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Luca Lodi

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UNIVERSITE PARIS I PANTHÉON SORBONNE

THÈSE

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Luca LODI

Essays on International Trade

*Theory and Applications of the Structural Gravity Model
with Country-Specific Features and Domestic Policies*

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Quantitative Methods for Policy Evaluation
Curriculum: Nowcasting, big data, networks and web scraping
XXXV cycle

Essays on International Trade

*Theory and Applications of the Structural Gravity Model
with Country-Specific Features and Domestic Policies*

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Essays on International Trade

*Theory and Applications of the Structural Gravity Model
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Abstract

The thesis aims to extend and enrich the literature on structural gravity, in particular providing new applications and a theoretical interpretation of the methods of Heid, Larch and Yotov (2021) and Freeman, Larch, Theodorakopoulos and Yotov (2021) to for the analysis of unilateral variables (country-specific features, domestic policies or also unilateral trade policy). The main goal of this work, since the flexibility of the structural gravity framework, is to provide a framework that takes into account: "fundamental productivity" (geography, climate, infrastructure, and institutions that have an impact on the producers' productivity in a given country and sector) as defined in Costinot, Donaldson and Komunjer (2012), both theoretically and empirically. Two exercises aim to extend and update the results of other seminal articles as Redding and Venables (2004) for what concerns economic geography, and Levchenko (2007) and Nunn (2007) in the study of institutions and trade. All these do not exploit the bilateral dimension of trade flows, the role of domestic sales and the control for multilateral resistance terms. Here, the thesis proposes a way to merge the new advances in the literature, as the above-mentioned works of Heid et al. (2021) and Freeman et al. (2021), but also Allen, Arkolakis and Takahashi (2020), with the previous literature. The main scope is to make progress on the solution of the problem of perfect collinearity between unilateral variables and the set of fixed effects (as in Heid et al. (2021)) and to give it further theoretical grounding. The hope is that it will inspire and ease more investigations into these topics. Furthermore, the thesis contains an application for current policy matters, such as the Covid-19 pandemic, which in the understanding of the economic consequences of it. This last

exercise has a further goal: using gravity with high reference data (monthly trade) to give instruments for policymakers to make short-run decisions.

Keywords: International Economics, Economic Geography, Quantitative Methods

Luca LODI

Essais sur le commerce international

*Théorie et applications du modèle de gravité structurelle
avec des caractéristiques spécifiques à chaque pays et des
politiques domestiques*

Résumé

La thèse vise à étendre et enrichir la littérature sur la gravité structurelle, en particulier en fournissant de nouvelles applications et une interprétation théorique des méthodes de Heid, Larch et Yotov (2021) ainsi que de Freeman, Larch, Theodorakopoulos et Yotov (2021) pour l'analyse des variables unilatérales (caractéristiques spécifiques à chaque pays, politiques internes ou encore politique commerciale unilatérale). L'objectif principal de ce travail, étant donné la flexibilité du cadre de la gravité structurelle, est de fournir un cadre qui prend en compte la "productivité fondamentale" (géographie, climat, infrastructure et institutions ayant un impact sur la productivité des producteurs dans un pays et un secteur économique) telle que définie dans Costinot, Donaldson et Komunjer (2012), à la fois théoriquement et empiriquement. Deux exercices visent à étendre et mettre à jour les résultats d'autres articles fondateurs, tels que Redding et Venables (2004) en ce qui concerne la géographie économique et Levchenko (2007) et Nunn (2007) sur l'étude des institutions et du commerce. Tous ces travaux n'exploitent pas la dimension bilatérale des flux commerciaux, le rôle des ventes nationales et le contrôle des termes de résistance multilatéraux. Ici, la thèse propose une manière de fusionner les nouvelles avancées de la littérature, comme les travaux susmentionnés de Heid et al. (2021) et Freeman et al. (2021), ainsi qu'Allen, Arkolakis et Takahashi (2020), avec la littérature précédente. L'objectif principal est de progresser dans la résolution du problème de la colinéarité parfaite entre les variables unilatérales et l'ensemble des effets fixes (comme dans Heid

et al. (2021)) et de lui donner une base théorique plus solide. L'espoir est que cela inspirera et facilitera davantage d'investigations sur ces sujets. De plus, la thèse contient une application pour les questions politiques actuelles, telles que la pandémie de Covid-19, et sa compréhension des conséquences économiques qui en découlent. Cet exercice final a un objectif supplémentaire : utiliser la gravité avec des données de référence élevées (commerce mensuel) pour fournir des instruments aux décideurs politiques afin de prendre des décisions à court terme.

Mots clés en français: économie internationale, Géographie économique, Méthodes quantitatives

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Chapter 1

Population Density and Countries’ Export Performance: Evidence from Structural Gravity

1.1 Introduction

The main objective of the paper is to describe theoretically and empirically the effect of population density on international trade and does it through a theoretical framework based on [Allen and Arkolakis \(2014\)](#) and [Allen et al. \(2020\)](#) to derive a structural gravity setting that identifies the effect of country-specific features on bilateral exports and asses their contribution through the computation of specific parameter. The model provides a theoretical interpretation of the empirical approach developed by [Heid et al. \(2021\)](#) to measure unilateral policy variables’ effects in a theoretically grounded structural gravity model that overcomes the perfect collinearity with the importer and exporter fixed effects, needed to control for multilateral resistance terms ([Baldwin and Taglioni, 2006](#)). Moreover, our theoretical framework describes how domestic and international trade shares affect the value of the estimated

coefficient.

The focus on population density as a component of productivity and as a determinant of agglomeration forces,¹ allows testing *the hypothesis*, that population density also affects country specialization. The abundance of production factors and their spatial distribution within a country have consequences on comparative advantages and gains from trade.² Consequently, countries with great population density specialize in more labour-intensive economic activities, while others either specialize in more land (natural resources)-intensive industries or diversify their production.

The analysis investigates the contribution of population concentration on the supply side of the domestic economy, enriching the debate of density and agglomeration (mainly studied at the urban and regional levels) to understand the implication of the spatial distribution of the production factors at the macro level for different sectors, and for trade flows specialization. We propose a method to measure density sensitivity as in [Moscona and Levy \(2022\)](#), but our approach uses bilateral trade flows, and it also allows us to quantify the contribution of population density as productivity fundamental. This yields results in line with [Combes et al. \(2012\)](#) considering the macro-level and the international trade flows.

The framework has elements in common with the *New Economic Geography*,³ but models geography, as [Allen and Arkolakis \(2014\)](#) and [Allen et al. \(2020\)](#). One of the originalities of the proposed approach is to bridge the structural gravity literature to estimate unilateral variables,⁴ the *New Economic Geography* and the quantitative spatial economics ([Redding and Rossi-Hansberg, 2017](#)).

¹ [Duranton and Puga \(2004\)](#), [Rosenthal and Strange \(2004\)](#), [Allen and Arkolakis \(2014\)](#), [Bakker et al. \(2021\)](#), [Moscona and Levy \(2022\)](#).

² [Courant and Deardorff \(1992\)](#) [Courant and Deardorff \(1993\)](#).

³ This branch of the literature included scale effects related to Marshallian externalities, the cost of moving goods between locations and different market structures. Hence, the modelling features regard CES preferences as [Dixit and Stiglitz \(1977\)](#), icebergs trade costs [Samuelson \(1952\)](#), and the evolution of the Computer (meaning the possibility to perform computer simulation or solution of the model, especially when the complexity of the frameworks grows). In a vast literature, some of the relevant references are [Krugman \(1979\)](#), [Krugman \(1980\)](#) [Fujita et al. \(1999\)](#)

⁴ [Sellner \(2019a\)](#), [Heid et al. \(2021\)](#), [Freeman et al. \(2021\)](#).

The findings suggest that population density matters more in labour-intensive industries (Manufacturing). A 1% change in population density leads to a 0.3% of exports with respect to domestic sales, while the direct effect is slightly higher at 0.5%. Whereas natural resources depending on activities, such as Mining, show a negative correlation, both for relative impact and for the direct effect. Moreover, we evaluate potential biases from aggregate manufacturing trade by examining each industry in this sector. Our theoretical interpretation helps to assess whether aggregation generates biases, as discussed in [Redding and Weinstein \(2019\)](#) and [Breinlich et al. \(2022\)](#). In this work, using total bilateral trade in manufacturing does not change the main findings. However, disaggregated data provides a more complete understanding of the nexus of exports and population density. The contribution to Agriculture, Forestry and Fisheries is not robustly estimated since signs and significance are not consistent. These controversial results offer the opportunity for a new stand-alone analysis looking at differences industry level.

The discussion starts with a review of the contribution to the related literature (Section 1.2) and continues with the description of the theoretical model (Section 1.4) that is the guideline for the description of the empirical strategy (Section 1.5) and the discussion of results in Section 1.7.

1.2 Literature Review

The literature examining the intricate interplay between geography, population, and trade reveals a complex web of relationships. While existing research lacks a focused exploration of population density, it becomes imperative to elucidate how density intersects with agglomeration economies, productivity dynamics, and the repercussions of spatially uneven distribution of production factors.

The intricate nexus between population and exports unfurls a tapestry of conflicting findings. Different levels of analysis may produce heterogeneous results since some works use trade as its total and others refer to the bilateral flows from country to

country. Econometric specifications with dyadic data offer the possibility to consider translational linkages, which is crucial in international trade, but it is also more challenging from the econometric point of view. Our work wants to provide a theoretical framework and empirical strategies that may help overcome the issues to measure and interpret empirical evidence obtained from bilateral trade flows.

Among the articles looking at total country trade, a seminal framework introduced by [Redding and Venables \(2004a\)](#) stands as a pivotal theoretical and empirical cornerstone, delving into the impact of geography on a country's exports. This framework skillfully navigates multilateral resistances and provides a consistent methodology to discern country-specific features. Notably, [Redding and Venables \(2004b\)](#) presents a comparable analysis centered on inequality. The significance of this framework lies in its ability to untangle the intricate threads of multilateral resistances and isolate country-specific attributes, marking a watershed moment in research.⁵ Lately, using a similar approach, [Bleaney and Neaves \(2013\)](#) attempted to unpack the enigma of density's impact on trade openness. Although their cross-sectional analysis of the country-level effect doesn't account for temporal variations, it intriguingly contests the expected negative influence of population concentration on trade.

An article that uses bilateral trade to measure the effect of trade is [Yamarik and Ghosh \(2005\)](#), where the authors assessed new potential determinants of international trade through a naive gravity using bilateral trade flows. They used a measure of relative density (the difference in absolute values between the exporter and importer density) included together with variables concerning development levels, linguistic and colonial ties, geography, common currency and regional trade agreements.⁶ This difference represents the relative land endowments between the two countries and positively impacts bilateral trade. However, the absence of theoretical underpinnings

⁵ In these works, bilateral trade flows serve to measure market access measures, both for importer and exporters, which are, subsequently, included in the main estimates where trade is not dyadic

⁶ The authors mentioned: the Central American Common Market (CACM), Caribbean Community (Caricom), Mercado Común del Sur (Mercosur), Australia-New Zealand Closer Economic Relations Trade Agreement (ANZCERTA), and Asian Pacific Economic Cooperation (APEC).

leaves this relationship in a realm of empirical intrigue. [Sellner \(2019b\)](#) warn against using differences as bilateral measures because these may not represent pure dyadic variables. We add that in the case of population density, looking at the differences between importers and exporters levels does not distinguish between the supply and demand side effects of this country feature. On the exporters' (supply) side it is also associated with agglomeration forces, while for the importers (demand), it relates to market absorption (more people, larger markets means more buyers/consumers).

Recently, [Query \(2022\)](#) studied the interplay of population density and border effects, discerning no statistically significant outcomes in the context of inter-regional and intra-regional product trade between Canadian provinces and U.S. states. In this article, the empirical strategy, similar to ours, is the one from [Heid et al. \(2021\)](#). The difference with our analysis is that [Query \(2022\)](#) extend the exercise of [Anderson and van Wincoop \(2003\)](#), to add density impact on the role of the international and national border on trade between two countries. Our exercise focuses on density as a deterministic productivity factor and uses international borders to control the divide between domestic and international sales at the country level and consider the international trade network.

In the last few years, several relevant contributions on the linkages between trade and agglomeration have been released, but they are still unpublished, including works by [Moscona and Levy \(2022\)](#) and [Bakker et al. \(2021\)](#). The former, strongly connected to our paper, explores how domestic economic geography influences trade patterns, highlighting a country's population distribution as a significant factor in its comparative advantage. [Moscona and Levy \(2022\)](#) introduce a model of quantitative spatial economics ([Redding, 2016](#)), which formalize subnational level and rationalize aggregation,⁷ demonstrating how variations in productivity within a country can influence its export patterns in different industries, highlighting two essential factors: differing productivity levels across regions within a country and varying benefits of clustering different industries. Moreover, they introduce methods to assess the *population*

⁷ A similar modelling strategy to [Ramondo et al. \(2016\)](#)

density affinity of industries and the population concentration of regions. Findings reveal that both US states and countries with concentrated populations tend to export sectors aligned with high population density affinity. This study uses trade at the country level and not bilateral flows, we provide an alternative approach to obtain density sensitivity of different sectors by exploiting dyadic data and the properties of the structural gravity model. Our results confirm the main intuition of this paper.

We want to explore the channel by which density proxies agglomeration forces. Then, we also add country level evidence to a broad literature on population density and agglomeration economies from urban and regional studies. [Combes et al. \(2012\)](#) found that density and large cities are crucial in determining locations' total factor productivity, but they also point out that urban density is a source of advantages and disadvantages for the economy ([Duranton and Puga, 2020](#)). Therefore, it stimulates productivity and innovation, guarantees access to decent goods and services, reduces commuting distances, fosters energy-efficient housing and transport, and makes it easier to share scarce amenities. However, density generates congestion due to crowding, high living and travel costs, greater pollution levels and more likely spread of disease. [Duranton and Puga \(2004\)](#) describes the mechanism that leads to agglomeration (at the micro level). It arises when three conditions happen 1) *sharing*: splitting the cost of indivisible facilities, assuming share risk and having a common network of buyers and sellers; 2) *matching* labour supply and demand avoiding hold-up problems; 3) *learning* knowledge creation and diffusion.

At the macro level, density fits with the definition of *fundamental productivity* as discussed in [Costinot et al. \(2012\)](#)⁸ and enhances its role in determining trade patterns and specialization, comparative advantages and heterogeneous gains from trade. Moreover, the role of density captures the consequences of the uneven distribution of

⁸ [Costinot et al. \(2012\)](#) defines *fundamental productivity*: "captures factors such as climate, infrastructure, and institutions that affect the productivity of all producers in a given country and industry" (p.582). According to other works, ([Allen and Arkolakis, 2014](#); [Allen et al., 2020](#); [Bakker et al., 2021](#); [Moscona and Levy, 2022](#); [Rosenthal and Strange, 2004](#)) population density is part of productivity.

production factors defined as *lumpiness* by Courant and Deardorff (1992) and Courant and Deardorff (1993) by which the concentration of production factors endowments within a country matters as the abundance of them. These theoretical underpinnings examine aggregate country trade considering the spatial allocation of resources. However, the original formal setting does not allow a multi-country analysis.

Our work furnishes the tool to extract the contribution of density to productivity, similar to Combes et al. (2012) but at the macro level. And also, the country level implication of density on sector-specific productivity. Furthermore, we discuss that population density is associated with heterogeneity across industries. Evidence from Rosenthal and Strange (2004) together with the three forces above mentioned, also natural advantages, home market effects, consumption opportunities, and rent-seeking all play a part in how agglomeration and density affect trade. The article of Faggio et al. (2017) emphasizes the considerable heterogeneity across industries in the micro-foundations of agglomeration economies.

Empirically, most of the analysis focuses on the manufacturing sector⁹ and the advantages of dense areas. Less explored is the nexus with more natural or land-intensive sectors. Focusing on agriculture, Ricker-Gilbert et al. (2014) and Josephson et al. (2014), analyse Ethiopian and Malawian agricultural sectors, and find out the limits of Boserupian intensification.¹⁰ Thus, higher rural densities concern smaller farms size and lower farm wages, revenue per hectare and farm income are not increasing in population density. Concerning the impact on trade, not many works deal with the role of population density on agricultural commodity exports, most of them focus on the demand side. For instance, Morrison (1984) states that physiological density¹¹ is a significant long-run factor explaining cereal imports by developing countries.

⁹ Nakamura (1985), Rosenthal and Strange (2004), Bakker et al. (2021), Moscona and Levy (2022).

¹⁰ In brief, Boserupian theory refers to population growth as the prime cause of agricultural change. Boserup assessed that population growth does not necessarily lead to a total depletion of food (crops in particular), but people overcome issues through technological advances able to satisfy their needs.

¹¹ population density on arable land.

1.3 Background and Stylized Facts

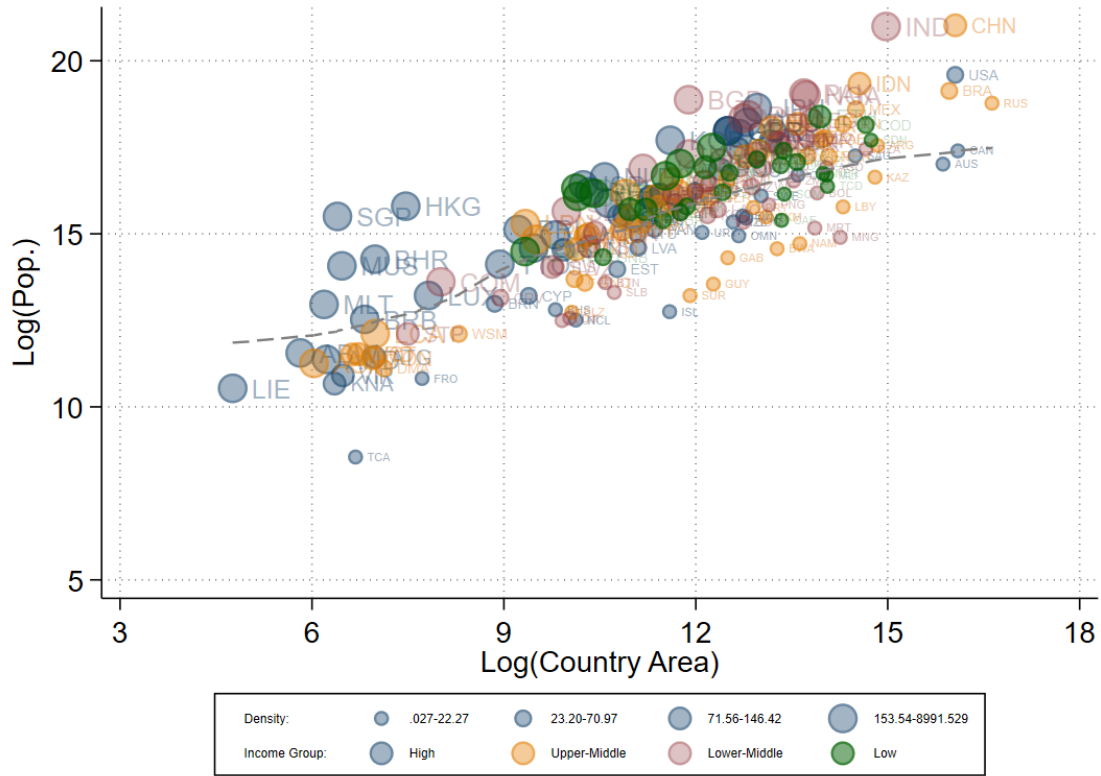
Before presenting the theoretical framework, here are shown some relevant facts on population density in general and its correlation with international trade.

Population Density, in particular at the country level, is a very slow-moving variable and it takes decades to change and often by a small amount. More interesting is to explore the features of population density and its distribution around the world and the contribution of its two main components (land area and population).

Figure 1.1 points to two obvious facts: 1) a larger country area implies more population but 2) density (represented by bubbles size in the graph) is higher in smaller countries (i.e. island on the bottom left of the graph). However, the relationship is not linear, the two extremes of the distribution present outliers and variability around the spline function that capture the local correlation between the two variables. On the bottom left, small islands like Turks and Caicos (TCA) and Faroe's Islands (FRO) are less inhabited, and on the top left larger and more populous countries are both highly dense (China, CHN and India, IND) but also low-dense like the US and Russia (RUS). Also, the world income distribution is heterogeneous.

Therefore, this complex view of population density across countries suggests that it could have a different impact on the export level and specialization in different industries and different countries. Country size and population concentration would have a specific effect either on sectors that are more labour or natural resources intensive, concerning also domestic specialisation. Moreover, other determinants of trade, such as bilateral trade costs and multilateral resistances, impact the volume and the margins of trade.

Figure 1.1: Population Density and Country Area by Income Groups



Source: Author's elaboration on population density (2015) and country area from HYDE 3.2, income groups classification is taken from the World Development Indicator of the World Bank. The non-linear fit is a lowess with running-mean smooth and tricube weighting function.

Figure 1.2 the correlation between total export and density (on the left) and between this and the share of exports over total production (on the right). The first column of graphs shows that population density and total exports have different nexus according to industries. Natural resources and/or land-intensive sectors (*Agriculture, Forestry and Fisheries and Mining*) have a negative correlation while *Manufacturing* which is (relatively) labour-intensive is positively related to density.

Different is the situation when considering relative export specialization, the graphs in the right column show a slightly different scenario. *Manufacturing* and *Mining* have the same relationship, respectively, positive and negative with population density. While *Agriculture, Forestry and Fisheries* in this case turns out to be positive,

meaning that denser countries sell abroad most of their output.

Figure 1.2 shows some outliers in the correlation between the ratio of export on production and population density. In particular, some small (in terms of areas) countries with high-density sell abroad more than half ($\geq 50\%$) of their production.

In *Agriculture, Forestry and Fisheries*, the export shares of Luxembourg,¹² Malta, Singapore and Malta exceed 50% of the total production. These countries produce and trade mostly processed products and just not raw materials (i.e., synthetic rubbers, oilseeds for Agriculture and board and plywood for Forestry products). Having more disaggregated data on production would help to understand better these specialization patterns. Moreover, Singapore it is been developing urban vertical farming since 2005.¹³

In *Manufacturing* as well these countries are involved in global value chains, so some manufacturing productions are settled in a place which does not necessarily furnish the domestic market. The mix of advantages of having high population density and the geographical strategic position make these countries ideal to locate a specific branch of production of manufactured goods. In this case, other outliers are some Eastern European countries (ie. Hungary, Estonia) where some automotive factories are placed.

This is important because suggests looking also at the country area and not only at its population concentration to understand the role of the spatial distribution of production factors. To sum up some interesting evidence from these pictures are:

- large countries with low population density export a high volume of goods in the natural resource of land-intensive goods;
- large countries with low population density countries are relevant exporters in

¹² see <https://resourcetrade.earth/?year=2015&exporter=442&category=1&units=value&autozoom=1>

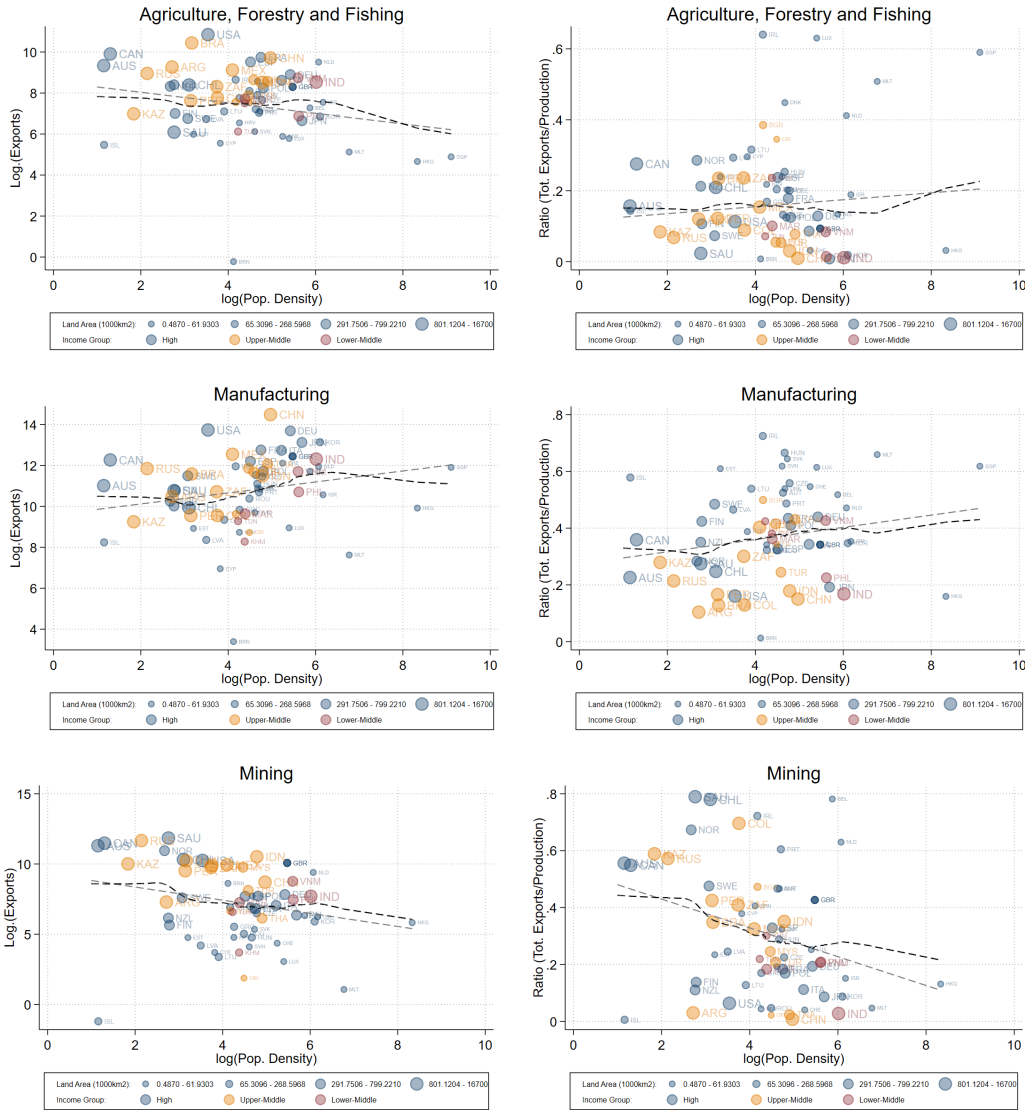
¹³ <https://ourworld.unu.edu/en/farming-in-the-sky-in-singapore>

all the broad sectors;

- large countries with high population density specialize in manufacturing;
- small countries with high-density export more manufactured goods;
- for small countries with high density sell abroad more than 40% of what they produce, but not for *Mining*;
- population density and country area capture also the effect of domestic demand. Agriculture, Forestry and Fisheries' output is absorbed in larger countries, while in small but dense countries is not true.

To sum up, labour-intensive activities are often associated with high population density, while industries relying on natural resources benefit from a more scattered concentration of people within a country. These findings align with the results obtained from the econometric specification. Additionally, graphs in Figure 1.2, according to [De Benedictis et al. \(2009\)](#), illustrate that countries do not necessarily specialize in just one sector but rather diversify. Large countries can benefit from both urban agglomeration and available land, allowing them to become top exporters across multiple sectors. On the other hand, even small countries with high population density, despite not being top exporters, are able to sell a significant portion of their production abroad. This is due to the positive influence of population density on productivity, which prevails over the effect of domestic demand absorption.

Figure 1.2: Countries' Exports, Export Shares and Density by Sectors



Source: Author's elaboration on population density (2015) and country area from HYDE 3.2, gross exports from TiVA 2018, and income groups classification are taken from the World Development Indicator of the World Bank. The non-linear fit is a loess with running-mean smooth and tricube weighting function.

1.4 Theory

In this section, we present the theoretical framework and the derivation of the structural gravity model and the main equations that interpret the empirical strategy based on [Heid et al. \(2021\)](#) and [Freeman et al. \(2021\)](#).

Set Up. The economy consists, in a multi-country setting, of $N \times N$ countries, where i are the exporters $i = 1, \dots, N$ and j the importers $j = 1, \dots, N$. Each country produces a tradable good with infinite varieties¹⁴ $\omega \in \Omega \equiv 1, \dots, +\infty$ using just one immobile production factor, labour, where L_i is the number of workers in country i and the unit cost of labour, wages, w_i .

Preferences. Using CES assumptions (Dixit and Stiglitz, 1977), the utility of the representative consumer:

$$u(x_j(\omega)) = \sum_j^N (x_j(\omega))^{\frac{\sigma-1}{\sigma}}, \quad (1.1)$$

where $\sigma > 1 + \theta$, is the elasticity of substitution between varieties. The maximization problem leads to the demand (expenditure) for the varieties ω in the country j :

$$x_j = \left[\frac{p_j(\omega)}{p_j} \right]^{1-\sigma} \alpha_j w_j L_j, \quad (1.2)$$

where α_j is the consumption share of country j and then $\alpha_j w_j L_j$ represents the expenditure of country j .

Trade Costs. Moving goods from country i to country j is costly. According to the iceberg trade costs assumption, For each unit of good shipped from country i to country j , only $\frac{1}{\tau_{ij}} \leq 1$ units arrive, selling domestically is costless, $\tau_{ii} = 1$. For τ_{ij} hold the triangle inequality such that $\tau_{ij} \leq \tau_{il} \tau_{jl}$

Market Structure. The market is characterized by perfect competition. In any country j , the price $p_j(\omega)$ paid by buyers of a variety ω the lowest:

¹⁴ we use infinite varieties as in Costinot et al. (2012), as the authors pointed this does not differ substantially by a continuum of goods, this eludes the technical complication of implementing the law of large numbers with a continuum of i.i.d. variables, and the number of varieties per industry is exogenously given. Since we build on their model using their main functional forms, we keep this assumption for coherence with the framework.

$$p_j(\omega) = \min_{1 \leq i \leq I} [c_{ij}(\omega)] \quad (1.3)$$

where $c_{ij}(\omega) = \frac{\tau_{ij} w_i}{A_i} > 0$ is the cost of producing and delivering one unit of this variety from country i to the country j .

Technology. Using [Costinot et al. \(2012\)](#) Assumption 1, for all countries i and their varieties ω , productivity $A_i(\omega)$ is a random variable, drawn independently from a Fréchet distribution $F_i(\cdot)$ such that;

$$F_i(A) = e^{-\left(\frac{A}{A_i}\right)^{-\theta}} \quad (1.4)$$

where $A_i > 0$ is the *fundamental productivity* (deterministic) which represents also the absolute advantages of a country- $\theta > 1$ is the *intra-industry heterogeneity* (stochastic) that parameterizes the impact of changes in fundamental productivity level A_i , and capture comparative advantages between countries.

In the deterministic productivity component we add, as in [Allen and Arkolakis \(2014\)](#) and [Allen et al. \(2020\)](#), a specific element for labour contribution and its sensitivity to population density, η :

$$A_i = \bar{A}_i (L_i)^\eta \quad (1.5)$$

where \bar{A}_i represents the exogenous country productivity, $\eta \in \mathbb{R}$ is the extent by which agglomeration (population density) affects productivity, η is specific for each sector as in [Moscona and Levy \(2022\)](#), we assume that different industries do not benefit by population density in the same way.

At the moment there is not any specific assumption on the value of density sensitivity. Therefore, η , as in [Allen and Arkolakis \(2014\)](#), could be either positive or negative: $\eta > 0$ means that a certain industry benefits from the scale effects of population agglomeration: on the other hand, $\eta < 0$ indicates that an excessive number of workers imply diseconomies related to an excessive population level according to specific industries that rely mostly on other factors (i.e. natural resources for raw materials and intermediates) for their production process.

Expenditure Share - Trade. Given the price from 1.3 and the expenditure share 1.2 obtain, and the productivity function from equation 1.5:

$$X_{ij} = \frac{\left(\frac{w_i \tau_{ij}}{A_i L_i^\eta}\right)^{-\theta}}{\sum_{j=1}^N \left(\frac{w_i \tau_{ij}}{A_i L_i^\eta}\right)^{-\theta}} \alpha_j w_j L_j, \quad (1.6)$$

the first part of equation 1.6, $\pi_{ij} = \left(\frac{w_i \tau_{ij}}{A_i L_i^\eta}\right)^{-\theta} / \sum_{j=1}^N \left(\frac{w_i \tau_{ij}}{A_i L_i^\eta}\right)^{-\theta}$ is the *trade share*, representing the probability that country i supply goods at the minimum price in country j . The second term is the expenditure of country j , $E_j = \alpha_j w_j L_j$.

This equation helps to understand why we choose the functional form of productivity from [Costinot et al. \(2012\)](#). First, we have $(w_i \tau_{ij} / A_i)^{-\theta}$, which stress the role of A_i affecting the domestic cost (w_i) and the cost of selling goods abroad (τ_{ij}). Moreover, in this case, η and θ interact in the contribution of L_i to productivity, and as shown when estimating the effect of sensitivity to density the role of the comparative advantages parameter is crucial to not overestimate its impact.

Market Clearing. In equilibrium, the model assumes that Goods Market is cleared when:

$$Y_i = \sum_{j=1}^N x_{ij}, \quad (1.7)$$

meaning that the domestic output contains both the amount of produced goods

shipped and sold to j and also the part for the domestic market. On the production side, Labour Market clears when:

$$Y_i = w_i L_i, \quad (1.8)$$

Price Distribution. From 1.3 we obtain the price distribution from a Frechét (Eaton and Kortum, 2002). The cheapest good in country j will have a price lower than p unless each price of i is greater than p . So if j buys at a lower price than p , the distribution is:

$$G_j(p) = Pr[P_j \leq p] = 1 - \prod_{j=1}^J [1 - G_{ij}(p)], \quad (1.9)$$

The equation gives the price parameter;

$$\Phi_j = \sum_{j=1}^N (A_i)^\theta (w_i \tau_{ij})^{-\theta} \quad (1.10)$$

Φ_j , as in Eaton and Kortum (2002),¹⁵ concerns the world's state of the technology, and the geographic features that determine prices in each country j . The exact price index is

$$P_j = \gamma (\Phi_j)^{-\frac{1}{\theta}} ; \Phi_j = \gamma^\theta (P_j)^{-\theta} \quad (1.11)$$

The exact price index and the price distribution parameter are proportional and this helps to derive the multilateral resistance terms.

