregate impact is driven mostly by a direct impact on TFP and GDP, or indirectly through variations in the productivity and production of the interlinked industries and regions.

Decomposing the aggregate TFP elasticity as in equation (27), these are lower than 1 per cent in all cases, as a result of the above mentioned impact of trade. However, sectoral linkages and trade also play a relevant role. The higher use of internally-produced intermediate inputs, i.e., inputs that the sector itself is producing to use by itself as an intermediate, reduces the impact of that sector on aggregate TFP. This is true in the case of manufacturing and construction (both around 0.44 per cent), which have higher coefficients of their own products in the input-output tables. The reason why is because improvements in productivity do not spread out that much to other sectors, which uses the intermediate inputs of these sectors in lower quantities and so, have a lower impact on their sectoral GDP and employment.

Table 4: Aggregate TFP and GDP elasticities of common sectoral shocks

Sector	Agg. TFP elast.	Agg. GDP elast..
Agriculture	0.558	1.439
Mining, quarrying, and energy supply	0.581	1.352
Manufacturing	0.439	0.875
Construction	0.448	0.744
Distribution, hotels and restaurants	0.536	0.786
Transport, storage and communication	0.539	1.29
Financial intermediation	0.551	1.318
Real estate and business activities	0.685	1.131
Non-market services	0.564	0.644

In turn, it is manufacturing and construction that show the lower impact on aggregate GDP, of 0.74 per cent and 0.78 per cent, respectively. In contrast, positive productivity shocks of 1 per cent in agriculture, mining and energy, financial intermediation, and transportation and communications have the higher impact on aggregate GDP, ranging between 1.3 and 1.45 per cent. As earlier, these magnitudes stem from a combination of increases in sectoral GDP, movements of workers across sectors, and relative factor price effects.

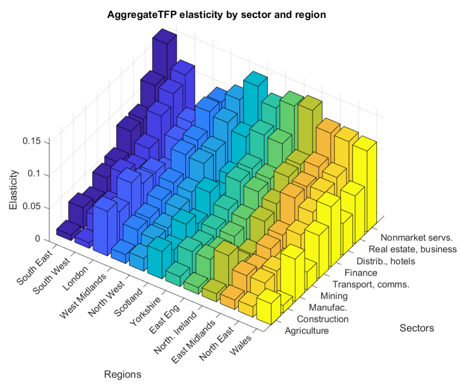
Distribution, hotels and restaurants, and non-market services are special cases regarding their comparatively lower impact on aggregate GDP. This is because these sectors exhibit strong local consumption bias—a significant portion of their output is consumed as final goods within the same region where it is produced, rather than traded as intermediate inputs to other sectors or regions. In the context of our model, this manifests through two complementary channels. First, their consumption shares (the ψ^j parameters) are relatively high, meaning productivity improvements primarily benefit local consumers through lower prices rather than enhancing the competitiveness of downstream industries. Second, as services with limited tradability (particularly for non-market services), the potential for positive spillovers through regional trade networks is constrained. While a fundamental productivity shock in these sectors raises regional real income, the limited scope for interregional reallocation of activity—through either trade in intermediates or labour migration toward more productive locations—reduces their aggregate GDP impact. Consequently, the benefits remain more geographically contained compared to sectors, where productivity gains rapidly propagate through domestic supply chains.

6.3 Regional- and sectoral-specific productivity shocks

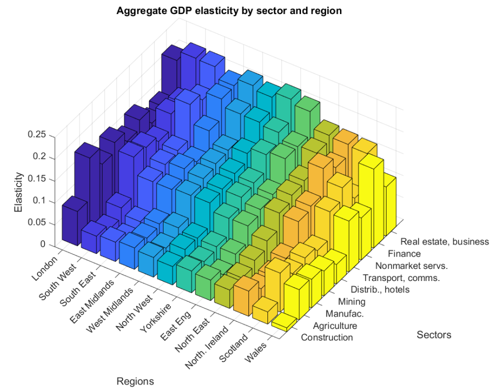
With this framework we can also trace the way in which TFP changes in specific regions and sectors propagate across all other sectors and regions in the UK economy. Figure 13 shows a representation of the impact of these shocks across the channels described above.

The aggregate TFP and GDP elasticities are displayed on panels a) and b), respectively, which show that the highest aggregate impacts on TFP and GDP result from improving productivity in the service sectors of London and the Southern regions. A 1 per cent productivity gain in non-market Services in the South East boosts aggregate GDP by 0.195 per cent—the single largest effect of any region-sector pair. Similarly, shocks to real estate & business activities in London and the South East, and to financial intermediation in the West Midlands and East Midlands, yield aggregate GDP elasticities above 0.2 per cent. Conversely, shocks in the devolved nations and peripheral English regions generally have smaller aggregate impacts. For instance, a comparable productivity improvement in Agriculture in Northern Ireland increases aggregate GDP by only 0.036 per cent. The exception is non-market Services in Scotland and Northern Ireland, which show relatively high elasticities (0.147 and 0.173 per cent, respectively).

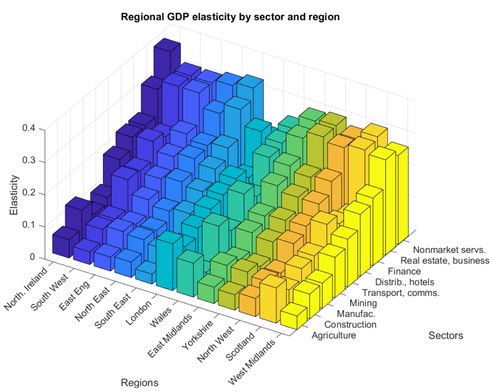
Figure 13: Aggregate and regional elasticities from a 1% shock to fundamental productivity.



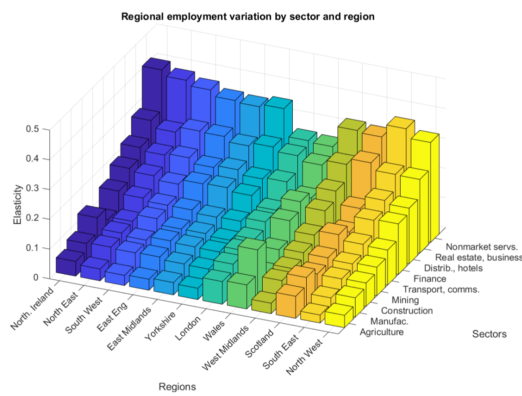
(a) Aggregate TFP elasticity



(b) Aggregate GDP elasticity



(c) Regional GDP elasticity



(d) Regional employment elasticity

Note: simulation results of individual shocks to fundamental productivity. Results show either the impact on aggregate GDP of a shock to a specific sector and region, or how regional GDP, employment and the congestion effect in that sector and region pair changes as a result of the shock. Elasticities are sorted out by average variation.

