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Essays on International Trade

Theory and applications of the structural gravity model with country-specific features and domestic policies

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Introduction

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 et al. (2021) and Freeman et al. (2021) for the analysis of unilateral variables (country-specific features, domestic policies or also unilateral trade policy).

The gravity model celebrated 60 years since its first appearance in Tinbergen (1962). The success is due to the fact that it is an intuitive and theoretically grounded framework with also strong predictive power. Moreover, the feasibility of its environment gives the opportunity to create new valuable contributions both to the literature in international economics and to answer policy questions (Yotov, 2022). The applications concern both the econometric and the general equilibrium analysis when appropriate.

The main goal of this work, since the flexibility of the structural gravity, 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, such 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, due to timing, do not exploit the bilateral dimension of trade flows, the role of domestic sales and the control for multilateral resistance terms. Here, I propose a way to merge the new advance 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, I provide an application for current policy matters, such as the Covid-19 pandemic to understand its economic consequences. This last exercise has a further goal is using gravity with high reference data (monthly trade) to give instruments for policymakers to take short-run decisions.

The first chapter, *Population Density and Export Performance: Evidence from a Structural Gravity*, starts from the idea of Redding and Venables (2004) and from the more recent papers of Lévy and Moscona (2020) and Bakker (2021). Population density is a determinant of productivity, either because of the agglomeration forces arising from people's concentration (big cities, industrial clusters) or also because of the trade gains generated by the uneven (or not) distribution of resources, referring to the concept of *lumpiness* in Courant and Deardorff (1992) of Courant and Deardorff (1993). Thus, combining an adaptation of the model with geography from Allen et al. (2020) and the theoretical part of Freeman et al. (2021), I develop a model which allows estimating the impact of density on international trade taking into account the role of domestic sales. This framework eases the interpretation of the method in Heid et al. (2021) and enriches the theoretical part of Freeman et al. (2021). Moreover, it is also possible to estimate the specific effect of the parameter of labour density sensitivity of the producers which appears in Allen and Arkolakis (2014) and Allen et al. (2020). The findings suggest that density level affects trade differently by industries. In particular, those depend more on labour (manufacturing) than the ones that rely mostly on natural resources (agriculture, fishing and forestry and mining). This chapter contains the main explanation of the theoretical underpinnings used in the rest of the thesis.

The second chapter *Domestic Institutions and International Trade: empirical investigation and policy implications*, focuses mostly on the approach of Heid et al. (2021) and applies it to the analysis of the nexus between domestic institutions and trade, both from the econometric point of view and also through a general equilibrium analysis. Similar to Beverelli, Keck, Larch and Yotov (2018*b*), but it differs because institutions are modelled as factors of fundamental productivity and the empirical investigation studies the different implications of institutional functioning (quality) and the form (legal system), the interplay with bilateral cultural ties and also the heterogeneous effect in several industries using the definition and measure of contract intensity provided by Nunn (2007). General equilibrium implications are studied with a counterfactual exercise that wants to shed light on what would happen if all countries have good institutions.

The third chapter *The effect of domestic policies on international trade: a lesson from Covid-19* differs from the previous one because it considers domestic policies as simple frictions contained in the vector of trade costs. This assumption helps to assess the impact on the earliest month of the pandemic by looking at the direct effect of the national policies (the stringency index of the Oxford Policy Tracker) and the indirect effect through the effect on labour mobility (Google data) and on the maritime traffic (data on port calls provided by COMTRADE). As another element of originality, I propose a way to estimate monthly domestic production in order to include domestic sales and keep also the properties of structural gravity[1]. Moreover, I also propose an extension in which I try to include network analysis in a structural gravity with high-frequency data.

The last section concludes and discusses the results and the further applications of each chapter.

[1]On the relevance of domestic sales for the application of structural gravity models see Yotov (2021)

Chapter 1

Population Density and Export Performance: Evidence from a Structural Gravity

1.1 Introduction

Population density is recognised in the literature as a factor of fundamental productivity (Costinot et al., 2012). Most of the previous works focus on its role in production, here the attention is pointed to the effect on bilateral exports, adapting a structural gravity framework to identify and to understand theoretically how density affects export and the different implications between international and internal sales.

The challenges regarding climate change and the demographic forecasts for the following decades make understanding the implication of population density at the macroeconomic level crucial for policy design. The number of people concentrating on the land area represents the human ability to settle with respect to its capacity to adapt to geography. And also, the combination of big flourishing cities, the creation of efficient transportation networks and the endowment of natural resources affect significantly economic integration, production specialization and openness of a country. The implications on trade are also relevant because these factors shape trade patterns, export specialization and gains from trade. Furthermore, worldwide there is a high heterogeneity across countries, especially between developed and developing (and least developed) countries. For these in particular, population concentrations have different features and specific consequences on the economy.

The last projections published by the UNDESA (2022), predict that the world's population increase to 9.7 billion in 2050 albeit the growth rate is slowing down, from 1 to 0.5 between 2020 and 2050. Macro-regional differences show that Sub-Saharian African countries are likely to double their population in 2050 (from 1,401 to 2,094 million) while in Europe population will drop by around -0.05 per cent by 2050. These numbers give interesting insights into how the global economy will be shaped in the future.

Recent works shade the lights again on the nexus between trade and agglomeration. Bakker (2021) looking mostly at the firms level and Lévy and Moscona (2020) analysing sub-national flows. Differing from them, this paper wants to study the macro-level and bilateral flows. To do so, here are combined modelling features of economic geography from frameworks with the literature on structural gravity on the estimation of unilateral non-discriminatory policies and unilateral specific variables [1]. More precisely, adapting the demand-side derivation model of Freeman et al. (2021) to a supply-side version of it, in order to add a productivity function, as in Allen and Arkolakis (2014) and Allen et al. (2020), that allows to include the sensitivity to density of production factor. This theoretical effort is needed for a better interpretation of the empirical results and to provide an updated analysis, which considers directly the bilateral dimension, of the seminal work of Redding and Venables (2004).

This paper wants to contribute theoretically and empirically to the identification of country-specific features in a structural gravity model, investigating the role of eco-

[1] Heid et al. (2021), Beverelli, Keck, Larch and Yotov (2018*a*), Sellner (2019) and Freeman et al. (2021)

nomic geography and agglomeration forces at the macro level. Hence, it is organized starting from a review of the main works of the related literature (Section 1.2), and continuing with the description of the theoretical model (Section 1.3) which is the guideline for the discussion on the empirical strategy (Section 1.4) and the results in Section 1.6.

1.2 Literature Review

In the literature, the attempt to model geography and how it affects the economic system has always been a challenge. Earlier relevant contribution were provided by the *New Economic Geography*[2]. This branch tries to include scale effects related to Marshallian externalities, the cost of moving goods between locations and different market structures. The main modelling tricks 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).

Although the success of this approach over time, it received some criticism about its main assumptions. Ottaviano, Tabuchi and Thisse (2002) that wrote a fundamental theoretical contribution to the nexus between trade and agglomeration. The authors criticize the "tricks" from *New Economic Geography*. Firstly, assuming constant elasticities among varieties of goods. They formalize consumer behaviour with quasilinear utility with a quadratic sub-utility. And also the iceberg trade cost hypothesis is considered unrealistic by them. In their view, it is more likely that demand elasticity varies with distances while prices are related to the demand level and competition intensity, instead that prices vary with distances and hence trade costs.

There are many more articles dealing with the theoretical debate on this topic but

[2]Among many works, Krugman (1979), Krugman (1980) Fujita, Krugman and Venables (1999)

less concerning empirical findings on the influence of agglomeration on trade. Or more precisely, previous works mostly consider regional, urban or firm levels data. Exist a gap in the empirical literature at the country level and in particular for bilateral trade.

The seminal work of Redding and Venables (2004) offers a theoretical and empirical analysis of the effect of geography and agglomeration forces (measured by population density and urbanization level) and institutions on exports. The contribution of the theory is essential because they propose a way to model the costs of access to foreign markets(for buyers and sellers). The mathematics matches also the statistical part, and from bilateral trade data, these measures can be computed. The limit of this work is that the main analysis is done on total exports and not on bilateral flows.

Recent relevant contributions, still unpublished, on the linkages between trade and agglomeration, are from Lévy and Moscona (2020) Bakker (2021). The first, from which this paper is taking more inspiration, made a huge effort in terms of modelling combining many other works. The model builds on the Redding (2016) to consider housing/land markets. They use the productivity function including density sensitivity as in Allen and Arkolakis (2014), in a multisectoral setting as Costinot et al. (2012) to add also comparative advantages. The most interesting part is that the framework starts from the sub-national level and aggregates at national levels as in Ramondo, Rodríguez-Clare and Saborío-Rodríguez (2016). Unfortunately, the empirical part measures the impact of density just on total exports.

The article of Allen et al. (2020) aims to unify the theory behind gravity models. It proposed also a version of it including geography and agglomeration and congestion forces which is feasible both for regional/urban studies and macroeconomic investigations.

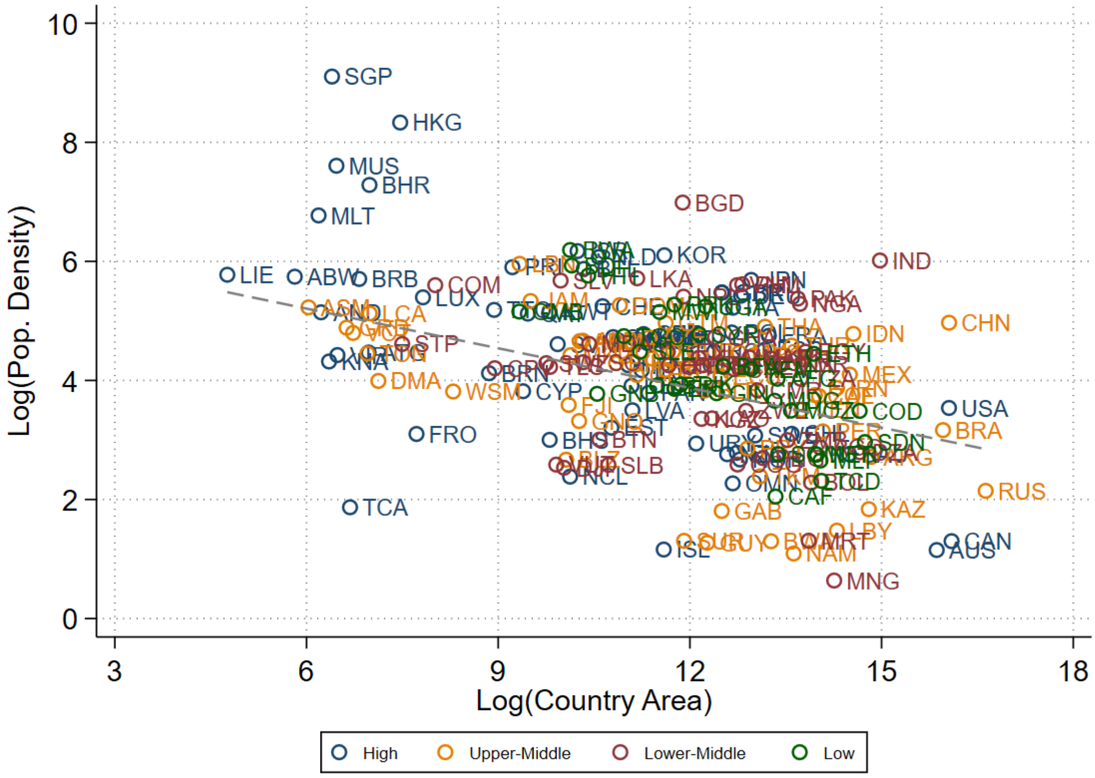
1.3 Theory

1.3.1 Background and Stylized Facts

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

Population Density, in particular at the country level, is a very slow-moving trend and it took decades to change and often by a small amount. More interesting is its correlation with country size. Obviously, larger countries should be less dense compared with those with lower areas, Figure 1.1 shows this negative correlation. On the left of the graph, there are mostly small states and islands while on the right there are most of the biggest economies. The distinction by income groups displays that on the two tails of the density distribution are located most of the richer countries belonging to high and upper middle groups with few exceptions. Whereas, poorer countries are hidden the scatter with the other wealth categories.

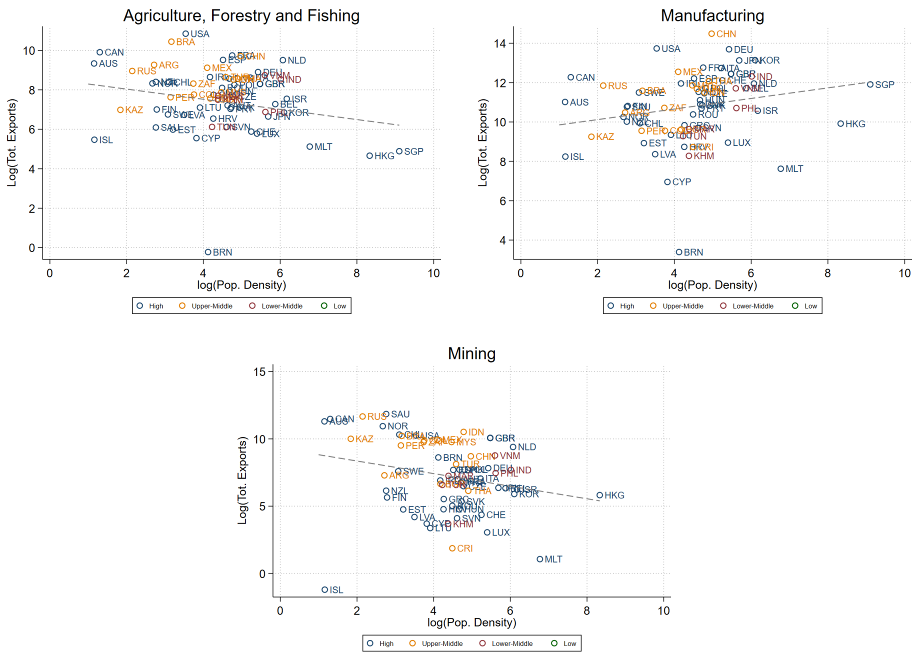
Figure 1.1: Population Density and Country Area by Income Groups



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 purpose of this paper is to shed light on the heterogeneous features of density with export performance. A further distinction is done in terms of industries, looking at broad sectors in Figure 1.2 the first relevant fact is that density affinity varies across industries. Especially, in sectors where natural resources are more involved in the production process (i.e. Agriculture and Mining), population concentration is negatively correlated with the total amount of international sales. In contrast, in the manufacturing sector where labour forces (and sure also technology) are massively employed in production happens the opposite. This intuition is crucial both for the definition of the parameter in the theoretical section and also for the interpretation of the econometric specification.

