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Effects of trade barriers on bilateral trade of potable water

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Abstract

This paper empirically examines the effects of trade barriers on international transfers of potable water. In this context, potable water is defined as natural water that is neither flavored nor contains added sugar or other sweeteners. Based on a structural gravity model we analyze the determinants of bilateral trade flows in potable water by applying Heckman's selection model to control for a potentially systematic selection of trade participating countries. The output shows that bilateral trade barriers crucially determine the countries' probability of trading potable water as well as the volume of water traded. This raises the question of how reduced trade barriers would change the trade patterns and which countries are the beneficiaries or losers of such a trade reform. The subsequent counterfactual analysis provides the answer. It allows us to determine how a specific (hypothetical) reduction of trade barriers between the trading partners influence (a) their world market shares and (b) the average demand and supply prices of potable water. We find that water rich exporting countries that ship water to water poor importers benefit most from reduced trade barriers as they experience a considerably increase in their world market shares. The magnitude of the changes in market shares depends on the indirect price effects associated to reduced distance costs. Furthermore, the counterfactual analysis indicates that specific reductions of trade barriers increase (decrease) the average demand (supply) price of water rich importers (exporters) which points at a possible convergence in average prices between water rich and water poor countries.

Keywords: International trade, gravity model, potable water.

JEL classification: F14, F18, Q25, Q27.

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1 Introduction

Water is a necessity for human living and economic activities. Due to the increasing population, growing economic activities and climate change water stress to humanity will likely increase in the future. Among other things, the transfer of water is perceived as one possibility to alleviate this pressure (El Ayoubi & McNiven 2006), although trade in water is seen as highly controversial (Gleick, Wolff, Chalecki & Reyes 2002).

This paper contributes to the literature by addressing one aspect of this controversy by empirically investigating the observable bilateral trade in potable water. Although trade in (potable) water is widely discussed on normative grounds, empirical studies on this issue are rare. In fact, we are not aware of any study that investigates bilateral trade flows of potable water empirically. We aim at empirically analyzing the role of bilateral trade barriers for international trade in potable water by examining bilateral flows in natural water that is neither flavored nor contains added sugar or other sweeteners. We address three research questions: (1) How do trade barriers influence the probability of trading potable water and the volume of bilateral water imports? (2) How would the trade patterns in terms of world market shares change if the trading partners were closer together (i.e. lower/no barriers between countries)? This question comprises the determination of distribution effects, such as examining whether a reduction in distance induces a redistribution in favor of water scarce countries. (3) How do reduced trade barriers influence the average prices at the demand and the supply side, respectively?

The empirical model to answer these questions is based on a structural gravity equation (Anderson & van Wincoop 2003, Anderson & Yotov 2010) and is estimated using Heckman's sample selection model (Heckman 1976) to adequately control for a possibly systematic selection of countries which participate in potable water trade. We find empirical evidence that distance factors crucially matters for international trade in potable water: The higher the barriers the lower is the probability of trading water as well as the volume of water traded. The comparative statics show that a specific reduction in the bilateral distances primarily favors the water rich exporters that ship water to water poor importers: They could increase their world market share by 1.3 % to 9.7 % compared to the status quo level, i.e., when trade barriers are not reduced. The comparative statics further reveals that the direct effects of the reduction in bilateral distances on the world market shares are weakened by the associated price effects. Finally, the analysis also provides information on how reduced trade barriers between the countries influence their supply and demand

prices. On average we find that the demand (supply) price of water rich importing (exporting) countries increase (decrease) when distance costs are reduced.

The remainder of the paper is organized as follows: In Section 2 we provide background information, some stylized facts and summarize the relevant literature. Section 3 discusses the theoretical model and the econometric specification. Section 4 presents the data, descriptive statistics and the regression analysis. Section 5 contains the counterfactual analysis and Section 6 concludes.

2 Background and previous literature

Due to its vital condition for humanity trade in potable water is subject of controversial discussions. The debate starts with whether water should be treated as an economic good to which market rules apply or whether it is different from other natural resources. Whether water per se is a tradeable good and the restrictions, if any, to be imposed on the export of water are further objects of discussion. Gleick et al. (2002) and Hanemann (2006) provide an excellent overview and argue on the controversies involved. Different from trade in raw water, trade in processed water products such as bottled water is of less controversy. In fact, the market for bottled water has rapidly grown over the past years (Gleick et al. 2002, Rodwan Jr. 2009).

In general, trading commodities has the potential to alleviate certain shortages by reallocating plentifully available goods in abundant countries to places where they are scarce and needed. Generally, this also applies to potable water, a good which is far from being evenly distributed over the Earth and where huge regional variations in the access and abundance prevail. This uneven geographical distribution of water is pictured in Figure 1. It plots on the x-axis the log of the countries' total renewable water resources comprising groundwater and surface water (rivers, lakes) and on the y-axis the countries' population (in logs). Beside the information on the water endowment in each country (the farther right, the water richer) this graph also provides a preliminary overview on which countries may face increased water stress due to high population but low water endowment.

The previous literature mainly focuses on virtual water trade which refers to water used in production and services (Allen 2003). These studies often address the potential of virtual (embedded) water trade to alleviate water stress by exporting/importing water intensive goods (e.g. Yang & Zehnder 2002, Sayan 2003, Velázquez 2007, Yang, Wang & Zehnder 2007, Novo, Garrido & Varela-Ortega 2009). Another strand of literature argues on the potential of water markets and reallocation of water (Howe, Lazo & Weber 1990, Turrall, EtcHELLS, Malano, Wijedasa,

