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# The Invisible Walls: how Freight Transport Costs shape European Internal Trade

Paolo Costa[a], Roberto Roson[a], Martina Sartori[b,*]

[a]*Department of Economics, Ca' Foscari University of Venice, Venice 30123, Italy*

[b]*Department of Economics, Statistics and Business, Universitas Mercatorum, Rome 00186, Italy*

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ABSTRACT

This paper investigates the magnitude and macroeconomic relevance of internal trade frictions—specifically freight transport and logistics costs—within the European Union, framing them as sui generis internal duties or non-tariff barriers that create "invisible walls" across the Single Market. Due to the severe limitations and reliability issues inherent in official statistical databases regarding bilateral transit margins, we propose an alternative empirical strategy. By harmonizing Eurostat's SITC Rev. 4 trade data with the multi-sectoral structural framework of the Global Trade Analysis Project (GTAP) social accounting matrix, we estimate bilateral origin-destination distribution margins across all 27 EU member states for six transportable commodity sectors. Our empirical findings reveal an average intra-European distribution margin of 6%, driven heavily by a commodity's value-to-weight ratio and country-specific geographic features, such as peripheral isolation or infrastructure bottlenecks. To evaluate the systemic and general equilibrium impacts of these frictions, the estimated margins are integrated into a global Computable General Equilibrium (CGE) simulation model. We simulate a hypothetical 50% reduction in all intra-European logistics costs, uncovering profound macroeconomic implications. The optimization of internal distribution networks generates an aggregate welfare gain of approximately $161 billion annually for the European Union and stimulates intra-EU trade flows by 5.72%, while simultaneously inducing a strategic trade diversion that contracts imports from extra-EU partners like China. Furthermore, the general equilibrium effects manifest asymmetrically across member states. While the continent's largest economies secure the highest absolute welfare benefits (quantifiable at $33 billion for Germany and $19 billion for France), the most transformative expansions in gross production volume are concentrated within highly open, smaller economies, led by Lithuania (+0.54%), Hungary (+0.45%), and Slovakia (+0.43%). Ultimately, the study highlights that sustaining the long-term international competitiveness of the Single Market requires European trade policy to expand beyond legal harmonization and actively invest in dismantling physical network inefficiencies.

## 1.Introduction

The European Union is "much more than a market", but the European single market remains its core business and the most valuable tool at its disposal and that of its member states to strengthen their international competitiveness in a world today subjected to geoeconomic and geopolitical tensions unimaginable until recently. A single European market based

* Corresponding author.
E-mail address: martina.sartori@unimercatorum.it.
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on the four freedoms of movement of goods, people, services, and capital, not all of which are yet fully guaranteed.

The free movement of goods, which we are concerned with here, is the instrument that has allowed and continues to allow the gradual unification of the European market for each good. In the sense that every producer of any good, whatever the member state in which it produces it, "may" (is free to) sell his product in any other member state. The consequent increase in the potential scale of the market for each good makes it possible for producers to exploit its economies of scale, which, in markets made more competitive also thanks to the free movement of goods, translate into lower prices to the benefit of consumers, whose stimulated demand could lead to further increases in scale with the start of a possible virtuous circle.

The issue of the effective freedom of movement of goods within the Union has recently returned to the center of the economic policy debate, in relation to the presence and incidence of the so-called "internal duties", which – it is argued – we should worry much more about than the duties imposed by other countries.

Clearly, since the EU is a customs union, it is obvious that the so-called internal duties are not and cannot be, technically, duties. On the other hand, in the face of excessively generous quantifications, some sources have wanted to include, in these "pseudo-duties", heterogeneous cost elements that are completely unrelated to the actual volume of commercial exchange. This approach is misleading or at least does not justify the use of the phrase "internal duties", for which only frictional costs in trade (transport, distribution, and similar costs) should be included, which only in this case could be assimilated to "non-tariff barriers".

The monitoring and interpretation of trade costs represent a fundamental challenge for understanding the current landscape of European economic integration, where these invisible walls act as barriers to prosperity far more significant than traditional tariffs. Scientific literature defines these costs broadly, encompassing all expenses incurred in delivering a good from the producer to the final user, excluding only the marginal cost of production[1]. For a representative industrialized economy, total trade costs have been estimated to reach an ad valorem tax equivalent of approximately 170%[1]. This imposing figure breaks down into 21% transportation costs, 44% border-related barriers, and 55% local distribution costs[1]. Within the European Union, the persistence of these frictions is evidenced by the home bias phenomenon, where intranational trade remains, on average, ten times higher than international trade with partners of comparable economic mass and geographic distance[2]. This resistance to exchange is not merely a result of administrative red tape but critically reflects the physical and logistical frictions inherent in freight transport networks and the varying efficiencies of different transportation modes[3].