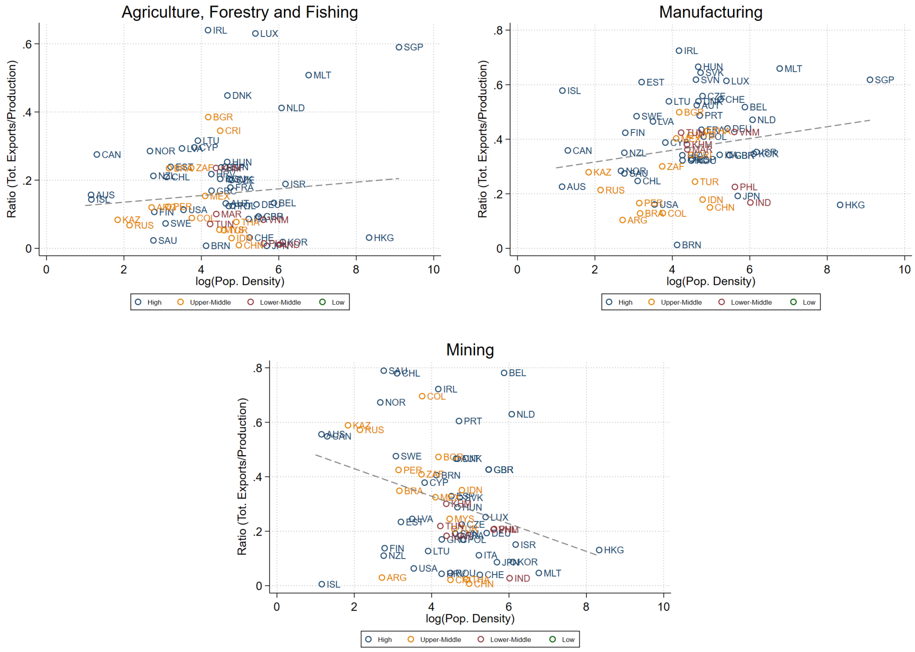
Figure 1.2: Total Exports and Density by Sectors and Income Groups



Source: Author's elaboration on population density (2015) from HYDE 3.2, gross exports from TiVA 2018, and income groups classification are taken from the World Development Indicator of the World Bank.

Another intriguing fact regards the implication in terms of specialization. From Figure 1.2, those countries with large areas and low-density levels export (in levels) more and in more sectors than others. The US are in the top exporters of all the broad sectors while small countries, like Singapore which is one of the densest countries in the sample, sell abroad low amounts of agricultural and mining products; similar but from a different point of view is Suadi Arabia which is in the top exporters of Mining Products but ships abroad fewer goods from the other industries. Observing specialization in relative terms in Figure 1.3, the scenario is a bit different even if the main relation with density is similar to the previous example, larger and richer countries furnish mostly the domestic market and small one export half (or even more) of what they produce.

Figure 1.3: Ratio of Total Exports over Production and Density by Sectors and Income Groups



Source: Author's elaboration on population density (2015) from HYDE 3.2, gross exports and gross production from TiVA 2018, and income groups classification is taken from the World Development Indicator of the World Bank.

1.3.2 The model

Set Up. The economy consists in a multi-country settings $N \times N$ countries, where i are the exporters $i = 1, ..., N$ and j the importers $j = 1, ..., N$. Each country produces a tradable good with infinite varieties $\omega \in \Omega \equiv 1, ..., +\infty$ using just one immobile production factor, labour L_i.

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

$$F_i(A) = e^{-\left(\frac{A}{A_i}\right)^{-\theta}} \tag{1.1}$$

where $A_i > 0$ *fundamental productivity* (deterministic) and $\theta > 1$ is the *intra-industry heterogeneity* (stochastic) parameterizes the impact of changes in fundamental productivity level A_i.

In the deterministic productivity component is added, as in Allen and Arkolakis (2014) and Allen et al. (2020), a specific element for labour contribution and its sensitivity to population density:

$$A_i = \bar{A}_i(L_i)^{\eta} \tag{1.2}$$

where $\bar{A}_i$ represents the exogenous productivity amenities, $\eta \in$ is the extent by which agglomeration (population density) affects productivity, it is specific for each sector as in Lévy and Moscona (2020), it is likely to assume that needs different industries to benefit differently by population concentration.

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. To explain better the meaning of it, $\eta > 0$ means that a certain industry benefits from the scale effects of population agglomeration. On the other hand - $\eta < 0$ - an excessive number of workers should 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.

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

$$u(x_j(\omega)) = \sum_{j}^{N}(x_j(\omega)^{\frac{\sigma-1}{\sigma}}) \tag{1.3}$$

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:

$$x_j = \Big[\frac{p_j(\omega)}{p_j}\Big]^{1-\sigma}\alpha_j w_j L_j \tag{1.4}$$

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 $\tau_{il} \leq \tau_{ij}\tau_{jl}$

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:

$$p_j(\omega) = \min_{1\leq i\leq I}[c_{ij}(\omega)] \tag{1.5}$$

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.

Expenditure Share - Trade. Given the price from 1.5 and the expenditure share 1.4 obtain:

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

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

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

$$Y_i = \sum_{j=1}^{N} x_{ij} \tag{1.7}$$

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:

$$Y_i = w_i L_i \tag{1.8}$$

Price Distribution. From 1.5 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:

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

The equation gives the price parameter;

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

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

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

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 related exact price index are defined it is possible to derive the *Multilateral Resis-*

tance Terms. These terms are the cost of importing and exporting that each country faces, which are also essential for general equilibrium analysis and represent also the main difference between a naive and a theoretically grounded structural gravity model.

From Anderson and van Wincoop (2003) define the Outward Multilateral Resistance Term (OMR)[3]:

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

and the Inward Multilateral Resistance Term (IMR):

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

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

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

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 1.2 substitute w_i into value of output 1.8,

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

[3]see Appendix A for derivation

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

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

1.4 Empirical Strategy

Following Freeman et al. (2021), doing a log and an exponential transformation of equation 1.16, gives the empirical equation for a Poisson Pseudo Maximum Likelihood (PPML):

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

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

However, identifying country-specific variables in a theoretically grounded model, or in other words in the model where multilateral resistance terms [4] are included, is challenging and not always possible. To do so, the work of Heid et al. (2021) suggests a rigorous solution to this issue: multiplying the unilateral variable of interest by the international borders dummy $INTL_{ij}$[5]. Even though it allows the inclusion of any country-specific or unilateral policy measure, this approach has limitations in the

[4] origin and destination fixed effects in cross-section and origin by time and destination by time fixed effects

[5] $INTL_{ij} = 1$ for $i \neq j$ and $INTL_{ij} = 0$ otherwise

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.

The recent 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. Here is propose an application to a cross-sectional setting to compare baseline results.

1.4.1 Method 1: Heid et al. (2021)

Applying the approach of Heid et al. (2021) to this framework, the reduced form for estimating the effect of population density on exports is:

$$X_{ij} = exp[\beta_2 ln(L_i) XINTL + \beta_4 ln(\tau_{ij}) + \mu_i + \chi_j] \times \varepsilon_{ij} \tag{1.18}$$

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 the β_2, the coefficient capturing the density impact limitations. However, as pointed out previously, using this method, 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 just a unilateral trade cost but also 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[6], so it is needed also 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, it is provided with a further 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 for it, here is provided with a theoretical discussion for the interpretation when domestic and international flows are included in the sample.

1.4.2 Theoretical Interpretation of Method 1

The understating of the differential effect of density starts from the log-transformed version of the trade share, π_{ij}, with the price parameter a la Eaton and Kortum (2002), ϕ_j:

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

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

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

[6]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)

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

See proof in appendix 1.8.3 for the derivation.

What follows is based on the first equation. Hence, 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 differential effect between external and internal dimensions which is formalized as:

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

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

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

where η and $(\pi_{jj} - \pi_{ij})$ drive the sign. From the literature[7] 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. More precisely, for aggregate trade, the

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

two shares are almost balanced (close to 50%), while for sectoral trade it depends on industries and the differences are larger.

Nevertheless, even if θ has been widely studied in former works, 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.

1.4.3 The Role of the International Border Dummy

Once a theoretical interpretation of the main coefficient $\beta_2 L_i \times INTL_{ij}$, now few points on the empirical part. Since 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 for estimates is:

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

This term plays a relevant role in the model specification, in particular 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), dividing domestic and international sales. On the other end, 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 variable multiplying the international border dummy and the dummy itself, I follow the formalization of a typical mincerian type equation with dummies, defining the model when the international border is equal to one:

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

and when it is equal to zero which means that considers the domestic component of the data, both trade and explanatory variables:

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

The difference between these two is the estimated model which takes the following form:

$$\hat{X}_{ij} = E(X_{ij}|INTL = 1, ln(L_i), ...) - E(X_{ij}|INTL = 0, ln(L_i), ...) =$$
$$= \beta_2 ln(L_i) + \delta_0 - \theta(ln(\tau_{ij}) - ln(\tau_{jj})) \qquad (1.27)$$

Now it is clear that the effect captured by the coefficient for borders dummy, δ_0, is affecting the specification of the model. But to have clearer its role it is necessary to go back to the equations in the previous section and substitute $beta_2$ and δ_0[8] with their theoretical interpretation:

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

here is formalized the importance of the international border dummy as in Yotov, Piermartini, Monteiro and Larch (2016), in control for all the 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 effect of density (or any other country-specific

[8]see appendix 1.8.3 for its definition

variables representing a component of fundamental productivity) is measured.

1.4.4 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:

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

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:

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

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:

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

1.4.5 Theoretical interpretation of Method 2

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

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

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

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

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

1.5 Data

The dependent variable, exports, accounts also for domestic sales. Data are from TiVA version 2018; international trade regards gross exports and domestic flows which is the difference between gross production and total exports Yotov (2021). These data are grouped to obtain three broad sectors i) Agriculture, Forestry and Fisheries[9], ii) Manufacturing iii) and Mining[10]. The sample is a $N \times N$ matrix (64 X 64 countries) for each year from 2005 to 2015.

Population density is computed from the *History Database of the Global Envi-*

[9]TiVA does not contain disaggregated sector for it

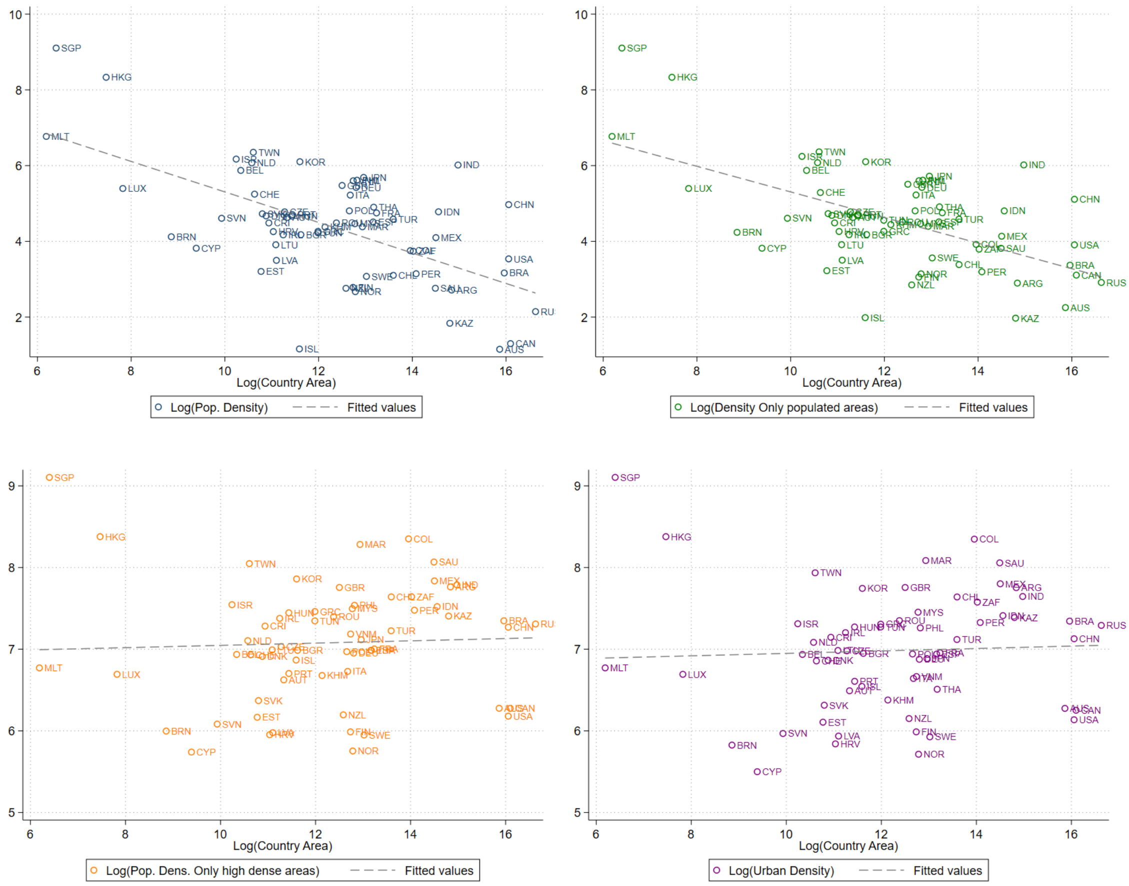
[10]This sector has both energy and non-energy products. It is grouped maintaining the category *Mining support service activities*, which does not change significantly results

ronment (HYDE 3.2) (Klein Goldewijk, Beusen, Doelman and Stehfest, 2017). This data set combines updated population (grid) estimates and land use for the past (considering also Before Christ periods) 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 the robustness:

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 (high-density cells)**: consider just urban population and are only from cells classified as *Urban* and *Dense Settlements*

The first two measures are similar, see Figure 1.4, 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 1.4: 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 last set of unilateral variables represents further controls for geographical features that might affect production and productivity together with 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).

The bilateral covariates used 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, Goujon and Santoni, 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 in order to avoid strong assumptions on the geographic domestic frictions of those countries.

1.6 Results

First, I 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, I show what implies using different density measures. Always using this methodology I estimates 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, I 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.

1.6.1 Method 1: Heid et al. (2021)

1.6.2 Results: Cross-Section

Baseline estimates are done for 2015. The temporal dimension is not examined in the theoretical part and as is shown later panel analysis yields slightly different and less robust results. The main equation for cross-sectional results is:

$$\begin{aligned} X_{ij} = exp[\beta_2 ln(L_i) \times INTL_{ij} + \delta_0 INTL_{ij} + \\ + \boldsymbol{\beta} GEO\_CONTROLS_i \times INTL_{ij} - \theta ln(\tau_{ij}) + \mu_i + \chi j] \times \varepsilon_{ij} \end{aligned} \tag{1.34}$$

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 $ln(\tau_{ij})$ with different measures of distances, 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 borders dummy and exporter-specific geographic features, $GEO\_CONTROLS_i$.

The first set of results, Table I1, confirms the prediction. Where international trade with respect to domestic components benefits positively from the agglomeration effect related to density level. For agricultural products, the picture is not clear. An explanation would be done by the heterogeneity within industries. Forestry relies mostly on natural resources while other agricultural products, such as horticulture goods, are more technology-intensive (or less land/natural endowments intensive) because in many cases they grow in greenhouses. Hence, the aggregation provided by TiVA does not allow the proper identification of density impact on agricultural trade (the parameter η in the model) because of the diversity among products. Finally, mining gives a negative and significant sign which according to the theoretical interpretation of the $_2$ coefficient means that η is negative, meaning that an increase in labour force reduces exports, this could be related to diseconomies from people concentration or because this sector is more natural resources intensive.

From the theoretical prediction on the coefficient β_2, also the parameter θ plays a role, the literature says that it is positive, but as in Eaton and Kortum (2002) it is determined by geographic barriers. To test the sensitivity of these results to this parameter it is used a different measure of shipping distances is, regarding sea travel, used. From Table I2, coefficients do not change in terms of significance and sign. Furthermore, the magnitude varies by a few decimal units in all the sectors.

Data allow delving deeply just within manufacturing sectors. Splitting by its subcategories and running the same regression as in Table I1. The results from Table I4 show that almost all the industries have a positive and significant sign and suggest that the η is positive in all the cases, the different sizes suggest different levels of sensitivity to agglomeration forces of exports.

