# Essays in International Trade

Author: Laura Bonacorsi

Boston College

The Graduate School of Arts and Sciences

Department of Economics

# Essays in International Trade

a dissertation

by

LAURA BONACORSI

submitted in partial fulfillment of the requirements

for the degree of

Doctor of Philosophy

December 2016

# Essays in International Trade


## Laura Bonacorsi

Advised by Professor James Anderson


## Abstract


The gravity model proved to to be one of the most successful framework for analyzing international trade flows, being referred to as the "workhorse" in the international trade literature (Head and Mayer (2014)). Microfoundations to this model has been provided in Anderson (1979) and it has often been employed to estimate the effects of a variety of trade policies (see Cipollina and Salvatici (2010) for a meta-analysis on reciprocal trade agreements, Rose (2000) for the effects of currency unions). The two chapters of this dissertation, which are independent empirical pieces, both make use of gravity equations for the estimation of trade flows, although with different purposes. The first chapter focuses on the specification of the gravity equation. In the second chapter, instead, gravity equations are employed for assessing the relationship between trade and growth: in fact, their estimation represents the first step for the creation of an instrumental variable for export flows.

In the first chapter, a solo-authored work titled **Scale Economies in European Trade**, I show that European data support the existence of economies of scale in trade flows. The impact of trade costs on trade flows, in fact, is assumed to be constant by almost all empirical studies employing the gravity framework. Anderson et al. (2016) are the first to depart from this assumption, allowing trade costs to vary as a function of trade volumes. Their model nests the more traditional one and hence can be used to test for the existence of these scale economies, which are shown to be in place for trade between US and Canada. For my analysis I construct a comprehensive dataset for

European trade in manufacturing over a long time span (from 1980 to 2013), on which I employ the same methodology. My results show that scale economies in trade costs are indeed a strong empirical fact outside of the American continent, and this holds for all the 26 manufacturing sectors considered, with an estimated average of 0.64% decrease in trade costs given by a 10% increase in trade volume. The focus on Europe allows me to test whether the EU expansion affected these economies of scale. While this is not true on average, it seems to be the case for some industries: trade with a EU partner entails scale elasticities 50% lower than trade with a non-EU member for 11 sectors out of the 26 considered. I also investigate whether scale elasticities can be rationalized by the existence of informational asymmetries. Using detailed product-level data, I do not find evidence that the degree of product homogeneity can account for the observed cross-sectoral variation. The scale coefficients are instead linked to country-specific institutional variables, such as the level of corruption: exporting to the country whose level of corruption is the lowest in the sample entails half the scale elasticity than exporting to the most corrupted one. In other words, corruption depresses trade to an higher extent on longer distances.

In the second chapter, joint with Carlo Altomonte and Italo Colantone and titled **Trade and Growth in the Age of Global Value Chains**, we revisit the relationship between trade and income, taking into account the recent surge of global value chains (GVCs). First, we develop a new geography-based, time-varying instrument for export, exploiting the sharp increase (almost tripling) in the maximum size of container ships between 1995 and 2007. This global shock has an asymmetric impact on bilateral trade flows across countries, affecting disproportionately more countries endowed with a larger number of deep-water ports, which are needed to accommodate the new, much larger ships. We exploit this heterogeneity for identification, building up the instrument for export in a gravity framework. Our result show that export has a positive effect on GDP per capita, with a 0.6

elasticity. Evidence at the country-level shows that this effect works through capital accumulation. Exploiting the decomposition methodology by Wang et al. (2013), we show that differences in the value added composition of exports matter for trade-growth nexus. We find evidence in favor of an income premium for countries that upgrade their positioning in GVCs, whereas the degree of participation to GVCs does not seem to play a role. Consistent with this finding, we show that countries whose average level of upstreamness (a' la Antras and Chor (2013)) increases the most over time exhibit a higher trade elasticity of income.

Both papers indirectly deal with the effect of geographical distance on international trade flows. One of the strongest regularities in economics is certainly the negative role played on trade flows by the distance between origin and destination. Disdier and Head (2004), comparing 1,467 different studies, compute an average distance elasticity of trade of about -0.9. Hummels (2007) shows that the distance elasticity of trade does not seem to diminish over time, as it would do should distance be capturing only transportation costs, thanks to the technological developments witnessed in the transportation sector. Distance seems then to refer to trade costs in general, including institutional, policy and regulatory barriers that, also for historical reasons, often increase the further away countries are located.

In the first paper, I show that the impact of distance on trade flows is not constant but varies with trade volumes. This corresponds with having a component of the composite friction described before, *hidden* in the distance term, being fixed and is consistent with micro-evidence on the export behavior obtained from firm-level data (Roberts and Tybout (1997)). It seems natural, then, to test whether some characteristics, either at the product-level or at the country-level, have a prominent role in explaining the non-linear effect that distance has on trade. My results find in level of corruption of the destination country an important determinant. In the second paper, we test whether the distance elasticity of trade varies as a function of the number of deep water ports on both the importer's and the exporter's shores, capturing the extent to which countries can trade via container vessels. The data support this claim for all the manufacturing sectors considered, showing that geographical distance, even though non-exclusively, captures the incidence of transportation costs on export flows.

## Acknowledgments

I would like to express my gratitude to my committee for supporting me in these years. In particular, I would like to thank Professor James Anderson for not giving up on me and tirelessly answering all my questions. This made me feel still in Boston, even though I was not.

My gratitude goes to the all my friends in Boston who shared this journey with me. In particular to Giacomo, who has been my best friend and study companion for the last seven years, and to Rossella, whose determination was a great source of inspiration for me.

I wish to thank my mother Barbara, my father Ettore and my brother Domenico for their faith in me. Being apart was not easy. I am deeply grateful to Giuseppe and Silvana for pushing me hard into completing my studies. Thank you.

My gratitude goes to my husband Filippo and my daughter Beatrice. Their love made this happen.

Finally, I would like to dedicate this thesis to my grandfather Luigi.
I know that you will always be standing in front of the school door, waiting for me to come outside.

# Contents

# Chapter 1

# Scale Economies in European Trade

## 1.1 Introduction

Gravity models have been widely used in studying international trade flows in the last decades (see Head and Mayer (2014) for a detailed review). Generally speaking, these models assume that trade flows between two regions depend positively on the size of both the origin and the destination but are negatively correlated with the geographical distance between them. Microfoundations for such a specification, which may resemble the Newtonian gravity formulation in physics at first sight, was provided in Anderson (1979). In particular, trade frictions are assumed as region-pair specific "iceberg" trade cost, meaning that a constant proportion of every shipment will melt during transport. In empirical testing, trade cost are usually proxied by geographical measures such as the distance and the contiguity between the trade partners.

Trade costs are usually introduced as a *constant* impediment to trade flows, in particular they are assumed to play the same role independently from the volume of goods and services traded (*i.e.*

they are linear in trade flows). Anderson et al. (2016) (from now on, AVY (2016)) are the first to relax this assumption: they show that, for the US-Canadian case, the elasticity of trade costs with respect to trade volumes is negative in 36 out of 56 sectors in their sample, whereas the remaining cases exhibit constant returns to scale. This means that, for the majority of the sectors considered, the trade costs is lower the higher the trade volume.

This paper represents the first investigation of the sensitiveness of trade costs with respect to trade volumes in the European setting. My focus on Europe derives from different reasons. First of all, I will prove that the scale economies in trade costs estimated by AVY (2016) are an empirical regularity in other parts of the world. In fact, this paper shows that economies of scale in European international trade are strong and significant for all the sectors considered over the 1980-2013 period and that their average magnitude is very similar to the one found by AVY (2016): a 10% increase in trade volumes corresponds to a 0.64% decrease in trade costs. Second, since scale elasticities are a consequence of fixed trade costs, I will test whether they have been altered by the EU expansion, which should have in principle lowered trade costs (at least in their regulatory component). Focusing on European data allows me to test for this hypothesis while keeping the specification as simple as possible: in fact, I will be assuming uniformity in the scale elasticity parameter in this part of the analysis[1].

My results show that belonging to the EU does not affect scale elasticities in aggregate terms. When considering separately the manufacturing sectors, however, I find that the EU expansion makes a difference in terms of scale economies, even though for eleven sectors only. For all these sectors, the differences are quite high and have the same sign: economies of scale in trade costs are

[1]Considering non-European countries would imply a departure from this uniformity assumption. In fact, trade with non-European countries entails higher scale elasticities on average, due to lower trade volumes, as I will show in Section 4.

about 50% *higher* when at least one trade partner is not member of the EU yet, as higher fixed trade costs when crossing the EU border would imply. What these industry have in common is a high *weight to value* ratio: for a given monetary value, they produce heavy goods. This finding contributes to the literature on the effects of the EU expansion on international trade: showing that there is strong cross-sectoral variation, I merge the gap between the results by Beltramo (2010), who documents a drop in trade costs, and the ones by Nitsch (2000) and Chen (2004), showing that trade between EU countries is subject to frictions that have not been removed yet.

Trade costs do not only represent transport costs but can be capturing *"policy barriers (tariffs and non-tariff barriers), information costs, contract enforcement costs, costs associated with the use of different currencies, legal and regulatory costs, and local distribution costs (wholesale and retail)"* (Anderson and van Wincoop, 2004). All these frictions could vary at the product level, at the country level or both and this could generate cross-sectoral or cross-country variation in scale elasticities. Therefore, it may be worthwhile to analyze whether scale elasticities depend on informational or institutional barriers.

Should informational frictions play a role, one would expect the average gain from an increase in trade volume to be lower for more standardized goods (Rauch, 1999), hence we would observe lower scale elasticities for those commodities. In order to test for this hypothesis, I consider disaggregated data at the product level (SITC classification) and I show that the degree of product differentiation does not explain the magnitude of the estimated coefficients. On the other hand, my results show that European scale elasticities are linked to country-specific institutional variables such as the level of corruption. In fact, I prove that a 10% increase in trade volumes implies a 0.38% decrease in trade costs when trading with a partner with poor institutional level (high level of corruption) but implies a 0.16% decrease in trade costs when the partner's level of corruption is low. Moreover, this strong effect of corruption on scale elasticities is not altered by the EU membership of the countries considered.

The paper will proceed as follows. Section 2 will outline the model, taken from AVY (2016), and the estimating equation. Section 3 will present the data. Section 4 will prove the existence of scale economies in Europe and show that crossing the EU border implies higher scale coefficients, though for some sectors only. Section 5 will show that the cross-sectoral variation cannot be linked to the degree of product differentiation, as informational asymmetries would imply. Moreover, it will prove that scale elasticities depend on institutional variables at the country level. Section 6 will conclude.

## 1.2 The Model

The model follows closely the one of Anderson et al. (2016), being its adaptation to the European setting. Instead of considering bilateral trade flows between different Canadian provinces and US states as AVY (2016) do, in fact, I will consider those between different European countries, which join the EU at different points in time.

Anderson and van Wincoop (2003a) show that the trade flow between $i$ and $j$ in sector $k$ ($X_{i,j}^k$) can be expressed as

$$X_{i,j}^k = Y^k s_i^k b_j^k \left(\frac{t_{i,j}^k}{\Pi_i^k P_j^k}\right)^{1-\sigma_k}$$

where $Y^k$ is the total of world shipments, $s_i^k$ is the share of world shipment coming from origin $i$ ($s_i^k = \frac{Y_i^k}{Y^k}$) and $b_j^k$ is the share of world shipment arriving to destination $j$ from all possible origins

($b_j^k = \frac{E_j^k}{Y^k}$). $t_{i,j}^k$ represents the bilateral "iceberg" trade cost: for each unit shipped, only $\frac{1}{t_{i,j}^k}$ reaches the destination. $\Pi_i^k$ and $P_j^k$ represent respectively the outward and the inward multilateral resistance terms, taking into account that bilateral trade depends on trade frictions that importer and exporter face when trading with all their trade partners, and can be written as

$$(\Pi_{i,t}^k)^{1-\sigma_k} = \sum_j \left( \frac{t_{i,j}^k}{P_{j,t}^k} \right)^{1-\sigma_k} b_{j,t}^k \tag{1.2.1}$$

$$(P_{j,t}^k)^{1-\sigma_k} = \sum_j \left( \frac{t_{i,j}^k}{Pi_{i,t}^k} \right)^{1-\sigma_k} s_{i,t}^k \tag{1.2.2}$$

Therefore, gravity can be estimated taking the following formula to the data:

$$X_{i,j,t}^k = Y_t^k \frac{s_{i,t}^k}{(\Pi_{i,t}^k)^{1-\sigma_k}} \frac{b_{j,t}^k}{(P_{j,t}^k)^{1-\sigma_k}} (t_{i,j}^k)^{1-\sigma_k} \tag{1.2.3}$$

$$= c_t x_{i,t}^k m_{j,t}^k (t_{i,j}^k)^{1-\sigma_k} \tag{1.2.4}$$

up to an i.i.d. error, where $c_t = Y_t^k$ is a constant and $x_{i_t}^k = \frac{s_{i,t}^k}{(\Pi_{i,t}^k)^{1-\sigma_k}}$ and $m_{j,t}^k = \frac{b_{j,t}^k}{(P_{j,t}^k)^{1-\sigma_k}}$ are respectively an exporter-time and an importer-time fixed effects.

It is important to notice that trade costs $t_{i,j}^k$, whose empirical counterpart is usually represented by geographical measures such as distance and contiguity, represent a *constant* barrier to trade flows: in order for one unit of good to reach destination $j$, $t_{i,j}^k$ units need to be shipped *independently* from any pair-specific variable, including the trade volume between the two trade partners. One could imagine, instead, that trade costs are increasing in trade volumes due to congestion (Anderson and Bandiera, 2006) or that there are economies of scale in trade costs because of the existence of a fixed-cost component. Chaney (2014) suggests that the export behavior of firms is the result of the creation of a network, whose links are created by pair specific buyer-seller investments. Aggregating the links across countries would imply bilateral scale economies in trade costs. I will show in the next section that allowing for the existence of elasticity of trade cost with respect to trade volume $v$ would be entering the previous expression and alter the interpretation of the estimated coefficients, providing a test for the existence of such scale economies.

### 1.2.1 Scale economies in Trade Costs

AVY (2016) allow and test for economies (diseconomies) of scale by assuming that

$$t_{i,j,t} = \tau_{i,j} \left( \frac{r_{i,t}}{r_{j,t}} \right)^{\rho} V_{i,j,t}^{\phi_{i,j}} \tag{1.2.5}$$

where $\tau_{i,j}$ is the traditional iceberg cost and $r_{i,t}$ and $r_{j,t}$ represent the appreciation of currencies $i$ and $j$ with respect to a base period. The exponent $\rho$ is the pass-through elasticity, which I assume to be constant for all destinations for simplicity, differently from what AVY (2016) do. From now on, I will be dropping the superscript $k$ to ease the notation. All regressions will be nonetheless run at the sector level, unless otherwise specified.

$V_{i,j,t}$ is trade volume in physical terms, which can be written as

$$V_{i,j_t} = \frac{X_{i,j,t}}{t_{i,j,t}} \frac{r_{i,t}}{r_{j,t}} \tag{1.2.6}$$

where $t_{i,j}$ discounts for the iceberg costs encountered in the shipment and $\frac{r_{i,t}}{r_{j,t}}$ takes into account the fact that $X_{i,j,t}$ is expressed in monetary terms and the nominal exchange rate may not be unitary.

$\phi_{i,j}$ is the crucial parameter, as it represents the elasticity of trade costs with respect to the trade volume:

$$\phi_{i,j} = \frac{\partial t_{i,j,t}}{\partial Vi,j,t} \frac{Vi,j,t}{t_{i,j,t}}$$

$\phi_{i,j}$ is assumed to be equal to $B_{i,j}\phi$, where $B_{i,j} = 1$ if $i$ and $j$ are two countries separated by a border and zero otherwise. In other words, $\phi_{i,j}$ is zero in case of internal trade. $\phi$ represents the scale elasticity: if it is positive, trade costs are increasing in trade volumes. If $\phi_{i,j}$ is negative, instead, trade becomes cheaper the higher the trade volume (increasing returns to scale), whereas we get constant returns to scale and we are back to the traditional formulation in case $\phi_{i,j}$ equals zero. In the latter case, we are back to the original gravity model: it is nested in this specification, so that it will be for the data to tell whether scale economies in international trade do exist.

AVY (2016) analyze US states and Canadian provinces so that there are three possible types of trade flows: between two US states, between two Canadian provinces or between a US state and a Canadian province. This setup allows the authors to consider nation-specific (i.e. US and Canadian) scale elasticities. In this paper, given that the units of interest are 28 European countries, I decided not to consider destination-specific scale elasticity. I will start with assuming uniformity in the scale elasticity, i.e. I will impose that the elasticity parameter is the same across all destinations (for each sector $k$). In section 4.1 I will check the validity of this hypothesis by testing whether scale elasticities are differentiated for *large* and *small* countries. Such a partition of the sample will be defined alternatively in terms of population or GDP.

Moreover, since the AVY (2016) work deals with data at the provincial and state level, there are multiple observations that correspond to internal flows: for example, trade between Massachusetts and Maine and trade between Iowa and Montana are both considered cases of internal trade. Notice that the dataset I will be using for estimating scale economies in the European setting is at the country-level. For this reason, I have only one observation representing the overall internal trade flow (i.e. Italy-Italy trade) for each sector.

Plugging equation (2.4) in (2.6) and substituting for $t_{i,j,t}$ from equation (2.5), it is possible to get the following expression for $V_{i,j,t}$:

$$V_{i,j,t} = \left[c_t x_{i,t} m_{j,t} \tau_{i,j}^{-\sigma} \left(\frac{r_{i,t}}{r_{j,t}}\right)^{1-\rho\sigma}\right]^{\frac{1}{1+\sigma\phi_{i,j}}} \tag{1.2.7}$$

The latter can be plugged in (3.5) in order to solve for $t_{i,j,t}$:

$$t_{i,j,t} = \left[\tau_{i,j} \left(\frac{r_{i,t}}{r_{j,t}}\right)^{\rho-\phi_{i,j}} (c_t x_{i,t} m_{j,t})^{\phi_{i,j}}\right]^{\frac{1}{1+\sigma\phi_{i,j}}} \tag{1.2.8}$$

We can notice that trade costs turn out to be a function of $\tau_{i,j}$, of the relative exchange rate appreciation terms $\left(\frac{r_{i,t}}{r_{j,t}}\right)$ and of multilateral resistances via fixed effect $x_{i,t}$ and $m_{j,t}$. The effect that each one of these components has on trade costs is a function of the scale elasticity $\phi_{i,j}$, and this makes the estimating equation different from the standard gravity one (2.4).