Comparing with the results in previous sections, a striking pattern emerges: productivity improvements in non-market services generate the highest aggregate GDP elasticities when the shock is confined to a single region. This stands in contrast to the sector-wide analysis, where non-market services showed the lowest aggregate GDP impact. The high local impact arises from different sources. First, non-market services constitute a large share of economic activity in every UK region. A productivity shock therefore generates a large initial regional GDP effect. Second, benefits are concentrated locally, as this sector is relatively less connected through trade in intermediate inputs, limiting positive spillovers to other regions. The productivity gain is not exported through cheaper inputs but instead translates directly into lower prices for local producers and consumers. In addition, as the sector is quite labour-intensive, the demand for labour increases substantially. This attracts workers from other sectors within the same region and from other regions. The resulting migration inflow creates a multiplier effect on regional GDP. While this labour inflow creates a negative congestion effect (reducing the local capital-labour ratio), the net effect on local GDP remains strongly positive due to the sheer scale of employment growth. On the aggregate impact, this interregional labour reallocation provokes a reduction of workers in other regions, resulting in reductions of output. The net effect on aggregate national GDP, while positive, is tempered by these offsetting reductions elsewhere, contributing to the the lower elasticities.

6.4 Variations in regional capital stock

Our framework features a fixed factor that we measure as the difference between gross value added and the compensation of workers in the data. Thus, we can use our calibrated model to analyse changes in capital infrastructure that result from particular investment projects or public transfers. To do so, we feed into the model an increase of 1% to the local capital stock in respective regions, and compute the regional aggregate TFP and GDP effects[4]. These shocks are best interpreted as the outcome of a bundle of infrastructure projects and complementary reforms that, taken together and possibly over multiple years, would raise the effective productive capital available to firms by 1%, rather than as the budget of a single programme.

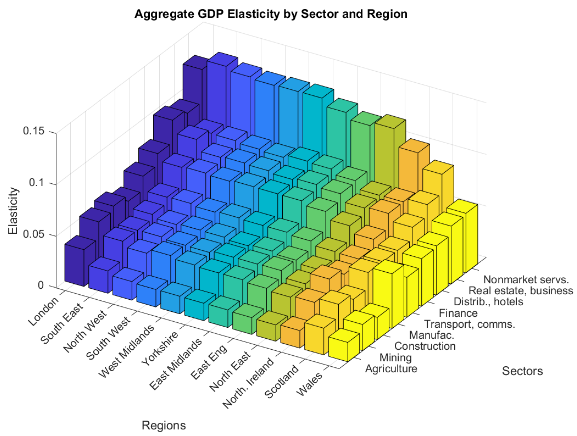
Capital stock changes also influence measured total factor productivity (TFP) through the channel identified in equation (27). Unlike a direct fundamental productivity shock ($\widehat{T}_i^j$), an increase in capital infrastructures affects measured TFP indirectly by altering production costs and regional trade patterns. From (17), depending on the initial factor allocation, the wage-capital rent ratio will increase in a higher proportion, increasing accordingly the unit production cost x_i^j. Through the gravity equation governing expenditures on intermediate inputs from either region (7), the origin region will have an increase in the expenditure on the domestically-produced inputs inputs through this mechanism, therefore contributing negatively to aggregate TFP. Our estimated TFP elasticities are all negative, but very small. This can be interpreted as a reduced gain from interregional trade, as the region relies less on potentially more efficient suppliers elsewhere. This is more a matter of measurement of gross output TFP rather than an actual deterioration of productivity, as the resulting increase in productive capacity is reflected in GDP rather than in measured TFP.

We summarise the results in figure 14, which as earlier, shows the ranking by sectors and regions of the impact of an increase in the capital infrastructure stock of 1 per cent in the specific region on aggregate TFP and GDP, which are of a maximum of a $0.15 - 0.2$ per cent elasticity.

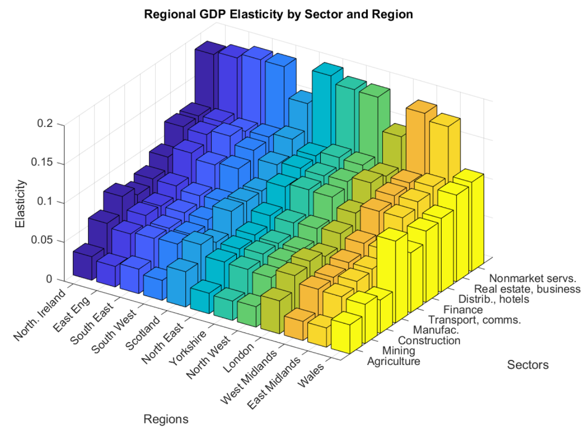
The results mirror those of the previous section regarding the impact of a productivity shock to specific regions and sectors qualitatively, however, the magnitude of the elasticities is comparatively lower when the shock is to the capital stock. This is because the shocks only alter the capital-labour ratio and subsequently, their relative cost, triggering changes in the total production costs that are

[4]In our calibration, we calibrate the size of capital rents by the difference between gross value added and the compensation of workers. Under this calibration, a 1% increase in capital stock corresponds to capital-equivalent injections of roughly £1,131 million in London and £948 million in the South East, with smaller regions requiring proportionately smaller amounts (e.g., around £211 million in the North East and £147 million in Northern Ireland). A more precise calibration would require regional and sectoral capital stock estimates. See Gardiner et al. (2020) and Daams et al. (2023) for recent analytical efforts employing regional measures.

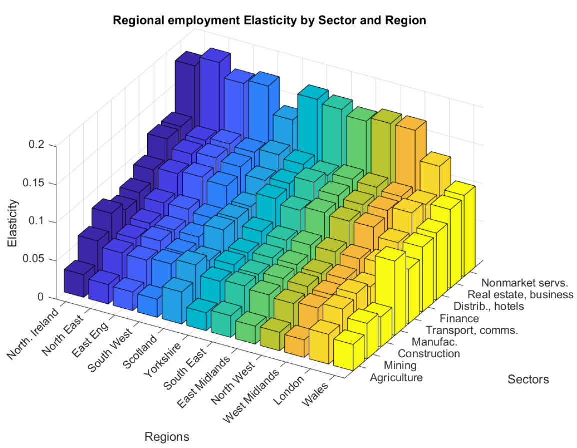
Figure 14: Aggregate and regional elasticities from a 1% shock to capital stock, by sector and region