Some robustness checks are done in Table I3. Using density considering just populated cells the value of the impact on manufacturing is similar to the baseline. This one is slightly larger (0.38 instead of 0.32). 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. Therefore, these robustness checks propose that the effect captured by density at the aggregate level is related to the specialization and the performance given countries' spatial distribution of production factors, similar to the concept of *lumpiness* of Courant and Deardorff (1992) and Courant and Deardorff (1993). As Figure 1.4 shows, considering urban density there is less variability between countries and the density is not necessarily related to the size of the countries. Hence, agglomeration forces related to urbanization are not just a matter of the number of inhabitants.

1.6.3 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 for a panel estimation without big changes. Then the equations for the next set of estimates are, for table I5:

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

and for Table I6:

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

The main difference concerns the second equation, 1.36, instead of including the gravity covariates here are added pair fixed effects, γ_{ij}. These absorb all the bilateral and unilateral not time-varying (as $GEO\_CONTROLS_i$) and control for all the possible bilateral trade frictions between countries and also for each country's wedge of domestic and foreign sales. In other words, the second equation helps to test if other models' specifications are affected by latent variables or other issues.

The difference between the two tables is that even if in Table I5 the outcomes yielded are in line with the cross-section estimates when using a more rigorous identification results change. Manufacturing remains the same but the coefficient is almost three times bigger. In contrast, agriculture now is significant and large and mining is not significant anymore. This discrepancy in the outcomes means that a better theoretical discussion has to be done when the time dimension is added to understand the nexus of trade and agglomeration.

1.6.4 Method 2: Freeman et al. (2021)

Using the novel approach of Freeman et al. (2021), which drives the estimation of the following equation:

$$X_{ij} = exp[\beta_2 ln(L_i) + \delta_0 INTL_{ij} + \beta GEO\_CONTROLS_i + \widehat{ln(\Pi_i)} + \chi_j] \times \varepsilon_{ij} \quad (1.37)$$

the difference with previous estimations is that here $INTL_{ij}$ is added just a stand-alone control and does not interact with unilateral explanatory variables. Only importer fixed effects, χ_j are included while for the exporters 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 in levels of the variable of interest.

1.6.5 Comparison

The results in Table I7 confirm the findings in Table I1. Just to recap, the positive and significant coefficient for manufacturing has no statistically relevant effect on agricultural and related goods and a negative effect on minings. The difference is that here the acceptable results are both higher than the baseline. The interpretation is that both the dimension (international and domestic) are influenced in the same way by density. And 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 I7 the sign is negative as expected since it represents a cost term. While in column 3 this is not verified, a plausible explanation would be given by the fact that when including domestic flows in the estimation, the effect of internal frictions operating in the domestic market is higher than international. Hence, frictions in domestic markets are lower than in foreign ones, if the domestic demand absorbs the largest part of the output the selling costs are lower overall.

Table I8 provides a further comparison of the two methods. Here the two are mixed, exporter fixed effects are substituted by the OMR index and the main 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 also 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 I7 and greater than the coefficient of 0.32 of the baseline results. Finally, all these attempts confirm the mechanism described in the theory but my application of the new method of Freeman et al. (2021) has a main issue. The sample size (for each industry sample): the first stage is done at a panel level and some of the country-fixed effects are omitted because of redundancy, then indexes have some missing values. Using values from a cross-section approach of the first step yields indexes of the multilateral resistance terms perfect collinear.

1.6.6 Assessing the value of the density sensitivity parameter, η

The theoretical discussion above helps the interpretation of the coefficients and it can be also exploited to isolate the effect of η and measures it. According to this paper, there are two ways to do it, one following Heid et al. (2021):

$$\eta = \hat{\beta}_2 \Big(\frac{1}{\theta(\pi_{jj} - \pi_{ij})} \Big) \tag{1.38}$$

and the other using the methods in Freeman et al. (2021):

$$\eta = \hat{\beta}_2 \Big(\frac{1}{\theta \pi_{jj} \pi_{ij}} \Big) \tag{1.39}$$

As already stated θ is given by the literature and here the focus is on the seminal work of Eaton and Kortum (2002) and Costinot et al. (2012). The main attention is given to the manufacturing sectors which showed more robust results.

From Figure 1.5 and Figure 1.6 [11], there are no relevant differences. In general, a higher value of the technology parameter[12], 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 heterogeneity over varieties, comparative advantages affect mostly trade more than geographic barriers. In this case, the effect is all on *eta* it may overestimate its contribution. The relevant values are when $6 \le \theta \le 8$, given relatively low values of η and making its quantification reasonable. Remember that the effect of labour on output is $1 + \eta$, hence the scaling of the production factor on overall output is admissible.

1.7 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 to measure if there are scale effects or not. This 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, I 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

[11] Table I10 and Table I11 sum up the detailed results

[12] this means that $\lim_{\theta \to \infty} \eta(\theta) = 0$

Figure 1.5: η (from Heid et al. (2021) based estimates) values according to θ measures in literature

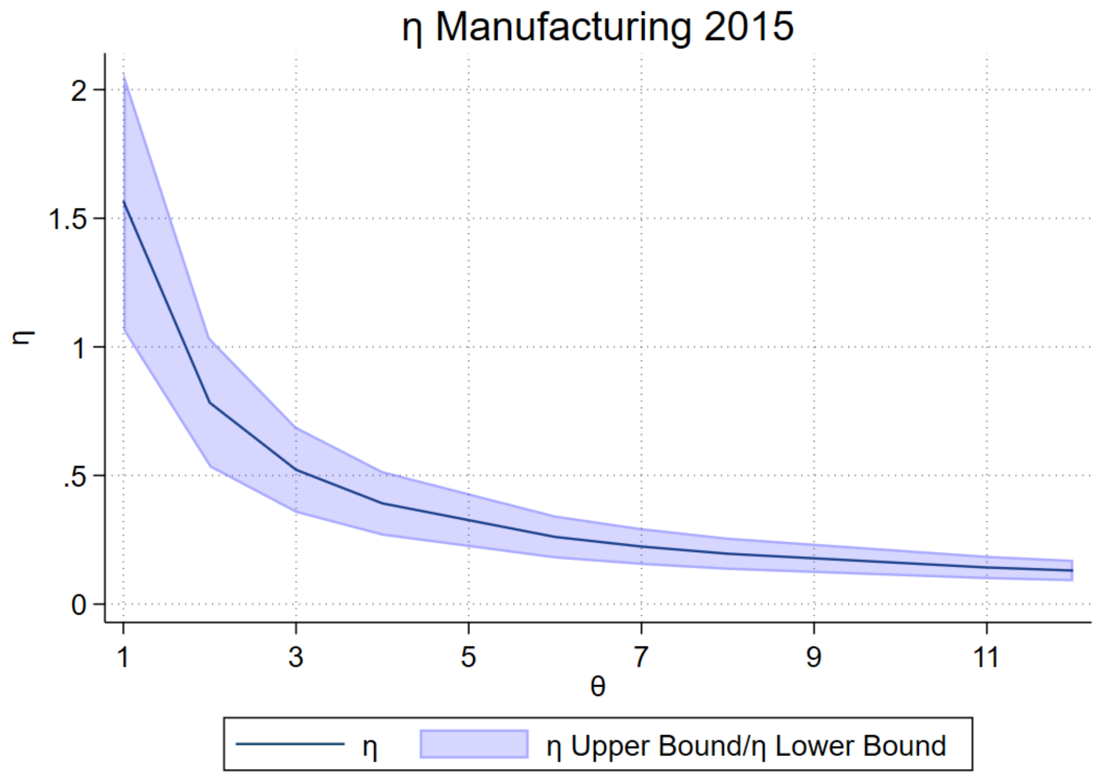
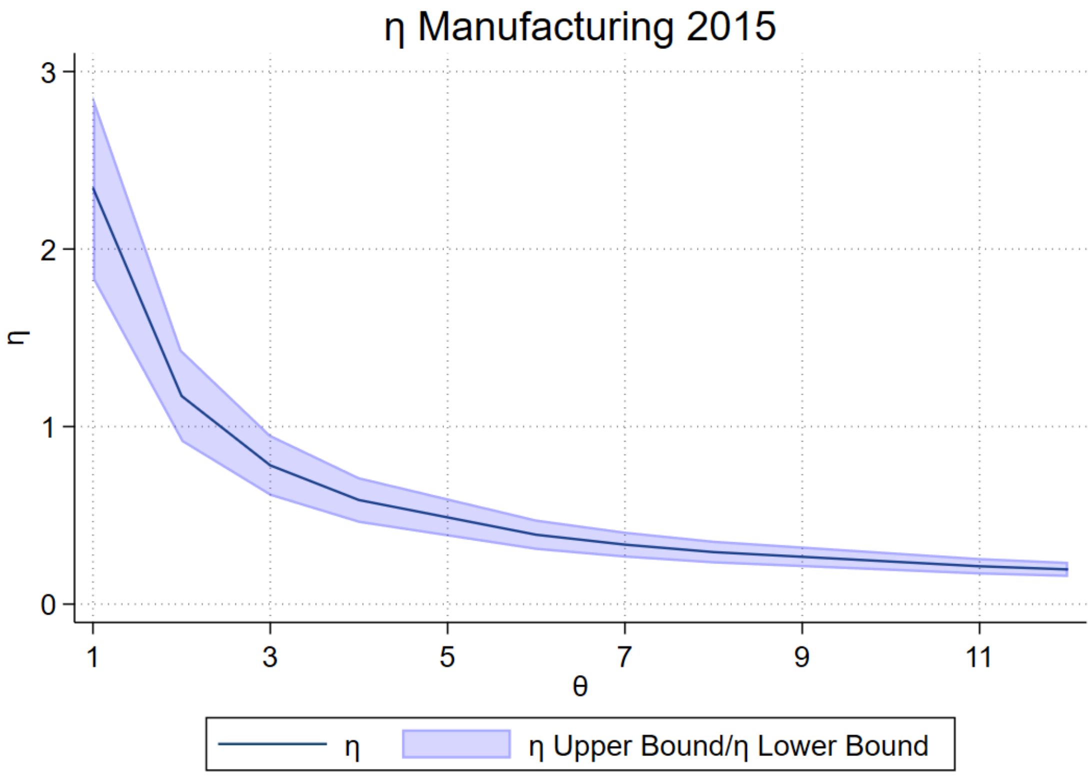


Figure 1.6: η (from Freeman et al. (2021) based estimates) values according to θ measures in literature



to other variables that are affecting both domestic and international dimensions. This is important because following this method I can also design counterfactual and policy experiments. The flexibility of this framework gives the opportunity also to replicate the analysis on the brand new work 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. The estimates say 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, Density by itself is a variable that captures resources endowments and distribution while when urbanization level is taken into account is 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. Here this part is omitted for simplicity and also because the supply-side framework proposed congestion forces are encountered by the Outward Multilateral Resistance Terms for the exporters.

This work gives several opportunities for further research as 1) developing a model to run counterfactual analysis including density sensitivity parameters (as adapting Dekle, Eaton and Kortum (2008)) it is a starting point to measure how population dynamics as transitional growth [13] 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

[13] This can be done modifying Anderson, Larch and Yotov (2020)

et al. (2016).

1.8 Appendix A

1.8.1 Multilateral Resistance Terms Derivation

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

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

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 $E_j = w_j L_j$:

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

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

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

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

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

and the Inward Multilateral Resistance Term (IMR):

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

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

Rewrite the trade equation, 1.6:

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

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

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

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

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

1.8.3 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:

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

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

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

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

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

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

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

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

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

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

1.9 Appendix B

1.9.1 Cross-Section

Table I1: Baseline Estimates, PPML, Cross-Section: Gross Exports, 2015

VARIABLES	(1) Manufacturing	(2) Agric. Forest. and Fish.	(3) Mining
Log(Density) X INTL	0.3200***	-0.0156	-0.2703**
	(0.0525)	(0.0767)	(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

Table I2: Alternative distances measure: PPML, Cross-Section: Gross Exports, 2015

VARIABLES	(1) Manufacturing	(2) Agric. Forest. and Fish.	(3) Mining
Log(Density) X INTL	0.3377***	0.1311*	-0.1554
	(0.0587)	(0.0790)	(0.1416)
Log(Sea Distances) includes domestic	-0.4460***	-0.5901***	-0.8049***
	(0.0233)	(0.0443)	(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

Table I3: Robustness check with alternative measures of density, Cross-Section(2015)

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

Table I4: PPML Results 1: Within Manufacturing (Cross-Section)

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

1.9.2 Panel

Table I5: PPML: Gross Exports, 2005-2015

VARIABLES	(1) Manufacturing	(2) Agric. Forest. and Fish.	(3) Mining
Log(Density) X INTL	0.3246***	-0.0538	-0.2737***
	(0.0877)	(0.1168)	(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 X INTL	YES	YES	YES
Clusters	Exporter × Importer	Exporter × Importer	Exporter × 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

Table I6: PPML Gross Exports (Pair FE), 2005-2015

	(1)	(2)	(3)
VARIABLES	Manufacturing	Agric. Forest. and Fish.	Mining
Log(Density) X INTL	0.9616*	0.9704*	-1.2013
	(0.5557)	(0.5545)	(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 × Importer	Exporter × Importer	Exporter × 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). $GEO_{C}ONTROL$ 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 I7: Alternative Cross Section Estimates 2015: method of Freeman et al. (2021)

VARIABLES	(1) Manufacturing	(2) Agric. Forest. and Fish.	(3) Mining
Log(Pop. Density)	0.5619***	-0.0996	-0.5413***
	(0.0633)	(0.0628)	(0.1078)
OMR(i)	-1.3402***	0.0932	0.2396**
	(0.1200)	(0.1640)	(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 X INTL	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.

Table I8: Alternative Cross Section Estimates 2015: method of Freeman et al. (2021) - Robustness

	(1)	(2)	(3)
VARIABLES	Manufacturing	Agric. Forest. and Fish.	Mining
Log(Density) X INTL	0.4840***	-0.1413**	-0.3241***
	(0.0576)	(0.0628)	(0.1130)
OMR(i)	-1.2246***	0.1460	0.3282***
	(0.0992)	(0.1549)	(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 X INTL	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.

Table I9: 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 I10: 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 I11: η values from *Method 2* (Freeman et al., 2021)

θ	η	η Upper Bound	η Lower Bound
1	-2.19	-1.34	-3.05
2	-1.10	-0.67	-1.52
3	-0.73	-0.45	-1.02
4	-0.55	-0.33	-0.76
6	-0.37	-0.22	-0.51
7	-0.31	-0.19	-0.44
8	-0.27	-0.17	-0.38
11	-0.20	-0.12	-0.28
12	-0.18	-0.11	-0.25

Chapter 2

Domestic Institutions and International Trade: empirical investigation and policy implications

2.1 Introduction

The 16^{th} Sustainable Development Goal - *PEACE, JUSTICE AND STRONG INSTITUTIONS* - says "We cannot hope for sustainable development without peace, stability, human rights and effective governance, based on the **rule of law**[1]. This work wants to answer the question: *What is the effect of domestic institutions on international trade?* Firstly, modelling institutions as a determinant of fundamental productivity and then testing empirically *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

[1]UNDP web page

distances), *iii)* the differences related to different industries and the related contract intensity (Levchenko, 2007; Nunn, 2007) and *iv)* a counterfactual exercise to assess which could be the welfare gains (or losses) of having strong institutions in every country.

The theoretical contribution is an extension of the supply-side gravity models like Eaton and Kortum (2002) and Costinot et al. (2012), which includes domestic institutions as a determinant of productivity fundamentals to consider them as a source of comparative advantages as Levchenko (2007) but in a multi-country setting[2]. This framework allows interpreting the results of structural gravity models with country-specific variables as Heid et al. (2021) but extends the application and the interpretation of variables that could be considered not just as trade costs. Moreover, this approach allows testing the findings of Nunn (2007) at a bilateral level.