Multilateral Resistance Terms. Once price distribution, price parameter and the

¹⁵ the model of Eaton and Kortum (2002) considers also intermediate inputs, in their framework these price parameter

related exact price index are defined, it is possible to derive the *Multilateral Resistance Terms*. These are the structural terms defined by [Anderson and van Wincoop \(2003\)](#), that capture market importer (*inward*) and exporter (*outward*) access determinants

From [Anderson and van Wincoop \(2003\)](#) define the Outward Multilateral Resistance Term (OMR):¹⁶

$$\Pi_i = \sum_{j=1}^N \left(\frac{\tau_{ij}}{P_j} \right)^{-\theta} \frac{E_j}{Y}, \quad (1.12)$$

and the Inward Multilateral Resistance Term (IMR):

$$P_i = \sum_{i=1}^N \left(\frac{\tau_{ij}}{\Pi_i} \right)^{-\theta} \frac{Y_i}{Y}, \quad (1.13)$$

As shown in the appendix, now define the factory gate price or wage:

$$w_i = \left(\frac{Y_i/Y}{(\Pi_i)^{-\theta} (A_i)^\theta} \right)^{-\frac{1}{\theta}}, \quad (1.14)$$

this equation is different from its typical formalization because here includes also the productivity of the country i and not just the costs of exporting captured by Π_i . The Outward Multilateral resistance term also proxies unobservable congestion forces operating in each country i . Then domestic prices are lower if productivity is higher, and also higher cost of reaching a foreign market (Π_i) obliges countries to lower production costs for being competitive in the global markets. Remembering that productivity is given by 1.5, substitute w_i into equation 1.8,

$$Y_i = (\bar{A}_i)^{\frac{\theta}{1+\theta}} (L_i)^{\frac{\theta(1+\eta)}{1+\theta}} (\Pi_i)^{-\frac{\theta}{1+\theta}} (Y)^{\frac{1}{1+\theta}}, \quad (1.15)$$

¹⁶ see Appendix 1.9 for derivation.

Then adding the 1.15 into the main gravity equation 1.47, gives the extended gravity equation with exporters' specific variables:

$$X_{ij} = \frac{(\bar{A}_i)^{\frac{\theta}{1+\theta}} (L_i)^{\frac{\theta(1+\eta)}{1+\theta}} E_j (\tau_{ij})^{-\theta}}{(Y)^{-\frac{1}{1+\theta}} (\Pi_i)^{\theta - \frac{\theta}{1+\theta}} (P_j)^{-\theta}}, \quad (1.16)$$

1.5 Empirical Strategy

This section discusses how to bridge theory and econometrics. To do so we need to look at the literature focused on the estimation of unilateral variables into a structural gravity model.

Firstly looking at the published work of [Heid et al. \(2021\)](#), where is provided a solution to solve the perfect collinearity issues arising in including country-specific variables in a gravity model with importer and exporter fixed effect (a framework not falling in the *gold medal mistake* ([Baldwin and Taglioni, 2006](#))). Solving this issue needs to include domestic sales¹⁷ and multiplying the unilateral variable of interest by the international borders dummy $INTL_{ij}$.¹⁸ Even though it allows the inclusion of any country-specific or unilateral policy measure, this approach has limitations in the interpretation of the results since the coefficient besides the impact of the covariate of interest contains also its differential effect on international trade with respect to domestic sales. This article presents the empirical solutions to it but it does not include a theoretical interpretation of the results.

The other approach, from [Freeman et al. \(2021\)](#), wants to build a framework and a methodology to measure the direct effect of unilateral variables on international trade through a structural gravity model.

Following this paper, the logarithm and an exponential transformation of equation

¹⁷ total production minus exports

¹⁸ $INTL_{ij} = 1$ for $i \neq j$ and $INTL_{ij} = 0$ otherwise.

1.16, gives the empirical equation for a Poisson Pseudo Maximum Likelihood (PPML),

$$X_{ij} = \exp[\beta_1 \ln(\bar{A}_i) + \beta_2 \ln(L_i) + \beta_3 \ln(E_j) + \beta_4 \ln(\tau_{ij}) + \beta_5 \ln(\Pi_i) + \beta_6 \ln(P_j) + \beta_7 \ln(Y)] \times \varepsilon_{ij}, \quad (1.17)$$

and the coefficient can be interpreted thanks to the parameter associated with each variable in the theoretical exports function, 1.16. Therefore, $\beta_1 = \frac{\theta}{1+\theta}$, $\beta_2 = \frac{\theta(1+\eta)}{1+\theta}$, $\beta_3 = 1$, $\beta_4 = -\theta$, $\beta_5 = \theta - \frac{\theta}{1+\theta}$, $\beta_6 = -\theta$, $\beta_7 = -\frac{1}{1+\theta}$. The most important coefficient is β_2 , which includes both trade elasticities $\frac{\theta}{1+\theta}$ and also the agglomeration/scale effect captured by density, $1 + \eta$.

The work of [Freeman et al. \(2021\)](#) proposes an alternative estimation method which overcomes the identification issues related to source and destination fixed effect but still uses a theoretically grounded gravity model. They developed a two-stage procedure in which multilateral resistance terms are proxied by two indices measured from the origin and destination fixed effects. Here we propose an application of the two methodologies to a cross-sectional setting to compare baseline results.

1.5.1 Method 1: [Heid et al. \(2021\)](#)

Applying the approach of [Heid et al. \(2021\)](#) to the present theoretical framework, the reduced form for estimating the effect of population density on exports is:

$$X_{ij} = \exp[\beta_2 \ln(L_i) \times INTL + \delta_0 INTL_{ij} + \beta_4 \ln(\tau_{ij}) + \mu_i + \chi_j] \times \varepsilon_{ij}, \quad (1.18)$$

where, as already wrote above, $INTL = 1$ for $i \neq j$ and $INTL = 0$ for $i = j$, $\ln(\tau_{ij})$ concerns bilateral trade barriers. For the moment, exogenous productivity, \bar{A}_i is omitted, it is reasonable to assume that it is contained in the export fixed effects, μ_i , and it is considered just the cross-sectional setting. The last term, χ_j , is the

destinations/importers fixed effect which controls for all the costs of importing, for country j expenditure and trade imbalances.

The purpose of the empirical section is the focus on β_2 , the coefficient capturing the density impact. However, as pointed out previously, using the method, of multiplying the main variable for the international border dummy, is going to measure the effect of population density on international trade with respect to domestic sales.

Therefore, in the following paragraph, it is provided with a theoretical interpretation of [Heid et al. \(2021\)](#) method. This is useful for two reasons: 1) because the main variable is not considered as just a unilateral trade cost but also as a productivity component and it contains an additional parameter, η , that needs to be explained and interpreted properly; 2) data contains both international and domestic flows,¹⁹ so is needed as well an interpretation of the role of these two components and how they drive the results.

Moreover, to test the robustness and the interpretation of the density coefficient, we replicate the analysis following the method of [Freeman et al. \(2021\)](#). This new approach allows the estimation of the direct effect of the country-specific variable. Also in this case, we provide a theoretical discussion of the interpretation when domestic and international flows are both in the sample.

1.5.2 Theoretical Interpretation of Method 1

The trade share, π_{ij} , with the price parameter a la [Eaton and Kortum \(2002\)](#), ϕ_j , is log-transformed:

$$\log(\pi_{ij}) = \theta \log(\bar{A}_i) + \eta \theta \log(L_i) - \theta(\log(w_i) + \log(\tau_{ij}) - \log(\phi_j)). \quad (1.19)$$

¹⁹ Using data with both the dimension is better both for merely empirical work and to run general equilibrium analysis. The advantages of using a complete dataset are widely explained in [Yotov \(2021\)](#).

This equation allows a better theoretical interpretation of the coefficient of interest. Obtaining the partial effect of $\log(L_i)$ in percentage changes and in changes respectively:²⁰

$$\frac{\partial \log(\pi_{ij})}{\partial \log(L_i)} = \eta\theta(1 - \pi_{ij}) \quad (1.20)$$

$$\frac{\partial \pi_{ij}}{\partial \log(L_i)} = \eta\theta(1 - \pi_{ij})\pi_{ij} \quad (1.21)$$

Now we focus on equation 1.20, the first general interpretation of the per cent change in population density is that:

- for large π_{ij} the effect on international sales is smaller, while is greater for domestic sales.
- Positive or negative changes are related to η .

However, the exact coefficient takes into account the differential effect between external and internal dimensions which is formalized as:

$$\beta_2 = \frac{\partial \log(\pi_{ij})}{\partial \log(L_i)} - \frac{\partial \log(\pi_{jj})}{\partial \log(L_i)} = \eta\theta(1 - \pi_{ij}) - \eta\theta(1 - \pi_{jj}) = \eta\theta\pi_{jj} - \eta\theta\pi_{ij} \quad (1.22)$$

This means that following [Heid et al. \(2021\)](#), it is likely to assume that the model measures:

$$\beta_2 = \eta\theta(\pi_{jj} - \pi_{ij}) \quad (1.23)$$

²⁰ See proof in appendix 1.9.3 for the derivation.

where η and $(\pi_{jj} - \pi_{ij})$ drive the sign. From the literature²¹ the parameter θ is positive. Also from literature and empirical evidence, the proportion between domestic and international trade share, $\pi_{jj} - \pi_{ij} > 0$, is that the domestic component is higher than the whole international sales.²² More precisely, for aggregate trade, the two shares are almost balanced (close to 50%), while for sectoral trade it depends on industries and the differences can be larger.

The interpretation of η must consider that the coefficient measures only the relative effect of density on international trade. Then, η is the sensitivity to the density of international trade with respect to domestic sales. When $\pi_{jj} - \pi_{ij} > 0$ holds:

- $\eta > 0$ ($\beta_2 > 0$); the marginal contribution in the differential effect of population density is more sensitive to international sales. It contributes more to reaching foreign markets (smaller trade share than to the domestic market) than internal markets. In this case, the supply effect from productivity is clearly evident.
- $\eta < 0$ ($\beta_2 < 0$); the marginal contribution in the differential effect of population density is more sensitive to domestic sales. Even if the internal share is larger, the domestic market absorbs the density effect on trade. There are two possible explanations for this: the first is that the supply-side effect related to productivity works on economic integration (this would be the case for a sample of developing countries), and the second is that the domestic demand effect is higher than the supply one. Then, a large domestic market absorbs the greatest part of the production, as for *minings* and the extraction of fuels and other energetic sources.

To make our formalization more complete, considering the case in which $\pi_{jj} - \pi_{ij} < 0$ would provide a different interpretation of η as the sensitivity to the density of

²¹ Eaton and Kortum (2002) for aggregate trade and Costinot et al. (2012) in a multisectoral setting.

²² The trade shares here considered are the average value of the sample, for each country this condition is not always true, as shown in the graph, as in the case of Singapore and Malta

international trade with respect to domestic sales. We will discuss better this point using empirical evidence from Table 1.3.

Nevertheless, even if θ has been widely studied in former contributions, a correct specification of this component in the empirical part is crucial because it might affect seriously the results. This point is going to be discussed in the following paragraph.

1.5.3 The Role of the International Border Dummy

In the previous section, equation 1.18 represents our main empirical model and it contains an international border dummy, $INTL_{ij}$, both multiplied with the main variable of interest (population density) and also alone. Therefore, after the theoretical interpretation of the main coefficient $\beta_2 L_i \times INTL_{ij}$, now we focus on the role of the dummy that allows us to identify the main coefficient. The implications of the variable for international borders, $INTL_{ij}$, is widely debated in the literature in seminal work as (Anderson and van Wincoop, 2003) and (Balistreri and Hillberry, 2007) and in our baseline estimates it is used both with the country-specific variable, population density, and alone. The baseline equation is:

$$X_{ij} = \exp[\beta_2 \ln(L_i) \times INTL + \delta_0 INTL - \theta \ln(\tau_{ij}) + \mu_i + \chi_j] \times \varepsilon_{ij} \quad (1.24)$$

The $INTL_{ij}$ dummy is crucial in the model specification, especially in cross-sectional settings. It is exogenous by construction and captures the effects of all possible determinants of trade not modelled explicitly, along with gravity covariates (geography and language), making domestic and international sales. On the other hand, this cannot catch the heterogeneous effect of international borders across countries and does not allow it to break up into its determinants. To analyze the model with country-specific variables multiplying the international border dummy and the dummy itself. We follow the formalization of an econometric model with dummy variables, defining the model when the international border is equal to one:

$$E(X_{ij}|INTL = 1, \ln(L_i), \dots) = \beta_2 \ln(L_i) + \delta_0 - \theta \ln(\tau_{ij}) + \mu_i + \chi_j \quad (1.25)$$

when $INTL = 0$, the model refers to the domestic component of the data, both trade and explanatory variables:

$$E(X_{jj}|INTL = 0, \ln(L_i), \dots) = -\theta \ln(\tau_{jj}) + \mu_i + \chi_j \quad (1.26)$$

The difference between 1.25 and 1.26 is the estimated model which takes the following form:

$$\begin{aligned} \hat{X}_{ij} &= E(X_{ij}|INTL = 1, \ln(L_i), \dots) - E(X_{ij}|INTL = 0, \ln(L_i), \dots) = \\ &= \beta_2 \ln(L_i) + \delta_0 - \theta(\ln(\tau_{ij}) - \ln(\tau_{jj})) \end{aligned} \quad (1.27)$$

Now it is clear that the effect captured by the coefficient for borders dummy, δ_0 , is affecting the model specification. But to explain better its role, we need to go back to the equation 1.23 in the previous section and substitute β_2 and δ_0 ²³ with their theoretical interpretation:

$$\hat{X}_{ij} = \eta \theta (\pi_{jj} - \pi_{ij}) \ln(L_i) - \theta (\pi_{jj} - \pi_{ij}) - \theta (\ln(\tau_{ij}) - \ln(\tau_{jj})) \quad (1.28)$$

this equation shows the content of the international border dummy as in [Yotov et al. \(2016\)](#). It controls all possible exogenous sources of trade frictions and the wedge between domestic and international sales. Moreover, it allows controlling for potential bias arising from the difference between the two dimensions, $(\pi_{jj} - \pi_{ij})$, when the

²³ see Appendix 1.9.3 for its definition.

effect of density (or any other country-specific variables representing a component of fundamental productivity) is measured.

1.5.4 Method 2: Freeman et al. (2021)

An alternative method (hereafter called Method 2) to identify the effect of country-specific variables is provided by Freeman et al. (2021).

It consists in a two-step procedure, where the first stage is a basic gravity estimated with a PPML with panel data:

$$X_{ij,t} = \exp[\mu_{i,t} + \chi_{j,t} + \tau_{ij}] \times \varepsilon_{ij,t} \quad (1.29)$$

where μ_i are the exporter fixed effect, χ_j the importer fixed effect and τ_{ij} the country-pair fixed effect. This estimation is useful to obtain the source and destination fixed effect to compute the related indexes for the estimated multilateral resistance terms:

$$\hat{\Pi}_i = \frac{Y_i}{\exp(\hat{\mu}_i)} \times \frac{E_0}{Y} ; \hat{P}_i = \frac{E_j}{\exp(\hat{\chi}_j)} \times \frac{1}{E_0} \quad (1.30)$$

where E_0 is the expenditure of the numeraire country. These terms are added in the second stage which is done with cross-section data to compare better the results of the two methods:

$$X_{ij} = \exp[\beta_1 \ln(\bar{A}_i) + \beta_2 \ln(L_i) + \beta_3 \ln(E_j) + \beta_4 \ln(\tau_i) + \beta_5 \ln(\hat{\Pi}_i) + \beta_6 \ln(\hat{P}_j)] \times \varepsilon_{ij} \quad (1.31)$$

1.5.5 Theoretical interpretation of Method 2

The interpretation of β_2 , in this case, would be following the [Freeman et al. \(2021\)](#) from equation 1.16:

$$\beta_2 = \frac{\partial \log(\pi_{ij})}{\partial \log(L_i)} = (1 + \eta) \frac{\theta}{1 + \theta} \quad (1.32)$$

this statement is true if the data contains only international flows. Following the formalization proposed before but expressed in levels:

$$\beta_2 = \frac{\pi_{ij}}{\partial \log(L_i)} = \eta \theta (1 - \pi_{ij}) \pi_{ij} \quad (1.33)$$

the interpretation is the same as provided in the previous section. Since θ is positive by the literature, η drives the sign of the effect. The magnitude is affected by the variance of trade shares, $(1 - \pi_{ij})\pi_{ij}$, which is always positive.

Using this method, we can obtain the simple density sensitivity easier to interpret since here is ignored the differential effect of the two dimensions and then η represents the contribution of density to productivity. In the case of $\eta > 0$, we have an agglomeration effect due to the natural advantages of having a large population concentration. By contrast, when $\eta < 0$, technology and market size have a positive impact. Moreover, the natural advantages are mostly related to the natural endowments, and an increase in population density may generate diseconomies.

1.6 Data

This section describes the variables and the data sources used for the estimation; data on exports and production by sectors, population density and the different measures we test and the unilateral and bilateral geographic controls.

The dependent variable is bilateral exports which accounts also for domestic sales. Data are from TiVA (version 2018); international trade includes gross exports and domestic flows, the latter is the difference between gross production and total exports (Yotov, 2022b). These data are grouped to obtain three broad sectors i) Agriculture, Forestry and Fisheries,²⁴ ii) Manufacturing iii) and Mining.²⁵ The sample is a $N \times N$ matrix (64 X 64 countries)²⁶ for each year from 2005 to 2015.

We use the TiVA sample because it is a balanced trade matrix (in terms of linkages and year) that allows us to have international and domestic flows in the same unit of measure (gross terms). It has a slightly greater country coverage than other data sources having values for each sector for trade and production. Moreover, the 64 countries in it represent a heterogeneous composition regarding geographical and economic features. We leave out services in this analysis since we find stronger evidence related to the ratio of population and land endowments.

Population density is computed from the *History Database of the Global Environment* (HYDE 3.2) (Klein Goldewijk et al., 2017). This data set combines updated population (grid) estimates and land use for the past and for a more contemporary range of time. It classifies land into several categories by different crop and irrigation systems and other anthromes. The population is also split into total, urban and rural. The results rely on different measures of density to test for robustness:

²⁴ TiVA does not contain disaggregated sector for it

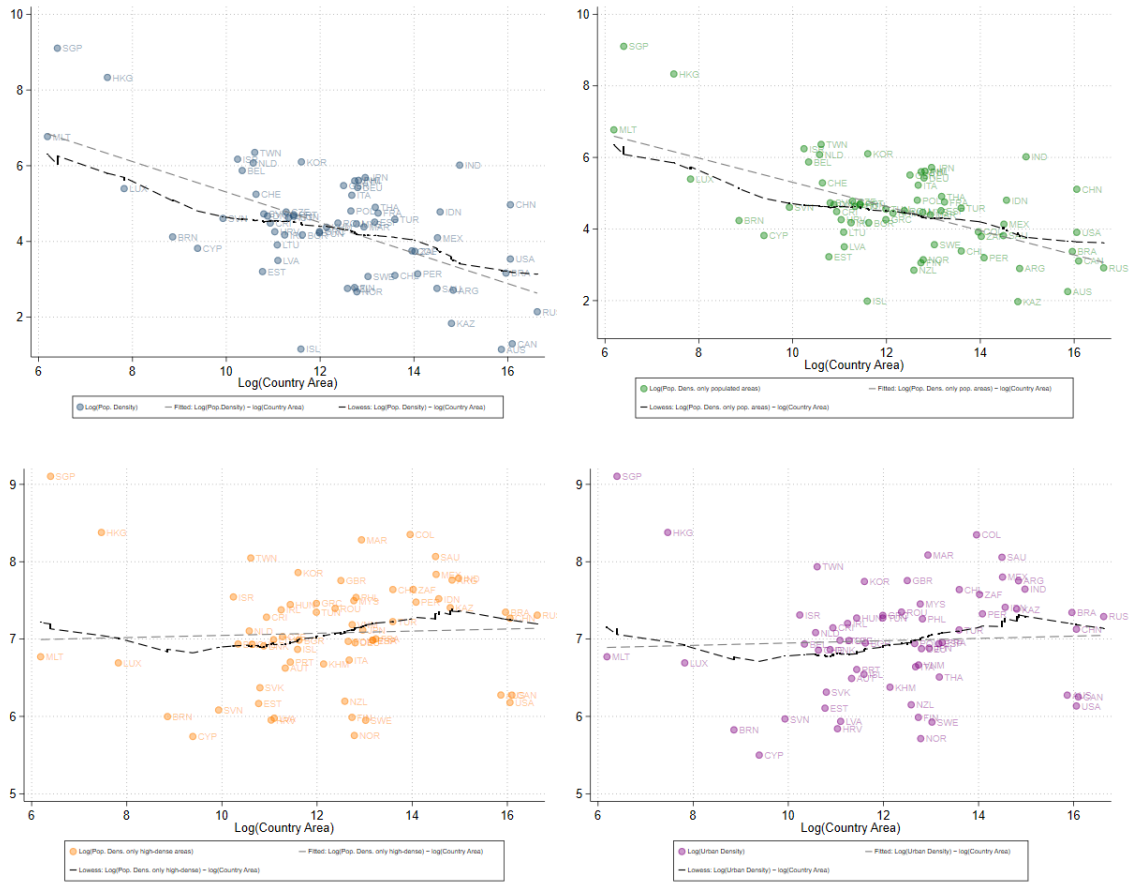
²⁵ This sector has both energy and non-energy products. It is grouped maintaining the category *Mining support service activities*. which does not change significantly results

²⁶ The countries and their ISO3-CODE are: Argentina (ARG), Australia (AUS), Austria (AUT), Belgium (BEL), Bulgaria (BGR), Brazil (BRA), Brunei (BRN), Canada (CAN), Switzerland (CHE), Chile (CHL), China (CHN), Colombia (COL), Costa Rica (CRI), Cyprus (CYP), Czech Rep. (CZE), Germany (DEU), Denmark (DNK), Spain (ESP), Estonia (EST), Finland (FIN), France (FRA), Switzerland(CHE), United Kingdom (GBR), Greece(GRC), China (CHN) , Hong Kong SAR (HKG), Croatia (HRV), Hungary (HUN), Indonesia (IDN), India (IND), Ireland(IRL), Iceland (ISL), Israel (ISR), Italy (ITA), Japan(JPN), Kazakhstan (KAZ), Cambodia (KHM), Rep. of Korea (KOR), Lithuania (LTU), Luxembourg (LUX), Latvia (LVA), Morocco (MAR), Mexico (MEX), Malta (MLT), Malaysia (MYS), Netherlands (NLD), Norway (NOR), New Zealand (NZL), Peru (PER), Philippines (PHL), Poland (POL), Portugal (PRT), Romania (ROU), Russian Fed. (RUS), Saudi Arabia (SAU), Singapore (SGP), Slovakia (SVK), Slovenia (SVN), Sweden (SWE), Thailand (THA), Tunisia (TUN), Turkey (TUR), Taiwan (TWN), United States (USA), Viet Nam (VNM), South Africa (ZAF).

1. **Population Density**: the standard measures of $\frac{Population}{Area(km^2)}$. The area does not count lakes.
2. **Population Density (only populated cells)**: considers the area of the cells where the population is greater than zero
3. **Population Density (high density cells)**: consider total population and area only from cells classified as *Urban* and *Dense Settlements*
4. **Urban Density (urban cells)**: consider just urban population and are only from cells classified as *Urban*

The first two measures are similar (see Figure 1.3) larger countries (in terms of area) have less density and vice versa. These capture the uneven distribution of the population with respect to land. Differently, Population Density (high-density cells) and Urban Density (high-density cells) have the opposite relation with size and also less variability.

Figure 1.3: Comparing Population Density Measures



Source: Author's elaboration with HYDE 3.2 data

Note: The country area in the x-axis is the original measure (the one used for population density) and it is the same in all the graphs. It is done to compare the heterogeneity of these variables. The linear and non-linear fit regress the different density measures on the total country area. The non-linear fit is a lowess with running-mean smooth and tricube weighting function.

The last set of unilateral variables represents further controls for geographical features that might affect production, productivity, and density. These are taken from the seminal work of [Nunn and Puga \(2012\)](#) and they are *ruggedness*, *soil fertility* (percentage of land), *tropical climate*, *desert percentage of land*, *gemstones* (Gem diamond extraction 1958-2000 (1000 carats)), *near coast* (percentage Within 100 km. of ice-free coast). To make a robustness check on potential omitted variables we use nominal GDP per capita from CEPII, and total employment and human capital from Penn's World Table.

The bilateral covariates are the weighted distance, contiguity, official common language and colonial links taken from the *GeoDist Database* (Mayer and Zignago, 2011). An alternative measure of distance concern sailing length. The dyadic components (distance from country A to country B) are provided by the CERDI Sea Distances dataset (Bertoli et al., 2016). This measure does not include internal distances which are computed by the author using the Router Project Open Street Map. To do so, according to the assumption of domestic trade costs from Ramondo et al. (2016), these are the average distance related to country size. Here including country size in the internal distance is considered as a starting point for the centroid of each country. Then the road distances using Open Street Maps tools measure the kilometres to reach the main port according to the CERDI data. For landlocked countries, internal distances are imputed regressing weighted distances on the road distance. The imputation is done to avoid strong assumptions on the geographic domestic frictions of those countries.

1.7 Results

First, we present the baseline results, a cross-section for 2015, based on Heid et al. (2021). The robustness checks are made using the sea distance measure integrated with domestic road distance from the country's centroid to the main port. Then, we show the effect of using different density measures and including other variables to check if there is a problem with omitted variables. With a focus on manufacturing, we run the same analysis for each industry contained in the aggregate trade, to check potential biases related to aggregation as suggested in Redding and Weinstein (2019) and Breinlich et al. (2022). Always using this methodology (Heid et al., 2021) we estimate also the effect of density on international trade with respect to domestic sales in a panel setting (2005-2015) and check bilateral determinants firstly with gravity covariates and also with country pairs fixed effects. Thereafter, we explore the implication of a cross-section version of the approach in Freeman et al. (2021), which measure the direct effect of density on overall trade.

1.7.1 Method 1: [Heid et al. \(2021\)](#).

1.7.2 Results: Cross-Section

Baseline estimates refer to 2015. The time dimension is not examined in the theoretical part and it is shown later, the panel analysis yields slightly different and less robust results. The main cross-sectional equation is:

$$\begin{aligned} X_{ij} = \exp[\beta_2 \ln(L_i) \times INTL_{ij} + \delta_0 INTL_{ij} + \\ + \beta GEO_CONTROLS_i \times INTL_{ij} - \theta \ln(\tau_{ij}) + \mu_i + \chi_j] \times \varepsilon_{ij} \end{aligned} \quad (1.34)$$

Using a PPML to estimate the effect of density, $\ln(L_i) \times INTL_{ij}$, on exports with respect to domestic sales, and including gravity covariates $\ln(\tau_{ij})$ including different measures of distance, controlling for multilateral resistance terms with the exporter, μ_i , and importer, χ_i , fixed effects, and controlling for international and internal trade with the border dummy and exporter-specific geographic features, $GEO_CONTROLS_i$, from [Nunn and Puga \(2012\)](#).

Table 1.1: Baseline Estimates, PPML, Cross-Section: Gross Exports, 2015

VARIABLES	(1)	(2)	(3)
	Manufacturing	Agric. Forest. and Fish.	Mining
$\text{Log}(\text{Density}) \times \text{INTL}$	0.3200*** (0.0525)	-0.0156 (0.0767)	-0.2703** (0.1295)
Observations	4,096	4,050	3,670
Exporter FE	YES	YES	YES
Importer FE	YES	YES	YES
GRAVITY	YES	YES	YES
INTL	YES	YES	YES
GEO Control X INTL	YES	YES	YES
Clusters	Pair	Pair	Pair

Note: The difference in sample size in different sectors is due to singletons and duplicates which in Agriculture et al. and Mining are dropped by the importer and exporter fixed effect. *GRAVITY* concerns *log. of weighted distance*, *contiguity* (dummy) and *common official language* (dummy) from [Conte et al. \(2022\)](#). *GEO_CONTROL* contains the variables from [Nunn and Puga \(2012\)](#) and they are *ruggedness*, *soil fertility* (percentage of land), *tropical climate*, *desert percentage of land*, *gemstones* (Gem diamond extraction 1958-2000 (1000 carats)), *near coast* (percentage Within 100 km. of ice-free coast), all are multiplied by the international border dummy INTL_{ij} . Clustered by pair (exporter-importer, non-symmetric) robust standard errors in parentheses. Significance level *** p<0.01, ** p<0.05, * p<0.1

The first set of results, Table 1.1, measures population density elasticities for the three broad sectors. Manufacturing gross exports increase by 0.32% with respect to domestic sales consequently to a 1% increase in population density. Drawing from the theoretical interpretation presented in Section 1.5.2, as well as the trade shares data in Table 1.11, the density sensitivity, denoted as η , positively influences export performance with respect to domestic trade.

The outcomes for agricultural sectors lack significance due to inherent industry heterogeneity that we cannot explore given data classification. For instance, forestry relies mainly on natural resources, while other products like horticulture goods come from more technology intensive activities, and in many cases, grown in greenhouses, requiring less land and natural resources. However, the diversity among products makes it challenging to properly identify the impact of density on agricultural trade using the aggregation provided by TiVA, as indicated by the parameter η in the model.

Mining exhibits a negative and statistically significant coefficient in accordance with the theoretical interpretation of the β_2 . Thus, the mining export elasticities with respect to domestic sales lead to a variation of -0.27% of trade if population density rise by 1%. Consequently, based on our theoretical prediction, a negative η suggests that an increase in the labour force reduces exports, possibly due to diseconomies resulting from population concentration or the sector's higher dependence on natural resources.

The role of the parameter θ also emerges from the theoretical prediction concerning the coefficient β_2 . In the literature, it has positive value and, as in [Eaton and Kortum \(2002\)](#), is estimated using geographic barriers. To test the sensitivity of these results to this parameter, we used a different measure of shipping distances regarding sea travel. In Table 1.2, coefficients do not change by significance and sign. In manufacturing, the elasticity slightly increases from 0.32% to 0.33%.

Table 1.2: Alternative distances measure: PPML, Cross-Section: Gross Exports, 2015

VARIABLES	(1)	(2)	(3)
	Manufacturing	Agric. Forest. and Fish.	Mining
$\text{Log}(\text{Density}) \times \text{INTL}$	0.3377*** (0.0587)	0.1311* (0.0790)	-0.1554 (0.1416)
Log(Sea Distances) includes domestic	-0.4460*** (0.0233)	-0.5901*** (0.0443)	-0.8049*** (0.0778)
Observations	4,096	4,050	3,670
Exporter FE	YES	YES	YES
Importer FE	YES	YES	YES
GRAVITY	YES	YES	YES
INTL	YES	YES	YES
GEO Control X INTL	YES	YES	YES
Clusters	Pair	Pair	Pair

Note: The difference in sample size in different sectors is due to singletons and duplicates which in Agriculture et al. and Mining are dropped by the importer and exporter fixed effect. *GRAVITY* concerns *log. of weighted distance*, *contiguity* (dummy) and *common official language* (dummy) from [Conte et al. \(2022\)](#). *GEO-CONTROL* contains the variables from [Nunn and Puga \(2012\)](#) and they are *ruggedness*, *soil fertility* (percentage of land), *tropical climate*, *desert percentage of land*, *gemstones* (Gem diamond extraction 1958-2000 (1000 carats)), *near coast* (percentage Within 100 km. of ice-free coast), all are multiplied by the international border dummy INTL_{ij} . *Sea Distance* is from [Bertoli et al. \(2016\)](#) plus author value on domestic road distance (from centroid to main port): landlocked distances are imputed. Clustered by pair (exporter-importer, non-symmetric) robust standard errors in parentheses. Significance level *** p<0.01, ** p<0.05, * p<0.1

1.7.3 Robustness check: Aggregation

The works of Redding and Weinstein (2019) and Breinlich et al. (2022) discussed the potential biases arising from different aggregation (or disaggregation levels) according to various sectors and product classifications.

The sample we use allows us to check if the results for the aggregate manufacturing obtained in Table 1.1 show potential bias due to considering manufacturing as a broad sector. Thus in Table 1.8, we run the same analysis for each industry. Most of them have a positive and significant sign and suggest that the η is positive in all the cases. The different coefficient magnitudes imply different levels of sensitivity to agglomeration forces of exports.

Table 1.3: Coefficients, trade shares and density sensitivity by Manufacturing Industries (TiVA, 2015)

Industries	$\beta_2 \ln(L_i) \times INTL_{ij}$	π_{jj}	π_{ij}		
Basic metals	0.0388	0.4853	0.5147	$\pi_{jj} - \pi_{ij} < 0$	$\eta < 0$
Chemicals	0.2461***	0.509	0.491	$\pi_{jj} - \pi_{ij} > 0$	$\eta > 0$
Coke and refined	0.5303 ***	0.6496	0.3504	$\pi_{jj} - \pi_{ij} > 0$	$\eta > 0$
Computer, electr.	0.2259	0.3569	0.6431	$\pi_{jj} - \pi_{ij} < 0$	$\eta < 0$
Electrical equip.	0.2202	0.4091	0.5909	$\pi_{jj} - \pi_{ij} < 0$	$\eta < 0$
Fabricated metal	0.2928***	0.6569	0.3431	$\pi_{jj} - \pi_{ij} > 0$	$\eta > 0$
Food products	0.201***	0.795	0.205	$\pi_{jj} - \pi_{ij} > 0$	$\eta > 0$
Machinery and eq.	0.3383***	0.3898	0.6102	$\pi_{jj} - \pi_{ij} < 0$	$\eta < 0$
Motor vehicles	-0.0535	0.4085	0.5915	$\pi_{jj} - \pi_{ij} < 0$	$\eta > 0$
Other manufactur.	0.4954***	0.665	0.335	$\pi_{jj} - \pi_{ij} > 0$	$\eta > 0$
Other non-metall.	0.4513***	0.7631	0.2369	$\pi_{jj} - \pi_{ij} > 0$	$\eta > 0$
Other transport	0.3804***	0.3655	0.6345	$\pi_{jj} - \pi_{ij} < 0$	$\eta < 0$
Paper products	0.2317***	0.7283	0.2717	$\pi_{jj} - \pi_{ij} > 0$	$\eta > 0$
Rubber and plast.	0.2015 **	0.5457	0.4543	$\pi_{jj} - \pi_{ij} > 0$	$\eta > 0$
Textiles, wearin.	0.367 ***	0.4766	0.5234	$\pi_{jj} - \pi_{ij} < 0$	$\eta < 0$
Wood and product.	0.3608 ***	0.7338	0.2662	$\pi_{jj} - \pi_{ij} > 0$	$\eta > 0$
Total Average	0.283	0.5586	0.4414		

Note: Full results are in Table 1.8. Manufacturing sectors are the one provided by TiVA (version 2018) *GRAVITY* concerns *log. of weighted distance*, *contiguity* (dummy) and *common official language* (dummy) from Conte et al. (2022). *GEO_CONTROL* contains the variables from Nunn and Puga (2012) and they are *ruggedness*, *soil fertility* (percentage of land), *tropical climate*, *desert percentage of land*, *gemstones* (Gem diamond extraction 1958-2000 (1000 carats)), *near coast* (percentage Within 100 km. of ice-free coast), all are multiplied by the international border dummy $INTL_{ij}$. Clustered by pair (exporter-importer, non-symmetric) robust standard errors in parentheses. Significance level *** p<0.01, ** p<0.05, * p<0.1

Our theoretical discussion helps to integrate the work of [Breinlich et al. \(2022\)](#). This article discusses how differences in parameters and trade costs may produce different results from aggregate and disaggregate trade. We add the implication of domestic and international trade shares thanks to our theoretical framework. In Table 1.3, we compare the coefficients of each industry with their average trade shares (international and domestic) of the sample. At first, we notice that even if trade shares are slightly different from the baseline estimates' sample. However, even while holding the condition $\pi_{jj} - \pi_{ij} > 0$, it's notable that the average coefficient across all industries is approximately 0.28% (total average), which isn't significantly different from the main results.