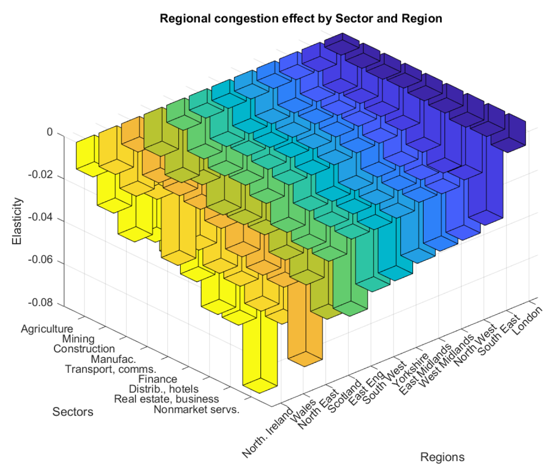
(a) Aggregate GDP elasticity



(b) Regional GDP elasticity



(c) Regional employment elasticity



(d) Regional congestion effect

Note: simulation results of individual shocks to capital infrastructure. Results show either the impact on aggregate GDP of a shock to a specific sector and region, or how regional GDP, employment and the congestion effect in that sector and region pair changes as a result of the shock. Elasticities are sorted out by average variation.

not accompanied with improvements in productivity, as in the earlier case. The mechanism for this divergence lies in how capital shocks propagate. Unlike a productivity gain that improves efficiency, a capital injection increases the scale of production in a location. Particularly for labour-intensive sectors, such as non-market services, this attracts inward migration of labour to complement the newly isntalled capital stock, adding to the positive contribution of regional GDP made by the increase in capital stock. The migration flows out of the other regions might improve or not their regional GDP, as on the one hand they decrease their labour input use, while on the other hand it alleviates the congestion effect on the existing local capital infrastructures in the out-migrated regions.

Panel a) in figure 14 shows that increasing capital stock infrastructure by 1 per cent primarily in London would give on average the highest impact on aggregate GDP, followed by the Southern regions, the North West and the West Midlands. These contributions are mostly concentrated in the services sectors. On the regional GDP variations, as in panel b), Northern Ireland, the East of England and the South East would see the highest increases in percentage terms, concentrated in the services sectors, as a result of the relatively lower capital-labour ratio in these regions and sectors. As such, these regions as well attract the most workers (panel c)), while the negative congestion effects from expanding their capital stock is the lowest across all regions (panel d)). These congestion effects, capturing changes in the wage relative to the overall input cost, are uniformly negative but varies substantially across regions and sectors. These are systematically more pronounced in peripheral regions (Wales, Northern Ireland, the North East) than in core regions (London, South East). This reflects differences in initial economic structure: peripheral regions tend to have higher employment shares in labour-intensive sectors, making them more sensitive to variations in the capital-labour ratio. In contrast, London's more capital-intensive economic structure allows it to absorb additional workers with less deterioration in factor proportions.

6.5 Changes in trade costs

In this section, we analyse how reductions in trade costs can have positive effects not just in specific regions, but also through their aggregate impact on GDP. We alter the gravity equation (7) in our model by reducing the trade cost parameter between two partner regions i and n, τ_{in}, by 1%, from a baseline value of 1. We could interpret this approach as a decrease in the cost of exporting goods and services due to less regulatory constraints, improvements in digital technologies that create trading opportunities across distant regions, or the effect of public expenditure on the highways or railroads connecting regions. Using our trade cost index, this represents a decrease in either the expected time taken and/or an increase in road distance travelled for a representative truck of goods between two regions. In this sense, a 1% change should be understood as a small change in an effective iceberg trade cost: it could reflect either a modest improvement in infrastructure performance (time/reliability), a reduction in administrative and information frictions, or changes that lower the fixed and variable costs of trading intermediate services across regions (e.g., interoperability of procurement and digital delivery). We compare the resulting equilibrium allocation and aggregation values with respect to our baseline allocations. More specifically, we compare the resulting regional and aggregate GDP with respect to the baseline scenario.

From the gravity equation (7), a reduction in trade costs will have the following impact. First, the share of a region's expenditure on goods produced in the other region will increase, and vice versa. From the expression of measured TFP (27), this also involves an increase in regional TFP, as both regions would be decreasing their expenditure share on domestically-produced inputs. This in turn will have a positive effect on regional GDP, as shown by equation (29). The magnitude by which regional and aggregate GDP would increase will depend on the new access each region will have to cheaper intermediate inputs being produced in their partner regions, effectively increasing production. The relative price ratio between primary inputs (capital and labour) and the price of the intermediate input bundle will determine whether these partner regions substitute labour with cheaper intermediate inputs, or the increase in production improves the marginal productivity of labour, attracting inflows of workers from other regions.

Table 5: Ranking of regional trade partners that increase aggregate GDP

Region 1	Region 2	Elasticity
West Midlands	Wales	0.0997
North West	Yorkshire	0.0956
Yorkshire	East Midlands	0.0893
London	Scotland	0.0798
South West	Wales	0.0755
London	South East	0.0727
East Midlands	West Midlands	0.0685
East Eng	London	0.0639
North West	East Midlands	0.0616
East Midlands	East Eng	0.0612
South East	South West	0.0605
North West	London	0.0561
Yorkshire	London	0.0510
North West	West Midlands	0.0508
North West	Scotland	0.0498
West Midlands	London	0.0494
West Midlands	Scotland	0.0492
North East	Yorkshire	0.0452
East Midlands	London	0.0450
London	South West	0.0444

Table 5 shows the ranking of trade partners whose reduction in the trade cost index by 1 per cent would increase aggregate GDP the most. Although the magnitudes are modest (ranging from 0.04% to 0.10%), several important patterns emerge from these results. First, the top three pairs—West Midlands-Wales (0.10%), North West-Yorkshire (0.096%), and Yorkshire-East Midlands (0.089%)—form a connected cluster of Northern and Midlands regions, suggesting that strengthening trade linkages within this industrial heartland yields the highest national aggregate returns. Notably, the West Midlands-Wales connection stands out as the most impactful single pair, highlighting the importance of cross-regional supply chains between Welsh manufacturing and Midlands industry. In addition, London appears in several pairs, but its most impactful connections are with Scotland (0.08%), the South East (0.073%), and East England (0.064%)—suggesting that improving London's links with peripheral regions yields greater aggregate benefits than intensifying connections with its immediate neighbours. This finding has important policy implications: investments in transport and digital infrastructure that better integrate London with distant regions could generate spillover effects comparable to or exceeding those from improving local connectivity.