The extension of the previous work permit to asses that the role of institutions measured by country-specific variables is more robust and interpretable than from estimates from total trade or with self-constructed bilateral variables. Moreover, takes into account home biases and the value of international sales with respect to the domestic market. The role of culture matters but needs a specific framework to distinguish the implication of different cultural dimensions and the correlation with geographical features. Following the methodology of Heid et al. (2021) I can extend the results to the policy debate running a counterfactual exercise as in Beverelli et al. (2018*b*) and discuss welfare implications of an improvement in institutional quality.

The paper first provides a discussion of the literature on institutions and their nexus with trade in Section 2.2, then in Section 2.3 are presented the theoretical framework for aggregate and sectoral analysis. Once the theoretical background is defined, Section 2.4 describes the empirical strategy and the theoretical interpretation of the results. Section 2.5 presents the data source to obtain results in Section 2.6 and to run the counterfactual exercise in Section 2.7. Finally, Section 2.7.1 concludes.

[2]The model here presented is more simple than the one in Levchenko (2007), but it considers multiple importers and exporters both theoretically and empirically

2.2 Literature

Institutions have been widely studied by economists because they are considered a key factor in the determination of transaction costs and growth dynamics. Having good institutions implies more investments and more efficiency. The linkages between trade and institutions are strong: exchanging goods domestically and internationally needs formal and informal constraints (uses and customs, laws and other specific institutional infrastructures) that guarantee the proper execution of the transactions. Moreover, these activities may also play a role in the development of the institutions. Here I sum up more relevant contributions on the economic implication of institutions. Firstly, focusing on the literature on growth and then on the works discussing the nexus of trade and institutions.

Douglass North defined institutions as the set of constraints designed by humans to structure political, social and economic interactions aiming to create order and reduce uncertainty in the exchange (North, 1991, p.97). The dynamics of all the dimensions have the scope to create the economic conditions that lead to increased productivity (North, 1991). Williamson (2000) suggested looking at institutions considering different levels: *embeddedness* referring to culture, social customs and all the features "embedded" in the society, *rule of the game* like property rights and the other tools regulating contract enforcement, *the play of the game* represented by the governance and *resources allocation* which refers on the economic dimension.

The role of institutions is relevant in the long-run dynamics, reducing transaction costs and improving economic performanceNorth (1994). In this perspective, heterogeneous institutions produce different outcomes and they help also to explain differences in countries' income levels.

Acemoglu wrote several seminal works in which he and his co-authors explain the historical determinants of institutions and the implications on the recent economic outcomes. First, in Acemoglu, Johnson and Robinson (2001) the differences in income per capita are due to the colonial policies and how these shaped institutions. Using mortality rate to identify places easier for European colonisers to settle, the authors wanted to specify where was easier to locate people and created better institutions, while where it was harder prevailed the extractive state which affects lower income levels today.

Another point of view is developed in Acemoglu, Johnson and Robinson (2005) in which the attention is focused on the power allocation and group of interests. The idea of this framework is that economic institutions that foster economic growth develop when political institutions distribute power to groups with interests in broad-based property rights enforcement when they create effective constraints on power-holders, and when these receive relatively few rents. The sluggish economic growth during the Middle-Age was related to the absence of property rights for the whole population and all the political power in charge of kings and monarchies which preserved the property rights only for these particular elites. Together with the high probability of land expropriation by the strongest group, this generated very low incentives to invest in land, physical and human capital.

Also referred to the quality of property rights, Acemoglu and Johnson (2005) distinguished between *property rights institutions*, those who protect citizens against expropriation by the government and powerful group, and *contracting institutions*, which determines private contracts between citizens. The aim was to shed light on the various elements composing institutions and understand more about the importance of contracting and property rights institutions at the macroeconomic level.

Trade is strongly related to institutions (and institutional quality) concerning good exchanges both within and between countries. North (1991) pointed out that institutions can capture gains from trade. When economic transactions went beyond the village, the market size increased as well as costs and the need for instruments to measure, enforce and prevent conflicts arising from trading between various locations. Hence, the set of skills and knowledge developed during history by several societies helped to improve economies through the growth of output and value-added, the division of labour, the creation of economies of scale and expanding both the volume and distances of traded goods. Although, this evolution did not happen homogeneously.

The enlargement of trade presented two main issues one related to the agency problem and another to negotiation and enforcement (North, 1991). Literature focused on these aspects to understand the features that shaped institutions and the economy via exchanges and implied human interactions.

Greif (1989) studied the role of reputation and coalition and the system conceived by Maghribi traders in the 11th century. Exploring the *geniza* documents[3], Mediterranean traders during the Middle Ages were organized in *coalitions*, non-market institutions grounded upon a reputation mechanism to manage merchants and agents relations for shipping goods overseas. Moreover, Greif, Milgrom and Weingast (1994) analyzed also the role of this specific institution together with the Merchants' Law[4], stressing on the importance of non-market institutions in shaping an institutional framework that foster market integration. Similarly, Milgrom, North and Weingast (1990) found out that the creation of a set of rules inducing merchants to behave honestly, sanctioning those who misbehaved and allowing clear information on anyone's conduct facilitated transactions between people.

In the literature on trade and institutions, several works focused on how these are related to comparative advantages. Hence, how they affect specialization and trade patterns in global markets. In the understanding of the institutional determinants of comparative advantages, two important concepts are relationship-specific investments and incomplete contracts [5]

[3] *geniza* is a collection of administrative documents

[4] Also known as law merchant or lex mercatoria was a set of customary rules and principles regulating merchant and mercantile transactions in the Middle Ages. It was based on Roman Law with some Germanic influences and it also contributed to the creation of Commercial Law. Another interesting feature, it was applied by quasi-judicial courts, such as guilds in Italy and piepoudre courts in the United Kingdom (from Britannica Online)

[5] Some works on incomplete contracts are Antras (2003) Nunn and Trefler (2013)

A clear review of the literature discussing this nexus is provided by Nunn and Trefler (2014). A simple example made by the authors concerns the production of commercial airliners and jeans. The first requires huge efforts in technology levels and quality standards from the parties involved (i.e. producers of intermediate goods and specific components), these are difficult to be validated in a complete legal frame. While blue jeans need less contracting capacity for sourcing inputs. Hence, countries with better contracting institutions specialize in airliners because is costly for them and those with weaker institutions produce blue jeans.

The work of Levchenko (2007) gave a theoretical interpretation of this. His model formalized a world where are produced labour, capital and mixed goods. The last two types concern relation-specific investments which lead to the classical holdup problem. Thus, Institutional quality helps contract enforcement. Moreover, to study the determinants of comparative advantages, he included a northern country with better institutional quality and a southern country with lower quality. The theoretical predictions assess that the country of the South faces contradictory effects: opening to trade could reinforce the sector producing goods with less institutional content but the others may disappear. And also, factor revenues (prices) take different paths as a result of trade. The empirical section of this work confirmed the "institutional content of trade".

Another important element of economic exchanges is culture as pointed out in Guiso, Sapienza and Zingales (2009). It can be considered as a non-market (or informal) institution as in the above-mentioned work of Williamson (2000) determining preferences. Therefore, it is also a source of comparative advantages. The work of Belloc and Bowles (2017) provided a theoretical description of the interplay of institutions and culture in determining trade patterns and the related comparative advantages. The framework is a 2-factor, 2-good, and 2-country model where the differences in culture (preferences) and contracts (institutions) are endogenously formalized. Preferences and contracts are complementary, this generates multiple equilibria in which countries with different endowments both have a comparative advantage in their specific production. Furthermore, trade liberalization does not lead to a Pareto-optimal equilibrium with new configurations of institutions and culture but the persistence of these is stronger.

Other works focused more on the empirical identification of the nexus of international trade and institutions. Islam and Reshef (2012) provided an empirical analysis that also tested the differences between the function and form of institutions. The first refers to institutional quality, as the evaluation of rule of law, while the latter regards the legal systems. This distinction is really important in terms of policy implications. The authors want to answer a fundamental question: When designing policies to improve institutional quality, is it better to change the legal system, and the institutional design, or intervene in the several elements composing the institutional environment? Their results showed that function matters more, meaning that the efforts must be addressed to improve institutional infrastructure defining quality.

Nunn (2007) explored the sectoral differences related to the specific contract intensities of different industries. They proposed measurements of contract intensity based on the content of the share of inputs involved to realize the final goods. They distinguish between inputs sold in organized exchange or sold with reference prices and those that are not sold any of these[6]. The findings revealed that contracts and their enforcement have a more relevant role than capital and labour.

The empirical works described in the previous paragraphs even if are considerable contributions do not exploit properly bilateral trade flows. Although the unpublished work of Beverelli et al. (2018*b*) do this. The authors included institutions in a structural gravity framework considering them as unilateral trade costs. The papers solved the empirical challenges of including unilateral variables in this kind of model without falling in the *gold medal mistake*. The results confirmed what previous works already said, institutions are good for trade and also that it is likely that they contribute more to international trade than to domestic sales when domestic markets are sufficiently

[6]To this, they used the Rauch (1999) classification which allows also to obtain alternative measures and classify commodities either from a liberal or a conservative point of view

large and integrated.

2.3 Theory

The theoretical section provides a model for the general case of aggregate trade and an extension including sectors in order 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, I proposed a model where these are formalized in productivity function. Costinot et al. (2012) recognize institutions as part of *fundamental productivity.*. Here I considered them as exogenous because this framework aims to identify their impact on international trade taking into account domestic sales and a multicountry trade network.

Productivity is randomly drawn from a Fréchet $F_i = exp^{-(\frac{A}{A_i})^{-\theta}}$ 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 also a production factor here. It is modelled as 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:

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

where π_{ij} are the trade share.

2.3.2 Sector Trade: including the role of contract intensity

In this section, I expand the previous framework to consider also contract intensity as defined in Nunn (2007). The setup is the same as above. the only differences concern that the productivity is randomly drawn from a Fréchet:

$$F_i = exp^{-(\frac{A}{A_i^k})^{-\theta}} \tag{2.2}$$

where $A_i^k = z^k I_i$, where z^k the contract intensity for each sector, and varies $0 < z^k < 1.$, and I_i is the institutional quality(quality of contract enforcement). Iceberg trade costs, $t_i j^k = z^k \tau_{ij}$, where τ_{ij}would represent bilateral cultural features which are the transaction cost related to contract enforcement. In this case, the effect is bonded to the contract intensity related to the sector. Hence the expenditure in this case are:

$$X_{ij}^k = \pi_{ij}^k E_j^k = \frac{(z^k I_i^{\zeta})^{\theta} (w_i t_{ij}^k)^{-\theta}}{\Phi_j^k} E_j^k \tag{2.3}$$

where π_{ij}^k is the trade share for each sector k.

2.3.3 The Structural Gravity System

Once expenditure functions are defined, considering 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. I obtain the structural gravity system with inward, P_j and outward, Π_i, multilateral resistance terms.

Exports are formalized as:

$$X_{ij} = \frac{Y_i' E_j}{Y}\Big(\frac{t_{ij}}{P_j \Pi_{ij}}\Big)^{-\theta} \tag{2.4}$$

Inward and Outward Multilateral Resistance terms:

$$P_j = \sum_i \Big(\frac{t_{ij}}{\Pi_i}\Big)^{-\theta} \frac{Y_i'}{Y} \ ; \ \Pi_i = \sum_j \Big(\frac{t_{ij}}{P_j}\Big)^{-\theta} \frac{E_j}{Y} \tag{2.5}$$

The factory gate price:

$$w_i = \Big(\frac{Y_i/Y)}{\Pi_i^\theta A_i^\theta}\Big)^{-\frac{1}{\theta}} \tag{2.6}$$

where in equation 2.4 $Y_i' = \bar{A}_i L_i$, since the institutional quality is moved in $t_{ij}^{-\theta} = \frac{\tau_{ij}}{I_i^{\zeta/\theta}}$. This change is made to make 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, I assume the interaction between bilateral trade costs and country-specific trade easiness from productivity fundamentals which have the opposite effect (sign) of trade frictions. The system with different industries is similar to the one presented here, just adding the k sectors subscript and the modified vector of trade frictions is $(t_{ij}^k)^{-\theta} = \frac{\tau_{ij}^h}{(z^k I_i)^{\zeta/\theta}}$. However, the counterfactual exercise is done with aggregate trade.

2.4 Empirical Strategy: From Theory to Measurement

Baseline estimates are made with Pseudo-Poisson Maximum Likelihood (PPML) and must 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 I want to include 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

$$X_{ij} = exp[\beta I_i \times INTL_{ij} + \gamma GRAVITY_{ij} + \delta_0 INTL_{ij} + \mu_i + \chi_j] \times \varepsilon_{ij} \tag{2.7}$$

where I_i refers to the institutions variables, $GRAVITY_{ij}$ are the gravity covariates which refers 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 exporter and the importer fixed effects.

2.4.1 Theoretical interpretation

$$\frac{\partial ln(\pi_{ij})}{\partial ln(I_i)} - \frac{\partial ln(\pi_{jj})}{\partial ln(I_i)} = \zeta\theta(\pi_{jj} - \pi_{ij}) \tag{2.8}$$

where $\zeta > 0$ I assume 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 the data the average domestic trade shares are greater than the international. Meaning that 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 also comparative advantages) parameters. Adding sectors the interpretation is:

$$\frac{\partial ln(\pi_{ij}^k)}{\partial ln(I_i)} - \frac{\partial ln(\pi_{jj}^k)}{\partial ln(I_i)} = z_k \zeta \theta (\pi_{jj} - \pi_{ij}) \tag{2.9}$$

It is similar to the previous equation 2.8, but here the role of contract intensity z^k lowers the overall effect determined by the parameters and the differences between the two shares. In this way, the impact of institutional quality is related to the contract content of each industry, in sectors with low intensity the quality matter less and where intensity is higher the effect of institutions is proportional to it.

2.5 Data

The trade data I use to test the hypothesis contains both bilateral international trade and domestic sales (the difference between total production and total exports). The data come from several sources. Baseline estimates are made with the replication data of Fontagné, Rocha, Ruta and Santoni (2022) to analyze the impact on aggregate trade and also to run the counterfactual exercise. The main sample concerns a square trade matrix of 98 × 98 countries for the year 2000 which is used both for the empirical and the counterfactual, and one of 65 × 65 because of the cultural distances data from De Benedictis, Rondinelli and Vinciotti (2020) country coverage. For robustness and to assess the role of contract intensity and the heterogeneity across industries data come from WIOD, covering 45 × 45 countries for 10 manufacturing industries[7] (also her for 2000) and ITPD version 2 Borchert, Larch, Shikher and Yotov (2022), this last set of data allow to investigate for 25 manufacturing industries including also domestic sales but here the sample is unbalanced.

[7]these ten industries are not the original from WIOD but are grouped by me in order to match sectors in the contract intensity measures from Nunn (2007)

Institutional quality is from the *World Governance Indicator*, I select just one of the six indexes, the *Rule of Law*. This index captures people's perception of the rule of society, such as quality of contract enforcement, property rights and justice Kaufmann, Kraay and Mastruzzi (2010). Thus, it is the best choice for my purposes and it is also the concept mentioned by the 16th SDG (see Introduction). The other indexes could be other interesting potential candidates. Although, in my opinion, their definitions imply extending the conceptual framework to other aspects such as the political systems, democracy levels and corruption which need a different, and more extended, formalization of the theoretical model. The indicator for *Rule of Law* has a range between -1.60 (worst institutional quality) to 1.98 (best institutional environment. The average level, which can be considered the minimum average standard for contract enforcement, is 0.21. It is relatively low because it is centred given the value of the standard deviation (1.01 as shown in Table I1).