When looking at the coefficients for individual industries, most exhibit positive differentials between domestic and international trade shares. However, a subset does not satisfy this condition—namely, *Basic metals*, *Computer, electr.*, *Electrical equip.*, and *Motor vehicles*—rendering their results statistically insignificant. Conversely, industries such as *Textiles and wearing*, *Other transport*, and *Machinery and equipment* validate the condition $\pi_{jj} - \pi_{ij} < 0$. For these, international sales surpass domestic ones. This aligns with our predictions; the positive coefficients imply $\eta < 0$, suggesting that sensitivity to the density of international sales concerning domestic flows influences a country's domestic market. A plausible explanation is that agglomeration forces, via density sensitivity, impact domestic flows, consequently increasing total production and, in turn, fostering exports. Hence, a negative η , which measures the relative effect of density, fosters economic integration. An alternative interpretation could be that these economic activities are influenced by their positions within global value chains. They might be strategically located in specific regions for particular reasons, which could lead to distinct roles for domestic markets. In such cases, incorporating input-output linkages could provide a clearer understanding of how population density contributes to these dynamics.

To better quantify θ , we would require the θ value for each manufacturing activity.

Unfortunately, only a few works offer such detailed information. [Caliendo and Parro \(2015\)](#) has the measures of the dispersion of productivity estimates, which has a value for each industry, but unfortunately, these do not precisely match our classification.

To conclude, within manufacturing, there are differences in the parameters and the trade share. All these generate different coefficients, but the overall effect is not biased. However, looking just at aggregate trade may hide the heterogeneity and specificity of each economic activity.

1.7.4 Robustness check: Different measures of density

Some robustness checks are done in Table 1.4 using the alternative density measure presented in Section 1.6. The coefficient of density on just populated cells, the effect on manufacturing is similar to the baseline, 0.38 instead of 0.32 from the baseline. While the other two measures do not generate any statistically significant results for the manufacturing sectors. For the other industries, the first attempt does not yield relevant outcomes. Although, the measures of the density of *highly dense* and *urban* areas produce negative and significant results for both the indicators and both the sectors (*Agriculture, Forestry and Fisheries* and *Mining*). Therefore, these robustness checks suggest that the effect captured by density at the aggregate level is related to the specialization and the performance due to countries' spatial distribution of production factors, similar to the concept of *lumpiness* of [Courant and Deardorff \(1992\)](#) and [Courant and Deardorff \(1993\)](#). As Figure 1.3 shows, considering urban density, the heterogeneity between countries' density almost disappears, and country areas do not matter. Hence, we can state that agglomeration forces related to urbanization are not just a matter of the number of inhabitants.

Table 1.4: Robustness check with alternative measures of density, Cross-Section(2015)

	(1)	(2)	(3)
VARIABLES	Manufacturing	Agric. Forest. and Fish.	Mining
Log(Pop. Density (only populated cells)) × INTL	0.3806*** (0.0676)	-0.0388 (0.0979)	-0.0802 (0.1546)
Observations	4,096	4,050	3,670
	(4)	(5)	(6)
VARIABLES	Manufacturing	Agric. Forest. and Fish.	Mining
Log(Pop. Dens. Only high dense areas) × INTL	0.0331 (0.1129)	-0.4850*** (0.1437)	-0.6420*** (0.2079)
Observations	4,096	4,050	3,670
	(7)	(8)	(9)
VARIABLES	Manufacturing	Agric. Forest. and Fish.	Mining
Log(Urban Density) × INTL	-0.0048 (0.1125)	-0.4523*** (0.1500)	-0.5763*** (0.2134)
Observations	4,096	4,050	3,670
Exporter FE	YES	YES	YES
Importer FE	YES	YES	YES
GRAVITY	YES	YES	YES
INTL	YES	YES	YES
GEO Control X INTL	YES	YES	YES
Clusters	Pair	Pair	Pair

Note: The difference in sample size in different sectors is due to singletons and duplicates which in Agriculture et al. and Mining are dropped by the importer and exporter fixed effect. *GRAVITY* concerns *log. of weighted distance*, *contiguity* (dummy) and *common official language* (dummy) from [Conte et al. \(2022\)](#). *GEO_CONTROL* contains the variables from [Nunn and Puga \(2012\)](#) and they are *ruggedness*, *soil fertility* (percentage of land), *tropical climate*, *desert percentage of land*, *gemstones* (Gem diamond extraction 1958-2000 (1000 carats)), *near coast* (percentage Within 100 km. of ice-free coast), all are multiplied by the international border dummy $INTL_{ij}$. Clustered by pair (exporter-importer, non-symmetric) robust standard errors in parentheses. Significance level *** p<0.01, ** p<0.05, * p<0.1

1.7.5 Robustness check: omitted variable(s)

In the previous analysis, we used geographic determinants. Table 1.5, focusing on the manufacturing sector, we include variables related to the development level, in particular, GDP per capita (current US\$), overall employment (not by sectors) and human capital (the last two from Penn's World Table).

We include these variables in the regression as they are because they are easier to

interpret, and we are not interested in quantifying their effect. This table wants to verify if our baseline results are sensitive if adding other country-specific variables.

The main result is in column (4), where including all these variables, which are also all statistically significant and determine a relative positive effect on international trade, the elasticity of population density on gross exports is similar in magnitude and sign to our baseline results.

Table 1.5: Robustness Check: Other Development Features

VARIABLES	(1) Manufacturing	(2) Manufacturing	(3) Manufacturing	(4) Manufacturing
$\text{Log}(\text{Density}) \times \text{INTL}$	0.4507*** (0.0476)	0.3278*** (0.0518)	0.4315*** (0.0438)	0.3317*** (0.0407)
GDP per capita \times INTL	0.0252*** (0.0037)			0.0167*** (0.0039)
Employment \times INTL		-0.0001 (0.0003)		0.0014*** (0.0003)
Human Capital \times INTL			1.0992*** (0.1098)	0.9657*** (0.1519)
Observations	4,096	4,096	4,096	4,096
Exporter FE	YES	YES	YES	YES
Importer FE	YES	YES	YES	YES
GRAVITY	YES	YES	YES	YES
INTL	YES	YES	YES	YES
GEO Control \times INTL	YES	YES	YES	YES
Clusters	Pair	Pair	Pair	Pair

Note: The difference in sample size in different sectors is due to singletons and duplicates which in Agriculture et al. and Mining are dropped by the importer and exporter fixed effect. *GRAVITY* concerns *log. of weighted distance*, *contiguity* (dummy) and *common official language* (dummy) from [Conte et al. \(2022\)](#). *GEO_CONTROL* contains the variables from [Nunn and Puga \(2012\)](#) and they are *ruggedness*, *soil fertility* (percentage of land), *tropical climate*, *desert percentage of land*, *gemstones* (Gem diamond extraction 1958-2000 (1000 carats)), *near coast* (percentage Within 100 km. of ice-free coast), all are multiplied by the international border dummy INTL_{ij} . Clustered by pair (exporter-importer, non-symmetric) robust standard errors in parentheses. Significance level *** p<0.01, ** p<0.05, * p<0.1

1.7.6 Results: Panel

Even if the model does not consider a dynamic setting, from the literature on structural gravity, it is possible to extend the static setting to a panel one without extending the theoretical framework. Then the equations for the next set of estimates are, for table 1.6:

$$\begin{aligned}
X_{ij,t} = & \exp[\beta_2 \ln(L_{i,t}) \times INTL_{ij} + \\
& + \beta GEO_CONTROLS_i \times INTL_{ij} - \theta \ln(\tau_{ij}) + \mu_{i,t} + \chi_j, t] \times \varepsilon_{ij,t}
\end{aligned} \tag{1.35}$$

and for Table 1.10 (in Appendix B):

$$X_{ij,t} = \exp[\beta_2 \ln(L_{i,t}) \times INTL_{ij} + \gamma_{ij} + \mu_{i,t} + \chi_j, t] \times \varepsilon_{ij,t} \tag{1.36}$$

The outcomes in Table 1.6 align with cross-section estimates: the density elasticity is 0.32% in manufacturing, insignificant for agriculture, and negative and significant for mining (value of -0.27%).

To check the robustness, instead of including the gravity covariates, we added pair fixed effects, γ_{ij} , in equation 1.36. These absorb all the bilateral and unilateral not time-varying variables (such as $GEO_CONTROLS_i$) and control for all possible bilateral trade frictions between countries and each country's wedge of domestic and foreign sales. In other words, the second equation aims to check if other models' specifications are affected by latent bilateral variables or other pair-specific issues.

These fixed effects lead to varying results (as seen in Table 1.10 in Appendix B). While manufacturing remains consistent, the coefficient increases by nearly three times, agriculture is positive and significant and mining loses statistical significance. The difference in the results is probably due to the absence of geographical bilateral determinants because these are crucial to identify the impact of population density.

Not including specifically the bilateral and unilateral determinants makes hard to determine which are the interplays of geographical and other kinds of features that determine bilateral trade flows and the nexus with population density. Moreover, density is country-specific and a very slow-moving trend, controlling for bilateral di-

mensions may not be the best approach to compare the magnitude of the coefficients.

Table 1.6: PPML: Gross Exports, 2005-2015

VARIABLES	(1)	(2)	(3)
	Manufacturing	Agric. Forest. and Fish.	Mining
$\text{Log}(\text{Density}) \times \text{INTL}$	0.3246*** (0.0877)	-0.0538 (0.1168)	-0.2737*** (0.1021)
Observations	44,671	42,284	36,740
Exporter X Time FE	YES	YES	YES
Importer X Time FE	YES	YES	YES
Pair FEs	NO	NO	NO
GRAVITY	YES	YES	YES
INTL	YES	YES	YES
GEO Control \times INTL	YES	YES	YES
Clusters	Exporter \times Importer	Exporter \times Importer	Exporter \times Importer

Note: The difference in sample size in different sectors is due to singleton and duplicates which in Agriculture et al. and Mining are dropped by the importer-time and exporter-time fixed effect. *GRAVITY* concerns *log. of weighted distance, contiguity* (dummy) and *common official language* (dummy) from [Conte et al. \(2022\)](#). *GEO_CONTROL* contains the variables from [Nunn and Puga \(2012\)](#) and they are *ruggedness, soil fertility* (percentage of land), *tropical climate, desert percentage of land, gemstones* (Gem diamond extraction 1958-2000 (1000 carats)), *near coast* (percentage Within 100 km. of ice-free coast), all are multiplied by the international border dummy INTL_{ij} and are time-invariant. 2-way clustered robust standard errors in parentheses. Significance level *** p<0.01, ** p<0.05, * p<0.1

1.7.7 Method 2: [Freeman et al. \(2021\)](#)

As discussed in Sub-section 1.5.4, [Freeman et al. \(2021\)](#) proposes a new methodology, theoretically grounded, that allows to estimate unilateral variables with multilateral resistance terms but not necessarily using importer and importer fixed effects in the same regression. Then it is possible to identify the direct coefficient of country-specific variables and avoiding any perfect collinearity issues.

To make this consistent, they propose a two-stage procedure: the first stage regression (see equation 1.29) provides the fixed effects used to compute the indices of the outward and inward multilateral resistance terms. We run a first stage on the panel setting (2005-2015) to check potential differences across years for our cross-section specification described below.

Therefore, using the novel approach of [Freeman et al. \(2021\)](#), which drives the esti-

mation of the following equation:

$$X_{ij} = \exp[\beta_2 \ln(L_i) + \delta_0 INTL_{ij} + \beta GEO_CONTROLS_i + \ln(\hat{\Pi}_i) + \chi_j] \times \varepsilon_{ij}. \quad (1.37)$$

The difference with the previous tables is that $INTL_{ij}$ is a stand-alone control and does not interact with unilateral explanatory variables. Only importer fixed effects, χ_j are included, while for the exporter's side, the Outward Multilateral Resistance Terms is the index estimated as in the section above. The main point of this method is to estimate the direct effect on levels of the variable of interest.

Table 1.7: Alternative Cross Section Estimates 2015: method of [Freeman et al. \(2021\)](#)

VARIABLES	(1)	(2)	(3)
	Manufacturing	Agric. Forest. and Fish.	Mining
$Log(Pop.Density)$	0.5619*** (0.0633)	-0.0996 (0.0628)	-0.5413*** (0.1078)
$Log(\hat{\Pi}_i)$	-1.3402*** (0.1200)	0.0932 (0.1640)	0.2396** (0.1187)
Observations	4,061	3,844	3,340
Exporter FE	NO	NO	NO
Importer FE	YES	YES	YES
GRAVITY	YES	YES	YES
INTL	YES	YES	YES
GEO Control	YES	YES	YES
Clusters	Pair	Pair	Pair

Note: The difference in sample size in different sectors is due to singleton and duplicates which in Agriculture et al and Mining are dropped by the importer and exporter fixed effects. The small reduction of the observations in all samples is due to the first-stage estimates. *GRAVITY* concerns *log. of weighted distance*, *contiguity* (dummy) and *common official language* (dummy) from [Conte et al. \(2022\)](#). *GEO_CONTROL* contains the variables from [Nunn and Puga \(2012\)](#) and they are *ruggedness*, *soil fertility* (percentage of land), *tropical climate*, *desert percentage of land*, *gemstones* (gem diamond extraction 1958-2000, 1000 carats), *near coast* (percentage within 100 km of ice-free coast), all are multiplied by the international border dummy $INTL_{ij}$. $OMR(i)$ is computed as in [Freeman et al. \(2021\)](#). Clustered by pair (exporter-importer, non-symmetric) robust standard errors in parentheses. Significance level *** p<0.01, ** p<0.05, * p<0.1.

1.7.8 Comparison

The main difference between the two methods is that conceptually with method 1 (Heid et al., 2021) we measure the effect of the density of international trade with respect to internal trade and as well as the density sensitivity. Method 2 (Freeman et al., 2021) furnishes a straightforward method to assess density impact. Although the first approach provides more robust results.

The results in Table 1.7 confirm the findings in Table 1.1: the positive and significant coefficient for manufacturing, no statistically relevant effect on agricultural and related goods and negative and significant results for minings. The difference is that the coefficients are greater than the baseline. The interpretation is that both the dimensions (international and domestic) are influenced in the same way by density. In line with the theoretical interpretation, the parameter η determines the sign and then the type of impact density has on different sectors.

A further explanation is needed for the OMR index, in column 1 of Table 1.7, the sign is negative as expected since it represents a cost term. While in column 3 this is not verified, a plausible explanation is that when including domestic flows in the estimation, the effect of internal frictions operating in the domestic market is higher than international. Hence, trade barriers in domestic markets are lower than in foreign ones. The domestic demand absorbs the largest part of the output the selling costs are lower overall.

Table 1.9 provides a further check of the two approaches. In this case, we combine the two methods, to control for exporter multilateral resistance, we include the OMR index instead of fixed effects, and the dependent variable is the log of population density multiplied by the international border dummy. The main difference is that the agricultural sector here is negative, as expected, and significant. This reinforces the idea that better disaggregation is needed to have robust and coherent results for it. Mining is in line with all the other results, also here negative and significant, and the

magnitude does not differ much from the other outcome. Moreover, manufacturing has the same behaviour as the previous estimates, but the coefficient of 0.48 is slightly lower than the direct impact estimates in Table 1.7 and larger than the coefficient of 0.32 of the baseline results. Finally, all these attempts confirm the mechanism described in the theory but the application of the new method of [Freeman et al. \(2021\)](#) could be improved.

1.7.9 Assessing the value of the density sensitivity parameter, η

The theoretical discussion above helps the interpretation of the coefficients, and it can also isolate the effect of η and quantify it. We propose two ways to do it, one following [Heid et al. \(2021\)](#),

$$\eta = \hat{\beta}_2 \left(\frac{1}{\theta(\pi_{jj} - \pi_{ij})} \right), \quad (1.38)$$

and the other using the methods in [Freeman et al. \(2021\)](#),

$$\eta = \hat{\beta}_2 \left(\frac{1}{\theta \pi_{jj} \pi_{ij}} \right). \quad (1.39)$$

The value of η is the share by which density sensitivity contributes to the overall population density elasticities on trade. As already stated, θ is measured by previous contributions, as [Eaton and Kortum \(2002\)](#) and [Costinot et al. \(2012\)](#). We focus on the manufacturing sector since it shows robust results. From Figure 1.4 and Figure 1.5, ²⁷ there are no relevant differences. In general, a higher value of the technology parameter,²⁸ θ reduces the magnitude of density sensitivity. To test the sensitivity of the parameter and enhance the role of θ , when it is equal to one, high

²⁷ Table 1.12 and Table 1.13 sum up the detailed results.

²⁸ this means that $\lim_{\theta \rightarrow \infty} \eta(\theta) = 0$.

heterogeneity over varieties, comparative advantages affect mostly trade more than geographic barriers. In this case, the effect is all on η it may overestimate its contribution. The relevant values are when $6 \leq \theta \leq 8$, then $0.26 \geq \eta \geq 0.20$.

According to these values of θ , the increase of 0.32% (see coefficient from Table 1.1 obtained using [Heid et al. \(2021\)](#) method) in manufacturing gross exports with respect to domestic sales the specific contribution to the density is between the 20% and the 26% of the overall effect (which is also determined by the difference between average trade shares of the sample and the technology parameter). And also, the larger the technology impact lower is the effect of the density. Slightly larger is the pure density effect of on trade measured using [Freeman et al. \(2021\)](#), between 0.29 and 0.39 for θ respectively of value 8 and 6. The only difference is the interpretation since in this case, we have the direct effect instead of the relative one.

Using both methods, the values obtained are acceptable since the effect of labour on output is $1 + \eta$, then scaling of the production factor on overall country output is admissible. Furthermore, these results represent the country-level version of the findings of [Combes et al. \(2012\)](#) on the contribution of large cities to productivity. Our work differs from the unit of analysis, both at the administrative level and by sector classification.

Figure 1.4: η (from [Heid et al. \(2021\)](#) based estimates) values according to θ measures in literature

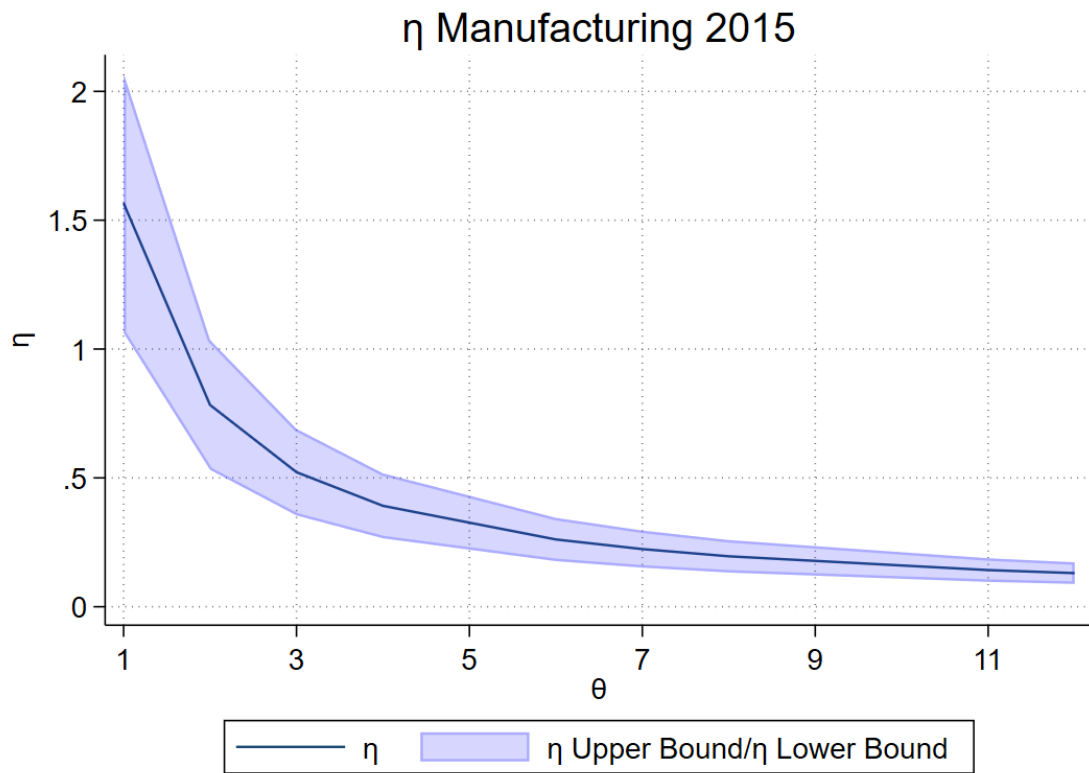
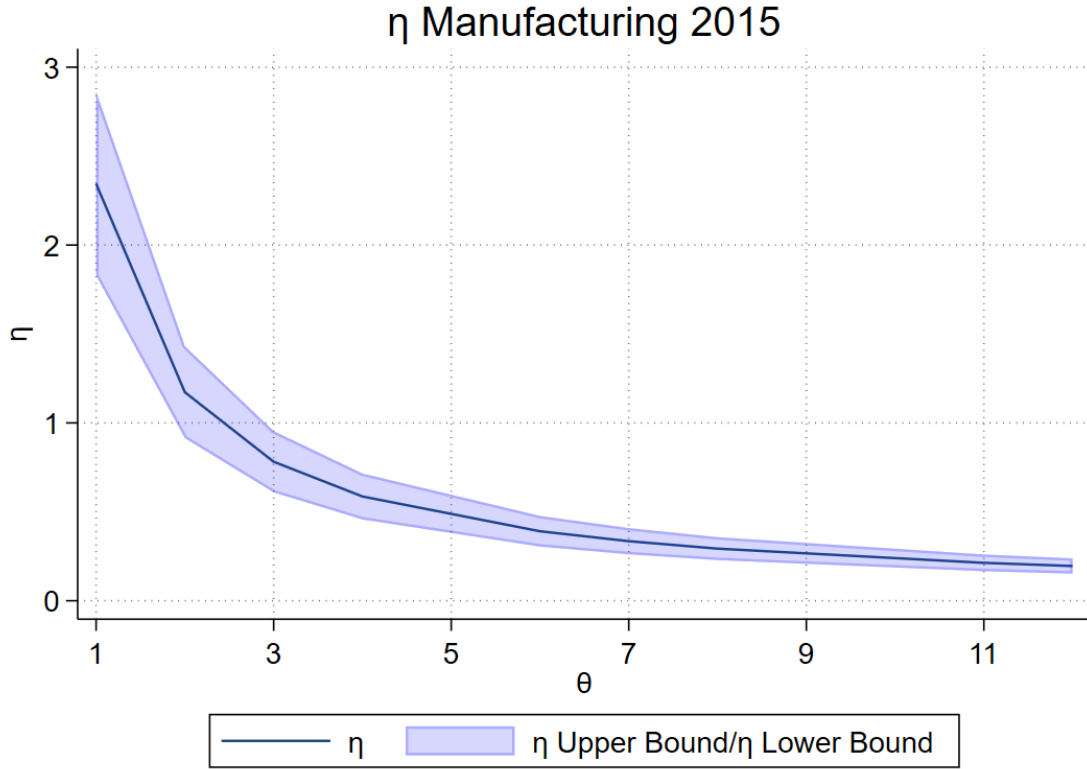


Figure 1.5: η (from [Freeman et al. \(2021\)](#) based estimates) values according to θ measures in literature



1.8 Conclusion

This work assesses the impact of density, a fundamental productivity component, on exports. From the theoretical point of view, it includes labour contribution to productivity and allows quantifying the possible scale effects or not. The approach wants to merge theory from [Allen and Arkolakis \(2014\)](#) and [Allen et al. \(2020\)](#) to measure structural gravity framework with country-specific geography.

Moreover, we provide a theoretical interpretation of the approach proposed by [Heid et al. \(2021\)](#) which allows extending this approach not only to trade frictions but also to other variables that are affecting both domestic and international dimensions. This is important because following this method we can also design counterfactual

and policy experiments. The flexibility of this framework interprets the analysis of [Freeman et al. \(2021\)](#), which is important to quantify the direct effect of unilateral variables and policy in a theoretically grounded structural gravity model. We give evidence that the manufacturing sector (and its industries) benefits from population concentration in the country area. While other sectors, which are less labour-intensive and more natural resources dependent, uninhabited land area is more important. Agriculture, Forestry and Fisheries may need a deeper and more specific analysis: thinking better about land uses, technology heterogeneity within their industries and the differences between markets.

Looking at different measures of density, the traditional way to measure it produces a variable that captures resources endowments and distribution, while considering only the urbanization is slightly different. Urbanization in numbers may not vary or not captures proper heterogeneity across countries. What differs in cities is the size, quality, and how agglomeration and congestion forces work.

Congestion forces in [Allen and Arkolakis \(2014\)](#) and [Allen et al. \(2020\)](#) are explicitly modelled in the demand. These are more relevant in general equilibrium, while our work provides a partial equilibrium analysis. Moreover, multilateral resistance terms control these country-specific forces that we do not model explicitly.

This work gives several opportunities for further research as 1) developing a model to run counterfactual analysis including density sensitivity parameters (as adapting [Dekle et al. \(2008\)](#)) it is a starting point to measure how population dynamics as transitional growth ²⁹ affect growth and trade and includes path dependency and persistence ([Allen and Donaldson, 2020](#)), 3) applies to sub-national analysis, and it may address policy evaluation related to economic geography implications and also the linkage between regional and country-level units as in [Ramondo et al. \(2016\)](#).

²⁹ This can be done modifying [Anderson et al. \(2020\)](#).

1.9 Appendix A

1.9.1 Multilateral Resistance Terms Derivation

To define these terms in theory, we start from goods market clearing 1.7 and including 1.6

$$Y_i = \left(\frac{w_i}{A_i}\right)^{-\theta} \sum_{j=1}^N \frac{\left(\tau_{ij}\right)^{-\theta}}{\sum_{j=1}^N \left(\frac{w_i \tau_{ij}}{A_i}\right)^{-\theta}} w_j L_j \quad (1.40)$$

Normalize 1.40 by world income as in (Freeman et al., 2021), $\sum_{i=1}^N Y_i = Y$, and substitute the denominator with the price parameter of the price distribution 1.10 and $E_j = w_j L_j$:

$$\frac{Y_i}{Y} = \left(\frac{w_i}{A_i}\right)^{-\theta} \sum_{j=1}^N \frac{\left(\tau_{ij}\right)^{-\theta}}{\left(\Phi_j\right)^{-\theta}} \frac{E_j}{Y} \quad (1.41)$$

As stated in equation 1.11, price index P_j is proportional to Φ_j and equation 1.41 takes the form:

$$\frac{Y_i}{Y} = \left(\frac{w_i}{A_i}\right)^{-\theta} \sum_{j=1}^N \frac{\left(\tau_{ij}\right)^{-\theta}}{\gamma^\theta (P_j)^{-\theta}} \frac{E_j}{Y} \quad (1.42)$$

and then it is possible to obtain Multilateral resistance terms, the Outward (OMR):

$$\Pi_i = \sum_{j=1}^N \left(\frac{\tau_{ij}}{P_j}\right)^{-\theta} \frac{E_j}{Y} \quad (1.43)$$

and the Inward Multilateral Resistance Term (IMR):

$$P_i = \sum_{i=1}^N \left(\frac{\tau_{ij}}{\Pi_i} \right)^{-\theta} \frac{Y_i}{Y} \quad (1.44)$$

1.9.2 Obtain wages including country productivity and output function to add in the gravity

Rewrite the trade equation, 1.6:

$$X_{ij} = \frac{[(A_i)^\theta (w_i)^{-\theta}] E_i}{(P_j)^{-\theta}} \quad (1.45)$$

Combine equation 1.42 with the OMR, P_j , terms and solve for $[(A_i)^\theta (w_i)^{-\theta}]$ and obtain:

$$[(A_i)^\theta (w_i)^{-\theta}] = \frac{Y_i/Y}{(\Pi_i)^{-\theta}} \quad (1.46)$$

To obtain the standard structural gravity equation substitute 1.46 in 1.45:

$$X_{ij} = \frac{Y_i E_j}{Y} \left(\frac{\tau_{ij}}{\Pi_i P_j} \right)^{-\theta} \quad (1.47)$$

1.9.3 Derivation of the theoretical interpretation of density coefficient and the international border dummy.

Here is presented a generalization of the problem, deriving all the elements contained in the productivity A_i , adding a specific parameter like η does not change the algebra to obtain the results in section

Starting from the log-transformed trade shares:

$$\ln(\pi_{ij}) = \theta \ln(A_i) - \theta(\ln(w_i - \ln(\tau_{ij})) - \ln\Phi_j) \quad (1.48)$$

assume $\ln(A_i) = t$, then $\ln(\pi_{ij}) = \theta t - \dots - \ln\Phi_j(t)$:

$$\frac{\partial \ln(\pi_{ij})}{\partial t} = \theta - \frac{1}{\Phi_j} \frac{d}{dt} (e^{\theta t}) (w_i \tau_{ij})^{-\theta} \quad (1.49)$$

$$\frac{\partial \ln(\pi_{ij})}{\partial t} = \theta - \frac{1}{\Phi_j} \theta (e^{\theta t}) (w_i \tau_{ij})^{-\theta} \quad (1.50)$$

$e^{\theta t} = e^{\theta \ln(A_i)} = A_i^\theta$, $\Phi_{ij} = A_i^\theta (w_i \tau_{ij})^{-\theta}$ and $\pi_{ij} = \Phi_{ij} / \Phi_j$, meaning that:

$$\frac{\partial \ln(\pi_{ij})}{\partial \ln(A_i)} = \theta - \theta \frac{\Phi_{ij}}{\Phi_j} = \theta(1 - \pi_{ij}) \quad (1.51)$$

The same procedure applies to $\ln(\tau_{ij})$, the result is different because of $-\theta$ and yields:

$$\frac{\partial \ln(\pi_{ij})}{\partial \ln(\tau_{ij})} = \theta(\pi_{ij} - 1) < 0 \quad (1.52)$$

Defining the differential effect of international trade costs with respect to domestic trade costs:

$$\frac{\partial \ln(\pi_{ij})}{\partial \ln(\tau_{ij})} - \frac{\partial \ln(\pi_{jj})}{\partial \ln(\tau_{jj}^k)} = \theta(\pi_{ij} - \pi_{jj}) \quad (1.53)$$

1.10 Appendix B

1.10.1 Cross-Section

Table 1.8: PPML Results 1: Within Manufacturing (Cross-Section)

	(1)	(2)	(3)	(4)
	Food/Bev./Tob.	Textiles	Wood paper prod.	Wood cork prod.
$\text{Log}(\text{Density}) \times \text{INTL}$	0.201*** (0.04)	0.367*** (0.08)	0.361*** (0.10)	0.232*** (0.06)
N	4096	4096	4096	4096
	(5)	(6)	(7)	(8)
	Coke/petr. prod.	Chemic./Pharma	Rubber/Plast.	Other non-metal.
$\text{Log}(\text{Density}) \times \text{INTL}$	0.530*** (0.10)	0.246*** (0.05)	0.202** (0.06)	0.451*** (0.06)
N	4096	4096	4096	4096
	(9)	(10)	(11)	(12)
	Basic metal	Fabric. metal	Computer/electro.	Electric. equip.
$\text{Log}(\text{Density}) \times \text{INTL}$	0.039 (0.06)	0.293*** (0.06)	0.226 (0.16)	0.220 (0.11)
N	4096	4096	4096	4096
	(13)	(14)	(15)	(16)
	Machin.	Motor veich.	Other trans.	Other manuf.
$\text{Log}(\text{Density}) \times \text{INTL}$	0.338*** (0.07)	-0.054 (0.12)	0.380*** (0.11)	0.495*** (0.07)
N	4096	4096	4096	4096
Exporter FE	✓	✓	✓	✓
Importer FE	✓	✓	✓	✓
GRAVITY	✓	✓	✓	✓
INTL	✓	✓	✓	✓
GEO Controls X INTL	✓	✓	✓	✓
Clusters	Pair	Pair	Pair	Pair

Note: Manufacturing sectors are the one provided by TiVA (version 2018) *GRAVITY* concerns *log. of weighted distance*, *contiguity* (dummy) and *common official language* (dummy) from [Conte et al. \(2022\)](#). *GEO_CONTROL* contains the variables from [Nunn and Puga \(2012\)](#) and they are *ruggedness*, *soil fertility* (percentage of land), *tropical climate*, *desert percentage of land*, *gemstones* (Gem diamond extraction 1958-2000 (1000 carats)), *near coast* (percentage Within 100 km. of ice-free coast), all are multiplied by the international border dummy INTL_{ij} . Clustered by pair (exporter-importer, non-symmetric) robust standard errors in parentheses. Significance level *** p<0.01, ** p<0.05, * p<0.1

Table 1.9: Alternative Cross Section Estimates 2015: method of [Freeman et al. \(2021\)](#) - Robustness

VARIABLES	(1)	(2)	(3)
	Manufacturing	Agric. Forest. and Fish.	Mining
$\text{Log}(\text{Density}) \times \text{INTL}$	0.4840*** (0.0576)	-0.1413** (0.0628)	-0.3241*** (0.1130)
$\text{Log}(\hat{\Pi}_i)$	-1.2246*** (0.0992)	0.1460 (0.1549)	0.3282*** (0.1262)
Observations	4,061	3,844	3,340
Exporter FE	NO	NO	NO
Importer FE	YES	YES	YES
GRAVITY	YES	YES	YES
INTL	YES	YES	YES
GEO Control	YES	YES	YES
Clusters	Pair	Pair	Pair

Note: The difference in sample size in different sectors is due to singleton and duplicates which in Agriculture et al and Mining are dropped by the importer and exporter fixed effects. The small reduction of the observations in all samples is due to the first-stage estimates. *GRAVITY* concerns *log. of weighted distance*, *contiguity* (dummy) and *common official language* (dummy) from [Conte et al. \(2022\)](#). *GEO_CONTROL* contains the variables from [Nunn and Puga \(2012\)](#) and they are *ruggedness*, *soil fertility* (percentage of land), *tropical climate*, *desert percentage of land*, *gemstones* (gem diamond extraction 1958-2000, 1000 carats), *near coast* (percentage within 100 km of ice-free coast), all are multiplied by the international border dummy INTL_{ij} . $\text{OMR}(i)$ is computed as in [Freeman et al. \(2021\)](#). Clustered by pair (exporter-importer, non-symmetric) robust standard errors in parentheses. Significance level *** p<0.01, ** p<0.05, * p<0.1.