Figure 15: Aggregate GDP elasticity of home region from reduced trade cost with trading partner

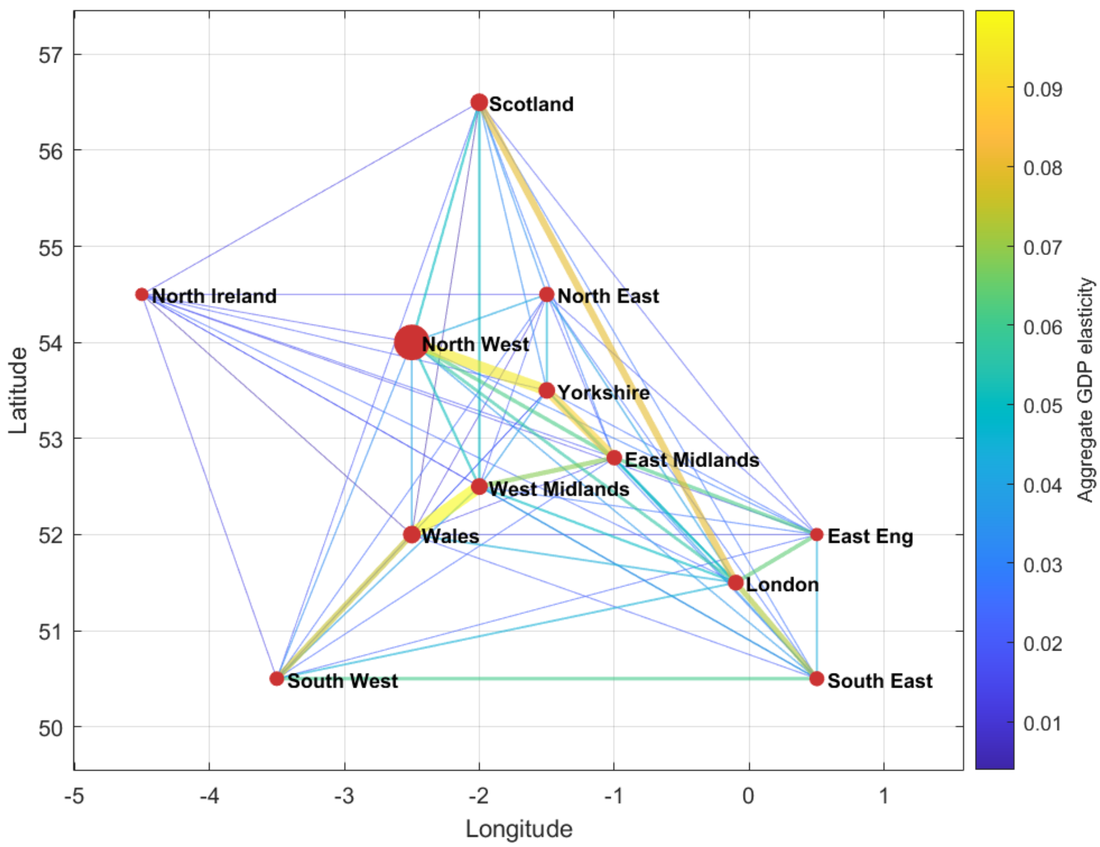


Figure 15 displays the network of the 11 ITL1 interregional trading partners in the United Kingdom. The size of each region's node represents an adjusted measure of that region's total contribution to aggregate GDP when its trade costs are reduced with any partner. The visualization reveals a clear hierarchy: the North West, West Midlands, and Yorkshire emerge as the most influential nodes, followed closely by Wales and the East Midlands. This suggests that policies targeting improved tradability with these central regions would yield the highest aggregate returns. The edges, representing the top connections from Table 5, form a cohesive network centred on the North West-Yorkshire-East Midlands axis, with important spokes extending to Wales and the South West. Notably, London and Scotland, while geographically peripheral, maintain critical bridging connections that integrate the network.

Table 6: Ranking of regional partners that increase regional GDP of Home region

Home region	Trading partner	Elasticity
West Midlands	Wales	0.2677
South West	Wales	0.2165
North West	Yorkshire	0.1885
Wales	West Midlands	0.1668
Yorkshire	East Midlands	0.1588
North West	North East	0.1445
London	Scotland	0.1387
East Midlands	Yorkshire	0.1361
North West	Wales	0.1316
North West	East Midlands	0.1308
South East	London	0.1306
Yorkshire	North West	0.1284
Scotland	London	0.1257
Yorkshire	North East	0.1225
London	Wales	0.1213
South East	South West	0.1196
East Eng	East Midlands	0.1189
West Midlands	East Midlands	0.1179
London	North East	0.1132
Wales	South West	0.1121

The regional GDP elasticities in Table 6 reveal substantially larger magnitudes than the aggregate effects—up to 0.27% for a 1% trade cost reduction—demonstrating that benefits concentrate heavily in the directly connected regions. The West Midlands-Wales pair stands out as uniquely beneficial for both parties: West Midlands gains 0.27% from reduced costs with Wales, while Wales gains 0.17% from reduced costs with West Midlands (ranked fourth). This mutual benefit suggests a particularly strong complementary relationship, likely reflecting deep integration in automotive and manufacturing supply chains.

The North West emerges as the most versatile region, appearing in five of the top twenty pairs with different partners (Yorkshire, North East, Wales, and East Midlands), with elasticities ranging from 0.13% to 0.19%. This versatility suggests that the North West functions as a critical hub in the northern economy, where improvements in multiple trade linkages could generate compounding benefits. Similarly, Yorkshire appears in four high-value pairs (with East Midlands, North West, and North East), reinforcing the importance of intra-Northern connectivity.

Figure 16: Regional GDP elasticity of home region from reduced trade cost with trading partner

