
Comparing Gravity Model Specifications to Estimate NTBs Using the GTAP Framework

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1 Introduction

WTO market access analyses are an important topic in computable general equilibrium (CGE) modeling. Methods to calculate detailed tariff cuts, e.g., at the HS6 digit level, are well established and regularly used not least because of remarkable achievements like TASTE (Horridge and Laborde, 2008). In contrast, the detailed implementation of non-tariff barriers (NTBs) has yet received too little attention. This can be traced back to several reasons. Firstly, CGE modeling of WTO implementation has focused on the reduction and elimination of tariffs according to the commitments of the WTO agreements. Secondly, the effects of implemented NTBs (e.g., technical and sanitary regulations) are not always working in the same direction. The more NTBs are implemented the more difficult it gets to directly quantify their effects on trade mainly due to a lack of comprehensive data. Thirdly, currently available methods to estimate the effects of NTBs result in different outcomes which make it problematic to standardize a method and implement NTBs in CGE models.

In recent years research has concentrated on using gravity models to estimate effects of NTBs. The gravity model explains the trade volume between two countries by the exporter's production, the importer's consumption and the trade barriers between the two countries. Due to the deficiency of detailed information on NTBs several indirect approaches to quantify the effects of NTBs exist. One of the most commonly used approaches is the border effect approach which shows by how much international trade is different from the intra-country trade (McCallum, 1995). Controlling for all possible trade barriers such as transport costs and tariffs in the gravity equation, the border effect thus reflects the impact of NTBs on trade (Winchester, 2009). This methodology is considerably extended over time. Anderson and van Wincoop (2003) include multilateral resistance (MR) representing unobserved relative trade barriers that a country has with all other trading partners. The authors used non-linear programming to include MR terms. Alternatively, Feenstra (2002) shows that it is possible to apply importer and exporter fixed effects to obtain approximately similar results. Finally, Baier and Bergstrand (2009) introduce variables of MR approximations which produce consistent estimates, but are easier to calculate than applying non-linear least squares (NLS) programs. The country fixed effect and the MR approximation approach are mostly applied when specifying a theory-based gravity model. According to Baier and Bergstrand (2009) the two methods approximately produce the same results. Our paper aims to compare the two approaches by implementing the estimated NTBs in the Global Trade Analysis Project (GTAP) model. In so doing, we utilize the two gravity specifications to estimate the average effect of NTBs between the EU and Turkey. Following Anderson and van Wincoop (2003) and others we use the antilog and the elasticity of substitution to convert the quantity effects into ad-valorem tariff equivalents (AVEs). Finally, we implement the differently estimated NTBs in GTAP following Francois (1999, 2001) and remove in case of an EU enlargement all trade barriers, i.e., tariffs and NTBs. In so doing, we draw on the "iceberg cost approach" also used by Fugazza and Maur (2008) and others. We run two scenarios which are differentiated by only a changing set of AVEs of NTBs coming from alternative gravity specifications.

The paper is organized as follows. After the introduction the second chapter introduces the theoretical background of the gravity model. The third chapter discusses the alternative gravity specifications to estimate the effects of NTBs between the EU and Turkey and compares the results. After implementing AVEs of NTBs into the GTAP model chapter four compares the deviations in the simulation results. Finally, chapter five concludes.

2 Estimating the Effects of Non-Tariff Barriers using the Gravity Approach

2.1 Background and Theoretical Model

There are different methods to estimate AVEs of NTBs. The literature identifies two main approaches, namely price-based methods (i.e., price gap or econometric approach) and quantity-based methods¹. The latter mainly consists of different variants of gravity type trade models. The basic gravity model predicts in economic sense that the bilateral trade is positively determined by the economic size of the trading partners and negatively determined by the distance. Thereby, distance is a proxy for transport costs and with it for trade costs between the two countries. Introduced by Anderson (1979) and extended by Bergstrand (1985, 1989), Deardorff (1998) as well as Eaton and Kortum (2002) the gravity model was theoretically grounded through a variety of trade models. Especially in the course of the New Trade Theory a gravity equation was derived which describes intra-sectoral trade of similar economies (Anderson and van Wincoop, 2003). This led to its empirical success in the analysis of foreign trade relations. Advanced specifications include further factors to better capture trade costs. Contrary to other approaches the gravity model uses easily accessible trade data and makes it possible to estimate AVEs of NTBs in absence of explicit NTB information.