1.10.2 Panel

Table 1.10: PPML Gross Exports (Pair FE), 2005-2015

VARIABLES	(1)	(2)	(3)
	Manufacturing	Agric. Forest. and Fish.	Mining
$\text{Log}(\text{Density}) \times \text{INTL}$	0.9616* (0.5557)	0.9704* (0.5545)	-1.2013 (1.3494)
Observations	44,671	42,284	36,740
Exporter X Time FE	YES	YES	YES
Importer X Time FE	YES	YES	YES
Pair FEs	YES	YES	YES
GRAVITY	NO	NO	NO
INTL	NO	NO	NO
GEO Control X INTL	YES	YES	YES
Clusters	Exporter \times Importer	Exporter \times Importer	Exporter \times Importer

Note: The difference in sample size in different sectors is due to singleton and duplicates which in Agriculture et al. are dropped by the importer-time and exporter-time fixed effect. *GRAVITY* concerns *log. of weighted distance*, *contiguity* (dummy) and *common official language* (dummy) from [Conte et al. \(2022\)](#). *GEO_CONTROL* contains the variables from [Nunn and Puga \(2012\)](#) and they are *ruggedness*, *soil fertility* (percentage of land), *tropical climate*, *desert percentage of land*, *gemstones* (Gem diamond extraction 1958-2000 (1000 carats)), *near coast* (percentage Within 100 km. of ice-free coast), all are multiplied by the international border dummy INTL_{ij} and are time-invariant. 2-way clustered robust standard errors in parentheses. Significance level *** p<0.01, ** p<0.05, * p<0.1

Table 1.11: Trade Share by broad sectors in TiVA

2015						
Manufacturing		Agriculture, Forestry and Fisheries			Mining	
group by i	grouped by j	group by i	grouped by j	group by i	grouped by j	
π_{jj}	0.6483	0.6021	0.8412	0.8469	0.7131	0.5548
π_{ij}	0.3516	0.3979	0.1588	0.1531	0.2869	0.4452
Total	0.3563	0.4011	0.1695	0.1640	0.2936	0.4469

Table 1.12: η values from *Method 1* ([Heid et al., 2021](#))

θ	η	η Upper Bound	η Lower Bound
1	1.57	2.07	1.06
2	0.78	1.04	0.53
3	0.52	0.69	0.35
4	0.39	0.52	0.27
6	0.26	0.35	0.18
7	0.22	0.30	0.15
8	0.20	0.26	0.13
11	0.14	0.19	0.10
12	0.13	0.17	0.09

Table 1.13: η values from *Method 2* (Freeman et al., 2021)

θ	η	η Upper Bound	η Lower Bound
1	2.35	2.86	1.83
2	1.17	1.43	0.91
3	0.78	0.95	0.61
4	0.59	0.72	0.46
6	0.39	0.48	0.3
7	0.34	0.41	0.26
8	0.29	0.36	0.23
11	0.21	0.26	0.17
12	0.2	0.24	0.15

Chapter 2

Domestic Institutions and International Trade: empirical investigation and policy implications

2.1 Introduction

The 16th Sustainable Development Goal - *PEACE, JUSTICE AND STRONG INSTITUTIONS* - states, "*We cannot hope for sustainable development without peace, stability, human rights, and effective governance, based on the **rule of law***".¹ This work aims to answer the question: *How do domestic institutions affect international trade?* Firstly, by modelling institutions as determinants of fundamental productivity and then empirically testing *i)* whether the functioning (institutional quality) is more or less relevant than the form (legal system) ([Islam and Reshef, 2012](#)), *ii)* the interplay of domestic institutions and bilateral cultural linkages (proximity and

¹ UNDP web page.

distances), *iii*) the differences between industries and the related contract intensity (Levchenko, 2007; Nunn, 2007), and *iv*) conducting a counterfactual exercise to assess the potential welfare gains (or losses) of achieving average institutional quality worldwide.

The theoretical contribution extends supply-side gravity models such as Eaton and Kortum (2002) and Costinot et al. (2012), incorporating domestic institutions as determinants of productivity fundamentals. Thus, institutions are considered sources of comparative advantages akin to Levchenko (2007), but in a multi-country setting.² The framework facilitates interpreting results of structural gravity models with country-specific variables as in Heid et al. (2021) while extending this application to variables that encompass more than unilateral trade costs. The analysis also allows us to test findings related to relationship-specific characteristics by sector (as discussed in Nunn (2007) and Martin et al. (2020)) on a bilateral level. Moreover, the counterfactual exercise yields policy implications aligned with the 2030 Agenda.

The analysis of institutions as country-specific variables is easier to interpret and yields robust results. The framework, both empirically and theoretically, is adaptable and can be readily expanded to encompass multiple sectors. The role of culture is significant but warrants further investigation to distinguish the implications of various cultural dimensions and their correlation with geographical features. Following the methodology of Heid et al. (2021), the results contribute to policy discussions through a counterfactual exercise, akin to Beverelli et al. (2023), to explore welfare implications of enhanced institutional quality. This article corroborates and enhances the findings of previous work by expanding the number of countries in the analysis and employing a distinct counterfactual scenario. We found that an increase in the relative effect of institutions on international trade with respect to domestic sales leads to an increase of the real output between 0.06% and 13.58% and in some developing countries as Sudan and Bangladesh, the institutional improvement increases

² The model presented here is simpler than the one in Levchenko (2007), yet it theoretically and empirically considers multiple importers and exporters.

export values respectively of 25% and 28%.

To distinguish the distinct impacts of domestic institutions across industries, we extend the model to incorporate relation-specific measures for each sector, aiding in the interpretation of the empirical specification. The principal outcomes are derived using relationship stickiness from [Martin et al. \(2020\)](#), revealing that the rule of law positively influences trade concerning domestic sales. In this specification, we also examine the interplay of bilateral cultural ties, although these ties do not exhibit statistical significance. While utilizing contract intensity from [Nunn \(2007\)](#), the marginal contribution of the rule of law in more contract-intense sectors is not significant. In these estimates, the role of culture carries more weight but demonstrates less robustness.

The paper commences with a discussion of the literature on institutions and their connection with trade in Section 2.2. Section 2.3 presents the theoretical framework for aggregate trade, while Section 2.4 outlines the empirical strategy and theoretical interpretation of results. Section 2.5 delves into the data sources used to generate the outcomes discussed in Section 2.6 and to conduct the counterfactual exercise detailed in Section 2.7. In Section 2.8, we propose an extension of the model that incorporates sectors and corresponding results, incorporating relation-specific measures (contract intensity and relationship stickiness). Section 2.7.1 concludes the paper

2.2 Literature

Our analysis contributes to understanding the role of institutions in the economy. Economists have recognized that the proper functioning of institutions can lead to increased investments and efficiency, while inadequate institutions can hinder economic progress. In particular, we examine the nexus between trade and institutions, updating empirical findings on the impact on bilateral trade and sector specialization, and considering them as a source of comparative advantages.

Institutions and how they affect the economy have been widely studied in the literature. Here we rely on the concept of institutions in economics, as human-created constraints shaping interactions, is crucial for growth³, trade⁴, and reducing uncertainty in exchanges (North, 1991; Williamson, 2000).

This work focuses on the nexus between trade and institutions and how these affect the international exchange of goods. To include the theoretical underpinnings of trade and institutions, we refer to incomplete markets (Antras, 2003; Nunn and Trefler, 2013), relation-specific features (Levchenko, 2007; Martin et al., 2020; Nunn, 2007) and institutions as a source of comparative advantages (Nunn and Trefler, 2014)⁵

Our findings update gravity estimation and theory of previous works, as the seminal of Anderson and Marcouiller (2002) and other previous articles,⁶ without falling into the *gold medal mistake* (Baldwin and Taglioni, 2006), solving perfect collinearity between fixed effects and unilateral variables (Heid et al., 2021) and adding a theoretical interpretation of the empirical strategy. Furthermore, the analysis of bilateral flows integrates the results of estimation based on total country trade.⁷

One of the first studies that include institutions in a gravity framework is Anderson and Marcouiller (2002). The article demonstrates that failing to account for institutional quality indices can lead to biased estimates in gravity models, which may obscure the negative relationship between per capita income and the share of total expenditure devoted to traded goods. The authors suggest that corruption and imperfect contract enforcement seriously affect international trade. Bad institutions in the importer's country enable economic predators to extort rents at its border. A complementary contribution is Berkowitz et al. (2006). The authors examine how the quality of national institutions that enforce the rule of law influences international

³ (Acemoglu and Johnson, 2005; Acemoglu et al., 2001,0)

⁴ (Greif, 1989,9; Milgrom et al., 1990)

⁵ See also Levchenko (2007) Costinot (2009) Chor (2010) Cuñat and Melitz (2012) Belloc and Bowles (2017).

⁶ de Groot et al. (2004), Berkowitz et al. (2006), Ranjan and Tobias (2007), Méon and Sekkat (2008), Islam and Reshef (2012), Álvarez et al. (2018).

⁷ Levchenko (2007), Nunn (2007), Méon and Sekkat (2008).

trade. They show that good institutions in the exporter's country can enhance international trade, particularly for complex products whose characteristics are difficult to be fully specified in a contract. They find that institutions have a strong influence on trade via production costs (comparative advantage) than through international transaction costs.

Similar to the previous reference, [de Groot et al. \(2004\)](#) use a gravity model approach to explore the effect of institutions on trade flows, focusing on the relevance of the quality of governance and the extent of familiarity with the resulting framework of rules and norms in explaining bilateral trade patterns. The authors find that a similar institutional framework promotes bilateral trade by 13% on average and that an increase in overall institutional quality of one standard deviation from the mean leads to an estimated increase of 30-44% in bilateral trade, depending on whether the country is an importer or exporter.

The work of [Ranjan and Tobias \(2007\)](#) is relevant because they offered an original solution to deal with origin and destination multilateral resistances. The authors extend the gravity model by incorporating country-specific effects and Bayesian non-parametric methods to explore the impact of contract enforcement on international trade. They find that contract enforcement has a statistically significant effect on international bilateral trade.

Exploring the heterogenous impact on different types of goods, [Méon and Sekkat \(2008\)](#) observe that the quality of institutions affects exports of manufactured goods positively, while total exports and non-manufactured exports show no significant correlation. Their analysis, which employs panel data analysis at the country level, highlights the importance of institutions in shaping the relationship trade patterns.

The recent article of [Álvarez et al. \(2018\)](#) finds that the institutional distance between exporting and importing countries, together with institutional quality, is a critical factor in bilateral trade. Their study, which analyzes data across economic sectors,

highlights the higher relevance of institutions for bilateral trade in agriculture and raw materials than in manufacturing and services. However, their empirical results based on country-level data, do not account for domestic flows, and they use exporter and importer fixed effects to control for multilateral resistance, with some reliance on other importers' controls. Other studies, such as [Islam and Reshef \(2012\)](#), use bilateral variables for institutional quality. This paper discusses also a relevant policy scope on the differences between function (i.e. quality) and form (legal systems). They found that institutional quality per se is most important than the legal system it bases on. We test this hypothesis and discuss the advantages and disadvantages of creating bilateral variables for institutional quality and form.

The analysis presents another point of view compared to [Beverelli et al. \(2023\)](#), modelling institutions as a productivity component, this extends the literature on country-specific variables in the structural gravity model [Heid et al. \(2021\)](#), this help to properly distinguish between factors that determine trade costs and other that represents trade easiness.

The model provides a theoretical interpretation of the empirical strategy and thanks to the flexibility of the theory we propose an extension that includes sectors and enriches the results from [Numm \(2007\)](#) using bilateral trade flows and using also stickiness from [Martin et al. \(2020\)](#) as a different relationship-specific measure to identify the heterogeneous effect of institutional quality in different economic activities.

Moreover, we provide counterfactual experiments on the institutional change in developing countries that is coherent with the findings of [Beverelli et al. \(2023\)](#) and integrate them. Our approach differs from the scenario we defined, and we use a sample including more developing countries from [Fontagné et al. \(2022\)](#).

2.3 Theory

The theoretical section provides a model for aggregate trade and an extension including sectors, to add contract intensity and have a framework to interpret different empirical investigations.

The set up based on [Eaton and Kortum \(2002\)](#) and [Costinot et al. \(2012\)](#) an economy of N exporters i and importers j with CES preferences across varieties. The market structure is perfect competition and one immobile production factor, labour L_i . Iceberg trade costs, τ_{ij} .

2.3.1 Aggregate Trade

Since institutions and their quality are considered a source of comparative advantages. Thus, the model includes these in the productivity function. [Costinot et al. \(2012\)](#) recognize institutions as part of *fundamental productivity*. Here are exogenous because this framework aims to identify their impact on international trade, considering domestic sales and a multicountry trade network.

Productivity is randomly drawn from a Fréchet $F_i = \exp^{-(\frac{A}{\bar{A}_i})^{-\theta}}$ where $A_i = \bar{A}_i I_i^\zeta$. Where I_i is the institutional quality (quality of contract enforcement) and $\zeta > 0$ is the parameter capturing productivity sensitivity to institutional quality and \bar{A}_i is exogenous productivity. I_i is not a production factor here, it is a factor of productivity explicitly formalized to capture its effect on international and domestic sales.

The expenditure function resulting from the assumption of this framework is the following:

$$X_{ij} = \pi_{ij} E_j = \frac{(\bar{A}_i I_i^\zeta)^\theta (w_i t_{ij})^{-\theta}}{\Phi_j} E_j \quad (2.1)$$

where π_{ij} is the trade share, and these includes $(\bar{A}_i I_i^\zeta)^\theta$ is the productivity containing

exogenous element, \bar{A}_i and the institutional quality, where I_i is the level of quality and ζ , the institutional sensitivity which is also affected by the technological heterogeneity parameter, θ . The costs are represented i) domestically by the unit labour cost, w_i and 2) the cost of shipping goods abroad τ_{ij} (by assumption internal trade is costless, then $\tau_{ii} = 1$). At the denominator, $\Phi_j = \sum_j (\bar{A}_i I_i^\zeta)^\theta (w_i t_{ij})^{-\theta}$ is the price distribution parameter (as in [Eaton and Kortum \(2002\)](#)) capturing the trade cost determinants in all other countries. Expenditure, $E_j = \alpha_j Y_j$, where $0 < \alpha_j < 1$, is the consumption share in country j .

2.3.2 The Structural Gravity System

Once expenditure functions are defined, consider market clearing condition: for the labour market, $Y_i = w_i L_i$ and for goods, $Y_i = \sum_j X_{ij}$. Normalizing for world income, Y . Obtain the structural gravity system with inward, P_j and outward, Π_i , multilateral resistance terms. Thus exports are :

$$X_{ij} = \frac{Y'_i E_j}{Y} \left(\frac{t_{ij}}{P_j \Pi_{ij}} \right)^{-\theta} \quad (2.2)$$

Inward and Outward Multilateral Resistance terms:

$$P_j = \sum_i \left(\frac{t_{ij}}{\Pi_i} \right)^{-\theta} \frac{Y'_i}{Y} ; \quad \Pi_i = \sum_j \left(\frac{t_{ij}}{P_j} \right)^{-\theta} \frac{E_j}{Y} \quad (2.3)$$

The factory gate price:

$$w_i = \left(\frac{Y_i/Y}{\Pi_i^\theta A_i^\theta} \right)^{-\frac{1}{\theta}} \quad (2.4)$$

where in equation 2.14 $Y'_i = \bar{A}_i L_i$, since the institutional quality is moved in $t_{ij}^{-\theta} = \frac{\tau_{ij}}{I_i^{\zeta/\theta}}$. This change makes the theory more consistent with the applied part. In particular for the policy experiment presented in Section 2.7. The counterfactual change passes

from the vector of trade costs. In this case, the assumption regards the interaction between bilateral trade costs and country-specific trade easiness from productivity fundamentals which have the opposite effect (sign) of trade frictions.

2.4 Empirical Strategy: From Theory to Measurement

Baseline estimates are made with Pseudo-Poisson Maximum Likelihood (PPML) (Santos Silva and Tenreyro, 2006) and include importer and exporter fixed effects both to avoid biases in the estimates (Baldwin and Taglioni, 2006) but also to match theory and empirics and to control for inward and outward multilateral resistances as in Anderson and van Wincoop (2003). Thus, any country-specific variables included in the model suffer from collinearity with the origin and destination fixed effects, making direct identification impossible. Then the econometric model must be done following the approach of Heid et al. (2021), in this, the main equation is the following:

$$X_{ij} = \exp[\beta I_i \times INTL_{ij} + \gamma GRAVITY_{ij} + \delta_0 INTL_{ij} + \mu_i + \chi_j] \times \varepsilon_{ij} \quad (2.5)$$

where I_i refers to the institutions' variables, $GRAVITY_{ij}$ are the gravity covariates which refer to τ_{ij} in the theory, $INTL_{ij}$ is the international border dummy (equal to 1 when $i \neq j$ and 0 otherwise). μ_i and χ_j are respectively the exporters and the importer fixed effects. The following section shows the theoretical implication of this approach, assessing the role of parameters and domestic and international trade shares.

2.4.1 Theoretical interpretation

Considering trade shares, π_{ij} , from equation 2.1, doing a log-transformation to obtain the partial derivative of productivity, A_i both for the domestic and international

shares. The difference between these two gives the institution coefficient of the main equation:

$$\beta = \frac{\partial \ln(\pi_{ij})}{\partial \ln(I_i)} - \frac{\partial \ln(\pi_{jj})}{\partial \ln(I_i)} = \zeta \theta (\pi_{jj} - \pi_{ij}) \quad (2.6)$$

where $\zeta > 0$, assumes that institutions affect positively trade, $\theta > 0$ as define in the previous literature (Eaton and Kortum, 2002) (Costinot et al., 2012). Usually $\pi_{jj} - \pi_{ij} > 0$, from observed data the average domestic trade shares are greater than the international. Therefore, these two dimensions affect the magnitude and sign of the coefficient. The lower is difference between domestic and international shares larger the effect of the coefficient according to the institutional and the technology (and comparative advantages) parameters.

2.5 Data

Here, we present the various data sources employed for the analysis in which trade is the dependent variable and always contains (the difference between total production and total exports) domestic and international sales. The bilateral and unilateral covariates representing the explanatory variables come from datasets widely used in the gravity literature and from brand-new contributions.

The trade data used to test the different hypotheses originate from several sources. Baseline estimates are derived from the replication data of Fontagné et al. (2022), assessing the effect of institutions on aggregate trade and also for running the counterfactual exercise. The main sample pertains to a square trade matrix of 98×98 countries for the year 2000 (used for both empirical and counterfactual analysis), as well as a 65×65 country matrix due to the coverage of cultural distances data from De Benedictis et al. (2020).

For the sake of robustness and to assess the role of contract intensity data are sourced

from WIOD, covering 43×43 countries for 10 manufacturing industries⁸ in the year 2000. Additionally, data from ITPD version 2 [Borchert et al. \(2022\)](#) are utilized, which enables the investigation of 25 manufacturing industries. Here, the sample is unbalanced when using [Nunn \(2007\)](#), and includes 118 industries from the original classification when using relationship stickiness from [Martin et al. \(2020\)](#). We employ different data sources due to the necessity for domestic trade flows, while also addressing the country coverage limitations of specific datasets. The aggregate data from [Fontagné et al. \(2022\)](#) provide comprehensive country coverage, including domestic flows for certain African countries, and present a square trade matrix ($N \times N$) for each year, a crucial element for counterfactual analysis. Concerning trade by industry, WIOD is useful for baseline estimates as it provides a square trade matrix with domestic trade flows for major economies, despite limited coverage. Subsequently, we integrate results using ITPD, which includes data for African countries and other smaller and developing nations. This combination enhances the study of the impact of domestic institutions related to sector-specific measures on trade. Institutional quality is sourced from the *World Governance Indicator* (WGI), specifically the *Rule of Law* index. This index captures society’s perception of the rule of law, encompassing contract enforcement, property rights, and justice [Kaufmann et al. \(2010\)](#). Thus, it is ideal for this framework and aligns with the concept highlighted by the 16th SDG (see Introduction). While other WGI indexes are potential candidates, their definitions necessitate extending the conceptual framework, involving political systems, democracy levels, and corruption, requiring a more complex formalization of the theoretical model. The *Rule of Law* indicator ranges from -1.60 (indicating weak institutional quality) to 1.98 (representing a strong institutional environment). The average level, serving as a minimum average standard for contract enforcement, is 0.21. Despite its relatively low value, the standard deviation (1.01, as shown in Table 2.7) indicates limited variability. To test the hypothesis from [Islam and Reshef \(2012\)](#) and distinguish between form (legal system) and function (in this case, the

⁸ These ten industries were grouped to match sectors in the contract intensity measures from [Nunn \(2007\)](#).

Rule of Law), the variable for institutional form is the legal origin from CEPII [Conte et al. \(2022\)](#), particularly focusing on post-transition periods (after the fall of the USSR). Examining Table 2.7, it's observed that approximately 53% of exporters in the sample (primarily from [Fontagné et al. \(2022\)](#)) have a French legal origin. The remaining exporters are divided among British, German, and Scandinavian origins (with the latter accounting for a small share of 0.05, representing trade networks between Scandinavian countries).

We use Bilateral cultural ties, proximity and distance measures regarding various cultural dimensions are employed. Proximity measures: 1) one is language proximity based on the similarity between two languages, sourced from [Gurevich et al. \(2021\)](#), 2) the other is the common religion index by [Disdier and Mayer \(2007\)](#) as provided in [Conte et al. \(2022\)](#). Cultural distances come from the recent work of [De Benedictis et al. \(2020\)](#), which utilizes a Bayesian approach and a copula graphical model for discrete data to infer a country's cultural networks, and subsequently determine international distances. The variables pertinent to this empirical analysis are the *mean* of all dimensions and the distance in *trust* between each pair of countries, leading to variations in sample size based on countries' coverage. Traditional gravity covariates from CEPII are employed, including weighted distances (in log), contiguity, and official common language (both represented as dummy variables) [Conte et al. \(2022\)](#). Finally, two measures are used to proxy sector relation specificity. One involves the contract intensity measure from the replication files of [Nunn \(2007\)](#), specifically the relation-specific variable referring to the fraction of inputs not exchanged on a market and lacking reference pricing. The authors assessed the input composition of each commodity from the 1997 US input-output table, making the investigation period 2000. This year closely aligns with [Nunn \(2007\)](#)'s contract intensity, ensuring more consistent comparisons across different samples. The other measure is relationship stickiness from [Martin et al. \(2020\)](#), where the authors utilized French firm-level data to compute an index of relationship stickiness for over 5,000 HS2002 6-digit products based on the duration of firm-to-firm trade. This measure is aggregated with industry

classification data from ITPD version 2 (Borchert et al., 2022).

2.6 Results: Empirical

The empirical section aims to test the three main hypotheses: *i*) if the functioning (institutional quality) is more or less relevant than the form (legal system) (Islam and Reshef, 2012), *ii*) the interplay of domestic institutions and bilateral cultural linkages (proximity and distances, *iii*) the differences related to various industries and contract intensity (Levchenko, 2007; Nunn, 2007).

i) If the functioning (institutional quality) is more or less relevant than the form (legal system) (Islam and Reshef, 2012).

Firstly, looking at the functioning:

$$X_{ij} = \exp[\beta RoL_i \times INTL_{ij} + \gamma GRAVITY_{ij} + \delta_0 INTL_{ij} + \mu_i + \chi_j] \times \varepsilon_{ij} \quad (2.7)$$

then at the form with:

$$X_{ij} = \exp[\beta RoL_i \times INTL_{ij} + \beta_1 Legal_System_i \times INTL_{ij} + \gamma GRAVITY_{ij} + \delta_0 INTL_{ij} + \mu_i + \chi_j] \times \varepsilon_{ij} \quad (2.8)$$

In addition, we consider the interplay between the two by adding $RoL_i \times Legal_System_i \times INTL_{ij}$, to catch the heterogeneity of functioning according to the types of forms. Table 2.1 collects the results. The French one is the reference population, German and British legal systems have a positive effect and it is larger than institutional quality. Scandinavian is not significant but it captures a network of few exporters. The interaction between the legal system and the rule of law reveals similar findings; UK and German forms have a greater impact than the French ones. However, it is also true that more countries (in particular in this sample) have a French system which

implies more variability in the related institutional functioning. Therefore, the form per se would not be enough to improve institutional infrastructure in a country.

Table 2.1: Aggregate Trade: Baseline

VARIABLES	(1)	(2)	(3)	(4)
	PPML - 2000	PPML - 2000	PPML - 2000	PPML - 2000
RoL × INTL (Exp.)	0.5726*** (0.0922)			
RoL × INTL (Imp.)		0.5726*** (0.0922)		
Legal Origin UK × INTL			1.1038*** (0.1756)	
Legal Origin German × INTL			0.6582*** (0.1395)	
Legal Origin Scandinavian × INTL			0.1881 (0.1706)	
RoL×Legal Or. French × INTL				0.3489** (0.1437)
RoL×Legal Or. UK × INTL				0.8843*** (0.0955)
RoL×Legal Or. German × INTL				0.5933*** (0.1075)
RoL×Legal Or. Scandinav. × INTL				0.1387 (0.0999)
Observations	9,604	9,604	9,604	9,604
Exporter FE	YES	YES	YES	YES
Importer FE	YES	YES	YES	YES
INTL	YES	YES	YES	YES
GRAVITY	YES	YES	YES	YES
Clusters	Pair	Pair	Pair	Pair

Note: The sample is the one from [Fontagné et al. \(2022\)](#), it includes 98×98 countries for the 2000. *GRAVITY* contains log weighted distance, contiguity and common official language from [Conte et al. \(2022\)](#). Legal systems refer to the post-transition classification in [Conte et al. \(2022\)](#). Clustered robust standard error in parenthesis. Significance level *** p<0.01, ** p<0.05, * p<0.1

Further investigation about from and functions are made using bilateral variables. For institutional quality, we create two dyadic measures, RoL_{ij} , one measures the differences between i and j and another the sum of the two as in [Islam and Reshef \(2012\)](#). $Legal_System_{ij}$ concerns is a dummy equal to one if two countries have common legal systems and it is split also by type of legal system. Table 2.2 estimates

different combinations of the following equation:

$$X_{ij} = \exp[\beta RoL_{ij} \times INTL_{ij} + \beta_3 Legal_System_{ij} \times INTL_{ij} + \gamma GRAVITY_{ij} + \delta_0 INTL_{ij} + \mu_i + \chi_j] \times \varepsilon_{ij} \quad (2.9)$$

A first remark on this set of results is that the bilateral measures of the World Governance Indicator, RoL_{ij} , impose zero value for the domestic component, otherwise, also these variables suffer collinearity with the fixed effects. Using these bilateral covariates, the effect of institutional quality turns out to be bigger than the legal form. Although, using the form's bilateral variables reveal pair-specific relevance such as the coefficient for the common legal Scandinavian system which captures a relatively small cross-border trade network, and then the effect of these covariates would have other latent factors biasing the coefficients. Even if the measures for institutional functioning are significant, these look less robust, just the sum shows a stronger significance. However, their interpretation is less intuitive compared to the country-specific variables coefficients. And also, we had to give zero value to the domestic part. This means that creating bilateral variables through a linear transformation would have the same issues as the unilateral covariates.

Table 2.2: Aggregate Trade: Function vs Form Bilateral Variables

VARIABLES	(1) PPML - 2000	(2) PPML - 2000	(3) PPML - 2000	(4) PPML - 2000	(5) PPML - 2000
<i>RoL_{ij}</i> :					
Abs Val. Diff. between Rol	-0.1253*				
	(0.0756)				
(RoL (exp) + RoL (imp))×INTL		0.2863***		0.2906***	0.2790***
		(0.0461)		(0.0492)	(0.0481)
<i>Legal System_{ij}</i> :					
1 = Common legal origins after transition			-0.0452	0.0540	
			(0.0715)	(0.0859)	
Same Legal Origin French					0.2471***
					(0.0700)
Same Legal Origin UK					-0.2084*
					(0.1084)
Same Legal Origin German					-0.0845
					(0.0701)
Same Legal Origin Scandinav.					0.4859***
					(0.0875)
Observations	9,604	9,604	9,604	9,604	9,604
Exporter FE	YES	YES	YES	YES	YES
Importer FE	YES	YES	YES	YES	YES
INTL	YES	YES	YES	YES	YES
GRAVITY	YES	YES	YES	YES	YES
Clusters	Pair	Pair	Pair	Pair	Pair

Note: The sample is the one from [Fontagné et al. \(2022\)](#), it includes 98×98 countries for the 2000. *GRAVITY* contains log weighted distance, contiguity and common official language from [Conte et al. \(2022\)](#). Legal systems (origin) refer to the post-transition classification in [Conte et al. \(2022\)](#). Clustered robust standard error in parenthesis. Significance level *** p<0.01, ** p<0.05, * p<0.1

ii) *The interplay of domestic institutions and bilateral cultural linkages (proximity and distances).*

Once find out that the domestic variables and institutional quality are more robust and easy to interpret. We want to explore which bilateral features are relevant and the implication on the role of domestic institutions. Hence, we choose several bilateral variables capturing cultural proximity and distances to estimate the following general equation:

$$X_{ij} = \exp[\beta RoL_i \times INTL_{ij} + \beta_2 Culture_{ij} + \gamma GRAVITY_{ij} + \delta_0 INTL_{ij} + \mu_i + \chi_j] \times \varepsilon_{ij} \quad (2.10)$$

Table 2.3 and Table 2.4 show the results. we provide two different tables because the measures of distance from [De Benedictis et al. \(2020\)](#) contain fewer pairs of

countries compared to our baseline estimates: then the sample size varies. However, this variation is useful to test the robustness of these outcomes. Cultural proximity proxies lower the coefficient of the rule of law of a few decimal points as well as the smaller sample size in Table 2.4. The strongest variable is the common religion index which is significant in all the attempts. Cultural distances are less robust as explanatory variables even if distances in trust and exporters' rule of law provide a statistically significant model.

Table 2.3: Aggregate Trade Role of Culture (1)

VARIABLES	(1) PPML - 2000	(2) PPML - 2000	(3) PPML - 2000
RoL× INTL (Exp.)	0.5642*** (0.0946)	0.5274*** (0.0846)	0.5311*** (0.0873)
Similarity between two languages: Continuous Index	0.0953 (0.1577)		-0.0493 (0.1570)
Common religion index		0.7527*** (0.1726)	0.7641*** (0.1826)
Observations	9,604	9,604	9,604
Exporter FE	YES	YES	YES
Importer FE	YES	YES	YES
INTL	YES	YES	YES
GRAVITY	YES	YES	YES
Clusters	Pair	Pair	Pair

Note: The sample is the one from [Fontagné et al. \(2022\)](#), it includes 98×98 countries for the 2000. *GRAVITY* contains log weighted distance, contiguity and common official language from [Conte et al. \(2022\)](#). Clustered robust standard error in parenthesis. Significance level *** p<0.01, ** p<0.05, * p<0.1

Table 2.4: Aggregate Trade Role of Culture (2)

VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)
	PPML - 2000	PPML - 2000	PPML - 2000	PPML - 2000	PPML - 2000	PPML - 2000
RoL× INTL (Exp.)	0.3618*** (0.1002)	0.3118*** (0.0864)	0.3813*** (0.0993)	0.3127*** (0.0904)	0.3763*** (0.0995)	0.3119*** (0.0876)
Similarity between two languages: Continuous Index	0.0442 (0.1749)				-0.1340 (0.1777)	-0.1593 (0.1751)
Common religion index		0.9892*** (0.2123)			1.0927*** (0.2410)	0.9994*** (0.2111)
Cultural Distances: Average			0.0085 (0.0163)		0.0322* (0.0175)	
Cultural Distance: Trust				-0.2270** (0.0986)		-0.0584 (0.0880)
Observations	4,225	4,225	4,225	4,225	4,225	4,225
Exporter FE	YES	YES	YES	YES	YES	YES
Importer FE	YES	YES	YES	YES	YES	YES
INTL	YES	YES	YES	YES	YES	YES
GRAVITY	YES	YES	YES	YES	YES	YES
Clusters	Pair	Pair	Pair	Pair	Pair	Pair

Note: The sample is from [Fontagné et al. \(2022\)](#) for 2000, it differs because data for cultural distances ([De Benedictis et al., 2020](#)) has a different country coverage. *GRAVITY* contains log weighted distance, contiguity and common official language from [Conte et al. \(2022\)](#). Clustered robust standard error in parenthesis.. Significance level *** p<0.01, ** p<0.05, * p<0.1

2.7 Counterfactual Analysis

We propose an experiment based on the effect of the Rule of Law on aggregate trade that wants to answer the question: *What happens if all countries turn to have good institutions (positive values)?* Then the counterfactual scenario considers a situation in which countries with a negative value (bad institutions) of the WGI index face a change to the average value (0.2, see Table 2.7) and no variation for the countries that already have a positive value (good institutions).