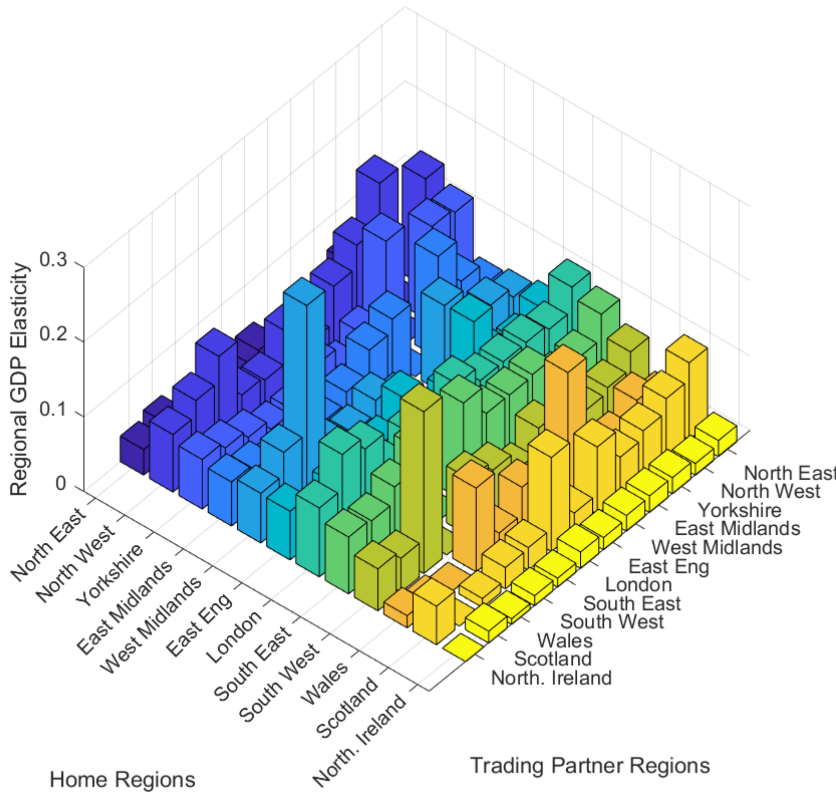


Figure 16 displays all regional GDP elasticities by trading partner, with regions sorted from North to South. The visualization reveals a striking north-south gradient: Northern regions (North East, North West, Yorkshire) consistently show higher elasticities when trading with other Northern regions than with Southern ones. This pattern suggests the existence of a self-reinforcing "northern economic cluster" where trade cost reductions generate amplified local benefits. For London, paradoxically, the highest regional GDP gains come from connections with the most distant regions—Scotland (0.139%) and the North East (0.113%)—rather than its immediate neighbours in the South East. This finding challenges the conventional wisdom that proximity determines the value of trade linkages; instead, it suggests that reducing frictions with economically distinct, distant regions allows London to access differentiated inputs and markets that complement its specialised service economy.

These results carry important policy implications. First, infrastructure investments that reduce trade costs between Northern regions could yield self-reinforcing growth in the "northern powerhouse," with benefits an order of magnitude larger than those suggested by aggregate analysis alone. Second, policies linking London with peripheral regions—particularly Scotland and the North East—could generate significant regional gains for the capital while simultaneously benefiting the connected periphery. Third, the mutual benefits between Wales and the West Midlands suggest that targeted investments in cross-border connectivity could yield particularly high returns, potentially helping to address the persistent Wales-England economic divide. More broadly, these findings indicate that trade cost reduction policies should be strategically targeted based on regional complementarities rather than applied uniformly, as the distribution of benefits is highly heterogeneous across pairs.

Comparing the aggregate and regional results reveals an important insight: the pairs that generate the largest aggregate GDP gains (e.g., West Midlands-Wales, North West-Yorkshire) also tend to appear among the top regional beneficiaries, but the regional elasticities are 2-3 times larger than their aggregate counterparts. This multiplier effect implies that policies facilitating interregional trade not only generate concentrated benefits for directly connected regions but also produce positive spillovers that propagate through the wider economy. The challenge for policymakers is to design interventions that capture these spillovers while ensuring that the concentrated regional benefits translate into sustained local development rather than transitory gains.

7 Conclusion

In this paper, we have provided an analysis of the links between sectoral and regional economic structures and aggregate productivity in the United Kingdom. By integrating a unique dataset on interregional trade in goods and services into a quantitative spatial model, we have traced the propagation of economic shocks through the complex network of regional and sectoral linkages. Our findings reveal an homogenous landscape, with a highly differentiated aggregate impact that is concentrated in London and the Southern regions, highlighting the North-South divide in the United Kingdom.

A key contribution of our empirical strategy was the estimation of sector-specific trade elasticities for the UK context, which revealed considerable variation across sectors—from a low of 1.36 in manufacturing to a high of 2.03 in non-market services. These estimates, which align intuitively with measures of sectoral sparsity, are critical for our quantitative exercises; they determine how sensitively regional comparative advantage and trade patterns respond to cost shocks, thereby shaping the ultimate propagation of productivity improvements through the economy.

Our counterfactual exercises, underpinned by these elasticities, yield several key policy-relevant insights. These insights should be interpreted as model-based rankings of relative leverage across regions and sectors, rather than as causal estimates of the effects of specific policy programmes. First, we find that the aggregate benefits of regional productivity improvements are proportional to regional economic size. While London and the South East exert the largest influence on aggregate GDP due to their scale, regions like the East of England and the South West exhibit a slightly higher potential for driving aggregate TFP gains. Second, from a sectoral perspective, shocks to agriculture, mining and finance's productivity are most effective at boosting aggregate GDP, while improvements in services sectors, particularly real estate and professional business services, have the most significant impact on aggregate TFP.

Two considerations are important for interpreting these results. First, our framework is static and therefore captures a comparison of equilibria under fixed local capital. For policies that are inherently dynamic (e.g., infrastructure investment, capital deepening, and regional development), the reported elasticities should be read as short-run comparative-statics, whereas longer-run effects will depend on investment adjustment costs, gradual migration, and other frictions that can either attenuate or amplify the propagation mechanisms. Second, our benchmark calibration relies on 2010 interregional input-output data. Because this period predates Brexit and COVID, the quantitative magnitudes may differ under today's production network; nonetheless, the analysis remains informative about the key channels through which shocks propagate and about the relative leverage of regions, sectors, and trade partnerships.

Our analysis of capital investment underscores that place-based policies, such as targeted infrastructure spending, can have meaningful spillover effects. We show that increases in a region's capital stock not only boost local output but also reallocate labour and alter production costs nationwide, with the largest aggregate GDP effects arising from investments in London and other southern regions. Finally, our exploration of trade cost reductions highlights the importance of specific regional partnerships. Policies that enhance connectivity—for instance, between the West Midlands and Wales, or between the Northern regions of the North West, Yorkshire, and the East Midlands—offer some of the highest returns in terms of aggregate GDP growth.

Overall, our results underscore the importance of a dual approach to economic policy that is both regionally sensitive and sectorally targeted. A one-size-fits-all national strategy is ill-suited to address the deep-seated UK regional disparities. Instead, effective policy should account for the specific comparative advantages and sectoral specializations of different areas. Policies that combine targeted investment in physical and human capital with measures to reduce trade frictions, such as improving transport links and promoting e-commerce in services within the United Kingdom, could unlock significant gains in both local and national economic performance.

This research opens several avenues for future work. First, international trade constitutes a significant share of intermediate and final goods consumption across most UK regions. Consequently, changes to the domestic mechanisms analyzed in this paper may indirectly influence these international flows and, in turn, modify interregional relationships within the United Kingdom. Another key limitation of our static framework is the treatment of capital as a fixed, local factor. A dynamic model with capital accumulation and investment flows across regions would provide an improved understanding of adjustment paths regarding variations in the allocation towards labour and capital. Alternatively, incorporating a more granular analysis of labour skills or housing markets (such as distinguishing what fraction of capital infrastructure is dedicate to private commercial uses) would allow for a deeper investigation of the barriers to mobility that perpetuate regional inequalities. Finally, applying this framework to evaluate specific, real-world policy interventions, such as the UK government's "Levelling Up" agenda, would be a natural and valuable extension.