Network incompleteness and logistical bottlenecks serve as primary drivers of trade resistance within the European space. Transportation infrastructure is rarely a seamless web; instead, it is often based on hub-and-spoke models where the majority of goods are shipped indirectly, stopping at one or more logistical centers or warehouses before reaching their final destination[4]. This indirect routing connects remote regions to global markets but creates multiple points of potential failure where goods risk standing still[4]. Bottlenecks are particularly acute at maritime ports and border crossings, where physical capacity constraints and layers of procedures cause significant delays[5]. Empirical evidence suggests that each additional day in transit for manufactured goods is equivalent to an ad valorem tariff of between 0.6% and 2.3%[6,7]. In some contexts, a single day's delay at a port or border is equivalent to moving a trading partner 70 kilometers further away[6].

The persistence of physical and historical barriers is exemplified by the case of German reunification, which provides a natural experiment on the impact of transport network incompleteness. Despite the total removal of political and administrative walls in 1990, the economic impact of the former East-West border remained clearly visible in trade data for decades[8]. This is largely attributed to the initial lack of functional infrastructure, as the transport network across the old border had been deliberately depleted during decades of division[9]. While massive road and rail investment plans were implemented to re-stitch the network, research indicates that it takes at least 33 to 40 years for the economic impact of a defunct political border to fully vanish[8]. This suggests that trade patterns are anchored in the physical reality of connections and the established business networks that utilize them[8,9].

Incompleteness in the European network is further compounded by the backhaul problem, where trade imbalances lead to the inefficient movement of empty containers[3]. For example, in trade between Europe and Asia, the cost of shipping a container can be significantly lower in one direction because carriers must return empty units to export-heavy regions, making the return journey anomalously cheap regardless of distance[3]. Such dynamics illustrate how transport costs are highly sensitive to market demand and network density rather than simple mileage[3]. Furthermore, the quality of internal infrastructure varies enormously across the continent; landlocked countries face transport costs approximately 55% higher than their coastal counterparts[10]. In these regions, a deterioration of infrastructure from the median to the 75th percentile can increase transport costs by 12% and reduce trade volumes by 28%[10].

For European services, the logistical frictions are often tied directly to the movement of physical goods. Recent empirical findings suggest that the exports of many business, financial, and transport services are exported as a bundle with physical products[11]. Therefore, barriers that hamper the flow of goods, such as port congestion or inadequate road links, proportionally penalize the services sector as well[11]. While policy integration through harmonization and mutual recognition has addressed technical barriers to trade, the underlying physical and logistical constraints remain a major source of market fragmentation[12].

The central empirical problem remains of assessing the size of the phenomenon. Theoretically, it would be a matter of comparing the price at origin of a good or service produced in one EU country, including taxes and costs not related to the sale in a different country, with the final market price, as recorded in a different country of destination. That is to say, the mark-up generated by movement within the Union.

Unfortunately, there is no official data of this nature, and even information to help estimate these quantities is extremely

scarce. From Eurostat's COMEXT database, exports[1] and imports from each EU country to the rest of the Union can be obtained for six categories of goods classified SITC, but without identification of the country of origin or destination. In addition, while exports are valued at FOB (Free on Board) prices, imports are valued at CIF (Cost, Insurance, and Freight) prices. Analyzing these data, although partial for our purposes, we have found several critical issues, which cast doubt on the quality and reliability of the information provided.[2]

Eurostat collects, systematizes, and makes more uniform the data collected by the statistical institutes of the various European countries, but the construction of an integrated system of European economic accounts is still a long way off. Efforts in this direction have been mostly limited and experimental in nature, for example, with the FIGARO project[3], developed at the Joint Research Centre of the European Commission[13].

In this paper, we propose an alternative strategy, based on data from the GTAP (Global Trade Analysis Project) social accounting matrix[4]. This is an extensive database of the world economy, developed at Purdue University, which includes detailed data on production, consumption, international trade, input-output matrices, and trade barriers (tariffs and subsidies) for 163 countries and 65 manufacturing sectors around the world. The database has a multi-regional and multi-sectoral structure and is updated regularly every 2-3 years[14] with a specific base year (for the latest version available, version 12, is 2023).

