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Deglobalization and the reorganization of supply chains: Effects on regional inequalities in the EU

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Deglobalization and the reorganization of supply chains: Effects on regional inequalities in the EU*

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Abstract

After decades of globalization, many countries are now considering various measures to reduce their dependence on third countries and to incentivize domestic production. This paper analyzes a policy toolbox encompassing trade, industrial, and public policies and their effects on the EU and its geographical regions. We develop a multi-sector, multi-region general equilibrium framework with imperfect competition, input-output linkages, and external economies of scale. Regional and supranational governments set policies and raise taxes and provide subsidies to fund these. We calibrate our framework using detailed data on 235 EU NUTS2 regions and 25 Rest of the World aggregates, with 55 sectors and input-output linkages both within and across regions. Our results show that raising trade barriers reduces EU welfare, with substantial variation across regions. Industrial policy generates positive welfare effects. Public policy results are ambiguous. Across all policies, input-output linkages significantly amplify positive and negative welfare changes, dominating other channels such as classical gains from trade or economies of scale channels. Even common policies, like trade policy, can generate significant winners and losers across regions within the same country. Moreover, the same region can gain under one policy but lose under another. These results highlight that one policy objective can be implemented through multiple instruments, generating positive or negative aggregate welfare effects under each instrument, while obfuscating massive heterogeneity in regional outcomes, even within countries.

Keywords: Deglobalization, Regional Inequalities, Trade policy, Industrial Policy, Public Policy, Supply Chains, General Equilibrium.

JEL codes: F10, R12.

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1 Introduction

The past decades have been characterized by a massive wave of globalization. Technological progress, trade liberalization, and increased capital mobility, spearheaded by institutions such as the IMF, World Bank, and GATT/WTO, have contributed to the reallocation and fragmentation of production processes into global value chains (GVCs). These efforts have induced further efficiency gains from specialization, lowered prices, and provided global market access to a wide variety of goods. However, the momentum of globalization has slowed in recent years, particularly following the global financial crisis of 2008-2009. Both natural and political events, including supply chain disruptions such as the 2011 Tohoku earthquake and the Covid-19 pandemic, as well as geopolitical developments like the US-China tariff wars and multiple armed conflicts, have painfully revealed the vulnerabilities of many sectors and regions from both direct and indirect exposures to the rest of the world.

These recent events raise crucial trade-offs for policy makers: how to balance the gains from globalization and integration with the need for security and stability of production and consumption chains? Major political blocks have since then implemented various measures to become less dependent on third parties and incentivize domestic production.[1] Some examples include the Infrastructure Investment and Jobs Act (2021), CHIPS and Science Act (2022), Defence Production Act (2022), Inflation Reduction Act (2022) in the USA, and the Recovery and Resilience Facility (2021), relaxation of EU state aid rules (2022), the (Open) Strategic Autonomy paradigm (2013), RePowerEU (2023), and the European Chips Act (2023) in the EU. Within blocks, individual countries such as France and Germany have triggered a revival of industrial policy and state aid. Even sub-national regions coordinate across country borders, including the European Semiconductor Regions Alliance (2023), with 27 EU regions participating across 12 EU member states.

In this paper, we study the impact of multiple policies that aim to increase domestic production and consumption on both EU welfare and the potential heterogeneity in outcomes across its various regions. The policy toolbox consists of trade policy, industrial policy, and public policy. Trade policy is set at the aggregate level, while industrial and public policy are decided at the regional levels. Yet, both common and local policies can have highly heterogeneous impacts on economic outcomes. For example, raising tariffs (an EU-level competence) on e.g. computer chips to become less dependent on third countries can have vastly different effects on the production and consumption patterns across all EU sector-regions. First, regions that use these chips as imported inputs into their production processes are directly affected, and their exposure depends on the share of these inputs used in production. Second, EU sector-regions are connected intra-regionally, inter-regionally, and internationally through intricate supply chains. Sector-regions that do not use these chips in their production or consumption processes are not directly exposed to these tariffs, but can be indirectly affected through these linkages. Similarly, local policies such as industrial or public policy do not only affect the respective regions in which these policies are decided and implemented, but also other regions through supply chain linkages and other general equilibrium effects. Hence, both common and regional policies can affect aggregate EU outcomes such as welfare, output, trade, consumption, as well as prices and quantities of factors, goods, and services.

To quantitatively evaluate the effects of the policy toolbox, we develop a general equilibrium framework with multiple sectors, regions, and factors. Production, consumption, and trade are connected through

[1] Multiple indicators suggest a clear global trend towards protectionism. The number of yearly new unilateral protectionist measures has surged from 214 in 2009 up to 3,276 in 2023—a fifteenfold increase in just 15 years (Evenett and Fritz (2024)). Measures include the rising use of tariffs and other trade barriers, export controls, investment screening mechanisms, industrial policy, and state aid and subsidies. In parallel, several countries have undermined the functioning of the WTO's dispute settlement system by blocking the appointment of members to its Appellate Body (Howse and Langille (2023)).

input-output relationships both within and across regions. The model exhibits monopolistic competition, love for variety, and external economies of scale. There are two layers of government. Regional governments can issue industrial and public policy. These governments raise local taxes and provide subsidies, and can run unbalanced budgets. A supranational (EU) government sets common trade policy. It collects tariff revenues and redistributes local government surpluses and deficits such that it runs a balanced budget. As a result, regions can be net contributors or recipients of supranational funds.

We calibrate the model using detailed information from the RHOMOLO database at the Joint Research Center of the European Commission. This database contains information on 235 EU regions at the NUTS2 level, plus 25 extra-EU aggregates that constitute the Rest of the World for the year 2017. Each region contains production data for 55 NACE sectors, as well as their sources of value added and components of final demand for each sector, and multi-regional input-output tables for all regions. Our setup allows us to match exactly each entry of this database to model objects for the quantitative analysis.

We then simulate the toolbox of policies and evaluate their impact on the outcomes for EU regions. In particular, for trade policy, we simulate a 10% increase in iceberg trade costs for imports from the rest of the world to the EU. As a result, gross output increases in most EU regions due to trade diversion towards EU suppliers. Output increases more in regions that were initially more open than others. However, welfare decreases in the aggregate and in most EU regions. The intuition is simple: trade policy forces producers to source from more expensive providers, increasing the value of gross output, albeit at higher prices, which have a negative effect on welfare. There is also large geographical variation: while East EU regions see the highest increase in output and the largest reduction in welfare, South EU regions are less affected overall. For industrial policy, we induce a 10% increase to production subsidies across manufacturing sectors in all regions. This subsidy is paid by regional governments to their local sectors, and can induce budgetary deficits. While output increases in most EU regions, similar to trade policy, the welfare effects are now positive for the EU and for most regions. This is because industrial policy lowers the marginal cost of production, inducing more input sourcing, higher output, and a lower price index. Again, the East EU regions gain most, while the South EU gain least. Finally, for public policy, we implement a 10% increase in the government component of final demand. Public expenditures are paid by local governments to their local sectors. Gross output increases in most EU regions, while welfare effects vary a lot across regions.

Aggregate welfare effects are in the range of 0-2%, similar to most results in this class of static models (e.g. Arkolakis et al. (2012); Caliendo and Parro (2015)). However, these aggregate results conceal massive heterogeneity across regions, with both significant winners and losers across regions, even within the same country. We also compare the welfare effects of the different channels in the model by shutting down these channels and re-estimating the restricted models for each policy. We find that the contribution of the classical gains from trade to welfare are rather small. Adding external economies of scale generates positive aggregate welfare effects across policies. However, both effects are strongly dominated by the existence of supply chains: under each policy, and for each region, input-output linkages amplify both positive and negative welfare effects.

Our results highlight that different policies to incentivize domestic production and consumption can have very different and even opposing aggregate welfare effects, generating or destroying welfare under each policy. Moreover, a region can be a winner under one policy, but a loser under another. Finally, production and consumption patterns are strongly connected across regions, significantly amplifying classical welfare effects in either direction. Failing to account for this regional heterogeneity and their input-output linkages grossly underestimates such welfare effects.

This paper relates to the literatures on global value chains, production networks, and policy interventions. The literature on global value chains has exploded thanks to the availability of various sources of input-output data and the development of structural frameworks. Several papers have analyzed supply chains from different points of view: offshoring decisions (Grossman and Rossi-Hansberg (2008); Baldwin and Venables (2013)), trade flows and their value added component (Johnson and Noguera (2012); Koopman et al. (2014)), the positioning of countries and industries in global supply chains (Antràs and Chor (2013); Alfaro et al. (2019)) or their geography (Antràs and De Gortari (2020)). Progress on the theoretical side on quantitative general equilibrium models of trade, reviewed by Costinot and Rodríguez-Clare (2014) and based on the seminal work of Eaton and Kortum (2002), made it possible to analyze the effects of trade liberalization on several macroeconomic outcomes, such as welfare (Caliendo and Parro (2015)), labor market dynamics (Caliendo et al. (2019)), and inequality (Bernon and Magerman (2022); Galle et al. (2023)). Eppinger et al. (2021) use a quantitative trade model to evaluate the impact of de-linking from global supply chains by simulating a trade shock. Similarly, Bonadio et al. (2021) examine the propagation of supply shocks caused by the Covid-19 pandemic along the supply chain.

This paper is also related to a burgeoning literature on production networks. Triggered by the seminal work of Acemoglu et al. (2012), this literature studies how production networks can affect macroeconomic outcomes by propagating and aggregating productivity or demand shocks (e.g. Acemoglu et al. (2016); Baqaee and Farhi (2019), Baqaee and Farhi (2020)), with recent attention to policies such as industrial policy (Liu (2019)), labor market frictions (Bernon and Magerman (2022)), and monetary policy (Rubbo (2023)). Finally, this paper speaks to the broader literature on incentives for economic policies. The recent rise of and rationale for industrial policy is studied in e.g. Lashkaripour and Lugovskyy (2023), Bartelme et al. (2024), Juhász et al. (2024), and Goldberg et al. (2024). Other work analyzes e.g. environmental policies (Conte et al. (2022); Schmitz et al. (2024)), or public policy (Fajgelbaum and Gaubert (2020)).

We contribute to these literatures by developing a quantitative framework that includes input-output linkages, external economies of scale, and multiple layers of government to study the impact of a policy toolbox on aggregate welfare and regional disparities.

2 Facts on EU regional heterogeneity, budget, and policies

In this section, we present key empirical findings on the economic activity, production, and trade patterns of EU NUTS2-level regions. These facts show significant heterogeneity across regions, with differences often larger within countries than across. We then describe the structure and rules of the EU budget, and the position of regions as either net contributors or net recipients. Next, we describe the link between EU regions, the budget, and the policies we study in this paper. The quantitative framework introduced in Section 3 exploits the EU budget balance as a market clearing condition for taxes and subsidies, with a region's net contribution to the EU budget emerging as an endogenous outcome. In Section 4, we calibrate the model to production with input-output linkages, international trade, and consumption data for 235 EU regions and the rest of the world. In Section 5, we show how policy interventions affect aggregate EU outcomes, and can either exacerbate or reduce regional heterogeneity in economic outcomes.

2.1 Economic activity across EU regions

We document some key facts on economic activity and its massive heterogeneity across 235 NUTS2-level EU regions.[2] Throughout, we use the EU Multi-regional Input Output (MRIO) Tables for the year 2017, which are described in more detail in Section 4.

First, output and income per capita levels vary massively across EU regions. Figure 1 shows Gross Domestic Product (GDP) per capita (panel a) and Gross National Income (GNI) per capita (panel b) for each NUTS2 region. Values are expressed in euros and binned into deciles. The gap between the richest and poorest regions is enormous: GDP per capita ranges from 4,674 euro to over 90,000 euro, representing a 19-fold difference within the EU27. In other words, the top EU region produces almost 20 times more value added *per person* than the bottom region. To put these numbers into perspective, a GDP per capita of 5,000 euro in 2017 is comparable to that of countries like Ghana or Honduras, placing it at the bottom quartile globally. In contrast, the top EU region region ranks among the top three highest GDP per capita regions in the world.[3] Although this comparison may be influenced by outliers, the ratio between the 90th percentile and the 10th percentile regions remains substantial, at 4.5. The variation in income is similarly stark: GNI per capita ranges from 4,281 euro to over 59,000 euro, or a factor of 14 difference. The ratio between the 90th and 10th percentile region in terms of income per capita is 4.