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8 Appendix

8.1 Derivations: Intermediate inputs

In region $i \in 1,...,N$ and sector j there is a continuum of goods' producers $z \in [0,1]$ whose production technology is given by

$$q^j_{i,t} = Z^j_{i,t}\left[T^j_{i,t}(L^j_{i,t})^{\beta^j_i}(K^j_{i,t})^{1-\beta^j_i}\right]^{\gamma^j_i}\left[\prod_{h=1}^{J}\left(M^{jh}_{i,t}\right)^{\lambda^{jh}_i}\right]^{1-\gamma^j_i} \tag{33}$$

The unit cost of producing varieties with draw z^j is given by

$$\min_{L^j_{it},K^j_{it},\{M^{jh}_{it}\}^J_{h=1}} w_{it}L^j_{it} + r_{it}K^j_{it} + \sum_{h=1}^{J} P^j_{it}M^{jh}_{it} \tag{34}$$

$$\text{s.t.} \quad Z^j_{i,t}\left[T^j_{i,t}(L^j_{i,t})^{\beta^j_i}(K^j_{i,t})^{1-\beta^j_i}\right]^{\gamma^j_i}\left[\prod_{h=1}^{J}\left(M^{jh}_{i,t}\right)^{\lambda^{jh}_i}\right]^{1-\gamma^j_i} = 1 \tag{35}$$

where P_{it}^j is the price of final goods in sector j in region i. Let x_{it}^j denote the cost of the input bundle needed to produce intermediate input varieties in (i, j). Then

$$x_{it}^j = \Phi_i^{jh} \left[(w_{it})^{\beta_i^j} (r_{it})^{1-\beta_i^j} \right]^{\gamma_i^j} \left(\prod_{h=1} (p_{it}^h)^{\lambda_i^{jh}} \right)^{1-\gamma_i^j} \tag{36}$$

where

$$\Phi_i^{jh} = \left((1 - \beta_i^j) \gamma_i^j \right)^{-\gamma_i^j} \left(\frac{\beta_i^j}{1 - \beta_i^j} \right)^{-\gamma_i^j \beta_i^j} \left(\frac{\prod_{h=1} \lambda_i^{jh - \lambda_i^{jh}}}{1 - \gamma_i^j} \right) \tag{37}$$

The unit cost of an intermediate input with idiosyncratic draw Z_i^j in region-sector pair (i,j) is then given by

$$\frac{x_{it}^j}{Z_{it}^j T_{it}^{j\,\gamma_i^j}} \tag{38}$$

Firms located in region i and operating in sector j will be motivated to produce the variety whose productivity draw is Z_i^j as long as its price matches or exceeds $x_{it}^j / Z_{it}^j T_{it}^{j\,\gamma_i^j}$.

Because the production function is Cobb-Douglas, profit maximisation implies that input demands for all supplier sectors h satisfy

$$\frac{w_{it} L_{it}^j}{p_{it}^j q_{it}^j} = \gamma_i^j \beta_i^j \tag{39}$$

$$\frac{r_{it} K_{it}^j}{p_{it}^j q_{it}^j} = \gamma_i^j (1 - \beta_i^j) \tag{40}$$

$$\frac{p_{it}^h M_{it}^{jh}}{p_{it}^j q_{it}^j} = \lambda_i^{jh} (1 - \gamma_i^j) \tag{41}$$

These conditions imply that

$$w_{it} L_{it}^j = \frac{\beta_i^j}{1 - \beta_i^j} r_{it} K_{it}^j$$

8.2 Detailed tables of results

Table 7: Figure 13, panel a): Aggregate GDP elasticities from a 1% shock to fundamental productivity.

	NE	NW	YH	EM	WM	EE	LDN	SE	SW	WL	SC	NI
AG	0.016	0.02	0.015	0.015	0.014	0.01	0.068	0.008	0.008	0.033	0.042	0.012
MIN	0.029	0.042	0.034	0.039	0.044	0.035	0.058	0.042	0.061	0.028	0.031	0.02
MANUF	0.035	0.031	0.028	0.026	0.034	0.029	0.077	0.024	0.029	0.065	0.048	0.023
CONS	0.034	0.031	0.036	0.034	0.034	0.035	0.05	0.033	0.029	0.012	0.027	0.053
DIST HH	0.084	0.077	0.074	0.082	0.082	0.07	0.07	0.08	0.096	0.049	0.051	0.085
TPT COM	0.055	0.05	0.046	0.043	0.052	0.043	0.057	0.048	0.05	0.066	0.061	0.052
FIN	0.072	0.076	0.072	0.082	0.078	0.068	0.04	0.079	0.064	0.092	0.039	0.061
REST BUS	0.09	0.103	0.108	0.094	0.108	0.106	0.08	0.113	0.112	0.073	0.093	0.086
NMKT SERV	0.127	0.121	0.131	0.128	0.105	0.146	0.063	0.159	0.124	0.124	0.153	0.151

Table 8: Figure 13, panel b): Aggregate GDP elasticities from a 1% shock to fundamental productivity.

	NE	NW	YH	EM	WM	EE	LDN	SE	SW	WL	SC	NI
AG	0.042	0.054	0.044	0.044	0.039	0.032	0.173	0.025	0.027	0.069	0.089	0.036
MIN	0.072	0.105	0.088	0.1	0.105	0.089	0.154	0.1	0.139	0.057	0.069	0.05
MANUF	0.055	0.052	0.051	0.049	0.058	0.051	0.132	0.036	0.05	0.066	0.06	0.037
CONS	0.042	0.042	0.05	0.049	0.045	0.047	0.079	0.044	0.04	0.009	0.028	0.057
DIST HH	0.108	0.11	0.109	0.12	0.116	0.099	0.13	0.112	0.133	0.045	0.059	0.107
TPT COM	0.122	0.118	0.114	0.109	0.122	0.106	0.151	0.116	0.12	0.116	0.12	0.115
FIN	0.163	0.18	0.175	0.198	0.181	0.16	0.126	0.178	0.153	0.181	0.096	0.148
REST BUS	0.177	0.21	0.223	0.201	0.219	0.213	0.205	0.226	0.228	0.112	0.171	0.174
NMKT SERV	0.128	0.136	0.151	0.152	0.126	0.16	0.116	0.195	0.155	0.096	0.147	0.173

Table 9: Figure 13, panel c): Regional GDP elasticities from a 1% shock to fundamental productivity.