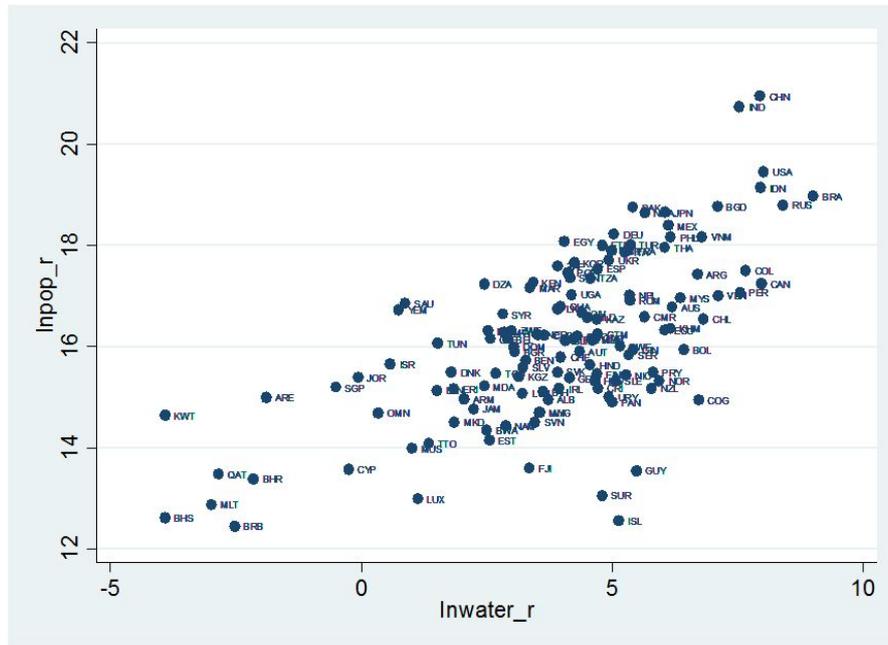


Figure 1: Unevenly distributed water resources

Taylor, McMahon & Austin 2005, Meinzen-Dick 2008, Hadjigeorgalis 2009). So far, the analysis of actual water transfers is restricted to rather narrow areas and mainly focuses on water transfers for agricultural purposes such as irrigation. Apart from the studies on bottled water demand (Gleick 2004, Friberg & Ganslandt 2006, He, Jordan & Paudel 2008, Bonnet & Dubois 2010), we are not aware of any study which empirically investigates international flows of potable water.

Besides the scarcity of potable water, poorly managed water pools are very often a problem of the poor countries. Opponents of selling water argue that trade in water does not have the potential to help the poor because exporters of water are expected to sell to the highest bidder and/or to places that are easy to reach. Specifically, the poor countries are typically clustered in regions that can only be served at high transportation costs. With respect to bulk water, Gleick et al. (2002) assume that due to the high costs of water transport (relative to its value) exports over a longer time period and distance are unlikely. Figure 2 supports the latter statement. The graph pictures the trade value of potable water, accumulated over the bilateral distances for two types of potable water: mineral waters and aerated waters (left graph) and ordinary natural water, ice and snow (right graph). Obviously, distance plays a crucial role for international trade in potable water: About 70 % (85 %) of the mineral (bulk) water are traded within a distance of 5,000 kilometers.

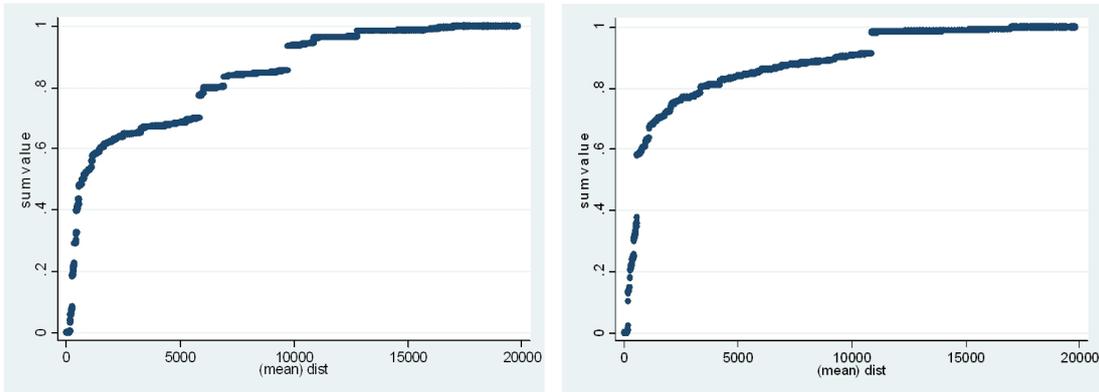


Figure 2: Role of distance in potable water trade; Mineral (left) and bulk (right) water

In this study we elaborate on the importance of trade barriers for the international trade in potable water and analyze the effects of reduced barriers on the countries' world market shares and their average demand and supply prices for potable water. This comprises the determination of possible distribution effects, for example, which countries gain/lose most from a reduction of specific distance parameters.

3 Theoretical model and empirical specification

3.1 The structural gravity equation

We consider a model of monopolistic competition in a world with J countries focusing on the water markets only. Consumers of country j spend a constant share of their income on water. Let n_i be the set of water extracting firms (varieties) in country i and denote the elasticity of substitution by σ , which is constant and uniform across countries with $\sigma \geq 1$. Maximizing utility subject to the usual budget constraint leads to the demand c_{ij} for water that is produced in country i and consumed in country j :

$$c_{ij} = \left(\frac{p_i t_{ij}}{P_j} \right)^{-\sigma} \frac{\phi Y_j}{P_j}, \quad (1)$$

where $\phi Y_j = \sum_{i=1}^N n_i p_i t_{ij} c_{ij}$ denotes total expenditures of country j on water. ϕ is a fixed share in total income that is spent on water. p_i is the mills price in country i , t_{ij} denotes bilateral iceberg trading costs with $t_{ij} \geq 1$. Lastly, P_j is the ideal price

index in country j and is defined as

$$P_j = \left(\sum_{i=1}^J n_i (p_i t_{ij})^{1-\sigma} V_{ij} \right)^{\frac{1}{1-\sigma}}. \quad (2)$$

The indicator variable V_{ij} takes the value 1 if market j is actually served from country i firms and is zero otherwise. Using the first order condition for profit maximization (mark-up pricing), the aggregate value of exports from country i to j , X_{ij} , then amounts to

$$X_{ij} = n_i \left(\frac{\sigma}{\sigma-1} \frac{t_{ij} p_i}{P_j} \right)^{1-\sigma} \phi Y_j V_{ij}. \quad (3)$$

Following Anderson & van Wincoop (2003), one can aggregate the value of the varieties that are produced in country i to obtain the total value of water production of country i denoted by Q_i which is assumed to be fixed. Using the condition that the expenditures on water originating from country i aggregated over all the importing countries has to be equal to the production value Q_i , one obtains

$$Q_i = \sum_{h=1}^J X_{ih} = n_i \left(\frac{\sigma}{\sigma-1} p_i \right)^{1-\sigma} \phi Y_w \sum_{h=1}^J \left(\frac{t_{ih}}{P_h} \right)^{1-\sigma} \theta_h V_{ih} \quad (4)$$

with the expenditure share of country h defined as $\theta_h = \frac{Y_h}{\sum_k Y_k} = \frac{Y_h}{Y_w}$. Next, we define the endowment share of water in country i as $\kappa_i = \frac{Q_i}{\sum_k Q_k} = \frac{Q_i}{Q_w}$. Inserting (4) in (3) yields