While there is a clear divide between Western and Eastern EU member states, substantial differences also exist within countries. Capital regions, in particular, tend to be significantly more prosperous than other regions. Similarly, regions with strong international connections often have higher per capita values (such as Antwerp, Rotterdam, and Hamburg due to their large ports). These shipping activities not only serve as distribution hubs but also generate sizable economic activity within their regions. Additionally, regions may be more economically similar to nearby regions in neighboring countries than to those within their own country. This includes some regions with the highest GDP and GNI per capita values in the EU, such as the European 'Megalopolis' covering the Benelux, Rhineland, Southern Germany, Alsace-Moselle, Basel, Zürich, Milan, Turin, and Genoa.[4]

Next, Figure 2 shows the production and trade patterns of the 235 EU regions. The within-country regional heterogeneity in production and trade is even more pronounced than the production and income levels above. In panel (a), the Krugman Specialization Index (KSI) measures the degree of sectoral specialization within a region, comparing the distribution of value added across sectors in a region to that of the EU27 as a whole.[5] A lower KSI value indicates that the region's production structure closely mirrors that of the EU27, while a higher value signifies a distinct pattern, suggesting specialization or concentration in a few sectors. Generally, regions in France, Germany, and Italy show values between 0.30 and 0.41, closely aligning with the EU aggregate. In contrast, regions in Central and Eastern member states can display high dissimilarity from the EU benchmark. Within-country variation in regional specialization is often much larger than the variation across countries, with regions exhibiting both the lowest and highest KSI values

[2]The NUTS classification (Nomenclature des Unités Territoriales Statistiques) is a system to partition the territory of the EU for the purpose of collecting, developing, and harmonizing regional statistics, as well as conducting socio-economic analysis. NUTS2 is the standard level of granularity for implementing regional policies. This level of detail includes, for example the 38 Regierungsbezirke in Germany, 27 Régions and Collectivités Territoriales in France, 21 Regioni in Italy, and the 11 and 12 Provinces in Belgium and the Netherlands, respectively. More information is available here.

[3]Country rankings are calculated using nominal GDP per capita from the World Development Indicators at the World Bank and the average USD/EUR exchange rate of 1.13 in 2017 from www.exchangerates.org.uk.

[4]This Megalopolis, stretching from Milan to Liverpool, has also been referred to as the 'backbone of the EU' (Brunet, 1989).

[5]In particular, $KSI_i = \sum_s abs\left[\frac{X_i^s}{X_i} - \frac{(X^s - X_i^s)}{(X - X_i)}\right]$ where X_i^s is the gross value added of sector s in region i, X^s the EU aggregate for sector s, X_i the aggregate for region i, and X gross value added of the EU27. The KSI ranges from 0 to 2.

often neighboring each other (e.g., in Germany, Italy, and Portugal).[6] Additionally, compared to per capita production and income levels, regional clustering is much less pronounced.

Finally, we illustrate how exposed individual regions are to imports from outside the EU. Panel (b) of Figure 2 shows the import penetration ratio for manufacturing.[7] Some regions are less open to trade, such as parts of Spain, Romania and Bulgaria, with import penetration values ranging from 3% to 6%. In contrast, regions like Paris and North Brabant in the Netherlands have values exceeding 40%. Again, capital regions tend to be more open to trade than other regions within the same country. Similar to the KSI, there can be significant variation in import exposure even within countries. This is particularly evident in regions like South West Germany, Finland, and Bulgaria, where some of the most and least import-oriented areas are located side by side.

These basic statistics demonstrate that economic activity is not confined to national borders but can vary substantially across regions within the same country. Some regions are far more exposed to potential production or trade shocks than others, leading to vastly different economic outcomes, even within the same country. This massive heterogeneity cannot be adequately captured by standard country-level datasets. For instance, a shock to the steel industry in China could have varying effects across EU regions, even within a single country, due to differences in production, trade, and income patterns, as some regions may be highly dependent on imports or use Chinese steel as a direct or indirect input in their production processes. Despite the importance of these regional disparities, we know very little about this regional variation, particularly regarding the impact of both aggregate or region-specific policies on EU regional outcomes.

2.2 EU budget, sources of revenues, and expenditures

Next, we provide some information on the working of the EU budget that is relevant for our model setup and quantitative analysis. The EU budget serves as the primary financial framework that funds the policies, programs, and activities across the EU. It operates under the Multi-annual Financial Framework (MFF), which outlines the EU's budgetary limits and spending priorities over five- to seven-year periods (e.g., the recent MFF 2014-2020 or MFF 2021-2027). Within these MFF limits, an annual budget is negotiated and adopted, detailing the spending plans for each year and allocating funds across the programs and initiatives.[8]

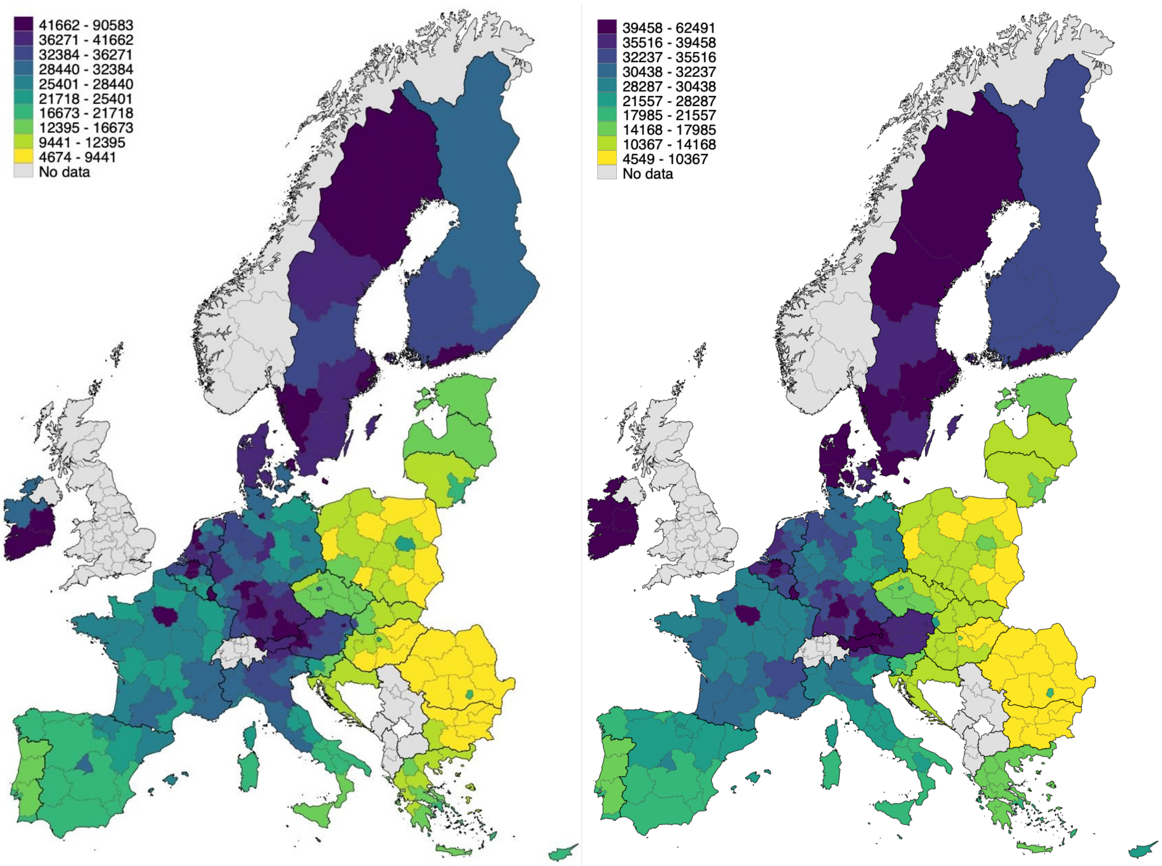
The EU's annual budget must be balanced, as stipulated by Article 310 of the Treaty on the Functioning of the European Union (TFEU).[9] Member states have more flexibility in managing their finances, and are not required to run balanced budgets. However, they are subject to EU oversight. In particular, the Stability and Growth Pact (SGP) establishes fiscal rules for EU member states, including deficit and debt ceilings of 3% and 60% of GDP, respectively. Non-compliance with these criteria can lead to penalties or disciplinary action. The MFF 2014-2020 was set at 1.08 trillion euros, with the annual budget amounting to 139 billion

[6] As an alternative measure, we also compute the Herfindahl-Hirschman Index (HHI) for value added across sectors within regions. The HHI ranges from 0.04 to 0.18 across regions, with a p90/p10 ratio of 1.6. Regional outcomes are very similar to the KSI.

[7] The import penetration ratio represents the share of demand for goods met by foreign producers rather than domestic production. It is calculated as total imports over domestic production plus imports minus exports in manufacturing.

[8] The European Commission drafts the budget proposal based on the MFF. This proposal must be unanimously approved by the Council of the European Union, representing the member states. Additionally, the European Parliament must give its consent, effectively holding a *de facto* veto. This process ensures that both member states, through the Council, and EU citizens, via the Parliament, play a role in the EU's long-term budgetary planning. Once adopted, the European Commission is responsible for implementing the budget, ensuring that funds are used efficiently and in compliance with EU rules. The European Court of Auditors audits the budget to ensure sound financial management and proper use of funds.

[9] In fact, we use this EU budget balance as a market-clearing condition for taxes and subsidies in Section 3.



(a) Gross domestic product (GDP) per capita, euro.

(b) Gross National Income (GNI) per capita, euro.

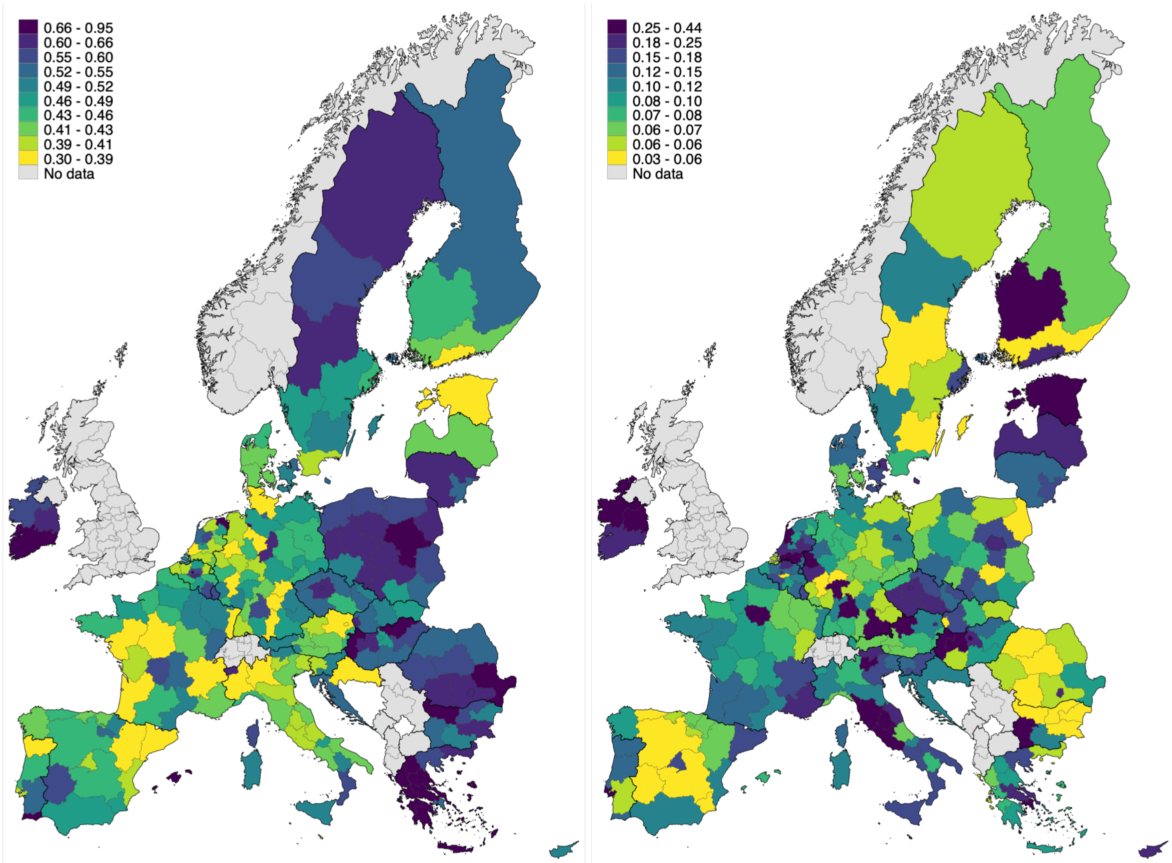
Figure 1: Economic activity (NUTS2, 2017).

euros in 2017.