To test the hypothesis from Islam and Reshef (2012) and distinguishing between form (legal system) and functions (in my case Rule of Law). The variable for the institutional form is the legal origin from CEPII Conte et al. (2022), I choose the one for post-transitions (after the fall of the USSR). Looking at Table I1 around 53% of the exporters in the sample (the main from Fontagné et al. (2022)) have a French legal origin. The rest is divided between British, German and Scandinavian (this one is a very small share, 0.05, it catches the trade network between Scandinavian countries).

Since I want to test also the effect of institutions together with bilateral cultural ties, I use both proximity and distances regarding different cultural dimensions. For proximity, I choose a measure language proximity from Gurevich, Herman, Toubal and Yotov (2021) using the variable for the similarity between two languages. The other is the common religion index by Disdier and Mayer (2007) contained in Conte et al. (2022). Cultural distances are taken from the brand new paper of De Benedictis et al. (2020). This paper provides an innovative way to measure cultural distances using a Bayesian approach, a copula graphical model for discrete data, to infer a country's cultural network[8] and then determine the international distances. The variables useful for this empirical analysis are the **mean** of all the dimensions and the distance in**trust** between each pair of countries. Including these, sample size varies due to countries' coverage.

The traditional gravity covariates come from CEPII: weighted distances (in log), contiguity and official common language (both dummy variables) Conte et al. (2022).

Finally, the measure of contract intensity is taken from the replication files of Nunn (2007), I use the relation-specific measure that fraction of inputs not sold on an exchange and not ref priced. The authors assess the input composition of each commodity from the 1997 US input-output table. This is why I chose 2000 as the period of investigation because is not too far from Nunn (2007) timing and allows me to compare different samples and exploit all the explanatory variables.

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 different industries and the related 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).

[8]cultural networks are measured from the World Value Survey, looking at people's opinions on trust, justification of abortion, justification of homosexuality, respect of authority, the importance of good, postmaterialism, a voice through petitions, level of happiness, national pride and obedience vs independence

Firstly, looking at the functions:

$$X_{ij} = exp[\beta RoL_i \times INTL_{ij} + \gamma GRAVITY_{ij} + \delta_0 INTL_{ij} + \mu_i + \chi_j] \times \varepsilon_{ij} \tag{2.10}$$

then at the form with:

$$X_{ij} = exp[\beta RoL_i \times INTL_{ij} + \beta_1 Legal\_System_i \times INTL_{ij} + \gamma GRAVITY_{ij} + \delta_0 INTL_{ij} + \mu_i + \chi_j] \times \varepsilon_{ij} \tag{2.11}$$

And also the interplay between the two adding a variable $RoL_i \times Legal\_System_i \times INTL_{ij}$, in order to catch the heterogeneity of functioning according to the types of forms. Table I2 collects the results. Using the French as a reference population German and British legal systems have a positive and larger effect than institutional quality. Scandinavian is not significant but it is capturing the effect of a few exporters. The interaction between the legal system and the rule of law reveals the same findings UK and German approaches have a larger impact than the French ones. However, it is also true that more countries, in particular in this sample, have a french system which implies that the form per se would not be enough to improve institutional infrastructure in a country.

Further investigation about from and functions are made using also bilateral variables. For institutional quality. I create two dyadic measures of the rule, RoL_{ij}, one is measured as the differences between i and j and another as the sum of the two as in Islam and Reshef (2012). $Legal\_System_{ij}$ concerns the common legal system, it is also split by type of legal system. Table I3, estimates different combinations of the following equation:

$$X_{ij} = exp[\beta RoL_{ij} \times INTL_{ij} + \beta_3 Legal\_System_{ij} \times INTL_{ij} + \gamma GRAVITY_{ij} + \delta_0 INTL_{ij} + \mu_i + \chi_j] \times \varepsilon_{ij} \tag{2.12}$$

A first remark is that the bilateral measure of the World Governance Indicator Index imposes to have zero for the domestic (as it is multiplied by the international border dummy) otherwise also these variables suffer collinearity with the fixed effects. Using this bilateral dimension the effect of institutional quality turns out to be bigger than the legal form. Although, using bilateral variables reveal pair-specific relevance such as the coefficient for the common legal Scandinavian system which is capturing a cross-border trade network, then the effect of these variables has other latent factors biasing the coefficients. Even if the measures for institutional functioning are more successful, these look less robust just the sum is strongly statistically significant. In comparison with country-specific variables, the interpretation of it is less intuitive.

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

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

$$X_{ij} = exp[\beta RoL_i \times INTL_{ij} + \beta_2 Culture_{ij} + \gamma GRAVITY_{ij} + \delta_0 INTL_{ij} + \mu_i + \chi_j] \times \varepsilon_{ij} \tag{2.13}$$

Table I4 and Table I5 show the results. The need of having two different tables is because the measures of distance from De Benedictis et al. (2020) contain fewer pairs of countries and the sample size varies. This variation is useful to test the robustness of these outcomes. Cultural proximity proxies lower the coefficient of rule of law of a few decimal points as well as the smaller sample size in Table I5. 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.

iii) the differences related to different industries and the related contract intensity (Levchenko, 2007; Nunn, 2007).

Moving the analysis to the sectoral level, Tables I6 and I7, using respectively WIOD and ITPD (Version 2) I estimate the model:

$$\begin{aligned} X_{ij} = exp[\beta RoL_i \times INTL_{ij} + \bar{z}^k \beta' RoL_i \times INTL_{ij} + \\ \beta_2 Culture_{ij} + \bar{z}^k \beta_2' Culture_{ij} + \gamma GRAVITY_{ij} + \delta_0 INTL_{ij}^k + \mu_i + \chi_j] \times \varepsilon_{ij} \end{aligned} \quad (2.14)$$

where $\bar{z}^k$ is the standardize contract intensity. This approach allows measuring the effect of contract intensity related to the average institutional quality. The control $INTL_{ij}^k$ is done for each industry k. Also in this case using two different samples helps to check the robustness of the findings. Data from ITPD covers more countries but they are unbalanced while WIOD provides a squared trade matrix. In both the tables results are consistent. These results confirm also that the magnitude of the domestic institutions coefficient is affected by sample size and composition, a larger sample lower impact compare to a smaller sample as shown in Table I5. The test on how much contract intensity matters with respect to the average institutional quality is not significant either for rule of law or for common religion. Nonetheless, is significant in both cases the language proximity and the contract intensity term. The interpretation suggested that language has a heterogeneous effect according to contract capacity and maybe also skill contents of the sector.

2.7 Counterfactual Analysis

Once the impact of domestic institutions is studied. Focusing just on the countries' Rule of Law I propose an experiment that wants to answer the question: *What happens if all countries turn to have good institutions?*. To do so, the counterfactual scenario considers a situation in which all the countries with a negative value (bad institutions) of the WGI index face a change to the average value (0.2, see Table I1) and no variation for the countries that already have a positive value (good institutions).

The baseline results refer to column 1 in Table I2. Thus on an aggregate trade sample of 98 × 98 countries in 2000:

$$X_{ij} = exp[0.57 \times I_i \times INTL_{ij} - 0 - 66 \times log(Distances_{ij}) + 0.72 \times Contiguity_{ij} + \\ + 0.30 \times Common\ Language_{ij} - 3.03 \times INTL_{ij} + \mu_i + \chi_j] \times \varepsilon_{ij} \quad (2.15)$$

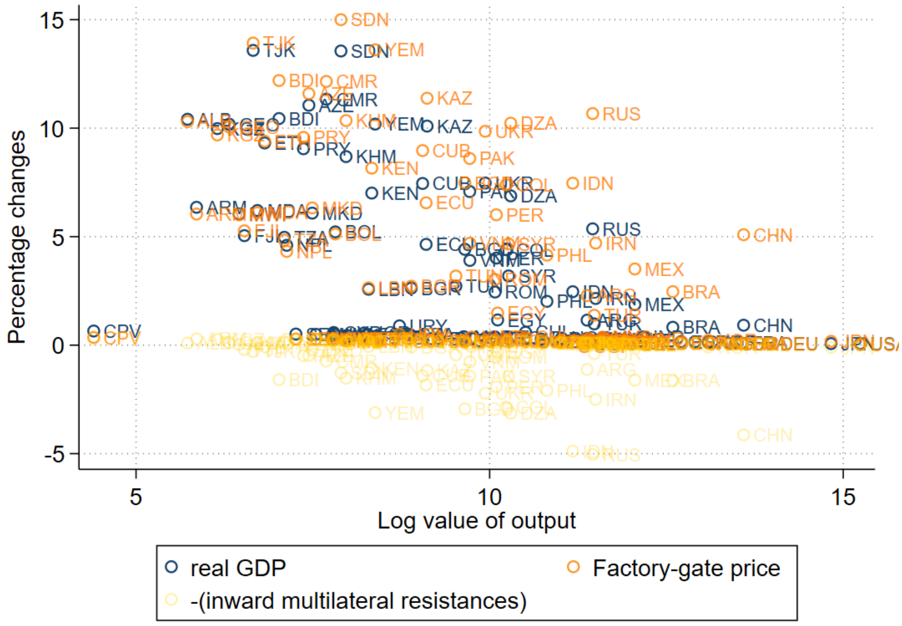
Using the methodology from Yotov, Piermartini, Monteiro and Larch (2017) to run the exercise *trade without borders* which looks the most appropriate to run an analysis with unilateral variable. This procedure allows me to measure the variation in real terms and the general equilibrium implications. Changes from baseline to counterfactual of the t_{ij} vector affect inward and outward multilateral resistance terms and consequently the factory gate price which 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 this experiment I show the variation in consumer prices ($-1 \times P_j$), in domestic prices (factory gate price, w_i) and in real output. Moreover, I display the consequences of export in conditional and full endowment equilibrium.

Firstly, I 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 2.6). Thus, the net effect of a fall in import prices and a large increase in domestic prices generate an improvement in total output.

In a country like Sudan (SDN), characterized by bad institutions and a low baseline output that is really 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 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 would have a relatively small improvement from aligning their institutional quality with the average.

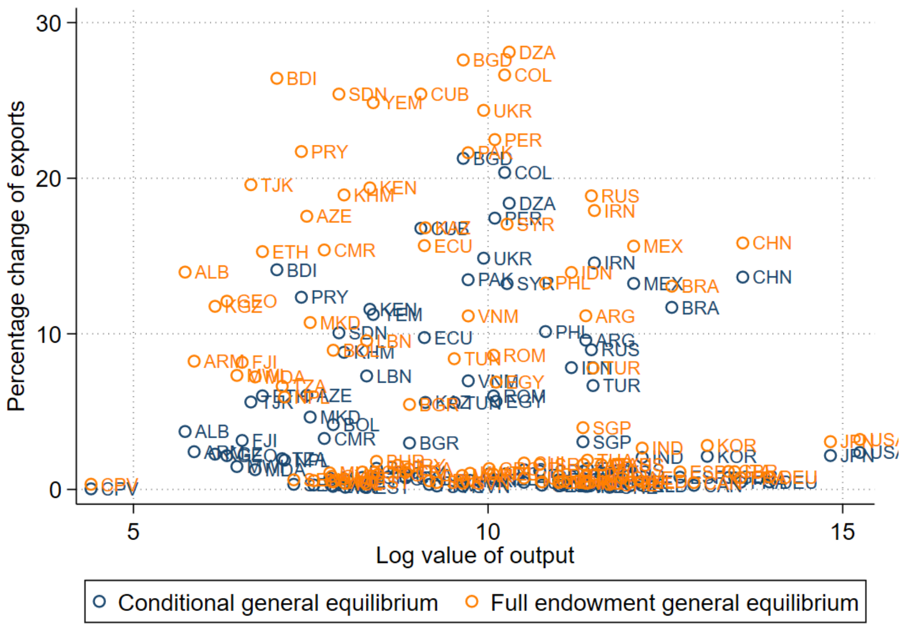
Figure 2.1: Counterfactual Analysis: changes in consumer prices, domestic prices and real GDP



Source: Author's elaboration

Figure 2.1 shows the changes in export levels and I can 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 I8 and Table I9 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 for all countries, 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.

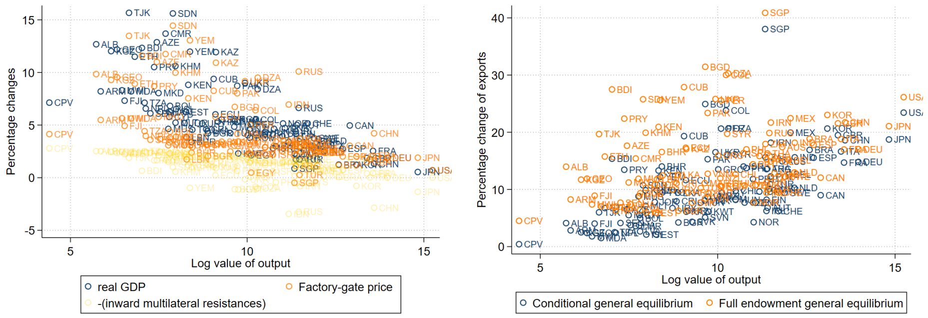
2.7.1 Counterfactual: sensitivity analysis

The results from the main analysis confirm the prediction of the benefit from 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 my results I replicate my exercise but extend 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[9].

This counterfactual scenario produces a similar output to the exercise I took as a reference (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. This last results confirm the robustness of the methodology applied and also add an intuition for which institutional improvement have a better effect if it happens worldwide, countries with a proper institutional environment should contribute to improving third countries' institution and keep upgrading their ones.

[9]for lower values the results do not vary much compared to the main application

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



2.8 Conclusion

The analysis of the effect of domestic institutions I proposed here suggested 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-specific institutional environment. Using bilateral variables, either for form or functions does not provide robust results and these are influenced by the assumption made to create a bilateral measure.

The role of bilateral cultural ties, both 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. In order to understand better and define the mechanism of different cultural dimensions, alone and combined. Moreover, a deeper investigation of the nexus between bilateral geographical features[10] to distinguish the clear effect of these variables.

[10] an analysis on gravity covariates and cultural distances is provided by De Benedictis et al. (2020)

The further contribution of this work is a theoretical explanation of the methods of Heid et al. (2021) which allows also to run policy experiments as in Beverelli et al. (2018*b*). The counterfactual I present 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. Therefore, the increase of almost 30% of the value of exports meaning that is the change that a country needs to have an average value of its good in line with the rest of the world.

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 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.

2.9 Appendix A

2.9.1 Descriptive Statistics

Table I1: 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.