To estimate international trade flows, the GTAP consortium integrates several primary statistical sources, the most important of which is UN Comtrade, the United Nations database, which is the most comprehensive source of international trade statistics, with detailed data by product and trading partner. These data are integrated and harmonised with other sources, such as the WTO, UNCTAD TRAINS, national and international statistical bodies (including Eurostat).

The reason that pushes us to use this database is not so much to use a more complete and possibly reliable source of information, but that linked to the very nature of the database, given that it has been built with the primary objective of allowing the estimation of structural parameters within the general equilibrium model (Computable General Equilibrium, CGE), or rather of the CGE family of models developed by the GTAP consortium itself[15].

In fact, there is a long tradition of applying numerical macroeconomic simulation models, of the CGE class, for the analysis of international trade policies. In this field, the GTAP model and database constitute a defacto standard. A classic example of application is that of international trade agreements[16], and another that of regional free trade agreements[17], including the European Union[18]. More recently, several contributions have analyzed the impacts of trade wars[20].

The main advantage in using these models is the possibility of identifying the systemic and structural effects that, starting from a change in relative prices, and therefore in competitiveness, allow for evaluating the consequences in terms of trade creation (or destruction), and trade diversion. In addition, the high degree of detail of the models allows to estimate other important macroeconomic variables, such as, for example, terms of trade, expanding and contracting sectors in each country, consumer welfare, employment, and others.

Therefore, in this work we propose, on the one hand, to quantify (to the best of the available information) the magnitude and relative incidence of the frictional costs of intra-European trade (attributable to transport and logistics costs), and on the other hand, to evaluate the role played by these within the structure of trade, and in the European economic system. This second objective is pursued by employing the same data and the same tools that are normally used for the simulation of international trade policies, thus insisting on the interpretation of transport margins as sui generis duties.

## 2.An estimate of transport margins between European Union countries

In this section, we present an estimate of trade flows per pair of countries in the European Union. As anticipated, this figure is not officially produced by any statistical agency; Eurostat limits itself to providing a quantification of national exports (measured in terms of FOB values, Free On Board) to the rest of the EU, as well as national imports from the rest of the EU (measured in terms of CIF, Cost, Insurance and Freight values).

EUROSTAT data are available until 2024, and for six categories (SITC Rev. 4) of physically transportable goods:[5]

- Food, Beverages and Tobacco
- Raw Materials
- Mineral Fuels, Lubricants, and Related Products
- Chemicals and Related Products
- Other Manufactured Goods
- Machinery and Transport Equipment

In this study, we first aggregated the GTAP data (version 12, year 2023), with a product classification compatible with Eurostat's SITC Rev.4, keeping the 27 countries of the European Union disaggregated. This has allowed us to obtain, for each category of transportable goods, two origin/destination matrices of trade flows, one of which has values that can be interpreted as recorded at the origin, and the

[1] Standard International Trade Classification (https://oec.world/en/product-landing/sitc).

[2] Both flows are assessed at the border but, since there is no physical customs point, the distribution costs to/from the border are estimated, it is not clear with what methodology. Therefore, adjacent countries, such as France and Spain, should have a difference between CIF and FOB values close to zero, but this is not the case. Indeed, paradoxically, the total CIF flows are *lower* than the total FOB flows. This paradox is not new at international level, where the problem of underestimation of imports is well known, but it is surprising that this can emerge in the context of intra-European trade.

[3] The project aims to reconstruct complete multiregional input-output matrices (of the use-make type), between EU countries and towards some countries in the rest of the world. However, flows are calculated only as *agent price* values so, lacking market prices, it is not possible to derive the margins of our interest. In addition, from 2024–2025 Eurostat has withdrawn the FIGARO database from online publication, moving it to an area accessible only by direct request.

[4] https://www.gtap.agecon.purdue.edu/databases/default.asp

[5] https://ec.europa.eu/eurostat/databrowser/product/page/ext_lt_intratrd__custom_18739111

other with values that can be interpreted as selling prices in the destination market. Therefore, a direct comparison between each pair of matrices allows you to derive the transport margins, expressed as a percentage of the original price (mark-up).

The structure of the six matrices at source prices was used as an a priori distribution in a maximum likelihood estimate[6], where the Eurostat data of 2024 are imposed as marginal constraints[7]. The result is six new 27x27 square matrices of trade flows, which then update the data from 2023 to 2024. On these matrices, using the transport margins obtained previously, it is possible to trace the corresponding origin/destination matrices at market prices.