The EU budget is financed through multiple revenue sources, see Figure 3 panel (a). The GNI-based own resource is by far the largest source of income, accounting for 56% of the total 2017 annual budget. This resource represents a percentage contribution of each member state's GNI to the EU budget, ensuring that contributions are proportional to the size of each country's economy. For the 2014-2020 period, the GNI contribution was set at 1.02% of the EU's total GNI. The other three sources of revenue include traditional own resources, which consist of tariffs collected on imports from outside the EU, the VAT-based own resource, which involves a small percentage of each member state's VAT revenues, and additional sources such as fines and penalties imposed on companies that violate EU competition laws, contributions from non-EU countries to certain EU programs, and adjustments and corrections from previous years.[10] The main sources of revenue are adjusted to ensure sufficient funds for planned expenditures and to maintain a balanced budget. Any surplus, such as from unexpected fines, is carried forward to the next budgetary period.

On the expenditure side, these revenues fund a wide range of activities aimed at promoting cohesion,

[10]For the 2014-2020 period, the VAT-based resource accounted for 0.30% of VAT revenues for most member states, with Germany, the Netherlands, and Sweden benefiting from a reduced call rate of 0.15%.



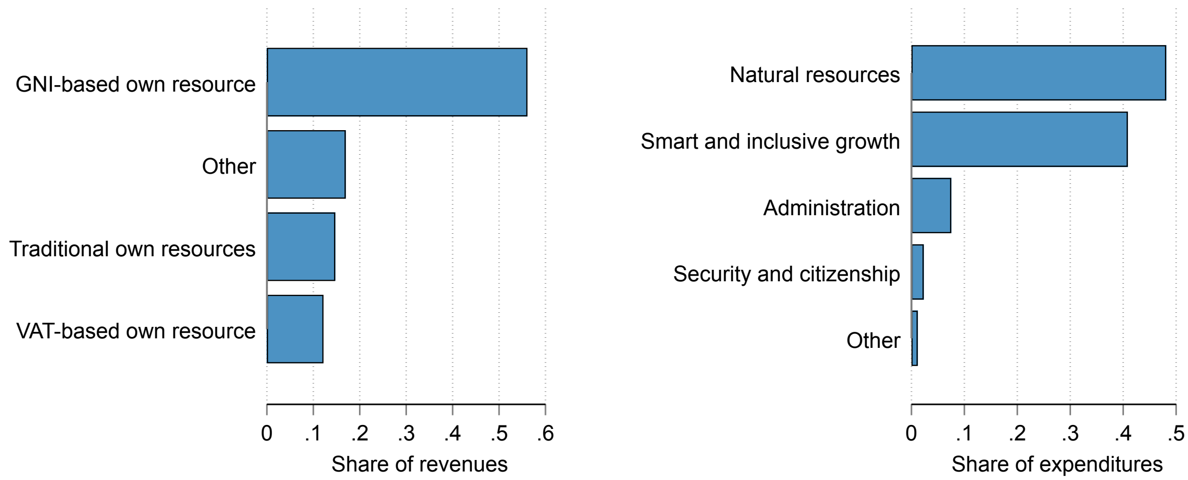
(a) Krugman Specialization Index (value added).

(b) Import penetration ratio (manufacturing).

Figure 2: Specialization patterns (NUTS2, 2017).

growth, and competitiveness across member states. Figure 3 panel (b) shows the main areas of expenditures. The largest spending categories include natural resources (48%), which encompasses the well-known Common Agricultural Policy, and smart and inclusive growth (41%). The latter includes the EU's Cohesion Policy, InvestEU (financial instruments supporting investment, innovation, and job creation), as well as funding for research and innovation (e.g., Horizon 2020) and education (e.g., Erasmus+). Together, these channels account for 89% of total expenditures. The remaining 11% is allocated to other channels. Administrative expenditures cover the operational costs of EU institutions, including salaries, pensions, and other expenses. Security and citizenship expenditures address areas such as migration and border management, internal security, and programs like the Asylum, Migration, and Integration Fund. Finally, other expenditures include programs like Global Europe, which funds the EU's external actions, including development aid, humanitarian assistance, and foreign policy initiatives.

Each member state contributes to the EU budget and potentially receives funding through one of the policies of the EU. Figure 4 panel (a) shows the position of each member state as a net contributor to or recipient of the EU budget, expressed as a percentage of their GNI for the year 2017. Traditionally, richer countries are net contributors to the EU budget, up to around 0.5% of their GNI. On the other hand, poorer countries typically receive net funding from the EU budget, with receipts amounting to as much as 3% of

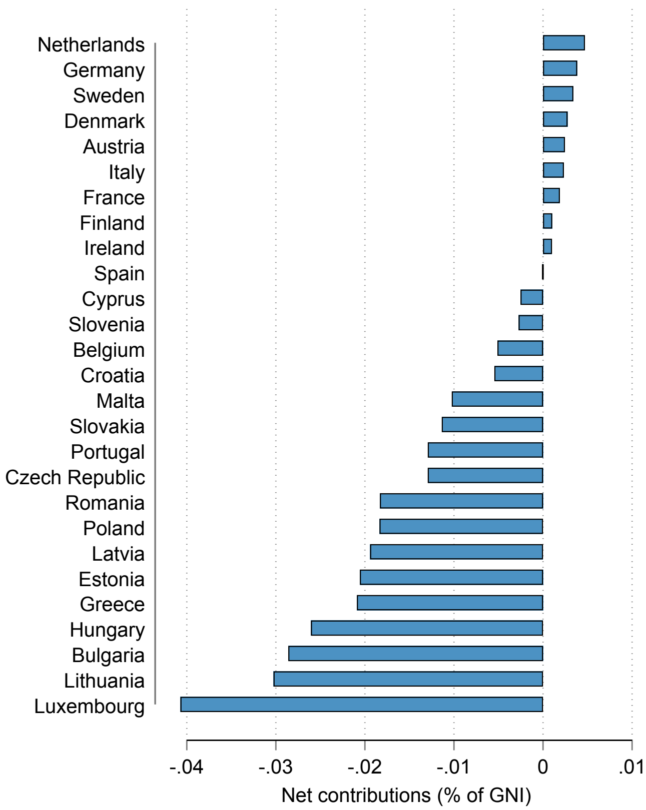


(a) Revenues.

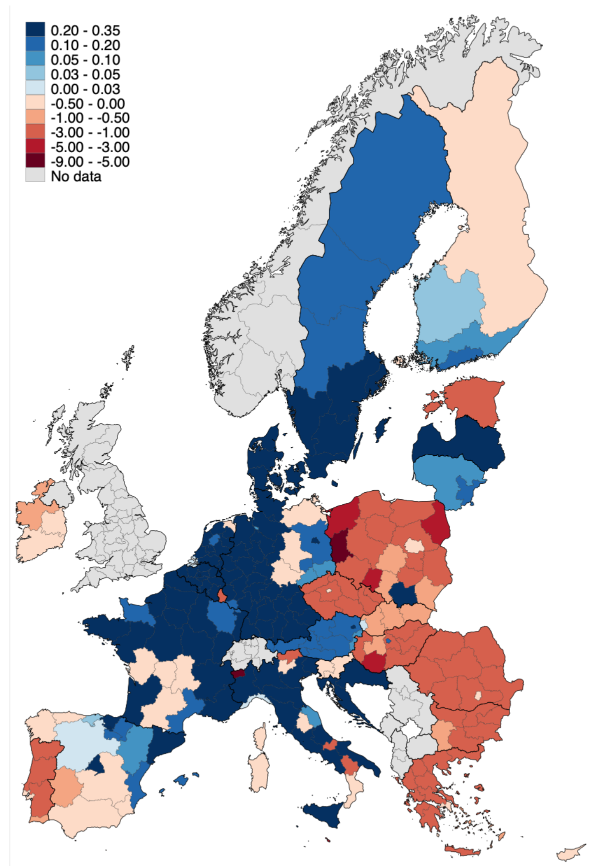
(b) Expenditures.

Figure 3: EU Budget: revenues and expenditures (2017).

their GNI. Luxembourg is an exception, being a net recipient due to administrative support for the various EU institutions located there. This information is readily available at the level of member states. To obtain regional net positions, we project these contributions and receipts to the regional level in panel (b). In particular, we use data from the EU Commission's cohesion database on the EU's regional investments at the NUTS2 level (available here). As there is no available data at the NUTS2 level for contributions, we calculate a region's contribution based on its share of GNI in the EU's total GNI. The regional net position is then computed as the difference between contributions and receipts. Again, we observe considerable heterogeneity across regions, even within the same country. For example, although Italy is a net contributor, some Italian regions are net contributors while others are net recipients. The same pattern is evident in Spain, Poland, and Croatia. Even within France and Germany, some regions are net contributors while others are net recipients. We will use these regional net positions to calibrate the initial values of our quantitative framework in Section 5.



(a) Net budgetary position of member states.



(b) Net budgetary positions of NUTS2 regions.

Figure 4: EU Budget: net contributors and recipients (2017).

3 Model

In this section, we develop a quantitative framework with multiple sectors, regions, and factors of production. Production, consumption, and trade are interconnected through input-output relationships across sectors both within and across regions. The model exhibits love of variety across both regions and product varieties, market power, external economies of scale, and input-output linkages, and nests Arkolakis et al. (2012) and Lashkaripour and Lugovskyy (2023) as special cases. Local and supranational governments levy taxes and implement a range of policies, including trade, industrial, and public policy. While local governments can run budget imbalances, the supranational government maintains a balanced budget. The model provides equilibrium outcomes for output, trade, consumption, specialization, welfare, trade imbalances, and local budget deficits or surpluses for each region. We employ this framework to evaluate the policy toolbox in Section 5.

3.1 Preferences

Demand There are $i, j \in N$ regions and $s, r \in S$ sectors. In each region j, a measure L_j of representative households have homothetic preferences. They maximize utility according to:

$$U_j(C_j, G_j) = C_j^{\eta_j} G_j^{1-\eta_j}$$

where C_j and G_j are bundles of private and public goods consumed in j, respectively, and η_j is the budget share of private good consumption in j. Both bundles aggregate consumption across sectors, such that:

$$C_j = \prod_{s=1}^{S} \left(Q_j^s\right)^{\alpha_j^s} \quad \text{and} \quad G_j = \prod_{s=1}^{S} \left(G_j^s\right)^{\delta_j^s}$$

where G_j^s and Q_j^s are consumption indices in each sector s in region j. The parameters α_j^s and δ_j^s represent the budget shares of sector s private and public goods consumed in j, respectively. Public goods financed by local governments, produced by the private sector, and consumed by households. Sector s private goods Q_j^s are further characterized by a nested constant elasticity of substitution (CES) structure of the form:

$$Q_j^s = \left(\sum_{i=1}^{N} (Q_{ij}^s)^{\frac{\sigma^s-1}{\sigma^s}} \right)^{\frac{\sigma^s}{\sigma^s-1}} \quad \text{with} \quad Q_{ij}^s = \left[\int_{\omega \in \Omega} q_{ij}^s(\omega)^{\frac{\theta^s-1}{\theta^s}} d\omega \right]^{\frac{\theta^s}{\theta^s-1}} \tag{1}$$

where Q_{ij}^s represent sector s goods produced in region i and consumed in region j, with elasticity of substitution $\sigma^s > 1$, and $q_{ij}^s(\omega)$ represents the consumption quantity of variety $\omega \in \Omega$, where Ω is the measure of varieties available within the tuple $\{i, j, s\}$, endogenously determined in equilibrium, and with elasticity of substitution $\theta^s > 1$. Intuitively, Q_j^s aggregates across supplying regions i, reflecting the love of variety across *regions*, while Q_{ij}^s aggregates across varieties ω, capturing love of variety across *product varieties* within each region pair for sector s goods.[11]

The demand for variety ω, produced in region i and consumed in region j for sector s goods, is then

[11] Love of variety across regions also provides an incentive to 'derisk' global value chains through diversifying inputs across source locations.

given by:

$$q_{ij}^s(\omega) = \left(\frac{p_{ij}^s(\omega)}{P_{ij}^s}\right)^{-\theta^s} \left(\frac{P_{ij}^s}{P_j^s}\right)^{-\sigma^s} Q_j^s$$

where $p_{ij}^s(\omega)$ is the price of variety ω of sector s goods produced in i and consumed in j, $P_{ij}^s = [\int_{\omega\in\Omega} p_{ij}^s(\omega)^{1-\theta^s} d\omega]^{\frac{1}{1-\theta^s}}$ is the price index across varieties ω in sector s from i to j and $P_j^s = [\sum_{i=1}^N (P_{ij}^s)^{1-\sigma^s}]^{\frac{1}{1-\sigma^s}}$ is the price index for sector s goods available in j.