For our analysis we use the border effect approach to identify NTBs in the agricultural trade between Turkey and the EU in 2007. Originated by McCallum (1995) and advanced by Anderson and van Wincoop (2003) the border effect compares intra-national with international trade. It reveals how much international trade falls below the trade within countries due to barriers resulting from international borders, i.e., tariffs, non-tariffs measures and all other factors that might hinder trade². The advantage of this approach is that the border effect summarizes all impediments including those that are difficult to measure directly. Particularly in agriculture there is a lack of reliable and updated statistics on technical regulations and phytosanitary standards which significantly influence agro-food trade. There is a vast amount of studies dealing with the magnitude of border effects (e.g. Helliwell, 1996, 1998; Head and Mayer, 2000, Nitsch, 2000, Wolf, 2000), but there are only few papers applying the theory based border effect approach on agricultural trade, namely Chen (2004), Olper and Raimondi (2008a), Olper and Raimondi (2008b), Winchester (2009) as well as Chang and Hayakawa (2010).

We adopt the generalized gravity model developed by Anderson and van Wincoop (2003, 2004) in that the endogeneity of prices is accounted properly. In equilibrium situation bilateral trade depends on exporter and importer price levels which themselves depend on trade barriers. The model takes the following form

$$x_{ij} = \frac{y_i y_j}{y_w} \left(\frac{t_{ij}}{P_i P_j} \right)^{1-\sigma} \quad (1)$$

where x_{ij} is the export value from i to j , y_i (y_j) is the exporter (importer) production (consumption), y_w is the global output, t_{ij} is the bilateral trade resistance, σ is the elasticity of substitution between all goods; P_i (P_j) are CES consumer price indices for i and j , respectively. They are defined as a function of each country's full set of bilateral trade resistance terms:

¹ See Deardorff and Stern (1997) and Ferrantino (2006) for a more thorough review of methods.

² The border effect approach is conceptually identical to the home bias effect that describes the national tendency to prefer domestic goods over foreign goods. Alike home bias is the result of trade policies and inherent consumer preferences (Ghazalian, 2011).

$$P_i = \left(\sum_{j=1}^J \left(\frac{t_{ij}}{P_j} \right)^{1-\sigma} \theta_j \right)^{1/(1-\sigma)} \quad P_j = \left(\sum_{i=1}^I \left(\frac{t_{ij}}{P_i} \right)^{1-\sigma} \theta_i \right)^{1/(1-\sigma)} \quad (2)$$

Here, θ_{ij} indicates the income shares of country i and j . The component t_{ij} as a function of unobservable trade costs can be replaced by observable trade costs in form of transport costs d_{ij} and a border variable b_{ij}

$$t_{ij} = d_{ij}^\rho b_{ij}^{\delta_{ij}} \quad (3)$$

where d_{ij} is the distance between i and j and ρ the corresponding coefficient. $(b_{ij} - 1)$ is the AVE of all trade barriers resulting from an international border. The factor δ_{ij} takes the value of one if i and j are different countries and zero if i and j are the same country which represents international and intra-national trade, respectively (Anderson and van Wincoop, 2003). Typically, a further set of continuous variables (tariffs, export subsidies) and dummy variables (contiguity, common language and colonial history) are components of the trade cost function.