Let us now briefly review some characteristics of the data we estimated. Figure 1 presents a map in which the colour attributed to each country has an intensity proportional to its share in the total intra-EU trade. Germany clearly dominates with a share of 21%, followed by the Netherlands (14.7%), Belgium (8.3%), Italy (7.9%), France (7.8%), and Poland (6.5%). These six countries together account for more than two-thirds of intra-European trade. The centrality of Germany, the Netherlands, and Belgium can be traced back to the presence of important logistics hubs (such as the ports of Rotterdam, Antwerp, and Hamburg) and a production structure strongly oriented towards foreign trade.

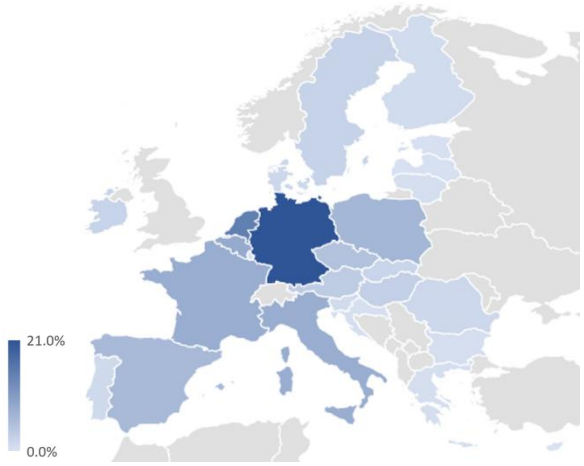


Fig 1. Map of intra-European trade relevance

Figure 2 presents a second map, in which the intensity of the colour attributed to each country refers to its specific average distribution margin, calculated as the ratio of total distribution costs to total volume of trade, both inbound and outbound.

The highest average logistics margins are predominantly recorded in geographically peripheral or specific transit regions, including Latvia (6.8%), followed closely by Croatia, France, Poland, Finland, and Greece (all at 6.3%), and Italy, Bulgaria, Sweden, and Portugal (6.2%). These elevated margins indicate that transport and logistics costs exert a greater relative incidence on export values. This pattern can be attributed to several compounding factors: geographic distance from central European logistics hubs, an industrial specialization in low value-to-weight commodities, or weaker integration into core European transport corridors. Conversely, the lowest average margins occur in Cyprus (5.1%), Czechia, and Slovakia (both at 5.3%). These lower figures likely reflect highly integrated domestic logistics systems, proximity to key destination markets, or a trade mix weighted toward high-value-added goods like machinery and complex manufactures.

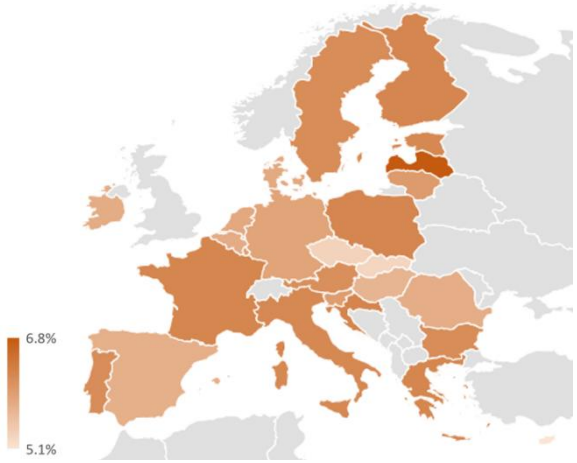


Fig 2. Map of the average distribution margin

High distribution costs inherently diminish export competitiveness in destination markets, implying a potential reduction in trade volumes where transport and logistics expenses are pronounced. However, logistics expenses constitute only a single component—and frequently not the primary determinant—of final market prices. Indeed, our calculated correlation coefficient between logistics margins and trade flows across EU country pairs is near zero and statistically insignificant.

Nevertheless, country-specific cases warrant closer examination, most notably Cyprus, where the expected negative correlation holds and it is statistically significant. Despite its geographic isolation, Cyprus exhibits the lowest average logistics margin in the sample, likely because the vast majority of its trade is maritime, which benefits from significant economies of scale. Furthermore, Cypriot trade is heavily concentrated with Greece, its nearest EU partner. When isolating bilateral trade flows involving Cyprus, the correlation coefficient drops to -0.36. This statistically significant negative relationship confirms that, for specific isolated economies, trade volumes contract as relative distribution costs increase.