	NE	NW	YH	EM	WM	EE	LDN	SE	SW	WL	SC	NI
AG	0.048	0.057	0.048	0.051	0.043	0.043	0.145	0.031	0.039	0.105	0.11	0.057
MIN	0.107	0.127	0.112	0.121	0.125	0.122	0.153	0.119	0.164	0.107	0.11	0.088
MANUF	0.08	0.069	0.069	0.068	0.078	0.078	0.128	0.048	0.075	0.154	0.103	0.07
CONS	0.084	0.075	0.085	0.085	0.077	0.09	0.103	0.075	0.076	0.044	0.07	0.115
DIST HH	0.204	0.184	0.185	0.2	0.193	0.19	0.182	0.191	0.217	0.146	0.143	0.21
TPT COM	0.165	0.148	0.146	0.139	0.149	0.154	0.165	0.154	0.159	0.188	0.174	0.174
FIN	0.211	0.221	0.214	0.229	0.21	0.227	0.152	0.224	0.198	0.235	0.13	0.212
REST BUS	0.278	0.293	0.306	0.282	0.296	0.321	0.263	0.31	0.322	0.247	0.306	0.292
NMKT SERV	0.331	0.287	0.308	0.302	0.276	0.319	0.207	0.344	0.321	0.257	0.314	0.376

Table 10: Figure 13, panel d): Regional employment elasticities from a 1% shock to fundamental productivity.

	NE	NW	YH	EM	WM	EE	LDN	SE	SW	WL	SC	NI
AG	0.04	0.042	0.038	0.041	0.035	0.037	0.076	0.027	0.034	0.081	0.074	0.05
MIN	0.092	0.096	0.092	0.099	0.097	0.098	0.112	0.091	0.117	0.092	0.096	0.083
MANUF	0.077	0.065	0.067	0.068	0.075	0.076	0.099	0.049	0.074	0.163	0.102	0.074
CONS	0.089	0.079	0.088	0.09	0.08	0.094	0.109	0.077	0.081	0.05	0.078	0.125
DIST HH	0.208	0.187	0.191	0.206	0.197	0.198	0.196	0.197	0.214	0.158	0.154	0.218
TPT COM	0.135	0.118	0.12	0.118	0.121	0.127	0.134	0.121	0.127	0.153	0.138	0.143
FIN	0.174	0.17	0.171	0.181	0.167	0.179	0.137	0.166	0.162	0.181	0.111	0.183
REST BUS	0.249	0.248	0.262	0.25	0.251	0.266	0.249	0.249	0.268	0.233	0.272	0.273
NMKT SERV	0.388	0.336	0.355	0.346	0.329	0.351	0.264	0.367	0.371	0.259	0.323	0.407

Table 11: Figure 13: Regional congestion effect elasticities from a 1% shock to fundamental productivity.

	NE	NW	YH	EM	WM	EE	LDN	SE	SW	WL	SC	NI
AG	0.002	0.012	0.006	0.003	0.004	-0.005	0.097	-0.002	-0.007	-0.012	0.015	-0.014
MIN	-0.02	0.01	-0.004	0.002	0.007	-0.01	0.043	0.009	0.021	-0.035	-0.027	-0.033
MANUF	-0.022	-0.013	-0.016	-0.019	-0.017	-0.025	0.033	-0.012	-0.024	-0.097	-0.041	-0.037
CONS	-0.047	-0.037	-0.039	-0.041	-0.035	-0.047	-0.03	-0.033	-0.041	-0.041	-0.05	-0.068
DIST HH	-0.1	-0.077	-0.082	-0.085	-0.082	-0.099	-0.067	-0.085	-0.081	-0.114	-0.096	-0.111
TPT COM	-0.013	0	-0.006	-0.009	0.002	-0.021	0.017	-0.005	-0.007	-0.037	-0.018	-0.028
FIN	-0.011	0.01	0.004	0.016	0.015	-0.018	-0.011	0.012	-0.009	-0.001	-0.015	-0.035
REST BUS	-0.073	-0.038	-0.039	-0.049	-0.032	-0.053	-0.044	-0.023	-0.041	-0.121	-0.101	-0.099
NMKT SERV	-0.26	-0.2	-0.204	-0.194	-0.204	-0.191	-0.147	-0.172	-0.216	-0.163	-0.176	-0.233

Table 12: Figure 14, panel a): Aggregate GDP elasticities from a 1% shock to capital stock.

	NE	NW	YH	EM	WM	EE	LDN	SE	SW	WL	SC	NI
AG	0.016	0.018	0.017	0.017	0.017	0.016	0.036	0.022	0.017	0.019	0.026	0.017
MIN	0.032	0.035	0.036	0.036	0.037	0.034	0.052	0.04	0.039	0.025	0.038	0.034
MANUF	0.037	0.041	0.04	0.042	0.042	0.04	0.05	0.044	0.042	0.053	0.048	0.039
CONS	0.034	0.04	0.04	0.04	0.038	0.04	0.056	0.04	0.038	0.022	0.032	0.046
DIST HH	0.065	0.074	0.072	0.074	0.074	0.072	0.097	0.085	0.075	0.048	0.059	0.066
TPT COM	0.044	0.051	0.049	0.049	0.05	0.048	0.064	0.05	0.049	0.039	0.048	0.043
FIN	0.058	0.069	0.069	0.069	0.07	0.065	0.075	0.068	0.068	0.046	0.048	0.052
REST BUS	0.066	0.079	0.079	0.079	0.077	0.074	0.093	0.08	0.078	0.056	0.07	0.067
NMKT SERV	0.12	0.131	0.13	0.123	0.13	0.117	0.124	0.134	0.129	0.058	0.089	0.103

Table 13: Figure 14, panel b): Regional GDP elasticities from a 1% shock to capital stock.

	NE	NW	YH	EM	WM	EE	LDN	SE	SW	WL	SC	NI
AG	0.026	0.026	0.025	0.025	0.025	0.026	0.042	0.031	0.026	0.037	0.045	0.03
MIN	0.053	0.051	0.052	0.052	0.053	0.055	0.062	0.058	0.059	0.05	0.067	0.06
MANUF	0.061	0.06	0.059	0.061	0.06	0.064	0.06	0.064	0.064	0.105	0.083	0.07
CONS	0.057	0.058	0.059	0.058	0.055	0.065	0.067	0.058	0.058	0.043	0.057	0.081
DIST HH	0.108	0.107	0.106	0.107	0.107	0.116	0.115	0.123	0.113	0.095	0.103	0.118
TPT COM	0.073	0.074	0.072	0.072	0.072	0.077	0.076	0.073	0.074	0.077	0.083	0.077
FIN	0.097	0.101	0.102	0.1	0.1	0.106	0.089	0.099	0.103	0.092	0.083	0.092
REST BUS	0.11	0.115	0.117	0.114	0.11	0.119	0.11	0.116	0.117	0.111	0.123	0.119
NMKT SERV	0.2	0.19	0.191	0.178	0.186	0.188	0.147	0.195	0.195	0.115	0.156	0.184

Table 14: Figure 14, panel c): Regional employment elasticities from a 1% shock to capital stock.