2.2 Empirical Specification

We replace the cost function in equation (1) with (3) and take the logarithms to derive an empirical log-linear form.

$$\ln x_{ij} = c + \ln y_i + \ln y_j + (1-\sigma)\rho \ln d_{ij} + (1-\sigma)\delta_{ij} \ln b_{ij} - (1-\sigma) \ln(P_i) - (1-\sigma) \ln(P_j) \quad (4)$$

where $c = -\ln y_w$ is the constant. The most important part in order to estimate the above equation is the accounting of the price indices. They comprise the endogenous multilateral resistance capturing costs of bilateral trade between two regions which are affected by the average trade cost of each region with the rest of its trading partners. They form the substitutability between country's different trading partners and allow accounting for unobserved heterogeneity in econometric sense (Anderson and van Wincoop, 2003). The omission of these relative trade costs led to the misspecification of traditional cross-sectional gravity equations and hence to biased gravity equation estimates. After the refinement of the theoretical foundation the problem occur how to consider these unobservable price resistance terms for exporting and importing countries. Early attempts included remoteness as a proxy in form of GDP-weighted averages of each country's distance from all its trading partners (e.g. Wei, 1996; Wolf, 1997; Helliwell, 1996; Head and Mayer, 2000). However, these remoteness variables are not motivated by theory. Anderson and van Wincoop (2003) used NLS programming to calculate the price terms. However, this is a computationally burdensome method so that the practical application has not become accepted. A simpler technique and for this reason the most common is to use importer and exporter fixed effects which capture the country-specific prices (e.g., Feenstra, 2002; Chen, 2004; Olper and Raimondi, 2008a; Winchester, 2009). The final possibility is to calculate multilateral resistance variables following the approach of Baier and Bergstrand (2009) and Baier et al. (2010). The authors approximate MRTs using a first order log-linear Taylor-series expansion to the system of price equations (2). In that way they generate a reduced-form gravity equation with theory-motivated MRTs that only include exogenous variables. The advantage over the NLS approach is the simplicity and comparing with fixed effects estimation this approach allows for explicit estimation of country-specific variables. Additionally, there is a practical advantage. The inclusion of fixed effects is subject to the dimension of the data. A dataset consisting of pair, time and sector dimensions would require the inclusion of thousands of dummies

into the equation which can be computationally problematic. In order to estimate theory-consistent border effects we set up two different gravity equation settings. The first setting includes MRTs as in Baier and Bergstrand (2009) (MRTs) and the second one includes fixed effects for exporters and importers (FE). For sensitivity analysis we also run equations without accounting for multilateral resistance (no MR) and with atheoretic remoteness variables (RV). We further include additional bilateral variables and an error term to obtain the following estimable equation:

$$\begin{aligned} \ln x_{ij} = & \beta_1 + \beta_2 \ln \text{Prod}_i + \beta_3 \ln \text{Consum}_j + \beta_4 \ln \text{Dist}_{ij} + \beta_5 \text{Landlocked} \\ & + \beta_6 \text{Contig}_{ij} + \beta_7 \text{Lang}_{ij} + \beta_8 \text{RTA} + \beta_9 \ln(1 + \text{AVE}_{\text{tariff}}) + \beta_{10} \ln(1 + \text{AVE}_{\text{esub}}) \\ & + \beta_{11} b_{\text{EU}} + \beta_{12} b_{\text{EU/TUR}} + \beta_{13} b_{\text{TUR/EU}} + \beta_{14} b_{\text{OTHER}} + P_i + P_j + \varepsilon_{ij} \end{aligned} \quad (5)$$

x_{ijk}	Export value from i to j
Prod_{ik}	Production value of i of j
Consum_{jk}	Consumption value of j
Dist_{ij}	Distance between i and j
Landlocked	Ordered discrete variable expressing the number of landlocked countries (0,1, or 2)
Contig_{ij}	Dummy variable taking the value one for contiguity of the two countries
Lang_{ij}	Equal to one if a language is spoken by at least 9% of the population in both countries
RTA	Equal to one if both countries are members in an RTA
$\text{AVE}_{\text{tariff}}$	Ad-valorem tariff imposed by region j on exports from i
AVE_{esub}	Ad-valorem export subsidy imposed by region i on exports to j
b_{EU}	Equal to 1 if the dependent variable measures intra-EU trade
$b_{\text{EU/TUR}}$	Equal to 1 if the dependent variable measures the exports from EU to Turkey
$b_{\text{TUR/EU}}$	Equal to 1 if the dependent variable measures the exports from Turkey to EU
b_{OTHER}	Equal to 1 if the dependent variable measures cross-border trade not mentioned before
P_i, P_j	Factors to account for multilateral resistance (RV, FE, or MRTs for each bilateral variable)
ε_{ij}	Error term