$$X_{ij} = Q_i \frac{\left(\frac{t_{ij}}{P_j} \right)^{1-\sigma} \theta_j V_{ij}}{\left(\sum_{h=1}^J \left(\frac{t_{ih}}{P_h} \right)^{1-\sigma} \theta_h V_{ih} \right)} = \kappa_i Q_w \theta_j V_{ij} \left(\frac{t_{ij}}{P_j \Pi_i} \right)^{1-\sigma}. \quad (5)$$

with

$$\Pi_i^{1-\sigma} = \sum_{h=1}^J \left(\frac{t_{ih}}{P_h} \right)^{1-\sigma} \theta_h V_{ih} \quad (6)$$

$$P_j^{1-\sigma} = \sum_{h=1}^J \left(\frac{t_{hj}}{\Pi_h} \right)^{1-\sigma} \kappa_h V_{hj}. \quad (7)$$

where P_j (Π_i) represents the inward (outward) multilateral trade resistance term of the importer (exporter).¹ The former reflects the average distance and size weighted price index at the demand side and depends on the remoteness of the respective importing country from its trading partners. The latter represents the impact of trade resistances on the average price of suppliers and is likewise determined by the distance of the exporting country from its trading partners. As Anderson & Yotov (2010) argue, P_j can be also interpreted as a uniform markup on the world market price for the bundle of goods that are purchased at the world market, while Π_i represents the average trade costs. These trade resistance terms remain unobserved as they are implicitly defined in a non-linear system of equations.

Equation 5 indicates that trade in potable water can be only observed, if exporter i serves the import market j , i.e., if $V_{ij} = 1$. Countries may systematically select into the group of potable water traders. The decision to participate in water trading depends on the country i 's firms operating profits and their fixed costs f_{ij} of serving the foreign market j . Following the literature, we assume free entry of suppliers into the import markets at fixed costs f_{ij} , which drives profits in each importer market down to zero in the long run equilibrium. Note, overall profits of a country i 's firm are assumed to be separable across importing countries and costs are separated across export destinations (Helpman, Melitz & Rubinstein 2008). The profits of a typical firm in country i in market j are then given by

$$\pi_{ij} = \frac{1}{\sigma - 1} d_i t_{ij} c_{ij} - f_{ij} \quad (8)$$

where d_i denotes the marginal costs of extracting and possibly bottling water. This implies that market j is served by country i whenever $\pi_{ij} \geq 0$. Since we assume that firms are always active in the domestic market we can normalize the latent variable for the propensity of firms from country i to serve market j as

$$V_{ij}^* = (1 - \sigma) \ln t_{ij} + (\sigma - 1) \ln P_j + (1 - \sigma) \ln d_i + \ln(\phi Y_j) - \ln f_{ij} - (1 + \sigma) \ln(\sigma - 1) - \sigma \ln \sigma \quad (9)$$

$V_{ij} = 1$ if $V_{ij}^* > 0$ and is unobserved otherwise.

¹See also Eaton & Kortum (2002), who derive

$$X_{ni} = \phi Q_i \frac{\left(\frac{t_{in}}{p_n}\right)^\theta X_n}{\sum_{h=1}^J \left(\frac{t_{ih}}{p_h}\right)^\theta X_h}$$

where n is the importer and i is the exporter, X_n is total spending and θ relates to the parameter of the distribution of productivity. Their approach is based on a Ricardian setting. Note, at the pure product level this approach is less plausible and it is usually applied to the aggregate level.

This specification implies that exports from i to j are more likely observed the lower the trade barriers t_{ij} , the lower the marginal costs of production d_i , the lower the fixed trade costs f_{ij} and the higher the expenditures on water ϕY_j in the importing market are. Note, the importer trade resistance terms P_j positively affect the propensity to export since a higher average price level in a market increases the operating profits earned there.

Concluding, trade barriers do not only influence the magnitude of the trade flows (internal margin), but also the decision of an exporter to serve a foreign market at all (external margin).

3.2 Econometric specification

We start with analyzing the determinants of bilateral trade flows using a gravity model which is widely used and is consistent with theoretical models of trade (see Feenstra, Markusen & Rose (2001) and Feenstra (2002) for a discussion). The theoretical model derived in Section 3.1 motivates the application of Heckman's sample selection model (Heckman 1976) to consider a possibly systematic selection of countries. The empirical specification controls for various distance factors and includes exporter and importer fixed effects. These country dummies capture all unobserved determinants that are either importer or exporter specific and take relative (to the rest of the world) trade costs into account (Anderson & van Wincoop 2003, Anderson & Yotov 2010). We estimate country i 's participation in potable water trade to country j as

$$\ln V_{ij}^* = b_0 + b_1 \mathbf{X}_{ij} + \xi_i + \mu_j + \nu_{ij} \quad (10)$$

and country i 's nominal exports, i.e., its non-zero trade flows (if $V_{ij} = 1$), to country j as

$$\ln X_{ij} = a_0 + a_1 \mathbf{X}_{ij} + \xi_i + \mu_j + \epsilon_{ij} \quad (11)$$

The distance vector \mathbf{X}_{ij} comprises several indicators of bilateral trade barriers between the trading partners: Geographical distance measured in kilometers between the countries' capitals, dummies indicating whether a regional trade agreement is in force, whether the countries share a common border, a common language or whether they have (had) colonial links. ξ_i and μ_j are the exporter and importer fixed effects which capture the exporter and importer trade resistance terms and allow to consistently estimate the parameters of the model without solving the system (see equations 6 and 7). ν_{ij} and ϵ_{ij} represent stochastic error terms which are

allowed to be correlated to account for systematic selection of import destinations as in Heckman’s sample selection model (Feenstra 2002).

4 Data and estimation results

4.1 Data description

The data stem from different sources. Information on bilateral water imports are taken from the UN’s commodity trade statistic database which reports trade data up to a 6 digit classification of products. In particular, we examine the trade flows of ‘mineral and aerated waters not sweetened or flavored’ (code 220110).² Geographical information (distance between the trading partners, contiguity, common language, (former) colonial links) is given in the CEPII data base.³ Finally, regional trade agreements (RTA) in force are taken from Baier, Bergstrand, Egger & McLaughlin (2008) and from the WTO’s Regional Trade Agreements Information System.⁴

The data on bilateral trade flows cover a period of 15 years (1992–2006). As for some countries only a few observations per year are available we decided to average our sample over time. To control for potential systematic selection of countries into the group of traders, we start with a sample including all exporting and importing countries with at least one bilateral trade flow. Our final data set used for analyzing the bilateral flow of potable water consists of 16,900 observations and includes information on 130 exporting and importing countries.

4.2 Descriptive statistics

Before we present the empirical results, we provide information on the location of the trading countries, their importance in potable water trade and discuss the descriptive statistics of the dependent and explanatory variables.