Substituting for $t_{i,j,t}$ in the gravity equation (2.3) and simplifying, it is possible to get the following formula

$$X^k_{i,j,t} = (c_t x^k_{i,t} m^k_{j,t})^{\frac{1+\phi_{i,j}}{1+\sigma\phi_{i,j}}} (\tau_{i,j})^{\frac{1-\sigma}{1+\sigma\phi_{i,j}}} \left(\frac{r_{i,t}}{r_{j,t}}\right)^{\frac{(\rho-\phi_{i,j})(1-\sigma)}{1+\sigma\phi_{i,j}}} \tag{1.2.9}$$

After taking logs, the previous expression becomes

$$log(X^k_{i,j,t}) = \left(\frac{1+\phi_{i,j}}{1+\sigma\phi_{i,j}}\right) log(c_t x^k_{i,t} m^k_{j,t}) + \left(\frac{1-\sigma}{1+\sigma\phi_{i,j}}\right)\tau_{i,j} + \left(\frac{(\rho-\phi_{i,j})(1-\sigma)}{1+\sigma\phi_{i,j}}\right)\left(\frac{r_{i,t}}{r_{j,t}}\right) \tag{1.2.10}$$

which will be taken to the data up to an i.i.d. error.

### 1.2.2 Testing for the Existence of Scale Elasticities

Equation (2.10) can be taken to the data using the following expression

$$X^k_{i,j,t} = exp[\alpha_0 + \alpha_1 INTERNAL\_DIST_{i,i} + \alpha_2 INTERNAT\_DIST_{i,j} + \delta CONTIGUITY_{i,j} + \zeta EXCH\_RATE_{i,j,t} + \beta_{BORDER} B_{i,j} + \theta_{j,t} + \eta_{i,t}] + \varepsilon_{i,j,t} \tag{1.2.11}$$

where the coefficients correspond to the structural parameters of the model in the following fashion:

$$\alpha_1 = \gamma_1(1-\sigma)$$
$$\alpha_2 = \frac{\gamma_1(1-\sigma)}{1+\sigma\phi}$$
$$\delta = \frac{\gamma_2(1-\sigma)}{1+\sigma\phi}$$
$$\zeta = \Big(\frac{(\rho-\phi)(1-\sigma)}{1+\sigma\phi}\Big)$$

In fact, AVY (2016) show that, since the fixed effect terms enter equation (2.4) in a non-linear fashion, it is possible to approximate them using a Taylor's Series that gives us the following:

$$\Big(\frac{1+\phi_{i,j}}{1+\sigma\phi_{i,j}}\Big) log(x^k_{i,t} m^k_{j,t}) = \eta_{i,t} + \theta_{j,t} + \beta_{BORDER} B_{i,j} \tag{1.2.12}$$

where $\beta_{BORDER}$ represents the direct effect on trade of being separated by an international border.

Notice that either one of the distance variables $INTERNAL\_DIST_{i,i}$ and $INTERNAT\_DIST_{i,j}$ will always equal zero: in case of internal trade (*i.e.* $B_{i,j} = 0$), $INTERNAT\_DIST_{i,j}$ will equal zero, whereas in case of international trade (*i.e.* $B_{i,j} = 1$) $INTERNAL\_DIST_{i,j}$ will equal zero. This will allow to test whether the effect that distance, the empirical proxy for the trade costs, has on the trade flow is differentiated in case of internal or international trade, which is exactly what the existence of scale economies would imply. In fact, it is possible to check for economies (diseconomies) of scale by checking whether the difference between $\alpha_1$ and $\alpha_2$ is statistically different from zero. In particular, in case of economies of scale, we will have that $\phi < 0$ and therefore that $|\alpha_1| < |\alpha_2|$. Moreover, I can get an estimate of the scale elasticity $\phi$ by using the above expressions for the $\alpha_s$ coefficient:

$$\phi = \frac{1}{\sigma}\left(\frac{\alpha_1}{\alpha_2} - 1\right)$$

## 1.3 Data

The database used in this paper comprises the period from 1980 to 2013 and was constructed by the author using different sources: TradeProd, Comext and Prodcom.

The TradeProd database (de Sousa et al., 2012) covers bilateral annual trade flows as well as production over 26 industrial sectors (ISIC2 - 3digits). I will use this data for the period 1980 to 1995. For the subsequent period (1996-2013) I will use the Eurostat databases for trade (Comext) and production (Prodcom), which I was able to convert to the ISIC2 3-digits classification. Details are reported in the Appendix. As a result, I get a 23year-long time series for 26 manufacturing sectors. Table 1.1 lists the sectors considered. The data report missing trade flows for 0.7% of the country pair-year observations.

Notice that the Comext-Prodcom data is originally available at the product level. I will exploit this feature in Section 5, where I will consider such a detailed level of disaggregation to check weather the degree of product homogeneity is a determinant for scale elasticities.

Distances are population-weighted and follow the CEPII notes by Mayer and Zignago (2011)[2]. Exchange rate data at annual frequency come from the World Bank website[3]. Data on the level of corruption in a given country are available come from the WGI database (Worldwide Governance Indicators[4]). The database covers the period from 1996 to 2012 and reports the so-called *control of corruption* index, which *"reflects perceptions of the extent to which public power is exercised for private gain, including both petty and grand forms of corruption, as well as "capture" of the state by elites and private interests"*. Its frequency is biannual before 2002 and becomes annual from 2003 onwards. The index ranges from approximately -2.5 (weak) to 2.5 (strong) governance performance. The most corrupted countries in the sample are Croatia and Latvia in 1996 (-0.642), whereas the least ones are Finland in 2000 and Denmark in 2006 (2.5).

My analysis will focus only on those European countries which are currently (2016) members of the European Union. One possible concern could be that the sample period includes the introduction of the Euro, which happened in 2001. Frankel and Rose (2002) among many others show that the introduction of a common currency has significant effects on trade and income and this fact could alter the meaning of the estimated coefficients. Nonetheless, including the whole sample in the regressions does not alter the magnitude of the results, therefore I decided to consider the entire 1980-2013 period[5]. Moreover, analyzing the whole sample allows me to consider the full EU expansion, up until the last accession of Croatia in 2013.

[2]The CEPII database reports trade flows for Belgium and Luxembourg as if they were a unique country. For this reason, I recomputed distances following the CEPII notes.
[3]http://data.worldbank.org/indicator/PA.NUS.FCRF
[4]http://data.worldbank.org/data-catalog/worldwide-governance-indicators
[5]I will test for Eurozone specific scale elasticities in Section 4.2

## 1.4 Results

The results for the period 1980-2013 are reported in Tables 1.3, 1.4, 1.5 and 1.6. As expected, the estimated coefficient $\hat{\delta}$ is positive when it is statistically significant, exception made for three sectors (Beverages, Tobacco, and Other Chemicals): being adjacent increases the trade flow between two countries. The opposite holds for the estimated coefficients associated with the distances variables ($\hat{\alpha_1}$ and $\hat{\alpha_2}$): they are negative and significant at the 1% level for all sectors (apart from Tobacco, Wearing Apparel and Petroleum Refineries): the higher the distance between trade partners, the lower the trade flow.

Scale (dis)economies in trade costs will be present if $\hat{\alpha_1}$ and $\hat{\alpha_2}$ are statistically different: this would mean that the internal distance plays a different role than the international one, *i.e.* that there exist scale elasticities in trade costs when an international border needs to be crossed. Table 1.7 reports the estimated scale coefficient $\hat{\phi}$ for each sector considered, obtained using the following formula:

$$\hat{\phi} = \frac{1}{\sigma}\Big(\frac{\hat{\alpha_1}}{\hat{\alpha_2}} - 1\Big)$$

Trade costs exhibit economies of scale for all the 26 sectors considered, and the estimated $\hat{\phi}$ is statistically significant at the 1% level for 24 of them. There is strong cross-sectoral variation in the coefficients, ranging from 1.95% in case of Tobacco to 0.14% in case of Transportation Equipment. The average $\hat{\phi}$ is -0.064: a 10% increase in trade volumes corresponds to a 0.64% decrease in trade costs. This result is similar to the one found by AVY (2016), as they show that a 10% increase in trade volumes would lower trade costs from US to Canada and from Canada to US by respectively 1.2% and 0.6% (they estimate direction-specific scale elasticities).

Since I found significant economies of scale for the vast majority of the sectors included in my sample, I represent trade costs using a simple function, which includes both a fixed ($F$) a variable ($c$) component:

$$t = \frac{F}{v} + c$$

where $t$ is the unitary trade cost and $v$ is the trade volume. This formulation is consistent with the literature: Roberts and Tybout (1997), among others, proved empirically the existence of fixed trade costs, which have been assumed as a crucial determinant in the decision of exporting in theoretical papers (Melitz, 2003). Then, it is possible to write the scale elasticity parameter $\phi$ as follows:

$$\phi = \frac{\partial t}{\partial v}\frac{v}{t} = -\frac{F}{F + vc} \qquad (1.4.1)$$

Provided that fixed costs of exporting are positive, the scale parameter $\phi$ will be negative[6]. Notice that $\phi$ is decreasing in $F$: $\frac{\partial \phi}{\partial F} = -\frac{vc}{(F+vc)^2}$: the higher the fixed trade cost, the higher will be the absolute value of the scale elasticity, and increasing trade volumes will entail a higher gain in lowering trade costs. On the other hand, an increase in trade volumes will move the scale elasticity closer to zero: $\frac{\partial \phi}{\partial v} = \frac{cF}{(F+vc)^2}$. This will result in larger markets exhibiting lower scale coefficients in absolute value.

The fact that $\phi$ depends on trade volumes could explain why the sector-specific scale elasticities I estimate do not align with those obtained by AVY (2016). For instance, they find constant returns to scale for Wood Products and Petroleum Refineries whereas the $\hat{\phi}$ I estimate for those sectors are among the highest parameters, in absolute value, that I find (-0.108 and -0.156 respectively). This could be given by the relative size of sectors in North America, probably very different than in

[6] Notice that I took an agnostic perspective when testing for the existence of scale elasticities, as the estimating equation allows for decreasing returns to scale ($\phi > 0$) as well.

Europe. In fact, both Wood Products and Petroleum Refineries are characterized by very high and concentrated trade volumes in the US-Canadian trade and this could be responsible for driving the elasticity very close to zero[7].

Further research, analyzing the sectoral composition of European trade and comparing it to the North American one, will hopefully shed light on this puzzle. As a matter of fact, this finding poses a challenge to the assumption of uniformity of the scale parameter that I initially made. For this reason, in the next section I will show that uniformity is surely an approximation, which however does not seem too strong to be made.

### 1.4.1 Country size ad Scale Elasticities

So far I assumed uniformity in the scale elasticity, *i.e.* I imposed that the gain from trade volumes is the same across all country-pairs and can vary only across the sectoral dimension. However, the high degree of cross-sectoral variation in the estimated coefficients, together with a comparison of the coefficients with the one by AVY (2016), seem to suggest that uniformity may be too strong of an assumption. In this section, I will slightly modify the model and test its validity, allowing scale elasticities to differ depending on country size. In particular, I partition the sample in two subgroups, *large* and *small*, according to two different criteria: population and GDP[8]. Countries are then divided in two groups depending on whether their size is above (*large*) or below (*small*) the sample median. Therefore, I am now assuming that the scale parameter is the same across destinations having the same country size (for each sector $k$).

[7] The estimated scale elasticities for Petroleum, Tobacco and Wearing Apparel could suffer from a mis-specification of the trade cost function, as the positive coefficient for INTERNAL_DIST suggests

[8] These variables being time-varying, I considered their average over the sample for each country. Data on population and GDP (at constant 2010$ prices) were collected from the WorldBank website.

Country size seems the most natural dimension to challenge the assumption of uniformity with. In fact, if uniformity is not a good approximation, I will observe lower scale elasticities (in absolute value) for larger countries. First of all, this would happen because trade volumes $v$ are higher for larger markets, hence the scale elasticity should be closer to zero for them (see Section 4). Moreover, should trade result from the creation of buyer-seller links a' la Chaney (2014), the probability of finding a buyer in a specific area needs to be scaled by the size of that location: firms are more likely to export to countries where there are more potential business contacts to be made. Since the creation of such contacts involves only the extensive margin of trade, in my setting this would correspond to scaling the fixed component of trade costs, making it less costly to export to larger markets (and, again, shifting the elasticity closer to zero). For both these reasons, if uniformity across all country pairs has to be rejected by the data, then it seems plausible that scale coefficients will be lower (in absolute value) for larger destinations.

The model will be modified as follows

$$\begin{aligned} X^k_{i,j,t} = exp[&\alpha_0 + \alpha_1 INTERNAL\_DIST_{i,i} + \alpha_2 INTERNAT\_DIST\_BIG_{i,j} + \\ &\alpha_3 INTERNAT\_DIST\_SMALL_{i,j} + \delta_1 CONTIG\_BIG_{i,j} + \delta_2 CONTIG\_SMALL_{i,j} + \\ &\zeta_1 EXCH\_RATE\_BIG_{i,j,t} + \zeta_2 EXCH\_RATE\_SMALL_{i,j,t} + \beta_{BORDERB} B\_BIG_{i,j} \\ &\beta_{BORDERS} B\_SMALL_{i,j} + \theta_{j,t} + \eta_{i,t}] + \varepsilon_{i,j,t} \end{aligned} \tag{1.4.2}$$

and therefore I will be able to back out the following parameters

$$\phi_{BIG} = \frac{1}{\sigma}\Big(\frac{\alpha_1}{\alpha_2} - 1\Big) \qquad \phi_{SMALL} = \frac{1}{\sigma}\Big(\frac{\alpha_1}{\alpha_3} - 1\Big)$$

Table 1.8 reports the estimated scale elasticities in aggregate terms, *i.e.* obtained using bilateral trade flows at the country level disregarding the sectoral dimension. As expected, the estimated parameters are higher (in absolute value) when considering flows towards a *small* trade partner, both in terms of population (20% higher) and of GDP (10% higher). However, when looking at the estimates obtained at the sectoral level, I find that $\phi_{BIG}$ and $\phi_{SMALL}$ are significantly different only for a very small minority of the 26 sectors considered. Moreover, even though statistically different, these coefficients have basically the same magnitude.

Not having found compelling evidence at the sectoral level for the rejection of the uniformity assumption, I will maintain it in the remainder of the analysis, in order to ease the notation and the interpretation of the coefficients. Notice that all regressions will be run sector by sector, thus allowing heterogeneity in economies of scale across industries.

### 1.4.2 Scale Elasticities and the EU Expansion

The European Union is currently (2016) made up of 28 countries. Its process of creation and expansion lasted 62 year: from the creation of the European Coal and Steel Community (ECSC) in 1951, followed by the creation of the European Economic Community (EEC) in 1957, to the accession of the last member state to join (Croatia, 2013). The European Union incorporated the pre-existing European Communities in 1993, according to the provisions of the Maastricht Treaty.

Table 1.2 tracks the expansion of the European Union over time.

The main purpose of the creation of the EEC was to promote economic integration among member states. The EEC was indeed established as a customs union. However, this measure was considered insufficient and this led to the Single Market Programme, starting from 1992. It is established that *"The Union shall comprise a customs union which shall cover all trade in goods and which shall involve the prohibition between Member States of customs duties on imports and exports and of all charges having equivalent effect, and the adoption of a common customs tariff in their relations with third countries."*[9]. Quantitative restrictions on imports and exports between member states are also prohibited.[10]

Apart from tariff and non-tariff barriers, trade costs comprise obstacles such as information costs and legal costs (Anderson and van Wincoop, 2004). Joining the European Union should decreases the asymmetry between countries with respect to these frictions as well: for example, cross-border insolvency disputes involving member states are regulated by the EU Insolvency Regulation, which was adopted in 2000. We expect common membership to facilitate trade. In particular, fixed trade costs should be lower when trade partners are both EU members, exactly because they share a common set of laws and practices. Therefore, the gain from an increase in trade volumes, which could be considered a proxy of the frequency at which transactions take place, should be lower. As a consequence, scale elasticities should be lower as well when both countries belong to the EU.

[9] Article 28 TFEU

[10] Articles 34 to 36 TFEU

**Testing for European Union elasticities**

In the second specification, I will consider a version of equation (2.11) that allows me to take into account possible differences implied by the expansion of the European Union. In particular

$$t_{i,j,t} = \tau_{i,j}\left(\frac{r_{i,t}}{r_{j,t}}\right)^{\rho_j} V^{\phi_{i,j,t}}$$

The main difference with equation (2.5) is given by the fact that the scale elasticity coefficient is now time varying. In fact, I am assuming that

$$\phi_{i,j,t} = B_{i,j}[\phi_1 + \phi_2 U_{i,j,t}]$$

where $U_{i,j,t}$ takes value 1 if $i$ and $j$ are separated by a non-EU border at time $t$, *i.e.* if at least one of the two is not a member of the European Union at time $t$. As a consequence, $\phi_{i,j,t}$ will equal 0 in case of internal trade, it will equal $\phi_1$ in case of trade between EU members and it will equal $\phi_1 + \phi_2$ if at least one of the two countries is not a EU member. This will allow me to see whether scale economies in trade costs are independent from the EU membership or are affected by it. Notice the $t$ subscript: the same couple of countries will have a different scale coefficient at different points in time as the EU expands. Figure 1.1 depicts the example of Spain, which became a member in 1986.