We apply the above equation for four aggregated sectors (heavy and light manufacturing, services, extraction) and for 20 disaggregated agricultural sectors³. In the aggregated regressions we also include sectoral dummies to account for sector specific unobserved heterogeneity⁴. In the disaggregated sector regressions with country fixed effects we do not include production and consumption due to collinearity problem. To our best knowledge this paper is the first one considering multilateral resistance in the form of BB MRTs for disaggregated sector regressions and comparing to fixed effects estimation results. Although the theory based gravity equation implies size-adjusted trade ($\beta_2 = \beta_3 = 1$), we do not impose this constraint. We also keep the constant unconstrained. Furthermore, according to the theory the MR approximation terms should be restricted to equal but opposite coefficients to underlying respective bilateral variables. However, we leave them unrestricted. The most interesting parameters to estimate are coefficients of the border dummies. A negative sign indicate the preference for trading within the country rather than with other countries. The border coefficient equals to $\beta_{bij} = (1-\sigma)\ln b_{ij}$. Taking the antilog of the estimated border coefficient we obtain the magnitude of the border effect quantifying how much intra-national trade is larger than international trade. Or in other words how much international trade falls below intra-country trade.

³ See sectoral aggregation in Table A2 in the Appendix.

⁴ Actually our setting requires the inclusion of exporter-sector and importer-sector fixed effects. However, this would lead to the inclusion of 3762 (=2*33*57) dummy variables which is technically infeasible.

2.3 Data and Estimation Technique

We source data on bilateral exports, production values, consumption values, bilateral tariffs and export subsidies from version 8 (base year 2007) of the GTAP data base. In order to apply the border effect approach we also need intra-national trade. Following Wei (1996), Chen (2004) and other authors thereafter, we calculate a country's exports to itself by subtracting each country's aggregate exports (to all international destinations) from its domestic production in each sector. The GTAP data base offers 129 regions and 57 sectors. We reduce the number of regions to 33 OECD countries. Our regression analysis includes 62073 observations. Of those 60192 ($=33*32*57$) are bilateral cross-border trade observations and 1881 ($=33*57$) are intra-country trade observations. Information on distance, contiguity, common language and colonial relationships are from the Centre D'Etudes Prospectives et D'Informations Internationales (CEPII)⁵. For our analysis we use bilateral distances between two countries as population-weighted average distances between major cities in countries of interest. This enables us to also use intra-national distances⁶. One serious problem in estimating a gravity model in the typical log-linear specification is the presence of zero trade flows (6.8% of the export flows in our dataset). Because logarithms of zero are not defined, a truncation or rescaling of the dependent variable would be needed. Furthermore, Santo Silva and Tenreyro (2006) show that using OLS to estimate the log-linear equation results in biased and inconsistent estimates in the presence of heteroskedasticity. Instead the authors employ the more advantageous Poisson pseudo-maximum likelihood (PPML) estimator⁷. Burger et al. (2009) discuss the suitability of other Poisson family estimators (Negative Binomial (NBR) and Zero-Inflated Poisson (ZIP)) in the case of overdispersion and presence of excess zeros. We decided on the ZIP estimator to have an economic rationale for higher frequency of zeros⁸. Depending on the size of zero observations in each sector and on the Vuong test statistic we apply the PPML or the ZIP regression. Applying the Poisson regression we rearrange the gravity equation given in equation (5) according to an exponential function.