Income Households receive income from three sources: labor, capital, and net foreign income. Labor and capital are inelastically supplied, perfectly mobile across sectors within regions, but immobile across regions. Capital refers to buildings, structures and land. Households collect returns on capital and transfer these returns to a supranational portfolio, in which they own a share. Households also pay lump sum taxes to local and supranational governments. Household income in region j is then given by:

$$I_j = \underbrace{w_j L_j + r_j K_j}_{\text{factor payments}} + \underbrace{\chi_j \textstyle\sum_{i=1}^N r_i K_i - r_j K_j}_{\text{net foreign income}} - \underbrace{T_j^{LOC} - T_j^{EU}}_{\text{taxes}} \tag{2}$$

where domestic value added includes labor L_j and capital K_j with wage w_j and rents r_j. Net foreign income is the net returns on the international portfolio of which each household owns a share $\chi_j = \frac{D_j + r_j K_j}{\sum_i r_i K_i}$.[12] Taxes consist of local government taxes T_j^{LOC} and supranational government taxes T_j^{EU}. The contribution to the supranational government is proportional to the region's GNI, so that $T_j^{EU} = \phi_j T^{EU}$, where $\phi_j = GNI_j / \sum_{i\in EU} GNI_i$ represents region j's income share in the total EU income.[13]

3.2 Production

Intermediate goods Firms in sector s in region i each produce a variety ω. They combine factors and intermediate goods to produce output, which is sold to other firms and final demand. Production follows a constant returns to scale (CRS) technology of the form:

$$q_i^s(\omega) = Z_i^s \left[L_i^s(\omega)^{\gamma_i} K_i^s(\omega)^{1-\gamma_i}\right]^{1-\beta_i^s} \prod_{r=1}^S \left[(Q_i^r)^{\rho_i^{rs}}\right]^{\beta_i^s}$$

where Z_i^s is a Hicks-neutral productivity shifter, L_i and K_i are labor and capital use, and Q_i^r is a composite bundle of intermediate inputs from sector r, with the same structure as the aggregator in eq(1). Parameters β_i^s, γ_i^s, and ρ_i^{rs} represent the expenditure share of intermediate goods, the value added share of labor, and the expenditure share of inputs sourced from sector r, respectively. Z_i^s is common to all firms within $\{i, s\}$. Governments can influence Z_i^s through sector-level productivity investments, one of two instruments of industrial policy.

The unit cost function is given by

$$c_i^s(\omega) = \Upsilon_i^s \left[w_i^{\gamma_i} r_i^{1-\gamma_i}\right]^{1-\beta_i^s} \prod_{r=1}^S \left[(P_i^r)^{\rho_i^{rs}}\right]^{\beta_i^s} \tag{3}$$

[12] The sum of rents from the portfolio and remittances are also the regional trade deficit (or current account) D_j.

[13] Appendix A provides a detailed overview of the mapping between national accounting identities, model counterparts, and the data we use to quantify the various channels.

where Y is a constant that maps the production function to the cost function.[14]

Final goods Producers of final goods of sector s in region j assemble intermediate goods from supplying sector r. Final goods can also be traded. The production technology has the same form as the CES consumption index aggregator in eq(1). Hence, final producers and households share the same consumption decisions.

Prices and trade flows Firms in sector s in region i are monopolistically competitive and produce a unique variety ω in equilibrium. Prices are set as constant markups over marginal costs. Shipping goods involves iceberg trade costs $d_{ij}^s \geq 1$, with intra-regional trade normalized to one, as well as potential *ad valorem* tariffs $t_{ij}^s \geq 0$, which operationalize the government's trade policy.

Moreover, the unit cost of production of goods of sector s in region i can differ from its efficient value due to a wedge $\tau_i^s = 1 + \tilde{\tau}_i^s$, where $\tilde{\tau}_i^s$ is the net tax rate on s goods from i, imposed by governments as the second instrument for industrial policy. A net subsidy, $\tilde{\tau}_i^s < 0$, lowers prices $p_{ij}^s(\omega)$, everything else equal. The price for goods produced by sector s in region i and consumed in region j is common across all ω within this tuple, and given by

$$p_{ij}^s(\omega) = \frac{\theta^s}{\theta^s - 1} \frac{c_i^s \tau_i^s \kappa_{ij}^s}{Z_i} \tag{4}$$

where $\frac{\theta^s}{\theta^s-1}$ denotes the constant markup and $\kappa_{ij}^{sr} = (1 + t_{ij}^s) d_{ij}^s$ is a trade cost parameter that contains the iceberg trade costs d_{ij}^s and tariffs t_{ij}^s.

External economies of scale Aggregating eq(4) over firm-level varieties within sectors and region pairs, we obtain:

$$P_{ij}^s = \frac{\theta^s}{\theta^s - 1} \frac{c_i^s \tau_i^s \kappa_{ij}^s}{Z_i^s} M_i^{s^{-\frac{1}{\theta^s - 1}}} \tag{5}$$

where M_i^s represents the endogenous mass of active firms of sector s in region i. Eq(5) characterizes sector-regional level external economies of scale: a larger mass of firms implies a decrease in the price index P_{ij}^s. In particular, the industry-level scale elasticity is given by:

$$-\frac{\partial \ln P_{ij}^s}{\partial \ln M_i^s} = \frac{1}{\theta^s - 1} = \mu_i^s \tag{6}$$

where μ_i^s is the markup rate in industry s in region i. External economies of scale induce a decrease of prices as the mass of firms in $\{i, j, s\}$ increases, benefiting all firms within this tuple (e.g. through shared knowledge, a skilled labor pool, or infrastructure improvements). Eq(6) also reflexts the extensive margin in this model: it represents the mass of firms that can sustain in equilibrium given θ^s.

Firm entry To enter the market, firms in sector s must pay an entry cost f^s before producing. This cost is paid in terms of all inputs of production, c_i^s. Free entry implies that equilibrium profits are zero after paying the entry cost, leading to the free entry condition:

$$c_i^s f^s = \frac{1}{\theta^s} \frac{Y_i^s}{M_i^s} \tag{7}$$

[14] In particular, $\Upsilon_i^s = \left[(1-\beta_i^s)\gamma_i^{s\gamma_i^s}(1-\gamma_i^s)^{1-\gamma_i^s}\right]^{-(1-\beta_i^s)} \prod_{r=1}^{S}(\beta_i^s \rho_i^{rs})^{-\beta_i^s \rho_i^{rs}}$.

where Y_i^s is sector gross output and $\frac{Y_i^s}{M_i^s}$ is the output per firm within sector s in i.[15] Hence, firm entry has a direct impact on consumer welfare through both price and variety effects as M_i^s increases.

3.3 Governments

Local government Local governments can implement industrial policy by taxing or subsidizing production, as well as public policy by providing public goods. To fund these policies, local governments levy lump sum taxes, potentially operating with a budgetary imbalance. In particular, a local government in region i provides *ad valorem* production taxes T_i^s and/or subsidies S_i^s to sector s, so that total net tax revenues $\bar{T}_i \equiv T_i - S_i$ are given by:

$$\bar{T}_i = \sum_{s=1}^{S} (T_i^s - S_i^s) = \sum_{s=1}^{S} Y_i^s c_i^s \tilde{\tau}_i^s$$

The local government can also provide public goods G_i^s, so that total public consumption in i is:

$$\bar{G}_i = \sum_{s=1}^{S} P_i^s G_i^s$$

where $\bar{G}_i$ represents total public expenditures in i. This characterizes the local governments' public policy choices. Finally, the local government levies lump sum local taxes T_i^{LOC}.[16] The government budget may be unbalanced, with its budget constraint given by:

$$\bar{T}_i + T_i^{LOC} + B_i = \bar{G}_i \tag{8}$$

where $B_i \gtrless 0$ is the budget imbalance of the local government in region i, with $B_i > 0$ indicating a local budget deficit.

Supranational government The supranational government sets trade policy through common external tariffs, collects the respective tariff revenues $R_i = \sum_{j \in N} \sum_{s \in S} t_{ij}^s X_j^s$, as well as local contributions to EU taxes T_i^{EU}, and redistributes funds to local governments running deficits B_i. The supranational government runs a balanced budget, so that:

$$\sum_{i \in EU} R_i + \sum_{i \in EU} \phi_i T^{EU} - \sum_{i \in EU} B_i = 0 \tag{9}$$

Each region i contributes $\phi_i T^{EU}$ to the supranational government. Thus, a region i can be *net recipient* (if $T_i^{EU} - B_i < 0$) or *net contributor* (if $T_i^{EU} - B_i > 0$) of public funds.

Combining equations Eq. (8) and Eq. (9) we get:

$$\sum_{i \in EU} \phi_i T^{EU} + \sum_{i \in EU} R_i = \sum_{i \in EU} (\bar{G}_i - \bar{T}_i - T_i^{LOC}) \tag{10}$$

where R_i are total tariff revenues of region i from imports of intermediate and final goods.

[15]Only firms that produce can be subject to taxes on production. Therefore, any policy affecting the net tax rate does not influence the entry cost. However, production taxes or subsidies can affect firm entry through Y_i^s. For example, a net subsidy increases production Y_i^s which in turn triggers other firms to enter, generating additional varieties.

[16]These lump sum taxes include all other taxes raised by the local government. In the empirical analysis, we compute these local lump sum taxes as the residual of eq(8), where all other objects are directly observed in the data.

3.4 Trade flows

Denoting X_{ij}^s as the expenditures made by region j in goods of sector s produced in region i, and observing that these are equivalent to total sales $P_{ij}^s Q_{ij}^s$, we can derive the gravity equation:

$$X_{ij}^s = \left(\frac{1}{\theta^s}\right)^{-\frac{1-\sigma^s}{\theta^s-1}} \left(\frac{\theta^s}{\theta^s-1}\right)^{1-\sigma^s} (c_i^s \tau_i^s \kappa_{ij}^s)^{1-\sigma^s} Z_i^{s\,\gamma_i(\sigma^s-1)} \left(\frac{Y_i^s}{c_i^s f^s}\right)^{-\frac{1-\sigma^s}{\theta^s-1}} X_j^s P_j^{s\,\sigma^s-1} \tag{11}$$

where P_j^s is the unit price of the final good sold by sector s region j:

$$P_j^s = \left(\frac{1}{\theta^s}\right)^{-\frac{1}{\theta^s-1}} \frac{\theta^s}{\theta^s-1} \left[\sum_{i=1}^{N} (c_i^s \tau_i^s \kappa_{ij}^s)^{1-\sigma^s} Z_i^{s\,\gamma_i(\sigma^s-1)} \left(\frac{Y_i^s}{c_i^s f^s}\right)^{-\frac{1-\sigma^s}{\theta^s-1}}\right]^{\frac{1}{1-\sigma^s}} \tag{12}$$

We can define the corresponding expenditure share as:

$$\lambda_{ij}^s = \frac{X_{ij}^s}{X_j^s} = \frac{(c_i^s \tau_i^s \kappa_{ij}^s)^{1-\sigma^s} Z_i^{s\,\gamma_i(\sigma_n^s-1)} \left(\frac{Y_i^s}{c_i^s f^s}\right)^{-\frac{1-\sigma^s}{\theta^s-1}}}{\sum_{n=1}^{N} (c_n^s \tau_n^s \kappa_{nj}^s)^{1-\sigma^s} Z_n^{s\,\gamma_n(\sigma_n^s-1)} \left(\frac{Y_n^s}{c_n^s f^s}\right)^{-\frac{1-\sigma_n^s}{\theta_n^s-1}}} \tag{13}$$

3.5 Market clearing and trade balance

Goods market clearing requires that total production of sector s in region i equals total expenditure worldwide. Thus, total gross output is:

$$Y_i^s = \sum_{j=1}^{N} X_{ij}^s + P_i^s G_i^s = \underbrace{\sum_{j=1}^{N}\sum_{r=1}^{S} \frac{\lambda_{ij}^s}{1+t_{ij}^s} \beta_j^r \rho_j^{sr} Y_j^r}_{\text{intermediate sales}} + \underbrace{\sum_{j=1}^{N} \frac{\lambda_{ij}^s}{1+t_{ij}^s} \alpha_j^s I_j}_{\substack{\text{final sales}\\ \text{(households)}}} + \underbrace{P_i^s G_i^s}_{\substack{\text{final sales}\\ \text{(government)}}} \tag{14}$$