I estimate the following equation

$$\begin{aligned} X_{i,j,t}^{k} = exp[&\alpha_0 + \alpha_1 INTERNAL\_DIST_{i,i} + \alpha_2 INTERNAT\_DIST\_EU_{i,j,t} + \\ &\alpha_3 INTERNAT\_DIST\_NONEU_{i,j,t} + \delta_1 CONTIGUITY\_EU_{i,j} + \\ &\delta_2 CONTIGUITY\_NONEU_{i,j} + \zeta_1 EXCH\_RATE\_EU_{i,j,t} + \\ &\zeta_2 EXCH\_RATE\_NONEU_{i,j,t} + \beta_{BORDEREU} B_{i,j}(U_{i,j,t} = 0) + \\ &\beta_{BORDERNONEU} B_{i,j}(U_{i,j,t} = 1) + \theta_{j,t} + \eta_{i,t}] + \varepsilon_{i,j,t} \end{aligned} \tag{1.4.3}$$

where the coefficients correspond to the structural parameters of the model in the following fashion:

$$\begin{aligned} \alpha_1 &= \gamma_1(1-\sigma) \\ \alpha_2 &= \frac{\gamma_1(1-\sigma)}{1+\sigma\phi_1} \\ \alpha_3 &= \frac{\gamma_1(1-\sigma)}{1+\sigma(\phi_1+\phi_2)} \\ \delta_1 &= \frac{\gamma_2(1-\sigma)}{1+\sigma\phi_1} \\ \delta_2 &= \frac{\gamma_2(1-\sigma)}{1+\sigma(\phi_1+\phi_2)} \\ \zeta_1 &= \Big(\frac{(\rho-\phi_1)(1-\sigma)}{1+\sigma\phi_1}\Big) \\ \zeta_2 &= \Big(\frac{(\rho-\phi_1-\phi_2)(1-\sigma)}{1+\sigma(\phi_1+\phi_2)}\Big) \end{aligned}$$

It is possible to test for economies (diseconomies) of scale by checking whether the differences between $\alpha_1$ and $\alpha_2$ and $\alpha_1$ and $\alpha_3$ are statistically different from zero. In case of economies of scale, we will have that $\phi_1 < 0$ and $\phi_1 + \phi_2 < 0$ therefore that $|\alpha_2| < |\alpha_3|$. Moreover, $\alpha_2$ and $\alpha_3$ will be statistically different when $\phi_2$ is statistically different from zero, *i.e.* when economies of scale are different when at least one of the trade partners is not a member of the EU. We can also back out the scale elasticities $\phi_1$ and $\phi_2$ using the expressions for the $\alpha_s$ coefficients. In fact,

$$\phi_1 = \frac{1}{\sigma}\Big(\frac{\alpha_1}{\alpha_2} - 1\Big)$$
$$\phi_2 = \frac{\alpha_1}{\sigma}\Big(\frac{1}{\alpha_3} - \frac{1}{\alpha_2}\Big)$$

**Results**

The estimated $\phi_1$ and $\phi_2$ are reported in Table 1.9. Aggregating across all goods, I find no statistically significant difference in scale elasticities when one of the trade partners is not a member of the EU. This means that, on average, fixed trade costs when trading with a fellow EU member are not different than those met when trading with a country that in not in the Union yet.

Breaking down the results by sectors, however, I find that there is heterogeneity: scale elasticities when crossing the EU border are about 50% higher on average for a minority of sectors. These sectors are Beverages, Textiles, Wearing Apparel, Pottery, Glass&Prod, FabricMetPr, Machin., Machin.Electric, PlasticProd and TransportEquip. Interestingly, I find that seven of these sectors[11] rank above the median in terms of *'weight to value"* ratio, *i.e.* the weight in kilograms per euro shipped, in average terms across all years and country-pairs. Moreover, all sectors above the 75th percentile in this ranking, *i.e.* those having the highest *'weight to value"* ratio, exhibit significantly higher scale elasticities when crossing the EU border. This means that there might have been a decline in fixed trade costs due to the EU expansion, but only for those goods that are heavy to transport[12].

[11] Machin.,Beverages,Textiles,Machin.Electric, PlasticProd, TransportEquip. and FabricMetPr

[12] I computed the *'weight to value"* ratio for 19 of the 26 sectors considered in the main regressions using trade data from Eurostat (available from 1988 onward), reporting volume (in tons) and value per product category. In order to do so, I followed the procedure by Chen (2004), who constructs a sector-specific variable averaged across all country pairs $i, j$.

Interestingly, I find that scale elasticities are lower in absolute value if both the trade partners are among the six EU founders: the estimated coefficient is 0.68% whereas it is 0.83% in case at least one of the trade partner is a "new" members. Using a similar procedure, I found that trade within the Eurozone entails higher gains from volume increase than trade between EU members that do not share the same currency, differently from what we would expect: on average, scale elasticities are 0.94% when selling to a Eurozone member and 0.79% when selling to a EU member not in the Eurozone.

As a robustness check, I can see whether the scale elasticities are larger when considering trade with non European countries. In particular, I will consider USA, Russia, China and Japan. Results are reported in Table 1.10[13]. The estimated coefficient $\chi_1$ refers to intra-European trade whereas $\chi_1 + \chi_2$ refers to trade with one of the non-European countries considered. As a consequence, if $\chi_2$ is statistically significant we can conclude that the scale effects are significantly different when considering extra-European trade flows. Clearly, we expect scale economies to be either unchanged or greater in absolute value when trading with one of these extra-European countries. On average, this is exactly what I find: trade between European countries entail scale economies whose magnitude is 0.69%, whereas trade with an extra-European destination entails scale economies that are 26% higher ($\chi_1$+$\chi_2$=-0.69-0.18=-0.87%). For eleven sectors, the estimated $\hat{\chi_2}$ are significant and negative: gains from increases in volume are bigger when at least one country is not European. This is likely due to lower trade volumes when trading with countries that are much farther away than European ones.

[13] Two sectors are excluded because there are not sufficient observations withing country-year pairs for the multilateral resistance fixed effect to yield consistent estimates.

## 1.5 Investigating Scale Elasticities

### 1.5.1 Product Differentiation

In Section 4, I showed that the estimated $\phi$s exhibit a strong cross-sectoral variation. This could be due to differences in the size of markets, as I previously discussed, but it could also be a consequence of different product characteristics, responsible for different parameters in the trade cost function assumed in Section 4. For instance, the degree of product homogeneity could play a role in this respect. Rauch (1999) shows that proximity and cultural links such as common language and colonial ties have stronger effects in the market for differentiated goods. This finding provides empirical evidence for the existence of a "search" model of international trade: when goods are not homogeneous, but differ along dimensions such as quality, prices are not completely informative and markets are substituted by *networks*: exchanges happen after a buyer-seller connection has formed (Chaney (2014) develops a model on the formation of such networks). For this reason, cultural links and proximity play a greater role for these commodities.

If scale effects are the consequence, in aggregate terms, of the existence of buyer-seller links a' la Chaney (2014) and if informational asymmetries play a role in this respect, $\phi$ should be higher (in absolute value) when products are differentiated, because the creation of a relationship between buyer and seller is crucial when there are some non-standardized characteristics of the good, such as its quality. On the other hand, the fixed costs due to the creation of such links should be negligible for goods traded in organized markets, such as petroleum or gold. Therefore, I expect the scale coefficient to be lower (in absolute value) for those commodities.

I consider the more conservative classification by Rauch (1999), who divides goods in three categories according to their SITC Rev.2 classification: homogeneous goods traded in organized exchanges, homogeneous goods not traded in organized exchanges, but characterized by the presence of a "reference price", and differentiated goods. Notice that the Rauch classification involves goods and not sectors. For this reason, I will use the more disaggregated Eurostat dataset, available at the product-level. Because of this, I can consider only a subset of the main data (from 1996 onward). This data is available at the CN (Combined Nomenclature) level and has been converted to the SITC Rev.2 level following the steps described in the Appendix.

I will run regression (2.11) interacting the $INTERNATIONAL\_DIST$ variable with a dummy taking different values according to the different degree of homogeneity of the product considered. The estimating regression is as follows:

$$\begin{aligned} X^k_{i,j,k,t} = exp[&\alpha_0 + \alpha_1 INTERNAL\_DIST_{i,i} + \alpha_2 INTERNAT\_DIST_{i,j} + \\ &\alpha_3 (INTERNAT\_DIST_{i,j} \times DEGREE\_HOMOG_k) + \\ &\delta CONTIGUITY_{i,j} + \zeta EXCH\_RATE_{i,j,t} + \beta_{BORDER} B_{i,j} + \theta_{j,t} + \eta_{i,t}] + \varepsilon_{i,j,k,t} \end{aligned} \tag{1.5.1}$$

None of the resulting $\phi$s is statistically significant. This could be due to the fact that I am restricting too much the sample: on average, I could match each of the 26 sectors with five different product codes only. However, when considering the entire Comext-Prodcom database (without limiting my attention to the 26 manufacturing sectors considered in the main regression), my results confirm the existence of statistically significant economies of scale in trade costs, still there is no connection between the degree of product homogeneity and the scale coefficient (see Table 1.11). Actually, I find that there are scale economies in trade costs for homogeneous goods only, for which frictions should be minimal.

I conclude that the degree of product homogeneity does not seem to explain the cross-sectoral variation in a manner consistent with the existence of informational frictions. A plausible explanation, then, could be that the volume of goods traded in organized exchanges is smaller than the volume of differentiated goods, possibly compensating for the difference in fixed trade costs.

Using a similar approach, I explored the *weight to value ratio* as a possible product characteristic directly affecting scale coefficients, as well as regulatory barriers such as non tariff barriers and technical barriers to trade, which are heterogeneous across products and could rationalize the cross-sectoral variation obtained from the main regression. None of these seems to explain the result, again pointing at differences in volumes as important determinants for scale elasticities. Further research on this topic will hopefully provide some additional insights.

### 1.5.2 Corruption

Institutional variables such as the level of corruption have been shown to affect international trade flows. Anderson and Marcouiller (2002) show that corruption acts as an hidden tax, whose negative impact on international trade has about the same magnitude as the one of tariffs. Some studies provide evidence on how corruption can be pervasive at some countries' customs (see Parayno (1999) for Philippines). More recently, Dutt and Traca (2010) proved that there exist a non-linear relationship between corruption and trade: when the tariff level is low, corruption harms trade (extortion effect), whereas it enhances it when the level of protection is higher (evasion effect).

Scale elasticities measure the extent to which higher flows are reflected in lower trade costs. If the level of corruption affected trade costs, I would expect it to increase their fixed component and hence to increase scale elasticities as well (in absolute value). To check for this hypothesis, I will run the following regression

$$X^k_{i,j,t} = exp[\alpha_0 + \alpha_1 INTERNAL\_DIST_{i,i} + \alpha_2 INTERNAT\_DIST_{i,j} + \alpha_3 INTERNAT\_DIST_{i,j} \times CORRUP_{j,t} + \gamma CORRUP_{j,t} + \delta CONTIGUITY_{i,j} + \zeta EXCH\_RATE_{i,j,t} + \beta_{BORDER} B_{i,j} + \theta_{j,t} + \eta_{i,t}] + \varepsilon_{i,j,k,t} \tag{1.5.2}$$

Table 1.12 (Column (1)) reports the results. The corruption index is absorbed by the importer-time fixed effect that controls for one of the multilateral resistance terms, hence this equation does not measure the direct effect of corruption on trade. Interestingly, the interaction with the $INTERNATIONAL\_DIST$ variable is positive and significant: this means corruption depresses more trade on longer distances (recall that the corruption index is negative for country whose level of governance is weak). As a consequence, scale elasticities are higher (in absolute value) the higher the level of corruption measured in the importing country. To give an idea of the magnitude of the estimate, consider the following example: selling manufacturing goods to Romania in 2000 (whose corruption index, -0.477, is the highest in the regression subsample) entails a scale elasticity of 0.38%, whereas exporting the same additional quantity to Denmark in 2006 (2.5 is the corruption index) implies more than half the gain in terms of trade costs reduction (0.16%). The rationale is that higher trade volumes could reflect an higher number of transactions, which are clearly most beneficial towards trade costs reductions when the level of corruption of custom officials is high[14].

[14] This analysis assumes the general level of corruption of a country, measured by the WGI index, to be positively correlated with the one of customs officials.

Moreover, the level of corruption matters independently on the EU membership of the trade partners (see Column (2) in 1.12). Even though the estimates of the interaction coefficients are statistically different when both countries are EU members ($Bothmembers = 1$) or not ($Bothmembers = 0$), the estimated $\phi$ are basically the same. For instance, consider a good being sold from Czech Republic to its neighboring country, Poland, either in 2003 or in 2009. The index of corruption in Poland was 0.38 in 2003 and 0.37, basically unchanged, in 2009. Given the estimated coefficients, a 100% increase in imports from Czech Republic implied a 3.3% decrease in trade costs in 2003, when none of the country was a EU member, and a 3.2% decrease in 2009, when both countries were EU members (they both joined in 2004). I conclude that what matters for scale economies is the level of corruption per se and it is not mitigated by the EU expansion.

## 1.6 Conclusion

In this paper, I showed the existence of scale economies in European international trade for the totality of manufacturing sectors considered over a 23-year long time period (1980-2013). At the beginning of this period, the members of what would have become the European Union were only nine, whereas they reach the number of 28 in the last year considered. I explore the possibility that the EU expansion could have changed such scale economies, but the data reject this hypothesis in aggregate terms.[15]. When estimating sector-specific elasticities, however, I find that a minority of them were altered by the EU expansion in a way consistent with the reduction of fixed trade costs.

Scale economies in trade costs are not linked to sector-specific informational frictions, at least as they are measured by the degree of product homogeneity. Institutional characteristics of the

[15]The inclusion of extra-European countries as a robustness check, however, confirms the validity of my approach: extra-European elasticities are on average much higher than European one.

destination country, however, play a role: the higher the level of corruption in the importing country, the higher the gain from a trade volume increase, independently from the EU membership of the country considered.

Table 1.1: List of Sectors

| | |
|---|---|
| Food products | Miscellaneous petroleum and coal products |
| Beverages | Rubber products |
| Tobacco | Plastic products |
| Textiles | Pottery, china, earthenware |
| Wearing apparel, except footwear | Glass and products |
| Leather products | Other non-metallic mineral products |
| Footwear, except rubber or plastic | Iron and steel |
| Wood products, except furniture | Non-ferrous metals |
| Furniture, except metal | Fabricated metal products |
| Paper and products | Machinery, except electrical |
| Printing and publishing | Machinery, electric |
| Industrial chemicals | Transport equipment |
| Other chemicals | Professional and scientific equipment |
| Petroleum refineries | |

Table 1.2: EU Expansion

| Name | Accession | Name | Accession |
|---|---|---|---|
| Belgium | Founder | Sweden | 1-Jan-95 |
| France | Founder | Cyprus | 1-May-04 |
| Germany | Founder | Czech Rep. | 1-May-04 |
| Italy | Founder | Estonia | 1-May-04 |
| Luxembourg | Founder | Hungary | 1-May-04 |
| Netherlands | Founder | Latvia | 1-May-04 |
| Denmark | 1-Jan-73 | Lithuania | 1-May-04 |
| Ireland | 1-Jan-73 | Malta | 1-May-04 |
| UK | 1-Jan-73 | Poland | 1-May-04 |
| Greece | 1-Jan-81 | Slovakia | 1-May-04 |
| Portugal | 1-Jan-86 | Slovenia | 1-May-04 |
| Spain | 1-Jan-86 | Bulgaria | 1-Jan-07 |
| Austria | 1-Jan-95 | Romania | 1-Jan-07 |
| Finland | 1-Jan-95 | Croatia | 1-Jul-13 |

Figure 1.1: EU Elasticities: An Example

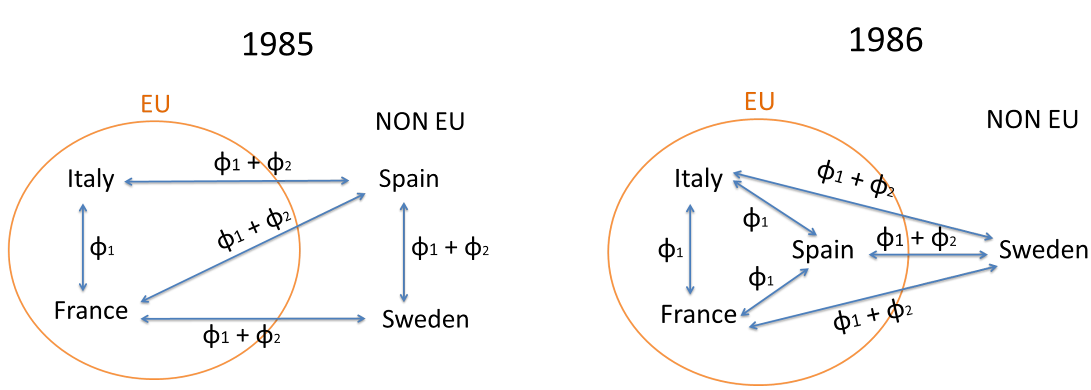


Table 1.3: Estimated Coefficients - A

| | Food Products | Beverages | Tobacco | Textiles | Wearing apparel | Leather pr | Footwear |
|---|---|---|---|---|---|---|---|
| Internal_Dist | -0.483*** | -1.547*** | 0.818*** | -0.824*** | 0.234*** | -1.128*** | -0.930*** |
| | (-6.46) | (-18.64) | (4.08) | (-10.11) | (2.98) | (-15.25) | (-11.01) |
| Internat_Dist | -1.678*** | -1.666*** | -2.246*** | -1.206*** | -1.371*** | -1.474*** | -1.577*** |
| | (-32.53) | (-23.87) | (-16.79) | (-23.83) | (-23.08) | (-25.93) | (-24.35) |
| Contiguity | 0.307*** | -0.244*** | -0.245** | 0.257*** | 0.255*** | 0.0381 | 0.214*** |
| | (5.65) | (-3.40) | (-2.01) | (3.99) | (3.84) | (0.64) | (4.14) |
| Exch. rate | 0.420*** | 11.97 | -1.574*** | 0.397*** | -0.680*** | 1.339 | -0.959*** |
| | (5.61) | (1.51) | (-10.81) | (3.39) | (-6.06) | (1.52) | (-7.36) |
| Border dummy | 4.276*** | -1.581*** | 14.05*** | 0.326 | 7.411*** | 0.678** | 1.518** |
| | (10.27) | (-3.99) | (9.04) | (0.89) | (14.24) | (1.97) | (2.49) |
| $N$ | 9548 | 8650 | 5262 | 9692 | 9451 | 8824 | 7762 |
| R2 | 0.99 | 0.99 | 0.99 | 0.97 | 0.96 | 0.99 | 0.99 |

