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February 2014

UNIVERSITY
OF TRENTO - Italy
School of International Studies

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SIS Working Paper N^o 2014–4

February 2014

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Abstract

This work investigates the determinants of virtual water trade (VWT) flows by means of an estimated gravity model of trade applied to the virtual water embodied in the agricultural goods exchanged across countries. In line with the recent literature on the gravity model, the paper presents a battery of estimation methods: cross-section and panel, OLS and pseudo maximum likelihood, with and without two-way fixed effects. The analysis shows that bilateral VWT flows are affected by the classical determinants of trade, but also by national water endowments as well as by the level of pressure on water resources. These general findings are robust, even though some variation can be observed across the estimation methods and, in particular, when smaller sub-samples of countries (such as continents and regional groups) are considered. This contributes to account for the mixed evidence in the literature on the importance of water endowments for the VWT flows.

Key words: Virtual Water, Gravity Model fo Trade,

JEL Classification: F11, F18, Q25, Q56

1. Virtual water trade: a brief overview

Virtual water is commonly defined as the volume of water used to produce a certain commodity. As commodities are internationally traded, one can depict a network of fluxes of the water that is somehow embodied in the goods exchanged across countries. This represents the core of the idea of Virtual Water Trade (VWT), which this work aims to investigate empirically.

The idea of VWT flows, originally proposed by Allan (1997, 1998) in path-breaking contributions on the topic, refers to a number of economic concepts developed in the standard international trade literature, in particular within the Heckscher-Ohlin-Vanek (HOV) paradigm.[1] Yet, probably because the virtual water concept does not originate within the economic literature, most studies provided at most suggestive results about the trade-related determinants of VWT flows.

As we shall discuss in what follows, one of the most important misunderstanding about VWT regards the role of water scarcity among the determinants of the VWT flows. The comparison of

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[1] See Heckscher (1919); Ohlin (1933); Samuelson (1949) and Vanek (1968).

countries absolute water endowments with the water content of their trade flows (in particular of agricultural products) has led several authors to conclude about the existence of a paradox in the network of international virtual water flows: countries endowed with little freshwater are net exporters of virtual water, and vice versa. As noted by Ansink (2010), most studies have in fact mixed up the concepts of relative and absolute scarcity, thereby erroneously concluding in favour of the existence of the paradox. For instance, as shown by Kumar and Singh (2005), both the quantity of available land and that of available freshwater limit the production of agricultural goods and thus the exports of virtual water. And the reasoning could be extended to physical capital too. If one were to look at the impact of water scarcity on VWT flows, in line with the concept of relative factor abundance encompassed in the HOV theory, she would need to focus on the relative endowments of all productive factors across countries and on the relative factor-intensities of all (traded and non-traded) products.

These observations reveal that the analysis on the determinants of VWT flows cannot focus only on water endowments. Indeed, as suggested by Wichelns (2004), a large number of forces influence production, consumption and trade flows of agricultural goods and of virtual water: production technologies, domestic factors' prices, domestic and international prices of the agricultural goods, trade barriers, and the like. This suggests that to account for the observed VWT flows one first needs to identify as many of their determinants as possible. To approach the problem in this way, it is natural to look at the gravity model of trade, which relates product trade flows to the mass of the trading countries, their geographical distance and other possible factors characterising either of the trading partners. This empirical trade model, whose success is well established in the economic literature , represents a powerful and promising tool to study the causes of the international flows of virtual water.[2]

Our analysis of the VWT flows follows the standard approaches to estimate the gravity model of trade in the economic literature. Our reference to this latter is justified by the fact that, as Reimer (2012) put it, the virtual water concept can rely on firm economic foundations. For instance, it is correct to conceptualize the VWT flows as the international exchanges of the *services of* the factors embodied in the traded goods, in line with the interpretation of the factor content of trade accepted in international trade theory (Davis and Weinstein, 2003). Moreover, following the economic literature, we shall identify a number of trade-related candidates among the possible determinants of VWT flows and we shall define the empirical measures adopted to introduce them in the estimation of a gravity model of VWT.

We are not the first to reckon that the gravity model of trade is a useful tool to investigate VWT flows. However, previous attempts to perform such kind of empirical analysis have mainly focused either on simplified linear specifications (Konar and Caylor, 2013) or on country-specific empirical relationships which, by definition, prevent from drawing general conclusions on the determinants of VWT flows (Tamea et al., 2014). In this work, we shall instead proceed in accordance with the

[2] On the gravity model of trade see, among others,Anderson (1979); Anderson and van Wincoop (2003); Baier and Bergstrand (2009); Bergstrand (1985); Eaton and Kortum (2001); Feenstra et al. (2001); Santos Silva and Tenreyro (2006); Helpman et al. (2008); Chaney (2008); Anderson (2011) and Head and Mayer (2013).

standard approach used in the trade literature, in the attempt to identify a gravity model that strikes a balance between parsimony and fit.

It is worth anticipating that we shall not venture into a normative evaluation of the ability of VWT to ameliorate global water efficiency.[3] As argued by Boelens and Vos (2012), the ultimate impact of efficiency-related policies on the welfare of the population and, specifically, on the poor is very complex and calls for a very sophisticated and comprehensive kind of analysis which this work does not intend to undertake.[4]

The remainder of the paper proceeds as follows. In Section 2 we shall discuss the candidate determinants of VWT flows and in Section 4 we shall illustrate the measures and the date adopted to operationalize them. The specification of the gravity will be presented in Section 3 and the empirical results will be discussed in Sections 5, 6 (cross-section analyses) and 7 (panel analysis). Further estimations on a number of sub-samples of countries are presented in Section 8. Section 9 concludes.

2. The candidate determinants of the international flows of virtual water

As mentioned in Section 1, several researchers (probably reminiscent of the Heckscher-Ohlin theory) have focused on the relationship between factor endowments and trade flows in the attempt to determine to what extent water availability impacts on the international trade of virtual water. In doing so, some confusion has emerged: while the Heckscher-Ohlin model predicts that goods intensive in water will be exported by countries with relatively abundant endowments of such factor, many authors have instead tested whether water abundance is positively related to net exports of virtual water. This approximation can be correct, but only under certain conditions: it is only when factor prices equalise or when trade is balanced (see Ansink, 2010; Reimer, 2012) that the factor content of trade (i.e., the factor volumes embodied in the traded goods) is such that a country surely exports (the services of) its more abundant factor. And, for this to occur, good prices have to be equalised as well. The equalisation of good and factor prices is however unlikely to hold in the case of agricultural products. Moreover, as long as international technology differences persist, VWT can reflect sources of comparative advantage different from relative factor endowments.

These simple observations suggest that different research questions regarding VWT may be tackled: i) do countries specialise in the agricultural goods whose relative water intensity is in line with the relative water endowments?; ii) do aggregated net VWT flows reflect countries relative water endowments?; iii) do bilateral VWT flows reflect country- and pair-specific factors which include, but are not limited to, relative water endowments and water pressure? In this work we

[3]Some authors interpret virtual water inflows as means of substituting domestic water with imported virtual water. VW imports are seen as a way to 'save' scarce domestic water endowments for safety and security reasons. Yet, once a Ricardian dimension is added to the analysis of trade flows, VW imports may also reflect differences in efficiency in water management (due for instance to technological gaps), so that VW imports signal backwardness rather than water scarcity. The policy implications in the case of technological backwardness would be far different from those in the case of water scarcity, as one would caution against promoting imports of virtual water and rather encourage to fix the domestic inefficiencies.

[4]Boelens and Vos, for instance, caution against the simplistic claim that water prices should be aligned to water costs to improve efficiency and thus welfare.

shall address the third of these questions, falling short of testing to what extent the HOV theory accounts for the VWT flows. It is worth noting that many papers on the contribution of water scarcity to VWT flows fail to clarify the question they actually address. This helps to explain why the available empirical results on the relationship between endowments and net VWT flows are mixed.

By focusing on crops that are intensive in water, a number of authors provide evidence in favour of a relationship between scarce water endowments and net imports: Novo et al. (2009) look at Spanish grain trade and Yang et al. (2003) investigate cereal imports in African and Asian countries. Yang and Zehnder (2007) find that the intensification of water scarcity is an important factor in explaining the increase in food imports in the Southern and Eastern Mediterranean countries. Short of a test on the entire set of traded goods and trading countries, these findings on aggregated VWT flows represent at most *prima facie* evidence in favour of the HOV theory in VWT. In fact, other studies reach opposite conclusions. Kumar and Singh (2005), for instance, extend the analysis to a large set of countries and find no statistically significant relationship between net VW flows and water scarcity. The very same relationship between scarce water endowments and net imports found in Yang et al. (2003) holds only below a certain water endowment (whereby cereal imports increase exponentially with the decline in per capita water resources availability). Other studies reach conclusions at variance with the hypothesis that countries with scarce water endowments are net importers of virtual water: these works show that food imports and relative water scarcity are not always related (see, for instance, De Fraiture et al., 2004; Ramirez-Vallejo and Rogers, 2004; Yang and Zehnder, 2007; Verma et al., 2009). Similarly, using a CGE model, Roson and Sartori (2013) show that, in the presence of market failures and other frictions, countries where water resources are scarce do not necessarily have a comparative disadvantage in water-intensive industries and do not end up being net importers of VW.

The reasons for such contrasting findings in the literature are potentially several. First, as pointed out by Ansink (2010), HOV relates net VW imports to relative water scarcity, whereas a number of studies focus on absolute scarcity.[5] Second, the variables contributing to impact on food exchanges and VWT are numerous, and water endowments are only one among them: thus, the studies that do not include several determinants of bilateral VWT flows in the empirical estimation fail to produce robust results (see, on this, Wichelns, 2004; Hoekstra and Hung, 2005; Ansink, 2010; Reimer, 2012). For instance, arable land is a key factor of production in the agricultural sector, which heavily impacts on food production and on VW exchanges. As shown by Kumar and Singh (2005), land availability can indeed constrain the production of agricultural goods as much as water endowments do.[6] The third reason of such mixed findings regards the differences in the samples of countries under investigation (intranational flows vs international exchanges) and in the adopted measures of VWT (bilateral exchanges vs. aggregated flows, gross vs. net exchanges, import vs.

[5] Wichelns (2010) forcefully argues that 'by focusing on the water resource endowment, alone, virtual water represents an application of absolute advantage, rather than comparative advantage'.

[6] This is not the only way the size of arable land positively affects the VWT exports. When access to arable land increases, the ability to utilize both green water and the blue water for irrigation increases too.

export flows). The fourth reason why relative water quantities may not be the main determinant of VWT flows is that factors' and goods' prices (as well as opportunity costs and agricultural efficiency) are unlikely to be equalised across countries.

The hypothesis of factor and good price equalisation is particularly controversial. The cost of water as a factor of production is delicate: first, as the rain falling on fields is by definition free, not all the water used in the production is burdened of the costs of irrigation; second, irrigation costs depend on political decisions as water in agriculture tends to be under-priced and subsidized. Indeed, the level of development, the strength of institutions, the enforcement of property rights are among the determinants of the extent to which the social costs of water extraction are internalized in production decisions and, hence, in prices.[7] Moreover, international trade of agricultural goods is subject to frictions, some connected with natural barriers (such as distance) and some with trade-distorting policy measures. Trade frictions are far from negligible for most agricultural goods and vary remarkably from country to country: tariffs and non-tariff barriers affect the patterns of trade and thus indirectly impact on the international exchanges of virtual water. Moreover, freight costs, which are often captured by the geographical distance separating the trading countries, tend to be relatively high in the agricultural sector, as shown by Reimer and Li (2010).

It follows that to understand the actual VWT flows across countries a large number of determinants need be included in the empirical analysis. Focusing on aggregated VWT data and measures of water scarcity to test the validity of the HOV theory is a possible empirical exercise, but it does not allow to account for the other determinants of VWT flows. This is instead what we endeavour to do in what follows, where we shall employ the most widely used tool for assessing international trade relationships, namely the gravity model of trade.