Table 1 presents the volume of trade in potable water for each continent pair in percent of the total observed import value amounting to 16,700 million USD. The figures refer to the sum of imported goods recorded in the years 1992 to 2006 and depict that about 55 % of the mineral waters is traded within Europe, 18 % (14 %) is due to trade flows from Europe to North America (Asia). With respect to the value of imported goods Europe is the largest exporter (its share amounts to 87 %

²For a definition of these commodities see <http://comtrade.un.org/db/mr/rfCommoditiesList.aspx?px=H1&cc=2201>.

³<http://www.cepii.fr/anglaisgraph/bdd/distances.htm>

⁴<http://rtais.wto.org/UI/PublicMaintainRTAHome.aspx>

of the total value traded) and at the same time the largest importer (55 %). Second ranks North America with its 9 % (26 %) share as exporter (importer) followed by Asia, the proportions of which amount to 2 % (17 %) with respect to its exports (imports).

Table 1: Volume of potable water trade in % of import value

<i>Exporter</i>	<i>Importer</i>						Total
	(1)	(2)	(3)	(4)	(5)	(6)	
Mineral water (code 220110), overall import value: 16,700 mill. USD							
(1) Africa	0.13	0.01	0.00	0.02	0.00	0.00	0.16
(2) Asia	0.02	1.31	0.02	0.43	0.06	0.00	1.83
(3) Australia	0.00	0.08	0.02	0.02	1.28	0.00	1.40
(4) Europe	0.47	13.80	0.76	54.55	17.51	0.17	87.43
(5) North America	0.01	2.00	0.02	0.18	7.14	0.01	9.37
(6) South America	0.00	0.00	0.00	0.00	0.02	0.03	0.05
Total	0.62	17.21	0.82	55.20	26.03	0.22	100.00

Table 2 reports the descriptive statistics of the variables included in the regression analysis. The first two columns of Table 2 refer to the total sample, columns 3 and 4 and 5 and 6 describe the two sub samples, i.e., countries that do not trade ($V_{ij} = 0$) and countries that trade ($V_{ij} = 1$), respectively.

Table 2: Descriptive statistics

Variable	Total Sample		No trade		Trade	
	Obs	Mean	Obs	Mean	Obs	Mean
Imports (in tsd. USD)					3583	414.57
Positive Trade=1	16900	0.21				
RTA	16900	0.79	13317	0.83	3583	0.64
Distance	16900	7262.75	13317	7809.66	3583	5230.06
Common language	16900	0.87	13317	0.89	3583	0.80
Common colonizer	16900	0.91	13317	0.90	3583	0.93
Colonial link	16900	0.98	13317	0.99	3583	0.95
Contiguity	16900	0.97	13317	0.98	3583	0.92

About one fifth of the bilateral country pairs are potable water traders whose average import values amount to 415,000 USD. All of the distance variables indicate higher trade barriers for the group of non traders than for the group of traders.⁵

⁵We redefined the distance variables so that they represent trade barriers by subtracting the dummies for RTA, common language, contiguity and colonies from one. This implies, for example, that contiguity is one if countries do NOT share a common border and is 0 otherwise.

In particular, 83 % (64 %) of the non-trading (trading) country pairs do not have a RTA in force, 89 % (80 %) do not share a common language, 10 % (7%) have had a common colonizer after 1945, and 1 % (5 %) have ever had colonial links. Only 2 % among the group of non-traders are neighbors while 8 % of the positive trade flows take place between neighboring countries. This geographical pattern is mirrored in the distance variable: The average distance between the non-trading (trading) countries amounts to 7810 (5230) kilometers.

To sum up, the descriptive analysis suggests that trade barriers play a major role for the international trade of water. In the next section we provide deeper insights into the relationship between trade barriers and potable water trade.

4.3 Regression analysis

The econometric results in Table 3 are based on the specifications discussed in Section 3.2. To take systematic differences between trading vs. non-trading countries into account we apply Heckman's sample selection model with exporter and importer dummies. Table 3 reports the selection equation which refers to the probability of trading and the output equation which relates to the nominal value of water traded.

Table 3: Heckman estimates

<i>Variable</i>	<i>Selection equation</i>		<i>Output equation</i>	
	<i>Coef.</i>	<i>Std. Err.</i>	<i>Coef.</i>	<i>Std. Err.</i>
RTA	-0.278***	0.050	-0.708***	0.099
ln(distance)	-0.987***	0.032	-1.015***	0.065
Common language	-0.589***	0.058	-0.549***	0.113
Common colonizer	-0.544***	0.076	-0.999***	0.173
Colony	-0.411***	0.124	-0.731***	0.169
Contiguity	-0.548***	0.105	-1.411***	0.147
Constant	4.757***	0.384	14.712***	0.881
Country fixed effects (χ^2)	3426.30***		8695.88***	
ρ			0.374***	0.040
Mills ratio			0.710***	0.081
Observations			16770	
Log-Likelihood			-11149	

Notes: *** indicates the significance level of 1 percent.

Considering that we redefined all the distance variables so that they represent trade barriers (see Footnote 5), the negative distance coefficients meet the expectations: The probability of trading as well as the volume of water trade significantly decrease with increasing trade barriers. The significant coefficients in the selection equation and the significant Mills ratio indicate that the selection of countries into the group of traders is systematic and has to be controlled for to ensure reliable estimates for the output equation.

The empirical results point at the importance of trade barriers for bilateral trade in potable water. In the subsequent section we consider a counterfactual world where specific trade barriers are considerably reduced or even eliminated. This allows us to examine how reduced trade costs influence existing trade patterns and to determine which countries would benefit/lose from reduced trade barriers.