$t$ statistics in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 1.4: Estimated Coefficients - B

| | Wood prod. | Furnit. | Paper&prod | Print&publ. | Ind.chem. | Other.Chem. |
|---|---|---|---|---|---|---|
| Internal_Dist | -0.366*** | -0.820*** | -0.597*** | -0.500*** | -0.865*** | -0.546*** |
| | (-6.13) | (-11.65) | (-10.66) | (-6.17) | (-9.77) | (-11.68) |
| Internat_Dist | -1.494*** | -1.992*** | -1.376*** | -1.699*** | -1.678*** | -1.932*** |
| | (-33.83) | (-31.86) | (-36.79) | (-25.66) | (-42.29) | (-55.34) |
| Contiguity | 0.600*** | 0.192*** | 0.365*** | 0.479*** | 0.121*** | -0.194*** |
| | (10.56) | (3.21) | (8.22) | (6.62) | (2.81) | (-4.92) |
| Exch. rate | 1.187*** | 1.209*** | 1.172*** | 1.032*** | 1.113*** | 1.451*** |
| | (10.01) | (14.42) | (11.53) | (9.53) | (10.68) | (11.67) |
| Border dummy | 3.812*** | 4.941*** | 2.502*** | 3.820*** | 4.036*** | 6.461*** |
| | (13.58) | (12.59) | (8.71) | (8.92) | (8.06) | (22.05) |
| *N* | 8917 | 8724 | 9019 | 9013 | 9502 | 9209 |
| R2 | 0.99 | 0.99 | 0.99 | 0.99 | 0.96 | 0.99 |

*t* statistics in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 1.5: Estimated Coefficients - C

| | Petrol.ref. | Rubber prod. | Plastic prod. | Pottery | Glass & prod. | Non.Metal.Min.Prod |
|---|---|---|---|---|---|---|
| Internal_Dist | 0.201** | -1.117*** | -0.939*** | -1.490*** | -1.563*** | -1.444*** |
| | (1.97) | (-17.56) | (-9.16) | (-16.14) | (-22.05) | (-13.81) |
| Internat_Dist | -2.157*** | -1.408*** | -1.351*** | -1.690*** | -1.791*** | -1.822*** |
| | (-25.32) | (-22.85) | (-20.44) | (-21.58) | (-35.02) | (-26.64) |
| Contiguity | -0.0760 | 0.189*** | 0.398*** | 0.158** | 0.197*** | 0.175** |
| | (-1.11) | (3.47) | (4.97) | (2.10) | (3.74) | (2.06) |
| Exch. rate | 1.213*** | 0.715*** | 0.960*** | 1.247*** | -0.599*** | -0.0921 |
| | (28.12) | (7.20) | (11.42) | (8.01) | (-3.10) | (-0.56) |
| Border dummy | 11.07*** | 0.230 | 0.450 | -0.664 | 0.0963 | 0.141 |
| | (20.31) | (0.57) | (0.79) | (-1.48) | (0.24) | (0.30) |
| *N* | 4409 | 9113 | 9196 | 8039 | 8727 | 9000 |
| R2 | 0.99 | 0.98 | 0.97 | 0.99 | 0.98 | 0.99 |

*t* statistics in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 1.6: Estimated Coefficients - D

| | Iron & steel | Non-ferr met | Fabric met pr | Machin | Machin, electric | Trans Equip | Profess Equip |
|---|---|---|---|---|---|---|---|
| Internal_Dist | -0.848*** | -0.929*** | -1.169*** | -1.198*** | -0.779*** | -1.316*** | 0.204 |
| | (-14.08) | (-9.32) | (-13.05) | (-20.88) | (-15.86) | (-17.03) | (1.09) |
| Internat_Dist | -1.412*** | -1.609*** | -1.585*** | -1.358*** | -1.273*** | -1.460*** | -1.531*** |
| | (-29.26) | (-33.30) | (-29.10) | (-39.26) | (-30.70) | (-28.96) | (-22.80) |
| Contiguity | 0.303*** | 0.192*** | 0.375*** | -0.00878 | 0.0430 | 0.219*** | -0.0504 |
| | (6.20) | (3.59) | (4.72) | (-0.24) | (0.99) | (4.60) | (-0.84) |
| Exch. rate | -0.249* | -0.311** | 1.085*** | 1.030*** | 1.427*** | 1.104*** | 0.828*** |
| | (-1.94) | (-2.51) | (13.76) | (16.92) | (11.58) | (6.02) | (4.34) |
| Border dummy | 1.185*** | 2.711*** | 0.688 | -0.248 | 1.020*** | -0.213 | 9.830*** |
| | (3.59) | (4.94) | (1.32) | (-0.86) | (3.63) | (-0.53) | (8.52) |
| $N$ | 7940 | 8364 | 9533 | 9749 | 9631 | 9264 | 9079 |
| R2 | 0.99 | 0.97 | 0.97 | 0.99 | 0.99 | 0.98 | 0.86 |

$t$ statistics in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 1.7: Estimated Scale Elasticities

| **Sector** | $\phi$ | **S.E.** |
|---|---|---|
| Aggregate | -0.064*** | (0.004) |
| Food Products | -0.102*** | (0.006) |
| Beverages | -0.01* | (0.006) |
| Tobacco | -0.195*** | (0.012) |
| Textiles | -0.045*** | (0.008) |
| Wearing apparel | -0.167*** | (0.008) |
| Leatherpr | -0.034*** | (0.006) |
| Footwear | -0.059*** | (0.008) |
| WoodProd. | -0.108*** | (0.005) |
| Furnit. | -0.084*** | (0.004) |
| Paper&prod | -0.081*** | (0.005) |
| Print&publ. | -0.101*** | (0.006) |
| Ind.chem. | -0.069*** | (0.007) |
| OtherChem. | -0.102*** | (0.003) |
| Petrol.ref. | -0.156*** | (0.007) |
| RubberProd. | -0.03*** | (0.006) |
| PlasticProd. | -0.044*** | (0.01) |
| Pottery | -0.017*** | (0.006) |
| Glass&prod. | -0.018*** | (0.005) |
| Non-metal.min.prod. | -0.03*** | (0.007) |
| Iron&steel | -0.057*** | (0.005) |
| Non-ferrMet | -0.06*** | (0.008) |
| FabricMetPr | -0.038*** | (0.008) |
| Machin | -0.017*** | (0.005) |
| Machin,Electric | -0.055*** | (0.005) |
| TransEquip | -0.014** | (0.007) |
| ProfessEquip | -0.162*** | (0.017) |

Table 1.8: Estimated Scale Elasticities - Big VS Small destinations

| **Criterion** | $\phi_{LARGE}$ | $\phi_{SMALL}$ |
|---|---|---|
| Population | -0.075*** | -0.090*** |
| | (0.006) | (0.005) |
| GDP | -0.086*** | -0.095*** |
| | (0.005) | (0.004) |
| N | 13029 | 13017 |
| R2 | 0.99 | 0.99 |

Table 1.9: Estimated Scale Elasticities - EU Expansion

| **Sector** | $\phi_1$ | $\phi_2$ |
|---|---|---|
| Aggregate | -0.073*** | 0.002 |
| | (0.004) | (0.002) |
| Food Products | -0.126*** | 0.003 |
| | (0.006) | (0.001) |
| Beverages | -0.02*** | -0.036*** |
| | (0.007) | (0.005) |
| Tobacco | -0.227*** | -0.793 |
| | (0.016) | (0.834) |
| Textiles | -0.064*** | -0.016*** |
| | (0.009) | (0.005) |
| Wearing apparel | -0.176*** | -0.038** |
| | (0.009) | (0.015) |
| Leatherpr | -0.037*** | -0.004 |
| | (0.006) | (0.004) |
| Footwear | -0.104*** | 0.001 |
| | (0.008) | (0.003) |
| WoodProd. | -0.097*** | 0.007 |
| | (0.005) | (0.002) |
| Furnit. | -0.085*** | 0.022 |
| | (0.005) | (0.002) |
| Paper&prod | -0.082*** | 0.006 |
| | (0.005) | (0.002) |
| Print&publ. | -0.111*** | 0.004 |
| | (0.007) | (0.002) |
| Ind.chem. | -0.085*** | 0.015 |
| | (0.008) | (0.003) |
| OtherChem. | -0.108*** | 0.023 |
| | (0.003) | (0.001) |

| **Sector** | $\phi_1$ | $\phi_2$ |
|---|---|---|
| Petrol.ref. | -0.13*** | 0.019 |
| | (0.007) | (0.01) |
| RubberProd. | -0.035*** | -0.01* |
| | (0.007) | (0.006) |
| PlasticProd. | -0.039*** | -0.017** |
| | (0.012) | (0.008) |
| Pottery | -0.031*** | -0.018*** |
| | (0.006) | (0.005) |
| Glass&prod. | -0.021*** | -0.01** |
| | (0.006) | (0.005) |
| Non-metal.min.prod. | -0.037*** | -0.012** |
| | (0.007) | (0.005) |
| Iron&steel | -0.075*** | 0.002 |
| | (0.006) | (0.003) |
| Non-ferrMet | -0.085*** | 0.01 |
| | (0.01) | (0.004) |
| FabricMetPr | -0.034*** | -0.013** |
| | (0.009) | (0.006) |
| Machin | -0.004 | -0.035*** |
| | (0.007) | (0.005) |
| Machin,Electric | -0.055*** | -0.015*** |
| | (0.006) | (0.004) |
| TransEquip | -0.012 | -0.036*** |
| | (0.009) | (0.007) |
| ProfessEquip | -0.174*** | -0.076 |
| | (0.017) | (0.075) |

Table 1.10: Estimated Scale Elasticities - Extra European Countries

| **Sector** | $\chi_1$ | $\chi_2$ |
|---|---|---|
| Aggregate | -0.069*** | -0.018*** |
| | (0.004) | (0.003) |
| Food Products | -0.11*** | -0.003 |
| | (0.006) | (0.002) |
| Tobacco | -0.193*** | -0.098* |
| | (0.012) | (0.055) |
| Textiles | -0.044*** | 0.029 |
| | (0.007) | (0.016) |
| Wearing apparel | -0.146*** | -0.004 |
| | (0.007) | (0.009) |
| Leatherpr | -0.024*** | 21.254 |
| | (0.005) | (434.768) |
| Footwear | -0.028*** | 0.217 |
| | (0.009) | (0.239) |
| WoodProd. | -0.103*** | 0.022 |
| | (0.004) | (0.009) |
| Furnit. | -0.084*** | 0.032 |
| | (0.004) | (0.015) |
| Paper&prod | -0.083*** | 0.044 |
| | (0.005) | (0.015) |
| Print&publ. | -0.109*** | -0.009*** |
| | (0.005) | (0.003) |
| Ind.chem. | -0.077*** | -0.018*** |
| | (0.008) | (0.003) |

| **Sector** | $\chi_1$ | $\chi_2$ |
|---|---|---|
| OtherChem. | -0.106*** | -0.005** |
| | (0.003) | (0.002) |
| Petrol.ref. | -0.157*** | 0.003 |
| | (0.007) | (0.002) |
| RubberProd. | -0.041*** | 0.081 |
| | (0.007) | (0.048) |
| PlasticProd. | -0.055*** | -0.016 |
| | (0.011) | (0.011) |
| Pottery | -0.018*** | -0.039*** |
| | (0.006) | (0.009) |
| Glass&prod. | -0.024*** | -0.011 |
| | (0.005) | (0.012) |
| Non-metal.min.prod. | -0.026*** | 0.109 |
| | (0.006) | (0.052) |
| Iron&steel | -0.06*** | -0.015** |
| | (0.005) | (0.007) |
| FabricMetPr | -0.041*** | -0.021*** |
| | (0.008) | (0.007) |
| Machin | -0.02*** | -0.051*** |
| | (0.006) | (0.005) |
| Machin,Electric | -0.064*** | -0.04*** |
| | (0.005) | (0.004) |
| TransEquip | -0.024*** | -0.066*** |
| | (0.007) | (0.006) |
| ProfessEquip | -0.22*** | 0.03 |
| | (0.027) | (0.012) |

Table 1.11: Estimated Scale Elasticities - Rauch Classification

| Coefficient | Estimate |
|---|---|
| $\phi_{differentiated}$ | -0.004 |
| | (0.007) |
| $\phi_{ref.priced}$ | -0.010 |
| | (0.007) |
| $\phi_{organized}$ | -0.016** |
| | (0.006) |
| N | 494401 |
| R2 | 0.19 |

Table 1.12: Estimated Scale Elasticities - Corruption Level

| | (1) | (2) |
|---|---|---|
| Internal_dist | -1.164*** | -1.141*** |
| | (-16.81) | (-16.26) |
| International_dist | -1.532*** | -1.515*** |
| | (-32.24) | (-31.42) |
| Corruption_impo × International_dist | 0.0826*** | |
| | (-17.69) | |
| Corruption_imp × International_dist × Bothmembers | | 0.0819*** |
| | | (17.59) |
| Corruption_imp × International_dist × (1-Bothmembers) | | 0.0616*** |
| | | (8.05) |
| N | 2796 | 2796 |
| R2 | 0.99 | 0.99 |

$t$ statistics in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

# Appendix

## Creation of the main dataset

Prodcom reports data according to the Nace Rev.2 classification. The Comext data is instead classified according to the CN (Combined Nomenclature) code, which I converted to the CPA code (8digit-level product code) using the RAMON Tables of conversion[16]. The latter uniquely corresponds to the Nace Rev.2 classification (the first four digits of the CPA code are indeed the Nace Rev.2 code).

In order to be consistent with the Tradeprod database, I created a conversion table linking the Nace Rev.2 classification to the ISIC2, 3digits one using the United Nations Statistics Division tables (See http://unstats.un.org/unsd/cr/registry): the Nace Rev.2 classification uniquely corresponds to ISIC Rev.4, which corresponds to ISIC Rev. 3.1, and the latter can be finally converted directly into ISIC2, 3digits.

For some of the Comext bilateral flows, two entries are included: the one reported by the importer and the one reported by the exporter. In these instances, I kept the importer's figure.

TradeProd data is in thousands of dollars. Prodcom data (in thousands of ECU) and Comext data (in Euro) were converted in dollars using the currency conversion tables provided by the Eurostat and the OANDA database (oanda.com) on historical currency rates.

## Creation of the product-level dataset used in Section 5

Rauch (1999) classifies goods according to the SITC Rev.2 system. The Comext data I collected are instead organized according to their CN code. I converted them to the CPA code and then to the HS2007 one, again using the RAMON Tables of conversion. Then, following the WITS

[16]See http://ec.europa.eu/eurostat/ramon/relations/index.cfm?TargetUrl=LST$_REL$

tables (http://wits.worldbank.org/product_concordance.html), I could link HS2007 to SITC Rev.2. I finally linked Nace2 codes to SITC Rev.2 codes and therefore I could attach a SITC Rev.2 code to the Prodcom data as well.

# Chapter 2

# Trade and Growth in the Age of Global Value Chains

*joint with Carlo Altomonte and Italo Colantone*

## 2.1 Introduction

Assessing the causal impact of trade on growth is a relevant but notoriously difficult exercise, because of the endogeneity of trade. Countries whose income is higher for reasons that are not driven by trade, in fact, may still engage in more trade. Since the seminal paper of Frankel and Romer (1999), the trade-growth relationship has been investigated through different instrumental variable strategies. The most recent studies provide evidence of a positive effect of trade on growth by exploiting shocks to transportation technology that have an asymmetric impact on different trade flows, depending on some geographic characteristics of country pairs (Feyrer (2009); Pascali (2014)). However, none of the existing studies considers the increasing role of global value chains (GVCs).

In fact, they exploit historical shocks for identification, dating before the surge of GVCs, and they focus solely on gross export data, which are not informative of the value-added contribution of each country to trade.

In the world of GVCs, as production processes are split across different nations, the gross exports of any country embody an increasing share of foreign value added. Moreover, since intermediate inputs cross borders multiple times (Koopman et al. (2014)), trade figures are subject to double-counting problems. Finally, countries are different in the extent to which they participate to global value chains, and also in their positioning within them, *i.e.* from assembling to higher up stages of the production chain. The implications of such processes for the trade-growth nexus have not been directly investigated so far. In this paper, we aim to shed light on this.

We make three contributions. First, we develop a new geography-based, time-varying instrument for trade encompassing the surge of GVCs. In order to do so, we exploit a recent technological shock: the sharp increase in the maximum size of container ships, which has roughly tripled between 1995 and 2007, increasing from 5,000 to 15,000 TEU[1]. This shock affects different trade flows asymmetrically, depending on the presence of deep-water ports (DWPs) across countries. In fact, the new larger ships can only enter such ports (deeper than 16 meters), which are unevenly distributed across countries. Exploiting this source of identification, we obtain an instrument for exports by estimating gravity equations. Second, we use this instrument to show that export has a positive effect on GDP per capita, with an elasticity of roughly 0.61. Exploiting country-level data, we also show that export affects growth through capital deepening. Third, using the export decomposition methodology by Wang et al. (2013), we show that differences in the value-added composition of exports

[1]A TEU stands for a Twenty-foot Equivalent Unit, a unit of cargo capacity generally used to describe the capacity of container ships and container terminals. See *infra* for more details.

matter for moderating the trade-growth nexus. In fact, we find evidence of a growth premium for those countries that upgrade their *positioning* in GVCs more than others over time. This result is robust to an alternative, demand-based definition of positioning such as the *upstreamness* measure proposed by Antras and Chor (2013). *Participation* in the GVCs, instead, does not seem to have a role for moderating the trade-growth nexus.

Our analysis covers 40 countries included in the WIOD database, accounting for more than 85% of world trade, from which we draw data on gross exports at the industry level for the period 1995-2007. Seaborne containerized trade has been the fastest growing modality of seaborne trade over the sample, ultimately accounting for about 40% of total trade in the world (WEO, 2012). Moreover, improvements in containerized trade have been pivotal for the surge of global value chains (see Bernhofen et al. (2013) and Memedovic et al. (2008)), whose implications are investigated in our analysis: the WIOD data, in fact, allows to decompose each gross export flows in its different value added components. In our sample of countries we have identified a total of 52 deep-water ports, needed for the larger ships introduced after 1995 to dock. The identification of these ports was non trivial, due to lack of a unique and ready-to-use data source. In particular, we had to collect information on the water depth (and other characteristics) for more than 3,500 ports, by performing a detailed text analysis of a number of different web sources. As a result of that, we have created a new original database containing comprehensive information for each port. The number of deep water ports in each country is fixed in our sample, and thus is a time-invariant geographic characteristic. Indeed, according to our port data, it is only after 2007 that countries have systematically started to transform standard ports into deep water ports by dredging (e.g. in New York). For this reason, we ensure the validity of the exclusion restriction by considering trade flows until 2007 only in our analysis.