3. The gravity model of trade in a nutshell

A basic gravity model of trade is a model of bilateral trade interactions in which size and distance effects enter multiplicatively: a gravity equation of this kind, dubbed as 'naive' by Head and Mayer (2013), can be represented as:

$$X_{ij} = GY_i^{\alpha} Y_j^{\beta} \Phi_{ij}^{\gamma}$$

where X_{ij} is the bilateral (directed) flow from country i to country j, G is a gravitational constant, Y_i and Y_j are the economic mass of the trading countries (typically the GDP), and Φ_{ij} is a bilateral measure of the accessibility of market j for the producers in country i (typically, this is measured by the geographical distance). A more general and correct specification of the gravity model of trade, however, includes a variety of determinants of bilateral trade, and can be written as follows

$$X_{ij} = GS_i^{\alpha} S_j^{\beta} \Phi_{ij}^{\gamma}$$

[7] As pointed out by Ansink (2010), the country with relatively ill-defined rights is more competitive in the production of the water-intensive good, thereby increasing the exports of virtual water. Under certain circumstances this may change the expected direction of net virtual trade fluxes. Similarly, the allocation of water across uses, sectors, and regions within a country is subject to political considerations which are not reflected in prices.

where S_i represents all the features that affect the exporter i as a supplier (vis-a-vis all partners), S_j captures all features of j as a destination market from all sources, and Φ_{ij} is a measure of the accessibility of market j for the producers in country i and it subsumes any other dyadic (i.e. pair-specific) factor influencing bilateral trade.

The multiplicative expression of the gravity equation can be more easily estimated by means of OLS after taking logs of the equation. In practice, the log-linear expression of the gravity equation can be expressed as:

$$x_{ij} = g + \alpha s_i + \beta s_j + \gamma \phi_{ij}$$

where s_i, s_j, ϕ_{ij} are vectors of variables (in logs) and α, β and γ are vectors of the coefficients.

Clearly, the inclusion of economic mass and geographical distance in the estimation is common to all gravity analyses. In our empirical exercise we shall include both the GDP per capita and the size of the population instead of the levels of GDP. While economic mass could be appropriately measured by the GDP alone, separating the GDP per capita and the population may capture other effects. But among the features affecting exporters and importers of VW (i.e., S_i and S_j), a number of other variables can be included. In this work we shall envisage a number of water-related variables, which will be discussed in the next section. Among the dyadic factors impacting on trade flows, distance is clearly one of the most relevant one as it affects transportation costs (and often cultural proximity). However, several other dyadic factors directly affect trade between the various pairs of countries: one can think of natural factors, such as linguistic heterogeneity and contiguity, and of policy-determined factors, such as trade and monetary arrangements.

In Section 4 we shall present the variables that will be included in the empirical analysis of the gravity model of VWT flows, the data sources and the actual functional forms to estimate.

4. Variables, data and empirical specification

To conduct the empirical analysis, we build two cross-sectional datasets, each including more than 130 countries, in two recent years, i.e. 2001 and 2006. Although data are available at an annual frequency for several variables, this is not the case for the water-related variables, whose values are recorded at a five-year frequency.

The dependent variable in the exercise is the total amount of virtual water contained in the agricultural products exchanged between any pair of countries in the sample. For a detailed description of the way the virtual water content of the trade flows was computed, we refer to Carr et al. (2012, 2013) and Tamea et al. (2014).[8] In short, the estimates of country-specific virtual water content for various crops provided by Mekonnen and Hoekstra (2011) were multiplied by the exchanged agricultural goods registered in the international trade data from the FAOSTAT database. The matrix of the total VWT flows was then obtained by summing the crop-specific virtual water trade matrices.

Among the explanatory variables of VWT flows, the first to be included are those proxying for

[8]We would like to thank the authors for having shared the data on VWT flows with us.

the economic mass of the countries (in this work, as mentioned, population -*Pop*- and GDP per capita -*GDPpc*) and geographical distance (*Distance*, i.e, the average physical distance between the most populated cities of any pair of countries, as calculated by CEPII).

As illustrated in Section 2, it is conceivable to include among the explanatory variables a number of potential candidates which refer to water availability and water pressure: the total amount of water available for agricultural purposes (i.e., 40% of the blue water and the entire amount of green water), which we take in per capita terms (*WAgrPc*) as in Gerten et al. (2011) so as to make it a measure of relative factor endowment; the water availability ratio calculated as the ratio between the total amount of water available (40% of total blue water plus total green water) over the total country-specific dietary requirement (*AvRatio*) as in Gerten et al. (2011); the water extraction index calculated as total freshwater withdrawn in a given year in percentage of the actual total renewable water resources (*WEI*) (the data - from the Aquastat dataset - refer to either 2000 or 2005); the share of agricultural freshwater withdrawals in total water withdrawals (as calculated for the World Bank) (*SAWW*). The fact that not all the water is provided through irrigation suggests distinguishing between green water (i.e., the infiltrated rainwater stored in unsaturated soils) and blue water (groundwater and surface water), of which irrigation represents the bulk:[9] we include measures of the total amounts of blue and green water available in per capita terms (*BluWpc, GreenWpc*), as done in Gerten et al. (2011).[10] Some of these variables have already been used by Lenzen et al. (2012), who estimate the relationship between *total* VW imports and national water endowments. More precisely, Lenzen et al. (2012) explore how various factors related to economic and agricultural development influence per-capita total (unweighted) water embodied in imports and find that water scarcity induces countries to import water-intensive commodities from elsewhere. Differently from Lenzen et al. (2012), our analysis does not focus on total VW imports, but on bilateral (directed) VW flows. Even though several conclusions from our investigation will turn out to be in line with the results found by Lenzen and coauthors, the approaches and the interpretation of the empirical estimates are different and, at most, self-enforcing.

The measure of land endowment we consider is the surface of the agricultural land, that is the land under temporary agricultural crops, temporary meadows and pastures, land under market and kitchen gardens and land temporarily fallow (less than five years), as well as permanent crops and permanent meadows and pastures (*AgrLand*).[11]

To account for trade barriers, we include in the estimation the weighted average of the agricultural import tariffs (*WeAvgTariff*) in force in 2001 and 2006 (or in the closest available year), as reported in the WITS dataset of the World Bank. This variable captures the average openness of the importing country with respect to the agricultural sector. Notably, even though it refers to trade,

[9]From an economic perspective, blue water can be thought as an economic good whose direct costs of production depend on irrigation costs. Disagreement remains on what the opportunity cost of green water is (see Novo et al., 2009, for a discussion of the issue).

[10]We owe a debt of gratitude to Martina Sartori and Roberto Roson who shared excellent data on water resources, in particular for the construction of the variables *WAgrPc, AvRatio, BluWpc, GreenWpc* and *SAWW*.

[11]An alternative measure would be the size of arable land, which refers to the agricultural land subject to temporary exploitation.

this variable is not specific to the pair of trading countries as it regards the importer vis-a-vis all the exporters.

In the tradition of gravity models of trade (such as Head et al., 2010), we include among the explanatory variables a series of pair-specific dummy variables on whether the countries have a common currency (*ComCur*), share a border (*ComBor*) and participate in the same regional trade agreement (*RTA*). Moreover, we add a dummy variable that takes value one if the exporter benefits of the Generalized System of Preferences (*GSP*) and another variables that takes value 1 if the exporter is in the African, Caribbean, and Pacific (ACP) group of states and the importer is in the EU (*ACPtoEU*).[12]

To the best of our knowledge there are no organised datasets with country-specific prices of water for irrigation purposes. As a proxy, we adopt the residential water rates (elaborated by the International Benchmarking Network for Water and Sanitation) which stay for generalized prices of water in the country (*WPrice*). Allegedly, these data can be loosely related to actual irrigation prices: this suggests looking at the results with some caution. Moreover, as water price data are available only for a limited number of countries (about 80), the estimates may possibly suffer of self-selection problems.[13] Accordingly, we report the estimates of the specifications including water price among the explanatory variables only in Tables (3) and (4).

Given the number of explanatory variables, the extended representation of the functional specification to test would be difficult. For the sake of brevity, we shall illustrate the functional form in a synthetic way. In accordance with most of the gravity literature, we start by performing an OLS estimation of the log-linearized version of the gravity equation:[14]

$$VWT_{ij} = \alpha + \beta_i M_i + \beta_j M_j + \gamma D_{ij} + \delta T_{ij} + \kappa_i L_i + \kappa_j L_j + \theta_i W_i + \theta_j W_j + \xi_{ij} \tag{1}$$

where VWT_{ij} is the virtual water embodied in the agricultural goods exported by country i to country j; M_i and M_j are the matrices of variables measuring economic mass (*GDPpc* and *Pop*) for, respectively, the exporting country i and the importing country j; D_{ij} stays for the geographical distance (*Distance*) between the countries; T_{ij} is a matrix of the trade-related pair-specific variables (*ComBor*, *ComCur*, *RTA*, *GSP*, *ACPtoEU*, *WeAvgTariff*);[15] L_i and L_j refer to the surface of agricultural land (*AgrLand*) in each of the countries; W_i and W_j are the matrices of water-related variables for, respectively, country i and country j (*WAgrPc*, *AvRatio*, *WEI*, *SAWW*, *BluWpc*, *GreenWpc*, and *WPrice* when relevant). All variables are in natural logarithms with the exception

[12] Since both the GSP and the ACP-EU preferential agreements are mainly directed to facilitate the exports from developing countries towards the developed ones, there is no reason to include dummy variables to account for the exports towards the ACP and GSP countries.

[13] This possibility is not explicitly investigated here, but the results in Section 8 provide some evidence on the large impact of modifying the sample on the estimated coefficients.

[14] This choice may lead to problems connected with sample truncation and the Jensen's inequality (see Santos Silva and Tenreyro, 2006). We shall address these potential drawbacks in Section 6.

[15] The variable *WeAvgTariff* refers to the weighted average tariff of the importing country. Accordingly, it is not a bilateral variable though it is included in the trade-related group of regressors.

of the dummies and $SAAW$.[16]

To facilitate the interpretation of the results, we shall proceed by inserting these various groups of variables one at the time. More precisely, the water-related variables will be considered individually (inserting one variable at a time) in columns IV to VIII in tables 1 and 2, and columns I to V in tables 3 and 4.

It is clear that some variables are potentially correlated with some others and the statistical significance of the individual coefficients may suffer of such high a collinearity. Were the variables independent, the point estimates would not be impacted by collinearity. In fact, some estimated parameters exhibit some variation when other variables are included in the estimation. Aware of this issue but unable to assess whether a causal relationship does actually exist, we shall discuss the results with a great deal of caution.

The groups of countries included in the estimation were chosen on the basis of data availability, starting from a very large sample of more than 200 countries. While the largest possible group would have included every country with at least one export or import relationship with another country, we decided to work on more balanced sub-samples of circa 130 countries, ensuring that every included country has both export and import relationships with at least 30 other countries. By doing so, we tried to ensure that the identification of the coefficients in the cross-sections exploits the variation across both importing and exporting countries. The countries entering in the 2001 and 2006 samples are listed in the appendix.

To account for both time-varying importer- and exporter-specific fixed effects (as the literature on gravity models suggests), in Section 7 we shall look at a panel dataset of 145 countries and we will develop dyadic measures of relative water endowments (as country-specific variables would otherwise be subsumed into the fixed effects). We shall come back on this in Section 7.

5. Empirical results

Leaving water prices aside for the moment, we would like to present the estimates of the specification 4 reported in Table 1 for 2001 and Table 2 for the 2006. To facilitate the interpretation of the results, as mentioned above, we insert each group of variables at a time.

Column I reports the results of a basic gravity model where only GDP per capita, population and distance are included. All the variables enter with the expected sign and are significant. The coefficients of GDP per capita differ when referring to the importing and to the exporting countries and in both cases they are smaller than unity. These findings are in line with expectations and reveal that the adoption of the gravity model of trade to explain bilateral VWT flows is appropriate.