Table 1. Distribution costs, trade flows, and related margins by sector

| Sectors | Distribution Costs | Trade Flows | Margins |
|---|---|---|---|
| Food, Beverages and Tobacco | 29.2 | 454.3 | 6.4% |
| Raw Materials | 18.0 | 135.9 | 13.2% |
| Fuels | 13.6 | 250.6 | 5.4% |
| Chemicals | 42.3 | 680.2 | 6.2% |
| Manufactured Goods | 64.2 | 1064.7 | 6.0% |
| Machinery | 71.1 | 1416.0 | 5.0% |
| ***TOTAL*** | ***238.4*** | ***4001.8*** | ***6.0%*** |

With regard to the six product sectors considered in this study, Table 1 presents the amount of distribution costs, as well as the value of trade flows at the starting prices from the exporting country. The total cost of intra-European distribution amounts to more than 238 billion euros, against flows of about 4 trillion euros, with an average margin of 6%.

[6] We performed a standard RAS matrix balancing, also known as iterative proportional fitting (https://en.wikipedia.org/wiki/Iterative_proportional_fitting)

[7] More precisely, the totals of outflows were made to coincide with the FOB Eurostat export data, while the totals of inflows were aligned with the structure of the CIF import carrier, but with the values of the latter appropriately scaled to coincide with the FOB totals. Since Eurostat includes in the FOB values an estimate of transport costs up to the border, it is assumed that this correction can be considered negligible.

Within distribution costs, the "Raw materials" sector exhibits the highest share relative to export value, at 13.2%. This suggests that transportation and logistics expenses exert a more pronounced effect on low-value, bulky commodities than on goods with higher value-to-weight or value-to-volume ratios. For instance, "Mineral fuels, lubricants and related products" command a lower average margin of 5.4%. This incidence drops further to 5.0% for "Transport machinery and tools," which comprises the bulk of trade flows. Consequently, a clear inverse relationship emerges between a commodity's unit value and its distribution cost incidence; higher-value goods more readily absorb weight-dependent transit fees.

## 3.Macroeconomic effects of a reduction in transport margins: a general equilibrium analysis

To the extent that distribution, trade, and transport margins between European countries function as de facto internal duties (or non-tariff barriers), this study proposes a simulation using the standard GTAP model[20]. Specifically, we model the impact of a hypothetical 50% reduction in all intra-European distribution margins, treating them within the model framework as a specific category of tariffs. This simulated reduction has no specific interpretation, except that of providing an empirical assessment of the relevance of frictional trade costs within the European Union.

The most significant results of this simulation are presented below. Table 2 outlines the resulting changes in total trade flows across macro-regions. The reduction in intra-European distribution margins generates a notable 5.72% increase in domestic flows. Concurrently, it reduces both extra-EU imports (most notably from China, at -2.61%) and extra-EU exports (averaging approximately -4.5%). As a second-order, indirect effect, non-European countries compensate for the lower volume of trade with Europe by increasing trade among themselves.

Table 2. Changes in trade flows (base elasticity)

| | European Union | United States | China | Rest of the World |
|---|---|---|---|---|
| European Union | 5.72% | -4.45% | -4.67% | -4.58% |
| United States | 0.07% | 0.43% | 0.19% | 0.43% |
| China | -2.61% | 0.60% | 0.34% | 0.71% |
| Rest of the World | -0.72% | 0.56% | 0.27% | 0.52% |

The results shown in Table 2 were obtained using the standard parameter values of the GTAP model—specifically, the top-layer elasticity of substitution between domestically produced and imported goods (the so-called "Armington" elasticities)[8]. As a sensitivity check, we conducted a second simulation in which these parameters were increased by two-thirds (+66.7%) for all EU countries. The resulting variations in aggregate trade flows are displayed in Table 3. As expected, a higher sensitivity to relative prices in international markets amplifies the effects observed in the first simulation, accelerating the growth of intra-European trade to +6.21%.