2.9.2 Empirical Analysis

Table I2: Aggregate Trade: Baseline

VARIABLES	(1) PPML - 2000	(2) PPML - 2000	(3) PPML - 2000	(4) PPML - 2000
RoL X INTL (Exp.)	0.5726***			
	(0.0922)			
RoL X INTL (Imp.)		0.5726***		
		(0.0922)		
Legal Origin UK X INTL			1.1038***	
			(0.1756)	
Legal Origin German X INTL			0.6582***	
			(0.1395)	
Legal Origin Scandinavian X INTL			0.1881	
			(0.1706)	
RoL X Legal Or. French X INTL				0.3489**
				(0.1437)
RoL X Legal Or. UK X INTL				0.8843***
				(0.0955)
RoL X Legal Or. German X INTL				0.5933***
				(0.1075)
RoL X Legal Or. Scandinav. X 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

Table I3: Aggregate Trade: Function vs Form Bilateral Variables

VARIABLES	(1) PPML - 2000	(2) PPML - 2000	(3) PPML - 2000	(4) PPML - 2000	(5) PPML - 2000
Abs Val. Diff. betwenn Rol	-0.1253*				
	(0.0756)				
(RoL (exp) + RoL (imp)) X INTL		0.2863***		0.2906***	0.2790***
		(0.0461)		(0.0492)	(0.0481)
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

Table I4: Aggregate Trade Role of Culture (1)

VARIABLES	(1) PPML - 2000	(2) PPML - 2000	(3) PPML - 2000
RoL X INTL (Exp.)	0.5642***	0.5274***	0.5311***
	(0.0946)	(0.0846)	(0.0873)
Similarity between two languages: Continuous Index	0.0953		-0.0493
	(0.1577)		(0.1570)
Common religion index		0.7527***	0.7641***
		(0.1726)	(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 I5: Aggregate Trade Role of Culture (2)

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

Table I6: Sectoral Trade: Contract Intensity (WIOD (1))

VARIABLES	(1) PPML - 2000	(2) PPML - 2000	(3) PPML - 2000	(4) PPML - 2000
RoL X INTL	1.3221***			1.3267***
	(0.0942)			(0.0992)
RoL X Contract Int. (Std) X INTL	-0.1552			-0.1163
	(0.1098)			(0.1144)
Similarity between two languages: Continuous Index		0.5854***		-0.1944
		(0.1754)		(0.1586)
Similarity between two languages X Contract Int. (Std) X INTL		-0.2795*		-0.1054
		(0.1613)		(0.1666)
Common religion index			0.5797***	0.2571
			(0.1675)	(0.1846)
Common Religion X Contract Int. (Std) X INTL			-0.3864***	-0.2387
			(0.1485)	(0.1585)
Observations	17,514	17,514	17,514	17,514
Exporter X Sector FE	YES	YES	YES	YES
Importer X Sector FE	YES	YES	YES	YES
INTL X 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 I7: Sectoral Trade: Contract Intensity (ITPDv2 (1))

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

2.9.3 Counterfactual Analysis

Table I8: Main counterfactual results (1/2)

	Exports		Factory gate price	IMR	OMR	Real output	Baseline output
Country ISO3	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. Δ% is the percentage changes of the variable of interest (100 × changes).

Table I9: Main counterfactual results (2/2)

	Exports		Factory gate price	IMR	OMR	Real output	Baseline output
Country ISO3	Δ % Conditional	Δ % Full	Δ % w_i	Δ % P_j	Δ % Π_i	Δ % 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. Δ% is the percentage changes of the variable of interest (100 × 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, as a serious implication for the health systems, in many countries in the world. Governments are facing an unprecedented challenge in terms of short-run response. Worldwide economies are hardly hit by the different types of intervention for containing the contagion, both directly and indirectly.

In this work, I want to answer a simple question: *What is the effect of pandemic containment policies on international trade?* This simple question leads to a better understanding of the relationship between domestic production, international and domestic sales and the implication of the short-run exogenous intervention. The policies for health crisis management affect the different dimensions of society (social distancing, curfew, closing schools, restriction of movements) and the economy (smart working, closing particular economic activity). The variety of interventions makes it hard to forecast and assess the implication for the domestic economy and the consequences for the international dimension.

The answer to the research question tests 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, Sheu and Zahler, 2019) since monthly trade has different trends from the annual.

During the first wave of the pandemic (which began in March 2020) the main international organizations were extremely pessimistic about the consequences on the economy. 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 concretely this decline was not that thorny, falling by the 5.3%.[1]

Since the begging, the pandemic was considered 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 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

[1] https://www.wto.org/english/tratop_e/covid19_e/faqcovid19_e.htm#collapse0

that make difficult to assess which 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. Introducing a method to measure monthly domestic production and obtain monthly domestic sales, it wants 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 is a bridge between the recent literature on pandemics and the economy. In particular, it discusses works on international trade empirical and theoretical and the gravity model.

At its beginning, the pandemic was considered a massive shock affecting demand and supply, and it has a high diffusion speed among big economies. Comparing it with previous crises, the rapidity and the spread make it an "unprecedented" crisis both for the health and economic system (Baldwin and Mauro, 2020), and the society as a whole. Besides the preoccupation with the medical emergency, the threat was the consequence of the lockdown and related shutdown of economic activities in the global economy (Baldwin, 2020).

One of the main policy problems is to find the best combination between containment measures and the survival of the economy. Acemoglu, Chernozhukov, Werning and Whinston (2020) provides an economic model integrated with SIR [2] based on US data, to find the best solution to maximize economic outcomes and minimize deaths. This work is useful for the domestic dimension, 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, Redding and Rossi-Hansberg (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. Hence, 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 which 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 is that when the pandemic arrived, the global economy was already at a particular moment. Researchers and institutions already notice that the phenomenon of *slowbalization* and *de-globalization* are happening [3]. 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 (temporary or paradigm shift (Gruszczynski, 2020)).

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

[3] 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

Antràs (2020) offers a theoretical framework describing the mechanism of the backlash in globalization and also can give the inspiration to make some preliminary considerations about the post-Covid world. It emerges that substantial change in the economic geography could be more related to the political tension than by other factors and if such shock will persist across years. As long as the pandemic shock is "temporary", the sunk costs that firms (mostly in large economies involved in modern Global Value Chains) face to act in the global economy make it difficult to change global sourcing strategies. Similar to the 2008-9 financial crises, the immediate effect is on the intensive rather than extensive margins of trade. These considerations are interesting to comment on findings in section 3.7.

Among empirical works on the impact of pandemic shocks on international trade, few of them consider a multi-country (bilateral) setting Espitia et al. (2021) from the World Bank as a valuable example, this analysis is inspired by them. The authors measure the demand, supply and third-country shocks on the monthly growth of bilateral export in 2020. They provide a sector analysis, and the findings suggest that supply shocks related to remote working and closure of working place affect positively the export rate in any sector. Demand shocks have a different impact related to the type of products, more durable goods are less sensitive to the others because some sectors, such as automotive, seriously drop due to the pandemic. While others, like electronics (i.e. computer, laptops), compensate because they are essential for working and schooling from home. Furthermore, they measure third-country effects. Firstly, competition has a negative correlation due to the lowered production level in third countries could foster export growth. Even if this coefficient is positive in some specification, meaning that a pro-competitive effect of production and trade is relevant. And also, through upstream shock (the shock of related input goods for each sector faced by other countries).

In Appendix 3.8 section 3.8.1 (Tables H1 and H2) contain a replication exercise of Espitia et al. (2021), where instead of an Ordinary Least Square (OLS) on the export growth rate the estimates concern a Pseudo Poisson Maximum Likelihood on export volume. This change confirms the sign and statistical significance of the results [4]

Other works with preliminary results of covid and trade. Hayakawa and Mukunoki (2020) use the number of cases and death to measure the "burden" of the pandemics on international trade flows in the first quarters of 2020. From their evidence, the effect on exporting countries is statically relevant rather than for importers and mostly hit sectors are the textile, footwear, and plastic industries.

To identify the consequence of the pandemic on trade, this work relies on a structural gravity model theoretically based. 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 this framework is a short-run analysis similar to Beverelli et al. (2018*a*), this paper offers estimates on the effect of institutions' quality on international trade relative to domestic sales. 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, I look at the effect of institutional response on international trade relative to domestic sales. Sellner (2019) 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 (2021). The measures for monthly domestic sales I 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

[4] Due to computational challenges, these replications do not contain third-country competition.

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, it is presented the Eaton and Kortum (2002) model to explain the mechanism of country-specific shock on international trade. Hence, to interpret the results for the econometric analysis.

The formalization of Eaton and Kortum (2002) can describe the dynamics of trade in a gravity framework, the only small difference I implement is on the input cost functions which in my 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 particular 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 affect also 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 countinuum of good $\omega \in \Omega$, consumers aggregate behavior is represented by CES preference[5]. Prices are determined in perfect competition, thus the price for a good exported by i to country j is

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

[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 elasticty of substitution. The utility is subject to budget constraint of the total expenditure of country j, E_j

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 make production more costly. This last term represents the charge on costs that government apply (directly and/or indirectly to domestic production. Assuming $\xi_i \in [1, \overline{\xi_i}]$. Each country i sets a different value for ξ_i, if equals one there is any intervention (then, no frictions) and $\overline{\xi}$ for a total shutdown of the economy. As in Eaton and Kortum (2002), $z_i(\omega)$, the efficiency distribution is Frechét[6].

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

$$p_j = min\{p_{ij}, i = 1, ..., N\} \tag{3.2}$$

The prices distribution:

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

and the price parameter:

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

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:

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

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

[6] The Frechét distribution, also named as 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. High T_i means it is more likely to draw high efficiency, low θ more variability (heterogeneity) and consequently more 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* $\gamma = \left[\Gamma\left(\frac{\theta+1-\sigma}{\theta}\right)\right]^{\frac{1}{1-\sigma}}$

The theoretical gravity equation is expressed as:

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

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

Sum up:

- Covid 19 shocks/policy are in the short run, the market-clearing condition is not verified;
- $c_i = w_i\xi_i$ means that containment positive constitutes an additional cost for domestic production. In general, this increase in 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

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

- $t_{ij} = \tau_{ij}\, \xi_i$, 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):

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

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

The Multilateral Resistance Terms, *inward* P_j and *outward*, Pi_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 two are useful to investigate on aggregate trade costs, capturing their asymmetries controlling for the unobservable "resistances" to trade specific of exporter and importer by time, and also between pair of countries.

The parameter θ, as explained above has the same 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 important to assess the difference between the domestic and international trade flows and how country-specific response to the pandemic.

3.4 Data

3.4.1 Dependent Variable: Trade

The main sample for the analysis contains 14 exporting countries and 212 importers, data for international trade are taken from COMTRADE [9]. The domestic sales are built using UNIDO INDSTAT2 data, both annual production and for the Index of Industrial Production. Combining these two, it comes out with a balanced panel data set from January to September.

Measuring Domestic Gross Production and Domestic Sales

The importance of having domestic flows is already pointed out above. Here I present how this measure is in gross terms. Since trade data are in gross terms[10] 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 consists of the calculation of the monthly values of domestic production for the base year of the index (2015). Secondly, it is possible to derive the value of 2020 production.

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

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

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

[9] `https://marketplace.officialstatistics.org/un-comtrade-monthly`
[10] for my knowledge there are not any high-frequency trade data in value added
[11] GDP at ant frequency is expressed in value-added.

$$Production_{i,t_{2020}} = \frac{Production_{i,t_{2015}} \times IIP_{i,t_{2020}}}{IIP_{i,t_{2015}}} \tag{3.8}$$

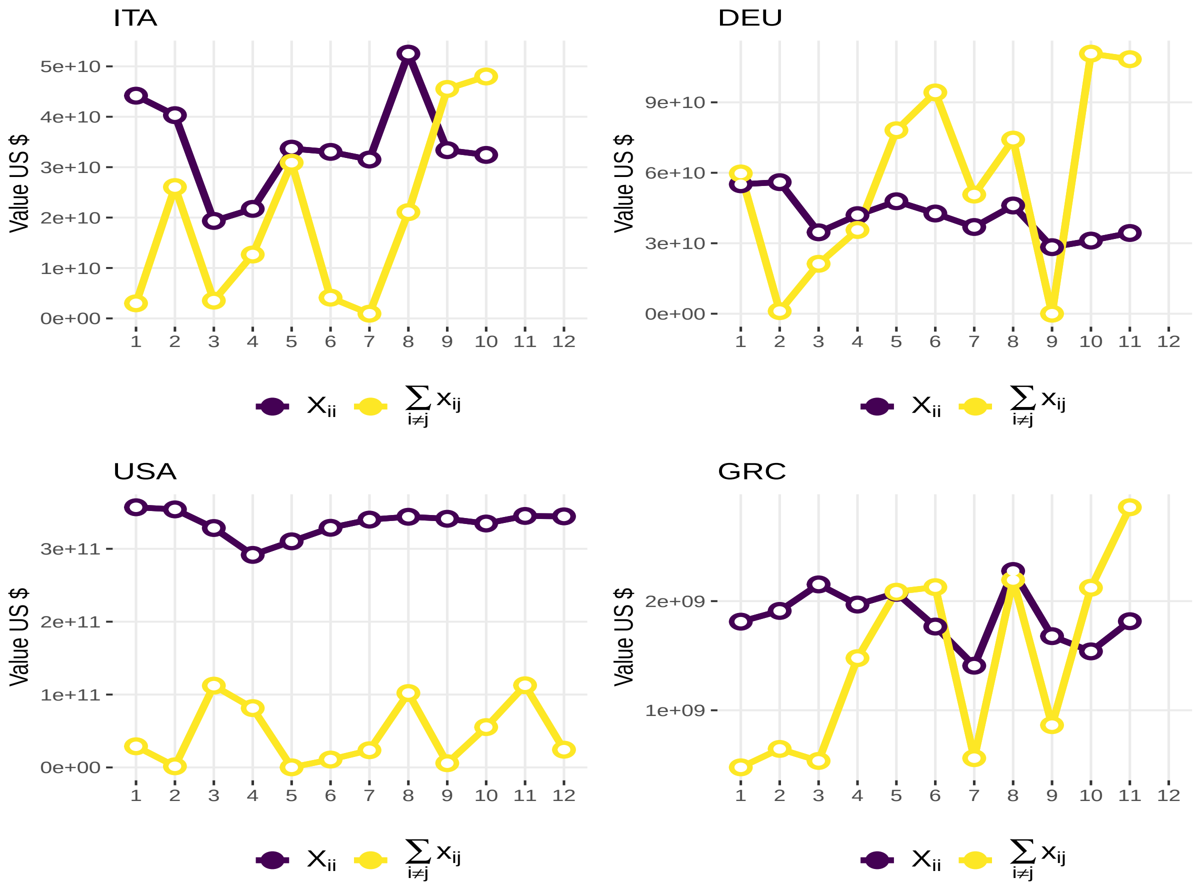
Finally, it is obtained the domestic sales included in the estimates:

$$X_{ii,t_{2020}} = Domestic\ Sales_{i,t_{2020}} = Prod_{i,t_{2020}} - Total\ Exports_{i,t_{2020}} \tag{3.9}$$

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 both fluctuate, and it could be hypothesized 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 exchange. 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 smaller.

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 as workers' mobility and maritime traffic.

Institutional Response: is measured by the Stringency Index computed by *Oxford's Covid-19 Government Response Tracker*[12], which an index about the restrictiveness

[12]Downloaded by `https://raw.githubusercontent.com/OxCGRT/covid-policy-tracker/master/data/OxCGRT_latest.csv,whichupdatedfrequently`

of containment policies. It is computed taking into account all ordinal containment and closure policy indicators[13] 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 are 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 5 weeks, Jan 3 – Feb 6 2020).