Column II differs from Column I in that we include additional variables that typically enter gravity models of trade. We find that average agricultural tariffs in the importing country are

[16]Taking the natural logarithm of the variables has the drawback of creating a missing observation whenever the original value is 0. To avoid this, we take the logarithm of the sum of the variable and 1. This, however, is done neither for the dependent variable VWT because of the problematic consequences pointed out by Santos Silva and Tenreyro (2006) (see Section 6), nor for the explanatory variables that are far larger than 0 (such as GDP per capita, population, and the like).

negatively correlated with VWT inflows. These latter are relatively larger when the trading countries are contiguous, share the same currency, and participate in the same regional trade bloc, as well as when the exporter either benefits of the GSP or, though just in 2001, is an ACP nation exporting towards the EU. The coefficients are relatively similar in Tables 1 and 2, but for the variable *ACPtoEU* .

In Column III we introduce the surface of land devoted to agricultural uses in the exporting and importing countries. Unsurprisingly, the variable enters with a positive coefficient in the case of the exporting country and negative for the importing one. This is in line with a sort of endowment effect found in previous works. What should be noted, however, is that the coefficients of the population variables also change by similar amounts (and in the opposite direction). As mentioned, it is not hard to imagine a possible relationship between population size and land surface. Some caution is therefore needed in the interpretation.

Column IV is the first one among those devoted to water-related variables. We add two variables (one for each country) that refer to the water available for agricultural uses in per capita terms (*WatAgrPc*), assuming that 40% of blue water is allocated to the agricultural sector. The coefficients are positive and negative for, respectively, the exporting and the importing country.[17] These results suggest that a water endowment effect is indeed at play. This clearly contrasts with some results in the previous literature and confirms what found by Lenzen et al. (2012) on the aggregated VW imports. We shall come back on the interpretation of these contrasting results in the last section.

As an alternative water-related variable, we include in the specification the Water Extraction Index (WEI), i.e. the total freshwater withdrawn in a given year as a percentage of the total renewable water resources. This variable is a measure of the pressure on the renewable water resources. The estimates are reported in Column V, in Tables 1 and 2. The more intensively a country exploits its water resources, the more it tends to import VW from foreign countries, while the higher the exploitation of renewable resources in the exporting countries, the lower the exports. These findings suggest that VWT flows reflect the pressure on renewable sources, and that VWT may represent a means of achieving greater water efficiency. It is worth noticing that the inclusion of this variable reduces the size of the sample due to limited data availability: this makes direct comparisons with the previous specifications difficult.

An alternative proxy for the pressure on water resources is represented by the ratio between the total amount of water available for agricultural uses (the sum of 40% of total blue water and the total amount of green water) and the overall dietary requirements of water in a country (*AvRatio*). Both in 2001 and 2006 there seems to be evidence (column VI) that the more abundant the resources with respect to the potential dietary needs, the greater the VW outflows of the exporting country. This is in line with our previous findings. The adjusted R-squared suggests however that this model explains less of the actual data than the previous specifications.

Column VII contains the estimates of a specification including the share of the total available

[17] The estimated coefficients of the population variables get again close to the values in columns I and II, while those of the land devoted to agricultural uses get smaller (in absolute terms). Again, one should be very careful in taking each of these coefficients in isolation.

freshwater that is used for agricultural purposes ($SAWW$). This is an alternative measure, our third one, of water pressure. The results confirm those obtained with the variables *AvRatio* and *WEI*, despite the difference in sample size due to the limited data availability of the latter. The more a country exploits its resources, the more virtual water it imports; the higher the share of renewable water resources used for agricultural purposes in the exporting countries, the lower the exports of VW.

Column VIII reports the estimates when we include in the baseline specification the amount of blue and green water available (in per capita terms) in the country. Again, the larger the domestic endowment of water, the greater the exports and the lower the VW imports, in accordance with the findings for *WatAgrPc*. The introduction of these new variables does have an effect on the estimates of the parameters of land surface; this suggests that these variables are related among each other even though the direction of causality is not obvious.

As mentioned in Section 4, we can also insert data on domestic water prices for a limited sample of countries. Although we are aware that these data are at most a proxy for the actual opportunity cost of the blue water for irrigation purposes and despite the large reduction in the sample size this inclusion brings about, we reproduce the results of the last five specifications once the price variables are added to each specification (Tables 3 for 2001 and 4 for 2006). In sum, we find that the estimated coefficient of water price in the exporting country is positive and significant, while we cannot conclude much on the estimated coefficient of the water price for the importing country.[18] A positive coefficient for the price of water in the exporting country could seem at variance with the intuition that the higher the cost of water, the lower the VW exports. In fact, it is well possible that water prices are relatively high where policy-induced distortions are low and that water efficiency is high (and water pressure low) were prices more closely reflect the opportunity cost of water.

Although the estimations with the inclusion of water prices are worth mentioning, we do not dwell on the interpretation of the results. The reason is twofold. First, data availability problems restrict the samples to a very limited number of countries and as far as data availability is correlated with some of the explanatory variables this may lead to spurious results. Second, agricultural water prices may be far different from those faced by households and firms and we would refrain from simplistic generalizations of our estimates.

6. Robustness checks

Notwithstanding the decision to adopt two cross-sectional samples quite balanced by the elimination of the countries with less than 30 partners, many bilateral VWT flows are still missing. Admittedly, this may still raise some problems of sample selection. Furthermore, many VWT flows in both cross-sections are equal to 0 (possibly also because of rounding errors in official statistics).

[18] Two additional effects stemming from the inclusion of water price variables are worth mentioning. When *WEI* and $SAAW$ enter together with water prices, the coefficient of these variables in the exporting country become statistically insignificant (suggesting a possible positive relationship between water price and water pressure) and the coefficient of agricultural land in the importing country becomes insignificant (suggesting some correlation between water price and water pressure).

The estimation of a log-linearized version of the gravity equation may thus lead to biased estimates, as explained in Eaton and Tamura (1994) and Santos Silva and Tenreyro (2006). One way to address these problems is using the Poisson Pseudo Maximum Likelihood (PPML) estimator proposed by Santos Silva and Tenreyro (2006). This helps to account for the two problems: the truncation due to some approximation in data collection and the problems arising in the estimation of a log-linear version of the gravity model in the presence of high-order moments of the errors.

It is worth noticing that, as shown in several works, transforming the VWT data in logarithms (after having added 1 to the series) and estimating a Tobit model is not an appropriate solution. The two-step Heckman estimation method by Helpman et al. (2008) is not better either in this case, as it would require exclusion restrictions that are typically hard to find for aggregated flows and alter the interpretation of the second step of the gravity model.[19] Following Head and Mayer (2013), we then run again the estimations by focusing on the PPML estimator. We reproduce the PPML estimates for the year 2006, with and without prices, in Tables 5 and 6.

All in all, the results obtained with this new estimation method are in line with the previous ones. Some differences, however, emerge. The weighted average of import tariffs and the dummy *ACPtoEU* turn insignificant in the specifications with and without water prices, while *RTA* is insignificant when water prices are included. This is most likely due to sample selection as it is very hard to imagine any systematic relationship between domestic water prices and the participation in preferential trade agreements. More interestingly, the coefficients of the water price variables are always statistically insignificant.

The adoption of the PPML estimator is motivated by the possible presence of heteroskedastic errors. To diagnose the error term and the importance of heteroskedasticity in the log-linear specification, we employ the test statistics designed by Manning and Mullahy (2001) for the hypothesis that the constant-elasticity model can be consistently estimated in the log-linear form. We do not report here the p-values of the statistics as they are all equal to 0, suggesting that the use of log-normal forms may not be fully appropriate. The coefficients estimated with the auxiliary regressions adopted to implement the Manning and Mullahy (2001) test are close to 2 (in line with the estimates of Head and Mayer, 2013, for general trade data), which would suggest that the Gamma pseudo Maximum Likelihood estimator (allowing for errors exhibiting a constant coefficient of variation) is to be preferred.[20] The very fact that the PPML estimates for the dyadic variables are smaller than the OLS ones also suggests adopting a GPML method.

The GPML estimator leads to estimates (in Table 7) that are closer to the OLS results than the PPML estimates are. On the one hand, this casts some doubts on the appropriateness of the PPML approach, as the latter may suffer of model misspecification. On the other hand, the presence of

[19]When using firm level data as Helpman et al. (2008) do, one can distinguish the extensive and intensive margins of trade, and thus identify different variables of interest in the two steps of the estimation. This is more difficult when aggregated data are used, as we do in this work.

[20]In the presence of heteroskedastic variance of the gravity's errors, it is possible to distinguish between two types of heteroskedastic errors: a constant variance to mean ratio type and a constant coefficient of variation type. In the latter, the Gamma PML estimator is relatively more efficient than the PPML estimator, though the former suffers more of the presence of many VWT flows equal to zero. In large enough samples, both estimators should lead to unbiased estimates. See Head and Mayer (2013) for Monte Carlo simulations.

many bilateral VWT flows equal to zero would warn against using the GPML estimator and would rather favour the use of the PPML method.

Being this as it may, it is worth noting that our main findings regarding the water-related variables are qualitatively robust across the OLS, PPML, and GPML approaches. Allegedly, this implies that errors' heteroskedasticity is not associated with water-related variables (so that the OLS log-linear estimates of the parameters do not suffer of biases due to the high order moments of the gravity's errors) and that it does not substantially matter what method to account for the presence of zero VWT flows is adopted.

7. Multilateral resistance and panel results

The cross-sectional estimates may potentially suffer of a limitation recently pointed out by many scholars in the literature on the gravity models of trade (Baldwin and Taglioni, 2007; Head et al., 2010; Head and Mayer, 2013). In practice, in our linear specification there are no variables able to account for 'multilateral resistance', i.e. what (as formally shown by Anderson and van Wincoop, 2003) captures any third country determinants on the bilateral exchange of interest.[21] Several methods have been developed to deal with this issue and, for the sake of brevity, one can distinguish those that get rid of all country- and role-specific terms (as Tetrad, used in Head et al., 2010) and those that include fixed effects (through either double demeaning or dummy variables).

The methods are not identical, each performing better or worse in accordance with the features of the data (number of missing observations, error in measurement, and the like). In our case, neither of these methods fit perfectly our needs. The approaches to deal with multilateral resistance, in fact, are meant to produce unbiased estimates of the dyadic terms (i.e. distance, transport costs, trade agreement, tariffs, and the like) at the expenses of no longer being able to identify country-level variables such as GDP, population, and the like. Thus, the use of import and export fixed effects in our case would allow to deal with the multilateral resistance but would prevent from estimating the impact of country-specific water-related variables on VWT flows. To address this issue, we develop a tentative approach to estimate a gravity model of trade that takes into account multilateral resistance but preserves the focus on water-related variables.

We start by building a panel dataset with the two available years so as to estimate the gravity model also by exploiting the temporal variation in the data. We then introduce time-varying importer-fixed effects and exporter-fixed effects that capture the constant factors affecting multilateral resistance. As explained, we drop all the country-specific variables which are captured by the fixed effects, that is *GDPpc*, *Pop*, *WeAvgTariff*, *AgrLand*, *GSP*. In order not to drop also the water-related country-specific variables we build some 'synthetic' dyadic measures capturing relative water endowments.

[21] An increase in the competitiveness (or in the degree of import protection) in country C does affect also the exchanges between country A and country B. Third country effects are not captured by the monadic and dyadic explanatory variables in the gravity specification. This implies that the error terms might be correlated with some of the explanatory variables, and this could bias the estimates of their coefficients.

We believe that additional information can be learnt from the comparison of these results with those obtained with OLS, PPML and GPML on the cross-sections for 2001 and 2006. There is a consensus in the gravity literature that the adoption of a set of alternative estimating approaches is to be preferred to the reliance on any one method. To be sure, the interpretation of the results may become more complicated, yet more reliable.

The samples of countries included in the two cross-sections used before were determined by data availability and by the restriction that all the included countries had at least 30 trading partners. Accordingly, the composition of the samples varies in the two years (see the appendix). In building the panel dataset, we adopt a twofold selection criterion to include the same countries in both years: we keep only the countries with a population of at least 1 million individuals and with at least 10 partners in 2001. These criteria are in line with what usually done in the panel data trade literature. The panel sample counts 145 countries (listed in the appendix) and about 20,000 observations.