The baseline results refer to column 1 in Table 2.1. Thus on an aggregate trade sample of 98×98 countries in 2000:

$$\begin{aligned}
 X_{ij} = \exp[& 0.57 \times I_i \times INTL_{ij} - 0.66 \times \log(Distances_{ij}) + 0.72 \times Contiguity_{ij} + \\
 & + 0.30 \times Common\ Language_{ij} - 3.03 \times INTL_{ij} + \mu_i + \chi_j] \times \varepsilon_{ij} \quad (2.11)
 \end{aligned}$$

Using the methodology from [Yotov et al. \(2017\)](#) to run the exercise, *trade without*

borders, that we identify as the most appropriate to run an analysis with unilateral variable. This procedure allows measuring the variation in real terms and the general equilibrium implications. Changes from baseline to the counterfactual of the t_{ij} vector affect inward and outward multilateral resistance terms and consequently, the factory gate price that defines the welfare changes due to an improvement of the institutional quality for a set of countries (the one with bad institutions).

To discuss the results of the experiment, we show the variation of consumer prices ($\Delta P\% = -1 \times \hat{P}_j$), domestic prices (factory gate price, $\Delta w_i\% = \hat{w}_i \times 100$) and the real output ($\Delta Y\% = \hat{Y}_i \times 100$). At this stage, we do not consider the parameter ζ since it is embedded in the coefficient. While the parameter θ used to run the counterfactual is set equal to 6 (since $\theta \simeq \sigma - 1$, and sigma is equal to 7).⁹ Moreover, we display the consequences of exports in conditional and full endowment equilibrium.

Firstly, we present the welfare effects in Figure 2.1. The effect on countries' output is positive for those facing an improvement in institutional quality. However, the effect on real GDP is the net effect between a lowering in import prices and domestic prices. The price of incoming goods can be considered the consumer prices and the factory gate prices contain the effect on the supply side (producer prices, which are a function of the outward multilateral resistance terms, see equation 2.4). Thus, the net effect of a fall in import prices and a large increase in domestic prices generate an improvement in total output.

A country like Sudan (SDN), characterized by bad institutions (high negative value of the Rule of Law indicator) and a low baseline output, is sensitive to this variation. It would improve the value of its output by around 14%, and both prices are also really sensitive to this shock. Another interesting case concern those countries with bad institutions but with large economies like Russia (RUS) and China (CHN). The welfare gains are smaller especially compared to prices response. An interpretation of

⁹ The value of this parameter is the "default" one according to [Yotov et al. \(2017\)](#), we are not interested in the sensitive of the prediction related with this parameter. Moreover, we use Germany as numeraire since is a country less sensitive to the shock.

these results is that improving domestic institutions is costly but it also increases the value of a country's total output. The magnitude of this gain is related to the size of the economy. Therefore, countries with bad institutions and small economic sizes would benefit more from institutional reform. While countries with a "negative" institutional performance but with a large economy, would have a relatively small improvement from aligning their institutional quality with the average.

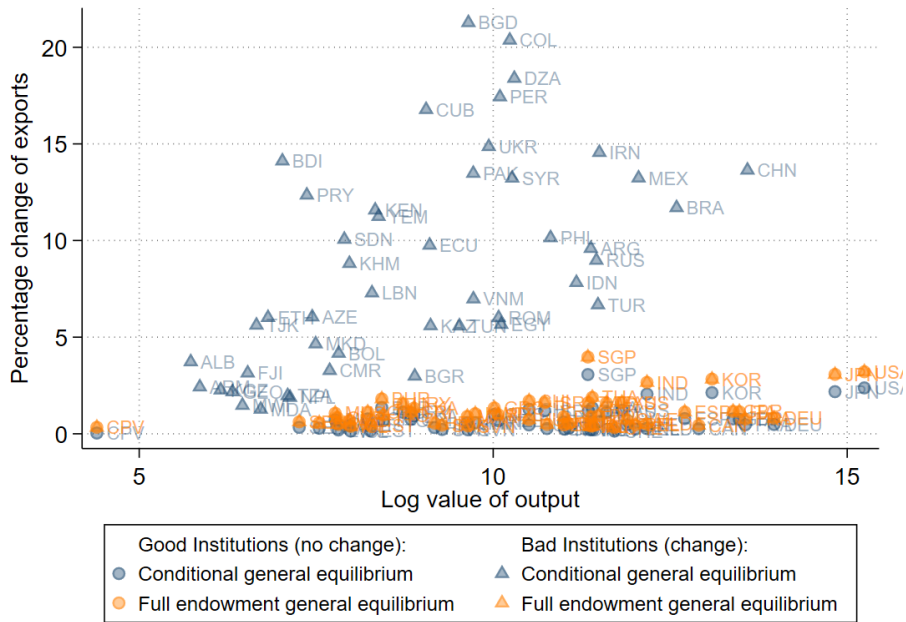
Figure 2.1: Counterfactual Analysis: changes in consumer prices, domestic prices and real GDP



Source: Author's elaboration

Figure 2.1 shows the changes in export levels and split the gains of the total into the part related to international trade. In this case, the situation is different from the picture above. The rise of exports reaches almost 30% for peripheral countries, and here also Russia (RUS) and China (CHN) have significant changes due to a hypothetical institutional reform (see Table 2.10 and Table 2.11 to check the complete results of this exercise).

Figure 2.2: Counterfactual Analysis: changes in exports



Source: Author's elaboration

The takeaways from this exercise are that bringing institutional quality at an average level, the exchange of goods happens in almost common conditions (*almost* because even if all the countries have good institutions there are still differences), are:

- Improving institutions is costly but it generates an increase in output values as a net effect of an increase in domestic prices and a drop in import prices.
- The welfare effect depends on the changes in institutional quality and the size of the economy.
- The impact on exports is relevant also for the big economies that improve their institutional environment.

The last remark concerns the fact that this exercise is static. Therefore, the larger effect on factory gate prices could be considered as the immediate response to a radical institutional change. It is likely that in a dynamic setting, the effect on prices would

have different paths and the welfare benefit may be larger also for all the countries.

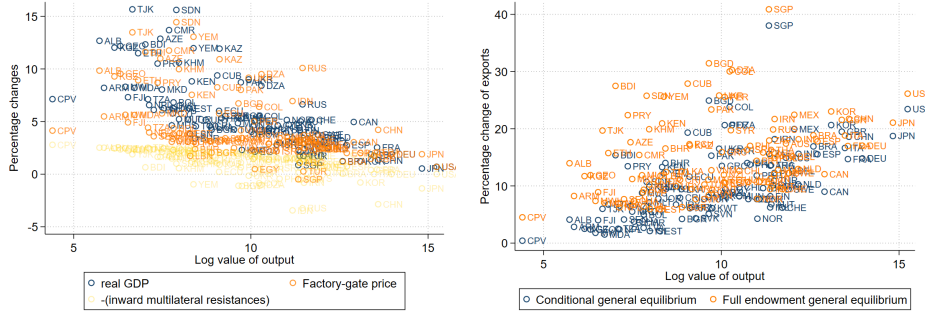
2.7.1 Counterfactual: sensitivity analysis

The results from the main analysis confirm the prediction of the benefit of an improvement in institutional quality. However, they show a controversial effect on prices. In particular, looking at the exercise *trade without borders* in [Yotov et al. \(2017\)](#), the outcomes are slightly different. In this case, the effect on real output is the sum of the increase in import and factory gate prices. Hence, to show the robustness of our results, we replicate the exercise extending the increase in the Rule of Law also to the countries with positive values. Then, the same changes for those with bad institutions (reaching the average value) but also a rise of +0.5 for the others.¹⁰

This counterfactual scenario produces a similar output to the reference exercise (see Figure 2.3). The effect on real GDP is the sum of a rise in both prices, just a few countries maintain the controversial effect as Russia, China, Algeria and Japan. The first two, which have similar behaviour in the main exercise, also, in this case, harm import prices. These last results confirm the robustness of the methodology applied and also add an intuition for which institutional improvement has a better effect if it happens worldwide. Countries with a proper institutional environment should contribute to improving third countries' institutions and keep upgrading their ones.

¹⁰ For lower values the results do not vary compared to the main application.

Figure 2.3: Counterfactual sensitivity analysis: welfare effect and changes in exports



Source: Author's elaboration

2.8 Sector Analysis and the role of relation specific measure

Once we assess the effect of domestic institutions as a trade easiness from fundamental productivity, we propose a simple extension of the model to include sectors and interpret the empirical analysis.

To identify the impact of domestic institutions on sector-based trade, we need to include a factor unique to each industry that captures its exposure to uncertainty in business relationships. Therefore, institutions impact differently according to each sector's vulnerability to search friction and market incompleteness. The literature offers various approaches to conceptualize and measure this industry-specific factor related to business relationships. Here we focus on *contract intensity* proposed by Nunn (2007) and *relationship stickiness* by Martin et al. (2020).

Contract Intensity measures the significance of relationship-specific investments across different industries. This measure quantifies the extent of relationship-specific investments for each good by calculating the proportion of its intermediate inputs that necessitate such investments. Relationship-specific investments involve inputs used

in producing final goods, which rely on specific relationships between involved parties. The method of identifying inputs that require relationship-specific investments involves using data from Rauch (1999), which determines whether an input is traded on an organized exchange. Input trading on an exchange implies a well-established market with numerous potential buyers and sellers.

Relationship Stickiness: for Martin et al. (2020), "stickiness" denotes the degree of persistence in firm-to-firm trade relationships, especially in input trade. It involves the duration of these relationships and provides insights into how specific the products are involved. The foundation of this concept comes from a theoretical framework where firms enter trade relationships and switch to new input suppliers only if prices offered are significantly lower than those of current partners, covering the costs of forming a new relationship. In markets with high stickiness, uncertainty shocks mainly impede the creation of new firm-to-firm relationships.

2.8.1 Sector Trade: including relation specific measure

In this section, we extend the previous framework to consider relation-specific measures, such as contract intensity as defined in Nunn (2007) and relationship stickiness from Martin et al. (2020). The setup is the same the aggregate model. Productivity is slightly different, it is drawn randomly from a Fréchet:

$$F_i = \exp\left(-\left(\frac{A}{A_i^k}\right)^{-\theta}\right) \quad (2.12)$$

$A_i^k = \bar{A}_i^k z^k I_i$, where $z^k \in \{-\infty, \infty\}$ relation specific parameter of each sector, and I_i is the institutional quality (quality of contract enforcement) and \bar{A}_i^k is the exogenous sector productivity for each sector k in country i . Iceberg trade costs, $t_{ij}^k = z^k \tau_{ij}$, where τ_{ij} would represent bilateral cultural features which are the transaction cost related to contract enforcement. In this case, the effect relates to the contract intensity of

each sector. Thus, the expenditure in this case are:

$$X_{ij}^k = \pi_{ij}^k E_j^k = \frac{(\bar{A}_i^k z^k I_i^c)^\theta (w_i t_{ij}^k)^{-\theta}}{\Phi_j^k} E_j^k \quad (2.13)$$

where π_{ij}^k is the trade share for each sector k . The other variables and parameters have the same interpretation of equation 2.1.

From this equation, we derive the main equation of the structural gravity system:

$$X_{ij}^k = \frac{Y_i'^k E_j^k}{Y^k} \left(\frac{t_{ij}^k}{P_j^k \Pi_{ij}^k} \right)^{-\theta} \quad (2.14)$$

The system with k sectors is similar to the one presented here, just adding the k sectors subscript. The modified vector of trade frictions is $(t_{ij}^k)^{-\theta} = \frac{\tau_{ij}^h}{(z^k I_i)^{c/\theta}}$.

2.8.2 Empirical Strategy: From theory to measurement

In this section, we are going to describe the empirical strategy and its theoretical content to estimate sectoral heterogeneity according to specific indexes that catch the heterogeneous impact of domestic institutions on international trade.

iii) The differences related to different industries and the related sector relation specificity (Levchenko, 2007; Martin et al., 2020; Nunn, 2007).

Moving the analysis to the sectoral level, Tables 2.8 and 2.9, using respectively WIOD and ITPD (Version 2) we estimate the following specification:

$$X_{ij}^k = \exp[\beta \bar{z}^k RoL_i \times INTL_{ij} + \beta' z^k RoL_i \times INTL_{ij} + \beta_2 \bar{z}^k Culture_{ij} + z^k \beta_2' Culture_{ij} + \gamma GRAVITY_{ij} + \delta_0 INTL_{ij}^k + \mu_i + \chi_j] \times \varepsilon_{ij} \quad (2.15)$$

To estimate this equation, we standardize the relation-specific measures (contract intensity by [Nunn \(2007\)](#) and relationship stickiness by [Martin et al. \(2020\)](#)) where $\bar{z}^k = 1$ since it is the average value of the standardised distribution. Hence β is the same as in equation 2.6. Since β' relates with z^k , this coefficient measures the marginal contribution of institutional quality with sector relation specific that deviates from the average. A practical example of sectoral difference in relation-specific features from [Nunn and Trefler \(2014\)](#) helps to understand better this. Comparing the production of commercial airliners and clothes. The former necessitates advanced technology and stringent quality benchmarks across various participants (namely, intermediate goods manufacturers and specialized component producers), which proves challenging to validate within a comprehensive legal framework. On the contrary, the production of clothing demands a less intricate contractual capacity for sourcing raw materials. Consequently, nations with robust contractual institutions tend to specialize in the production of airplanes due to the higher costs involved, while those with weaker institutions tend to focus on clothing manufacturing.

To understand better how to interpret the results, we formalize the impact of β' using the procedure described above and then the theoretical content of the coefficient is:

$$\beta' = \frac{\partial \ln(\pi_{ij}^k)}{\partial \ln(I_i)} - \frac{\partial \ln(\pi_{jj}^k)}{\partial \ln(I_i)} = z_k \zeta \theta (\pi_{jj} - \pi_{ij}) \quad (2.16)$$

It is similar to the previous equation 2.6, but here the role of contract intensity z^k changes the overall effect determined by the parameters and the differences between the two shares. In this way, the impact of institutional quality relates to the relation-specific content of each industry. In sectors with low intensity, the quality matters less, and for those with higher intensity, the effect of institutions is proportional to it.

From equation 2.15, the total effect of domestic institutions on trade is the sum of the two coefficients and with β' we can quantify the effect of more sensitive sectors

to relation-specific level as shown below:

$$total\ effect = \beta + \beta' = (\bar{z}^k + z^k)[\theta(\pi_{jj} - \pi_{ij})] \quad (2.17)$$

The same logic applies to β_2 and β'_2 , which are the coefficients measuring the effect of bilateral cultural ties.

The other elements of equation 2.15 are: the control $INTL_{ij}^k$ is done for each industry k .¹¹ Also in this case, different samples help checking the robustness of our findings. The ITPD data covers almost both developed and developing countries,¹² while WIOD provides a squared trade matrix with large economies.

2.8.3 Results

The main results refer to relationship stickiness from [Martin et al. \(2020\)](#). Table 2.5, to aggregate the stickiness variable from the 6-Digits HS2002 to ISIC rev. 3, we took the 99th percentile of the distribution to get the highest stickiness for each sector.

We obtain positive and significant coefficients in all the models and confirm the results of the aggregate estimates. In this table, the effect of domestic institutions on international trade with respect to domestic sales is almost doubled, and the total effect means an increase in one point of the rule of law leads to a positive change of 1.24% of exports (column 1), of this change, the 0.14% is due to stickiness. In columns 2 to 3, the total effect of the rule of law (on international trade with respect to domestic sales) is slightly lower by including cultural proximities (1.20% and 1.18%). The statistical significance of the dyadic cultural ties (common religion and language proximity) is not fully established. The acceptable coefficients are those yielded by religious proximity. In this case, stickiness lowers the average effect (from

¹¹ When we include relationship stickiness from [Martin et al. \(2020\)](#), we use $INTL_{ij}$ because the PPML struggle to converge since the sample is unbalanced

¹² This data are unbalanced from exporters and importers country coverage, and also for the time.

0.7658 to 0,7063).

Table 2.5: Relationship Stickiness - ITPDv2 - PPML 2000 (1)

VARIABLES	(1) PPML - 2000	(2) PPML - 2000	(3) PPML - 2000
Rule of Law×INTL (i)	1.0953*** (0.0757)	1.1056*** (0.0759)	1.0493*** (0.0739)
Rule of Law×INTL (i)×STD Stickiness (k) 99th pct	0.1400*** (0.0121)	0.0948*** (0.0136)	0.1329*** (0.0127)
Similarity between two languages: Continuous Index		0.1207 (0.1291)	
Similarity between two languages×STD Stickiness (k) 99th pct		-0.1373*** (0.0226)	
Common religion index			0.7658*** (0.1047)
Common religion index×STD Stickiness (k) 99th pct			-0.0595* (0.0327)
Observations	1,929,307	1,929,307	1,929,307
Exporter×Sector FE	YES	YES	YES
Importer×Sector FE	YES	YES	YES
INTL	YES	YES	YES
GRAVITY	YES	YES	YES
Clusters	Pair	Pair	Pair

Note: The sample contains 182 exporters and 191 importers for 118 industries from Agriculture, Manufacturing, Mining and Energy and Services. Significance: *** p<0.01, ** p<0.05, * p<0.1

Considering cultural differences makes the sample size smaller based on the countries covered in [De Benedictis et al. \(2020\)](#)'s data. We use this to check how well the results hold with different sample sizes and groups. The rule of law continues to have a positive and significant impact on international trade relative to internal trade. In Table 2.6, the overall impact of the rule of law decreases from about 1.20% (in the earlier table) to approximately 1.10%. This happens because domestic institutions have a smaller average impact, while the stickiness effect remains similar, ranging from 0.08% to 0.12%.

Table 2.6: Relationship Stickiness - ITPDv2 - PPML 2000 (2)

VARIABLES	(1) PPML - 2000	(2) PPML - 2000	(3) PPML - 2000	(4) PPML - 2000	(5) PPML - 2000
Rule of Law×INTL (i)	0.9873*** (0.0752)	1.0034*** (0.0763)	0.9030*** (0.0711)	0.9193*** (0.0726)	0.9601*** (0.0760)
Rule of Law×INTL (i)×STD Stickiness (k) 99th pct	0.1312*** (0.0119)	0.0828*** (0.0132)	0.1242*** (0.0123)	0.1262*** (0.0117)	0.1245*** (0.0129)
Similarity between two languages: Continuous Index		0.0366 (0.1421)			
Similarity between two languages×STD Stickiness (k) 99th pct		-0.1422*** (0.0224)			
Common religion index			0.9547*** (0.1301)		
Common religion index×STD Stickiness (k) 99th pct			-0.0474 (0.0337)		
Trust (cultural distance, ij)				-0.4810*** (0.0663)	
Trust (cultural distance, ij)×STD Stickiness (k) 99th pct				0.0378* (0.0209)	
Average cultural distance (ij)					-0.0212* (0.0122)
Average cultural distance (ij)×STD Stickiness (k) 99th pct					0.0038 (0.0031)
Observations	586,207	586,207	586,207	586,207	586,207
Exporter×Sector FE	YES	YES	YES	YES	YES
Importer×Sector FE	YES	YES	YES	YES	YES
INTL	YES	YES	YES	YES	YES
GRAVITY	YES	YES	YES	YES	YES
Clusters	Pair	Pair	Pair	Pair	Pair

Note: The sample contains 79 exporters and 80 importers for 118 industries from Agriculture, Manufacturing, Mining and Energy and Services.*** p<0.01, ** p<0.05, * p<0.1

The estimates using contract intensity from [Nunn \(2007\)](#) do not show the significance of the marginal contribution of the relation-specific measure. The two tables (Table 2.3 and 2.4 in Appendix) display consistent results and confirm that the magnitude of the domestic institutions coefficient is affected by sample size and composition. A larger sample size lowers the impact compared to a smaller size as shown in Table 2.4. The test on how much contract intensity matters concerning the average institutional quality is not significant either for the *Rule of Law* or for common religion. Nonetheless, the language proximity is statistically significant, and its combination with the contract intensity. The interpretation suggested that language has a heterogeneous effect according to contract capacity, probably due to the skill contents of a sector.

2.9 Conclusion

Our analysis of the effect of domestic institutions suggests that the best way to measure it is by using country-specific features that capture the functioning. The role of the form (country legal system) even if significant is affected by the set of countries included in the sample and is also related to the country's institutional environment. Using bilateral variables, either for form or function does not provide robust results, and these are biased by the assumption made to create such bilateral measures.

The role of bilateral cultural ties, proximity and distances, reveals that religion plays a relevant role in aggregate trade while language matters more in the sectoral analysis. It is sure that culture and domestic institutions together have a role in bilateral flows. Although, the latent factors not explored in this work suggest that a specific analysis of the role of culture through a structural gravity framework is needed. To understand better and define the mechanism of different cultural dimensions, alone and combined. Moreover, a deeper investigation of the nexus between bilateral geographical features¹³ to distinguish the effect of these variables.

The further contribution of this work is a theoretical explanation of the methods of [Heid et al. \(2021\)](#) which allows also us to run policy experiments as in [Beverelli et al. \(2023\)](#). The counterfactual in the previous section is in line with the 16th SDG and provides interesting hints for the policy debate. The results on export changes are probably too optimistic, even if greater improvement concerns the value of outgoing goods from poor countries.

The welfare effects show a controversial effect on prices as already discussed in other theoretical frameworks such as [Levchenko \(2007\)](#) and [Belloc and Bowles \(2017\)](#). In this case, the dominant effect is domestic prices, meaning that the positive effect passes through a rise in the value of the overall production. Countries with bad

¹³ An analysis on gravity covariates and cultural distances is provided by [De Benedictis et al. \(2020\)](#).

institutions and large markets benefit less in the overall welfare effect but still, they would face a significant improvement in their export values. The sensitivity analysis shows that part of the controversial effect on prices since just some countries develop their institutions. A more controllable effect on prices happens if all countries achieve to ameliorate their Rule of Law.

The extension at the sectoral level provides statistically significant results only with relationship stickiness provided by [Martin et al. \(2020\)](#). The marginal contribution of relationship stickiness amplifies the relevance of the country's institutional quality. The effect of bilateral cultural ties is not robust. Only when looking at the estimates obtained with WIOD data, where the number of countries is lower, and these are more integrated into the world economy. This leaves a door open for further research on the role of culture and institutions in different sectors and industries.

2.10 Appendix A

2.10.1 Descriptive Statistics

Table 2.7: Descriptive Statistics of the main sample

Variable	Obs	Mean	Std. dev.	Min	Max
Rule of Law (j)	9604	0.21	1.01	-1.60	1.98
Rule of Law (j)	9604	0.21	1.01	-1.60	1.98
Weighted distance (log)	9604	8.55	0.91	2.13	9.89
Contiguity	9604	0.03	0.16	0.00	1.00
Common Language (Official)	9604	0.09	0.29	0.00	1.00
Post Transition Legal System: French (i)	9604	0.53	0.50	0.00	1.00
Post Transition Legal System: British (i)	9604	0.25	0.43	0.00	1.00
Post Transition Legal System: German (i)	9604	0.16	0.37	0.00	1.00
Post Transition Legal System: Scandinavian (i)	9604	0.05	0.22	0.00	1.00
Same legal system: French	9604	0.50	0.50	0.00	1.00
Same legal system: British	9604	0.62	0.49	0.00	1.00
Same legal system: German	9604	0.73	0.45	0.00	1.00
Same legal system: Scandinavian	9604	0.90	0.30	0.00	1.00
Similarity between two languages: Continuous Index	9604	0.11	0.19	0.00	1.00
Common religion index	9604	0.16	0.25	0.00	0.99
Difference between Rule of Law (ij) (absolute value)	9604	1.16	0.83	0.00	3.58
Sum Rule of Law (ij)	9604	0.42	1.42	-3.06	3.96
Common legal system post-transition	9604	0.38	0.48	0.00	1.00

Note: The sample is the one from [Fontagné et al. \(2022\)](#), it includes 98×98 countries for the 2000.

2.10.2 Empirical Analysis

Table 2.8: Sectoral Trade: Contract Intensity (WIOD (1))

VARIABLES	(1) PPML - 2000	(2) PPML - 2000	(3) PPML - 2000	(4) PPML - 2000
RoL×INTL	1.3221*** (0.0942)			1.3267*** (0.0992)
RoL×Contract Int. (Std)×INTL	-0.1552 (0.1098)			-0.1163 (0.1144)
Similarity between two languages: Continuous Index		0.5854*** (0.1754)		-0.1944 (0.1586)
Similarity between two languages×Contract Int. (Std)×INTL		-0.2795* (0.1613)		-0.1054 (0.1666)
Common religion index			0.5797*** (0.1675)	0.2571 (0.1846)
Common Religion×Contract Int. (Std)×INTL			-0.3864*** (0.1485)	-0.2387 (0.1585)
Observations	17,514	17,514	17,514	17,514
Exporter×Sector FE	YES	YES	YES	YES
Importer×Sector FE	YES	YES	YES	YES
INTL×SECTOR	YES	YES	YES	YES
GRAVITY	YES	YES	YES	YES
Clusters	Pair	Pair	Pair	Pair

Note: Trade data and domestic trade flows are from the WIOD. The sample concerns the year 2000. The full composition is exporters and importers and 10 sectors but it is unbalanced. Clustered robust standard errors in parenthesis. Significance level: *** p<0.01, ** p<0.05, * p<0.1

Table 2.9: Sectoral Trade: Contract Intensity (ITPDv2 (1))

VARIABLES	(1) PPML - 2000	(2) PPML - 2000	(3) PPML - 2000	(4) PPML - 2000
RoL×INTL	0.7835*** (0.0968)			0.7085*** (0.0938)
RoL×Contract Int. (Std)×INTL	0.0449 (0.0392)			0.0571 (0.0418)
Similarity between two languages: Continuous Index		0.5003*** (0.1525)		0.2000 (0.1424)
Similarity between two languages×Contract Int. (Std)×INTL		-0.1224** (0.0555)		-0.1261** (0.0583)
Common religion index			1.0083*** (0.1447)	0.7196*** (0.1465)
Common Religion×Contract Int. (Std)×INTL			-0.0104 (0.0608)	0.0488 (0.0661)
Observations	158,862	158,862	158,862	158,862
Exporter×Sector FE	YES	YES	YES	YES
Importer×Sector FE	YES	YES	YES	YES
INTL×SECTOR	YES	YES	YES	YES
GRAVITY	YES	YES	YES	YES
Clusters	Pair	Pair	Pair	Pair

Note: Trade data and domestic trade flows are from the ITPD data version 2 (Borchert et al., 2022). The sample concerns the year 2000. The full composition is 78 exporters and 78 importers and 27 sectors but it is unbalanced. Clustered robust standard errors in parenthesis. Significance level: *** p<0.01, ** p<0.05, * p<0.1

2.10.3 Counterfactual Analysis

Table 2.10: Main counterfactual results (1/2)

Country ISO3	Exports		Factory gate price	IMR	OMR	Real output	Baseline output
	Δ % Conditional	Δ % Full	Δ % w_i	Δ % P_j	Δ % Π_i	Δ % Y_i	Y_i
ALB	3.72	13.97	10.30	-0.10	-10.81	10.41	307.25
ARG	9.59	11.16	2.29	1.12	-2.60	1.15	87368.09
ARM	2.42	8.24	6.04	-0.29	-6.62	6.35	349.14
AUS	1.22	1.62	0.21	-0.07	-0.24	0.28	135734.50
AUT	0.21	0.41	0.12	-0.05	-0.14	0.17	89905.80
AZE	6.05	17.55	11.59	0.48	-12.01	11.06	1708.63
BDI	14.12	26.42	12.20	1.59	-12.56	10.44	1120.90
BEL	0.25	0.47	0.07	-0.01	-0.08	0.08	164078.47
BGD	21.28	27.60	7.48	2.94	-8.07	4.41	15514.90
BGR	2.98	5.46	2.72	0.08	-3.08	2.63	7273.47
BHR	1.36	1.81	0.25	-0.13	-0.29	0.38	4565.53
BOL	4.17	8.94	5.12	-0.09	-5.66	5.22	2482.25
BRA	11.70	13.06	2.47	1.63	-2.80	0.82	293568.16
CAN	0.26	0.44	0.08	-0.08	-0.09	0.15	401424.09
CHE	0.14	0.32	0.10	-0.03	-0.11	0.12	122032.55
CHL	1.27	1.70	0.37	-0.23	-0.43	0.59	36563.11
CHN	13.64	15.84	5.09	4.13	-5.63	0.92	798846.00
CMR	3.28	15.39	12.15	0.74	-12.52	11.33	2187.30
COL	20.37	26.64	7.39	2.86	-7.98	4.40	27820.55
CPV	0.04	0.33	0.36	-0.29	-0.41	0.65	81.57
CRI	0.75	1.11	0.30	-0.19	-0.34	0.49	6900.10
CUB	16.78	25.41	8.97	1.41	-9.53	7.45	8534.27
CYP	0.52	0.84	0.31	-0.27	-0.36	0.58	2428.05
CZE	0.27	0.49	0.13	-0.05	-0.15	0.18	47078.29
DEU	0.48	0.80	0.07	0.00	-0.08	0.07	1163467.00
DNK	0.30	0.52	0.14	-0.06	-0.17	0.20	64092.76
DZA	18.39	28.10	10.23	3.14	-10.74	6.88	29668.97
ECU	9.76	15.67	6.56	1.83	-7.14	4.64	8967.32
EGY	5.66	6.90	1.48	0.31	-1.70	1.16	24647.35
ESP	0.79	1.13	0.11	-0.05	-0.13	0.16	329381.03
EST	0.16	0.45	0.30	-0.20	-0.35	0.50	3873.13
ETH	6.01	15.28	9.40	0.08	-9.95	9.32	915.03
FIN	0.53	0.85	0.22	-0.09	-0.26	0.31	87367.23
FJI	3.15	8.17	5.27	0.21	-5.82	5.05	686.81
FRA	0.47	0.76	0.08	-0.01	-0.09	0.09	775299.94
GBR	0.77	1.16	0.06	-0.02	-0.07	0.08	652393.19
GEO	2.17	12.10	10.05	-0.11	-10.58	10.18	554.14
GHA	0.29	0.56	0.28	-0.22	-0.32	0.50	1887.21
GRC	1.00	1.34	0.17	-0.16	-0.20	0.33	22361.31
HRV	0.32	0.56	0.18	-0.12	-0.21	0.30	9608.85
HUN	0.46	0.73	0.18	-0.10	-0.21	0.28	36503.73
IDN	7.83	13.94	7.47	4.88	-8.06	2.46	71317.08
IND	2.06	2.66	0.31	-0.07	-0.36	0.38	193345.47
IRL	0.20	0.40	0.12	-0.04	-0.14	0.16	87049.59
IRN	14.56	17.93	4.70	2.50	-5.22	2.15	98593.05
ISL	0.14	0.39	0.26	-0.19	-0.30	0.44	2944.78
ISR	1.18	1.61	0.19	-0.09	-0.22	0.28	45617.27
ITA	0.75	1.14	0.08	-0.01	-0.09	0.09	712397.69
JOR	0.77	1.12	0.31	-0.26	-0.36	0.57	3742.55

Note: The sample comes from the [Fontagné et al. \(2022\)](#) data, the year is 2000. $\Delta\%$ is the percentage changes of the variable of interest (100 \times changes).

Table 2.11: Main counterfactual results (2/2)

Country ISO3	Exports		Factory gate price	IMR	OMR	Real output	Baseline output
	$\Delta\%$ Conditional	$\Delta\%$ Full	$\Delta\%$ w_i	$\Delta\%$ P_j	$\Delta\%$ Π_i	$\Delta\%$ Y_i	Y_i
JPN	2.18	3.07	0.18	0.11	-0.21	0.07	2750758.25
KAZ	5.59	16.82	11.38	1.17	-11.82	10.10	9090.87
KEN	11.58	19.38	8.16	1.07	-8.74	7.01	4159.59
KGZ	2.27	11.77	9.69	-0.27	-10.23	9.98	468.69
KHM	8.81	18.93	10.35	1.53	-10.85	8.69	2889.87
KOR	2.13	2.83	0.22	0.08	-0.26	0.14	484031.06
KWT	0.58	1.04	0.37	0.07	-0.44	0.31	17087.72
LBN	7.29	9.56	2.64	0.06	-3.00	2.58	3974.31
LKA	0.92	1.32	0.33	-0.15	-0.38	0.48	7179.05
LVA	0.20	0.48	0.29	-0.20	-0.34	0.49	2472.74
MAR	0.58	0.90	0.23	-0.16	-0.26	0.39	15275.17
MDA	1.27	7.23	6.10	-0.10	-6.68	6.20	825.80
MEX	13.24	15.63	3.51	1.61	-3.95	1.87	171580.48
MKD	4.65	10.72	6.32	0.23	-6.90	6.09	1792.81
MLT	0.42	0.69	0.20	-0.14	-0.23	0.34	2898.76
MUS	0.72	1.06	0.27	-0.15	-0.31	0.42	2363.82
MWI	1.47	7.33	6.01	-0.03	-6.58	6.04	637.72
MYS	1.10	1.59	0.36	0.01	-0.42	0.35	108950.82
NLD	0.28	0.51	0.09	-0.02	-0.11	0.11	191356.03
NOR	0.24	0.49	0.22	-0.10	-0.26	0.32	60717.16
NPL	1.88	5.94	4.32	-0.27	-4.82	4.60	1249.09
NZL	0.67	0.99	0.25	-0.13	-0.29	0.39	23673.26
PAK	13.48	21.64	8.60	1.42	-9.18	7.08	16616.51
PER	17.43	22.48	6.01	1.92	-6.58	4.01	24210.92
PHL	10.15	13.26	4.15	2.09	-4.63	2.02	49496.66
POL	0.63	0.95	0.15	-0.07	-0.17	0.22	97956.47
PRT	0.61	0.88	0.14	-0.09	-0.16	0.22	59599.35
PRY	12.35	21.72	9.57	0.48	-10.12	9.05	1583.14
ROM	6.01	8.62	3.03	0.57	-3.42	2.45	23775.37
RUS	8.98	18.87	10.67	5.04	-11.16	5.36	94516.41
SDN	10.06	25.41	15.00	1.27	-15.05	13.56	2689.27
SEN	0.33	0.62	0.28	-0.23	-0.33	0.51	1422.16
SGP	3.06	3.97	-0.07	-0.14	0.08	0.07	83908.26
SVK	0.22	0.44	0.19	-0.12	-0.22	0.31	10702.13
SVN	0.20	0.41	0.15	-0.08	-0.18	0.24	15433.20
SWE	0.46	0.73	0.16	-0.05	-0.19	0.21	145489.03
SYR	13.23	17.05	4.67	1.43	-5.18	3.19	28790.54
THA	1.34	1.88	0.30	0.05	-0.35	0.26	89277.18
TJK	5.62	19.58	13.92	0.30	-14.11	13.58	777.27
TTO	0.67	0.96	0.20	-0.15	-0.23	0.35	4662.76
TUN	5.58	8.40	3.19	0.45	-3.59	2.72	13665.74
TUR	6.67	7.80	1.38	0.39	-1.58	0.98	96719.07
TZA	1.98	6.63	4.84	-0.13	-5.37	4.97	1208.04
UKR	14.86	24.36	9.86	2.22	-10.39	7.47	20685.73
URY	1.11	1.55	0.50	-0.39	-0.58	0.89	6155.77
USA	2.37	3.21	0.02	-0.06	-0.02	0.08	4163415.50
VNM	6.98	11.15	4.70	0.76	-5.21	3.90	16650.92
YEM	11.24	24.85	13.61	3.11	-13.83	10.19	4360.80
ZAF	1.17	1.62	0.17	-0.04	-0.20	0.20	84616.68

Note: The sample comes from the [Fontagné et al. \(2022\)](#) data, the year is 2000. $\Delta\%$ is the percentage changes of the variable of interest (100 \times changes).