Infrastructure: to capture the effect on infrastructure that the pandemic had, It captures the maritime traffic passing by the country's ports. These data are collected by AIS technology and COMTRADE's COVID-19 monitor elaborates to give the number of port calls by country. Then is computed a measure of the different rates of port traffic with respect to 2019 in the same month:

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

After the presentation of the three main explanatory variables (not common to the gravity framework) now it is shown the correlation with total exports. In panel (a) of Figure 3.2 it is evident that at 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 countries' economy, looking at this graph US and Germany recorded

[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

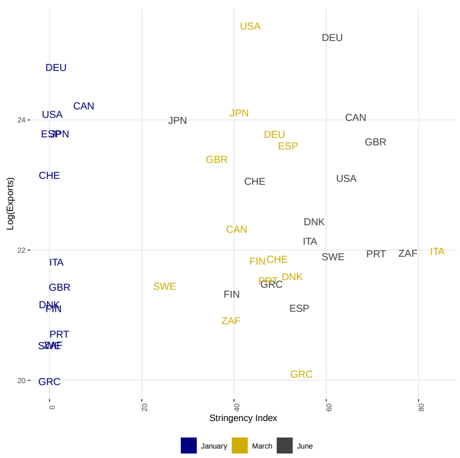
[14]It measures the Record presence of public info campaigns on an ordinary scale, looking at no Covid-19 information at all and the official public campaign and the coordinated ones (which includes also social media)

[15]`https://www.google.com/covid19/mobility/`

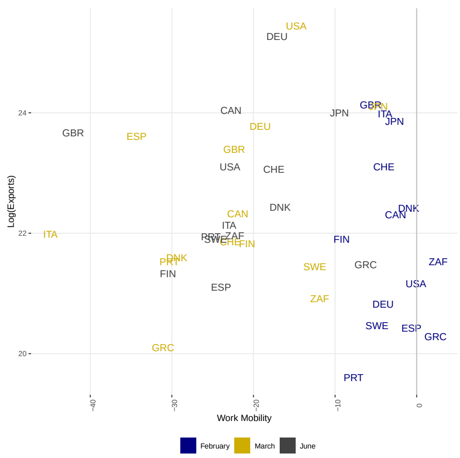
a relatively high level of export when stringency rise. Furthermore, the most relevant impact on the intensive margin of trade comes out by looking at the annual level instead of the monthly trends. In panel (b) of Figure 3.2 which focuses on work mobility and panel (c) on port calls, there is not a 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

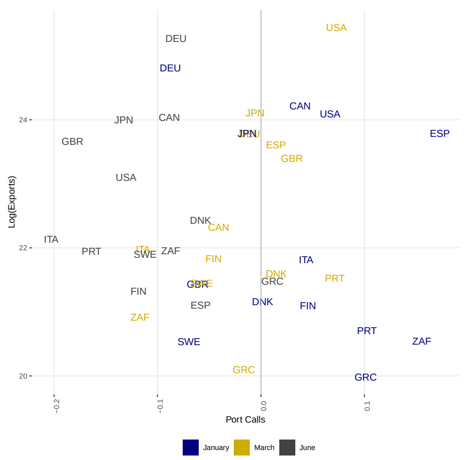
(a) Stringency Index



(b) Workers' Mobility



(c) Port Calls



Source: Author's elaboration

3.5 Empirical Strategy

The estimates relate to the literature on gravity and non-discriminatory trade policies and country-specific features (Beverelli et al., 2018*a*; Heid, Larch and Yotov, 2020; Sellner, 2019). 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 (Silva and Tenreyro, 2006). According to Yotov (2021), 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, Larch and Yotov (2020) to specify gravity with pair fixed effects and consecutive-time data.

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

- $\eta_{i,t}$: exporter-time fixed effects
- $\xi_{j,t}$: importer-time fixed effects
- μ_{ij}: bilateral fixed effects
- $GRAV_{ij,t}\beta$: 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).

$$X_{ij,t} = e^{[\eta_{i,t}+\chi_{j,t}+\mu_{ij}+GRAV_{ij,t}\beta+\gamma_1 WORK\_MOBILITY i,t \times INTL_{ij}+\gamma_2 CONTROL_{ij,t-1}]+\varepsilon_{ij,t}} \tag{3.12}$$

where $\gamma_1 WORK\_MOBILITY i,t$ is the index proposed by Google describe in section 4.

$$X_{ij,t} = e^{[\eta_{i,t}+\chi_{j,t}+\mu_{ij}+GRAV_{ij,t}\beta+\gamma_1 PORT\_CALLS\_RATE i,t \times INTL_{ij}+\gamma_2 CONTROL_{ij,t-1}]+\varepsilon_{ij,t-1}} \tag{3.13}$$

where $\gamma_1 PORT\_CALLS\_RATE i,t$ measures the effect of a variation of maritime traffic with respect 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:

$$\gamma_1 = \frac{\partial \pi_{ij}}{\partial \xi_i} = -\theta(\pi_{jj} - \pi_{ij}) \qquad (3.14)$$

where the expected sign is negative, meaning that higher frictions reduce trade with respect to 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. Since the sample composition and overall balance between the internal and outgoing exchange of goods may affect the magnitude of the coefficient. The larger the difference between the two dimensions larger the effect.

3.6 Results

Institutional Response: Tables H3 and H4 show that the Stringency Index have a heterogeneous impact on international trade relative to domestic sales. In column (1) in Table H3 the coefficient estimated with directional fixed effects is negative and suggests a decrease of almost 2% in terms of volume of trade. Columns (2-4) all include pair fixed effects but with different settings. The significant coefficient is positive, and its value is greater (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. Thus, containment policies would lead to a drop in exports while still maintaining alive multilateral commercial relationships and mitigating the effect of the pandemic. The dummy variable for trade in 2019 gives the idea the trade pattern are not disrupted on average. It suggests that perhaps the seasonality and the timing of export flows are different, but it is too early to assess if Covid-19 change radically these relationships.

Table H4 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 H3. 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.

Labor: Table H6 and H7 measures the impact of workplace mobility, and then the related closure or remote-working solutions. As for the previous estimates, a different set of fixed effects leads to different significant signs of the coefficients. The unidirectional fixed effects (column 1 Table H6) 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 H6) 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. Reducing and re-adapting the workforce and working conditions lower the cost of labour, generating more efficiency in production processes, and this reflects on the export level. The effect of labour is negative because less employee produces less. Although, there are some specific sectors and activities gaining (in some cases survive more) from this situation.

Table H7, looking only at the international dimension assesses that the positive relationship between trade and labour is predominant. Furthermore, Table H8 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 H6, 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 H3 and H5 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 H9 and H10 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 H9 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 H10) the sign is confirmed (just in column 5) and changing the fixed effect setting does not lead to any significant results. The role of infrastructure as the port is reasonable that 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 is trading 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 different 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 together with containment tries to support the economy domestic and international sales offset each other mitigating the negative effect. Of course, there are winners and losers that 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. Here the analysis is extended including the role of aggregate sunk costs and shock propagation with the attempt to include network statistics in a gravity model.

As Antràs (2020) pointed out the role of firms' sunk costs similar to Morales et al. (2019) I try to improve a previously unpublished work Magerman, De Bruyne and Van Hove (2013) which uses network centrality that tries to find observable measures of the "observable" elements in Multilateral Resistances in the gravity model.

Network analysis is applied to examine 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.

My 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 short-run 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, Nenci, Santoni, Tajoli and Vicarelli (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:

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

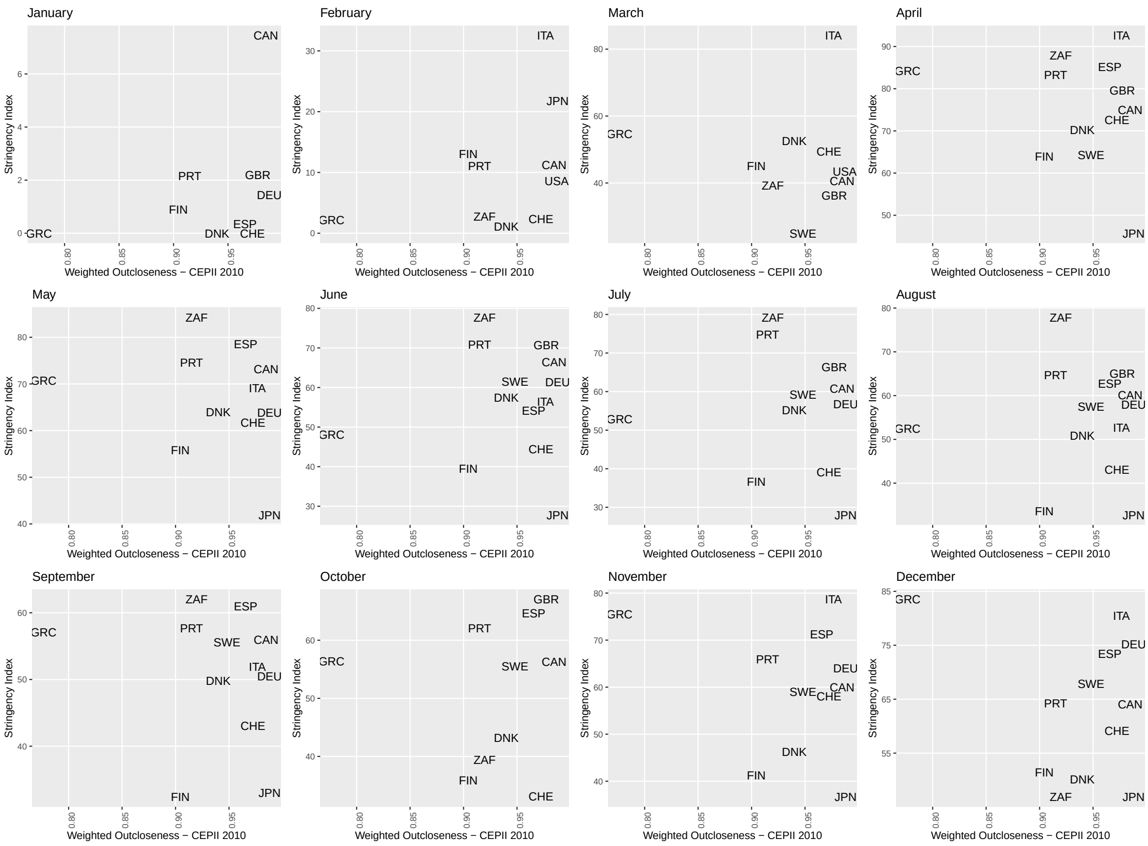
the geodesic distances are calculated over the weighted paths $\mathcal{L}_{ij} = min(\frac{1}{\alpha_{iz_1}} + \frac{1}{\alpha_{iz_2}} + \ldots + \frac{1}{\alpha_{z_{n-3}j}} + \frac{1}{\alpha_{z_{n-2}j}})$ where $\alpha_{ij} = N\frac{\mathcal{A}}{\sum_i \sum_j \mathcal{A}}$ is the share between pair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

Intuition

This section discusses if *weighted out-closeness* would be a good candidate to measure country reactivity to short-term 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 and they define the position of a country in an international trade network. As described in Morales et al. (2019) firms' 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 the variation of the correlation between weighted out closeness and stringency index and the difference 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, from March to November 2020 the containment policies follow other European countries in particular the 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. While Switzerland (CHE) behave more independently. Also, North American countries act very similarly and follow European trends. Slightly different timing in response is recorded for remote countries such as South Africa (ZAF) and Japan (JPN) the last applied less severe intervention after April 2020.

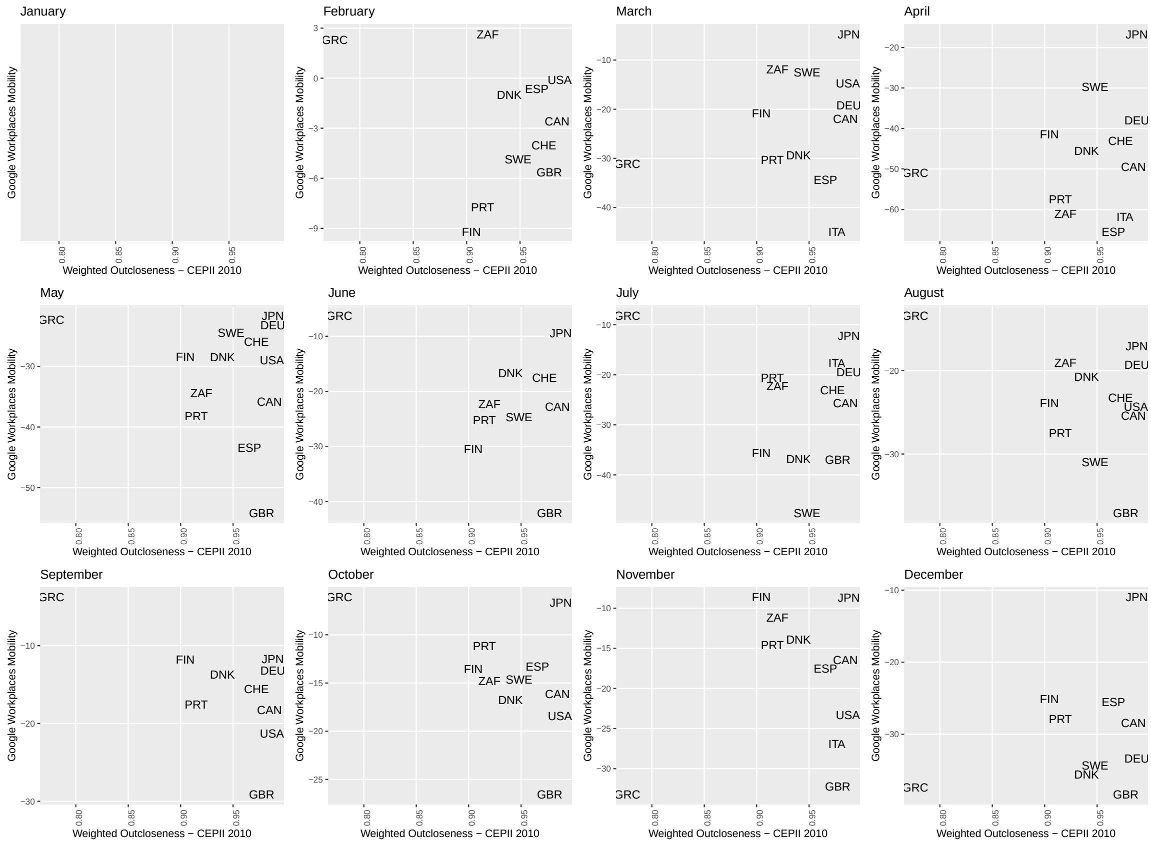
Figure 3.3: Weighted Out-Closeness (2010, CEPII) and Stringency Index



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

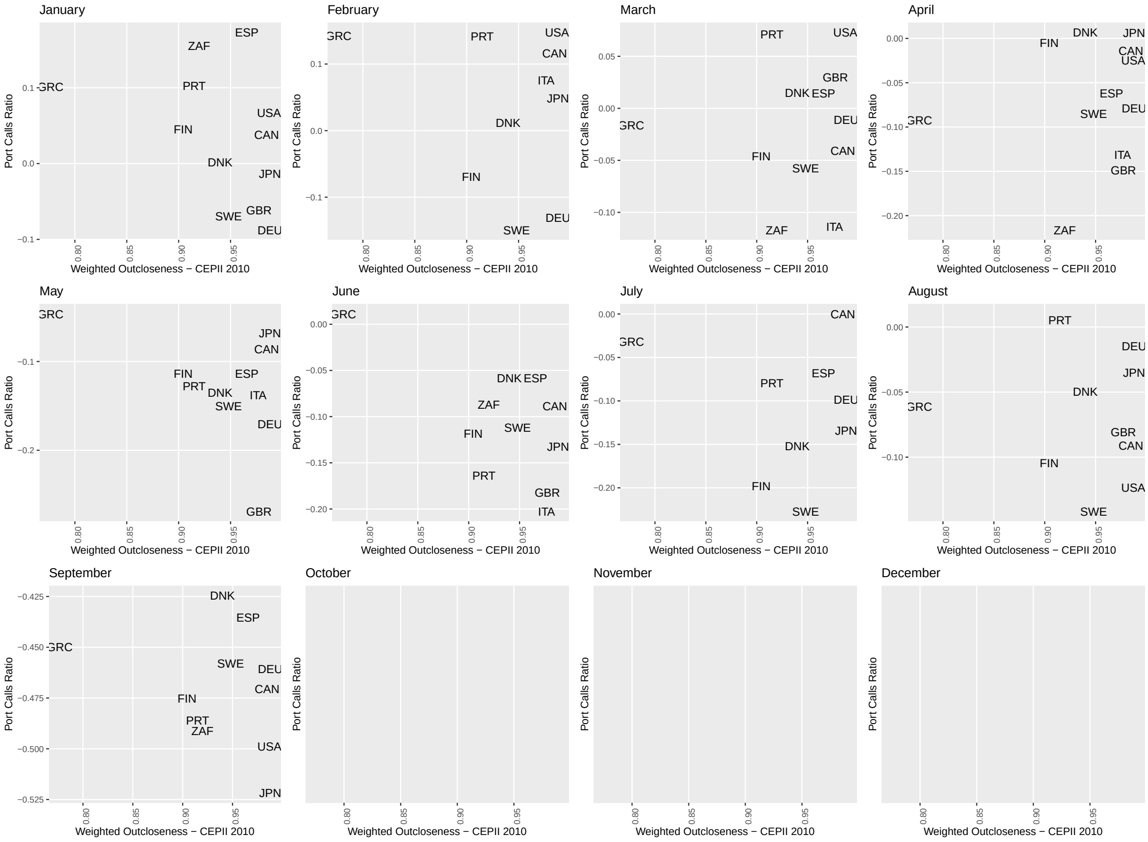


Source: Author's elaboration on CEPII Network centrality measures and Google's Community Mobility Report data

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

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

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, the network centrality measure enters in the cost function affecting the cost of the overall production:

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

in this case $c_i = c_i \nu_i \xi_i$ where $\xi_i \in [1, \overline{\xi}]$ 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.