The first term refers to intermediate sales: gross output of sector s in region i is used as an input for each sector r in every region j. The term $\beta_j^r \rho_j^{sr} Y_j^r$ represents total demand by sector r in region j of goods from sector s, multiplied by the share of this demand satisfied by region i. Alternatively, gross output can be sold to households (second term) in every region j, who demand a fraction α_i^s of their income for each good of sector s. Finally, gross output can be sold to the local government (third term), representing government final demand.[17] In equilibrium, total imports of sector s in region i net of the trade deficit must equal exports, both in intermediate and final sales. Hence:

[17]Government's final demand is not exported, meaning that local government can only increase final demand of a sector s within their own region.

$$\underbrace{\sum_{j=1}^{N}\sum_{s=1}^{S}\sum_{r=1}^{S}\frac{\lambda_{ji}^{s}}{1+t_{ji}^{s}}\beta_i^r\rho_i^{sr}Y_i^r}_{\text{imports in intermediate goods}}+\underbrace{\sum_{j=1}^{N}\sum_{s=1}^{S}\frac{\lambda_{ji}^{s}}{1+t_{ji}^{s}}\alpha_i^s I_i}_{\text{imports in final goods}}-D_i=$$

$$\underbrace{\sum_{j=1}^{N}\sum_{s=1}^{S}\sum_{r=1}^{S}\frac{\lambda_{ij}^{s}}{1+t_{ij}^{s}}\beta_j^r\rho_j^{sr}Y_j^r}_{\text{exports in intermediate goods}}+\underbrace{\sum_{j=1}^{N}\sum_{s=1}^{S}\frac{\lambda_{ij}^{s}}{1+t_{ij}^{s}}\alpha_j^s I_j}_{\text{exports in final goods}} \quad (15)$$

3.6 Equilibrium

Definition Equilibrium in this economy for all $i, j \in N$ regions and $s, r \in S$ sectors is given by vectors of prices $\{P_j^s\}$, wages $\{w_i\}$, rents $\{r_i\}$, mass of firms $\{M_i^s\}$, quantities $\{q_i^s\}$, labor $\{L_i^s\}$ and capital use $\{K_i^s\}$, private $\{C_j^s\}$ and public consumption bundles $\{G_j^s\}$, and trade flows $\{X_{ij}^s\}$, local $\{T_i^{LOC}\}$ and supranational taxes $\{T_i^{EU}\}$, tariff revenues $\{R_i\}$, budget deficits $\{B_i\}$, and trade imbalances $\{D_i\}$, tariffs $\{t_{ij}^s\}$, net taxes on production $\{\tilde{\tau}_i^s\}$, and government spending $\{G_i^s\}$, which are jointly determined by the following conditions:

(i) Households maximize utility;

(ii) Firms minimize costs and maximize profits;

(iii) Goods, labor, capital markets and the EU budget clear;

for a given set of parameters: consumption shares $\{\alpha_i^s\}$, $\{\delta_i^s\}$, $\{\eta_i^s\}$, production shares $\{\beta_i^s\}$, $\{\gamma_i\}$, $\{\rho_i^{sr}\}$, elasticities of substitution across regions and varieties $\{\sigma_i^s\}$ and $\{\theta_i^s\}$, productivity shifters $\{Z_i^s\}$ iceberg trade costs $\{d_{ij}^s\}$ and fixed costs f^s. We solve the model using hat algebra, as in Dekle et al. (2008). Thus, we rewrite the equilibrium conditions in equations (3), (12), (13), (14) and (15) in terms of relative changes from the baseline equilibrium:

$$\hat{c}_j^r = \hat{w}_j^{1-\beta_j^r}\prod_{s=1}^{S}(\hat{P}_j^s)^{\beta_j^r\rho_j^{sr}} \quad (16)$$

$$\hat{P}_j^s = \left[\sum_{i=1}^{N}\lambda_{ij}^s(\hat{c}_i^s\hat{\tau}_i^s\hat{\kappa}_{ij}^s)^{1-\sigma^s}\hat{Z}_i^{s\,\sigma^s-1}\left(\frac{\hat{Y}_i^s}{\hat{c}_i^s}\right)^{-\frac{1-\sigma^s}{\theta^s-1}}\right]^{\frac{1}{1-\sigma^s}} \quad (17)$$

$$\lambda_{ij}^{s'} = \lambda_{ij}^s\frac{(\hat{c}_i^s\hat{\tau}_i^s\hat{\kappa}_{ij}^s)^{1-\sigma^s}\hat{Z}_i^{s\,\sigma^s-1}\left(\frac{\hat{Y}_i^s}{\hat{c}_i^s}\right)^{-\frac{1-\sigma^s}{\theta^s-1}}}{\hat{P}_j^{s\,1-\sigma^s}} \quad (18)$$

$$\hat{Y}_i^s = \frac{1}{Y_i^s}\left[\sum_{j=1}^{N}\sum_{r=1}^{S}\frac{\lambda_{ij}^{s'}}{1+t_{ij}^{s'}}\beta_j^r\rho_j^{sr}\hat{Y}_j^r Y_j^r + \sum_{j=1}^{N}\frac{\lambda_{ij}^{s'}}{1+t_{ij}^{s'}}\alpha_j^s I_j' + \hat{P}_i^s\hat{G}_i^s(P_i^s G_i^s)\right] \quad (19)$$

$$\sum_{j=1}^{N}\sum_{s=1}^{S}\sum_{r=1}^{S}\frac{\lambda_{ji}^{s\prime}}{1+t_{ji}^{s\prime}}\beta_i^s\rho_i^{rs}\hat{Y}_i^s Y_i^s+\hat{w}_i(w_iL_i+r_iK_i)-T_i^{EU\prime}-T_i^{LOC}=$$
$$\sum_{j=1}^{N}\sum_{s=1}^{S}\sum_{r=1}^{S}\frac{\lambda_{ij}^{s\prime}}{1+t_{ij}^{s\prime}}\beta_j^r\rho_j^{sr}\hat{Y}_j^r Y_j^r+\sum_{j=1}^{N}\sum_{s=1}^{S}\frac{\lambda_{ij}^{s\prime}}{1+t_{ij}^{s\prime}}\alpha_j^s I_j' \quad (20)$$

where

$$I_j'=\hat{w}_j(w_jL_j+r_jK_j)-T_j^{EU\prime}-T_j^{LOC}+D_j'$$
$$T_j^{EU\prime}=\phi_jT^{EU\prime}=\phi_j\sum_{j\in EU}\left[\sum_{s=1}^{S}\hat{P}_j^s\hat{G}_j^s(P_j^sG_j^s)-\sum_{s=1}^{S}(\hat{Y}_j^s\hat{c}_j^s\hat{\tilde{\tau}}_j^s)(Y_j^sc_j^s\tilde{\tau}_j^s)-T_j^{LOC}-R_j'\right]$$
$$R_j'=\sum_{i=1}^{N}\sum_{s=1}^{S}t_{ij}^{s\prime}\frac{\lambda_{ij}^{s\prime}}{1+t_{ij}^{s\prime}}\underbrace{\left(\sum_{r=1}^{S}\beta_j^r\rho_j^{sr}\hat{Y}_j^rY_j^r+\alpha_j^sI_j'\right)}_{X_j^{s\prime}}$$

Equations (16)-(20) are used to estimate the deviation of the counterfactual scenario from the baseline equilibrium of the model.

Some intuition on equilibrium behavior Tax revenues T^{EU} endogenously adjust to any exogenous change in public consumption and production subsidies, depending on the amount of tariff and production tax revenues, to cover all the deficits $\bar{G}_i-\bar{T}_i-T_i^{LOC}$ made by local governments.[18] Essentially, any increase in public spending—whether due to public consumption or production subsidies—requires a corresponding increase in revenues. On the one hand, an increase in public consumption in sector s first boosts final demand and propagates upstream to the sectors providing intermediaries. This may lead to an increase in imports and, consequently, tariff revenues, reducing the need to raise T^{EU}. On the other hand, an increase in subsidies affects prices, making goods from subsidized industries more competitive and reducing imports, which lowers tariff revenues. This shock propagates downstream, enabling sourcing industries to lower input costs and prices. As a result, exports outside the EU increase while imports decrease, further reducing tariff revenues. In both scenarios, tax revenues adjust based on the additional wealth generated by the policy. Due to the non-trivial effects that each policy shock generates, we need to simulate the model to quantify the magnitude of these effects and their different channels.

3.7 Welfare

The quantitative results in the counterfactuals below are obtained from solving the entire non-linear system of equations defined in subsection 3.6. However, to understand better the different channels through which each policy affects welfare, we log-linearize the system of equations and analyze the first-order effects of any shock. Changes in welfare can be expressed as:

[18] Regions outside the EU do not report to a supranational government. In these cases, only the local government is active and collects tariff revenues. Moreover, since the total contribution channel T^{EU} is muted, local tax T_i^{LOC} adjusts to cover any change in public consumption and production subsidies. Thus, the budget constraint of non-EU local government becomes $\bar{T}_i+T_i^{LOC}+R_i=\bar{G}_i$. It is straightforward to see that the budget of non-EU local governments must be balanced.

$$\hat{W}_j = \left(\frac{\hat{I}_j}{\hat{P}_j}\right)^{\eta_j} \left(\hat{G}_j\right)^{1-\eta_j} \tag{21}$$

We proceed by log-linearizing the different components of the above equation.

Prices. To disentangle the different effects on prices, we log-linearize and totally differentiate equation (12), which after some manipulations becomes:

$$\mathrm{dlog}P_j^s = \frac{\mathrm{dlog}\lambda_{jj}^s}{\sigma^s - 1} + \mathrm{dlog}\tau_j^s - \mathrm{dlog}Z_j^s - \mu^s\,\mathrm{dlog}Y_j^s + (1+\mu^s)\,\mathrm{dlog}c_j^s \tag{22}$$

Now consider the change in the cost of the input bundle, $\mathrm{dlog}c_j^s$. Log-linearizing and totally differentiating equation (3) yields:

$$\mathrm{dlog}c_j^s = (1-\beta_j^s)\,\mathrm{dlog}w_j + \sum_{r=1}^{S} \beta_j^s \rho_j^{rs}\,\mathrm{dlog}P_j^r$$

By substituting this into equation (22) and solving iteratively, we obtain:

$$\mathrm{dlog}P_j^s = \sum_{r=1}^{S} \tilde{\psi}_j^{rs} \frac{\mathrm{dlog}\lambda_{jj}^r}{\sigma^r - 1} + \sum_{r=1}^{S} \tilde{\psi}_j^{rs}\,\mathrm{dlog}\tau_j^r - \sum_{r=1}^{S} \tilde{\psi}_j^{rs}\,\mathrm{dlog}Z_j^r - \sum_{r=1}^{S} \mu^r \tilde{\psi}_j^{rs}\left(\mathrm{dlog}Y_j^r - \mathrm{dlog}w_j\right) + \mathrm{dlog}w_j \tag{23}$$

Or, equivalently, in matrix form:

$$\mathbf{P} = \tilde{\mathbf{\Psi}}\mathbf{C} + \mathbf{w}$$

where $\tilde{\mathbf{\Psi}} = \left(\mathbf{I} - \tilde{\mathbf{A}}\right)^{-1}$ is the cost-based Leontief inverse (as in Baqaee and Farhi (2020)), $\mathbf{I}$ the identity matrix, and $\tilde{\mathbf{A}}$ is the matrix of technical coefficients $\tilde{a}_j^{rs} = \beta_j^s \rho_j^{rs}(1+\mu_j^s)$, which are the standard Leontief technical coefficients, now adjusted for markups.[19] Each element $\tilde{\psi}_j^{rs}$ of the cost-based Leontief inverse gives the change in sector s in region j's input costs following a change in sector r's prices.[20]

By noting that $w_j = \frac{1}{L_j}\sum_s \gamma_j(1-\beta_j^s)Y_j^s$, we can rewrite eq(27) as:

$$\mathrm{dlog}P_j^s = \underbrace{\sum_{r=1}^{S} \tilde{\psi}_j^{rs} \frac{\mathrm{dlog}\lambda_{jj}^r}{\sigma^r - 1}}_{\text{ACR}} + \underbrace{\sum_{r=1}^{S} \tilde{\psi}_j^{rs}\,\mathrm{dlog}\left(\frac{\tau_j^r}{Z_j^r}\right)}_{\text{Productivity}} - \underbrace{\sum_{r=1}^{S} \mu^r \tilde{\psi}_j^{rs}\left(\mathrm{dlog}Y_j^r - \sum_{k=1}^{S}\frac{L_j^k}{L_j}\,\mathrm{dlog}Y_j^k\right)}_{\text{EES}} + \mathrm{dlog}w_j \tag{24}$$

The first term of the above equation is the standard ACR effect, which captures price changes using the domestic trade share λ_{jj}^r and the trade elasticity $\sigma^s - 1$. This effect is amplified by forward input-output linkages (represented by $\tilde{\psi}_j^{rs}$), which propagate the effect on prices downstream through the supply chain. The second term reflects any change in productivity, whether from a Hicks-neutral shock or a policy change in the net tax rate. This effect also propagates downstream via forward input-output linkages. The third term captures the effect of external economies of scale. Consider the elements inside the parentheses: since the shares $\frac{L_j^r}{L_j}$ in the second term sum to 1, this can be seen as the size-weighted average of the log change in sales Y_j^s. We can rewrite this as $\mathrm{dlog}\bar{Y}_j$, interpreting the elements in the brackets as a measure of industry specialization. Whenever a region increases its output in industry r more than the average $\bar{Y}_j$, it is respecializing in that industry. If the industry benefits from economies of scale, the entry of new varieties drives

[19] Appendix B illustrates the exact definition and structure of the matrices used.
[20] This element does not depend on the supplier's region of origin due to construction of the production function in the model.

down prices, and the effect propagates downstream to all sectors. If the change in output is lower than the average, the effect is reversed, leading to a price increase. Thus, respecialization is profitable only when it occurs in a sector with economies of scale.