2.4 Estimation Results

Table 1⁹ presents the ZIP estimation results after pooling the observations across agro-food sectors. There are 21780 observations of which 1316 observations are zero. The first two columns show the results for the atheoretical gravity specifications and the last two columns show the results of the theoretical specifications considering MR. In terms of the logit regression, the probability for zero trade values increases with the distance and decreases with common border and common language. The coefficients are highly significant and according to our expectations. This confirms the use of the ZIP estimator. Also the significant positive Vuong test statistic supports the choice of the ZIP estimator. A joint Wald-test of the significance of the proxies of MR is rejected in all regressions. Also, there is a joint significance of the sector dummy variables in all aggregated sectors.

⁵ See <http://www.cepii.fr/anglaisgraph/bdd/distances.htm>

⁶ An accurately estimated intra-national distance measure is of great importance because an underestimation of distances would lead to larger border effects in order to explain the preference for domestic goods. There is a huge amount of studies analyzing the effect of different distance measures and geographical aggregations on the border effect (e.g. Head and Mayer, 2002; Hillberry and Hummels, 2008; Linao-Verduras et al., 2011).

⁷ See Gómez-Herrera (2012) for a review and comparison of estimation techniques.

⁸ The NBR estimator has been tested, but is not presented in this paper.

⁹ Because proxies for MR are included in the gravity equation to correct for omitted variable bias and do not serve for economic interpretation and for clarity reasons they do not appear in the table.

Table 1: Regression Results of Aggregated Agro-Food Sector¹⁾

	No MR	MR in Remoteness Variables	MR in Country Dummies	Approximation Terms of MR
Constant	-4.6148***	-2.24***	3.7753***	-5.014***
ln(Production)	.5559***	.56124***	.7532***	.56141***
ln(Consumption)	.5487***	.54771***	.3334***	.55152***
ln(Distance)	-.0454***	-.0938***	-.9524***	-.11626***
Contiguity	1.2689***	1.2279***	.40482***	1.2024***
Language	.7298***	.70528***	.79354***	.70562***
Landlocked	-.7039***	-.6926***	-.6256***	-.68332***
RTA	.4696***	.44259***	-.11221	.43383***
ln(1+AVE _{tariff})	-0.0875	-.08232	-.79188*	-.11475
ln(1+AVE _{esub})	.8479	.79506	1.7081**	.94568
bEU	-2.6507***	-2.5981***	-1.8696***	-2.569***
bEUTUR	-4.7009***	-4.6435***	-4.1366***	-4.9447***
bTUREU	-3.9739***	-3.9032***	-2.656***	-3.7173***
bOTHER	-3.4527***	-3.4156***	-2.6821***	-3.3826***
X _{ij} = 0				
Constant	-3.1938***	-3.1938***	-3.1871***	-3.1938***
ln(Distance)	0.0715***	0.0715***	0.0706***	0.0715***
Contiguity	-2.2583***	-2.2583***	-2.2601***	-2.2583***
Language	-0.5221***	-0.5221***	-0.5209***	-0.5221***
<i>N</i>	21780	21780	21780	21780
<i>Nonzero N</i>	20464	20464	20464	20464
<i>Zero N</i>	1316	1316	1316	1316
<i>log pseudo-likelihood</i>	-4.1E+11	-4.00E+11	-3.10E+11	-4.0E+11
Chi2	1.80E+05	1.70E+05	3.10E+05	1.80E+05
<i>Vuong</i>	19.22***	19.38***	18.80***	20.38***