As 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., 2020):

$$X_{ij,t} = e^{[\eta_{i,t}+\chi_{j,t}+\mu_{ij}+GRAV_{ij,t}\beta+\gamma_1 WOUTCLOSENESS_i \times INTL_{ij}+\gamma_2 CONTROL_{ij,t-1}]} \quad (3.17)$$

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

$$X_{ij,t} = e^{[\eta_{i,t}+\chi_{j,t}+\mu_{ij}+GRAV_{ij,t}\beta+\gamma_1 WOUTCLOSENESS_i \times \gamma_2 CONTROL_{ij,t-1}]+\varepsilon_{ij,t}} \quad (3.18)$$

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

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

$$X_{ij,t} = e^{[\eta_{i,t}+\chi_{j,t}+\mu_{ij}+GRAV_{ij,t}\beta+\gamma_1(WOUTCLOSENESS_i \times SHOCK_{i,t})+\gamma_2 CONTROL_{ij,t-1}]+\varepsilon_{ij,t}} \tag{3.19}$$

3.7.4 Results

Network Centrality Measures In the first column of Table I12 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 short term. The control variable for the existence of export flows in the previous year loses its statistical significance that in the previous results showed robustness. This suggests that closeness is a good predictor to capture structural features of trade and also provides another point of view. In column 2, including gravity variables and directional fixed effect, the combination of closeness and control dummy gives the same sign but a lower magnitude of the coefficient. In the other column, the sign is positive with pair fixed effects.

Institutional Response Table I13 measure the nexus 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.

Labor Table I14 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 I15 there is only a result that is statistically significant, 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 World Bank Extended Results

The following tables are an adaptation to the work of Espitia et al. (2021). Instead of using OLS and as dependent variable the export growth rate, my analysis is made using a Pseudo Poisson Maximum Likelihood (PPML) and then including zero trade flows and level of exports.

The explanatory variables are:

- *work mobility*: measures mobility trends for places of work
- *retail mobility*: captures mobility trends for places like restaurants, cafes, shopping centres, theme parks museums, libraries and movie theatres
- *upstream shock*: is the shocks in a third countries flows of intermediate inputs to related sectors

  $$upstream = \sum_{1}^{S} \left(\sum_{1}^{N} w_{ilsn} \right) * ipi_{st}$$

  where w_{ilsn} is the weight of input sector n from source country s in all imported inputs used by output sector l in exporter country i and ipi_{st} is the idustrial index of production of source country s by month t.
- *global output*: Computed using the UNIDO's industrial index of production
- The iterative terms that allows to split the effect by sectors:
  i) remote: Remote labour index by U.S. 2017 O*NET ranks by sector (ISIC Rev.3–2 digit) the average suitability to work by remote.
  ii) gvc: measures an exporter-sector's share of imported inputs in its exports
  iii) gvc parnter: a partner country-sector's dependence on imported inputs in its total imports

iv) durable: Durable, semi-durable and transport products defined by the UN-BEC classification (HS6-digit level).

Table H1: Espitia et al. (2021), replication using PPML and zero trade flows

VARIABLES	(1) exports	(2) exports	(3) exports	(4) exports
Supply: Work Mobility(i,t)	0.394***			0.362***
	(0.071)			(0.067)
Demand: Retail Mobility(j,t)		0.398***		0.390***
		(0.031)		(0.038)
Third Country: Upstream Shock			2.110***	1.292***
			(0.251)	(0.351)
Control: Global Output(m,t)	3.014***	2.975***	2.494***	2.991***
	(0.127)	(0.127)	(0.111)	(0.128)
Constant	10.953***	10.917***	10.985***	11.112***
	(0.019)	(0.013)	(0.018)	(0.027)
Observations	1,040,228	863,940	1,260,759	852,900
Exporter-Time FE	NO	YES	YES	NO
Importer-Time FE	YES	NO	YES	NO
Exporter-Partner-Sector FE	YES	YES	YES	YES
Sector-Time FE	YES	YES	YES	YES
Cluster	Pair	Pair	Pair	Pair

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

Table H2: Espitia et al. (2021), replication using PPML and zero trade flows, Sector characteristics

VARIABLES	(1) exports	(2) exports	(3) exports	(4) exports
Supply X Sector: work + remote (i,k,t)	0.328*			0.330
	(0.172)			(0.203)
Supply X Sector: work + gvc (i,k,t)	3.335***			2.915***
	(0.451)			(0.502)
Demand X Sector: retail + gvc partner (i,k,t)		-0.253***		-0.237***
		(0.031)		(0.044)
Demand X Sector: retail + durable (j,k,t)		0.977***		0.853***
		(0.063)		(0.060)
Third Country: Upstream Shock			2.502***	4.739***
			(0.277)	(0.488)
Control: Global Output(m,t)	2.600***	2.393***	2.427***	1.723***
	(0.115)	(0.121)	(0.118)	(0.110)
Constant	11.109***	10.818***	11.012***	11.414***
	(0.034)	(0.010)	(0.019)	(0.052)
Observations	983,634	628,337	1,252,475	591,758
Exporter-Time FE	YES	YES	YES	YES
Importer-Time FE	YES	YES	YES	YES
Exporter-Partner-Sector FE	YES	YES	YES	YES
Exporter-Partner-Time FE	YES	YES	YES	YES
Sector-Time FE	YES	YES	YES	YES
Cluster	Pair	Pair	Pair	Pair

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

3.8.2 Stringency Index Effect

Table H3: January to September 2020: Stringency = 0 for $i = j$

	PPML 2020			
	(1)	(2)	(3)	(4)
VARIABLES	Exports	Exports	Exports	Exports
Stringency Index (i,t)	-0.021***	0.004**	0.006***	0.010***
	(0.004)	(0.002)	(0.002)	(0.003)
Trade in 2019: Dummy	0.328***	0.235***	0.239***	0.153**
	(0.086)	(0.083)	(0.082)	(0.076)
Constant	31.061***	24.252***	24.223***	24.338***
	(0.571)	(0.075)	(0.075)	(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

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

Table H4: January to September 2020: Only international ($i \neq j$) flows

	PPML 2020						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
VARIABLES	Exports	Exports	Exports	Exports	Exports	Exports	Exports
Stringency Index (i,t)	0.002	0.004***	0.002	-0.007	-0.001	-0.002	0.004***
	(0.002)	(0.001)	(0.002)	(0.007)	(0.005)	(0.005)	(0.001)
Trade in 2019: Dummy	0.038	0.244**	-0.054	0.056	0.253**	-0.042	0.186*
	(0.116)	(0.116)	(0.109)	(0.109)	(0.109)	(0.103)	(0.101)
Constant	20.899***	24.149***	23.156***	21.335***	24.375***	23.282***	26.436***
	(1.306)	(1.211)	(1.237)	(1.423)	(1.307)	(1.229)	(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

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

Table H5: January to September 2020: Stringency = 0 for $i \neq j$

	PPML 2020			
	(1)	(2)	(3)	(4)
VARIABLES	Exports	Exports	Exports	Exports
Stringency Index (i,t)_intra	0.022***	-0.003***	-0.005***	-0.010***
	(0.004)	(0.000)	(0.001)	(0.003)
Trade in 2019: Dummy	0.327***	0.204**	0.223***	0.153**
	(0.085)	(0.085)	(0.083)	(0.076)
Constant	30.096***	24.407***	24.461***	24.791***
	(0.619)	(0.077)	(0.091)	(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

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

3.8.3 Workplaces Mobility Effect

Table H6: January to September 2020: Google Workplaces Mobility = 0 for $i = j$

	PPML 2020			
	(1)	(2)	(3)	(4)
VARIABLES	Exports	Exports	Exports	Exports
Google Workplaces Mobility (i,t)	0.045***	0.002	0.000	-0.012**
	(0.008)	(0.003)	(0.003)	(0.005)
Trade in 2019: Dummy	0.408***	0.205**	0.210**	0.162**
	(0.094)	(0.089)	(0.089)	(0.082)
Constant	31.176***	24.303***	24.292***	24.353***
	(0.541)	(0.079)	(0.079)	(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

Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Table H7: January to September 2020: Only international ($i \neq j$) flows

	PPML 2020						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
VARIABLES	Exports	Exports	Exports	Exports	Exports	Exports	Exports
Google Workplaces Mobility (i,t)	0.008**	0.002	0.009***	0.034***	0.034***	0.036***	0.002
	(0.003)	(0.002)	(0.003)	(0.007)	(0.007)	(0.005)	(0.002)
Trade in 2019: Dummy	-0.031	0.196*	-0.127	0.001	0.222**	-0.079	0.159*
	(0.101)	(0.105)	(0.092)	(0.101)	(0.100)	(0.091)	(0.089)
Constant	21.540***	24.530***	23.628***	22.304***	25.278***	24.253***	26.770***
	(1.297)	(1.173)	(1.097)	(1.268)	(1.134)	(0.921)	(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

Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Table H8: January to September 2020: Google Workplaces Mobility = 0 for $i \neq j$

	PPML 2020			
	(1)	(2)	(3)	(4)
VARIABLES	Exports	Exports	Exports	Exports
Google Workplaces Mobility (i,t)	-0.045***	0.005***	0.010***	0.012**
	(0.008)	(0.001)	(0.002)	(0.005)
Trade in 2019: Dummy	0.408***	0.206**	0.213**	0.162**
	(0.094)	(0.089)	(0.088)	(0.082)
Constant	30.243***	24.377***	24.443***	24.605***
	(0.584)	(0.080)	(0.085)	(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

Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

3.8.4 Maritime Port Traffic Effect

Table H9: January to September 2020: Port Calls Rate = 0 for $i = j$

	PPML 2020			
	(1)	(2)	(3)	(4)
VARIABLES	Exports	Exports	Exports	Exports
Port Calls Rate (i,t)	2.527***	0.027	-0.053	-0.009
	(0.560)	(0.262)	(0.271)	(0.482)
Trade in 2019: Dummy	0.584***	0.203**	0.197**	0.125
	(0.172)	(0.084)	(0.083)	(0.081)
Constant	31.436***	24.320***	24.325***	24.473***
	(0.695)	(0.075)	(0.074)	(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

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

Table H10: January to September 2020: Only international ($i \neq j$) flows

	PPML 2020						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
VARIABLES	Exports	Exports	Exports	Exports	Exports	Exports	Exports
Port Calls Ratio (i,t)	-0.183	0.064	-0.265	-0.289	1.294***	-0.611	0.043
	(0.288)	(0.261)	(0.273)	(0.575)	(0.461)	(0.519)	(0.270)
Trade in 2019: Dummy	0.037	0.224*	-0.059	0.049	0.255**	-0.043	0.159
	(0.116)	(0.120)	(0.110)	(0.112)	(0.109)	(0.104)	(0.104)
Constant	20.959***	24.335***	23.191***	20.957***	24.463***	23.169***	26.618***
	(1.272)	(1.188)	(1.205)	(1.277)	(1.195)	(1.208)	(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

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

Table H11: January to September 2020: Port Calls Rate = 0 for $i \neq j$

	PPML 2020			
	(1)	(2)	(3)	(4)
VARIABLES	Exports	Exports	Exports	Exports
Port Calls Ratio (i,t)	-2.527***	0.128	0.294	0.009
	(0.560)	(0.087)	(0.194)	(0.482)
Trade in 2019: Dummy	0.584***	0.204**	0.204**	0.125
	(0.172)	(0.085)	(0.084)	(0.081)
Constant	31.204***	24.328***	24.342***	24.474***
	(0.695)	(0.076)	(0.076)	(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

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 I12: Weighted Out-Closeness (Jan - Sep. 2020)

	PPML 2020				
	(1)	(2)	(3)	(4)	(5)
VARIABLES	Exports	Exports	Exports	Exports	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***	0.209**	0.201**	0.129
		(0.134)	(0.088)	(0.086)	(0.084)
Constant	30.216***	32.184***	24.476***	24.479***	24.569***
	(0.452)	(0.775)	(0.017)	(0.015)	(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

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

3.9.2 Weighted Out Closeness and Stringency Index

Table I13: Stringency Index and Weighted Out-Closeness (Jan - Sep. 2020)

	PPML 2020			
	(1)	(2)	(3)	(4)
VARIABLES	Exports	Exports	Exports	Exports
W Out Clo X Stringency	-0.022***	0.004**	0.006***	0.010***
	(0.004)	(0.002)	(0.002)	(0.003)
Trade in 2019: Dummy	0.326***	0.235***	0.240***	0.154**
	(0.085)	(0.083)	(0.082)	(0.076)
Constant	31.082***	24.251***	24.223***	24.337***
	(0.572)	(0.075)	(0.075)	(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

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

3.9.3 Weighted Out Closeness and Workplaces Mobility

Table I14: Work Mobility and Weighted Out-Closeness (Jan - Sep. 2020)

	PPML 2020			
	(1)	(2)	(3)	(4)
VARIABLES	Exports	Exports	Exports	Exports
W Out Clo X Work Mobility	0.047***	0.002	0.000	-0.013**
	(0.008)	(0.003)	(0.003)	(0.006)
Trade in 2019: Dummy	0.406***	0.205**	0.210**	0.161*
	(0.093)	(0.089)	(0.089)	(0.082)
Constant	31.194***	24.302***	24.291***	24.352***
	(0.543)	(0.079)	(0.079)	(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

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 I15: Port Calls and Weighted Out-Closeness (Jan - Sep. 2020)

	PPML 2020			
	(1)	(2)	(3)	(4)
VARIABLES	Exports	Exports	Exports	Exports
W Out Clo X Port Calls Ratio	2.610***	0.040	-0.039	0.018
	(0.580)	(0.271)	(0.280)	(0.500)
Trade in 2019: Dummy	0.583***	0.203**	0.197**	0.125
	(0.171)	(0.084)	(0.083)	(0.081)
Constant	31.442***	24.321***	24.326***	24.474***
	(0.695)	(0.075)	(0.074)	(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

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 that good institutions have on international trade and welfare.

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

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.

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 make a short-run analysis through a structural gravity, controlling for seasonality in monthly trade, 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 works 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 seasonality[20] 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. It is difficult to find other values with a wider time horizon. Although, 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.

[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

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