Chapter 3

The effect of domestic policies on international trade: a lesson from Covid-19

3.1 Introduction

The Covid-19 pandemic and the related policies have been affecting the economy since 2020. The "new" disease spread rapidly and (almost) simultaneously in every country in the world. Governments faced an unprecedented challenge in terms of immediate response. Worldwide economies are hardly hit by the different types of intervention for containing the contagion, both directly and indirectly.

In this study, we aim to address a straightforward research question: *What is the immediate impact of pandemic containment measures (and related consequences) on global trade?*¹ We want to examine the instant effect of domestic policies on the international exchange of goods. The strategies employed to manage health crises en-

¹ We refer to the immediate responses instead of short-run implication because it is more in line with our theoretical and empirical analysis

compass a range of societal facets (such as social distancing, curfews, school closures, and movement restrictions) and economic aspects (like remote work arrangements and the suspension of specific economic activities). The diverse array of interventions and their punctual implications on the economy offer a captivating phenomenon that needs to be studied to understand the immediate consequences on the international trade network.

Answering this research question, we test the hypothesis on the effect of the direct institutional response and the indirect effect that looks at the consequences on work mobility and the role of infrastructure. In addition, test seasonality and path dependence (Morales et al., 2019) because monthly trade has different trends from yearly flows.

During the first wave of the pandemic (which began in March 2020) the main international organizations were extremely pessimistic about the economic consequences. The IMF in the World Economic Outlook forecasts negative GDP growth for the whole economy. In comparison with the 2008's crisis, many more countries were negatively affected, even countries like China and India that in the previous global recession resisted such a spread shock (IMF-WEO, 2020). The WTO's forecast from last October estimated a drop in total trade in merchandise by 9.2%, while this decline was not that thorny, falling by 5.3%.²

Since the begging, the pandemic consists of both a supply and demand shock. The former is because of a drop in exports and the latter of the related fall in imports. The main threat for the manufacturing sectors was (and maybe still is) the disruption of supply and demand. Firstly, hitting East Asian countries, the top suppliers of intermediates and final goods of larger industrial economies. Moreover, macroeconomic components of the aggregate demand decreased drastically. In addition, high uncertainty affected consumption and investment behaviour (Baldwin and Mauro, 2020). Decision-makers in these months are always facing a trade-off between disease

² https://www.wto.org/english/tratop_e/covid19_e/faqcovid19_e.htm#collapse0

containment strategies and how to protect the economy. They are trying to find the right compromise with high-frequency combinations of restriction rules and support that make difficult to assess what is impacting the economy.

This work aims to assess the impact of Covid-19 shocks on international trade and contribute to the literature on non-discriminatory trade policies and country-specific features. We propose a new method to impute monthly domestic production and obtain monthly domestic sales. To our knowledge is the only paper that uses unilateral variables as as in [Heid et al. \(2021\)](#) to analyse the effect of the pandemic. We want to provide new tools to estimate a theory-based structural gravity with high-frequency data.

The structure of this work contains the recent literature on economics and Covid-19 and comments on previous seminal (and not only) works helpful for the understanding of the mechanic (Section 3.2). Section 3.3 discusses the framework explaining trade mechanism and derives the structural gravity model. Section 3.4 describes the data used for the econometric analysis and focuses on how to create domestic flows. Section 3.5 shows the strategy to identify country-specific policies, and Section 3.6 presents the results. Section 3.7 includes an extension of the framework adding aggregate sunk costs measured by network centrality measures.

3.2 Literature and Contribution

This section bridges the recent literature on pandemics and the economy and empirical and theoretical works on international and gravity models.

At its beginning, the pandemic was a massive demand and supply shock that affected mainly big economies. Compared to previous crises, its unprecedented speed and widespread impact distinguish it as a crisis of unparalleled magnitude, affecting not only the health and economic systems but society as a whole ([Baldwin and Mauro, 2020](#)). The medical emergency and the related shutdown of the economic activities

represented a threat to the global economy ([Baldwin, 2020](#)).

One of the main policy problems was the best combination between containment measures and the survival of the economy. [Acemoglu et al. \(2020\)](#) provides an economic model integrated with SIR ³ based on US data, to find the best solution to maximize economic outcomes and minimize deaths. This work helps to understand the domestic dimension, and from these results, a severe decline in GDP is inevitable (it is around a 24.3% decrease) if governments want to save as many lives as possible.

Similarly, [Antràs et al. \(2020\)](#) integrate the epidemiological framework into a theoretical general equilibrium gravity model to investigate the relationship between globalization and the pandemic. Compared to [Acemoglu et al. \(2020\)](#), here the focus is the international dimension and how the health crisis management (containment) of a country affects others. The authors define *cross-country epidemiological externalities* in the worldwide diffusion of the virus and its economic implications. In brief, their findings state that openness (globalization) exposes a country to contagion that means a contraction of labour supply that leads to an increase in relative wages and the *social-distance* equilibrium level lead to a reduction of trade output ratio, fewer gains from trade and lower aggregate welfare.

Another interesting point of view, when the pandemic started, the global economy was already in a crucial moment. Observers from academic and international institutions noticed that the phenomenon of *slowbalization* and *de-globalization* are happening. ⁴ Mainly these are related to the fact that (in any possible way to measure it) globalization cannot grow forever, and also political tension characterized by trade wars (China vs the US), Brexit and the rise of populism and a comeback of protectionist reforms. Therefore, the shutdown of economies at several dimensions through lockdowns and other containment interventions would drastically hamper the slowbalization process

³ SIR: Susceptible-Infected-Recovered is a well know model by epidemiologists and virologists to describe the disease dynamics within the population

⁴ This consideration is also discussed in the *World Development Report (World-Bank, 2020)* which has as focal point Global Value Chains dynamics and related policies implication.

(temporary or paradigm shift ([Gruszczynski, 2020](#))).

In the realm of empirical research on the pandemic's impact on global trade, only a few studies have explored a multi-country (bilateral) context. Our contribution fits in this literature and further tools to specify a structural gravity model considering recent advances in this methodology. We identify the effect of domestic policies in levels, we control for multilateral resistances through origin and destination fixed effect (avoiding gold medal mistake [Baldwin and Taglioni \(2006\)](#)), and controlling for the potential home biases provide a method to impute monthly domestic sales. Moreover, we include a strategy to deal with the seasonality of monthly trade and a novel way to include network centrality measures into a gravity model.

A notable example is the work by [Espitia et al. \(2021\)](#) at the World Bank, which served as an influential reference for this analysis. This paper measures the impact of the pandemic on the growth rate of bilateral exports. The authors of this study delve into the effects of demand, supply, and third-country shocks on the monthly growth of bilateral exports in 2020. Their sector-specific analysis reveals that supply shocks stemming from remote work arrangements and workplace closures exert a positive influence on export rates across sectors. Meanwhile, the impact of demand shocks varies according to product type. More durable goods display lesser sensitivity due to sectors like automotive experiencing a substantial decline amidst the pandemic. Conversely, sectors like electronics (e.g., computers, and laptops) exhibit compensatory effects as their products become indispensable for remote work and schooling. Additionally, the study gauges third-country effects, highlighting a negative correlation with competition due to decreased production levels in third countries that could stimulate export growth. Notably, certain specifications indicate a positive coefficient, implying a pro-competitive influence of production and trade, facilitated by upstream shocks involving related input goods across sectors and countries.

Another article investigating the pandemic's trade repercussions, [Masood et al. \(2022\)](#) adopt an approach that quantifies the impact through the count of confirmed deaths

per million people per month attributed to COVID-19 in both exporting and importing nations. Their findings underscore the detrimental effect of the pandemic on trade, with a heightened impact observed on perishable goods (e.g., fruits and vegetables) in comparison to overall trade volumes. This analysis doesn't incorporate fixed effects or controls for the multilateral resistance terms.

In their work, [Hayakawa and Mukunoki \(2021\)](#) found that irrespective of the metrics employed to gauge the COVID-19 pandemic's impact, the study identifies pronouncedly adverse effects on international trade in both exporting and importing nations. Furthermore, these effects, especially those arising from the exposure of importing countries to COVID-19, displayed a tendency of decreasing significance starting from July 2020. This observation suggests a partial accommodation of the deleterious trade impacts of COVID-19 following the initial wave of the pandemic. Lastly, the study uncovers varying effects across industries. Importantly, the analysis includes controls for country-pair-year fixed effects, country-pair-month fixed effects, and year-month fixed effects. However, it does not account for importer and exporter fixed effects.

Shedding light on the pivotal role of supply chain linkages in transmitting COVID-19-induced shocks, [Kejžar et al. \(2022\)](#) presents a comprehensive exploration. Their study hinges on the monthly trade activities of European Union Member States during the initial wave of the COVID-19 pandemic. Employing the gravity model framework, the analysis uncovers a substantial contraction of over 20% in trade across EU nations in the wake of the COVID-19 outbreak. It's discerned that both supply and demand shocks jointly contribute to this trade decline, a consequence of COVID-19's impact, with considerations extending to both the origin and destination countries, proxied either by infection rates or policy stringency indices. Notably, import demand shocks manifest an immediate influence on the trade slowdown, while the trade's sensitivity to the COVID-19 situation in the origin country grows over time. Our approach would be useful to extend an analysis like this one.

To identify the consequence of the pandemic on trade, this work relies on a structural gravity model, theoretically grounded. This ensures to have consistent and robust results, controlling for the structure of international commerce and also assessing different channels of the shock implications. The main theoretical mechanism refers to the seminal work of [Eaton and Kortum \(2002\)](#), in a world operating in perfect competition where firms draw randomly their technology/efficiency for production and geographical barriers to trade define the gravity linkages between domestic and international dimensions.

The empirical model derived by the framework the this paper offers estimates on the effect of institutions' quality on international trade relative to domestic sales, simialr to [Beverelli et al. \(2023\)](#). It is based on [Heid et al. \(2021\)](#), using their empirical strategy to estimate a structural gravity framework to assess the impact of country-specific features on international commerce. In detail, we look at the effect of institutional response on international trade relative to domestic sales. [Sellner \(2019b\)](#) provides a methodological discussion about this approach stressing the importance of it to have more robust and consistent estimates.

An essential element to build a theory-based gravity and to identify the effect of country-specific features and/ or policies are intra-national trade flows [Yotov \(2022b\)](#). The measures for monthly domestic sales we propose make it possible to apply a theory-consistent gravity, controlling for Multilateral Resistances (MR) as in [Anderson and van Wincoop \(2003\)](#) which allows to do not fall into the *gold medal mistake* ([Baldwin and Taglioni, 2006](#)). Moreover, such measure is useful from a "policy perspective" making it possible to consistently quantify the impact of countries' domestic policies.

3.3 Theory

In this section, we present the [Eaton and Kortum \(2002\)](#) model adapted to explain the mechanism of country-specific shock on international trade to interpret the results

for the econometric analysis.

The formalization of [Eaton and Kortum \(2002\)](#) describes the dynamics of trade in a gravity framework, the only small difference we implement this on the input cost functions, which in our opinion, is one of the crucial factors to explain the effect of the pandemic on the economy and in particular on international trade. Therefore, a domestic shock which is represented by a "shutdown" (as an institutional response or mobility in workplaces or usage of an infrastructure) can be represented as an increase in the input cost (cost of production) and consequently the adjustments work not only in price changes but also in the reduction of the quantity because the nature of such shocks affects the spending capacity of domestic and international buyers.

In a world with $i \in N$ exporting countries and $i \in N$ importing partners and a continuum of good $\omega \in \Omega$, consumers' aggregate behaviour is represented by CES preference.⁵ Prices are determined in perfect competition, then for goods exported by i to country j the price is

$$p_{ij} = \frac{c_i}{z_i(\omega)} \tau_{ij} \quad (3.1)$$

The function $c_i = w_i \xi_i$ where w_i is the cost of labour and ξ_i is a vector of domestic frictions which makes production more costly. This last term represents the charge on costs that government apply (directly and/or indirectly to domestic production. Assuming $\xi_i \in [1, \bar{\xi}_i]$. Each country i sets a different value for ξ_i , if equals one there is any intervention (then, no frictions) and $\bar{\xi}$ for a total shutdown of the economy. As in [Eaton and Kortum \(2002\)](#), $z_i(\omega)$, the efficiency distribution is Fréchet.⁶

⁵ The representative utility function is $U = \left[\int_{\omega}^{\Omega} Q(\omega)^{\frac{\sigma-1}{\sigma}} d\omega \right]^{\frac{\sigma}{\sigma-1}}$ where $\sigma > 0$ is the elasticity of substitution. The utility is subject to budget constraint of the total expenditure of country j , E_j .

⁶ The Fréchet distribution, also named the *Type II extreme value distribution* is expressed by $F_i(z) = e^{-T_i z^{-\theta}}$, where $T_i > 0$ is the location of the distribution and represents the absolute advantages, and $\theta > 1$ (the same for all countries) is the parameter captures the variation within the distribution and it captures the comparative advantages. For a large value of T_i is more likely to draw high efficiency, low θ means greater variability (heterogeneity) and consequently more

In this situation, buyers j choose the lowest possible price for each good and then:

$$p_j = \min\{p_{ij}, i = 1, \dots, N\} \quad (3.2)$$

The prices distribution:

$$G_j(p) = 1 - e^{-p^\theta \phi_j} \quad (3.3)$$

and the price parameter:

$$\phi_j = \sum_{i=1}^N T_i (c_i \tau_{ij})^\theta \quad (3.4)$$

These determine important properties:

1. the probability that country i provide goods to country j is equal to the fraction of goods that country j buy from i :

$$\pi_{ij} = \frac{T_i [c_i \tau_{ij}]^{-\theta}}{\phi_j} = \frac{T_i [c_i \tau_{ij}]^{-\theta}}{\sum_{k=1}^N T_k [c_k \tau_{kj}]^{-\theta}} = \frac{X_{ij}}{E_j} \quad (3.5)$$

2. Country j buys a good from any country i at a price with distribution $G_j(p)$ ⁷

The theoretical gravity equation is:

$$X_{ij} = \frac{T_i [w_i t_{ij}]^{-\theta}}{\phi_j} E_j \quad (3.6)$$

where X_{ij} is exporters' sales, including internal trade and E_j is the total purchases (expenditure) of the country j and grouping differently costs variable,⁸ $t_{ij} = \tau_{ij} \xi_i$.

comparative advantages.

⁷ Hence, intervention on the export side, ξ_i has a small impact on the product price, especially if this is happening in any country i . The price index from CES objective function, assuming $\sigma < 1 + \theta$ and the relationship between the parameter and the price index is $P_j =$

$\gamma \phi_j^{-1/\theta}$ where $\gamma = \left[\Gamma \left(\frac{\theta+1-\sigma}{\theta} \right) \right]^{\frac{1}{1-\sigma}}$

⁸ This allows deriving the standard structural gravity system including domestic frictions

To sum up:

- $c_i = w_i \xi_i$ means that containment positive constitutes an additional cost for domestic production. In general, the rise of costs would lead to an increase in prices or to some variation in the volume of goods sold by i and the purchase from j .
- [Eaton and Kortum \(2002\)](#) mechanism helps to explain that a worldwide domestic shock affects international trade about the volume of domestic production and sales-generating an overall decrease of that volume but keeping constant the share of bilateral trade. In other words, the effect of a policy has a negative effect in terms of volume, but it has contained the damage.

Now it is possible to derive a gravity model based on [Eaton and Kortum \(2002\)](#):

$$X_{ij} = \frac{Y_i E_j}{Y} \left(\frac{t_{ij}}{\Pi_i P_j} \right)^{-\theta}$$

where:

- X_{ij} bilateral trade flows from exporting country i to importing country j
- $t_{ij} = \tau_{ij} \xi_i$, τ_{ij} determinants of trade between countries i and j including bilateral trade barriers, bilateral and ξ_i captures unilateral frictions.
- Y_i total value of production in country i : $Y_i = X_{ii} + \sum_{i \neq j} X_{ij}$
- E_j total value of production in country j : $E_j = X_{jj} + \sum_{i \neq j} X_{ij}$
- Π_i and P_j respectively, structural outward and inward multilateral resistance terms (MRTs):

$$\Pi_i = \sum_j \left(\frac{t_{ij}}{P_j} \right)^{-\theta} \frac{E_j}{Y},$$

$$P_j = \sum_j \left(\frac{t_{ij}}{\Pi_i} \right)^{-\theta} \frac{Y_i}{Y}$$

The Multilateral Resistance Terms, *inward* P_j and *outward*, P_i , introduced to make the gravity model theoretical founded by [Anderson and van Wincoop \(2003\)](#) are relevant structural terms both for academics and policy analysis. These help the investigation of aggregate trade costs. They capture their asymmetries controlling for the unobservable "resistances" to trade specifically of exporter and importer by time, and also between country pairs.

The parameter θ has a similar role of the elasticity of substitution, σ , in [Armington \(1969\)](#) and [Anderson \(1979\)](#). The difference is that σ refers to preferences, θ measures technology heterogeneity.

For this paper, the relevant properties of multilateral resistances concern how they channel and capture the trade diversion effect. Therefore, they are essential to assess the difference between the domestic and international trade flows and how country-specific responses to the pandemic.

3.4 Data

This section describes the data sources, starting with the dependent variable, monthly trade and our methods to obtain monthly domestic sales through the imputation of monthly production. Then, we present the data and how we construct the explanatory variables for the econometric analysis.

3.4.1 Dependent Variable: Trade

The sample for the analysis contains 14 exporting countries and 212 importers. The data for international trade are from COMTRADE.⁹ The domestic sales are built using UNIDO INDSTAT2 data, combining data and the index of yearly production

⁹ <https://marketplace.officialstatistics.org/un-comtrade-monthly>

and the Index of Industrial Production (monthly), we obtain monthly production values from January to September 2020. Imputing domestic trade flows has two constraints: 1) country coverage of UNIDO production data and the monthly industrial production index, and 2) since internal flows are the differences between total production and total exports in a few cases, we got negative values, and we decided to drop the countries instead of making other imputation/adjustments. Hence, we kept 14 countries in all the estimates to have a sample size comparable across different specifications.

Measuring Domestic Gross Production and Domestic Sales

The importance of having domestic flows is pointed out above. Here we present how to obtain them. Since trade data are in gross terms¹⁰ it is preferred not to obtain them subtracting total exports by Gross Domestic Product (GDP).¹¹

The assumption is data-driven, and the annual values are re-proportioned by the monthly index. This procedure requires two steps. The first step measures the monthly values of domestic production for the index base year (2015). Secondly, it is possible to derive the value of 2020 production.

As a chemist doses the component for an experiment, here is done the same to compute base year monthly production:

$$Production_{i,t_{2015}} = \frac{Production_{i,y=2015} \times IIP_{i,t_{2015}}}{1200} \quad (3.7)$$

where t_y is the month of year y . Then the 2020's values:

$$Production_{i,t_{2020}} = \frac{Production_{i,t_{2015}} \times IIP_{i,t_{2020}}}{IIP_{i,t_{2015}}} \quad (3.8)$$

¹⁰ from our knowledge there are not any high-frequency trade data in value added

¹¹ GDP at ant frequency is expressed in value-added.

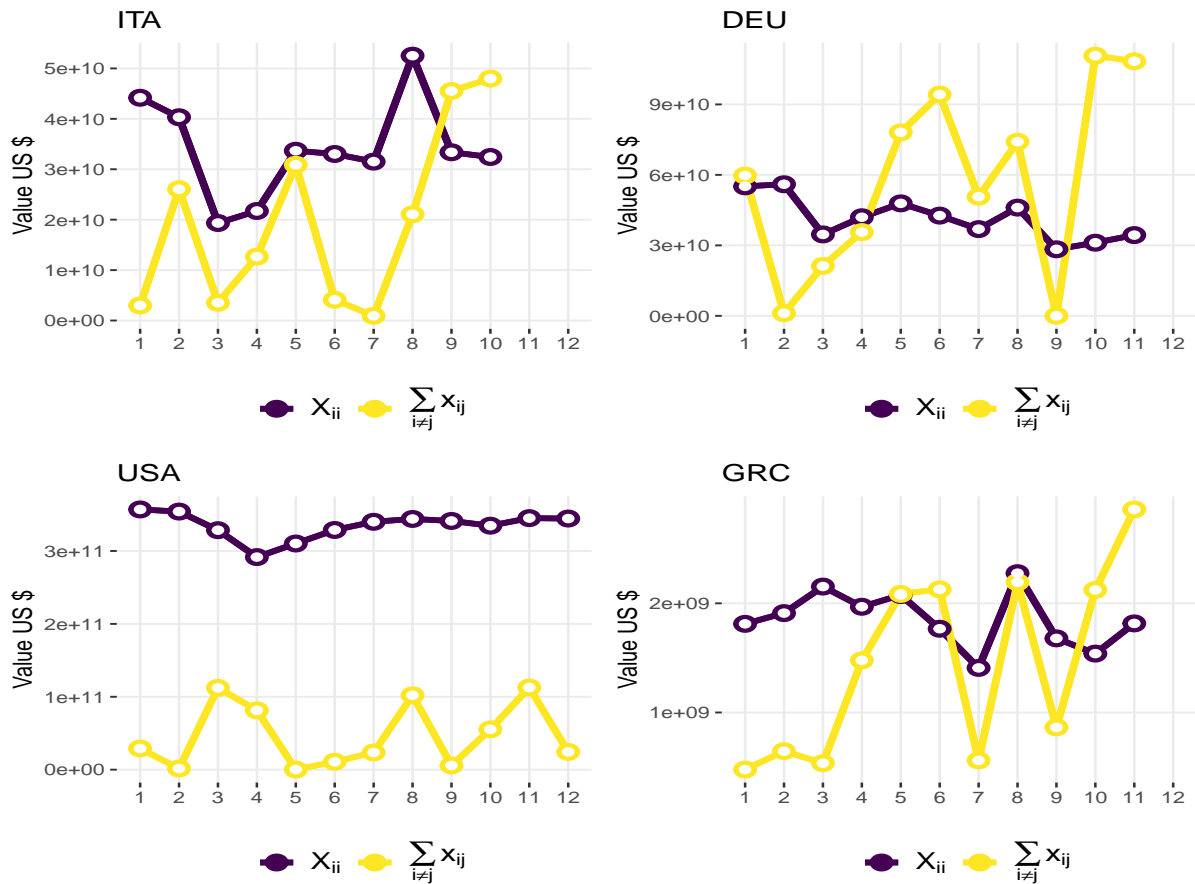
Finally, obtain the domestic sales included in the estimates:

$$X_{ii,t_{2020}} = \text{Domestic Sales}_{i,t_{2020}} = \text{Prod}_{i,t_{2020}} - \text{Total Exports}_{i,t_{2020}} \quad (3.9)$$

Figure 3.1 reports four examples of domestic (X_{ii} in blue) and international ($\sum_{i \neq j} X_{ij}$, yellow) in 2020 by month. The interesting fact that emerges from these graphs is that there are different behaviour:

- Internal exchange of goods is always higher than international. A large domestic market offset, for the whole period, drop and volatility of international trade (Figure 3.1, USA)
- The international and domestic trends fluctuate both, we can assume a compensation between these two. In the case of Italy (Figure 3.1, ITA), domestic sales are predominant and for Germany (Figure 3.1, DEU) international flows. This particular behaviour would be since both are in the EU.
- An example of a small economy (at least the smallest of the sample) like Greece (Figure 3.1, GRC) shows similar flows to the other European countries, but the range of variation is relatively small.

Figure 3.1: Selected Trends of Domestic and International Flows, 2020



Source: Author's elaboration on COMTRADE and the measures obtained by UNIDO INDSTAT2 and Industrial Index of Production

3.4.2 Explanatory Variables

The explanatory variables concern country-specific features that measure the direct effect of domestic policies as the institutional response measured by the stringency index and other indirect implications such as workers' mobility and maritime traffic.

Institutional Response: is measured by the Stringency Index computed by *Oxford's Covid-19 Government Response Tracker*¹², it is an index about the restrictiveness of containment policies. which takes into account all ordinal containment and closure

¹² Downloaded by https://raw.githubusercontent.com/OxCGRT/covid-policy-tracker/master/data/OxCGRT_latest.csv, updated almost in real time

policy indicators¹³ and an indicator for public information campaigns.¹⁴

Labor: an index that measures the flows of workers related to the closure of activities and "smart working" policies offered by the *Google's COVID-19 Community Mobility Reports*.¹⁵ It calculates a positive or negative percentage that records trends by region, across different kinds of locations, here it is used just the one regarding workplaces. It shows two ways of variation: one considers people flows in workplaces by baseline days which is a usual value for that day of the week (the median value from the 5th week, Jan 3 – Feb 6 2020).

Infrastructure: to capture the effect of infrastructure related to the pandemic, we measure maritime traffic passing by the country's ports. These data are from COM-TRADE's COVID-19 monitor, obtained by AIS technology, and provide the number of port calls by country. Then is computed a measure of the different rates of port traffic in references to 2019 in the same month:

$$Port\ calls\ rate_{i,t} = \frac{calls_{i,t_{2020}} - calls_{i,t_{2019}}}{calls_{i,t_{2019}}} \quad (3.10)$$

After the presentation of the three main explanatory variables, now we show the correlation with total exports. In panel (a) of Figure 3.2 it is evident that at the beginning of the year, only a few countries took stringency measures and these were barely strict. In the following months, the government responses are heterogeneous across countries and even the drop and recovery of export volumes. It means that the timing of the impact of containment policies varies by the country's economy. Looking at this graph US and Germany recorded a relatively high level of export when the

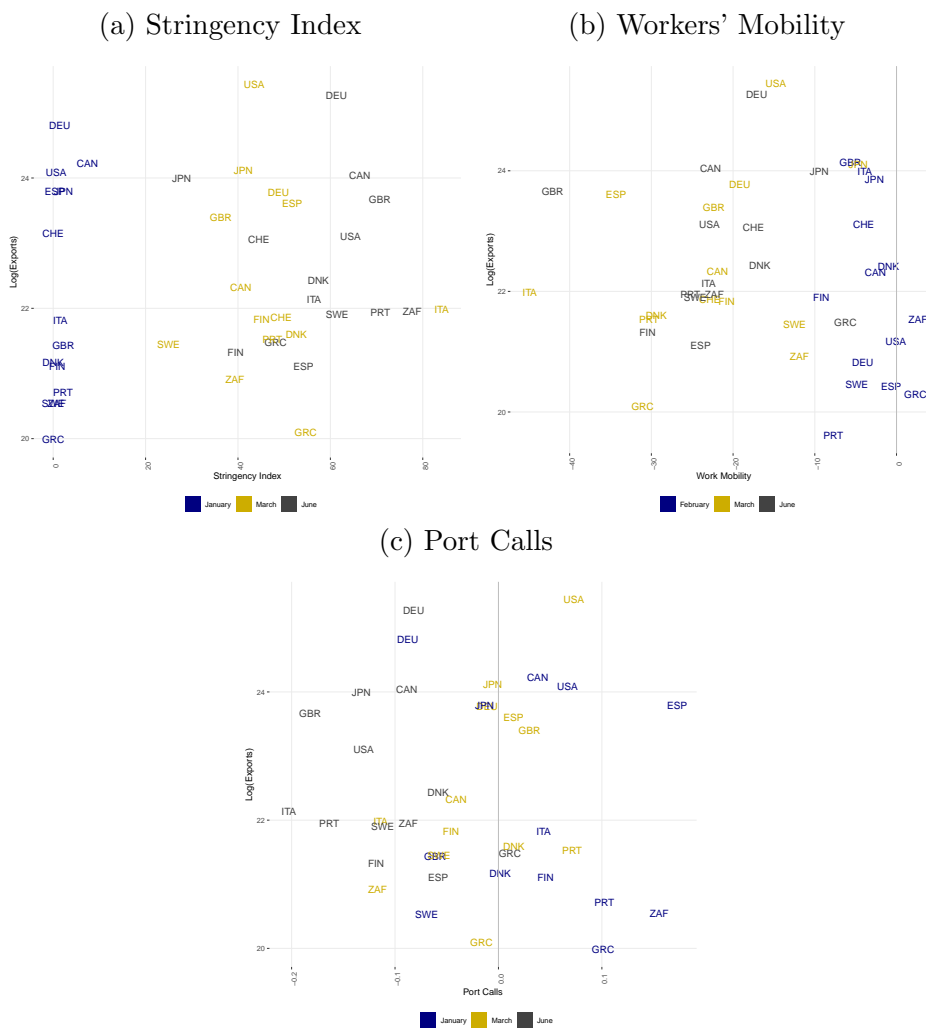
¹³ In detail these are: school and workplaces closing, cancel of public events, restriction on gatherings, interruption of public transportation, stay at home requirements, restriction on internal movements and international travel control

¹⁴ It measures the Record presence of public info campaigns on an ordinary scale, looking at no Covid-19 information at all and the official public campaign and the coordinated ones (includes also social media)

¹⁵ <https://www.google.com/covid19/mobility/>

stringency rise. Furthermore, the most relevant impact on the intensive margin of trade comes out by looking at the annual level instead of the monthly trends. In panel (b) of Figure 3.2 which focuses on work mobility and panel (c) on port calls, there is not a clear common pattern but still, the effect is heterogeneous and suggests that exports reaction to such shocks varies by country and by time. These point out the relevance of including high dimensional fixed effects in the econometric specification.

Figure 3.2: Shock and Exports Volume



Source: Author's elaboration

The bilateral variables, $GRAV_{ij}$, are from CEPII, and we used the bilateral weighted distances, contiguity, common official languages and colonial linkages.

3.5 Empirical Strategy

The estimates relate to the literature on gravity and non-discriminatory trade policies and country-specific features (Beverelli et al., 2023; Heid et al., 2021; Sellner, 2019b). The aim is to measure the effect of domestic shocks, in terms of institutional responses and labour and infrastructure, generate by the covid-19 pandemic on international trade related to domestic sales. The variable $INTL_{ij}$, equal one for $i \neq j$ and zeros otherwise, allows the identification of the effect of unilateral variables on international trade flows relative to the intra-national flows. It would be different if it is possible to give a specific value for $i \neq j$ and one for $i = j$ Unfortunately, this is not possible in our framework. A further limitation of this method measures the impact either for the exporter's or the importer's sides because using the same variable on both sides, for both i and j generates collinearity. The following estimates consider just the exporters' side.

The baseline estimates apply a Pseudo Maximum Likelihood Poisson (PPML) because it allows measuring for trade flows in level and including zeros reducing heteroskedasticity (Santos Silva and Tenreyro, 2006). According to Yotov (2022b), including domestic sales assures those gravity estimations are consistent with the theory of the intensive margin of trade, allows for a systematic analysis of the determinants of domestic trade costs and also investigates country-specific asymmetries in international trade costs. Moreover, adding the internal component ensures that estimates do not fall in the *gold medal mistake* (Baldwin and Taglioni, 2006) controlling for unidirectional, time and pair fixed effects. All the estimates concern a panel setting for nine (eight for Equation 3.12) consecutive months: to take into account adjustment to policy changes instead of using interval the approach suggested by Egger et al. (2020) to specify gravity with pair fixed effects and consecutive-time data.

$$X_{ij,t} = e^{[\eta_{i,t} + \chi_{j,t} + \mu_{ij} + GRAV_{ij,t} \beta + \gamma_1 STRINGENCY_{i,t} \times INTL_{ij} + \gamma_2 CONTROL_{ij,t-1}] + \varepsilon_{ij,t}} \quad (3.11)$$

- $\eta_{i,t}$: exporter-time fixed effects
- $\xi_{j,t}$: importer-time fixed effects
- μ_{ij} : bilateral fixed effects
- $GRAV_{ij,t}/\beta$: the set of gravity variables (log of distances, contiguity, colonial link, common language)
- $\gamma_1 STRINGENCY_{i,t} \times INTL_{ij}$: ξ_i represented by the index on the stringency of policies response to the pandemic. $INTL_{ij}$ is equal to 1 for $i \neq j$, it captures the effect of policies on export relative to domestic sales.
- $\gamma_2 CONTROL_{ij,t-1}$: a dummy equals 1 for trade in the same month in the previous year between pairs. It controls for seasonality and path dependence, a similar approach proposed by [Morales et al. \(2019\)](#).

$$X_{ij,t} = e^{[\eta_{i,t} + \chi_{j,t} + \mu_{ij} + GRAV_{ij,t}/\beta + \gamma_3 WORK_MOBILITY_{i,t} \times INTL_{ij} + \gamma_2 CONTROL_{ij,t-1}] + \varepsilon_{ij,t}} \quad (3.12)$$

where $\gamma_3 WORK_MOBILITY_{i,t}$ is the index proposed by Google described in Section 3.4.

$$X_{ij,t} = e^{[\eta_{i,t} + \chi_{j,t} + \mu_{ij} + GRAV_{ij,t}/\beta + \gamma_4 PORT_CALLS_RATE_{i,t} \times INTL_{ij} + \gamma_2 CONTROL_{ij,t-1}] + \varepsilon_{ij,t-1}} \quad (3.13)$$

where $\gamma_4 PORT_CALLS_RATE_{i,t}$ measures the effect of a variation of maritime traffic in reference to the previous year in the same month.