Let us now further analyze $\mathrm{dlog} Y_j^r$ by log-linearizing and totally differentiating the goods market clearing condition from equation (14):

$$\begin{aligned}\mathrm{dlog} Y_j^r &= \sum_{i=1}^{N}\sum_{s=1}^{S} \frac{\lambda_{ji}^r}{1+t_{ji}^r}\beta_i^s \rho_i^{rs} \frac{Y_i^s}{Y_j^r}\,\mathrm{dlog} Y_i^s + \underbrace{\sum_{i=1}^{N} \frac{\lambda_{ji}^r}{1+t_{ji}^r}\frac{\alpha_i^r}{Y_j^r} I_i\,\mathrm{dlog} I_i + \frac{P_j^r G_j^r}{Y_j^r}\,\mathrm{dlog}\big(P_j^r G_j^r\big)}_{\mathrm{dlog} F_j^r / Y_j^r} \\ &= \sum_{i=1}^{N}\sum_{s=1}^{S} b_{ji}^{rs}\,\mathrm{dlog} Y_i^s + \frac{\mathrm{dlog} F_j^r}{Y_j^r}\end{aligned}$$

where for simplicity we substituted F_j^r for total final demand (both by households and the government) for sector r's goods from region j. Most importantly, b_{ji}^{rs} is a coefficient calculated as the sales from industry r in region j to industry s in region i divided by total sales of industry r in region j. This is commonly known as the direct output or allocation coefficient, as opposed to the technical coefficient of the Leontief Input-Output model. This coefficient represents the distribution of sector r's output from region j across all other sectors and regions in the economy. Iteratively substituting and rewriting the above in matrix notation:

$$\mathrm{dlog}\mathbf{Y} = (\mathbf{I} - \mathbf{B})^{-1}\mathrm{dlog}\mathbf{f} \tag{25}$$

where $\mathbf{\Psi} = (\mathbf{I} - \mathbf{B})^{-1}$ is the Ghosh inverse, with $\mathbf{B}$ being the matrix of allocation coefficients b_{ji}^{rs} and $\mathrm{dlog}\mathbf{f}$ is a column vector with elements $\mathrm{dlog} F_i^s / Y_j^r$, representing final demand for sector s's goods in region i as a share of total output of sector r in region j.[21]

By noting that $w_j = \frac{1}{L_j}\sum_s \gamma_j (1-\beta_j^r) Y_j^r$, we can rewrite eq(27) as:

$$\begin{aligned}\mathrm{dlog} P_j^s = \sum_{r=1}^{S} \tilde{\psi}_j^{rs} \frac{\mathrm{dlog}\lambda_{jj}^r}{\sigma^r - 1} + \sum_{r=1}^{S} \tilde{\psi}_j^{rs}\,\mathrm{dlog}\Big(\frac{\tau_j^r}{Z_j^r}\Big) - \\ - \sum_{r=1}^{S} \mu^r \tilde{\psi}_j^{rs} \Big(\sum_{i=1}^{N}\sum_{k=1}^{S} \psi_{ji}^{rk}\,\mathrm{dlog} F_i^k - \sum_{r=1}^{S} \frac{L_j^r}{L_j} \sum_{i=1}^{N}\sum_{k=1}^{S} \psi_{ji}^{rk}\,\mathrm{dlog} F_i^k \Big) + \mathrm{dlog} w_j\end{aligned} \tag{27}$$

From this formula, we can see that, under economies of scale, demand shocks propagate both upstream and downstream. First, an increase of one unit of final demand in $\{i, s\}$ generates an increase in output Y_j^r equal to ψ_{ji}^{rs}. This increase is larger the farther $\{j, r\}$ is from final demand and the more important it is as a supplier of final demand in $\{i, s\}$. If the resulting effect is larger than the average effect in region j, the entry of new varieties into the market pushes prices down, reducing the input cost for industries downstream in the supply chain.

[21] Alternatively, the equation can be expressed in levels rather than in logs, leading to:

$$\mathrm{d}\mathbf{Y} = (\mathbf{I} - \mathbf{\Lambda A})^{-1}\mathrm{d}\mathbf{F} \tag{26}$$

where $(\mathbf{I} - \mathbf{\Lambda A})^{-1}$ is the revenue-based Leontief inverse (as described in Baqaee and Farhi (2020)) and $\mathbf{A}$ is the matrix of technical coefficients $\beta_j^s \rho_j^{rs}$, which are then multiplied by the elements of $\mathbf{\Lambda}$, a matrix containing the import shares $\frac{\lambda_{ji}^r}{1+t_{ji}^r}$ adjusted for tariffs. The details of this matrix multiplication can be found in Appendix B.

Income. Let us now proceed with decomposing the effects that small perturbation of the equilibrium has on income. By log-linearizing equation (2), we get:

$$\mathrm{dlog}I_j = \underbrace{\frac{w_j L_j}{I_j}\,\mathrm{dlog}w_j}_{\text{changes in cost of labor}} + \underbrace{\chi_j \sum_i \frac{r_i K_i}{I_j}\,\mathrm{dlog}w_i}_{\text{changes in portfolio returns}} - \underbrace{\phi_j \frac{\mathrm{d}T^{EU}}{I_j}}_{\text{changes in taxes}}$$

where the absolute change in the total EU tax revenue, $\mathrm{d}T^{EU}$, can be expressed as:

$$\mathrm{d}T^{EU} = \sum_{j\in EU}\Bigg[\underbrace{\mathrm{d}\bar{G}}_{\text{public policy}} \underbrace{-\sum_{s=1}^{S}\tilde{\tau}_j^s \mathrm{d}c_j^s - \sum_{s=1}^{S} c_j^s \mathrm{d}\tilde{\tau}_j^s}_{\text{industrial policy}} \underbrace{-\sum_{s=1}^{S}\sum_{i=1}^{N} IM_{ij}^s \mathrm{d}t_{ij}^s - \sum_{s=1}^{S}\sum_{i=1}^{N} t_{ij}^s \mathrm{d}IM_{ij}^s}_{\text{trade policy}}\Bigg]$$

where IM_{ij}^s are the imports of sector s that region i receives from j.

Welfare. Combining together the two above components by recalling that $\mathrm{dlog}P_j = \sum_{s=1}^{S}\alpha_j^s\,\mathrm{dlog}P_j^s$, and including the change in real government consumption G_j, we can derive the log-change in welfare for region j:

$$\begin{aligned}\mathrm{dlog}W_j = \;& \eta_j\Bigg[\left(\frac{w_j L_j}{I_j} - 1\right)\mathrm{dlog}w_j + \chi_j \sum_{i=1}^{N}\frac{r_i K_i}{I_j}\,\mathrm{dlog}w_i - \phi_j \frac{\mathrm{d}T^{EU}}{I_j} - \\ & - \sum_{s=1}^{S}\sum_{r=1}^{s}\alpha_j^s \tilde{\psi}_j^{rs}\frac{\mathrm{dlog}\lambda_{jj}^r}{\sigma^r - 1} - \sum_{s=1}^{S}\sum_{r=1}^{S}\alpha_j^s \tilde{\psi}_j^{rs}\,\mathrm{dlog}\left(\frac{\tau_j^r}{Z_j^r}\right) + \sum_{s=1}^{S}\sum_{r=1}^{S}\alpha_j^s \mu^r \tilde{\psi}_j^{rs}\left(\mathrm{dlog}Y_j^r - \mathrm{dlog}\bar{Y}_j\right)\Bigg] + \\ & + (1-\eta_j)\left[\sum_{s=1}^{S}\delta_j^s\,\mathrm{dlog}G_j^s\right]\end{aligned} \tag{28}$$

We can use this equation to disentangle the different channels that contribute to the change in welfare.

4 Data sources and calibration

We exploit detailed information on production, trade and input-output linkages for EU regions and the Rest of the World. In particular, we combine the following datasets:

1. **RHOMOLO V4 dataset from the JRC at the European Commission.**[22] This dataset provides information on production and consumption for 2017 across 235 EU NUTS2 regions and 25 extra-EU countries that make up the Rest of the World. For each EU region and extra-EU country, we have data on production and consumption across 55 NACE sectors, along with their sources of value added and final demand. Additionally, the RHOMOLO database includes a comprehensive Multi-regional Input-Output matrix detailing intermediate goods sold at intra-regional, inter-regional, and international levels. All entries are expressed in nominal values.

2. **Historic EU payments by region.**[23] This dataset contains payments from multiple programming periods and EU funds, regionalized at the NUTS2 level. We use the data for 2017 to align with the RHOMOLO input-output data.

[22] Additional information on this data can be found here.
[23] Additional information can be found here.

Calibration and link to the model parameters is described in Table 1.

Model object	Data
X_{ij}^s	Expenditure matrix
Y_i^s	Gross output
$w_i L_i$	Value added: compensation of employees
$r_i K_i$	Value added: compensation of employees
$\bar{T}_i^s$	Value added: net taxes on production
B_i	EU transfers to regions
$P_i^S G_i^s$	Government consumption
λ_{ij}^s	Expenditure shares, $X_{ij}^s / \sum_i X_{ij}^s$
β_j^r	intermediates cost share in production, $\sum_i \sum_s X_{ij}^{sr} / Y_j^r$
ρ_j^{sr}	Share of inputs bought from r, $\sum_i X_{ij}^{sr} / \sum_i \sum_s X_{ij}^{sr}$
α_i^s	Budget shares, $\frac{Y_i^s - P_i^s G_i^s - \sum_j \sum_r \beta_j^r \rho_j^{sr} Y_j^r}{I_i}$
γ_j	$w_i L_i / Y_j^r$
δ_j^r	$1 - \gamma_j - \beta_j^r$
μ_i^s	Industry-level markup (industry-level scale elasticity, 0.09)
σ^s	Elasticity of substitution across regions, (1+trade elasticity, 6)
θ^s	Elasticity of substitution across varieties
$\tilde{\tau}_j^r$	Net tax wedge, $\frac{\bar{T}_j^r}{\sum_i \sum_s X_{ij}^{sr} + w_j L_j + r_j K_j}$

Table 1: Calibration of model parameters and data sources.

5 Policy counterfactuals

5.1 Aggregate welfare effects

We now turn to the quantitative assessment of implementing three policies: trade, industrial and public policy. These simulations currently serve as a proof of concept for the mechanics of the model. In further iterations of this paper we will refine both the shocks and the regional analysis in detail. First, we simulate a 10% increase in iceberg trade costs κ_{ij}^s, for manufacturing imports from the rest of the world to the EU, while keeping those within the EU constant.[24] As a second shock, we simulate a 10% increase to production subsidies τ_i^s across all manufacturing sectors. Finally, we simulate a 10% increase in final demand for manufacturing sectors G_i^s. The size of these shocks is relatively small: for example the recent import tariffs on electrical vehicles from China to the US increased with 100%.