We build up our instrument by predicting bilateral industry-level exports in a gravity framework, similarly to Frankel and Romer (1999) and subsequent papers (e.g. Feyrer (2009); Felbermayr and Gröschl (2013)). Our gravity equation includes the standard dyadic controls (distance, contiguity, etc.) together with their interaction between the maximum size of container ships available in the world market in a given year multiplied by number of deep water ports, in both the origin and the destination country (normalized by the length of the coastal line). With this procedure, the increase in the size of container ships, common across countries, is allowed to have different effects on the each regressor's elasticity of trade. These effects can vary across bilateral flows thanks to the geographical source of exogenous variation across country-pairs that we are considering, *i.e.* countries' endowment of DWPs, which made the employment of larger container ships possible. Moreover, differently from the previously cited studies, we estimate gravity equation at the bilateral-*sectoral* level, allowing the increase in the size of container ships not only to have an asymmetric impact across country-pairs, but also to affect differently trade flows in different sectors.

Then, we use our gravity estimates to compute the component of each bilateral-sectoral flow that is predicted by our regressors, hence exogenous to the income formation process. We aggregate these values at the exporting country level and use such predicted export flows as an instrumental variable in the income regressions, in which we assess the impact of trade on per capita GDP. Our novel instrument appears to be a powerful predictor of exports. We find evidence of a positive effect of exports on GDP per capita, with an elasticity of about 0.61. This result is submitted to a large number of robustness and sensitivity checks, concerning the specification of the gravity and of the growth regressions, as well as the way in which DWPs are identified.

In the second part of the paper, we explore whether different roles played by countries in GVCs matter for the relationship between trade and income. To this purpose, we start by employing the methodology by Wang et al. (2013).[2], which allows for an exact decomposition of each bilateral-sectoral export flow into several value added components. Thanks to this decomposition we can construct two GVC indicators. The first indicator is a proxy for a country's *participation* to GVCs, and is defined as the share of foreign value accounted for by pure double counting (Wang et al., 2013). This indicator grows as cross-country production sharing deepens and a country gets more involved in global value chains. The second indicator reflects the *positioning* of a country within global value chains, defined as the share of foreign value that is embodied in intermediate exports (Wang et al., 2013). If a country engages mostly in assembling, *i.e.* at the bottom of the value chains, and thus exports mostly final goods, this indicator will be very low. Instead, it will increase as countries move to higher-up stages in the value chain. We also refer to the work by Antras and Chor (2013) and construct a third indicator: the *upstreamness* one, again related to the positioning of each country in the GVCs, but constructed from a different perspective. In fact, it is a demand-based measure, reporting the average "distance", in terms of production steps, from the consumption of the final good. We find evidence of a higher growth effect for those countries that upgrade their positioning in GVCs more than others over the sample. According to our estimates, this growth premium is about 30% of the average effect of export. Similarly, countries with higher growth levels of upstreamness gain more in terms of per capita GDP from an increase in trade. An increase in participation to GVCs, instead, does not play a significant role. Overall, our findings suggest that, in the age of global value chains, the trade-growth nexus is crucially moderated by the modalities through which a country participates to global production sharing.

[2]We are very grateful to Zhi Wang, Shang-Jin Wei, and Kunfu Zhu for having shared their data on the exports' decomposition with us.

The remainder of the paper is organized as follows. Section 2 reviews the related literature. Section 3 discusses the evolution of containerized trade over the sample, and the role of deep-water ports. Section 4 describes the empirical strategy. Section 5 presents the main results on trade and growth and discusses the role of GVCs. Finally, Section 6 concludes.

## 2.2 Related Literature

Our paper speaks to different strands of the literature. In particular, it contributes to the literature on trade and growth, in which a number of studies have adopted an instrumental variables approach based on gravity estimations. In their seminal paper, Frankel and Romer (1999) focused on geographical characteristics such as the bilateral distance between countries, which are indeed powerful determinants of trade flows. However, the exogeneity of such geographical variables to the income formation process has later been criticized as they might affect countries' growth through channels other than trade, thus violating the exclusion restriction. Evidence on this issue has been provided, for instance, with respect to the role of distance from the equator (Rodriguez and Rodrik, 2001).

Recent empirical contributions built on the Frankel and Romer (1999) approach by considering shocks to transportation technology as instruments for exports, which have an asymmetric effect across country pairs due to exogenous geographic characteristics, hence are exogenous to the income formation process (Feyrer (2009), and Pascali (2014)).[3]. Specifically, Feyrer (2009) exploits the reduction in air transportation costs between 1960 and 1995, which has had a larger positive effect on trade for country-pairs whose air distance is much shorter than sea distance. Pascali (2014) instead

[3] Felbermayr and Gröschl (2013) have also developed a time-varying instrument for trade in a gravity framework, by using natural disasters in partner countries as a source of variation over time, rather than a transportation shock.

exploits the introduction of the steam engine in the shipping industry, between the 1860s and the 1870s, which has reduced shipping costs relatively more for trade routes that were not favored by wind patterns. The time dimension of such instruments makes it possible to work with panel data, which is crucial in this context: it allows the inclusion of country fixed effects in the regressions, which control for any constant determinants of income, such as historical, institutional and geographical factors (including distance from the equator). However, none of these studies takes into account the role of global value chains. In fact, they exploit identification shocks that date before their surge, which started in the mid 90s. Moreover, they rely solely on gross exports data, which do not capture differences in the participation and positioning of countries in GVCs.

In this paper, we follow a similar identification strategy as in Pascali (2014) and Feyrer (2009). However, our gravity equation is estimated at the sectoral-bilateral level, allowing the transportation shock to have a differentiated impact across country-pairs as well as across sectors. Moreover, we rely on a more recent shock to transportation technology, which happens at the same time as the surge of global value chains and is pivotal for their development. This allows us to investigate the key role of GVCs in moderating the relationship between trade and growth. We regard this issue as crucial for today's trade policy.

Our results show that trade affects income via its effect on capital accumulation. This is consistent with several studies proving that the investment share increases as a consequence of trade liberalization and openness (see Wacziarg (2001) and Baldwin and Seghezza (1996)). Recently, Anderson et al. (2015) provided a microfoundation of the Frankel and Romer (1999) approach by developing and estimating a structural dynamic general equilibrium model in which capital accumulation is the key channel through which trade affect income growth.

Our work is also related to the growing literature on GVCs. From the methodological point of view, a number of contributions have provided the tools for decomposing gross export flows into their different value added components (Johnson and Noguera (2012); Koopman et al. (2014); Wang et al. (2013)). We capitalize on these studies, in particular Wang et al. (2013), for assessing how differences in the value added composition of gross exports moderate the trade-growth nexus. Other papers have exploited the decomposition by Koopman et al. (2014) for studying the evolution of value-added exports over the recent financial crisis (e.g. Nagengast and Stehrer (2015)). A recent study by Johnson (2014) focuses instead on the role of GVCs with respect to the synchronization of business cycles across countries. Our paper is different, as it studies the causal relation between exports and economic growth, taking into account the extent to and the modalities through which countries participate in global value chains.

## 2.3 Container ships and DWPs

Containers started to be developed and used for commerce in the US during the mid 50s. Before the introduction of container ships, goods were transported using break-bulk cargo, thus they needed to be moved individually. As a result, a large part of the shipping time was spent in ports, waiting for ships to be unloaded and loaded back again. Containers tremendously improved the efficiency of sea-transportation, shortening the time spent into port facilities, and soon the container technology started spreading to other countries. International standardization followed in 1965, and by the mid 80s containers were widely adopted worldwide[4]. The diffusion of containerized trade has had a positive impact on trade. In particular, Bernhofen et al. (2013) find that, during the period

[4]In a sample of 157 countries used to track the development of containerization, Bernhofen et al. (2013) find that 122 countries had adopted containerized trade (either by sea or rail) by 1983. The remaining 35 countries were mostly developing economies, none of which appears in our sample.

1962-1990, the joint adoption of containerized trade for two trading partners could increase their bilateral trade flows by up to 700%, cumulatively over 20 years. Containerization has thus been identified as an important driver of globalization.

Besides boosting trade in the 80s, containerization has also been instrumental for the development of GVCs from the mid 1990s. Indeed, it is widely recognized that the benefits associated with the break-up of production processes across countries could not be realized without significant parallel improvements in logistics, IT and transportation technology (see, for instance, Notteboom and Rodrigue (2008) and Memedovic et al. (2008)). In fact, during the surge of GVCs, with the associated acceleration in world merchandise trade, containerized seaborne trade experienced average growth rates exceeding 10 per cent per year in volumes. As a result, by 2010 this modality of trade accounted for around 40% of the total value of global merchandise trade[5].

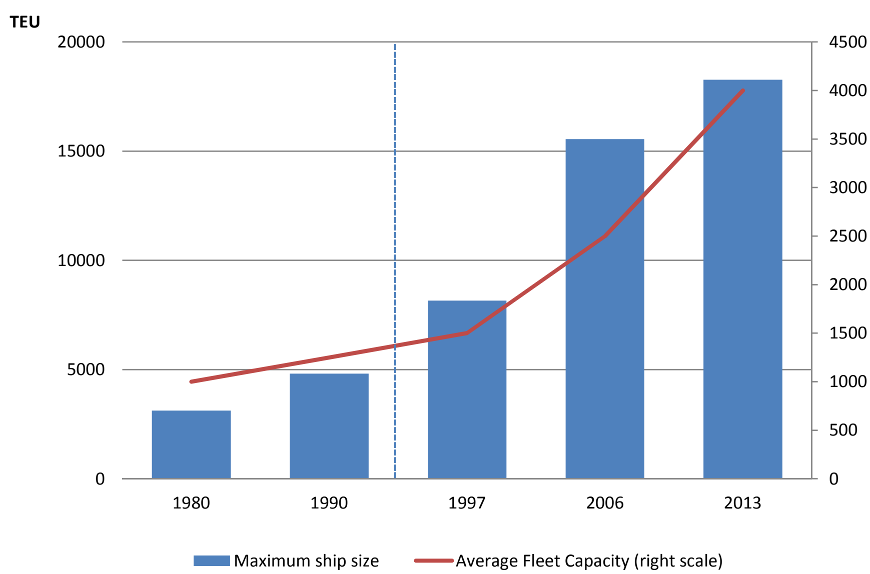
This recent growth of seaborne containerized trade is associated with a shock to transportation technology: between 1995 and 2007 the maximum capacity of container ships has roughly tripled, from around 5,000 to 15,000 TEU (see Figure 2.1)[6]. The shock was not an isolated event (e.g. a one-off launch of a large ship), but a true game changer for the industry. To give an idea of the relevance of the shock in terms of adoption of the new technology, consider the following: since the standardization and widespread adoption of container transport between the 70s and the mid 90s, the maximum size of container ships increased at a roughly linear pace of 110 TEU per year. As a result, it took 30 years for the world fleet of container ships to reach an average capacity of 1,500 TEU. Instead, in the 13 years between 1995 and 2007, the adoption of increasingly larger vessels

[5] In 2010 all forms of seaborne trade represented 75% of world merchandise trade volumes and 60% of value, with the large majority (around 60%) of seaborne trade value made up by containerized seaborne trade (WEO, 2012).

[6] A TEU stands for a Twenty-foot Equivalent Unit. It is based on the volume of an internationally standardized intermodal container, 20-feet-long (6.1 m) and 8-feet-wide (2.44 m). No precise standard exists on height, although in general the most common height is 8 feet 6 inches (2.59 m), to fit into railway tunnels.

led to a sharp increase in the average capacity of the world fleet of container ships: from 1,500 to roughly 2,500 TEU (see the solid line in Figure 2.1). This is unsurprising if one considers that an increase from 5,000 to 15,000 TEU in capacity is estimated to bring about a reduction in annual operation cost from around 700$ to 400US$ per TEU (OECD, 2015).

Figure 2.1: Development of container ships (TEU), 1970-2015




Source: Authors' elaboration from OECD, *The Impact of Mega-Ships*, 2015

The technological shock in the size of container ships generates an important source of exogenous variation in trade across countries. As a matter of fact, not all countries are equally endowed with ports that are deep enough to accommodate the new larger container ships. In particular, before 1994 ports whose depth was at least 13 meters could accommodate any container ships, as the maximum draft of these ships was 12 meters.[7] After 1994, new larger ships were introduced over

[7]The size of container ships was in fact constrained to fit the dimensions of the Panama canal's lock chambers. The so-called *Panamax* ships had to have maximum dimensions, as disciplined by the Panama Canal Authority, of 294,13 m (965 ft) in length, 32,31 m (106 ft) in width and 12,04 m (39.5 ft) in draft, which yielded a maximum physical payload capacity of around 4,500 TEU. The draft of the ship is defined as the distance between the surface of the water and the lowest point of the vessel.

time, as reported in Table 2.1. With the increase in dimensions and capacity, the maximum draft of container ships increased from 12 to roughly 16 meters, to a point in which these vessels could only access a restricted number of ports with adequate depth. We define *Deep Water Ports* (DWPs) those ports that have a container terminal and whose depth is at least 16 meters: these ports can accommodate all the container ships operating in our period of interest, *i.e.* from 1995 to 2007.[8]

Table 2.1: Evolution of Container Ships

| **Ship** | **Adoption** (year) | **Capacity** (TEU) | **LOA** (m) | **Breath** (m) | **Draft** (m) |
|---|---|---|---|---|---|
| Panamax | Before 1994 | 4,500 | 294 | 32 | 12 |
| NYK Altair | 1994 | 4,900 | 300 | 37 | 13 |
| Regina Maersk | 1996 | 7,100 | 318 | 43 | 14 |
| Sovereign Maersk | 1997 | 8,100 | 347 | 43 | 14 |
| Gudrun Maersk | 2005 | 10,150 | 367 | 43 | 15 |
| Emma Maersk | 2006 | 15,500 | 397 | 56 | 15.5 |

Authors' elaboration on data from Alphaliner, Maersk and www.containership-info.com

In order to identify DWPs across countries, we have started from an on-line repository of world ports (www.worldportsource.com), collecting information on 4,764 ports in 196 countries. We have then restricted the attention to ports located in the 40 countries covered by the WIOD dataset, for which we are able to decompose gross trade flows in value-added terms. The latter yielded 3,529 ports, which we have individually checked for maximum depth and container activity by performing a detailed text analysis of several web sources.[9] Figure 2.2 reports the number of ports, by depth and specialization, across the 40 countries. There are a total of 52 deep water ports according to our definition.[10] Their average depth is 18.3 meters. As it can be seen, there are 30 additional ports

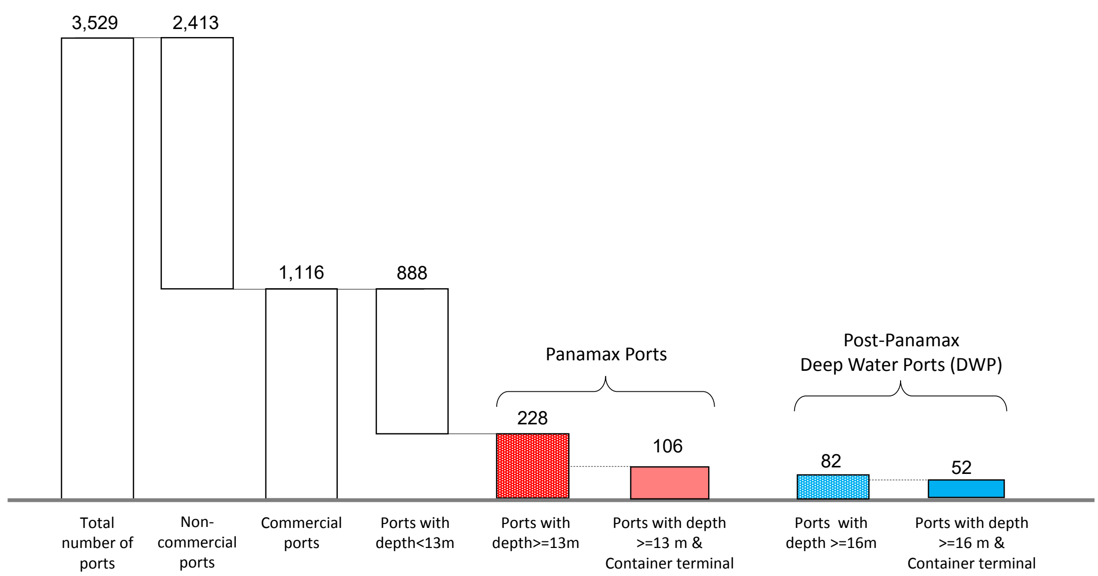
[8]The largest ships operating in our period of interest are the eight Maersk E Series ships of which the Emma Maersk was the first. These ships, with a draft at maximum load estimated between 15.5 and 16m, might not fit in the shallowest of our DWPs, *i.e.* those with a depth not much deeper than 16m. However, these ships would not be loaded always at maximum capacity, and they are operational only for the last year of our considered time period (they were launched in middle of 2006). Our results are in any case robust to employing a 17 meters threshold for the identification of DWPs.

[9]Worldportsource.com describes for each port its characteristics (number and length of berths, depth at quay, maximum depth, etc.) as well as the type of ongoing commercial activity, *i.e.* whether the port handles dry bulk cargo, oil and/or containers. If relevant information was missing, the latter has been recovered through the website of the specific port. Note that on Wikipedia it is possible to retrieve a list of DWPs presented as 'Panamax' ports. However, as also recognized on the same web page, the article is outdated, and the list incomplete and imprecise.

[10]In order for a port to satisfy the depth criterion, a depth of at least 16 meters has to be reported *alongside* quays,

that would qualify as DWPs in terms of depth, but do not have a container terminal. This means that, technically speaking, all the new larger ships introduced over the sample could enter those ports, but could not be loaded/unloaded there. In the empirical analysis, we discuss the sensitivity of the results with respect to considering also these additional ports, as well as the 106 ports with a container terminal that have a depth of at least 13 meters. Table 2.2 reports the distribution of the 52 deep water ports across countries.