5 Counterfactual analysis

5.1 Preliminaries

The calculation of the trade flows in the baseline and the counterfactual scenario upon which the comparative static analysis is based proceeds in three steps. First, for each scenario we derive predictions of both, the exporter status and the trade flows, based on the estimated and counterfactually changed parameters. In the outcome equation of the sample selection model, we ignore the fixed exporter and importer effects assuming that they mainly capture the unobserved trade resistance terms. With respect to the prediction of the exporter status (V_{ij}), for each country pair we construct a predicted binary indicator \widehat{V}_{ij} based on the corresponding continuous latent variable \widehat{V}_{ij}^* following Fossati (2009). In particular, we minimize a cost-weighted misclassification cost function in a grid search to obtain

$$\widehat{V}_{ij} = 1 \text{ if } \Phi\left(\widehat{V}_{ij}^*\right) > v^* \quad (12)$$

$$v^* = \arg \min_v \sum_{i=1}^J \sum_{j=1}^J (1-q) V_{ij} \left(1 - \widehat{V}_{ij}\right) + q (1 - V_{ij}) \widehat{V}_{ij}, \quad (13)$$

where the weight $q = 0.35$ is assumed. This weight is chosen to minimize the difference in the share of predicted versus observed non-zero exports. In the second step, we solve the system of trade resistance terms (equations (6) and (7)) based on the estimated values of $\widehat{t_{ij}^{1-\sigma}}$ and the predicted exporter status, \widehat{V}_{ij} , iteratively. In solving this system, we account for the endogeneity of the importer specific price

resistance term in the selection equation (9) so that in each iteration the exporter status is updated accordingly. Lastly, the predicted value of exports flows under each scenario is calculated as by $X_{ij} = \widehat{t_{ij}^{1-\sigma}} \left(\widehat{\Pi_i^{\sigma-1} \kappa_i} \right) \left(\widehat{P_j^{\sigma-1} \theta_j} \right)$. Note we solve the system in terms of $\left(\widehat{\Pi_i^{\sigma-1} \kappa_i} \right)$ and $\left(\widehat{P_j^{\sigma-1} \theta_j} \right)$. From these terms the exporter and importer price effects can be inferred by using observed values of κ_i and θ_j as well as an assumption on σ which remains unobserved. We therefore set $\sigma = 5$.

5.2 Design of experiments

The results of Table 3 form the basis for the subsequent comparative statics. To assess the importance of trade barriers for the volume of trade in potable water, we create a counterfactual world where we assume smaller trade barriers than in reality. In particular, we consider four different experiments: (i) a reduction in the bilateral distances by 10 %, (ii) a reduction in the bilateral distances by 40 %, (iii) common borders between all trading partners (contiguity=0), and (iv) RTAs in force for all country pairs (RTA=0). To argue on and summarize the occurrent distribution effects we distinguish between four groups of countries, namely water rich exporters and importers, and water poor exporting and importing countries. We define countries as water poor (rich) if their endowments in renewable water are below (above) the median endowment in the total sample.

5.3 Counterfactual vs. baseline scenario

The counterfactual analysis aims at answering two crucial questions: (1) How does a reduction of specific trade barriers change the distribution of world market shares? and (2) How does a reduction of specific trade barriers influence the average prices on the demand and supply side?

Figure 3 provides a preliminary answer to the first question, namely how reduced trade barriers influence the distribution of world market shares. Figure 3 plots on the x-axis the bilateral distance of the trade flows and on the y-axis the cumulative nominal trade volume. The black data points refer to the base case, the grey dots picture the counterfactual trade volume when distance is reduced by 10 % (left graph) or 40 % (right graph). Overall, the figure reveals that more remote areas receive a larger proportion of water if distance were reduced (grey line is below black line). However, if trading partners are rather close to (within 2,000 km) or very far (distance > 12,500 km) from each other the proportion of water traded does not change. This graphical pattern indicates that a reduction in trade barriers

only moderately influences the trade volumes in potable water if countries already face rather low transportation costs due to low bilateral distances (below 2,000 km) or if countries trade rather little with each other anyway due to huge geographical distances between them (distances > 9,000 km).

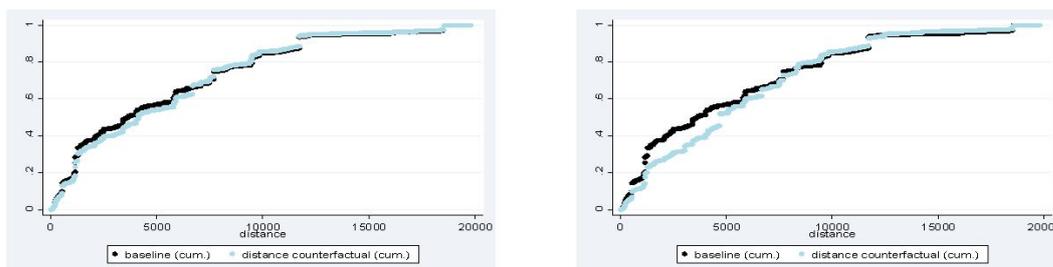


Figure 3: Cumulative nominal trade & distance; 10% (left) and 40 % (right) reduction in distance

The change in world market shares of exporting countries associated with reduced trade barriers may result from two sources: First, a direct bilateral effect due to reduced transportation costs and second, an indirect price effect originated from the change in the trade resistance terms. To understand the latter, we have to recall a crucial assumption in the theoretical model derived in Section 3.1: There, we assume that the endowment or supply of water is fixed and cannot be extended. This implies the following: Lower trade barriers reduce the transportation costs and the consumer price for water. Lower prices for water induce higher demand but as the supply of water is fixed higher demand has to result in higher supply prices so that the market is finally cleared (supply=demand).

To determine the relevance and magnitude of the direct (bilateral) and indirect (price) effects of reduced trade barriers on the countries' world market share, Table 4 reports the direct and total changes in the world market shares. These effects are summarized for the four different treatments, i.e., reduction of distance by 10 % and 40 %, implementation of contiguity for all countries; implementation of RTAs for all countries. We further group the exporters and importers according to their water endowments and distinguish between water rich and water poor countries.

The first two panels in Table 4 refer to the changes in world market shares if the geographical distance between the trading partners were reduced. We find a moderate increase of 1.3 % in the world market shares of water rich exporting countries when the distance is reduced by 10%. The effects increase considerably if the bilateral distance were reduced by 40 %. In this case, the world market shares of water rich exporters on the water poor importer market increase by 8.8 % at the

Table 4: Change (in %) in world market shares

Exporter	Direct effects		Total effects	
	Importer poor	rich	Importer poor	rich
Treatment 1: Reduction of distance by 10 %				
poor	-1.263	-0.178	-1.260	-0.179
rich	1.263	0.178	1.260	0.179
Treatment 2: Reduction of distance by 40 %				
poor	-8.786	2.211	-8.769	2.211
rich	8.786	-2.211	8.769	-2.211
Treatment 3: Implementation of contiguity				
poor	-14.537	3.804	-9.666	2.729
rich	14.537	-3.804	9.666	-2.729
Treatment 4: Implementation of RTA %				
poor	-7.981	3.429	-3.523	2.783
rich	7.981	-3.429	3.522	-2.783

costs of the water poor exporters serving water poor importer markets. However, if the exporter as well as the importer are water rich countries, the exporter's world market share decreases by 2.2 % for the benefit of the water poor exporters who export water to water rich importers. We find similar distribution effects when we assume that all countries have a common border or have RTAs in force. Again, compared to the baseline the group of water rich (poor) exporters shipping water to water poor (rich) importers can increase their world market shares. The direct effects range from an increase of 3.4 % (exports from water poor to water rich countries) when all countries have RTAs in force to 14.5 % (exports from water rich to water poor countries) if contiguity is introduced.