Table 3. Changes in trade flows (increased elasticity)

| | European Union | United States | China | Rest of the World |
|---|---|---|---|---|
| European Union | 6.21% | -4.46% | -4.69% | -4.59% |
| United States | 0.11% | 0.43% | 0.18% | 0.41% |
| China | -2.73% | 0.63% | 0.36% | 0.73% |
| Rest of the World | -0.72% | 0.56% | 0.26% | 0.51% |

Table 4. Changes in trade flows to/from rest EU, country level

| | **ExpEU_base** | **ExpEU_high** | **ImpEU_base** | **ImpEU_high** |
|---|---|---|---|---|
| Austria | 5.05% | 5.47% | 5.44% | 5.87% |
| Belgium | 4.74% | 5.27% | 6.33% | 6.83% |
| Bulgaria | 7.27% | 7.80% | 6.59% | 7.19% |
| Croatia | 4.34% | 4.77% | 5.38% | 5.78% |
| Cyprus | 4.11% | 4.45% | 2.37% | 2.51% |
| Czech R. | 4.91% | 5.31% | 6.51% | 7.05% |
| Denmark | 7.87% | 8.42% | 4.60% | 5.00% |
| Estonia | 5.76% | 6.15% | 5.18% | 5.56% |
| Finland | 5.62% | 6.18% | 4.82% | 5.20% |
| France | 5.59% | 6.17% | 5.78% | 6.26% |
| Germany | 6.48% | 7.03% | 5.79% | 6.31% |
| Greece | 4.91% | 5.40% | 5.84% | 6.29% |
| Hungary | 4.53% | 4.97% | 6.20% | 6.73% |
| Ireland | 3.69% | 3.86% | 1.07% | 1.14% |
| Italy | 6.12% | 6.70% | 6.18% | 6.75% |
| Latvia | 6.46% | 6.82% | 5.19% | 5.52% |
| Lithuania | 10.72% | 11.10% | 5.18% | 5.60% |
| Luxembourg | 4.02% | 4.20% | -0.20% | -0.25% |
| Malta | 2.41% | 2.59% | 2.59% | 2.77% |
| Netherlands | 6.26% | 6.74% | 5.39% | 5.90% |
| Poland | 6.13% | 6.60% | 7.34% | 7.98% |
| Portugal | 5.83% | 6.44% | 6.20% | 6.73% |
| Romania | 6.55% | 7.01% | 5.18% | 5.61% |
| Slovakia | 5.20% | 5.60% | 6.36% | 6.84% |
| Slovenia | 6.81% | 7.24% | 7.56% | 8.20% |
| Spain | 5.17% | 5.68% | 6.76% | 7.36% |
| Sweden | 5.20% | 5.65% | 4.94% | 5.30% |

Regarding the effects on individual European countries, we present two sets of results. Table 4 displays the percentage changes in import and export flows within the European Union, computed under both baseline ("base") and increased ("high") Armington elasticities.

Notably, the variation recorded by many individual countries is substantially higher than the European average. Lithuania, for instance, exhibits an increase in exports to the EU of approximately 11%. While countries like Italy experience gains in inflows and outflows of a similar magnitude, others (such as Denmark, Ireland, Lithuania, Cyprus, and Luxembourg) show highly asymmetric results. This asymmetry stems from differences in the structural composition of their imports and exports, both of which

[8] These Armington elasticities vary by product. In the standard GTAP model framework, for example, the parameters are set at 5.05 for paddy rice, 1.85 for vegetables and fruits, 17.20 for gas, 2.80 for electricity, and 1.90 for services.

include services—a sector for which distribution margins are considered negligible.

Table 5 presents some estimates of the equivalent variation—a monetary measure of the welfare impact, expressed in millions of 2023 dollars—alongside the percentage change in total gross national production volume.

Table 5. Equivalent variation and change in gross production, country level

| Country | EV | Product |
|---|---|---|
| Austria | 6503 | 0.19% |
| Belgium | 13289 | 0.37% |
| Bulgaria | 1172 | 0.15% |
| Croatia | 1215 | -0.03% |
| Cyprus | 226 | -0.07% |
| Czech R. | 6317 | 0.25% |
| Denmark | 3372 | 0.15% |
| Estonia | 698 | 0.25% |
| Finland | 2577 | -0.01% |
| France | 19547 | -0.01% |
| Germany | 32913 | 0.00% |
| Greece | 1613 | 0.00% |
| Hungary | 4148 | 0.45% |
| Ireland | 2847 | 0.03% |
| Italy | 14740 | -0.03% |
| Latvia | 749 | -0.05% |
| Lithuania | 608 | 0.54% |
| Luxembourg | 283 | 0.32% |
| Malta | 240 | 0.32% |
| Netherlands | 10582 | 0.29% |
| Poland | 10551 | 0.12% |
| Portugal | 3208 | 0.09% |
| Romania | 2924 | 0.01% |
| Slovakia | 2948 | 0.43% |
| Slovenia | 1432 | 0.38% |
| Spain | 10875 | 0.03% |
| Sweden | 5496 | -0.01% |

A clear pattern emerges, driven both by a country's economic size and its degree of trade openness with other European Union members. In terms of the absolute differences used to calculate Equivalent Variation (EV), the influence of economic size is prominent: the benefits for Germany are quantifiable at approximately 33 billion dollars, followed by France at over 19 billion dollars. For the European Union as a whole, the total benefit reaches roughly 161 billion dollars.