In Table 8 we report the estimates for the panel data with no fixed effects: the results are very similar to those discussed for the cross-sections, but a few differences emerge. The most relevant one is the change in sign for the variables *AvRatio* and *SAWW*. This would suggest that the effects identified while exploiting the cross-sectional variation are not identical to those along the temporal dimension. One could argue that the differences over time of *SAWW* are likely due to changes in the agricultural production given the stability of water endowments. In this case, an increase in *SAWW* could well be the consequence of an increased amount of exported agricultural goods: this would be captured in the estimation by the positive coefficient. This would suggest a possible issue of reverse causality, at least for what concerns the temporal variation of *SAWW* and VWT flows. Admittedly, however, this would not explain the change in the estimates of the coefficients of *AvRatio*, which does not vary over time.[22]

Being as it may, we proceed with the estimation of the functional form with time-varying importer and exporter fixed effects, as explained above. The introduction of these time-varying fixed-effects forces us to drop all country-specific variables. In order not to drop the water-related variables too, we build 'synthetic' dyadic measures capturing relative water endowments. More precisely, we calculate the ratios of the water-related variables (exporter over the importer). We obtain the following variables: *WatAgrPc Ratio, BluWpc Ratio, GreenWpc Ratio, SAWW Ratio, WEI Ratio, Av doubleRatio.*

As pointed out by Head and Mayer (2013), this approach is not always successful and the identification of the dyadic terms is not granted for these terms are 'spurious' variables, built to circumvent the limitations imposed by the inclusion of time-varying importer and exporter fixed effects. This is particularly likely, in our case, for the variables that capture relative water pressure: while relative per capita endowments reflect the HOV idea that bilateral trade flows are influenced by relative factor endowments (i.e. double ratios of countries - exporter and importer - and factors of production - people and water), relative measures of water pressure have no direct theoretical

[22]This effect is not due to the change in the sample of countries either. We run the cross-sectional regressions in 2001 and 2006 for the new sample and could not record any relevant difference with respect to the results discuss in the previous sections.

implication on bilateral exchanges.

We report the results of these estimations in Table 9. The estimated coefficients of the variables capturing natural dyadic terms are in line with those in the cross-sectional analysis. Some of water related variables seem to enter with the expected sign. Relative per capita (total and green) water endowments have estimated coefficients that are positive and significant. This suggests that the bilateral VWT flows are positively associated with the relative water abundance in the exporting countries. This is in line with the results in the cross-sections where we concluded that VWT flows are larger the richer the per capita availability of water in the exporting country and the lower per capita availability of water in the importing country.

Interestingly, we find a significant and positive coefficient of the cross-country ratio of the shares of the total available freshwater used for agricultural purposes (*SAWW Ratio*). This could be interpreted as evidence that the larger the gap in the level of water usage between the exporting and importing countries, the greater is the bilateral VWT flow. This finding is at variance with those in the cross-sections whereas it is in line with those obtained exploiting also the time-variation (Table 8). There are thus two possible explanations for these contrasting results. The first one is that the estimated coefficients in the panel merely reflect the (mechanical) relationship between greater exports of agricultural products and greater domestic use of water to produce them (as mentioned while commenting on the estimates in Table 8). The alternative interpretation is that agricultural trade flows are strongly influenced by the available share of water used for agricultural purposes, whereby goods' water intensity and countries' availability of water for agricultural purposes impact on bilateral trade flows.

The other measures of relative water pressure turn out to be insignificant.

8. Regional samples

Before moving to the closing remarks, we investigate the robustness of the results to changes in the regional coverage of the data. We shall show that focusing on smaller and geographically restricted samples of countries does not always lead to consistent findings. It must be stressed that this does not suggest that our previous results lack of robustness: first, our analysis covers more than 130 countries and, second, the estimated parameters do not qualitatively differ across the two cross-sections (in 2001 and 2006). Rather, this finding shows that arbitrary sample selection (as often done in studies focusing on a limited number of countries) may lead to spurious results.

The first experiment regards the sub-sample of the twenty-one Mediterranean countries in 2006.[23] Given the small number of observations, we dropped the groups of variables regarding bilateral trade relationships. This notwithstanding, there does not seem to be evidence in favour of the hypothesis that bilateral VWT flows among the Mediterranean countries are affected by water availability (see Table 10).

[23] Albania, Algeria, Croatia, Cyprus, Egypt, France, Gibraltar, Greece, Israel, Italy, Lebanon, Libya, Malta, Monaco, Montenegro, Morocco, Slovenia, Spain, Syrian Arab Republic, Tunisia, Turkey.

When the sample includes all the exporting countries but only the Mediterranean countries among the importers, the results in the main text would hold again. Moreover, the endowment of blue water per capita would turn out to be negative and significant: the larger the endowment of blue water, the lower the VWT inflows, in line with Yang and Zehnder (2007).

Some puzzling results emerge when restricting the sample to the developing countries in Sub-Saharan Africa. We consider separately the VW exports (and imports) of these countries towards (and from) the rest of the world. The estimates are reported in Tables 12 and 13. It is worth noticing that water-related variables in the importing Sub-Saharan African countries are all insignificant, while the features of the exporting countries continue to remain significant. The picture is slightly better in the case of VW exports from the Sub-Saharan African countries to the rest of the sample, yet still most of the variables of interest are insignificant.

Had we focused on the twenty-seven countries in the European Union (see Table 14), we would not have found major differences from the results in the main section.[24]

Though we do not explore the issue in detail, these results on various sub-samples suggest that water-related variables matter more for developed countries than for developing economies. This could be due to issues related to the agricultural production and trade or it could depend on the fact that in developing countries water scarcity is not adequately reflected in water prices so that the exchanges of VW are less affected by water pressure and water endowments.

Pushing the argument to an extreme, one could question the correctness of testing a general gravity law rather than country- and role-specific equations, as done for instance by Tamea et al. (2014). The use of panel data with import-specific and export-specific fixed effects in section 7 does introduce some flexibility in the constant term and also allows to account for the possible correlation between country- and role-specific unobserved factors and the explanatory variables. Asking whether this is enough is indeed equivalent to wonder whether countries can be pooled when studying VWT flows.[25] Although this issue deserves further empirical investigation, we should like to notice that the very adoption of a model recalling the gravity law entails embracing the idea that there exist some general and common traits in VWT flows. Moreover, while country- and role-based gravity laws do certainly allow to improve further the fit of the model, they do not allow to capture the role of dyadic terms that the economic literature has shown to be of utmost importance in the explanation of actual trade flows (see, for instace Head et al., 2010).

9. Closing remarks

A large number of factors influence production, consumption and trade flows of agricultural goods and of the virtual water embodied in them. This entails that to understand VWT flows it is important to assess as many determinants as possible. The gravity model of trade, which relates trade flows to a number of monadic and dyadic features of the trading countries stands as a very

[24]Given the small number of countries, we exclude some of variables. The results would not be qualitatively different with them in.

[25]See Schiavo and Vaona (2008) among the articles addressing poolability in large cross-sectional country-base data.

powerful tool to analyse the factors influencing bilateral VWT flows. In this work, focusing on various samples of more than 130 developed and developing countries for the years 2001 and 2006, we estimate gravity models of the bilateral VWT flows (in particular, those associated with trade in agricultural goods).

Our findings show that the usual determinants of bilateral trade flows (such as geographical distance, economic mass, trade barriers, and the like) are statistically significant sources of VWT flows. We also find that water endowments and water pressure matter for the bilateral VWT flows: countries tend not to over-exploit their domestic water resources by exporting water intensive agricultural goods and, rather, they import VW when domestic water pressure is high.

One would intuitively expect that water scarcity is among the important determinants of VWT flows: countries that have scarce water resources could allegedly find it hard to export VW and convenient to import the services of the water embodied in the incoming agricultural goods. This intuition finds some theoretical support in the HOV theorem, stating that, provided certain conditions apply, net goods trade flows reflect countries' relative factor endowments. The evidence in the literature on this is mixed, probably due to the fact that many studies focus on limited samples of countries/regions and implement inappropriate tests of the HOV theory.

Although the gravity model does not serve to test specifically the HOV theorem as in fact the gravity equation can be derived from very different theoretical trade models as shown by Deardorff (1998) and Head and Mayer (2013), the introduction of measures of water endowment and pressure in the specification of a gravity model can be a useful way to explain how water availability affects bilateral VWT flows.[26]

By focusing on both cross-sectional and panel data estimations over a very large sample of countries, we find that water endowments and water pressure do impact on the bilateral imports and exports of VW and that this occurs along the intuition illustrated above. These findings add to the existing literature and cast some light on the reasons why mixed conclusions have been reached so far. The results are quite robust to changes in the estimation methods and to small variations in the composition of the samples under investigation. Major changes in the samples, however, are conducive to results that are partially at variance with those found in our large samples: this suggests that the conclusions from case studies focusing on specific regions and countries should be generalized with great care. There is also some evidence that the estimates obtained exploiting the cross-sectional variation may differ from those obtained using the variation over time: this is a possible further source of mixed findings.

We refrain from discussing the policy implications of our findings. This would require to consider many more issues that do not enter the gravity model of trade, such as water efficiency, dietary regimes, regional disparities within countries, and the like. The most we can say at this stage of the

[26]In other words, the gravity model does not detect the role played by the cross-country relative scarcity of water, which according to the HOV theorem, is the key determinant of net trade flows. To assess the relative importance of the various sources of comparative advantages that shape the world net trade flows, Evenett and Keller (2002) condition bilateral trade relations on differences in factor endowment and on the share of intraindustry trade in the trading countries. This is an exercise that we do not undertake in this work, whose focus is not the discussion of which trade theory is better in explaining the VWT flows.

analysis is that there does not seem to be a patent problem of diffuse ‘water exploitation’ through the international trade in agricultural goods. This does not mean that the observed patterns of VWT flows form the best possible configuration of exchanges in terms of reducing water scarcity problems. More humbly, these findings suggest that the bilateral flows of VW do not exhibit, on average, the paradoxical trait found in many of the previous studies, whereby water-scarce countries tend to export VW towards water-rich nations. Still, clearly, some countries do so. Our investigation can help to identify them as a first step in more detailed case studies. These latter, indeed, will be a venue of future research.

10. Acknowledgments

Financial support received through the project The global virtual-water network: social, economic, and environmental implications (FIRB - RBFR12BA3Y) funded by the Italian Ministry of Education, University and Research (MIUR) is gratefully acknowledged. We are indebted to Stefano Schiavo and Martina Sartori for helpful comments and to Francesco Laio, Stefania Tamea, and Martina Sartori who kindly shared excellent data on virtual water trade and water resources.