Comparing the direct effects with the total effects in the case of reduced geographical distances we find that these two impacts are almost identical implying that the changes in the countries' world market shares are induced by the direct effects and are not influenced by indirect price reactions. This pattern differs when we look at the changes associated with implementing contiguity or RTAs in all countries. In these cases, indirect price effects considerably reduce the direct effects by around 5 % (1 %) for water rich (poor) exporters in water poor (rich) importer markets.

The different indirect price effects across the experiments can be explained considering the (a)symmetry in the assumed treatments: While the supposed reduction in geographical distances influences all countries proportionally, the hypothetical

implementation of contiguity or RTAs only applies for those countries that are not neighbors or are not in RTAs which implies an asymmetric change in trade barriers. The results in Table 4 indicate that price effects only occur for asymmetric reductions of trade barriers.

In the following paragraphs we examine the price effects associated with reduced trade barriers in detail. We distinguish between prices at the demand (denoted by P_j) vs. prices at the supply side (denoted by Π_i) and address the question how these prices would change if trade barriers were reduced. Analogously to Anderson & Yotov (2010), we relate the countries' demand prices to the price in a reference country. In our context, we use the demand prices in the USA as reference, i.e., $P_{USA} = 1$. Therefore, whenever countries face lower (higher) demand prices than the USA, the price ratio is lower (higher) than one.

Before we discuss the changes in the average prices we explain how the prices for water relate to the countries' water endowments. From the theoretical model derived in Section 3.1 we can infer that the changes in the average demand and supply prices depend on the countries' supply of water, i.e., their water endowment Q_i . The higher the water endowments of the exporting country, the lower is – due to the higher availability of water – the mills price. Assuming that the water endowments in each country are fixed, lower mills prices induce – ceteris paribus – higher average supply prices. This results from the market clearing condition given in equation (4) which implies that $\Pi_i = \frac{1}{p_i} \frac{(\sigma-1)Q_i}{\sigma n_i \phi Y_w}$. Consequently, if importing countries are water rich, they face high average supply prices Π_i . But as equation (7) shows, high supply prices Π_i are associated with low average demand prices P_j ($P_j = \sum_{h=1}^J (t_{ij}/\Pi_i) \kappa_h^{1/(1-\sigma)}$).

The question left is whether the data support these theoretically motivated expectations. Figure 4 provides an answer. The left panel shows the relation between demand prices P_j (y-axis) and the importers' water endowment (x-axis) and the right panel relates the exporter prices Π_i (y-axis) to the exporters' water endowments (x-axis). The lines in both panels represent the prediction of a linear regression of the average prices on the countries' water endowments. These fitted lines support the theoretical expectations as they clearly indicate decreasing (increasing) average demand (supply) prices with increasing endowments of water.

Table 5 and Figures 5 and 6 summarize which countries face relatively high/low demand and supply prices for water. Table 5 lists the 15 water poorest countries, reports their GDP per capita, their water endowments, the average demand (P) and supply (Π) price and shows their price ranking. A high ranking, i.e., a small number, indicates that the country faces high average prices. For example, water

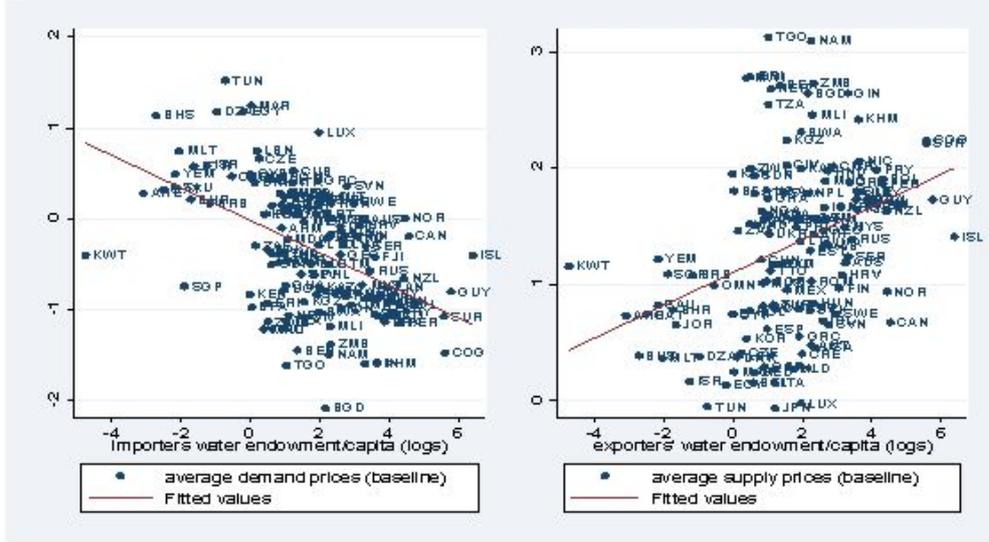


Figure 4: Relation between water endowment and average prices

poor Tunisia ranks first with respect to the demand prices which implies that its average relative consumer price is the highest among all countries and is 4.6 times as high as the USA's demand prices. At the same time, Tunisia has the 129th position regarding the average supply prices and therefore its supply price is among the lowest.

Table 5: Average price at demand and supply side – 15 water poorest countries

Importer	GDP_{pc}	$Water_{mio}$	P	Π	rank P	rank Π
KWT	0.127	0.009	0.669	3.171	72	77
ARE	0.224	0.046	1.318	2.079	28	102
BHS	0.016	0.066	3.106	1.477	5	114
QAT	0.068	0.082	1.379	2.096	24	101
YEM	0.030	0.115	1.626	3.377	14	72
SAU	0.626	0.116	1.410	2.270	23	91
MLT	0.012	0.129	2.097	1.444	8	118
SGP	0.292	0.151	0.476	2.969	86	79
BHR	0.025	0.178	1.235	2.187	34	95
JOR	0.030	0.195	1.786	1.921	11	105
ISR	0.379	0.285	1.796	1.182	10	124
BRB	0.007	0.314	1.179	2.932	38	81
DZA	0.185	0.382	3.247	1.467	3	116
TUN	0.064	0.484	4.569	0.950	1	129
OMN	0.064	0.585	1.588	2.697	15	85