Conversely, the percentage change in production is primarily driven by the degree of openness (measured, for example, as the ratio of imports or exports to GDP). The country experiencing the most significant impact is Lithuania (+0.54%), followed by Hungary (+0.45%), Slovakia (+0.43%), Slovenia (+0.38%), and Belgium (+0.37%).

Interestingly, sizeable welfare gains can coexist with negligible or even negative growth in gross domestic output. This discrepancy arises because Equivalent Variation reflects household consumption welfare, a metric that encompasses imported goods and services rather than just domestic production.

## 4.Concluding remarks

While formal import tariffs within the European Union have been successfully reduced to historic lows, this study demonstrates that the European Single Market remains fragmented by "invisible walls". Trade costs in Europe are a complex, multi-faceted phenomenon rooted deeply in the physical and logistical constraints of a continent that has removed legislative barriers but has yet to seamlessly unify its physical space. The dark costs associated with transport network incompleteness, trans-shipment bottlenecks, and the structural economic value of transit time continue to impede the full realization of the four freedoms. Crucially, our findings highlight that these barriers are not merely an unalterable consequence of physical geography or distance. Beyond simple mileage, distribution margins are systematically shaped by market architecture, where market imperfections, natural monopolies, localized oligopolies, network gaps, and capacity bottlenecks persist. Consequently, there remains a substantial and actionable margin for targeted European policy interventions, provided they are guided by empirically grounded data.

A core contribution of this paper is the empirical estimation of bilateral intra-European distribution costs, accomplished by harmonizing Eurostat's SITC Rev. 4 trade data with the multi-sectoral structural framework of the GTAP social accounting matrix. This alternative strategy bypassed the severe data limitations and reliability issues inherent in official statistical databases. The primary analytical obstacle encountered throughout this research was a glaring data vacuum. It remains a striking paradox that while the EU has systematically dismantled administrative and regulatory barriers to the movement of factors, statistical authorities have largely neglected the rigorous collection of data regarding the remaining physical frictions. The lack of systematic, official tracking of origin-destination transaction prices (FOB vs. CIF discrepancies) limits our collective understanding of spatial economics within the Union. Sustained long-term growth will inherently depend on the Union's commitment to optimizing logistics bureaucracy and building an integrated system of European economic accounts.

To evaluate the systemic and general equilibrium impacts of these frictions, we treated transport and logistics margins as sui generis internal duties within a global CGE framework. The simulation of a hypothetical 50% reduction in intra-European distribution costs reveals profound macroeconomic implications. Such a logistical optimization would unlock massive aggregate welfare gains, generating an estimated $161 billion annually for the European Union. Furthermore, a sharp reduction in internal margins would significantly stimulate intra-European trade flows—increasing domestic flows by 5.72% under baseline elasticities—while simultaneously triggering a strategic trade diversion away from third countries, notably reducing imports from China by 2.61%. These general equilibrium effects manifest unevenly across member states, driven by country-specific economic

size and openness. In absolute terms, the continent's industrial cores benefit the most, with welfare gains scaling up to approximately $33 billion for Germany and over $19 billion for France. Conversely, in terms of gross production volume, the most transformative gains are concentrated in highly open, smaller economies such as Lithuania (+0.54%), Hungary (+0.45%), and Slovakia (+0.43%).

Ultimately, the future competitive positioning of the European Union in an increasingly volatile geoeconomic landscape hinges on its ability to systematically lower these spatial mark-ups. European infrastructure planning, such as the Trans-European Transport Network (TEN-T) policy, must pivot from broad connectivity goals toward targeted interventions aimed at lowering the distribution cost margins identified in this study. Policy priority must be given to removing cross-border bottlenecks, standardizing rail and freight systems to eliminate transport backhaul inefficiencies, and investing heavily in peripheral infrastructure. Only by actively dismantling these invisible logistical walls can the European Union transition from a legally integrated market to a physically unified, globally competitive economic space.