Table 1: Cross-sectional OLS estimates. Year 2001

	I	II	III	IV	V	VI	VII	VIII
GDPpc_e	0.279***	0.321***	0.369***	0.355***	0.397***	0.337***	0.309***	0.420***
	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
GDPpc_i	0.639***	0.528***	0.486***	0.486***	0.470***	0.482***	0.539***	0.491***
	0.02	0.02	0.02	0.02	0.03	0.02	0.03	0.02
Pop_e	0.902***	0.888***	0.552***	0.845***	0.535***	0.613***	0.530***	0.977***
	-0.02	-0.02	-0.03	-0.04	-0.04	-0.03	-0.03	-0.04
Pop_i	0.824***	0.785***	0.938***	0.848***	0.837***	0.949***	0.936***	0.865***
	-0.02	-0.02	-0.03	-0.03	-0.04	-0.03	-0.03	-0.04
Distance	-1.158***	-0.911***	-0.982***	-1.101***	-1.009***	-1.009***	-0.986***	-1.070***
	-0.03	-0.04	-0.04	-0.04	-0.05	-0.04	-0.04	-0.04
WeAvgTariff		-0.053	-0.113*	-0.137**	-0.150**	-0.119*	-0.119*	-0.139**
		0.05	0.05	0.05	0.05	0.05	0.05	0.05
ComBor		1.777***	1.619***	1.470***	1.620***	1.530***	1.589***	1.550***
		0.13	0.13	0.13	0.15	0.13	0.14	0.13
ComCur		0.913***	0.917***	0.897***	1.132***	0.948***	0.866***	0.792***
		0.15	0.15	0.16	0.16	0.15	0.15	0.15
ACPtoEU		0.988***	0.797***	0.718***	0.762***	0.734***	0.738***	0.659***
		0.16	0.16	0.16	0.17	0.16	0.16	0.16
GSP		0.629***	0.739***	0.726***	0.893***	0.728***	0.779***	0.759***
		0.1	0.1	0.1	0.11	0.11	0.11	0.1
RTA		0.463***	0.407***	0.336***	0.212	0.470***	0.405***	0.286**
		0.09	0.09	0.09	0.11	0.1	0.1	0.09
AgrLand_e			0.396***	0.132***	0.434***	0.359***	0.398***	-0.024
			0.03	0.03	0.03	0.03	0.03	0.03
AgrLand_i			-0.166***	-0.064*	-0.098**	-0.160***	-0.187***	-0.062*
			0.03	0.03	0.03	0.03	0.03	0.03
WatAgrPc_e				0.496***				
				0.03				
WatAgrPc_i				-0.178***				
				0.03				
WEI_e					-0.154***			
					0.03			
WEI_i					0.192***			
					0.03			
AvRatio_e						0.015***		
						0		
AvRatio_i						0		
						0		
SAWW_e							-0.006***	
							0	
SAWW_i							0.005***	
							0	
BluWpc_e								0.221***
								0.03
BluWpc_i								-0.138***
								0.03
GreenWpc_e								0.717***
								0.05
GreenWpc_i								-0.065
								0.04
Cons	-11.103***	-11.924***	-10.269***	-13.533***	-9.126***	-10.784***	-9.522***	-17.833***
	0.61	0.66	0.68	0.81	0.83	0.69	0.73	0.88
R-squared	0.321	0.34	0.361	0.383	0.391	0.362	0.364	0.394
N	9309	9257	9257	9257	6630	8927	8306	9081

Dependent variable: VWT. Heteroskedasticity–robust standard errors in parentheses. Significance levels: * 10%; ** 5%; *** 1%.

Table 2: Cross-sectional OLS estimates. Year 2006

	I	II	III	IV	V	VI	VII	VIII
GDPpc_e	0.305***	0.327***	0.358***	0.331***	0.259***	0.302***	0.271***	0.363***
	0.02	0.02	0.02	0.02	0.04	0.02	0.03	0.02
GDPpc_i	0.562***	0.389***	0.344***	0.358***	0.267***	0.339***	0.413***	0.326***
	0.02	0.02	0.02	0.02	0.05	0.03	0.03	0.03
Pop_e	0.970***	0.956***	0.767***	0.899***	1.161***	0.675***	0.770***	0.997***
	0.02	0.02	0.03	0.04	0.06	0.03	0.03	0.04
Pop_i	0.821***	0.803***	0.981***	0.960***	0.980***	1.041***	0.975***	0.926***
	0.02	0.02	0.03	0.03	0.06	0.03	0.03	0.04
Distance	-1.217***	-0.923***	-0.937***	-1.152***	-1.134***	-1.079***	-0.938***	-1.153***
	0.03	0.04	0.04	0.04	0.07	0.04	0.04	0.04
WeAvgTariff		-0.245***	-0.252***	-0.287***	-0.551***	-0.318***	-0.281***	-0.328***
		0.05	0.05	0.06	0.13	0.06	0.05	0.06
ComBor		1.951***	1.935***	1.586***	1.823***	1.596***	1.855***	1.586***
		0.12	0.12	0.13	0.18	0.13	0.12	0.13
ComCur		0.756***	0.769***	0.717***	0.870***	0.803***	0.749***	0.665***
		0.14	0.14	0.15	0.23	0.14	0.14	0.15
ACPtoEU		0.325*	0.197	0.045	0.772*	0.036	0.157	0.071
		0.14	0.14	0.14	0.37	0.14	0.14	0.14
GSP		0.764***	0.916***	0.837***	0.829***	0.846***	0.962***	0.861***
		0.1	0.1	0.1	0.18	0.1	0.1	0.1
RTA		0.650***	0.650***	0.587***	0.752***	0.717***	0.669***	0.566***
		0.08	0.08	0.09	0.14	0.09	0.08	0.08
AgrLand_e			0.194***	0.153***	0.01	0.378***	0.197***	0.023
			0.02	0.03	0.05	0.03	0.02	0.03
AgrLand_i			-0.182***	-0.128***	-0.216***	-0.193***	-0.196***	-0.075*
			0.02	0.03	0.05	0.03	0.02	0.03
WatAgrPc_e				0.468***				
				0.03				
WatAgrPc_i				-0.104***				
				0.03				
WEI_e					-0.150***			
					0.04			
WEI_i					0.189***			
					0.03			
AvRatio_e						0.019***		
						0		
AvRatio_i						0.004*		
						0		
SAWW_e							-0.006***	
							0	
SAWW_i							0.007***	
							0	
BluWpc_e								0.251***
								0.03
BluWpc_i								-0.02
								0.02
GreenWpc_e								0.571***
								0.04
GreenWpc_i								-0.229***
								0.04
Cons	-11.604***	-11.989***	-11.683***	-14.569***	-12.512***	-11.058***	-11.316***	-15.909***
	0.58	0.65	0.67	0.82	1.22	0.69	0.71	0.9
R-squared	0.337	0.36	0.371	0.397	0.44	0.382	0.374	0.403
N	10451	10113	10113	9499	3036	9049	9530	9313

Dependent variable: VWT. Heteroskedasticity–robust standard errors in parentheses. Significance levels: * 10%; ** 5%; *** 1%.

Table 3: Cross-sectional OLS estimates (w/ *Wprice*). Year 2001

	I	II	III	IV	V
GDPpc_e	0.370***	0.444***	0.314***	0.341***	0.446***
	0.03	0.04	0.03	0.04	0.03
GDPpc_i	0.526***	0.480***	0.503***	0.538***	0.529***
	0.04	0.04	0.04	0.04	0.04
Pop_e	0.742***	0.463***	0.669***	0.577***	0.914***
	0.06	0.06	0.05	0.05	0.05
Pop_i	0.781***	0.806***	0.845***	0.878***	0.793***
	0.05	0.06	0.05	0.05	0.05
Distance	-1.103***	-1.037***	-1.103***	-1.017***	-1.025***
	0.06	0.07	0.06	0.07	0.06
WeAvgTariff	-0.203**	-0.183*	-0.223***	-0.195**	-0.202**
	0.07	0.07	0.07	0.07	0.06
ComBor	1.435***	1.634***	1.354***	1.540***	1.552***
	0.16	0.18	0.16	0.17	0.16
ComCur	0.771***	0.941***	0.869***	0.788***	0.751***
	0.17	0.18	0.17	0.17	0.17
ACPtoEU	0.587*	0.223	0.598*	0.472	0.569*
	0.28	0.31	0.28	0.28	0.27
GSP	0.553***	0.975***	0.594***	0.539***	0.686***
	0.13	0.15	0.14	0.15	0.13
RTA	0.376**	0.339*	0.492***	0.409***	0.307**
	0.12	0.14	0.12	0.12	0.12
AgrLand_e	0.264***	0.567***	0.362***	0.426***	0.054
	0.05	0.05	0.05	0.05	0.05
AgrLand_i	0.009	-0.079	-0.043	-0.117**	-0.003
	0.04	0.05	0.04	0.04	0.05
Wprice_e	0.044***	0.050***	0.051***	0.045***	0.038***
	0.01	0.01	0.01	0.01	0.01
Wprice_i	-0.036*	-0.029	-0.03	-0.037*	-0.038*
	0.02	0.02	0.02	0.02	0.02
WatAgrPc_e	0.362***				
	0.05				
WatAgrPc_i	-0.188***				
	0.04				
WEI_e		0.049			
		0.04			
WEI_i		0.228***			
		0.04			
AvRatio_e			0.028***		
			0.01		
AvRatio_i			-0.006		
			0		
SAWW_e				-0.002	
				0	
SAWW_i				0.002	
				0	
BluWpc_e					0.126**
					0.04
BluWpc_i					-0.146***
					0.04
GreenWpc_e					0.795***
					0.07
GreenWpc_i					-0.044
					0.07
Cons	-11.718***	-9.646***	-10.158***	-10.097***	-17.533***
	1.21	1.2	1	1.04	1.32
R-squared	0.402	0.425	0.397	0.387	0.419
N	4135	2964	4032	3891	4135

Dependent variable: VWT. Heteroskedasticity–robust standard errors in parentheses. Significance levels: * 10%; ** 5%; *** 1%.

Table 4: Cross-sectional OLS estimates (w/ *Wprice*). Year 2006

	I	II	III	IV	V
GDPpc_e	0.292***	0.182***	0.200***	0.266***	0.343***
	0.03	0.05	0.03	0.04	0.03
GDPpc_i	0.403***	0.265***	0.363***	0.454***	0.385***
	0.04	0.06	0.04	0.04	0.04
Pop_e	0.713***	1.012***	0.639***	0.777***	0.880***
	0.05	0.08	0.05	0.04	0.05
Pop_i	0.899***	0.909***	0.970***	0.965***	0.864***
	0.05	0.08	0.05	0.04	0.05
Distance	-1.198***	-1.390***	-1.223***	-1.037***	-1.167***
	0.06	0.09	0.06	0.06	0.06
WeAvgTariff	-0.386***	-0.419*	-0.438***	-0.381***	-0.372***
	0.09	0.19	0.09	0.08	0.09
ComBor	1.391***	1.257***	1.254***	1.666***	1.463***
	0.16	0.21	0.15	0.15	0.16
ComCur	0.855***	0.758**	0.984***	0.744***	0.857***
	0.16	0.24	0.15	0.15	0.15
ACPtoEU	-0.058	0.466	-0.053	-0.02	0.008
	0.25	0.45	0.25	0.25	0.24
GSP	0.651***	0.586**	0.638***	0.843***	0.770***
	0.13	0.22	0.14	0.14	0.13
RTA	0.562***	0.787***	0.719***	0.600***	0.500***
	0.11	0.17	0.12	0.11	0.11
AgrLand_e	0.287***	0.099	0.391***	0.179***	0.079
	0.05	0.07	0.05	0.04	0.05
AgrLand_i	-0.018	-0.113	-0.081*	-0.159***	0.024
	0.04	0.06	0.04	0.03	0.05
Wprice_e	0.019*	0.02	0.033***	0.007	0.013
	0.01	0.01	0.01	0.01	0.01
Wprice_i	0.002	0.043**	0.004	-0.003	0.002
	0.01	0.02	0.02	0.01	0.01
WatAgrPc_e	0.334***				
	0.05				
WatAgrPc_i	-0.156***				
	0.04				
WEI_e		-0.133*			
		0.05			
WEI_i		0.208***			
		0.05			
AvRatio_e			0.031***		
			0.01		
AvRatio_i			0.002		
			0		
SAWW_e				-0.004*	
				0	
SAWW_i				0.007***	
				0	
BluWpc_e					0.139**
					0.04
BluWpc_i					-0.062
					0.04
GreenWpc_e					0.692***
					0.08
GreenWpc_i					-0.214**
					0.07
Cons	-10.607***	-8.220***	-8.331***	-10.726***	-14.216***
	1.19	1.5	1.02	1.03	1.37
R-squared	0.409	0.462	0.408	0.387	0.423
N	4334	1782	4151	4430	4334

Dependent variable: VWT. Heteroskedasticity–robust standard errors in parentheses. Significance levels: * 10%; ** 5%; *** 1%.