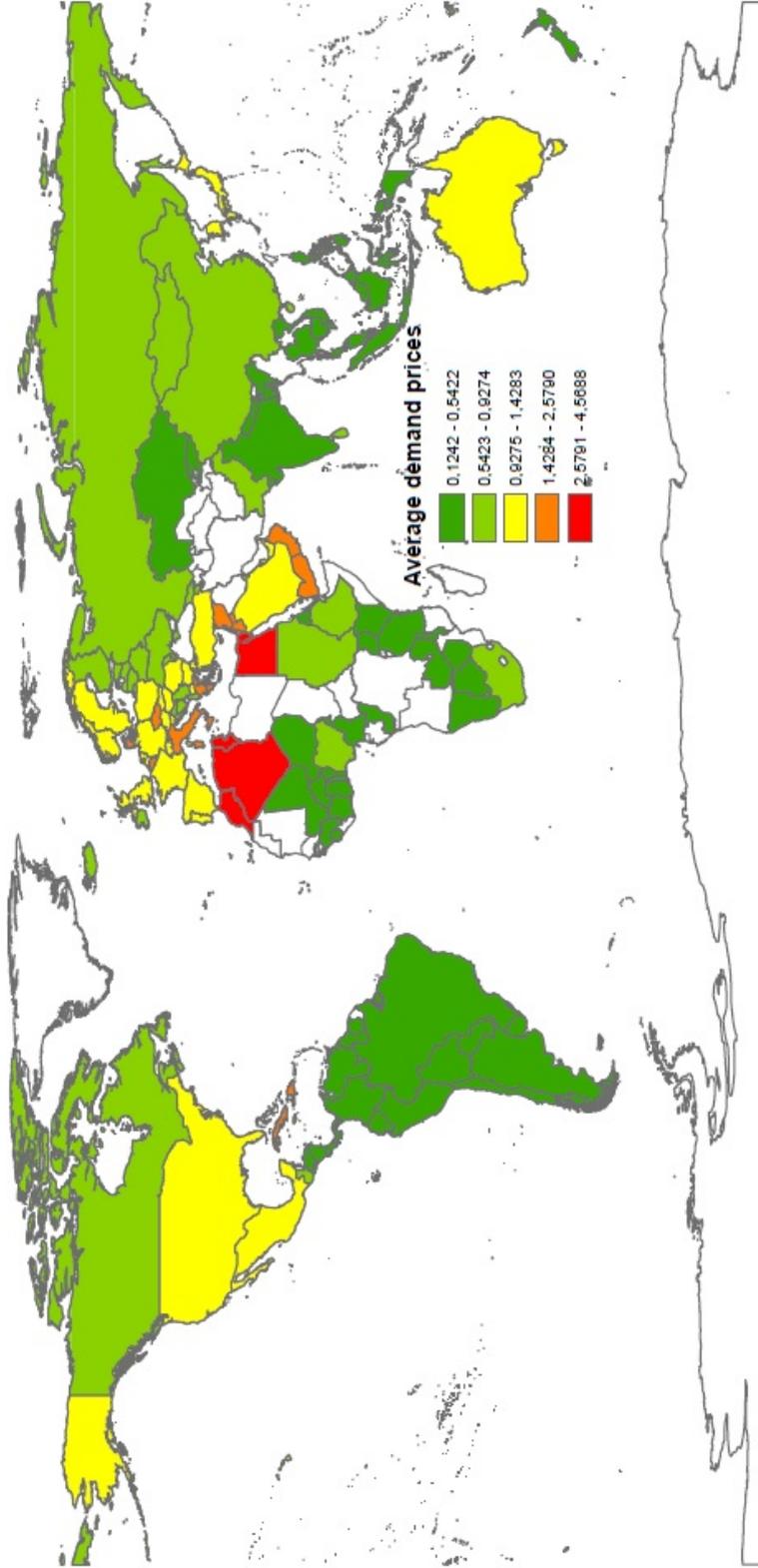


Figure 5: Average demand prices P

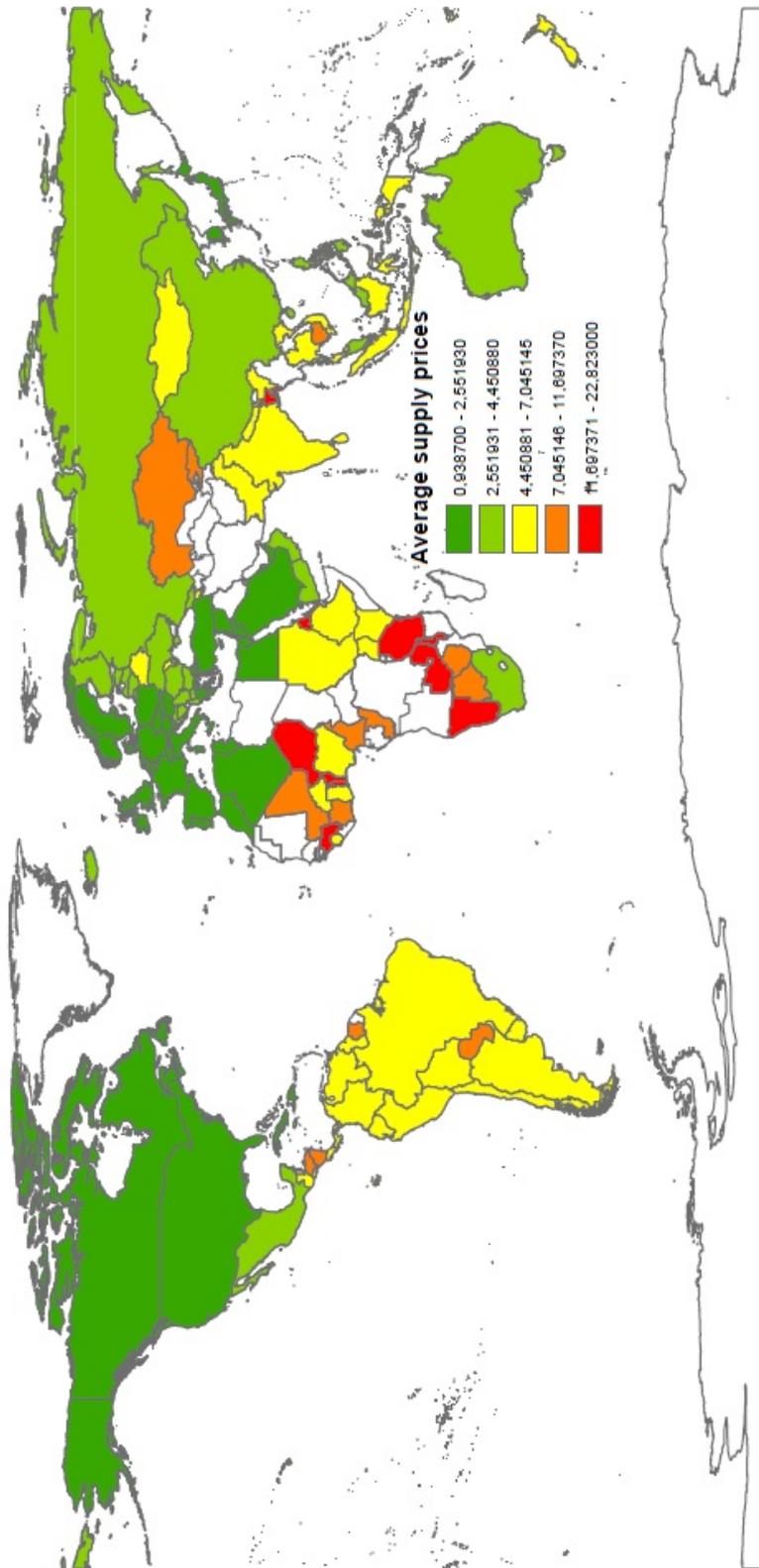


Figure 6: Average supply prices II

Figure 5 (Figure 6) plots the average demand (supply) prices for all the 130 countries in our sample. We see that Mexico, Australia, the majority of the European countries and Saudi Arabia face similar demand prices as the USA, while the average demand prices in the ‘green’ (red) countries are lower (higher) than the USA prices. With respect to the average supply prices pictured in Figure 6 we find that the supply prices in North America, in Europe, in Australia and in the majority of the Asian countries are considerably lower than the supply prices in Central Africa.

After having presented the average price levels on the demand and supply market we now turn to the question how these prices change if trade barriers were reduced. Analogously to the discussion of the change in world market shares, we again distinguish between water poor/rich exporters and importers and examine the change in prices due to the four experiments: reducing geographical distances by 10 % and 40 %, implementing contiguity and RTAs for all countries. In each panel of Table 6 we first list the demand prices followed by the supply prices. ‘*base*’ indicate the baseline prices which are compared to the counterfactual prices denoted by ‘*cf*’, i.e., the respective prices when trade barriers have been reduced.

The first two panels of Table 6 refer to the reduction of the geographical distance between the trading partners. They reveal that water poor importers face demand prices P that are about 31 % higher than the demand prices in the water rich importing countries. Contrary, the supply prices Π for water poor exporters are 28 % lower than the average supply prices for water rich exporters. A comparison of the base prices with the counterfactual prices shows that they are virtual identical indicating that a reduction in distance does not induce price changes. This outcome is consistent with the results regarding the changes in world market shares where we do not find evidence for indirect price effects.

The third panel shows the change in prices if all trading partners were neighboring countries. If all countries were neighbors, the average demand price in water rich importing countries would increase so that the demand prices between water rich and water poor countries converge and, hence, the price difference lowers to 26 % between the importing countries. A convergence of supply prices, i.e. lower differences between water rich and water poor exporting countries, is also observable which mainly results from reduced supply prices of water rich exporters.

In a world where all countries are involved in RTAs we find similar patterns as in the scenario with reduced geographical distances: The demand (supply) prices for water poor importers (exporters) are about 30 % (27 %) higher (lower) than the respective prices for water rich importing (exporting) countries. Here, we only find moderate changes of the counterfactual prices compared to the baseline.

Table 6: Change (in %) average price on demand and supply side

prices	Importer		Exporter		diff in %, p vs. r
	poor	rich	poor	rich	
Treatment 1: Reduction of distance by 10 %					
P_{base}	1.199	0.918			30.646
P_{cf}	1.199	0.918			30.651
Π_{base}			3.775	5.209	-27.530
Π_{cf}			3.674	5.070	-27.534
Treatment 2: Reduction of distance by 40 %					
P_{base}	1.199	0.918			30.646
P_{cf}	1.199	0.918			30.614
Π_{base}			3.775	5.209	-27.530
Π_{cf}			3.313	4.572	-27.532