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## Appendix

*A brief description of the GTAP model*

The Global Trade Analysis Project (GTAP) is a collaborative international initiative that develops and maintains a comprehensive database describing trade flows and economic interactions across sectors and regions worldwide. The database is organized as a Social Accounting Matrix (SAM), which provides a consistent representation of production, consumption, income generation, and trade relationships within the global economy.

This SAM framework is commonly employed to calibrate Computable General Equilibrium (CGE) models. In addition to the database itself, GTAP provides a widely used CGE modelling framework together with dedicated software tools. A detailed presentation of the model can be found in Hertel and Tsigas (1997). The following overview summarizes its main components, while Figure A1 illustrates the circular flow of income represented in the model, following Brockmeier (2001).

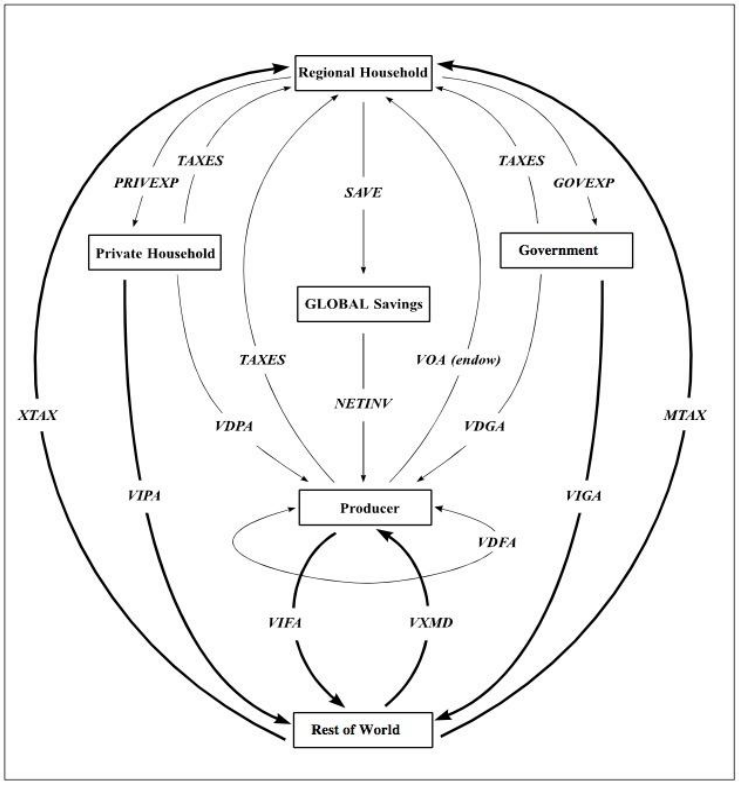


Fig A1. Income flows in the GTAP Model

The model is based on a set of equations and accounting identities describing the behaviour of economic agents and market interactions. At the regional level, sectoral output is distributed among intermediate inputs, household consumption, government expenditure, investment demand, and exports. The supply of primary production factors, such as labour and capital, is balanced against demand originating from domestic industries.

Prices for goods and services are determined by average production costs, including the effect of taxation. Firms are assumed to behave competitively and choose factor combinations that minimize production costs. Income generated through the ownership of primary factors accrues to domestic agents and constitutes national income, which is subsequently allocated among private consumption, public expenditure, and savings.

Savings generated in different regions are collected in a global investment pool and reallocated across regions according to expected rates of return on capital. Household consumption patterns are derived from utility-maximizing behaviour subject to budget constraints.

Both intermediate and final demand distinguish between domestically produced goods and imports. Imported products are further allocated among trading partners according to relative prices, taking into account transportation costs, distribution margins, and taxes. Following the Armington assumption, products belonging to the same sector but originating from different countries are treated as imperfect substitutes.

Factor mobility assumptions vary across production factors. Labour and capital are assumed to move freely among domestic industries, resulting in a common regional factor price, while international mobility is excluded. Land, by contrast, is only imperfectly mobile across sectors within a region, and its allocation responds to differences in sector-specific returns.

From a mathematical perspective, the GTAP model consists of a large-scale nonlinear system of equations calibrated to reproduce the observed economic structure of a selected benchmark year. Policy simulations are performed by modifying exogenous variables or model parameters and solving for a new equilibrium. The definition of endogenous and exogenous variables, as well as the degree of sectoral and regional aggregation, can be adapted according to the objectives of the specific analysis.