Table 5: Cross-sectional PPML estimates. Year 2006

	I	II	III	IV	V	VI	VII	VIII
GDPpc_e	0.368***	0.365***	0.361***	0.281***	0.459***	0.323***	0.320***	0.294***
	0.04	0.04	0.03	0.04	0.08	0.04	0.04	0.04
GDPpc_i	0.436***	0.325***	0.299***	0.282***	0.216**	0.301***	0.324***	0.269***
	0.03	0.04	0.03	0.03	0.08	0.04	0.04	0.03
Pop_e	0.701***	0.666***	0.359***	0.660***	0.628***	0.385***	0.349***	0.834***
	0.03	0.03	0.04	0.05	0.09	0.04	0.04	0.07
Pop_i	0.757***	0.729***	0.907***	0.865***	0.959***	0.906***	0.903***	0.785***
	0.04	0.04	0.05	0.06	0.13	0.06	0.05	0.05
Distance	-0.826***	-0.484***	-0.570***	-0.685***	-0.760***	-0.586***	-0.548***	-0.703***
	0.07	0.08	0.07	0.08	0.11	0.08	0.08	0.08
WeAvgTariff		-0.087	-0.124	-0.138	-0.009	-0.139	-0.139	-0.136
		0.09	0.08	0.08	0.23	0.08	0.08	0.08
ComBor		0.950***	0.837***	0.665***	1.021***	0.770***	0.844***	0.645***
		0.14	0.15	0.16	0.26	0.15	0.15	0.16
ComCur		0.526**	0.632***	0.862***	0.552*	0.709***	0.668***	0.882***
		0.17	0.17	0.19	0.27	0.18	0.17	0.19
ACPtoEU		0.414*	0.212	0.129	0.571	0.127	0.192	0.126
		0.2	0.2	0.2	0.38	0.21	0.2	0.2
GSP		0.301*	0.359**	0.369**	0.722**	0.329*	0.400**	0.451**
		0.14	0.14	0.14	0.23	0.14	0.14	0.14
RTA		0.418**	0.412**	0.423**	-0.001	0.467***	0.414**	0.381**
		0.13	0.13	0.14	0.23	0.14	0.13	0.14
AgrLand_e			0.337***	0.096	0.12	0.350***	0.350***	-0.124
			0.04	0.05	0.11	0.04	0.04	0.06
AgrLand_i			-0.167***	-0.141**	-0.196*	-0.172***	-0.168***	-0.05
			0.03	0.05	0.09	0.04	0.03	0.05
WatAgrPc_e				0.573***				
				0.05				
WatAgrPc_i				-0.163**				
				0.05				
WEI_e					-0.481***			
					0.09			
WEI_i					0.200***			
					0.05			
AvRatio_e						0.014***		
						0		
AvRatio_i						-0.009*		
						0		
SAWW_e							-0.004*	
							0	
SAWW_i							0.003	
							0	
BluWpc_e								0.375***
								0.05
BluWpc_i								-0.063
								0.04
GreenWpc_e								0.651***
								0.1
GreenWpc_i								-0.237***
								0.05
Cons	-6.326***	-7.137***	-5.572***	-9.531***	-6.855**	-5.682***	-5.413***	-11.634***
	1.26	1.48	1.33	1.52	2.59	1.36	1.35	1.85
R-squared	0.299	0.373	0.383	0.388	0.441	0.389	0.383	0.39
N	17292	16640	16640	15500	4355	14520	15624	15006

Dependent variable: VWT. Standard errors in parentheses. R-squared computed as the square of the correlation between trade and fitted values. Significance levels: * 10%; ** 5%; *** 1%.

Table 6: Cross-sectional PPML estimates (w/ *Wprice*). Year 2006

	I	II	III	IV	V
GDPpc_e	0.281***	0.681***	0.295***	0.357***	0.297***
	0.06	0.16	0.08	0.06	0.06
GDPpc_i	0.304***	0.349***	0.292***	0.338***	0.278***
	0.06	0.1	0.06	0.07	0.06
Pop_e	0.567***	0.599***	0.401***	0.321***	0.749***
	0.07	0.12	0.06	0.06	0.1
Pop_i	0.814***	0.876***	0.861***	0.879***	0.733***
	0.08	0.16	0.08	0.07	0.06
Distance	-0.682***	-0.882***	-0.626***	-0.594***	-0.702***
	0.1	0.12	0.1	0.1	0.1
WeAvgTariff	-0.155	0.254	-0.159	-0.165	-0.141
	0.12	0.27	0.12	0.12	0.11
ComBor	0.735***	0.976***	0.733***	0.830***	0.725***
	0.19	0.24	0.19	0.18	0.19
ComCur	0.903***	0.401	0.895***	0.691***	0.929***
	0.2	0.27	0.21	0.18	0.2
ACPtoEU	0.254	0.434	0.266	0.244	0.317
	0.26	0.44	0.27	0.27	0.26
GSP	0.401*	0.744*	0.406*	0.435*	0.510**
	0.18	0.29	0.19	0.18	0.18
RTA	0.298	-0.201	0.355	0.292	0.287
	0.2	0.25	0.2	0.17	0.19
AgrLand_e	0.124	0.129	0.301***	0.339***	-0.108
	0.07	0.12	0.06	0.06	0.09
AgrLand_i	-0.099	-0.139	-0.147*	-0.146***	-0.006
	0.07	0.11	0.06	0.04	0.05
Wprice_e	-0.007	-0.138	-0.024	-0.027	-0.009
	0.02	0.09	0.03	0.03	0.02
Wprice_i	-0.03	-0.045	-0.017	-0.016	-0.034
	0.03	0.05	0.03	0.03	0.03
WatAgrPc_e	0.514***				
	0.06				
WatAgrPc_i	-0.195**				
	0.07				
WEI_e		-0.394***			
		0.11			
WEI_i		0.224***			
		0.06			
AvRatio_e			0.028***		
			0.01		
AvRatio_i			-0.011		
			0.01		
SAWW_e				-0.003	
				0	
SAWW_i				0.002	
				0	
BluWpc_e					0.361***
					0.06
BluWpc_i					-0.065
					0.05
GreenWpc_e					0.592***
					0.14
GreenWpc_i					-0.300***
					0.07
Cons	-7.028**	-8.215*	-4.213	-4.552*	-8.835***
	2.18	3.79	2.21	1.97	2.54
R-squared	0.402	0.543	0.387	0.403	0.407
N	5402	2256	5112	5550	5402

Dependent variable: VWT. Standard errors in parentheses. R-squared computed as the square of the correlation between trade and fitted values. Significance levels: * 10%; ** 5%; *** 1%.

Table 7: Cross-sectional GPML estimates. Year 2006

	I	II	III	IV	V	VI	VII	VIII
GDPpc_e	0.430***	0.465***	0.506***	0.454***	0.392***	0.405***	0.498***	0.455***
	0.03	0.03	0.03	0.04	0.04	0.04	0.04	0.03
GDPpc_i	0.601***	0.443***	0.357***	0.313***	0.241***	0.321***	0.379***	0.280***
	0.03	0.04	0.04	0.05	0.05	0.06	0.05	0.04
Pop_e	0.986***	1.011***	0.877***	1.075***	1.011***	0.750***	0.881***	1.069***
	0.03	0.03	0.04	0.07	0.11	0.06	0.04	0.06
Pop_i	0.891***	0.873***	1.007***	0.949***	0.910***	0.952***	1.009***	0.923***
	0.03	0.03	0.07	0.07	0.08	0.1	0.08	0.07
Distance	-1.034***	-0.721***	-0.759***	-1.074***	-1.053***	-0.916***	-0.757***	-1.071***
	0.06	0.06	0.07	0.07	0.11	0.07	0.08	0.07
WeAvgTariff		-0.166*	-0.182*	-0.307***	-0.444**	-0.205*	-0.198**	-0.339***
		0.07	0.07	0.08	0.15	0.1	0.08	0.08
ComBor		1.078***	1.045***	0.969***	1.068***	0.764***	1.026***	0.999***
		0.19	0.21	0.19	0.26	0.2	0.21	0.2
ComCur		-0.575**	-0.497*	-0.194	0.198	-0.118	-0.487*	-0.157
		0.21	0.22	0.2	0.24	0.19	0.21	0.19
ACPtoEU		-0.053	-0.052	-0.081	0.477	-0.21	-0.05	-0.061
		0.17	0.16	0.16	0.38	0.17	0.17	0.15
GSP		1.012***	1.169***	0.891***	1.235***	1.179***	1.199***	0.874***
		0.14	0.13	0.14	0.24	0.16	0.13	0.13
RTA		1.067***	1.061***	0.629***	0.462*	0.882***	1.057***	0.561***
		0.23	0.23	0.15	0.18	0.2	0.23	0.14
AgrLand_e			0.134***	0.02	0.007	0.336***	0.122***	-0.019
			0.02	0.05	0.05	0.05	0.03	0.05
AgrLand_i			-0.145**	-0.104	-0.063	-0.108	-0.158**	-0.074
			0.05	0.05	0.06	0.07	0.05	0.06
WatAgrPc_e				0.568***				
				0.05				
WatAgrPc_i				-0.103*				
				0.04				
WEI_e					-0.270***			
					0.04			
WEI_i					0.188***			
					0.04			
AvRatio_e						0.017***		
						0		
AvRatio_i						-0.001		
						0		
SAWW_e							0.001	
							0	
SAWW_i							0.003	
							0	
BluWpc_e								0.318***
								0.04
BluWpc_i								-0.04
								0.05
GreenWpc_e								0.440***
								0.07
GreenWpc_i								-0.177*
								0.07
Cons	-13.608***	-15.337***	-14.544***	-16.284***	-9.666***	-11.396***	-14.735***	-15.501***
	1.1	1.06	1.17	1.58	1.32	1.41	1.22	1.59
N	17292	16640	16640	15500	4355	14520	15624	15006

Dependent variable: VWT. Standard errors in parentheses. Significance levels: * 10%; ** 5%; *** 1%.

Table 8: Pooled cross-sectional estimates. Years 2001-2006.

	I	II	III	IV	V	VI	VII	VIII
GDPpc_e	0.273***	0.301***	0.335***	0.322***	0.238**	0.350***	0.234**	0.353***
	(0.07)	(0.07)	(0.07)	(0.07)	(0.08)	(0.08)	(0.07)	(0.06)
GDPpc_i	0.516***	0.410***	0.375***	0.388***	0.410***	0.410***	0.398***	0.371***
	(0.03)	(0.03)	(0.03)	(0.03)	(0.04)	(0.04)	(0.03)	(0.03)
Pop_e	0.900***	0.884***	0.686***	0.820***	0.706***	0.606***	0.705***	0.938***
	(0.09)	(0.09)	(0.16)	(0.15)	(0.16)	(0.15)	(0.15)	(0.13)
Pop_i	0.758***	0.739***	0.895***	0.806***	0.885***	0.808***	0.882***	0.796***
	(0.02)	(0.03)	(0.04)	(0.04)	(0.04)	(0.05)	(0.04)	(0.04)
Distance	-1.214***	-0.964***	-0.979***	-1.153***	-0.952***	-1.001***	-1.131***	-1.125***
	(0.10)	(0.12)	(0.12)	(0.10)	(0.12)	(0.11)	(0.11)	(0.10)
W Avg Tariff		-0.068	-0.080*	-0.078*	-0.087*	-0.133**	-0.092**	-0.081*
		(0.03)	(0.03)	(0.03)	(0.03)	(0.05)	(0.03)	(0.03)
ComBor		1.758***	1.723***	1.445***	1.734***	1.624***	1.436***	1.503***
		(0.21)	(0.23)	(0.20)	(0.23)	(0.22)	(0.20)	(0.19)
ComCur		0.949***	0.953***	0.861**	0.874***	0.993***	0.964***	0.810**
		(0.22)	(0.23)	(0.26)	(0.22)	(0.24)	(0.25)	(0.26)
ACPtoEU		0.183	0.089	-0.027	0.014	0.379	0.034	0.009
		(0.22)	(0.23)	(0.22)	(0.23)	(0.32)	(0.24)	(0.21)
GSP		0.936***	1.041***	1.035***	1.029***	0.843***	1.072***	1.066***
		(0.22)	(0.23)	(0.21)	(0.23)	(0.23)	(0.23)	(0.21)
RTA		0.495***	0.490***	0.426***	0.477***	0.391**	0.504***	0.408**
		(0.12)	(0.13)	(0.13)	(0.13)	(0.15)	(0.13)	(0.13)
AgrLand_e			0.224	0.166	0.227	0.367**	0.293*	0.026
			(0.16)	(0.14)	(0.16)	(0.14)	(0.15)	(0.11)
AgrLand_i			-0.171***	-0.057*	-0.175***	-0.113***	-0.130***	-0.042
			(0.02)	(0.03)	(0.02)	(0.03)	(0.03)	(0.03)
WatAgrPc_e				0.480***				
				(0.14)				
WatAgrPc_i				-0.210***				
				(0.03)				
WEI_e					-0.009*			
					(0.00)			
WEI_i					0.002			
					(0.00)			
AvRatio_e						-0.194		
						(0.10)		
AvRatio_i						0.182***		
						(0.03)		
SAWW_e							0.045*	
							(0.02)	
SAWW_i							-0.008*	
							(0.00)	
BluWpc_e								0.208*
								(0.11)
BluWpc_i								-0.102***
								(0.03)
GreenWpc_e								0.647***
								(0.18)
GreenWpc_i								-0.171**
								(0.05)
Constant	-8.753***	-9.800***	-9.413***	-11.396***	-8.853***	-8.357***	-8.845***	-14.195***
	(1.99)	(2.04)	(2.10)	(2.52)	(2.13)	(2.14)	(1.92)	(2.16)
N	20815	20127	20127	19786	18386	10149	19474	19786

Dependent variable: VWT. No importer and exporter fixed effects. Standard errors in parentheses. Significance levels: * 10%; ** 5%; *** 1%.