The theoretical interpretation of the γ_1 coefficients, since it is based on the methods of [Heid et al. \(2021\)](#), deriving the marginal effect of ξ_i from the log transformation of the trade shares π_{ij} and making the difference between internal and domestic is:

$$\gamma_i = \frac{\partial \pi_{ij}}{\partial \xi_i} - \frac{\partial \pi_{jj}}{\partial \xi_i} = -\theta(\pi_{jj} - \pi_{ij}) \quad (3.14)$$

where the expected sign is negative, meaning that higher frictions reduce trade concerning domestic sales. The value of θ is positive by the literature. A crucial role is played by $\pi_{jj} - \pi_{ij}$, which usually is positive since domestic sales are larger than international. The magnitude of the effect depends on the difference between the two dimensions. However, given γ_3 and γ_4 refers to a per cent change the value of these two coefficients is expected to be positive according to our prediction. In the theory, these are trade costs and affect trade negatively. However, since these are changes, we expect for the negative values of these that trade decreases, while when these are positive it increases. More in detail, γ_3 is the coefficient for work mobility, then fewer workers are actively involved in production (especially for manufactured goods) which generates a slowdown of trade with respect to the domestic market. Then, γ_4 which proxies the changes compare to 2019 of maritime traffic the logic is the same. Fewer boats (negative change) are entering a country port, compared to the previous year in the same month, and fewer goods are shipped abroad (international trade reduction with respect to domestic sales).

3.6 Results

Institutional Response: Tables 3.1 and 3.2 show that the Stringency Index have a heterogeneous impact on international trade relative to domestic sales. In column (1) in Table 3.1, the coefficient estimated with directional fixed effects is negative, meaning a decrease of almost 2% in trade volume. In columns 2 to 4 (all including pair fixed effects but with different settings for each) the significant coefficient is positive,

and its value is great (0.10) with paired and directional fixed effects. It suggests that the effect of stringency policy harms the volume of trade: however, controlling for pairs, this drop is not the only channel. The control dummy variable for trade in 2019 says that, on average, trade patterns are not disrupted. It suggests that perhaps the seasonality and the timing of export flows are different, but it is too early to assess if Covid-19 radically changed these relationships. Therefore, containment policies would lead to a drop in exports maintaining alive multilateral commercial relationships and mitigating the effect of the pandemic.

Table 3.2 looks at the effect of stringency level considering only bilateral relationships. In this case, the coefficients are not always statistically relevant. In column (4), the only significant sign is the same as in column (2) of Table 3.1. In line with the theoretical framework, containment policies make total production more costly. At the same time, other countries can spend less to buy from foreign markets. Thus, prices adjust given the lower volumes of sales and trade shares do not vary significantly.

Labour: Table 3.4 and 3.5 measures the impact of workplace mobility and the related closure or remote-working solutions. As for the previous estimates, changing the set of fixed effects leads to different signs and significance of the coefficients. The unidirectional fixed effects (column 1 Table 3.4) generate a positive sign for variation in workers' mobility, which intuitively stays for less labour less trade, and vice versa. On the other hand, including pair fixed effects (columns 2-4 Table 3.4) the signs turn positive, and only one (column 4) is significant. The interpretation, as already said, is that workers' mobility is due to temporary closure and re-openings and smart-working solutions: therefore, the effect is heterogeneous. Such adjustments to the workforce and working conditions can impact labour costs by increasing efficiency in production processes with positive consequences on export volume. However, work reorganization, such as the implementation of remote working solutions, may also have a negative effect by potentially raising the cost of the labour force. Although, some specific sectors and activities are gaining from this situation.

Table 3.5, looking only at the international dimension assesses that the positive relationship between trade and labour is predominant. Furthermore, Table 3.6 measures the opposite: the effect of labour shock on domestic sales relative to international. The particularity of these results, which mirror the one of Table 3.4, is that signs are significant wherein the other tables are not. Since labour mobility impacts more on the domestic dimension than on international trade. Comparing Tables 3.1 and 3.3 the coefficients have opposite signs but are always significant.

Infrastructure: To test the role of infrastructure on the consequence of covid-19 on international trade, Tables 3.7 and 3.8 display the results for the variable *Port calls ratios* that compares traffic in 2020 to the one in 2019 in the same month. Column 1 of Table 3.7 has the only relevant results. The relationship is positive, which means that trade decreases if the maritime traffic by country ports is lower than in the previous year. In this case, also looking at the estimates based only on international flows (Table 3.8) the sign is confirmed (just in column 5) and changing the fixed effect setting does not lead to any significant results. The infrastructure's role, as ports, is reasonable and affects more export than internal flows.

Path Dependence and Seasonality: The variable *Trade in 2019: Dummy* controls for seasonality in monthly trade: it is not always verified because each country trades with their partners every month. And also, adapting the framework of [Morales et al. \(2019\)](#), it can check for the path dependence of bilateral trade. The coefficients for this dummy are positive and significant in all the estimates, the magnitude varies probably about the changing sample sizes due to the different time ranges of the shock variables and the fixed effects settings.

Production, Domestic and International Flows: a general consideration is that the pandemic affects production and trade by decreasing the volume at the early stage of the containment of the pandemic. However, after the economy adapts to the new rules, the government, through containment policies, support the economy in a critical situation. Domestic and international sales offset each other mitigating the negative

effect. Of course, winners and losers sharply come out from these results even if they look at aggregate trade, this would be more clear in a sector analysis as [Espitia et al. \(2021\)](#).

3.7 Extension

3.7.1 Literature and Motivation

Before the discussion focuses on the impact of domestic shocks on international trade. In this section, the analysis extends to consider the role of aggregate sunk costs and shock propagation, including network statistics in a gravity model.

As [Antràs \(2020\)](#) pointed out the role of firms' sunk costs similar to [Morales et al. \(2019\)](#), we wish to improve a previously unpublished work [Magerman et al. \(2013\)](#) which uses network centrality as observable measures of the "unobservable" elements in Multilateral Resistances.

Network analysis examines the centre-periphery relationship among countries in trade ([De Benedictis and Tajoli, 2011](#)). The recent work of [Vidya and Prabheesh \(2020\)](#) studied the effect of the pandemic on the international trade network in the earlier stage, using network centrality measures to describe changes that happened during the early months of 2020.

The work aims to distinguish the features and the dynamics of networks observed on the yearly dimension from the monthly. The annual trade network is the sum of the linkages accumulated during a whole year with different time-frequency for each pair of countries and depending on the goods exchanged. In other words, if Italy and China trade in 2020 (or any year) is not always true that they trade every month, especially for some types of products. Furthermore, network statistics can help to explain latent variables related to the small sample size and the empirical analysis proposed here.

3.7.2 Intuition and Theory

This paper focuses on one network centrality measure, *weighted out-closeness*. Data are taken from CEPII and refer to 2010. Updating these results needs a validation process because some values are slightly different from CEPII dataset.

Weighted out-closeness measured by [Benedictis et al. \(2014\)](#), is a measure of how close a node is related to all other nodes. It uses the shortest path between country i and country j , and also defined the geodesic distance between i and j , to count the number of steps needed for a given node to get to another node in the network, in trade a node is a country and the way to reach another one is exporting or importing. Given the aim of this analysis, it is considered only the export dimension taking into account out-closeness:

$$C_{COUT}^{NW} = \frac{(N-1)}{\sum_{j \neq i} \mathcal{L}_{ij}} \quad (3.15)$$

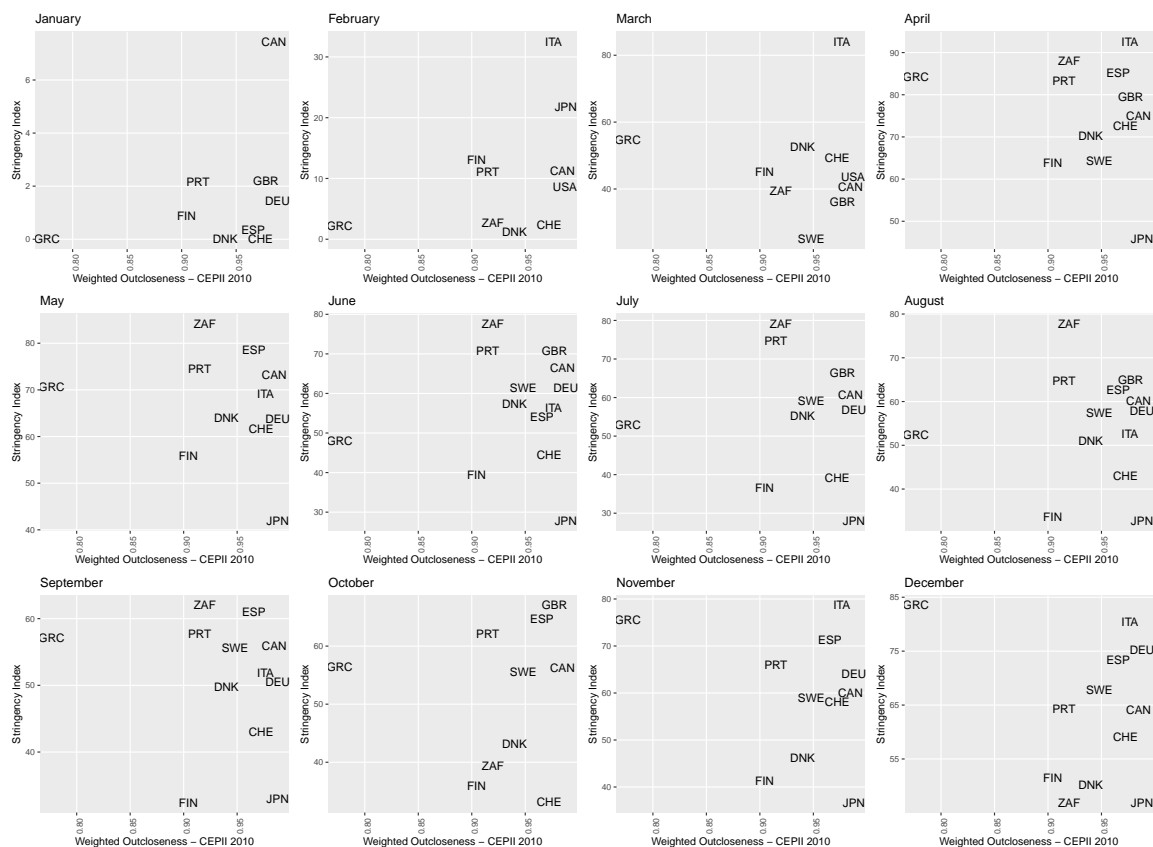
the geodesic distances are calculated over the weighted paths $\mathcal{L}_{ij} = \min(\frac{1}{\alpha_{iz_1}} + \frac{1}{\alpha_{iz_2}} + \dots + \frac{1}{\alpha_{z_{n-3}j}} + \frac{1}{\alpha_{z_{n-2}j}})$ where $\alpha_{ij} = N \frac{A}{\sum_i \sum_j A}$ is the share between pair flows over the average bilateral world trade. And z s are the intermediate steps needed to reach a node.

Intuition

This section discusses if *weighted out-closeness* would be the proper candidate to measure country reactivity to immediate shocks and their propagation. For this framework, network centrality measures are a proxy of aggregate sunk costs that firms in a country have been facing over time. Moreover, they define the position of a country in an international trade network. As described in [Morales et al. \(2019\)](#) firm's sunk costs represent the effort made in advertisements, recruitment, legal and quality adaptation to different standards for exporting, reducing language biases.

Institutional Response: Figure 3.3 shows how the correlation between weighted out closeness and stringency index varies month by month in 2020. At first, Greece (GRC) is the most peripheral country in the sample. At the beginning of 2020, it does not significantly react to COVID. Between March and November 2020, the containment policies follow other European countries, mainly southern (i.e. Italy, ITA, Spain, ESP). An interesting fact is that most countries in the European continent (also Great Britain, GBR) increase and decrease the stringency level simultaneously. Switzerland (CHE) behave more independently. Also, North American countries act very similarly and follow European trends. Remote countries such as South Africa (ZAF) and Japan (JPN) show a slightly different timing in response, the last has applied less severe intervention after April 2020.

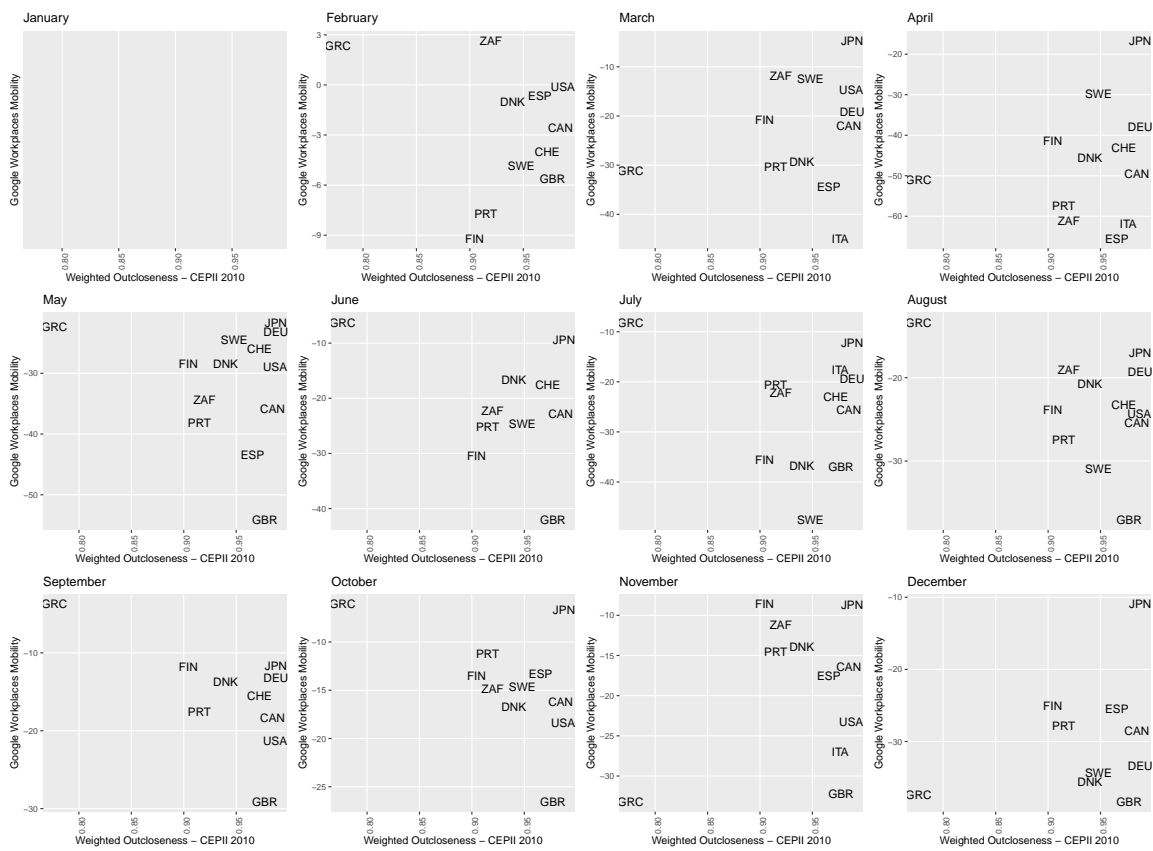
Figure 3.3: Weighted Out-Closeness (2010, CEPII) and Stringency Index



Source: Author's elaboration on CEPII Network centrality measures and Oxford Government Response Tracker data

Work Mobility: Figure 3.4 contains the same visualization exercise as before for Google Community Mobility. The first slot is empty because data collection started in February 2020. The picture is almost similar. In these graphs, the upper part regards lower shock in labour. Japan, one of the farthest (in geographic terms) country in the sample shows the lowest level (even if negative) for this shock. Until October, Greece, which has very close values, is more remote than the other given its closeness values.

Figure 3.4: Weighted Out-Closeness (2010, CEPII) and Google Workplaces Mobility

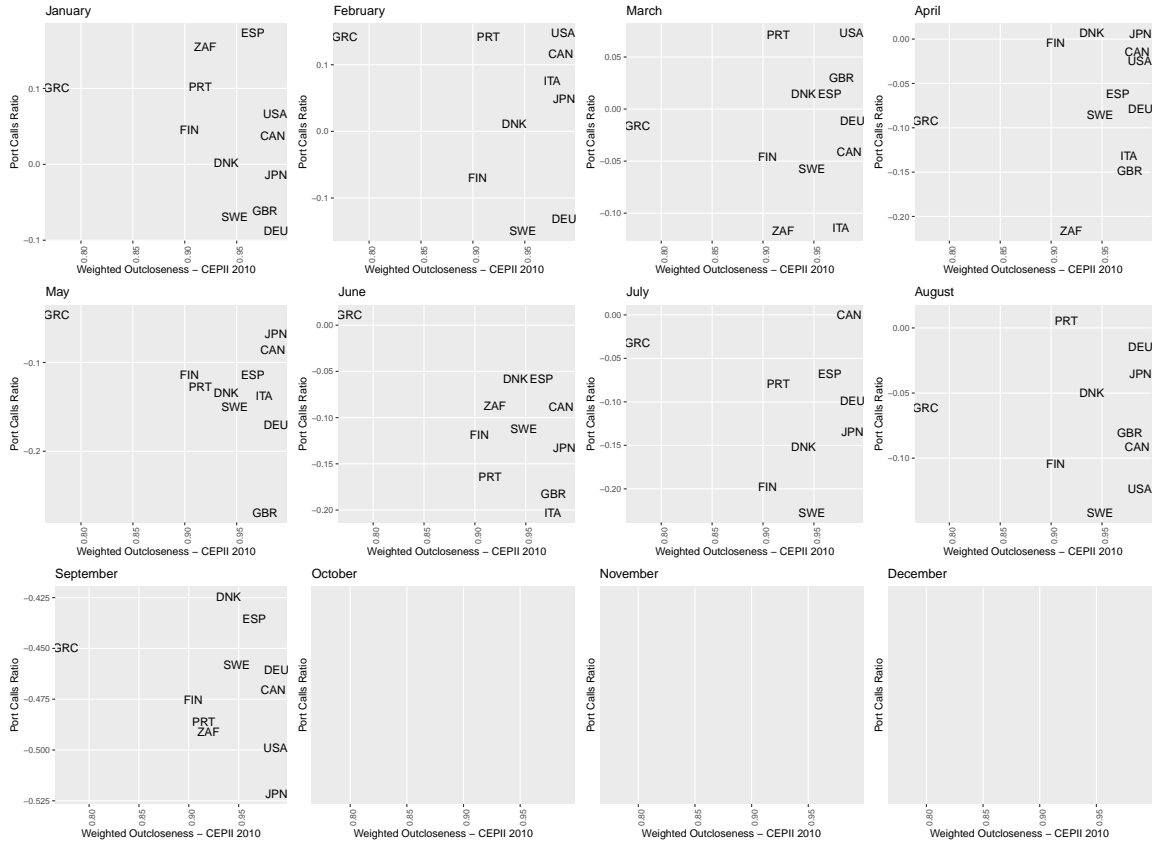


Source: Author's elaboration on CEPII Network centrality measures and Google's Community Mobility Report data

Infrastructure: Figure 3.5 looks at the maritime traffic by country-ports. Before April just a few countries recorded different drops in vessel transit compared to the previous year. Unfortunately, this data stops in September 2020, still, a peripheral country

such as Greece (GRC) seems to be less affected by lockdown policies.¹⁶ Japan which is an island recorded a serious drop. European and North American Countries show very heterogeneous behaviour.

Figure 3.5: Weighted Out-Closeness (2010, CEPII) and Port Calls Ratio



Source: Author's elaboration on CEPII Network centrality measures and COMTRADE Port Calls data

Theory

As discussed in Section 3.3, the network centrality measure enters the cost function affecting the cost of the overall production:

$$p_{ij} = \frac{c_i}{z_i(\omega)} \tau_{ij} \quad (3.16)$$

¹⁶ Greece also counts on a large internal maritime traffic due to the high number of islands on their sovereignty

in this case, $c_i = c_i \nu_i \xi_i$ where $\xi_i \in [1, \bar{\xi}]$ and $\nu_i \geq 0$ is the aggregate level of sunk cost the firms in a country collected across time to obtain certain features of production and the position in the international network (either trade or GVCs). This measure has the property of reducing or amplifying the effect of the shock. In other words, depending on the accumulated sunk costs of firms in their activity (patents, attracting high skills workers, legal and/or language capacity related to doing business abroad) react differently to the type of shock.

3.7.3 Empirical Strategy

The empirical model is a structural gravity estimated with Poisson Pseudo Maximum Likelihood, with bilateral panel data including directional and paired fixed effect.

First, the investigation is on the identification of the weighted out closeness ($WOUTCLOSENESS_i$) effect, using the approach for country-specific features (Heid et al., 2021):

$$X_{ij,t} = e^{[\eta_{i,t} + \chi_{j,t} + \mu_{ij} + GRAV_{ij,t} \beta + \gamma_5 WOUTCLOSENESS_i \times INTL_{ij} + \gamma_2 CONTROL_{ij,t-1}]} \quad (3.17)$$

The centrality measure is time-invariant, not allowing the identification with paired fixed effect, so it is multiplied by the dummy for past trade linkages ($CONTROL_{ij,t-1}$).

$$X_{ij,t} = e^{[\eta_{i,t} + \chi_{j,t} + \mu_{ij} + GRAV_{ij,t} \beta + \gamma_6 WOUTCLOSENESS_i \times CONTROL_{ij,t-1}] + \varepsilon_{ij,t}} \quad (3.18)$$

After the understanding of this variable by itself, it is combined for each shock (institutional response, labour and infrastructure).¹⁷

¹⁷ Here sectors are not included, this approach is inspired by the estimates of Espitia et al. (2021)

$$X_{ij,t} = e^{[\eta_{i,t} + \chi_{j,t} + \mu_{ij} + GRAV_{ij,t} \beta + \gamma_i (WOUTCLOSENESS_i \times SHOCK_{i,t}) + \gamma_2 CONTROL_{ij,t-1}] + \varepsilon_{ij,t}} \quad (3.19)$$

3.7.4 Results

Network Centrality Measures: in the first column of Table 3.10, the coefficient for the network statics is negative and significant, meaning that countries with a relevant position in trade networks (high level of out closeness) are more sensitive to trade volatility in the high-frequency trade data. The control variable for active trade linkages in the previous year is not statistically significant. Suggesting that closeness is a good predictor of capturing structural features of trade. In column 2, including gravity variables and directional fixed effect, the closeness and control dummy combination gives the same sign but a lower coefficient magnitude. In the other column, the sign is positive with pair fixed effects.

Institutional Response: Table 3.11 measures the nexus of trade and political intervention, and results are similar to the baseline estimates. Column 1 considers gravity plus exporter and importer fixed effects and shows a negative correlation. While in the other estimates with paired fixed effect, the sign is positive.

Labour: Table 3.12 shows a similar mechanism in the results, the directional fixed effects and the gravity variables lead to a positive and negative sign (Column 1) while substituting gravity with pair fixed effects, the size reduces and the sign becomes negative.

Infrastructure: Table 3.13 there is only a statistically significant result, the basic setting, the rest (pair fixed effects) do not produce any relevant coefficients. A reasonable interpretation, this variable catches a country-specific feature, and it is not crucial for specific dyads. Probably, bilateral measures of maritime trade would capture better the effect.

3.8 Appendix

3.8.1 Stringency Index Effect

Table 3.1: January to September 2020: Stringency = 0 for $i = j$

PPML 2020				
VARIABLES	(1) Exports	(2) Exports	(3) Exports	(4) Exports
Stringency Index (i,t)	-0.021*** (0.004)	0.004** (0.002)	0.006*** (0.002)	0.010*** (0.003)
Trade in 2019: Dummy	0.328*** (0.086)	0.235*** (0.083)	0.239*** (0.082)	0.153** (0.076)
Constant	31.061*** (0.571)	24.252*** (0.075)	24.223*** (0.075)	24.338*** (0.071)
Observations	26,208	24,858	24,858	24,743
GRAVITY	YES	NO	NO	NO
Pair FE	NO	YES	YES	YES
Importer X Month FE	YES	NO	NO	YES
Exporter X Month FE	YES	NO	NO	YES
Month FE	NO	NO	YES	NO
Cluster SE	Pair	NO	NO	NO

Clustered robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1

Table 3.2: January to September 2020: Only international ($i \neq j$) flows

PPML 2020							
VARIABLES	(1) Exports	(2) Exports	(3) Exports	(4) Exports	(5) Exports	(6) Exports	(7) Exports
Stringency Index (i,t)	0.002 (0.002)	0.004*** (0.001)	0.002 (0.002)	-0.007 (0.007)	-0.001 (0.005)	-0.002 (0.005)	0.004*** (0.001)
Trade in 2019: Dummy	0.038 (0.116)	0.244** (0.116)	-0.054 (0.109)	0.056 (0.109)	0.253** (0.109)	-0.042 (0.103)	0.186* (0.101)
Constant	20.899*** (1.306)	24.149*** (1.211)	23.156*** (1.237)	21.335*** (1.423)	24.375*** (1.307)	23.282*** (1.229)	26.436*** (0.570)
Observations	26,586	26,586	26,586	26,586	26,586	26,586	26,586
GRAVITY	YES	YES	YES	YES	YES	YES	YES
Exporter FE	NO	YES	NO	NO	YES	NO	YES
Importer FE	NO	NO	YES	NO	NO	YES	YES
Month FE	NO	NO	NO	YES	YES	YES	NO
Cluster SE	Pair	Pair	Pair	Pair	Pair	Pair	Pair

Clustered robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1

Table 3.3: January to September 2020: Stringency = 0 for $i \neq j$

PPML 2020				
VARIABLES	(1) Exports	(2) Exports	(3) Exports	(4) Exports
Stringency Index (i,t)_intra	0.022*** (0.004)	-0.003*** (0.000)	-0.005*** (0.001)	-0.010*** (0.003)
Trade in 2019: Dummy	0.327*** (0.085)	0.204** (0.085)	0.223*** (0.083)	0.153** (0.076)
Constant	30.096*** (0.619)	24.407*** (0.077)	24.461*** (0.091)	24.791*** (0.140)
Observations	26,208	24,858	24,858	24,743
GRAVITY	YES	NO	NO	NO
Pair FE	NO	YES	YES	YES
Importer X Month FE	YES	NO	NO	YES
Exporter X Month FE	YES	NO	NO	YES
Month FE	NO	NO	YES	NO
Cluster SE	Pair	NO	NO	NO

Clustered robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1

3.8.2 Workplaces Mobility Effect

Table 3.4: January to September 2020: Google Workplaces Mobility = 0 for $i = j$

PPML 2020				
VARIABLES	(1)	(2)	(3)	(4)
	Exports	Exports	Exports	Exports
Google Workplaces Mobility (i,t)	0.045*** (0.008)	0.002 (0.003)	0.000 (0.003)	-0.012** (0.005)
Trade in 2019: Dummy	0.408*** (0.094)	0.205** (0.089)	0.210** (0.089)	0.162** (0.082)
Constant	31.176*** (0.541)	24.303*** (0.079)	24.292*** (0.079)	24.353*** (0.069)
Observations	23,324	22,072	22,072	21,982
GRAVITY	YES	NO	NO	NO
Pair FE	NO	YES	YES	YES
Importer X Month FE	YES	NO	NO	YES
Exporter X Month FE	YES	NO	NO	YES
Month FE	NO	NO	YES	NO
Cluster SE	Pair	NO	NO	NO

Clustered robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Table 3.5: January to September 2020: Only international ($i \neq j$) flows

PPML 2020							
VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Exports	Exports	Exports	Exports	Exports	Exports	Exports
Google Workplaces Mobility (i,t)	0.008** (0.003)	0.002 (0.002)	0.009*** (0.003)	0.034*** (0.007)	0.034*** (0.007)	0.036*** (0.005)	0.002 (0.002)
Trade in 2019: Dummy	-0.031 (0.101)	0.196* (0.105)	-0.127 (0.092)	0.001 (0.101)	0.222** (0.100)	-0.079 (0.091)	0.159* (0.089)
Constant	21.540*** (1.297)	24.530*** (1.173)	23.628*** (1.097)	22.304*** (1.268)	25.278*** (1.134)	24.253*** (0.921)	26.770*** (0.573)
Observations	23,632	23,632	23,632	23,632	23,632	23,632	23,632
GRAVITY	YES	YES	YES	YES	YES	YES	YES
Exporter FE	NO	YES	NO	NO	YES	NO	YES
Importer FE	NO	NO	YES	NO	NO	YES	YES
Month FE	NO	NO	NO	YES	YES	YES	NO
Cluster SE	Pair	Pair	Pair	Pair	Pair	Pair	Pair

Clustered robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Table 3.6: January to September 2020: Google Workplaces Mobility = 0 for $i \neq j$

PPML 2020				
VARIABLES	(1) Exports	(2) Exports	(3) Exports	(4) Exports
Google Workplaces Mobility (i,t)	-0.045*** (0.008)	0.005*** (0.001)	0.010*** (0.002)	0.012** (0.005)
Trade in 2019: Dummy	0.408*** (0.094)	0.206** (0.089)	0.213** (0.088)	0.162** (0.082)
Constant	30.243*** (0.584)	24.377*** (0.080)	24.443*** (0.085)	24.605*** (0.123)
Observations	23,324	22,072	22,072	21,982
GRAVITY	YES	NO	NO	NO
Pair FE	NO	YES	YES	YES
Importer X Month FE	YES	NO	NO	YES
Exporter X Month FE	YES	NO	NO	YES
Month FE	NO	NO	YES	NO
Cluster SE	Pair	NO	NO	NO

Clustered robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

3.8.3 Maritime Port Traffic Effect

Table 3.7: January to September 2020: Port Calls Rate = 0 for $i = j$

PPML 2020				
VARIABLES	(1) Exports	(2) Exports	(3) Exports	(4) Exports
Port Calls Rate (i,t)	2.527*** (0.560)	0.027 (0.262)	-0.053 (0.271)	-0.009 (0.482)
Trade in 2019: Dummy	0.584*** (0.172)	0.203** (0.084)	0.197** (0.083)	0.125 (0.081)
Constant	31.436*** (0.695)	24.320*** (0.075)	24.325*** (0.074)	24.473*** (0.073)
Observations	26,208	24,858	24,858	24,743
GRAVITY	YES	NO	NO	NO
Pair FE	NO	YES	YES	YES
Importer X Month FE	YES	NO	NO	YES
Exporter X Month FE	YES	NO	NO	YES
Month FE	NO	NO	YES	NO
Cluster SE	Pair	NO	NO	NO

Clustered robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1

Table 3.8: January to September 2020: Only international ($i \neq j$) flows

PPML 2020							
VARIABLES	(1) Exports	(2) Exports	(3) Exports	(4) Exports	(5) Exports	(6) Exports	(7) Exports
Port Calls Ratio (i,t)	-0.183 (0.288)	0.064 (0.261)	-0.265 (0.273)	-0.289 (0.575)	1.294*** (0.461)	-0.611 (0.519)	0.043 (0.270)
Trade in 2019: Dummy	0.037 (0.116)	0.224* (0.120)	-0.059 (0.110)	0.049 (0.112)	0.255** (0.109)	-0.043 (0.104)	0.159 (0.104)
Constant	20.959*** (1.272)	24.335*** (1.188)	23.191*** (1.205)	20.957*** (1.277)	24.463*** (1.195)	23.169*** (1.208)	26.618*** (0.580)
Observations	26,586	26,586	26,586	26,586	26,586	26,586	26,586
GRAVITY	YES	YES	YES	YES	YES	YES	YES
Exporter FE	NO	YES	NO	NO	YES	NO	YES
Importer FE	NO	NO	YES	NO	NO	YES	YES
Month FE	NO	NO	NO	YES	YES	YES	NO
Cluster SE	Pair	Pair	Pair	Pair	Pair	Pair	Pair

Clustered robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1

Table 3.9: January to September 2020: Port Calls Rate = 0 for $i \neq j$

PPML 2020				
VARIABLES	(1) Exports	(2) Exports	(3) Exports	(4) Exports
Port Calls Ratio (i,t)	-2.527*** (0.560)	0.128 (0.087)	0.294 (0.194)	0.009 (0.482)
Trade in 2019: Dummy	0.584*** (0.172)	0.204** (0.085)	0.204** (0.084)	0.125 (0.081)
Constant	31.204*** (0.695)	24.328*** (0.076)	24.342*** (0.076)	24.474*** (0.076)
Observations	26,208	24,858	24,858	24,743
GRAVITY	YES	NO	NO	NO
Pair FE	NO	YES	YES	YES
Importer X Month FE	YES	NO	NO	YES
Exporter X Month FE	YES	NO	NO	YES
Month FE	NO	NO	YES	NO
Cluster SE	Pair	NO	NO	NO

Clustered robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1

3.9 Appendix Extension

3.9.1 Weighted Out Closeness

Table 3.10: Weighted Out-Closeness (Jan - Sep. 2020)

VARIABLES	PPML 2020				
	(1) Exports	(2) Exports	(3) Exports	(4) Exports	(5) Exports
W - Out Closeness - CEPII	-2.415*** (0.185)				
Trade in 2019: Dummy	0.024 (0.063)				
W Out Clos X Trade 2019		-0.591*** (0.134)	0.209** (0.088)	0.201** (0.086)	0.129 (0.084)
Constant	30.216*** (0.452)	32.184*** (0.775)	24.476*** (0.017)	24.479*** (0.015)	24.569*** (0.010)
Observations	26,208	26,208	24,858	24,858	24,743
GRAVITY	YES	YES	NO	NO	NO
Pair FE	NO	NO	YES	YES	YES
Importer X Month FE	YES	YES	NO	NO	YES
Exporter X Month FE	YES	YES	NO	NO	YES
Month FE	NO	NO	NO	YES	NO
Cluster SE	Pair	Pair	NO	NO	NO

Clustered robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

3.9.2 Weighted Out Closeness and Stringency Index

Table 3.11: Stringency Index and Weighted Out-Closeness (Jan - Sep. 2020)

VARIABLES	PPML 2020			
	(1) Exports	(2) Exports	(3) Exports	(4) Exports
W Out Clo X Stringency	-0.022*** (0.004)	0.004** (0.002)	0.006*** (0.002)	0.010*** (0.003)
Trade in 2019: Dummy	0.326*** (0.085)	0.235*** (0.083)	0.240*** (0.082)	0.154** (0.076)
Constant	31.082*** (0.572)	24.251*** (0.075)	24.223*** (0.075)	24.337*** (0.071)
Observations	26,208	24,858	24,858	24,743
GRAVITY	YES	NO	NO	NO
Pair FE	NO	YES	YES	YES
Importer X Month FE	YES	NO	NO	YES
Exporter X Month FE	YES	NO	NO	YES
Month FE	NO	NO	YES	NO
Cluster SE	Pair	NO	NO	NO

Clustered robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1

3.9.3 Weighted Out Closeness and Workplaces Mobility

Table 3.12: Work Mobility and Weighted Out-Closeness (Jan - Sep. 2020)

VARIABLES	PPML 2020			
	(1) Exports	(2) Exports	(3) Exports	(4) Exports
W Out Clo X Work Mobility	0.047*** (0.008)	0.002 (0.003)	0.000 (0.003)	-0.013** (0.006)
Trade in 2019: Dummy	0.406*** (0.093)	0.205** (0.089)	0.210** (0.089)	0.161* (0.082)
Constant	31.194*** (0.543)	24.302*** (0.079)	24.291*** (0.079)	24.352*** (0.069)
Observations	23,324	22,072	22,072	21,982
GRAVITY	YES	NO	NO	NO
Pair FE	NO	YES	YES	YES
Importer X Month FE	YES	NO	NO	YES
Exporter X Month FE	YES	NO	NO	YES
Month FE	NO	NO	YES	NO
Cluster SE	Pair	NO	NO	NO

Clustered robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1

3.9.4 Weighted Out Closeness and Port Calls Ratio

Table 3.13: Port Calls and Weighted Out-Closeness (Jan - Sep. 2020)

VARIABLES	PPML 2020			
	(1) Exports	(2) Exports	(3) Exports	(4) Exports
W Out Clo X Port Calls Ratio	2.610*** (0.580)	0.040 (0.271)	-0.039 (0.280)	0.018 (0.500)
Trade in 2019: Dummy	0.583*** (0.171)	0.203** (0.084)	0.197** (0.083)	0.125 (0.081)
Constant	31.442*** (0.695)	24.321*** (0.075)	24.326*** (0.074)	24.474*** (0.073)
Observations	26,208	24,858	24,858	24,743
GRAVITY	YES	NO	NO	NO
Pair FE	NO	YES	YES	YES
Importer X Month FE	YES	NO	NO	YES
Exporter X Month FE	YES	NO	NO	YES
Month FE	NO	NO	YES	NO
Cluster SE	Pair	NO	NO	NO

Clustered robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1

Conclusion

The common goal of the three essays is to provide a framework that allows the inclusion of country-specific variables (that cannot necessarily assume as trade costs) into a structural gravity framework, both theoretically and empirically. The three exercises propose different issues: *i*) modelling productivity contribution of production factors for the estimation of their effect on trade and to compute their specific parameters. *ii*) considering latent factors that determine fundamental productivity, the advantage of using unilateral variables instead of self-constructed bilateral measure and the robustness of using these measures also for a general equilibrium analysis and addressing the analysis to policy matters. Finally, *iii*) the framework developed in the previous chapters is also feasible to give more theoretical background to the case in which the object of the analysis is domestic friction.