For each shock, we simulate three versions of the model. The first version shuts down external economies of scale (EES) and input-output (IO) linkages, and the model collapses to Arkolakis et al. (2012) (henceforth ACR), albeit with an additional channel of government expenditures. The second version adds EES, and the model then coincides with Lashkaripour and Lugovskyy (2023). The last version reflects the full model of Section 3, incorporating both EES and IO linkages. For each policy, we obtain aggregate welfare changes, EU $\hat{W}$, as the weighted sum of welfare changes across all regions j, $\hat{W}_j$, with weights given by j's GNI share

[24] The next step in the project is to exploit data on tariffs and trade flows to simulate detailed tariff changes on 'strategic' products that enter the EU, which also affects tariff revenues and the budget of the EU.

ϕ_j. We also report the heterogeneity of welfare changes across all EU regions, measured as the (unweighted) standard deviation of $\hat{W}_j$.

Table 2 shows the aggregate welfare results for each counterfactual policy shock. The effects of trade policy are consistently negative across all versions, and IO linkages exacerbate these negative effects. This is intuitive: increasing trade costs leads to higher world prices for imports to the EU. In equilibrium, this also raises domestic prices, resulting in welfare losses. Higher import prices not only have a direct negative impact on imported goods but also indirectly increase the prices of downstream goods that rely on these imports as inputs for production. Industrial policy generates a small but positive welfare effect across all three versions. Public policy can induce small negative or positive welfare effects, depending on which channels are active in the model. Across versions, EES contribute positively to welfare changes, as each policy induces increased demand for domestic production, which, in turn, triggers entry into the market. When considering the variation in regional welfare changes across all policies, trade policy induces the largest dispersion in regional outcomes.

EU $\hat{W}$(%)	ACR	ACR + EES	Full	Stdev(Full)
Trade policy	-0.16	-0.11	-0.27	0.49
Industrial policy	0.00	0.01	0.03	0.15
Public policy	-0.03	-0.03	0.01	0.08

[1] EU aggregate welfare effects from GNI shares of regions: $\hat{W} = \sum_j \phi_j \hat{W}_j$.
[2] Stdev is the standard deviation across regional outcomes.

Table 2: Aggregate welfare effects

5.2 Regional welfare effects

Next, we analyze the heterogeneous effects of each policy on EU regions. Figure 5 shows the welfare effects by region on the y-axis, and the relative change in net contributions in percentage terms on the x-axis. When a trade shock occurs, imports decline, leading to a reallocation towards intra-EU suppliers, but at higher prices. This results in a welfare loss for almost every EU region. However, there is substantial variation in the welfare changes across different regions, ranging between 0% and -6%.

Also the budgetary impact of a trade shock can vary vastly across regions. In this case, there can be clear winners and losers, with changes in contributions ranging from -150% to +150%. However, there is no apparent correlation between the welfare and budgetary changes in response to the trade shock.

Figure 6 further details this massive heterogeneity in outcomes across regions and the three versions of the model. The Figure shows the top 10 and bottom 10 of the welfare change distribution. Once again, we simulate the model shutting down EES and IO linkages first, and then switch each channel on again. A key finding is that input-output linkages contribute most significantly to welfare changes across all regions. This implies that the connections of industries within the regional economies plays a crucial role in determining the welfare impacts of trade policies. Additionally, the plot highlights that even within individual countries, such as Germany, the Netherlands, and Hungary, there are stark contrasts in regional outcomes. Some regions emerge as top winners, benefiting greatly from the policy changes, while others become top losers, suffering significant welfare losses. This underscores the complexity and variability of regional responses to economic policies within the same national context.

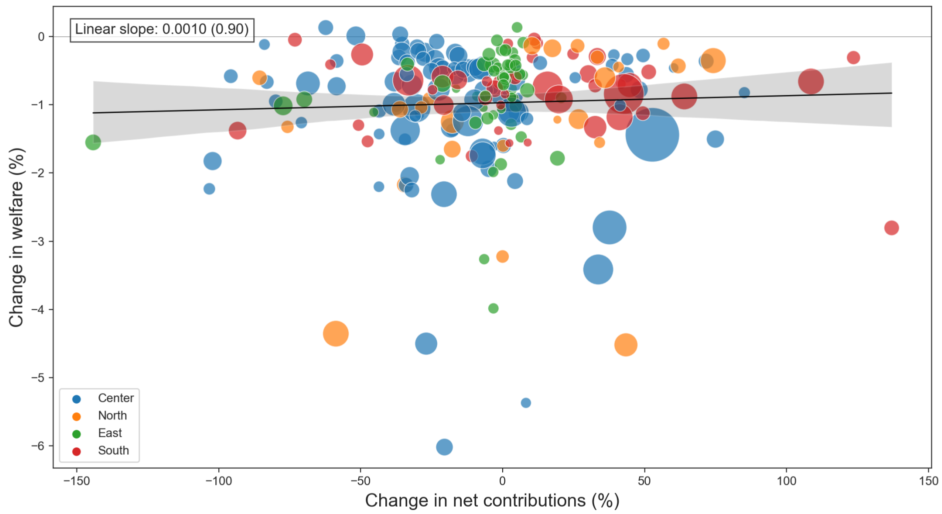


Figure 5: regional heterogeneity: trade policy

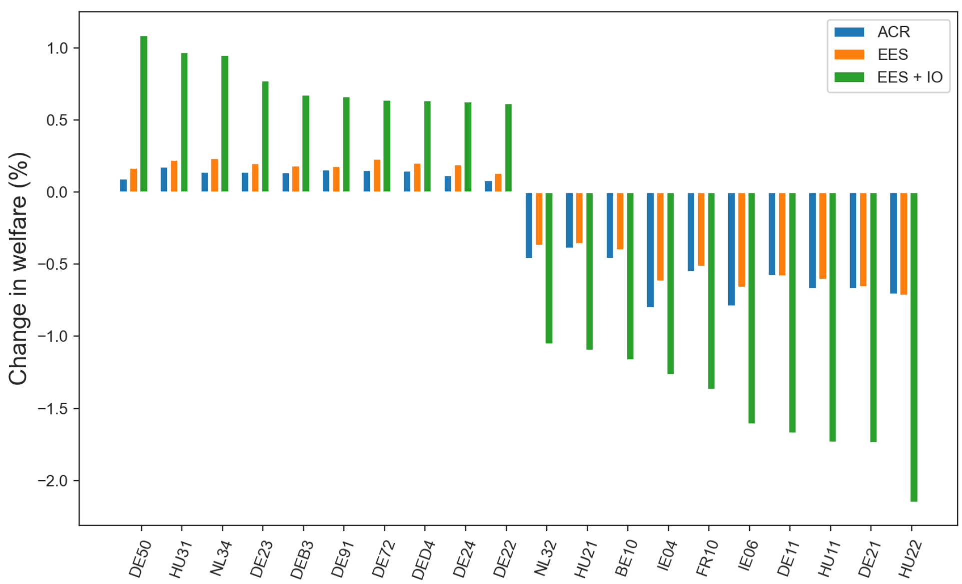


Figure 6: Welfare results across models: trade policy

As a second exercise, we shock industrial subsidies in manufacturing by 10%. A subsidy in production pushes down the cost of production, leading firms to reallocate their sourcing from extra-EU to intra-EU suppliers at lower prices. In terms of welfare, the policy creates both winners and losers, with the largest gains observed in the Northern and the largest losses in the Southern ones. This highlights the uneven distribution of benefits and costs across different regions. Also in terms of the budgetary impact of this measure, measured again in changes in net contributions, the effects are heterogeneous: regions in the North gain the most and simultaneously reduce their budget contributions the most, indicating a positive fiscal impact for these regions.

Figure 8 reveals again that input-output linkages contribute most significantly to welfare changes. Additionally, the welfare losses experienced by the regions which lose most from the policy are smaller than the welfare gains enjoyed by the regions which instead gain more. This indicates a net positive welfare impact overall, as described in Table 2, despite the presence of both gains and losses across different regions.

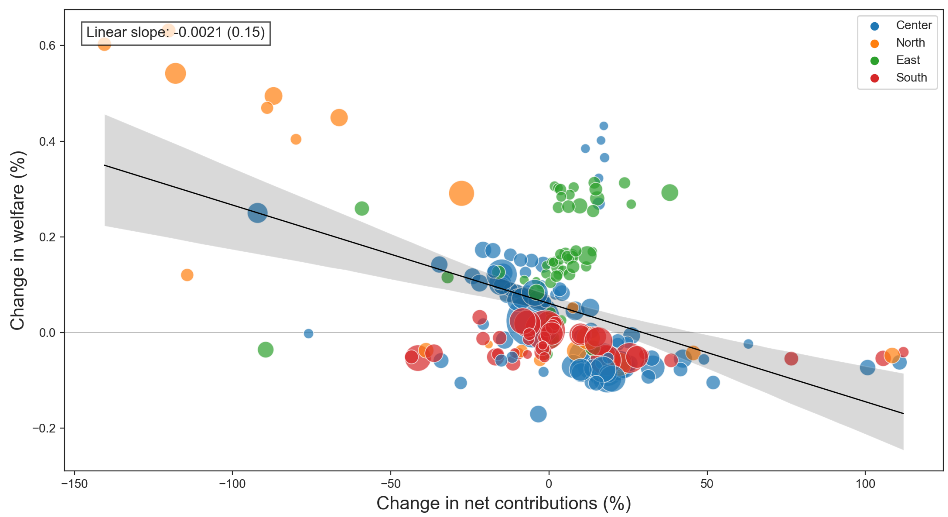


Figure 7: regional heterogeneity: industrial policy.

Finally, we shock government consumption in manufacturing sectors by 10%. Figure 9 shows the results. An increase in government spending boosts demand of the stimulated sector but this comes at the cost of higher taxes. In terms of welfare, the policy again creates both winners and losers, with the largest variance in welfare outcomes observed in the central regions. Moreover, regions in Eastern Europe experience the lowest variance in change in net contributions compared to other areas. Figure 10 shows again how input-output linkages contribute most significantly to welfare changes, with some regions even experiencing opposite effects compared to the same shock in a version of the model without linkages. Additionally, welfare losses are generally smaller and less dispersed compared to the gains.

While different policies can impact EU regions in varying ways, the same policy can also affect the same regions differently. This is clearly illustrated in Figure 11, which demonstrates how some regions can be winners under one policy and losers under another. These findings have significant implications for policymakers, as they highlight the complexity and variability of policy impacts. This also introduces potential political economy challenges that need to be considered in the decision-making process.

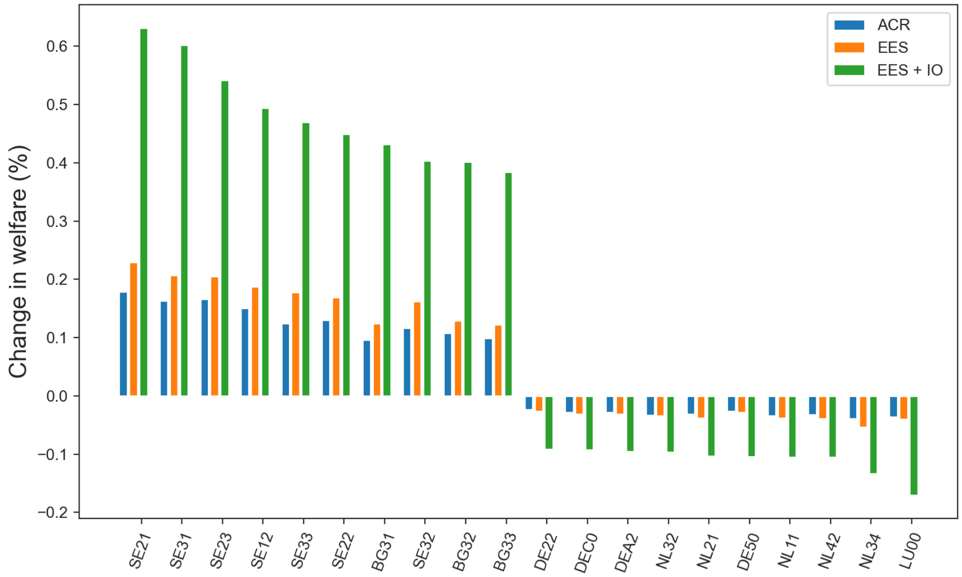


Figure 8: Welfare results across models: industrial policy.