Table 9: Panel data estimates with time-varying importer- and exporter- fixed effects.

	I	II	III	IV	V	VI
Distance	-1.475***	-1.471***	-1.466***	-1.456***	-1.408***	-1.449***
	0.03	0.03	0.03	0.03	0.04	0.03
ComBor	1.296***	1.335***	1.340***	1.303***	1.371***	1.349***
	0.09	0.09	0.09	0.09	0.12	0.09
ComCur	-0.209	-0.138	-0.137	-0.198	-0.175	-0.142
	0.12	0.12	0.12	0.12	0.15	0.12
ACPtoEU	1.001***	0.992***	0.998***	1.024***	1.242***	0.958***
	0.1	0.1	0.1	0.1	0.15	0.1
RTA	0.574***	0.553***	0.557***	0.636***	0.533***	0.562***
	0.06	0.06	0.06	0.06	0.08	0.06
WatAgrPc Ratio		0.674**				
		0.21				
GreenWpc Ratio			1.398**			
			0.45			
BlueWpc Ratio			-0.018			
			-0.05			
SAWW Ratio				0.263*		
				-0.1		
WEI Ratio					0.011	
					-0.01	
Av Doubleratio						0.08
						-0.1
N	21035	20340	20340	19213	10560	20026

Dependent variable: VWT. Time-varying importer and exporter fixed effects. Standard errors in parentheses. Significance levels: * 10%; ** 5%; *** 1%.

Table 10: Cross-sectional OLS estimates. Only Mediterranean countries. 2006

	I	II	III	IV	V	VI	VII
GDPpc_e	0.846***	0.836***	0.748***	1.044***	0.749***	0.971***	0.638***
	0.11	0.11	0.11	0.22	0.11	0.14	0.14
GDPpc_i	0.382**	0.371**	0.368**	0.281	0.372**	0.482**	0.323*
	0.13	0.13	0.13	0.3	0.13	0.17	0.14
Pop_e	1.313***	1.571***	1.699***	0.084	1.589***	1.324***	2.042***
	0.08	0.16	0.19	0.57	0.18	0.08	0.37
Pop_i	0.814***	1.033***	1.093***	0.557	1.091***	0.973***	1.258***
	0.08	0.19	0.21	0.59	0.2	0.22	0.29
Distant	-1.356***	-1.439***	-1.521***	-1.463***	-1.559***	-1.226***	-1.519***
	0.16	0.17	0.18	0.28	0.18	0.19	0.18
AgrLand_e		-0.206	-0.287	0.794*	-0.158		-0.586
		0.13	0.17	0.38	0.15		0.35
AgrLand_i		-0.175	-0.169	0.18	-0.179	-0.106	-0.314
		0.14	0.17	0.43	0.16	0.15	0.26
WatAgrPc_e			0.455				
			0.25				
WatAgrPc_i			-0.031				
			0.18				
WEI_e				0.610*			
				0.27			
WEI_i				0.607			
				0.32			
AvRatio_e					0.076		
					0.1		
AvRatio_i					-0.013		
					0.07		
SAWW_e						0.01	
						0.01	
SAWW_i						0.006	
						0.01	
BlueWpc_e							0.075
							0.21
BlueWpc_i							-0.096
							0.19
GreenWpc_e							0.446
							0.29
GreenWpc_i							0.173
							0.24
Constant	-19.414***	-23.218***	-27.343***	-6.872	-23.330***	-25.293***	-31.144***
	2.4	3.06	4.6	7.97	3.22	4.25	5.73
R-squared	0.602	0.605	0.564	0.624	0.557	0.605	0.563
N	278	278	247	61	247	226	247

Dependent variable: VWT. No importer and exporter fixed effects. Standard errors in parentheses. Significance levels: * 10%; ** 5%; *** 1%.

Table 11: Cross-sectional OLS estimates. Only Mediterranean VW imports. 2006

	I	II	III	IV	V	VI	VII
GDPpc_e	0.455***	0.495***	0.420***	0.406***	0.442***	0.335***	0.479***
	0.04	0.04	0.04	0.08	0.04	0.05	0.04
GDPpc_i	0.452***	0.444***	0.449***	0.391**	0.502***	0.493***	0.460***
	0.06	0.05	0.05	0.13	0.06	0.07	0.06
Pop_e	1.024***	0.750***	0.959***	1.208***	0.703***	1.069***	1.065***
	0.04	0.06	0.08	0.14	0.07	0.04	0.07
Pop_i	0.917***	1.062***	1.026***	0.314	1.074***	1.016***	1.098***
	0.04	0.08	0.08	0.35	0.08	0.09	0.13
Distance	-0.891***	-0.922***	-1.407***	-1.261***	-1.152***	-0.756***	-1.295***
	0.07	0.07	0.08	0.12	0.08	0.08	0.08
AgrLand_e		0.269***	0.168**	0.093	0.385***		0.024
		0.05	0.07	0.11	0.06		0.07
AgrLand_i		-0.121*	-0.043	0.267	-0.114	-0.102	-0.108
		0.06	0.07	0.23	0.07	0.06	0.12
WatAgrpc_e			0.571***				
			0.07				
WatAgrpc_i			-0.277**				
			0.09				
WEI_e				-0.266**			
				0.08			
WEI_i				0.526***			
				0.15			
AvRatio_e					0.012*		
					0.01		
AVRatio_i					-0.075		
					0.04		
SAWW_e						-0.010***	
						0	
SAWW_i						0.003	
						0	
BlueWpc_e							0.219***
							0.06
BlueWpc_i							-0.213*
							0.09
GreenWpc_e							0.750***
							0.1
GreenWpc_i							0.002
							0.11
Constant	-16.782***	-16.017***	-16.694***	-9.883**	-14.722***	-18.288***	-21.951***
	1.34	1.52	1.85	3.66	1.57	1.8	2.14
R-squared	0.412	0.425	0.425	0.433	0.4	0.394	0.441
N	1962	1962	1786	528	1744	1688	1770

Dependent variable: VWT. No importer and exporter fixed effects. Standard errors in parentheses. Significance levels: * 10%; ** 5%; *** 1%.

Table 12: Cross-sectional OLS estimates. Sub-Saharan African VWT exports. 2006

	I	II	III	IV	V	VI	VII
GDPpc_e	0.077	0.115	0.231**	0.132	0.244**	0.103	0.237**
	0.06	0.06	0.08	0.2	0.08	0.07	0.08
GDPpc_i	0.224***	0.211***	0.261***	0.132	0.226**	0.304***	0.246***
	0.07	0.06	0.07	0.23	0.07	0.07	0.07
Pop_e	0.645***	0.916***	1.174***	0.973***	1.051***	0.943***	1.196***
	0.05	0.09	0.13	0.25	0.11	0.09	0.13
Pop_i	0.813***	1.217***	1.211***	1.442***	1.377***	1.239***	1.247***
	0.04	0.06	0.08	0.2	0.07	0.06	0.09
Distance	-0.682***	-0.697***	-0.603***	-0.288	-0.754***	-0.782***	-0.648***
	0.14	0.14	0.16	0.53	0.16	0.15	0.17
W Avg Tariff	-0.172	-0.221	-0.191	-0.782	-0.268*	-0.294*	-0.248
	0.12	0.11	0.13	0.44	0.13	0.12	0.13
ComBor	1.446***	1.673***	1.923***	2.289*	1.728***	1.611***	1.900***
	0.33	0.33	0.35	0.92	0.35	0.34	0.35
ComCur	-0.073	0.213	0.43	2.484*	0.416	0.275	0.481
	0.33	0.34	0.35	1.25	0.35	0.34	0.36
ACPtoEU	0.455*	0.343	0.404*	0.259	0.572**	0.493*	0.477*
	0.18	0.18	0.2	0.56	0.21	0.19	0.21
GSP	0.782***	0.786***	0.758***	0.727	0.748***	0.754***	0.769***
	0.21	0.21	0.22	0.62	0.22	0.2	0.22
RTA	1.260***	1.446***	1.508***	1.047	1.437***	1.403***	1.509***
	0.24	0.24	0.27	0.96	0.26	0.24	0.27
AgrLand_e		-0.222***	-0.436***	-0.228	-0.329***	-0.190**	-0.460***
		0.06	0.11	0.19	0.09	0.06	0.11
AgrLand_i		-0.373***	-0.272***	-0.510**	-0.359***	-0.393***	-0.254***
		0.04	0.07	0.16	0.06	0.05	0.07
WatAgrPc_e			0.200*				
			0.1				
WatAgrPc_i			-0.170*				
			0.07				
WEI_e				-0.132			
				0.21			
WEI_i				0.064			
				0.14			
AvRatio_e					0.006		
					0.03		
AvRatio_i					0		
					0		
SAWW_e						-0.006	
						0	
SAWW_i						0.009***	
						0	
BluWpc_e							0.130*
							0.06
BluWpc_i							-0.145*
							0.06
GreenWpc_e							0.208
							0.18
GreenWpc_i							-0.105
							0.1
Cons	-6.352***	-11.986***	-17.420***	-16.941**	-16.500***	-12.827***	-18.155***
	1.63	1.78	2.51	5.57	1.99	1.87	2.59
R-Squared	0.283	0.314	0.325	0.29	0.318	0.309	0.323
N	1966	1966	1739	302	1687	1848	1716

Dependent variable: VWT. No importer and exporter fixed effects. Standard errors in parentheses. Significance levels: * 10%; ** 5%; *** 1%.