Figure 2.2: Number of ports, by depth and specialization, WIOD countries




Source: authors' elaboration on data from *Worldportsource.com* and secondary sources

The relative presence of DWPs across countries depends to a large extent on exogenous geographic

and not at anchoring, as container ships need to be berthed to quays in order to be loaded/unloaded by cranes. In this sense, container ships are different from oil carriers, that can be loaded/unloaded while anchored, via specific floating storage and offloading units moored offshore. Moreover, we have checked that access ways to the port quays, e.g. canals, also satisfy the minimum depth requirement of 16 meters.

characteristics, such as location and coastal conformation. For instance, oceanic coasts are more likely to host deep-water harbors than coasts of internal seas such as the Black Sea. In our baseline specification we will consider the 52 DWPs equipped with container terminals, because these are indeed those where the larger vessels introduced after 1995 can dock. Indeed, we will show in Section 5.3 that, if we consider all ports deeper than 16m irrespectively of their endowment of container facilities, our predictor of trade gets worse. However, one may wonder that an investment in supporting infrastructure is required in order to develop deep water ports, which could then be endogenous to the GDP growth of hosting countries. To make sure that the exclusion restriction is satisfied, we will run an additional robustness check considering only deep water ports in *destination* countries. Conditional on controls, in fact, the presence of DWPs in importer countries can have an impact on the exporter's GDP only through the trade channel. The result appears to be qualitatively unchanged.

One could even be worried that new deep water ports are created over time by dredging existing ports, in order to accommodate the new larger ships. We investigated the history of each port to make sure that the reported depth has not been artificially altered during the time span of our analysis. As a matter of fact, dredging activities have been systematically undertaken only after the end of our sample, for instance at the ports of New York and New Jersey, Baltimore, and Miami. Typically, port upgrading has happened after 2010, following the launch of the largest container ships and, most importantly, the expansion of the Panama Canal locks, whose project has been finalized in 2009, with completion expected in 2016.[11]

[11] The maximum dimension of ships in the new locks are 366 m (1,200 ft) in length, 49 m (160.7 ft) in width, and 15.2 m (49.9 ft) in draft).

Table 2.2: Number of DWPs with container terminal by country

| **Country** | **DWPs** | **Country** | **DWPs** |
|---|---|---|---|
| AUS | 2 | IRL | 0 |
| AUT | 0 | ITA | 3 |
| BEL | 1 | JPN | 2 |
| BGR | 0 | KOR | 3 |
| BRA | 1 | LTU | 0 |
| CAN | 1 | LUX | 0 |
| CHN | 9 | LVA | 0 |
| CYP | 0 | MEX | 2 |
| CZE | 0 | MLT | 0 |
| DEU | 2 | NLD | 1 |
| DNK | 0 | POL | 0 |
| ESP | 8 | PRT | 0 |
| EST | 1 | ROM | 1 |
| FIN | 0 | RUS | 0 |
| FRA | 3 | SVK | 0 |
| GBR | 1 | SVN | 0 |
| GRC | 1 | SWE | 0 |
| HUN | 0 | TUR | 0 |
| IDN | 0 | TWN | 3 |
| IND | 3 | USA | 4 |

## 2.4 Empirical Strategy

Our empirical strategy has three steps. In the first step, we estimate a modified gravity equation for exports from country $i$ to country $j$ in sector $z$ at time $t$ ($T_{i,j,z,t}$). In the second step, we use the estimates from the above gravity regressions, aggregated at the exporting-country level, to compute the component of countries' overall trade that in principle should not depend on income. In the third step, we use such estimated trade flows as an instrument to investigate the impact of actual trade on income.

The gravity equations are estimated on gross export flows at the bilateral country-industry level derived from the World Input-Output Database (WIOD), a project funded by the European Commission, Research Directorate General and carried out by a consortium of 12 research institutes (see Timmer et al. (2015) for a detailed description). The database provides information on export flows[12] and Input-Output matrices for 40 countries and 34 industries, including both manufacturing and services, and thus allows for the decomposition of gross exports in domestic vs. foreign value added components that we will employ in Section 5.3. The Appendix reports a list of the countries (Table A1) and of the manufacturing industries (Table A2) involved in our study.

In the first step, we estimate a gravity equation sector by sector over 14 manufacturing industries. The geographical, institutional and historical variables that we consider as possible determinants of trade flows are summarized in the following vector X:

[12] Zero trade flows are not included in the dataset, instead some figures are not reported. However, these missing observations account for only about 4% of country-sector-year observations for the manufacturing industries.

$$X = \begin{bmatrix} ln(dist)_{i,j} \\ contig_{i,j} \\ landlock_{i,j} \\ colony_{i,j} \\ comlegal_{i,j} \\ comlang_{i,j} \\ RTA_{i,j} \end{bmatrix}$$

where $dist_{i,j}$ is population-weighted distance. $contig_{i,j}$, $landlockedness_{i,j}$ are additional geographic controls, taking value 1 respectively if the two countries share a border or if at least one of them is landlocked (and zero otherwise). $colony_{i,j}$ and $comlegal_{i,j}$ are historical-institutional dyadic variables, referring to the countries ever being in a colonial relationship of having common legal origin, whereas $comlang_{i,j}$ and $RTA_{i,j}$ take value 1 if the countries share their common official language or are members of the same Regional Trade Agreement. All these dyadic variables were obtained from the CEPII database (Head et al., 2010).

For each one of these regressors, we will consider both its direct effect on trade flows as well as the interaction with the novel variables that we propose: $DWP_k \times log(MaxSize_t), k = (i, j)$, obtained interacting the number of DWPs on either the importer or the exporter's shore with the maximum size of container vessels available in each year. This specification is aimed to capture, and employ as source of exogenous variation in the income formation process, the asymmetrical effects that a common shock across countries, such as the increase in ships' size over time, had on trade flows between different countries via their different endowments with DWP. This corresponds to transforming each element $x$ of $X$ as follows:

$$\widetilde{x} = x\Big[\gamma_0 + \gamma_X DWP_i \times ln(MaxSize_t) + \gamma_M DWP_j \times ln(MaxSize_t)\Big] \tag{2.4.1}$$

With this procedure, we allow the effect of each regressor on export flows to vary with the number of DWPs in each country, needed for container ships to dock. In other words, the common technological shock across countries, *i.e.* the increase in size of container vessels, can affect the trade elasticity of each one of our regressors depending on each country's endowment of DWPs.

The gravity equation that we estimate takes then the following form:

$$\begin{aligned}\ln T_{i,j,z,t} =& \delta_{z,0} + \delta_{z,1} \widetilde{ln(dist)}_{i,j,t} + \delta_{z,2}\widetilde{contig}_{i,j,t} + \delta_{z,3}\widetilde{landlock}_{i,j,t} + \delta_{z,4}\widetilde{colony}_{i,j,t} + \\ & \delta_{z,5}\widetilde{comlegal}_{i,j,t} + \delta_{z,6}\widetilde{comlang}_{i,j,t} + \delta_{z,7}\widetilde{RTA}_{i,j,t} + \nu_{i,z,t} + \nu_{j,z,t} + \epsilon_{i,j,z,t}\end{aligned} \tag{2.4.2}$$

Notice that this gravity equation is consistent with theoretical microfoundations such as the one provided in Anderson and van Wincoop (2003b), as we included multilateral resistance terms, which we control for using importer-time and exporter-time fixed effects. This prevents us from directly including in the right-hand-side the first order interaction $DWP_k \times log(MaxSize_t), (k = i, j)$ terms, because they would be absorbed by the fixed effects. Our novel variables are then present only in the interaction terms. As a consequence, we estimate the effects of new larger ships in attenuating (or enhancing) the impact of each one of the dyadic controls on bilateral-sectoral trade flows. Moreover, all coefficients have been indexed with $z$ to indicate that regressions are run at the sector level. In fact, we are allowing the time-shock to have a differentiated impact not only across country-pairs, but also across sectors.

In the second step, we use the estimates obtained from the bilateral-sectoral gravity equations estimated above to construct the instrument for the growth regression. We exponentiate the bilateral-sectoral component of $ln(T_{i,j,z,t})$ predicted by our regressors together with all the $DWP_k \times log(MaxSize_t), (k = i, j)$ interaction terms, for each sector and each country-pair. Then, we aggregate such predicted values over sectors and partner countries to get an exporter-time measure of trade that can be used as instrument, since it does not depend on income.

$$EstimTrade_{i,t} = \sum_j \sum_z \exp(\hat{\delta}_z \tilde{X}) \tag{2.4.3}$$

In the third step, we take the logarithm of $EstimTrade_{i,t}$ and use the constructed $ln(EstimTrade_{i,t})$ as an instrumental variable to investigate the impact of actual trade on income. In particular, we will estimate

$$ln(GDPpc_{i,t}) = a_0 + b\ ln(T_{i,t}) + \mu_i + \mu_t + u_{i,t} \tag{2.4.4}$$

where $GDPpc_{it}$ and $T_{it}$ are respectively per capita GDP and total export of country $i$ at time $t$. The equation will be estimated using both OLS and 2SLS, in which $ln(EstimTrade_{i,t})$ constructed above will be used as instrumental variable for $T_{i,t}$. Importantly, the panel nature of our dataset allows for the inclusion of $\alpha_i$, a country-level fixed effect controlling for all non-time varying country's specific characteristic (such as the distance from the equator) and $\alpha_t$, a year fixed effect.

We also check for for potential sources of income growth, and specifically for changes in the capital stock per worker. Thanks to the data contained in the WIOD input-output tables, we can investigate this channel also at the country-industry level: in fact, the dataset includes information on physical capital per worker for each sector. Therefore, we can analyze to what extent trade affects growth through by estimating the following equation

$$ln(Cap_{i,z,t}) = c_0 + d\ ln(T_{i,z,t}) + \alpha_{i,z} + \alpha_t + u_{i,z,t} \tag{2.4.5}$$

Notice that, for this specification, we will instrument $ln(T_{i,z,t})$ with $ln(EstimTrade_{i,z,t})$, *i.e.* we need exporter-*industry* estimated trade flows. In order to do so, we will aggregate only across partner countries when performing the second step of our procedure, thus keeping the sectoral dimension. The same equation will be estimated at the country-level as well, aggregating the predicted trade values across sectors as in the baseline.

## 2.5 Results

### 2.5.1 Gravity Estimations

We estimated Equation (4.2) on the 14 manufacturing sectors included in the WIOD database. Table 2.R.1 reports the results for three of them: "Food, Beverage, Tobacco", "Textiles" and "Leather and Footwear".

Consistent with the literature, the distance coefficient is significant at the 1% level, negative and relatively stable across sectors, as one would expect: the farther away countries are, the more difficult it becomes for them to engage in international trade. The contiguity coefficient is positive and strongly significant, even though its magnitude varies across sectors. The estimated first-order effect of the other dyadic variables varies instead across sectors, both with respect of its sign as well as its magnitude.

The interactions of the previously described regressors with our novel variable $(DWP_k \times ln(MaxSize_t), k = (i, j))$ are statistically significant at the 1% level in most cases. Our gravity estimates stress the importance of containerized trade in the time period analyzed. Consider, for instance, distance between countries: one of the strongest empirical findings in international trade is its effect in depressing trade (Head and Mayer (2014)). Our results show that the distance elasticity of trade is significantly moderated (at the 1% confidence level) by countries' endowment of DWPs for all the 14 manufacturing sectors included in our analysis: for a given ships' size, distance has a lower impact in reducing trade the higher the number of DWPs in either the origin or the destination country. Moreover, we will show in Section 5.2 that the introduction of the interaction terms does also make a difference for our main result: in fact, the exogenous component of trade constructed including them in the gravity regression is a much better predictor of total trade than the one obtained considering the dyadic regressors only, *i.e.* without interacting them with our novel variable.

### 2.5.2 Trade and Income

Following the procedure described above, we exponentiate the estimated component of trade explained by geographical, institutional and historical variables and their interaction with our novel variable for each bilateral-sectoral observation. Hence, we aggregate them at the exporter-year level to get instrumental variables to be used in the income regression, according to the specification of Equation (4.4). The estimated coefficients for the growth regression at the country level are reported in Table 2.R.2, together with their OLS counterpart (Column (1)).

Column (2) reports the 2SLS result obtained including in the gravity regression all the dyadic regressors described above, together with their interaction with our novel variables (both for the importer and for the exporter). Our result shows that increasing export in manufacturing by 10% has a positive impact on GDP per capita of about 6.1% percent. This result is consistent with the one reported by Feyrer (2009), who finds a trade elasticity of about 0.5 for total trade. The Kleibergen-Paap F-statistic is well above the standard threshold of 10 proposed by Staiger and Stock (1997). The first stage result, *i.e.* the coefficient obtained regressing actual manufacturing trade on the one predicted, is significant at the 1% level and negative: as Table 2.R.1 shows, in fact, the coefficient associated with distance has the highest magnitude in all gravity regressions and distance has a negative effect on trade, thus explaining the sign of the first stage 2SLS coefficient.

Notice that the 2SLS coefficients are higher than the OLS ones, consistent with the results of the literature. The traditional explanation for this finding, put forward by Frankel and Romer (1999), is related to the fact that trade is an imperfect measure of income-enhancing interactions among countries. As such, it ends up being correlated with the error term in the OLS income regression, generating a standard downward bias in the estimated coefficient. Such a measurement error is instead corrected in the IV regression, to the extent that the instrument better accounts for the income-enhancing interactions among countries through the geographical and time variation.

Column (3) reports the result of the income regression obtained without including the interaction terms in the gravity equation, *i.e.* setting $\gamma_X$ and $\gamma_M$ in Equation (4.1) equal to zero. The F-statistic is above 10 even in this case, but it is much lower than the one reported in Column (2). This suggests that our interaction variables, capturing the differential impact that containerized trade had on different countries due to their different endowment of DWPs, does better than dyadic variables only in predicting trade. Moreover, the effect of trade on income is very close to the OLS one.

As a first sensitivity check on the power of our instrument, we performed the same exercise including *only* geographic characteristics in the gravity regression: distance, contiguity and landlockedness ("DCL" specification). Column (3) reports the trade-income result obtained interacting them with our novel variables. The trade elasticity of income is lower than the previous estimate and this result shows again that OLS biases this result downwards. As before, Column (4) reports the estimate obtained considering only the three geographic regressors in the right-hand-side of the gravity equation, without including DWP variables. This corresponds to predicting trade with geography only. The F statistic is now very low (about 4.8): again, the instruments constructed from our newly proposed variables seem to be a better predictor of trade than geographical characteristics alone.

Our result is robust to considering different lags of trade on the right hand side of Equation (4.2). Results are reported in Table 2.R.3 and show that the impact of international trade on income is statistically significant at the 1% level when considering lags up to t-4[13]. This seems to suggest that the effect of trade on income might build up over time. Figure 2.5 provides a graphical representation of the estimates. Moreover, we can estimate the impact of the change in predicted trade on the change in GDP per capita over the entire time period covered by our sample (1995-2007). Our results, reported in Column (6) of Table 2.R.3, show that the relationship is positive and significant, the coefficient being qualitatively similar to the estimates obtained by Feyrer (2009).

Table 2.R.4 looks at the effect of trade on the main channel for income growth, *i.e.* capital accumulation. In the first two columns, we consider variables at the country level. Our results show that trade positively affects physical capital per worker: in particular, a 10% increase in manufacturing exports boosts capital per worker by 6.5%, consistently with previous contributions.

[13]Notice, however, that the F statistic is above 10 only for the first and the second lag

When looking at country-industry level data (Columns (3) and (4)), we find that *sectoral* trade does not seem to have a positive impact on *sectoral* capital formation. This is probably due to the disaggregated nature of the data. One of the motives linking trade to additional investment, in fact, is the possibility of exploiting economies of scale due to increased market size (Wacziarg (2001)). While this seems to be into play for the aggregate economy, it does not have to be necessarily true for each one of the sectors composing it, especially if trade causes a reallocation of resources across different sectors.

### 2.5.3 Robustness Checks

Before moving to the analysis of the role of global value chains in the trade-growth relationship, we run a number of robustness and sensitivity checks of our results. In each one of them, we consider different specifications of the initial gravity regression through which our instrument (predicted trade flows) is constructed. Once again, we consider manufacturing trade in all regressions. Table 2.R.5 presents the estimated $\hat{\beta}$ coefficient of the IV regression at the country level for each robustness check, together with the F-statistic of the first-stage.

As previously discussed, we can expand the set of DWPs by including those ports that are not endowed with container facilities, even though their depth is enough for the largest ships to dock (greater than 16m). Our result shows a greater effect of trade in income, however the F statistic is much lower, only slightly above 10 (see specification 1). This seems to indicate that it is indeed the actual possibility for container ships to dock to matter for our baseline result. We also considered all ports endowed with container terminals but whose depth is only 13m or higher (specification 2). In this case, the estimated coefficient of the growth regression is basically unchanged.

Larger container ships were introduced when technology allowed for the construction of efficient larger vessels, but also when a sufficient number of trade routes became economically viable beyond the ones going through the Panama Canal. One possible source of concern, therefore, is that our technological shock has happened at the same time when China became a key player in the international trade scene. Chinese income growth, then, might be related to growth in other countries, challenging the exogeneity of our instrument. In principle, since our instrument is predicted exports, the impact that the Chinese boom may have had on other economies in the sample should not violate the exclusion restriction, as long as the income effect is channeled through international trade. Nonetheless, we performed a robustness check dropping all bilateral flows in which one of the trade partners is China when estimating the gravity equation. In order to be consistent, we also dropped all bilateral trade flows involving China when aggregating predicted trade at the exporting country level in order to build our instruments. Specification 3 shows that our result is again substantially unchanged.

In the baseline specification of the gravity equation, we regress $ij$ trade flows on our variables of interest, which include interactions with the number of DWP both on origin $i$ and on partner $j$'s shore. However, one could be worried about potential endogeneity of the home country's DWPs, as they could potentially be correlated with its income through channels other than trade (for instance, domestic investment needed for the creation and the set-up of container facilities). Specification 4 shows that our result holds when excluding home DWPs from the gravity regression, the trade elasticity of income being substantially unchanged. Clearly, we get an F statistic much lower than in our baseline: in fact, we are now predicting domestic trade by employing only the differential effects that DWPs in partner countries have in moderating the increase in the maximum size of container ships.