	NE	NW	YH	EM	WM	EE	LDN	SE	SW	WL	SC	NI
AG	0.025	0.024	0.023	0.024	0.023	0.024	0.039	0.028	0.024	0.035	0.042	0.03
MIN	0.051	0.046	0.049	0.049	0.049	0.051	0.057	0.052	0.055	0.047	0.062	0.058
MANUF	0.059	0.055	0.056	0.058	0.057	0.059	0.055	0.058	0.059	0.097	0.077	0.068
CONS	0.055	0.053	0.055	0.055	0.051	0.06	0.062	0.052	0.053	0.04	0.052	0.079
DIST HH	0.104	0.099	0.1	0.102	0.1	0.108	0.106	0.111	0.105	0.088	0.096	0.115
TPT COM	0.071	0.068	0.068	0.068	0.067	0.071	0.07	0.066	0.068	0.071	0.077	0.075
FIN	0.093	0.093	0.096	0.095	0.093	0.098	0.082	0.089	0.095	0.085	0.077	0.09
REST BUS	0.106	0.106	0.11	0.108	0.103	0.11	0.101	0.104	0.108	0.103	0.114	0.116
NMKT SERV	0.193	0.174	0.18	0.169	0.174	0.174	0.136	0.175	0.18	0.106	0.144	0.18

Table 15: Figure 14, panel d): Regional congestion effects from a 1% shock to capital stock.

	NE	NW	YH	EM	WM	EE	LDN	SE	SW	WL	SC	NI
AG	-0.01	-0.006	-0.006	-0.006	-0.006	-0.008	-0.003	-0.007	-0.007	-0.016	-0.016	-0.013
MIN	-0.019	-0.012	-0.014	-0.013	-0.013	-0.017	-0.005	-0.012	-0.015	-0.021	-0.024	-0.025
MANUF	-0.022	-0.014	-0.015	-0.016	-0.014	-0.02	-0.005	-0.014	-0.017	-0.044	-0.029	-0.029
CONS	-0.021	-0.013	-0.015	-0.015	-0.013	-0.02	-0.005	-0.012	-0.015	-0.018	-0.02	-0.034
DIST HH	-0.039	-0.025	-0.028	-0.028	-0.026	-0.036	-0.009	-0.026	-0.029	-0.04	-0.036	-0.049
TPT COM	-0.027	-0.017	-0.019	-0.018	-0.017	-0.024	-0.006	-0.015	-0.019	-0.032	-0.029	-0.032
FIN	-0.035	-0.023	-0.027	-0.026	-0.024	-0.032	-0.007	-0.021	-0.027	-0.039	-0.029	-0.038
REST BUS	-0.04	-0.027	-0.03	-0.029	-0.026	-0.037	-0.008	-0.024	-0.03	-0.047	-0.043	-0.049
NMKT SERV	-0.073	-0.044	-0.05	-0.046	-0.045	-0.058	-0.011	-0.041	-0.051	-0.048	-0.055	-0.076

Table 16: Table 5: Aggregate GDP elasticity of reduced trade cost between trading partners. Weighted using the sum of both regions GDP share.

	NE	NW	YH	EM	WM	EE	LDN	SE	SW	WL	SC	NI
NE	0	0.041	0.045	0.02	0.02	0.019	0.039	0.025	0.023	0.012	0.033	0.014
NW	0.041	0	0.096	0.062	0.051	0.028	0.056	0.036	0.032	0.04	0.05	0.016
YH	0.045	0.096	0	0.089	0.036	0.025	0.051	0.027	0.022	0.016	0.032	0.019
EM	0.02	0.062	0.089	0	0.068	0.061	0.045	0.036	0.023	0.015	0.027	0.019
WM	0.02	0.051	0.036	0.068	0	0.026	0.049	0.04	0.038	0.1	0.049	0.019
EE	0.019	0.028	0.025	0.061	0.026	0	0.064	0.043	0.022	0.016	0.017	0.015
LDN	0.039	0.056	0.051	0.045	0.049	0.064	0	0.073	0.044	0.043	0.08	0.023
SE	0.025	0.036	0.027	0.036	0.04	0.043	0.073	0	0.06	0.021	0.026	0.013
SW	0.023	0.032	0.022	0.023	0.038	0.022	0.044	0.06	0	0.076	0.02	0.013
WL	0.012	0.04	0.016	0.015	0.1	0.016	0.043	0.021	0.076	0	0.004	0.004
SC	0.033	0.05	0.032	0.027	0.049	0.017	0.08	0.026	0.02	0.004	0	0.013
NI	0.014	0.016	0.019	0.019	0.019	0.015	0.023	0.013	0.013	0.004	0.013	0

Table 17: Figure 16: Regional GDP elasticity of home region from reduced trade cost with trading partner

Trading partner →	% Variation in regional GDP											
Home region ↓	NE	NW	YH	EM	WM	EE	LDN	SE	SW	WL	SC	NI
NE	0	0.145	0.122	0.048	0.054	0.062	0.113	0.1	0.072	0.031	0.103	0.022
NW	0.046	0	0.128	0.078	0.069	0.043	0.082	0.066	0.049	0.055	0.08	0.016
YH	0.059	0.188	0	0.136	0.059	0.047	0.089	0.062	0.043	0.028	0.062	0.022
EM	0.028	0.131	0.159	0	0.118	0.119	0.088	0.094	0.048	0.026	0.051	0.022
WM	0.026	0.101	0.06	0.102	0	0.05	0.088	0.091	0.07	0.167	0.09	0.021
EE	0.024	0.051	0.038	0.086	0.041	0	0.108	0.092	0.038	0.026	0.027	0.017
LDN	0.042	0.089	0.068	0.055	0.066	0.091	0	0.131	0.063	0.063	0.126	0.022
SE	0.026	0.05	0.032	0.04	0.048	0.056	0.092	0	0.076	0.027	0.03	0.012
SW	0.028	0.055	0.032	0.03	0.054	0.037	0.072	0.12	0	0.112	0.028	0.014
WL	0.024	0.132	0.046	0.037	0.268	0.051	0.121	0.093	0.217	0	0.012	0.008
SC	0.044	0.098	0.057	0.051	0.096	0.038	0.139	0.073	0.045	0.008	0	0.016
NI	0.034	0.077	0.066	0.059	0.066	0.065	0.092	0.076	0.056	0.016	0.052	0