Table 13: Cross-sectional OLS estimates. Sub-Saharan African VWT imports. 2006

	I	II	III	IV	V	VI	VII
GDPpc_e	0.252***	0.256***	0.295***	0.427**	0.240***	0.250***	0.292***
	0.05	0.05	0.05	0.15	0.05	0.06	0.05
GDPpc_i	0.447***	0.459***	0.440***	0.464	0.410***	0.500***	0.436***
	0.07	0.07	0.09	0.25	0.1	0.07	0.09
Pop_e	0.794***	0.824***	0.926***	0.995***	0.872***	0.899***	0.973***
	0.05	0.07	0.09	0.22	0.08	0.07	0.09
Pop_i	0.558***	0.659***	0.761***	0.251	0.750***	0.697***	0.850***
	0.05	0.09	0.13	0.31	0.12	0.09	0.13
Distance	-0.518***	-0.523***	-0.896***	-0.099	-0.796***	-0.624***	-0.854***
	0.14	0.14	0.17	0.55	0.17	0.14	0.17
W Avg Tariff	-0.167	-0.163	-0.306	0.089	-0.353	-0.197	-0.269
	0.18	0.18	0.24	0.78	0.25	0.19	0.22
ComBor	1.942***	1.967***	1.609***	1.832	1.599***	1.850***	1.668***
	0.33	0.33	0.37	1.01	0.36	0.33	0.36
ComCur	-0.019	0.025	-0.136	1.695	0.056	0.004	-0.148
	0.32	0.32	0.35	1.39	0.34	0.33	0.36
RTA	1.151***	1.168***	0.827**	2.022*	1.031***	1.111***	0.838**
	0.24	0.24	0.27	0.98	0.26	0.24	0.27
AgrLand_e		-0.025	0.06	0.008	0.151*	-0.025	-0.014
		0.05	0.08	0.17	0.07	0.05	0.08
AgrLand_i		-0.076	-0.025	0.327*	-0.01	-0.086	-0.083
		0.06	0.1	0.14	0.08	0.06	0.1
WatAgrPc_e			0.283***				
			0.08				
WatAgrPc_i			0.06				
			0.1				
WEI_e				0.137			
				0.13			
WEI_i				0.406			
				0.29			
AvRatio_e					0.024***		
					0.01		
AvRatio_i					0.021		
					0.02		
SAWW_e						0	
						0	
SAWW_i						0	
						0	
BluWpc_e							0.129
							0.07
BluWpc_i							0.119
							0.07
GreenWpc_e							0.334***
							0.1
GreenWpc_i							-0.294
							0.18
Cons	-8.677***	-9.984***	-14.104***	-17.378**	-11.585***	-10.990***	-14.747***
	1.62	1.86	2.36	6.34	1.97	1.96	2.35
R-Squared	0.223	0.223	0.247	0.226	0.249	0.231	0.249
N	1891	1891	1601	263	1573	1853	1595

Dependent variable: VWT. No importer and exporter fixed effects. Standard errors in parentheses. Significance levels: * 10%; ** 5%; *** 1%.

Table 14: Cross-sectional OLS estimates. Only EU27 countries. 2006

	I	II	III	IV	V	VI	VII
GDPpc_e	0.531***	0.462***	0.412***	0.468***	0.449***	0.441***	0.652***
	0.1	0.1	0.1	0.12	0.11	0.09	0.12
GDPpc_i	0.375***	0.208	0.326**	0.678***	0.371**	0.193	0.191
	0.11	0.11	0.12	0.15	0.13	0.11	0.14
Pop_e	1.180***	1.448***	1.563***	1.304***	1.473***	1.468***	2.575***
	0.05	0.12	0.17	0.21	0.16	0.12	0.26
Pop_i	0.915***	1.565***	1.436***	0.443*	1.233***	1.554***	1.098***
	0.06	0.13	0.2	0.2	0.17	0.13	0.28
Distance	-1.602***	-1.732***	-1.824***	-1.902***	-1.805***	-2.058***	-1.802***
	0.1	0.09	0.1	0.15	0.1	0.11	0.11
AgrLand_e		-0.253**	-0.393*	-0.382*	-0.308*	-0.296**	-1.473***
		0.1	0.16	0.19	0.15	0.1	0.28
AgrLand_i		-0.586***	-0.381*	0.361	-0.185	-0.611***	-0.009
		0.11	0.19	0.18	0.15	0.11	0.3
WatAgrPc_e			0.029				
			0.15				
WatAgrPc_i			0.185				
			0.15				
WEI_e				0.581***			
				0.11			
WEI_i				0.472***			
				0.12			
AvRatio_e					-0.016		
					0.02		
AvRatio_i					-0.008		
					0.02		
SAWW_e						0.005*	
						0	
SAWW_i						0.020***	
						0	
BluWpc_e							0.226*
							0.1
BluWpc_i							0.119
							0.1
GreenWpc_e							1.363***
							0.34
GreenWpc_i							-0.511
							0.35
Cons	-13.514***	-18.150***	-20.169***	-10.404***	-16.966***	-15.518***	-32.871***
	2.09	2.41	3.29	2.9	2.52	2.36	7.85
R-squared	0.667	0.685	0.665	0.659	0.664	0.706	0.676
N	688	688	643	342	643	688	643

Dependent variable: VWT. No importer and exporter fixed effects. Standard errors in parentheses. Significance levels: * 10%; ** 5%; *** 1%.

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Appendix

Summary statistics

In this section we provide some summary statistics on the variables included in the cross-section analysis. We focus on the year 2006 as we provided the results under all the different estimation methods only for this year.

Table 15: Summary Statistics. Cross-sectional data for the year 2006

	Obs	Mean	Std. Dev.	Min	Max
Country-specific variables					
GDPpc	133	12309.74	17341.07	170.3787	91395.21
Pop	134	4.65E+07	1.56E+08	0	1.34E+09
W Avg Tariff	131	12.33206	10.80061	0	89.61
Agr	133	33258.46	78646.8	0	524000
WatAgrPc	127	9115.559	24679.39	92	222733
WEI	70	70.37226	249.8366	-6.346	1867
AvRatio	123	7.241545	22.53816	0.11	225.15
SAWW	128	55.20224	31.33774	0.2508	97.56
BlueWpc	127	8050.535	24291.4	32	218049
GreenWpc	127	1064.992	786.0485	0	4683
Wprice	78	2.368846	3.740788	0	30.04
Bilateral VWT flows					
VWT flows	17556	1.37E+08	1.11E+09	0	6.42E+10
Aggregated national VWT flows					
Tot VW Exp	17556	1.37E+08	2.85E+08	319755.1	1.81E+09
Tot VW Imp	17556	1.37E+08	2.39E+08	339857.1	1.48E+09

Country lists

For the 2001 cross-sectional data, the sample includes 132 countries: Afghanistan, Albania, Algeria, Argentina, Australia, Austria, Azerbaijan, Bangladesh, Barbados, Belarus, Belgium, Benin, Bolivia, Brazil, Bulgaria, Burkina Faso, Burundi, Cameroon, Canada, Central African Republic, Chile, China (Hong Kong SAR), China (Macao SAR), China (mainland), Colombia, Costa Rica, Croatia, Cuba, Cyprus, Czech Republic, Cte d'Ivoire, Denmark, Dominica, Dominican Republic, Ecuador, Egypt, El Salvador, Estonia, Ethiopia, Fiji, Finland, France, Georgia, Germany, Ghana, Greece, Guatemala, Guinea, Guyana, Honduras, Hungary, Iceland, India, Indonesia, Iran, Ireland, Israel, Italy, Jamaica, Japan, Jordan, Kazakhstan, Kenya, Kuwait, Kyrgyzstan, Latvia, Lebanon, Lithuania, Luxembourg, Madagascar, Malawi, Malaysia, Mali, Malta, Mauritius, Mexico, Morocco, Mozambique, Namibia, Netherlands, New Zealand, Nicaragua, Niger, Nigeria, Norway, Oman, Pakistan, Panama, Papua New Guinea, Paraguay, Peru, Philippines, Poland, Portugal, Republic of Korea, Republic of Moldova, Romania, Russian Federation, Saudi Arabia, Senegal, Serbia and Montenegro, Singapore, Slovakia, Slovenia, South Africa, Spain, Sri Lanka, Sudan, Swaziland, Sweden, Switzerland, Syrian Arab Republic, Thailand, former Yugoslav Republic of Macedonia, Togo, Trinidad and Tobago, Tunisia, Turkey, Turkmenistan, Uganda, Ukraine, United

Arab Emirates, United Kingdom, United Republic of Tanzania, United States of America, Uruguay, Uzbekistan, Venezuela, Viet Nam, Yemen, Zambia, Zimbabwe.

For the 2006 cross-sectional data, the sample includes 133 countries: Albania, Algeria, Antigua and Barbuda, Argentina, Armenia, Australia, Austria, Azerbaijan, Bahrain, Bangladesh, Belarus, Belgium, Belize, Benin, Bolivia, Bosnia and Herzegovina, Brazil, Bulgaria, Burkina Faso, Burundi, Cameroon, Canada, Chile, China (Hong Kong SAR), China (mainland), Colombia, Congo, Costa Rica, Croatia, Cuba, Cyprus, Czech Republic, Cte d'Ivoire, Denmark, Dominican Republic, Ecuador, Egypt, El Salvador, Estonia, Ethiopia, Fiji, Finland, France, Georgia, Germany, Ghana, Greece, Guatemala, Guinea, Guyana, Honduras, Hungary, Iceland, India, Indonesia, Iran , Ireland, Israel, Italy, Jamaica, Japan, Jordan, Kazakhstan, Kenya, Kyrgyzstan, Latvia, Lebanon, Lithuania, Luxembourg, Madagascar, Malaysia, Mali, Malta, Mauritius, Mexico, Morocco, Mozambique, Namibia, Netherlands, New Zealand, Nicaragua, Niger, Nigeria, Norway, Oman, Pakistan, Panama, Paraguay, Peru, Philippines, Poland, Portugal, Qatar, Republic of Korea, Republic of Moldova, Romania, Russian Federation, Rwanda, Saudi Arabia, Senegal, Serbia, Singapore, Slovakia, Slovenia, South Africa, Spain, Sri Lanka, Sudan, Swaziland, Sweden, Switzerland, Syrian Arab Republic, Tajikistan, Thailand, former Yugoslav Republic of Macedonia, Togo, Trinidad and Tobago, Tunisia, Turkey, Turkmenistan, Uganda, Ukraine, United Arab Emirates, United Kingdom, United Republic of Tanzania, United States of America, Uruguay, Uzbekistan, Venezuela , Viet Nam, Yemen, Zambia, Zimbabwe.

The panel dataset includes the following countries: Afghanistan, Albania, Algeria, Argentina, Armenia, Australia, Austria, Azerbaijan, Bangladesh, Belarus, Belgium, Benin, Bolivia, Bosnia and Herzegovina, Botswana, Brazil, Bulgaria, Burkina Faso, Burundi, Cambodia, Cameroon, Canada, Central African Republic, Chad, Chile, China (mainland), Colombia, Congo, Costa Rica, Croatia, Cuba, Czech Republic, Cte d'Ivoire, Democratic People's Republic of Korea, Democratic Republic of the Congo, Denmark, Dominican Republic, Ecuador, Egypt, El Salvador, Estonia, Ethiopia, Finland, France, Gabon, Gambia, Georgia, Germany, Ghana, Greece, Guatemala, Guinea, Haiti, Honduras, Hungary, India, Indonesia, Iran, Iraq, Ireland, Israel, Italy, Jamaica, Japan, Jordan, Kazakhstan, Kenya, Kuwait, Kyrgyzstan, Lao People's Democratic Republic, Latvia, Lebanon, Liberia, Libyan Arab Jamahiriya, Lithuania, Madagascar, Malawi, Malaysia, Mali, Mauritania, Mauritius, Mexico, Mongolia, Morocco, Mozambique, Myanmar, Namibia, Nepal, Netherlands, New Zealand, Nicaragua, Niger, Nigeria, Norway, Oman, Pakistan, Panama, Papua New Guinea, Paraguay, Peru, Philippines, Poland, Portugal, Republic of Korea, Republic of Moldova, Romania, Russian Federation, Rwanda, Saudi Arabia, Senegal, Serbia and Montenegro, Sierra Leone, Singapore, Slovakia, Slovenia, Somalia, South Africa, Spain, Sri Lanka, Sudan, Swaziland, Sweden, Switzerland, Syrian Arab Republic, Tajikistan, Thailand, The former Yugoslav Republic of Macedonia, Togo, Trinidad and Tobago, Tunisia, Turkey, Turkmenistan, Uganda, Ukraine, United Arab Emirates, United Kingdom, United Republic of Tanzania, United States of America, Uruguay, Uzbekistan, Venezuela, Viet Nam, Yemen, Zambia, Zimbabwe.