Moreover, our baseline regression allows for trade to be positively affected by containerization even though the home country $i$ has no DWPs or container facilities. As a matter of fact, the home country could even be landlocked (for example, when considering Austria or Czech Republic). Still, if we restrict our attention to those country pairs for which the home country has at least one DWP, our results hold (Line 5). Notice that the number of countries considered gets halved: only one every two countries is endowed with DWPs (see Table 2.2). Hence, similarly to what we did when excluding China, also in this case we excluded trade with countries not having a DWP from the aggregation of predicted trade flows used as instrument. Note also that the F test goes below the critical level of 10 in the latter specification. This is likely due to the lower number of observations we are now employing, with lower power: in fact, we are now estimating the relationship between income and trade employing only a fraction of trade for each country , *i.e.* the one with partner countries that have at least one DWP.

Our instrument is about seaborne trade. Most of the countries in our sample (27 out of 40), however, are European and probably due to their proximity trade more by rail or truck than they do by ship. For this reason, we want to verify the robustness of our results if we restrict the analysis to trade flows that are more likely to happen by sea routes, *i.e.* restricting our attention to countries that are far-away in terms of distance. For each one of the countries considered, we restrict our attention to trade flows with partners that are farther away than the 50th, 75th or 90th percentile in the sample (Lines 6, 7 and 8). Again the baseline result is confirmed, but the magnitude of the coefficient appears to be smaller. This could be again due to the fact that we are now disregarding a large part of each country's trade in explaining its income.

### 2.5.4 GVCs and the trade-growth nexus

#### Value-added trade data

Since the surge of GVCs, the gross value of export reported by national statistics has incorporated different information with respect to the past. In fact, when the production process is completed in different countries, intermediates crosses borders multiple times before being absorbed in their final destination. Some items will then be counted more then once (Koopman et al., 2014). Finally, countries are different in the extent to which they participate to global value chains, and also in their positioning within them, *i.e.* from assembling to higher up stages of the production chain. Countries that are mainly assemblers and exporters of finished products would exhibit high export values even though they are responsible for a tiny share of the value added to those goods. Hence, in order to investigate the implications of such processes for the trade-growth nexus, we need data on the exact composition of trade flows according to the location where value added was created.

To this extent, we rely on the methodology developed by Wang et al. (2013) who have generalized the work by Koopman et al. (2014), deriving a backward-linkage based decomposition of trade allowing for a precise partition of bilateral export flows at the industry level[14]. Essentially, given a gross export flow of 100 from the home country *HC*, in industry *X*, to the partner country *PC*, the methodology by Wang et al. (2013) allows us to disentangle which share of the gross flow corresponds to each value-added term as follows:

[14] As discussed by Wang et al. (2013), the measures of value-added trade currently used in the literature, such as Vertical Shares (Hummels et al. (2001)), VAX (Johnson and Noguera (2012)) or the Koopman et al. (2014) decomposition, are forward-linkage based, *i.e.* for each industry they include indirect value-added exports via gross exports from other industries of the same exporting country. These measures allow for an exact decomposition of aggregate export flows from each country towards the rest of the world. However, when working with bilateral flows, and/or at the industry level, the former measures are problematic, as there is not a one-to-one link between value-added exports and gross exports. For these reasons, if bilateral value-added trade measures at the industry level are needed, one has to use backward-linkage based measures of value-added exports, in which a given industry's gross exports includes domestic value added produced in all the vertically related industries.

- Domestic Value Added (DVA) is the value added generated in the exporting home country ($HC$) that is absorbed abroad (not necessarily in the partner country $PC$).

- Returned Domestic Value Added (RDV) is the domestic value added embodied in the export flows which returns home for final consumption. It includes the export of intermediates that are processed abroad and return home, both as final as well as more advanced intermediate goods.

- Foreign Value Added (FVA): it is the foreign value added embodied in domestic exports, both in final goods and in intermediates.

- Pure Double Counting (PDC): it is the portion of gross exports accounted for by intermediates crossing borders several times before being finally absorbed. PDC may include value added generated both in the home country ($HC$) and abroad.

Our data show that the break-up of the production process in different locations is indeed a relevant empirical fact over the period considered. Table 2.3 shows the share of gross exports accounted for by each value-added term, for each exporting country, on average across industries and years. DVA accounts on average for 78% of gross exports, followed by FVA with around 16%, and PDC with slightly more than 5%. RDV is on average much less relevant, below 1%, but it can rise above 40% for some export flows.[15]. Figure 2.3 reports information on the evolution of the VA shares by year, on average across countries and industries, and of total gross exports as a fraction of GDP. Consistent with the surge of GVCs, it can be noticed that the relative importance of DVA has been decreasing over the sample period, while FVA, RDV, and PDC have become more relevant. The change in the composition of exports brought about by global value chains motivates our analysis

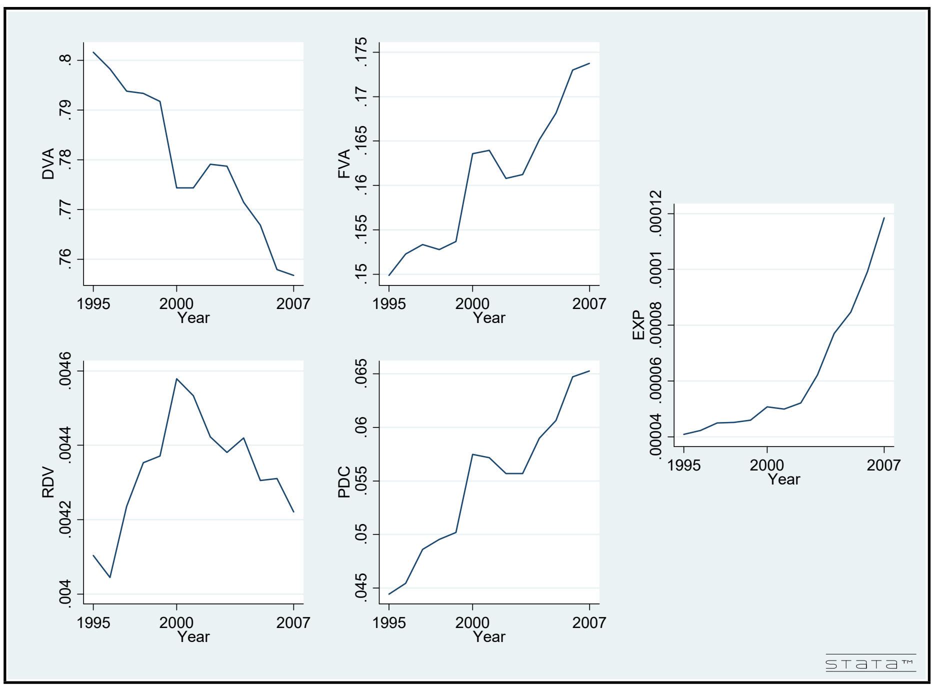
[15] Overall, the relative importance of the four components may change substantially across different export flows. For instance, foreign value added may account for up to 92% of gross exports for certain country-industry pairs in given years. These changes reflect differences in the relevance and shape of GVCs across countries and industries.

Table 2.3: Gross exports decomposition in VA

| | Mean | SD | Min | Max |
|---|---|---|---|---|
| DVA | 0.780 | 0.136 | 0.070 | 1 |
| FVA | 0.161 | 0.108 | 0 | 0.924 |
| RDV | 0.004 | 0.011 | 0 | 0.426 |
| PDC | 0.055 | 0.056 | 0 | 0.662 |

of the implications of GVCs for the relationship between trade and income growth.

Figure 2.3: Evolution of value-added components of exports over time

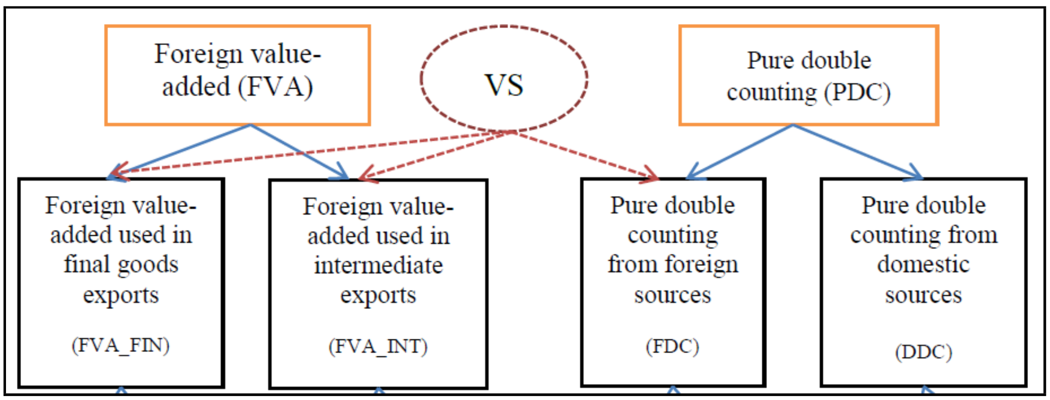



### The role of GVCs

We enrich our IV estimation of the trade-growth nexus with two indicators derived from the Wang et al. (2013) decomposition. By summing up the foreign value added used in final (FVA_FIN) and in intermediate (FVA_INT) good exports together with the PDC term from foreign sources (called

FDC), it is possible to compute a measure of Vertical Specialization, the so-called "VS_share", that Hummels et al. (2001) define as *"imported inputs embodied in goods that are exported"* (see Figure 2.4).

Figure 2.4: The VS share (from Wang et al. (2013))




The VS_share does not inform us on the specific role played by a country in the production chain. For that, we look at the different components of the same vertical specialization, to build up two indicators. The first one is an indicator for the change in the *positioning* of a country within global value chains, defined as the share of foreign value that is embodied in intermediate exports, *i.e.* the (FVA_INT)/VS ratio (Wang et al., 2013). If a country engages mostly in assembling, *i.e.* at the bottom of the value chains, and thus exports mostly final goods, this indicator will be very low. Instead, the indicator will increase as countries move to higher-up stages in the value chain. As a matter of fact, the data support this claim: we find that high growth rates of the FVA_INT/VS_share ratio are positively correlated with the share of hours worked by high skilled workers: one more dollar in foreign value added in intermediates (FVA_INT) is associated to a 35% increase in the share of hours worked by high skilled employees. The second indicator is a proxy for a country's *participation* to GVCs, and is defined as the share of foreign value accounted for by pure double counting (Wang et al., 2013) over VS, *i.e.* the FDC/VS share. This indicator grows as cross-country production sharing deepens, and a country gets more embedded in global value chains.

Moreover, it is possible to construct a third indicator on a country's role in the GVCs, this time based on a demand-side measure. Antras and Chor (2013) propose an index of *upstreamness* reporting the distance, measured in productive "steps", between each industry and the final consumer. When this indicator is close to one, we are considering an industry which is very "downstream", *i.e.* close to the final consumer. Differently from the two previously proposed measures, which are obtained using value added trade figures, this measure can be computed directly from the Input-Output coefficients. Miller and Temurshoev (2015) provided upstreamness measures at the country-industry-year level for the WIOD sample. Since we are estimating income regressions at the exporting-country level, we need to aggregate these upstreamness measures across sectors to get a measure for each country. We will do so constructing a weighted-average, in which sectoral weights reflect the export share of each sector on total manufacturing export[16]. Cyprus, Turkey and Mexico exhibit the lowest levels of country-level upstreamness constructed using this method. Moreover, it is interesting to notice that our measure of upstreamness grows by about 8% over the sample for upgrading countries (whose FVA_INT/VS growth rate is above the sample average), whereas its growth rate gets halved (about 4%) when considering non-upgrading countries.

To sum up, for each country we construct the growth rate over the sample period (1995-2007) of the following three variables:

- the FDC/VS share, indicating *participation* to the GVCs
- the FVA_INT/VS share, indicating *positioning* in the GVCs

[16]Results are basically unchanged when using GDP instead of export in the construction of the shares.

Table 2.4: Summary statistics on GVCs indexes

| | Mean | S.D. | Min | Max |
|---|---|---|---|---|
| VS share | 0.322 | 0.123 | 0.067 | 0.639 |
| FVA_INT/VS | 0.327 | 0.064 | 0.172 | 0.526 |
| FDC/VS | 0.236 | 0.065 | 0.067 | 0.423 |
| Upstreamness | 2.208 | 0.282 | 1.366 | 3.271 |

- upstreamness, a demand-side measure of *positioning* in the GVCs

Some descriptive statistics on these indexes, as well as of the VS share are reported in Table 2.4, showing that there is substantial variation across countries for all of them.

We consider whether different modalities of participation to the GVCs affect the trade-growth nexus by estimating again Equation (4.3), but this time we interact aggregate trade at the country level with dummy variables, which take value one if the growth rate of the GVCs-related index is above the sample mean for the country considered (and zero otherwise)[17]. Results are obtained using the same IV strategy described before and are reported in Table 2.R.6.

Our estimates show that the trade-growth nexus is crucially moderated by the modalities through which a country participates to global production sharing, but not by its degree of participation in it. Column (2), in fact, shows that higher participation to the GVCs does not enhance the growth-trade nexus. *Positioning* plays instead an important role: those countries moving away from purely assembling roles (*i.e.* having high FVA_INT/VS) exhibit an impact of trade on income 31% higher than non-upgrading countries, probably as a consequence of an increase in their capability of performing value-adding tasks (Column (3)). When considering the upstreamness measure, we get

[17]The results are substantially unchanged when using the levels of this indicators instead of dummy variables. We decided to report the results obtained with dummy variables to be consistent with Wang et al. (2013), who explicitly discuss the growth rate over time of FVA_INT as an indicator for positioning in the GVCs

results consistent with the latter finding: countries whose level of upstreamness grew more over the sample exhibit a stronger relationship between trade and income (Column (4)). Not all trade is the same and these findings show that the characteristics of trade flows are relevant when analyzing the impact that international trade has on economic development.

## 2.6 Conclusion

The last decade of the Twenty first century witnessed the surge of GVCs: the production process is now composed of different tasks, often performed in different locations. Containerization made this possible: it strongly decreases transportation costs, especially when new and larger container vessels were introduced. In this paper, we exploit this recent development to propose a novel instrument for assessing the link between international trade and economic growth.

The geography-based, time-varying variables that we employ for the construction of our instrument are constituted by the interaction between such a transportation shock, *i.e.* the increase in size of container ships, and a geographic (exogenous) characteristic, the presence of DWPs in home and partner's shore, which are needed to accommodate the new larger ships. These regressors are shown to mitigate the effects of standard gravity controls on export flows. In fact, the increase in the size of container vessels, common across countries, has an asymmetric impact on the estimated elasticities across different bilateral-sectoral trade flows, because of the relatively different endowment of DWPs of each country. We construct predicted values for gross export in a gravity framework and show that our novel variable does better than geographic and institutional characteristics only in predicting gross exports.

Our results show that trade has a positive effect on per capita income growth: over the period between 1995 and 2007, we estimate that a 10% increase in manufacturing exports corresponds to a 6.1% increase in income. Moreover, our result confirm that trade positively affects the capital accumulation process. We contribute to the literature on GVCs by showing that the positive effect of trade is not mediated by the degree of *participation* of a country to the GVCs, but is influenced by the different *positioning* in it. In fact, our results suggest that upgrading countries, moving away from the bottom of the chain, exhibit a 31% higher effect of trade on growth.

**Table 1 - Gravity estimation**

| | (1) | (2) | (3) |
|---|---|---|---|
| | Dependent Variable: log(trade) | | |
| Sector: | Food, Beverage, Tobacco | Texitiles | Leather and Footwear |
| Distance(log) | -1.639*** | -1.618*** | -1.694*** |
| | [0.025] | [0.027] | [0.032] |
| Contiguity | 0.482*** | 0.175*** | 0.434*** |
| | [0.058] | [0.061] | [0.075] |
| Landlockedness | -0.742*** | -0.268*** | -0.038 |
| | [0.085] | [0.089] | [0.104] |
| Colonial Relationship | 0.038 | 0.311*** | 0.697*** |
| | [0.095] | [0.098] | [0.102] |
| Common Legal Origin | 0.547*** | 0.118*** | 0.291*** |
| | [0.031] | [0.034] | [0.037] |
| Common Language | 0.079 | 0.293*** | 0.034 |
| | [0.076] | [0.075] | [0.085] |
| RTA | 0.247*** | -0.111*** | -0.346*** |
| | [0.037] | [0.038] | [0.045] |
| Distance(log)*Importer's DWP*MaxSize(log) | 0.006*** | -0.001*** | 0.005*** |
| | [0.000] | [0.001] | [0.001] |
| Contiguity*Importer's DWP*MaxSize(log) | 0.005** | -0.01 | -0.003 |
| | [0.002] | [0.002] | [0.002] |
| Landlockedness*Importer's DWP*MaxSize(log) | 0.011*** | 0.000 | 0.011*** |
| | [0.001] | [0.001] | [0.001] |
| Colonial Relationship*Importer's DWP*MaxSize(log) | 0.059*** | -0.03** | -0.013 |
| | [0.016] | [0.015] | [0.016] |
| Common Legal Origin*Importer's DWP*MaxSize(log) | 0.002*** | 0.006*** | -0.001 |
| | [0.001] | [0.001] | [0.001] |
| Common Language*Importer's DWP*MaxSize(log) | -0.004*** | -0.005*** | -0.003* |
| | [0.001] | [0.001] | [0.002] |
| RTA*Importer's DWP*MaxSize(log) | 0.002 | -0.010*** | 0.005*** |
| | [0.001] | [0.001] | [0.001] |
| Distance(log)*Exporter's DWP*MaxSize(log) | 0.002*** | 0.002*** | 0.002** |
| | [0.001] | [0.001] | [0.001] |
| Contiguity*Exporter's DWP*MaxSize(log) | 0.000 | 0.000 | -0.003 |
| | [0.002] | [0.002] | [0.003] |
| Landlockedness*Exporter's DWP*MaxSize(log) | 0.008*** | 0.007*** | 0.01*** |
| | [0.001] | [0.001] | [0.002] |
| Colonial Relationship*Exporter's DWP*MaxSize(log) | 0.078*** | -0.072*** | -0.099*** |
| | [0.02] | [0.022] | [0.02] |
| Common Legal Origin*Exporter's DWP*MaxSize(log) | 0.004*** | 0.004*** | 0.002*** |
| | [0.001] | [0.001] | [0.001] |
| Common Language*Exporter's DWP*MaxSize(log) | -0.005*** | -0.01*** | -0.009*** |
| | [0.001] | [0.001] | [0.002] |
| RTA*Exporter's DWP*MaxSize(log) | -0.002* | -0.003*** | 0.008*** |
| | [0.001] | [0.001] | [0.001] |
| Obs. | 20162 | 20208 | 19334 |
| R2 | 0.83 | 0.81 | 0.81 |