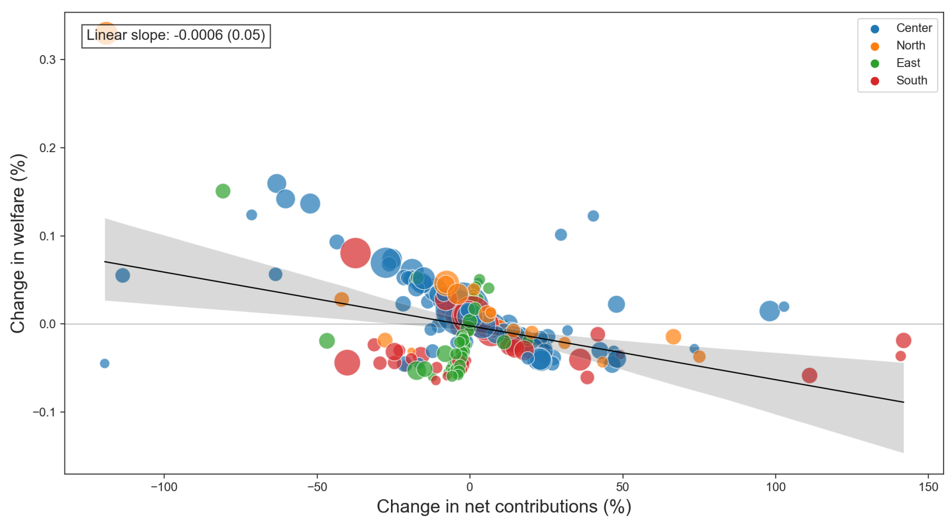


Figure 9: regional heterogeneity: public policy.

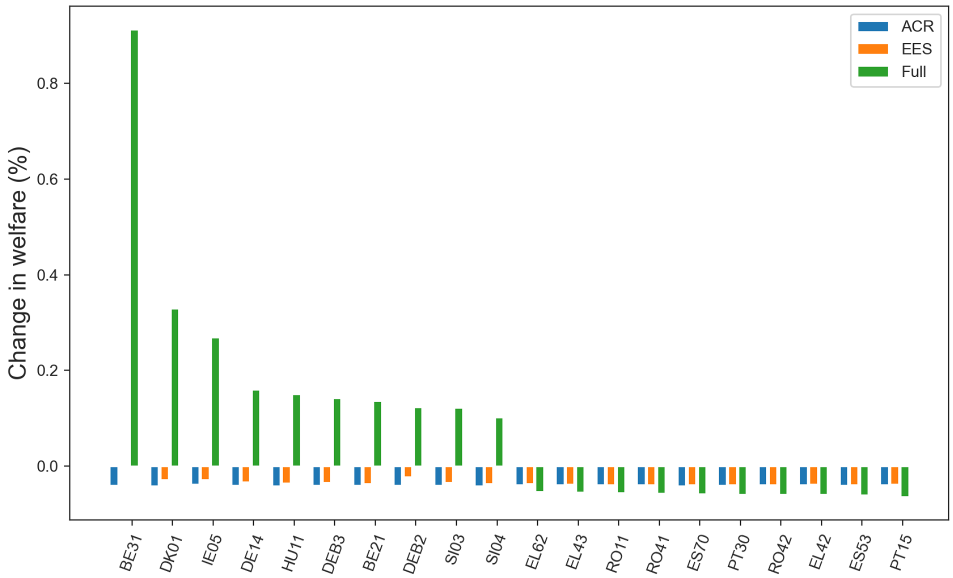


Figure 10: Welfare results across models: public policy.

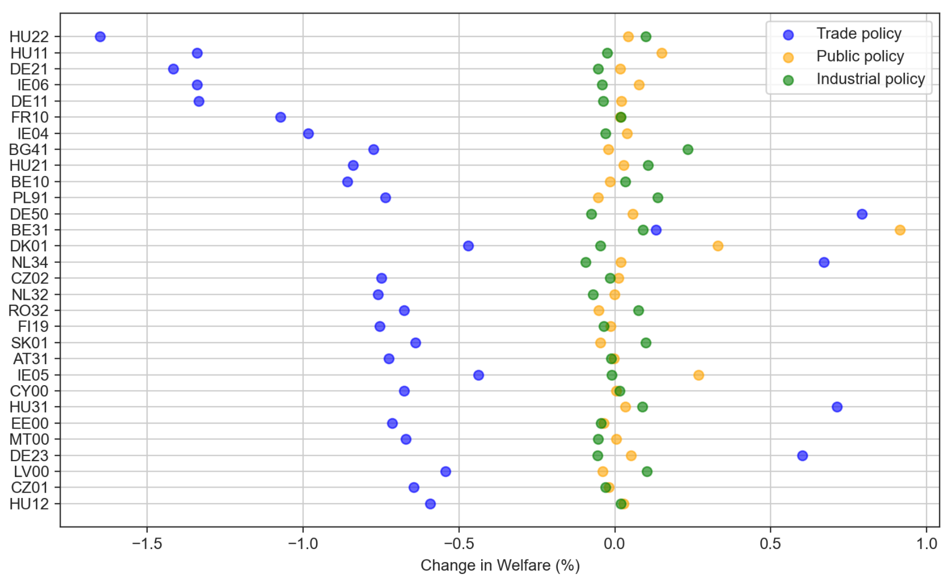


Figure 11: Summary of results by region.

6 Conclusion

We provide a detailed general equilibrium framework to study the impact of a toolbox of modern protectionist policy measures on socio-economic outcomes for EU regions. Our results show a high heterogeneity in the impact of all policies on European regions, showing the need for policymakers to take into account possible unintended consequences in terms of welfare and inequalities when pursuing protectionist measures.

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A Link to National Accounts

In National Accounts, the main macroeconomic aggregates used as indicators of economic performance are Gross Domestic Product (GDP) , Gross National Expenditure (GNE, also known as domestic absorption) and Gross National Income (GNI). These three indicators are closely related to each other through the following accounting identity:

$$GNI = \underbrace{\underbrace{C + I + G}_{=GNE} + \overbrace{(EX - IM)}^{} }_{=GDP}\! \overbrace{ + NFP}^{=CA} \tag{29}$$

where C, I and G are, respectively, private consumption, investments and government consumption. Moreover, CA is the Current Account and it is the sum of the trade balance (i.e. $EX - IM$) and net factor payments (NFP), which is the difference between income earned by home residents working or owning capital or land abroad and income paid out to foreigners working or owning capital or land abroad. If $GNI > GNE$, then $CA > 0$ and the economy earns more than what it spends, allocating the rest to savings. On the other hand, if the economy consumes more than what it earns it ends up with a CA deficit. In equilibrium, the sum of the CA and the Financial Account (FA) should be 0, which is called the Balance of Payments (BoP):

$$BoP = CA + FA = 0$$

The model we describe in Section 3 maps these aggregates at the regional level. In particular, there is a representative household in each region who consumes all of his income, implying that the budget constraint holds with equality $P_j C_j = I_j$. Moreover, also the local government consumes all of its income (either in the form of taxes levied on households or transfers from the supranational government), so that in equilibrium $GNE = GNI$ and:

$$GNE_j = I_j + \sum_s P_j^s G_j^s = GNI_j \tag{30}$$

In a model without government and no savings, the household income I_j coincides with GNI and GNE.

The fact that $GNE = GNI$ also implies that the CA is balanced, which in turn reveals our underlying assumption that the net factor income received by households is equal to the trade balance, namely:

$$\underbrace{IM_j - EX_j}_{D_j} = NFP_j$$

However, while GNE and GNI must be the same in equilibrium, this is not necessarily the case for GDP, as this can be higher or lower depending on the trade balance:

$$GDP_j = GNE_j + (EX_j - IM_j) = I_j + \sum_s P_j^s G_j^s - D_j \tag{31}$$

We can also get to an equivalent formulation of GDP calculated with the so-called *income approach* with some manipulation of the model equations. In particular, by taking the expenditures made by households and firms (not the government) in region j across all sectors s and substituting the households' income, we get:

$$X_j = \sum_s \sum_r \beta_j^r \rho_j^{sr} Y_j^r + w_j L_j + r_j K_j - T_j^{EU} - T_j^{LOC} + D_j$$

Substituting this into the trade balance of eq(15) in Section 3 and using the budget constraint of the local government of eq(8):

$$\sum_r (1 - \sum_s \beta_j^r \rho_j^{sr}) Y_j^r = w_j L_j + r_j K_j - \phi_j T^{EU} + B_j + \sum_r (Y_j^r c_j^r \tilde{\tau}_j^r)$$

The left-hand side of the equation is the GDP of region j computed with the *production approach* (i.e. gross output net of total intermediate consumption), while the right-hand side is the GDP formula for the *income approach*, which is the sum of national income (the first four terms of the equation) and net taxes on production (the last term). Moreover, the term $B_j - \phi_j T^{EU}$ is the *regional net contribution* and shows the additional (or diminished) income of region j supplied by the EU government.

B Input-Output matrices

The matrix $\tilde{\mathbf{A}}$ is the matrix of technical coefficients $\mathbf{A}$ adjusted for markups, also called the cost-based Input-Output matrix. In particular, $\mathbf{A}$ is a $SN \times SN$ block diagonal matrix of the form:

$$\mathbf{A} = \begin{pmatrix} \mathbf{A_1} & \mathbf{0} & \cdots & \mathbf{0} \\ \mathbf{0} & \mathbf{A_2} & \cdots & \mathbf{0} \\ \vdots & \vdots & \ddots & \vdots \\ \mathbf{0} & \mathbf{0} & \cdots & \mathbf{A_j} \end{pmatrix} \quad \text{with} \quad \mathbf{A_j} = \begin{pmatrix} \beta_j^1 \rho_j^{11} & \beta_j^2 \rho_j^{12} & \cdots & \beta_j^s \rho_j^{1s} \\ \beta_j^1 \rho_j^{21} & \beta_j^2 \rho_j^{22} & \cdots & \vdots \\ \vdots & \vdots & \ddots & \vdots \\ \beta_j^1 \rho_j^{r1} & \cdots & \cdots & \beta_j^s \rho_j^{rs} \end{pmatrix} \tag{32}$$

where $\mathbf{A_j}$ is a $S \times S$ matrix reporting the input use by each sector s in region j from any other sector r. Consider now the $SN \times SN$ matrix $\mathbf{M}$, a diagonal matrix containing the markup rates on the main diagonal:

$$\mathbf{M} = \begin{pmatrix} \mu_1^1 & 0 & \cdots & 0 \\ 0 & \mu_1^2 & \cdots & 0 \\ \vdots & \vdots & \ddots & \vdots \\ 0 & 0 & \cdots & \mu_j^s \end{pmatrix}$$

In order to obtain the cost-based Input-Output matrix, we need to multiply $\mathbf{A}$ by the sum of the identity matrix and the matrix $\mathbf{M}$, namely:

$$\tilde{\mathbf{A}} = \mathbf{A}(\mathbf{I} + \mathbf{M})$$

Moreover, as seen in subsection 3.7, the revenue-based Input-Output matrix is found by pre-multiplying the matrix of technical coefficient $\mathbf{A}$ of eq(32) by the block matrix $\mathbf{\Lambda}$, a $SN \times SN$ matrix where each block is a $S \times S$ diagonal matrix containing the import shares for each sector between a pair of regions $\{i, j\}$ deflated by the import tariff:

$$\mathbf{\Lambda} = \begin{pmatrix} \mathbf{\Lambda_{11}} & \mathbf{\Lambda_{12}} & \cdots & \mathbf{\Lambda_{1j}} \\ \mathbf{\Lambda_{21}} & \mathbf{\Lambda_{22}} & \cdots & \mathbf{\Lambda_{2j}} \\ \vdots & \vdots & \ddots & \vdots \\ \mathbf{\Lambda_{i1}} & \mathbf{\Lambda_{i2}} & \cdots & \mathbf{\Lambda_{ij}} \end{pmatrix} \quad \text{with} \quad \mathbf{\Lambda_{ij}} = \begin{pmatrix} \frac{\lambda_{ij}^1}{1+t_{ij}^1} & 0 & \cdots & 0 \\ 0 & \frac{\lambda_{ij}^2}{1+t_{ij}^2} & \cdots & 0 \\ \vdots & \vdots & \ddots & \vdots \\ 0 & 0 & \cdots & \frac{\lambda_{ij}^s}{1+t_{ij}^s} \end{pmatrix}$$

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