The first chapter proposes a theoretical interpretation of the two methods of [Heid et al. \(2021\)](#) and [Freeman et al. \(2021\)](#), giving an outline to understand the effect of productivity contribution of the production factor (in this case, the parameter to density sensitivity of labour) and the relationship of international and domestic sales. Even if the formalization is slightly different, the results of the two methods converge. Especially, when considering manufacturing and mining, the effect of agriculture, forestry and fisheries is less clear, probably due to the heterogeneity within the industries of a such broad sector. A further remark, given the robustness checks with alternative density measures, suggests that I caught an effect related to the concept of *lumpiness*, where the spatial distribution of production factors determines

specialization and performance.

The attention is pointed to the manufacturing sector. Thus, the parameter η (measuring density sensitivity similarly to [Allen and Arkolakis \(2014\)](#) and [Allen et al. \(2020\)](#)), obtained by both methods tends to zero if the technology heterogeneity parameter governing comparative advantage, θ , increases. The central value of η for the value of θ relevant for the literature,¹⁸ using the first method is between 0.26 and 0.19 and with the second between 0.39 and 0.29. In both cases, the values are reasonable because they do not predict an explosive effect of labour productivity on total output.

Therefore further applications of this chapter concern:

- create a unified framework with sub-national and national dynamics as in [Ramondo et al. \(2016\)](#);
- tests the validity of the η parameter in a *Quantitative Trade Model* as [Dekle et al. \(2008\)](#) and to understand implications in structural changes of the economy.
- Including dynamics, adapting the framework of [Anderson et al. \(2020\)](#) modelling population dynamics as transitional growth which is also likely that allows also to consider path dependence and persistence as in [Allen and Donaldson \(2020\)](#)
- includes in the theory and the empirical part the concepts and measurements of localization and specialization, the usage of the relative or absolute version of such indexes. Aiming to adapt this work also to the urban and regional economics literature.

The chapter on domestic institutions and trade offers another way to use the interpretation of the impact of country-specific features determining fundamental productivity. The econometric and the general equilibrium analysis confirm the positive effect

¹⁸ according to [Eaton and Kortum \(2002\)](#) and [Costinot et al. \(2012\)](#) I consider values of θ between 6 and 8

that good institutions have on international trade and welfare.

The empirical outcomes assess that it is better to use variables that capture institutional functioning at the country level. Firstly because other unilateral variables, such as the legal system, are harder to interpret and may be affected by other latent factors. Secondly, bilateral variables, even if robust, may be influenced by the way by which these are constructed. If these are made through a linear transformation the problem of perfect collinearity with the fixed effects remains. Moreover, the interpretation of the coefficient is less intuitive than using the original values. The sectoral analysis does not give significant results for the marginal contribution of contract intensity, while a more interesting outcome regards the role of bilateral cultural ties. The interplay with dyadic cultural features reveals interesting insights, as for sure they play a role together with a more formal measure of contract enforcement. The cultural contributions alone reveal the relevance of religious proximity, which lasts both in the aggregate and in the sectoral analysis. Furthermore, languages are crucial in sectoral trade and also with the contract intensity of each industry. We obtain different results if use relationship stickiness, the average effect of domestic institutions is positive and significant as well as the marginal contribution of more "sticky" industries, with this variables the role of culture is less robust.

The counterfactual exercise predicts gains from trade given an improvement in the institutional quality of those countries far below the average standard. Hence, reaching the mean value of the Rule of Law implies an increase of the real value of national output by around 15% and reaching the peak of almost 30% for the export value. Countries with "bad" institutions (baseline negative value) but with relevant trade shares would face less improvement in welfare but still, they will improve the value of their exports (i.e. Russia and China). The effect on prices is controversial since the greater rise in domestic prices compensates for the drop in import prices. A sensitivity analysis, to check if these results are biased, proves that these are because just a group of countries varies their baseline institutional quality. If the change happens

to anyone and at a certain threshold (plus 0.5 in this case), the odd effect on prices disappears, and the increase in the real value of total output is due to a rise in the value of both prices.

The future research related to this chapter regards:

- better investigation on cultural ties, exploiting better the brand new cultural distances measures from [De Benedictis et al. \(2020\)](#)¹⁹;
- modelling endogenous institutions;
- a model with more production factors;
- a framework that investigates the complementarity of substitutability of formal and informal institutions;

The last chapter offers several suggestions to apply a structural gravity to high-frequency data, controlling for seasonality in monthly flows, and exploiting new data sources generated from the growing trend of *Nowcasting*. The measure of domestic flows I proposed seems to be helpful and does not bias the outcome. This work attempts to put the gravity model in contact with network analysis. The results agree on the contraction of the volume of trade due to the domestic consequence that the pandemic had, both directly (shut down) and indirectly (labour mobility and maritime traffic). The control for seasonality²⁰ suggests that, at the aggregate level, there is not a substantial disruption of trade linkage. The relevant effect remains the drops in the volume of exchanged goods

It is just a starting point, the paper suffers from data availability since most of the explanatory variables have been made available since the beginning of the pandemic.

¹⁹ Using this data and exploiting the different dimensions that the authors propose gives interesting results that here are omitted just for the coherence with the main research question. In some cases, when including bilateral measures the variable of domestic institutions is omitted

²⁰ a dummy measuring if the trade link was active in the same month of the previous year

It is difficult to find other values with a wider time horizon. However, a relevant extension of this framework will be to analyse the relations between multilateral resistance in different time dimensions (monthly, quarterly and yearly). This would help in the advance of the literature on dynamic gravity as [Anderson and Yotov \(2020\)](#). And also to give rigorous tools to understand global economic matters in almost real-time.

Résumé en Français

Aperçu

La thèse vise à étendre et enrichir la littérature sur la gravité structurelle, en particulier en fournissant de nouvelles applications et une interprétation théorique des méthodes de [Heid et al. \(2021\)](#) et [Freeman et al. \(2021\)](#) pour l'analyse des variables unilatérales (caractéristiques propres aux pays, politiques nationales ou politiques commerciales unilatérales).

Le modèle de gravité a célébré ses 60 ans depuis sa première apparition dans [Tinbergen \(1962\)](#). Le succès est dû au fait qu'il s'agit d'un cadre intuitif et théoriquement fondé avec également une forte capacité prédictive. De plus, la faisabilité de son environnement offre l'opportunité de créer de nouvelles contributions précieuses à la fois à la littérature en économie internationale et pour répondre aux questions politiques ([Yotov, 2022a](#)). Les applications concernent à la fois l'analyse économétrique et l'analyse en équilibre général lorsque cela est approprié.

L'objectif principal de ce travail, en raison de la flexibilité du cadre de gravité structurelle, est de fournir un cadre qui prend en compte la "productivité fondamentale" (géographie, climat, infrastructures et institutions ayant un impact sur la productivité des producteurs dans un pays et un secteur donnés) telle que définie dans [Costinot et al. \(2012\)](#), à la fois sur le plan théorique et empirique.

Deux exercices visent à étendre et mettre à jour les résultats d'autres articles nécessaires

tels que [Redding and Venables \(2004b\)](#) en ce qui concerne la géographie économique, [Levchenko \(2007\)](#) et [Nunn \(2007\)](#) dans l'étude des institutions et du commerce. Tous ces travaux, en raison du timing, n'exploitent pas la dimension bilatérale des flux commerciaux, le rôle des ventes intérieures et le contrôle des termes de résistance multilatérale. Ici, je propose une manière de fusionner les nouvelles avancées de la littérature, comme les travaux susmentionnés de [Heid et al. \(2021\)](#) et [Freeman et al. \(2021\)](#), mais aussi [Allen et al. \(2020\)](#), avec la littérature antérieure. Le principal objectif est de progresser dans la résolution du problème de colinéarité parfaite entre les variables unilatérales et l'ensemble des effets fixes (comme dans [Heid et al. \(2021\)](#)) et de lui donner une base théorique supplémentaire. L'espoir est qu'il inspirera et facilitera davantage d'investigations sur ces sujets. De plus, je propose une application pour des questions politiques actuelles, telles que la pandémie de Covid-19, afin de mieux comprendre les conséquences économiques qui en découlent. Ce dernier exercice a pour objectif supplémentaire d'utiliser la gravité avec des données de référence élevées (commerce mensuel) pour fournir des instruments aux décideurs politiques pour prendre des décisions à court terme.

Chapitre 1. Densité de population et performance à l'exportation des pays

.

L'objectif principal de l'article est de décrire théoriquement et empiriquement l'effet de la densité de population sur le commerce international, en utilisant un cadre théorique basé sur [Allen and Arkolakis \(2014\)](#) et [Allen et al. \(2020\)](#) pour dériver un modèle de gravité structurel qui identifie l'effet des caractéristiques spécifiques des pays sur les exportations bilatérales et évalue leur contribution par le calcul de paramètres spécifiques. Le modèle offre une interprétation théorique de l'approche empirique développée par [Heid et al. \(2021\)](#) pour mesurer les effets des variables de politique unilatérale dans un modèle de gravité structurel ancré théoriquement, qui surmonte la colinéarité parfaite avec les effets fixes de l'importateur et de l'exportateur,

nécessaires pour contrôler les termes de résistance multilatérale (Baldwin and Taglioni, 2006). De plus, notre cadre théorique décrit comment les parts du commerce intérieur et international affectent la valeur du coefficient estimé.

L'accent mis sur la densité de population en tant que composante de la productivité et en tant que déterminant des forces d'agglomération, (Allen and Arkolakis, 2014; Bakker et al., 2021; Duranton and Puga, 2004; Moscona and Levy, 2022; Rosenthal and Strange, 2004) permet de tester *l'hypothèse* selon laquelle la densité de population affecte également la spécialisation des pays. L'abondance des facteurs de production et leur répartition spatiale au sein d'un pays ont des conséquences sur les avantages comparatifs et les gains du commerce (Courant and Deardorff, 1992,9). Par conséquent, les pays avec une grande densité de population se spécialisent dans des activités économiques plus intensives en main-d'œuvre, tandis que d'autres se spécialisent soit dans des industries plus intensives en terres (ressources naturelles), soit diversifient leur production.

L'analyse examine la contribution de la concentration de la population du côté de l'offre de l'économie intérieure, enrichissant le débat sur la densité et l'agglomération (principalement étudiés aux niveaux urbain et régional) pour comprendre les implications de la répartition spatiale des facteurs de production au niveau macro pour différents secteurs et pour la spécialisation des flux commerciaux. Nous proposons une méthode pour mesurer la sensibilité à la densité comme dans Moscona and Levy (2022), mais notre approche utilise les flux commerciaux bilatéraux et nous permet également de quantifier la contribution de la densité de population en tant que fondement de la productivité. Cela conduit à des résultats conformes à Combes et al. (2012), en tenant compte du niveau macro et des flux commerciaux internationaux.

Le cadre présente des éléments communs avec la *Nouvelle économie géographique*,

²¹ mais modélise la géographie, comme Allen and Arkolakis (2014) et Allen et al.

²¹ Cette branche de la littérature comprenait des effets d'échelle liés aux externalités marshalliennes, au coût du transport des marchandises entre les lieux et aux différentes structures de marché. Ainsi, les caractéristiques de modélisation concernent les préférences CES comme Dixit

(2020). L'une des originalités de l'approche proposée est de relier la littérature sur la gravité structurelle pour estimer des variables unilatérales (Freeman et al., 2021; Heid et al., 2021; Sellner, 2019a), la *Nouvelle économie géographique* et l'économie spatiale quantitative (Redding and Rossi-Hansberg, 2017).

Les résultats suggèrent que la densité de population compte davantage dans les industries intensives en main-d'œuvre (manufacturières). Un changement de 1% de la densité de population entraîne une variation de 0,3% des exportations par rapport aux ventes intérieures, tandis que l'effet direct est légèrement supérieur à 0,5%. En revanche, les activités dépendant des ressources naturelles, telles que l'extraction minière, montrent une corrélation négative, tant pour l'impact relatif que pour l'effet direct. La contribution à l'agriculture, à la sylviculture et à la pêche est estimée de manière robuste, car les signes et la significativité ne sont pas cohérents. Ces résultats controversés offrent l'opportunité d'une nouvelle analyse autonome examinant les différences des différents secteurs agricoles.

Chapitre 2: Institutions nationales et commerce international, enquête empirique et implications politiques

.

Le deuxième chapitre, *Institutions nationales et commerce international : enquête empirique et implications politiques*, se concentre principalement sur l'approche de Heid et al. (2021) et l'applique à l'analyse du lien entre les institutions nationales et le commerce, tant du point de vue économétrique que dans le cadre d'une analyse en équilibre général. Similaire à Beverelli et al. (2018), mais différent parce que les institutions sont modélisées comme des facteurs de productivité fondamentale et que l'enquête empirique étudie les différentes implications du fonctionnement institution-

and Stiglitz (1977), les coûts commerciaux des icebergs comme Samuelson (1952), et l'évolution de l'ordinateur (c'est-à-dire la possibilité de réaliser des simulations informatiques ou des solutions du modèle, en particulier lorsque la complexité des cadres augmente). Dans une vaste littérature, certaines des références pertinentes sont Krugman (1979), Krugman (1980), Fujita et al. (1999)

nel (qualité) et de la forme (système juridique), de l'interaction avec les liens culturels bilatéraux et également de l'effet hétérogène dans plusieurs industries en utilisant la définition et la mesure de l'intensité des contrats fournies par Nunn (2007). Les implications en équilibre général sont étudiées avec un exercice contrefactuel visant à éclairer ce qui se passerait si tous les pays avaient de bonnes institutions.

Le 16e objectif de développement durable - *PAIX, JUSTICE ET INSTITUTIONS EFFICACES* - affirme : "Nous ne pouvons pas espérer un développement durable sans paix, stabilité, droits de l'homme et gouvernance efficace, basés sur l'état de droit".²² Ce travail vise à répondre à la question suivante : *Comment les institutions nationales influencent-elles le commerce international?* Tout d'abord, en modélisant les institutions en tant que déterminants de la productivité fondamentale, puis en testant empiriquement *i*) si le fonctionnement (qualité institutionnelle) est plus ou moins pertinent que la forme (système juridique)²³, *ii*) l'interaction entre les institutions nationales et les liens culturels bilatéraux (proximité et distances), *iii*) les différences entre les industries et l'intensité contractuelle associée²⁴, et *iv*) en réalisant un exercice contrefactuel pour évaluer les gains (ou pertes) potentiels en termes de bien-être d'une qualité institutionnelle moyenne à l'échelle mondiale.

La contribution théorique élargit les modèles gravitationnels du côté de l'offre tels que Eaton and Kortum (2002) et Costinot et al. (2012), en incorporant les institutions nationales en tant que déterminants des fondamentaux de la productivité. Ainsi, les institutions sont considérées comme des sources d'avantages comparatifs à la manière de Levchenko (2007), mais dans un contexte multi-pays.²⁵ Le cadre facilite l'interprétation des résultats des modèles gravitationnels structurels avec des variables

²² Source : Page web du PNUD (https://www.undp.org/sustainable-development-goalsutm_source=EN&utm_medium=GSR&utm_content=US_UNDP_PaidSearch_Brand_English&utm_campaign=CENTRAL&c_src=CENTRAL&c_src2=GSR&gclid=CjwKCAiAy_CcBhBeEiwAcoMRHEWjYv6WWfdpBRIS26HVRsNT71K4_bg8oyLbEWuojWYgoZbafNj1VxoCkZcQAvD_BwE#peace-justice-and-strong-institutions)

²³ (Islam and Reshef, 2012)

²⁴ (Levchenko, 2007; Nunn, 2007)

²⁵ Le modèle présenté ici est plus simple que celui de Levchenko (2007), mais il prend en compte théoriquement et empiriquement plusieurs importateurs et exportateurs.

spécifiques à chaque pays comme dans [Heid et al. \(2021\)](#), tout en étendant cette application à des variables qui englobent plus que les coûts commerciaux unilatéraux. L'analyse nous permet également de tester les conclusions liées aux caractéristiques spécifiques aux relations par secteur (comme discuté dans [Nunn \(2007\)](#) et [Martin et al. \(2020\)](#)) au niveau bilatéral. De plus, l'exercice contrefactuel permet d'obtenir des implications politiques conformes au Programme 2030.

L'analyse des institutions en tant que variables spécifiques à chaque pays est plus facile à interpréter et produit des résultats robustes. Le cadre, à la fois empiriquement et théoriquement, est adaptable et peut être facilement étendu pour englober plusieurs secteurs. Le rôle de la culture est important mais nécessite des recherches supplémentaires pour distinguer les implications de différentes dimensions culturelles et leur corrélation avec les caractéristiques géographiques. En suivant la méthodologie de [Heid et al. \(2021\)](#), les résultats contribuent aux discussions politiques à travers un exercice contrefactuel, à la manière de [Beverelli et al. \(2023\)](#), pour explorer les implications en termes de bien-être d'une qualité institutionnelle accrue. Cet article confirme et enrichit les conclusions des travaux antérieurs en élargissant le nombre de pays dans l'analyse et en utilisant un scénario contrefactuel distinct.

Pour distinguer les impacts distincts des institutions nationales selon les industries, nous élargissons le modèle pour incorporer des mesures spécifiques aux relations pour chaque secteur, ce qui aide à interpréter la spécification empirique. Les principaux résultats sont obtenus en utilisant la "stickiness" relationnelle de [Martin et al. \(2020\)](#), révélant que l'état de droit influence positivement le commerce en ce qui concerne les ventes nationales. Dans cette spécification, nous examinons également l'interaction des liens culturels bilatéraux, bien que ces liens ne présentent pas de signification statistique. En utilisant l'intensité contractuelle de [Nunn \(2007\)](#), la contribution marginale de l'état de droit dans les secteurs plus intensifs en contrats n'est pas significative. Dans ces estimations, le rôle de la culture est plus important mais moins robuste.

Chapitre 3: L'effet des politiques nationales sur le commerce international, une leçon tirée de la Covid-19

Le troisième chapitre, *L'effet des politiques nationales sur le commerce international : une leçon tirée de la Covid-19*, diffère du précédent, car il considère les politiques nationales comme des frictions simples contenues dans le vecteur des coûts commerciaux. Cette hypothèse permet d'évaluer l'impact sur le premier mois de la pandémie en examinant l'effet direct des politiques nationales (en examinant l'indice de rigidité du suivi des politiques d'Oxford) et l'effet indirect à travers l'effet sur la mobilité de la main-d'œuvre (données Google) et sur le trafic maritime (données sur les escales portuaires fournies par COMTRADE). Comme autre élément d'originalité, je propose une méthode pour estimer la production nationale mensuelle afin d'inclure les ventes intérieures et de conserver également les propriétés de la gravité structurelle²⁶. De plus, je propose aussi une extension dans laquelle j'essaie d'inclure une analyse de réseau dans une gravité structurelle avec des données à haute fréquence.

La pandémie de Covid-19 et les politiques associées ont affecté l'économie depuis 2020. La maladie "nouvelle" s'est répandue rapidement et (presque) simultanément dans tous les pays du monde. Les gouvernements ont fait face à un défi sans précédent en termes de réponse à court terme. Les économies mondiales sont durement touchées par les différents types d'interventions pour contenir la contagion, à la fois directement et indirectement.

Dans ce travail, nous voulons répondre à une question simple : *Quel est l'effet des politiques de confinement liées à la pandémie sur le commerce international?* Cette question simple conduit à une meilleure compréhension de la relation entre la production nationale, les ventes internationales et nationales, et l'implication de l'intervention exogène à court terme. Les politiques de gestion des crises sanitaires

²⁶ Sur la pertinence des ventes intérieures pour l'application des modèles de gravité structurelle, voir [Yotov \(2021\)](#)

affectent différentes dimensions de la société (distanciation sociale, couvre-feu, fermeture des écoles, restrictions de déplacement) et de l'économie (télétravail, fermeture d'activités économiques particulières). La variété des interventions rend difficile la prévision et l'évaluation des implications pour l'économie nationale et les conséquences sur la dimension internationale.

La réponse à la question de recherche teste l'hypothèse sur l'effet de la réponse institutionnelle directe et l'effet indirect qui examine les conséquences sur la mobilité professionnelle et le rôle de l'infrastructure. De plus, il teste la saisonnalité et la dépendance au chemin ([Morales et al., 2019](#)) car le commerce mensuel a des tendances différentes des flux annuels.

Pendant la première vague de la pandémie (qui a commencé en mars 2020), les principales organisations internationales étaient extrêmement pessimistes quant aux conséquences économiques. Le FMI dans les Perspectives de l'économie mondiale prévoyait une croissance négative du PIB pour l'ensemble de l'économie. Comparé à la crise de 2008, beaucoup plus de pays ont été affectés négativement, même des pays comme la Chine et l'Inde qui avaient résisté à un tel choc de propagation lors de la précédente récession mondiale ([IMF-WEO, 2020](#)). Les prévisions de l'OMC d'octobre dernier estimaient une baisse du commerce mondial de marchandises de 9,2

Depuis le début, la pandémie consiste en un choc d'offre et de demande. Le premier est dû à une baisse des exportations et le second à la chute des importations associée. La principale menace pour les secteurs manufacturiers était (et peut-être est toujours) la perturbation de l'offre et de la demande. Tout d'abord, cela a frappé les pays d'Asie de l'Est, les principaux fournisseurs d'intermédiaires et de biens finaux des économies industrielles plus importantes. De plus, les composantes macroéconomiques de la demande agrégée ont diminué drastiquement. De plus, l'incertitude élevée a affecté les comportements de consommation et d'investissement ([Baldwin and Mauro, 2020](#)). Les décideurs de ces mois sont toujours confrontés à un compromis entre les stratégies de lutte contre la maladie et la protection de l'économie. Ils essaient de trouver le

bon équilibre avec des combinaisons à haute fréquence de règles de restriction et de mesures de soutien qui rendent difficile l'évaluation de l'impact sur l'économie.

Ce travail vise à évaluer l'impact des chocs de la Covid-19 sur le commerce international et à contribuer à la littérature sur les politiques commerciales non discriminatoires et les caractéristiques spécifiques aux pays. Nous proposons une nouvelle méthode pour estimer la production nationale mensuelle et obtenir les ventes nationales mensuelles. Nous souhaitons fournir de nouveaux outils pour estimer une gravité structurelle basée sur la théorie avec des données à haute fréquence.

Remarques Finales

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La dernière chapitre conclut et discute des résultats et des applications ultérieures de chaque chapitre. L'objectif commun des trois essais est de fournir un cadre permettant l'inclusion de variables spécifiques à chaque pays (qui ne peuvent pas nécessairement être considérées comme des coûts commerciaux) dans un cadre gravitationnel structurel, à la fois théoriquement et empiriquement. Les trois exercices abordent des questions différentes : *i*) modéliser la contribution de la productivité des facteurs de production pour estimer leur effet sur le commerce et calculer leurs paramètres spécifiques. *ii*) prendre en compte des facteurs latents qui déterminent la productivité fondamentale, l'avantage d'utiliser des variables unilatérales au lieu d'une mesure bilatérale auto-construite et la robustesse de l'utilisation de ces mesures également pour une analyse d'équilibre général et aborder l'analyse sous l'angle des questions politiques. Enfin, *iii*) le cadre développé dans les chapitres précédents est également applicable pour fournir un contexte théorique plus approfondi dans le cas où l'objet de l'analyse est la friction domestique.

Le premier chapitre propose une interprétation théorique des deux méthodes de [Heid et al. \(2021\)](#) et de [Freeman et al. \(2021\)](#), donnant un aperçu pour comprendre l'effet de

la contribution de la productivité du facteur de production (dans ce cas, le paramètre de sensibilité à la densité de la main-d'œuvre) et la relation entre les ventes internationales et nationales. Même si la formalisation est légèrement différente, les résultats des deux méthodes convergent. En particulier, en ce qui concerne la fabrication et l'extraction minière, l'effet de l'agriculture, de la sylviculture et de la pêche est moins clair, probablement en raison de l'hétérogénéité au sein des industries d'un secteur aussi vaste. Une remarque supplémentaire, compte tenu des vérifications de robustesse avec des mesures alternatives de densité, suggère que j'ai capturé un effet lié au concept de "lumpiness", où la distribution spatiale des facteurs de production détermine la spécialisation et la performance.

L'attention est portée sur le secteur manufacturier. Ainsi, le paramètre η (mesurant la sensibilité à la densité de manière similaire à [Allen and Arkolakis \(2014\)](#) et [Allen et al. \(2020\)](#)), obtenu par les deux méthodes, tend vers zéro si le paramètre d'hétérogénéité technologique qui régit l'avantage comparatif, θ , augmente. La valeur centrale de η pour la valeur de θ pertinente pour la littérature,²⁷ en utilisant la première méthode se situe entre 0,26 et 0,19 et avec la deuxième entre 0,39 et 0,29. Dans les deux cas, les valeurs sont raisonnables car elles ne prévoient pas un effet explosif de la productivité du travail sur la production totale.

Par conséquent, les applications futures de ce chapitre concernent :

- créer un cadre unifié avec des dynamiques infranationales et nationales comme dans [Ramondo et al. \(2016\)](#);
- tester la validité du paramètre η dans un "Modèle Quantitatif du Commerce" comme [Dekle et al. \(2008\)](#) et comprendre les implications dans les changements structurels de l'économie.
- Inclure les dynamiques, en adaptant le cadre de [Anderson et al. \(2020\)](#) en

²⁷ selon [Eaton and Kortum \(2002\)](#) et [Costinot et al. \(2012\)](#), je considère des valeurs de θ entre 6 et 8

modélisant les dynamiques de la population comme une croissance de transition, ce qui permet également de prendre en compte la dépendance au chemin et la persistance comme dans [Allen and Donaldson \(2020\)](#)

- inclure dans la théorie et la partie empirique les concepts et les mesures de localisation et de spécialisation, l'utilisation des versions relatives ou absolues de ces indices. Dans le but d'adapter également ce travail à la littérature en économie urbaine et régionale.

Le chapitre sur les institutions nationales et le commerce offre une autre façon d'utiliser l'interprétation de l'impact des caractéristiques spécifiques à chaque pays qui déterminent la productivité fondamentale. L'analyse économétrique et l'analyse d'équilibre général confirment l'effet positif que les bonnes institutions ont sur le commerce international et le bien-être.

Les résultats empiriques montrent qu'il est préférable d'utiliser des variables qui captent le fonctionnement institutionnel au niveau national. Tout d'abord, parce que d'autres variables unilatérales, comme le système juridique, sont plus difficiles à interpréter et peuvent être affectées par d'autres facteurs latents. Deuxièmement, les variables bilatérales, même si elles sont robustes, peuvent être influencées par la manière dont elles sont construites. Si elles sont créées par une transformation linéaire, le problème de la colinéarité parfaite avec les effets fixes persiste. De plus, l'interprétation du coefficient est moins intuitive que l'utilisation des valeurs d'origine. L'analyse sectorielle ne donne pas de résultats significatifs pour la contribution marginale de l'intensité contractuelle, tandis qu'un résultat plus intéressant concerne le rôle des liens culturels bilatéraux. L'interaction avec les caractéristiques culturelles dyadiques révèle des informations intéressantes, car elles jouent certainement un rôle en conjonction avec une mesure plus formelle de l'exécution des contrats. Les contributions culturelles seules révèlent la pertinence de la proximité religieuse, qui perdure à la fois dans l'analyse agrégée et sectorielle. De plus, les langues sont cruciales dans le commerce sectoriel et également avec l'intensité contractuelle de

chaque industrie.

L'exercice de contrefactuel prédit des gains commerciaux en cas d'amélioration de la qualité institutionnelle de ces pays bien en dessous de la moyenne. Ainsi, atteindre la valeur moyenne de l'État de droit entraîne une augmentation de la valeur réelle de la production nationale d'environ 15% et atteindre le pic de près de 30% pour la valeur d'exportation. Les pays avec de "mauvaises" institutions (valeur négative de référence) mais avec des parts de commerce importantes connaîtraient une amélioration moindre du bien-être, mais amélioreraient néanmoins la valeur de leurs exportations (c'est-à-dire la Russie et la Chine). L'effet sur les prix est controversé car la hausse plus importante des prix intérieurs compense la baisse des prix à l'importation. Une analyse de sensibilité, pour vérifier si ces résultats sont biaisés, prouve que ce sont les pays du groupe qui varient leur qualité institutionnelle de référence. Si le changement se produit pour n'importe qui et à un certain seuil (plus de 0,5 dans ce cas), l'effet étrange sur les prix disparaît et l'augmentation de la valeur réelle de la production totale est due à une augmentation de la valeur des prix.

Les recherches futures liées à ce chapitre concernent :

- une meilleure investigation des liens culturels, en exploitant mieux les nouvelles mesures de distances culturelles de [De Benedictis et al. \(2020\)](#)²⁸;
- la modélisation des institutions endogènes ;
- un modèle avec plus de facteurs de production ;
- un cadre qui étudie la complémentarité ou la substituabilité des institutions formelles et informelles ;

²⁸ L'utilisation de ces données et l'exploitation des différentes dimensions proposées par les auteurs donnent des résultats intéressants qui sont omis ici pour la cohérence avec la question de recherche principale. Dans certains cas, lorsque les mesures bilatérales sont incluses, la variable des institutions nationales est omise

Le dernier chapitre propose plusieurs suggestions pour réaliser une analyse à court terme à l'aide d'un modèle gravitationnel structurel, en tenant compte de la saisonnalité dans les échanges mensuels et en exploitant de nouvelles sources de données générées par la tendance croissante du "Nowcasting". La mesure des flux nationaux que j'ai proposée semble être utile et ne biaise pas les résultats. Ce travail tente de mettre le modèle gravitationnel en relation avec l'analyse des réseaux. Les résultats concordent sur la contraction du volume des échanges commerciaux en raison des conséquences nationales que la pandémie a eues, à la fois directement (fermeture) et indirectement (mobilité de la main-d'œuvre et trafic maritime). Le contrôle de la saisonnalité²⁹ suggère qu'au niveau agrégé, il n'y a pas de perturbation substantielle du lien commercial. L'effet pertinent reste la baisse du volume des biens échangés.

Ceci n'est qu'un point de départ, le document souffre d'un manque de disponibilité des données puisque la plupart des variables explicatives sont devenues disponibles depuis le début de la pandémie. Il est difficile de trouver d'autres valeurs avec une plus grande plage temporelle. Cependant, une extension importante de ce cadre consistera à analyser les relations entre la résistance multilatérale dans différentes dimensions temporelles (mensuelles, trimestrielles et annuelles). Cela aiderait à faire progresser la littérature sur la gravité dynamique comme [Anderson and Yotov \(2020\)](#). Et également à fournir des outils rigoureux pour comprendre les questions économiques mondiales en quasi temps réel.

²⁹ une variable binaire mesurant si le lien commercial était actif le même mois de l'année précédente

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