***, **, * = indicate significance at the 1, 5 and 10% level, respectively.
All regressions include importer-year and exporter-year fixed effects

**Table 2 - Country growth regressions**

| | (1) | (2) | (3) | (4) | (5) |
|---|---|---|---|---|---|
| | Dependent Variable: GDP p.c. | | | | |
| Considered trade: | Manufacturing exports | | | | |
| Gross exports | 0.270*** | 0.610*** | 0.284*** | 0.355*** | 0.149* |
| | [0.051] | [0.104] | [0.097] | [0.063] | [0.087] |
| Estimator | OLS | 2SLS | 2SLS | 2SLS | 2SLS |
| RHS Gravity equation | - | Full | Full | DCL | DCL |
| Interaction with DWP | - | yes | no | yes | no |
| Country effects | yes | yes | yes | yes | yes |
| Year effects | yes | yes | yes | yes | yes |
| Obs. | 507 | 507 | 507 | 507 | 507 |
| R2 | 0.82 | - | - | - | - |
| **First-stage results** | | | | | |
| Predicted trade flows from gravity | - | -1.056*** | -0.592*** | -1.164*** | -0.363** |
| | - | [0.179] | [0.172] | [0.218] | [0.166] |
| Kleibergen-Paap F-Statistic | - | 34.83 | 11.90 | 28.56 | 4.796 |

***, **, * = indicate significance at the 1, 5 and 10% level, respectively.

**Table 3 - Different specifications of growth regressions, manufacturing trade only**

| | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| | Dependent Variable: GDP p.c. | | | | | |
| Gross exports (t-1) | 0.625*** | | | | | |
| | [0.134] | | | | | |
| Gross exports (t-2) | | 0.645*** | | | | |
| | | [0.188] | | | | |
| Gross exports (t-3) | | | 0.802*** | | | |
| | | | [0.290] | | | |
| Gross exports (t-4) | | | | 0.860*** | | |
| | | | | [0.321] | | |
| Gross exports (t-5) | | | | | 1.196* | |
| | | | | | [0.619] | |
| ΔGross exports ('95-'07) | | | | | | 0.590*** |
| | | | | | | [0.155] |
| Estimator | 2SLS | 2SLS | 2SLS | 2SLS | 2SLS | 2SLS |
| Country effects | yes | yes | yes | yes | yes | - |
| Year effects | yes | yes | yes | yes | yes | - |
| RHS Gravity equation | - | Full | Full | Full | Full | Full |
| Obs. | 468 | 429 | 390 | 351 | 312 | 39 |
| **First-stage results** | | | | | | |
| Predicted trade flows from country gravity | -0.968*** | -0.837*** | -0.645*** | -0.660*** | -0.484* | -1.454*** |
| | [0.207] | [0.240] | [0.232] | [0.244] | [0.248] | [0.413] |
| Kleibergen-Paap F-Statistic | 21.91 | . 12.16 | 7.744 | 7.316 | 3.814 | 12.38 |

***, **, * = indicate significance at the 1, 5 and 10% level, respectively.

Figure 2.5: Effects of lagged exports on income

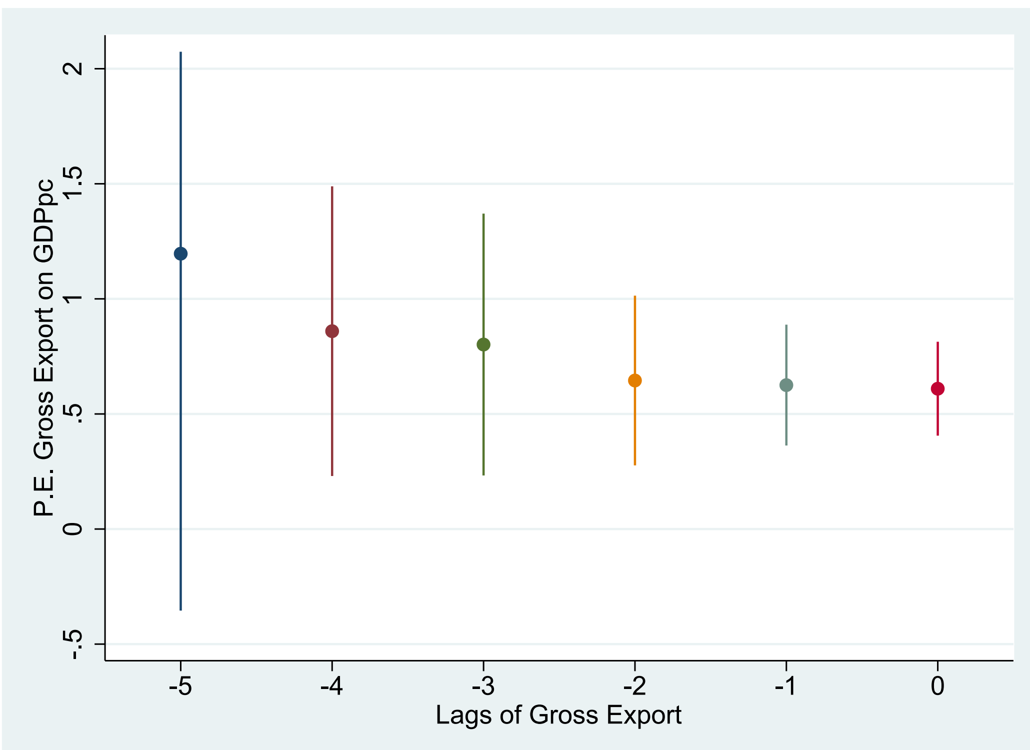


**Table 4 - Capital Deepening Regression**

| | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| | Dependent Variable: Physical Capital per worker | | | |
| Considered trade: | Manufacturing exports | | | |
| Gross exports | 0.183** | 0.655*** | 0.032 | 0.016 |
| | [0.072] | [0.159] | [0.035] | [0.124] |
| Estimator | OLS | 2SLS | OLS | 2SLS |
| Country-industry effect | no | no | yes | yes |
| Country effect | yes | yes | no | no |
| Year effect | no | no | yes | yes |
| Obs. | 507 | 507 | 507 | 507 |
| R2 | 0.72 | | 0.37 | - |
| **First-stage results** | | | | |
| Predicted trade flows | - | -1.044*** | - | -0.349*** |
| from gravity | - | [0.181] | - | [0.069] |
| Kleibergen-Paap F-Statistic | - | 33.41 | - | 25.50 |

***, **, * = indicate significance at the 1, 5 and 10%

**Table 5 - Country growth regressions, manufacturing trade only- Robustness checks**

| | **Dependent Variable: GDP p.c. (t)** | Coefficient | S.E. | Obs. | F-Stat |
|---|---|---|---|---|---|
| 1) | Depth>16m, no container terminal | 0.950*** | [0.218] | 507 | 10.09 |
| 2) | Depth>13m, container terminal | 0.699*** | [0.147] | 507 | 20.14 |
| 3) | Excluding China | 0.567*** | [0.095] | 494 | 35.12 |
| 4) | Considering only partner's DWP | 0.669*** | [0.141] | 507 | 15.92 |
| 5) | Considering only partner countries with at least one DWP | 0.521*** | [0.149] | 247 | 7.062 |
| 6) | Considering only far away country pairs (distance >median) | 0.261*** | [0.092] | 507 | 10.46 |
| 7) | Considering only far away country pairs (distance >75p) | 0.382*** | [0.131] | 507 | 11.70 |
| 8) | Considering only far away country pairs (distance >90p) | 0.318*** | [0.090] | 505 | 19.41 |

***, **, * = indicate significance at the 1, 5 and 10% level, respectively.
All growth regressions include country and time fixed effects.
All gravity regressions include importer-time and exporter-time fixed effects.
We consider ports with container facilities whose depth is greater than 16m unless otherwise specified.

**Table 6 - Growth regressions and value added trade, manufacturing trade only**

| **Panel A - OLS Regressions** | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| Dependent Variable: | | | | |
| Gross exports | 0.270*** | 0.202*** | 0.257*** | 0.252*** |
| | [0.051] | [0.057] | [0.038] | [0.047] |
| Gross exports * Dummy high growth of FDC/VS | | 0.091* | | |
| | | [0.053] | | |
| Gross exports * Dummy high growth of FVA_INT/VS | | | 0.089 | |
| | | | [0.057] | |
| Gross exports * Dummy high growth of Upstreamness | | | | 0.068 |
| | | | | [0.050] |
| Obs. | 507 | 507 | 507 | 507 |
| R2 | 0.82 | 0.83 | 0.83 | 0.83 |

| **Panel B - IV Regressions** | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| Gross exports | 0.610*** | 0.548*** | 0.615*** | 0.544*** |
| | [0.104] | [0.110] | [0.114] | [0.093] |
| Gross exports * Dummy high growth of FDC/VS | | 0.046 | | |
| | | [0.040] | | |
| Gross exports * Dummy high growth of FVA_INT/VS | | | 0.193*** | |
| | | | [0.063] | |
| Gross exports * Dummy high growth of Upstreamness | | | | 0.107** |
| | | | | [0.043] |
| Kleibergen-Paap F-Statistic | 34.83 | 15.78 | 9.804 | 20.42 |

***, **, * = indicate significance at the 1, 5 and 10% level, respectively.

All regressions include country and time fixed effects.

# Appendix

Table A1: Countries in the WIOD sample

| | |
|---|---|
| Australia | Japan |
| Austria | Latvia |
| Belgium | Lithuania |
| Brazil | Luxembourg |
| Bulgaria | Malta |
| Canada | Mexico |
| China | Netherlands |
| Cyprus | Poland |
| Czech Republic | Portugal |
| Denmark | Romania |
| Estonia | Russia |
| Finland | Slovak Republic |
| France | Slovenia |
| Germany | South Korea |
| Greece | Spain |
| Hungary | Sweden |
| India | Taiwan |
| Indonesia | Turkey |
| Ireland | U.S.A |
| Italy | United Kingdom |

Table A2: Manufacturing industries in the WIOD sample

| |
|---|
| Food, Beverages and Tobacco |
| Textiles and Textile Products |
| Leather and Footwear |
| Wood and Products of Wood |
| Pulp, Paper, Paper, Printing and Publishing |
| Coke, Refined Petroleum and Nuclear |
| Chemicals and Chemical Products |
| Rubber and Plastics |
| Other Non-Metallic Mineral |
| Basic Metals and Fabricated Metal |
| Machinery, Nec |
| Electrical and Optical Equipment |
| Transport Equipment |
| Manufacturing, Nec; Recycling |

# Bibliography

Anderson, J. E. (1979). A Theoretical Foundation for the Gravity Equation. *American Economic Review*, 69(1):106–16.

Anderson, J. E. and Bandiera, O. (2006). Traders, cops and robbers. *Journal of International Economics*, 70(1):197–215.

Anderson, J. E., Larch, M., and Yotov, Y. V. (2015). Growth and Trade with Frictions: A Structural Estimation Framework. NBER Working Papers 21377, National Bureau of Economic Research, Inc.

Anderson, J. E. and Marcouiller, D. (2002). Insecurity And The Pattern Of Trade: An Empirical Investigation. *The Review of Economics and Statistics*, 84(2):342–352.

Anderson, J. E. and van Wincoop, E. (2003a). Gravity with gravitas: A solution to the border puzzle. *American Economic Review*, 93(1):170–192.

Anderson, J. E. and van Wincoop, E. (2003b). Gravity with gravitas: A solution to the border puzzle. *American Economic Review*, 93(1):170–192.

Anderson, J. E. and van Wincoop, E. (2004). Trade Costs. *Journal of Economic Literature*, 42(3):691–751.

Anderson, J. E., Vesselovsky, M., and Yotov, Y. V. (2016). Gravity with scale effects. *Journal of International Economics*, 100(C):174–193.

Antras, P. and Chor, D. (2013). Organizing the Global Value Chain. *Econometrica*, 81(6):2127–2204.

Baldwin, R. E. and Seghezza, E. (1996). Testing for trade-induced investment-led growth. Working Paper 5416, National Bureau of Economic Research.

Beltramo, T. (2010). Changes in Bilateral Trade Costs between European Union Member States & Major Trading Partners: An Empirical Analysis from 1989 - 2006. MPRA Paper 24259, University Library of Munich, Germany.

Bernhofen, D., El-Sahli, Z., and Kneller, R. (2013). Estimating The Effects of the Container Revolution on World Trade. Discussion Papers 2013-02, University of Nottingham, GEP.

Chaney, T. (2014). The Network Structure of International Trade. *American Economic Review*, 104(11):3600–3634.

Chen, N. (2004). Intra-national versus international trade in the European Union: why do national borders matter? *Journal of International Economics*, 63(1):93–118.

Cipollina, M. and Salvatici, L. (2010). Reciprocal Trade Agreements in Gravity Models: A Meta-Analysis. *Review of International Economics*, 18(1):63–80.

de Sousa, J., Mayer, T., and Zignago, S. (2012). Market Access in Global and Regional Trade. CEPREMAP Working Papers (Docweb) 1201, CEPREMAP.

Disdier, A.-C. and Head, K. (2004). The Puzzling Persistence of the Distance Effect on Bilateral Trade. Development Working Papers 186, Centro Studi Luca d'Agliano, University of Milano.

Dutt, P. and Traca, D. (2010). Corruption and Bilateral Trade Flows: Extortion or Evasion? *The Review of Economics and Statistics*, 92(4):843–860.

Felbermayr, G. and Gröschl, J. (2013). Natural disasters and the effect of trade on income: A new panel IV approach. *European Economic Review*, 58(C):18–30.

Feyrer, J. (2009). Trade and Income – Exploiting Time Series in Geography. NBER Working Papers 14910, National Bureau of Economic Research, Inc.

Frankel, J. and Rose, A. (2002). An Estimate of the Effect of Common Currencies on Trade and Income. *The Quarterly Journal of Economics*, 117(2):437–466.

Frankel, J. A. and Romer, D. H. (1999). Does trade cause growth? *American Economic Review*, 89(3):379–399.

Head, K. and Mayer, T. (2014). *Gravity Equations: Workhorse,Toolkit, and Cookbook*, volume 4 of *Handbook of International Economics*, chapter 0, pages 131–195. Elsevier.

Head, K., Mayer, T., and Ries, J. (2010). The erosion of colonial trade linkages after independence. *Journal of International Economics*, 81(1):1–14.

Hummels, D. (2007). Transportation costs and international trade in the second era of globalization. *Journal of Economic Perspectives*, 21(3):131–154.

Hummels, D., Ishii, J., and Yi, K.-M. (2001). The nature and growth of vertical specialization in world trade. *Journal of International Economics*, 54(1):75–96.

Johnson, R. C. (2014). Trade in intermediate inputs and business cycle comovement. *American Economic Journal: Macroeconomics*, 6(4):39–83.

Johnson, R. C. and Noguera, G. (2012). Accounting for intermediates: Production sharing and trade in value added. *Journal of International Economics*, 86(2):224–236.

Koopman, R., Wang, Z., and Wei, S.-J. (2014). Tracing value-added and double counting in gross exports. *American Economic Review*, 104(2):459–94.

Mayer, T. and Zignago, S. (2011). Notes on cepiis distances measures: The geodist database. Working Papers 2011-25, CEPII.

Melitz, M. J. (2003). The Impact of Trade on Intra-Industry Reallocations and Aggregate Industry Productivity. *Econometrica*, 71(6):1695–1725.

Memedovic, O., Ojala, L., Rodrigue, J.-P., and Naula, T. (2008). Fuelling the global value chains: what role for logistics capabilities? *International Journal of Technological Learning, Innovation and Development*, 1(3):353–374.

Miller, R. E. and Temurshoev, U. (2015). Output upstreamness and input downstreamness of industries/countries in world production. *International Regional Science Review*, page 0160017615608095.

Nagengast, A. J. and Stehrer, R. (2015). The Great Collapse in Value Added Trade. wiiw Working Papers 112, The Vienna Institute for International Economic Studies.

Nitsch, V. (2000). National borders and international trade: evidence from the European Union. *Canadian Journal of Economics*, 33(4):1091–1105.

Notteboom, T. and Rodrigue, J.-P. (2008). Containerisation, Box Logistics and Global Supply Chains: The Integration of Ports and Liner Shipping Networks. *Maritime Economics & Logistics*, 10:152–174.

Parayno, G. L. (1999). Reforming the Philippines Customs Service through Electronic Governance. *JAsian and Pacific Economies: Conference Papers and Proceedings (Manila: Asian Development Bank and Organization for European Cooperation and Development).*

Pascali, L. (2014). The wind of change: Maritime technology, trade and economic development. Economics Working Papers 1428, Department of Economics and Business, Universitat Pompeu Fabra.

Rauch, J. E. (1999). Networks versus markets in international trade. *Journal of International Economics*, 48(1):7–35.

Roberts, M. J. and Tybout, J. R. (1997). The Decision to Export in Colombia: An Empirical Model of Entry with Sunk Costs. *American Economic Review*, 87(4):545–64.

Rodriguez, F. and Rodrik, D. (2001). Trade Policy and Economic Growth: A Skeptic's Guide to the Cross-National Evidence. *NBER Macroeconomics Annual*, 15:261–338.

Rose, A. K. (2000). One money, one market: the effect of common currencies on trade. *Economic Policy*, 15(30):7–46.

Staiger, D. and Stock, J. (1997). Instrumental variables regression with weak instruments. *Econometrica*, 65(3):557–586.

Timmer, M. P., Dietzenbacher, E., Los, B., Stehrer, R., and de Vries, G. J. (2015). An illustrated user guide to the world inputoutput database: the case of global automotive production. *Review of International Economics*, 23(3):575–605.

Wacziarg, R. (2001). Measuring the dynamic gains from trade. *The World Bank Economic Review*, 15(3):393–429.

Wang, Z., Wei, S.-J., and Zhu, K. (2013). Quantifying International Production Sharing at the Bilateral and Sector Levels. (19677).