Treatment 3: Implementation of contiguity					
P_{base}	1.199	0.917			30.647
P_{cf}	1.199	0.955			25.561
Π_{base}			3.762	5.195	-27.591
Π_{cf}			2.823	3.761	-24.942
Treatment 4: Implementation of RTA					
P_{base}	1.199	0.918			30.646
P_{cf}	1.213	0.932			30.217
Π_{base}			3.775	5.209	-27.530
Π_{cf}			3.287	4.474	-26.539

The results in Table 6 indicate that only the introduction of common borders leads to considerable price effects. It seems as if a symmetric reduction in trade barriers (which leaves relative distances unchanged) or the implementation of RTA (which still keeps the trading partners geographically parted) do neither influence the demand nor supply prices. It is the (non) contiguity of countries that crucially determine the average prices at the demand and supply side. And, as the results in Table 4 show, it is the contiguity of countries that induces the largest increase in world market shares.

Overall, we can conclude that a reduction of trade barriers influences the distribution of world market shares and also impacts the demand and supply prices of potable water. The magnitude of the changes induced depend on the treatments considered to reduce existing trade barriers.

6 Conclusion

This paper examines the determinants of bilateral flows of potable water defined as ‘mineral and aerated waters not sweetened or flavored’ (code 220110). To the best of our knowledge this is the first attempt to empirically investigate international trade flows in raw water.

Our regression results are based on a structural gravity equation which controls for bilateral trade barriers and importer and exporter fixed effects. We account for a possible systematic selection of countries into the group of water traders by applying Heckman’s sample selection model. The regression results and the subsequent counterfactual analysis highlight that trade barriers play a major role for the international trade of potable water.

First, we find that trade barriers significantly reduce the probability of participating in potable water trade as well as the volume of water traded. Second, the comparative statics reveals that reduced trade barriers influence the distribution of world market shares. In particular, if geographical distance (contiguity and RTA) were reduced (implemented), rich countries exporting to poor importers would experience the highest increase in world market shares. Third, we find that reduced trade barriers also affect the average supply and demand prices. The largest change in the average demand and supply prices occurs if trade barriers are asymmetrically reduced as it is the case if all trading partners were considered as neighbors: If contiguity were introduced, average demand (supply) prices of water rich importers (exporters) increases (decreases).

The results in this paper indicate that specific policy measures could increase potable water trade but the magnitude of the changes and the distribution effects may differ across various policies that aim at reducing distance costs. According to the counterfactual analysis, the most effective treatment is the asymmetric reduction of distance costs by reducing the barriers between non-neighboring countries. Such a policy leads to considerable changes in world market shares that favors exports from water rich to water poor countries. In addition, this asymmetric reduction increases (decreases) the average demand (supply) prices of water rich importers (exporters) and contributes to the convergence in prices of water poor and water rich countries.

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