1) * p < 0.05; ** p < 0.01; *** p < 0.001

Source: Author's own calculations

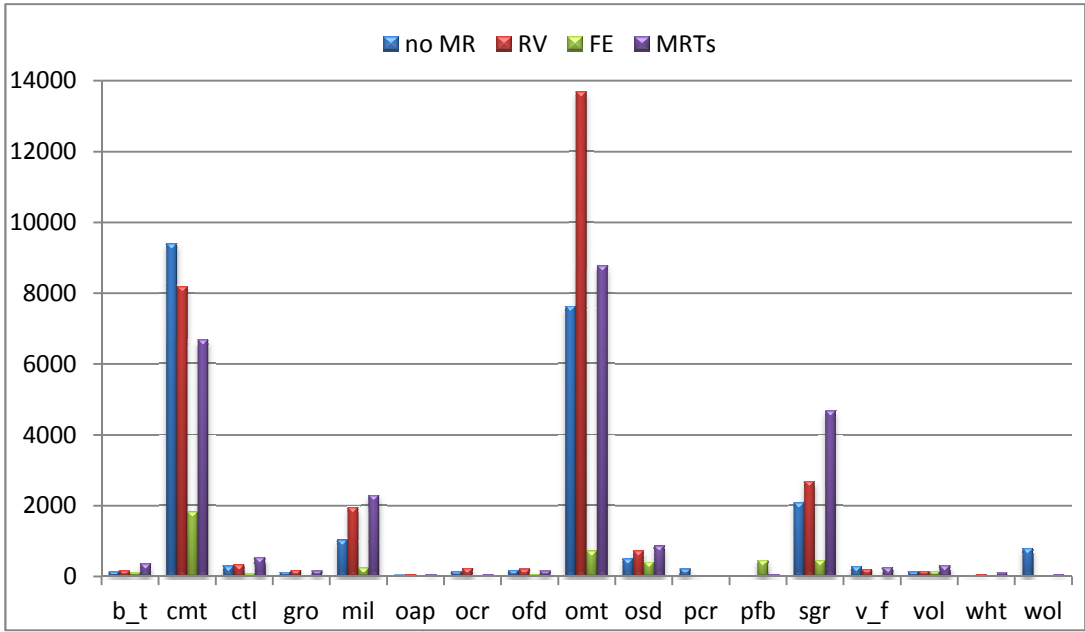
Most coefficients have the expected signs and are statistically significant. Consumption and production induce the expected positive effect on trade in all sectors and are highly significant. While the coefficients for

consumption and production are similar in values and also across atheoretical specification and MRTs specification, they are not in the FE estimation. Here, the variation in bilateral trade over the sectors is affected by supply and less by demand pull. The existence of a common border and language between two nations also positively influences trade in all sectors. While the coefficients for common border are higher in the regressions with no MR, RV and MRTs than in FE estimation, the coefficients for common language are similar in magnitude. The elasticity of trade with respect to distance is expectantly negative. Atheoretical specifications reveal much lower elasticities than theoretical specifications. Also, the coefficients for the variable landlocked are significantly negative in all equations. The elasticity of trade with respect to distance is highest in the fixed effects estimation. Exports decrease by 0.95% comparing to 0.11%, 0.09% and 0.05%, if the distance between two countries increases by 1%. As expected the coefficient for tariffs (subsidies) show a negative (positive) sign, but are only significant in the FE estimation. Exports decrease by 8% if tariffs increase by 1%. Winchester (2009) came to a similar result using fixed effects estimation. Exports increase by 1.7% if subsidies increase by 1%. The coefficients of the border dummies are negative and significant in all specifications. Accordingly, there is a negative influence of international borders. The lowest border effects are in the intra-EU trade and the highest in when EU is exporting to Turkey across all specifications. FE estimation results in the lowest border dummy coefficients whereas the other specifications show comparable results. After controlling for distance and other trade cost factors the ratio of i 's exports to j to i 's exports to itself is given by the exponential of the coefficient on the i - j border dummy, b_{ij} . The border coefficient for the EU in the FE estimation (MRTs estimation) of -1.8696 (-2.569) means that intra-country agricultural trade is, on average 6.49 ($=\exp(1.8696)$) (13.05 ($=\exp(2.569)$)) times larger than the cross-border trade within EU. Our estimated coefficients on intra-EU border dummies are in line with the results for border effects for intra-EU trade in Olper and Raimondi (2008a) as well as Chen (2004). Thus, depending on the MR specification the border effect can be doubled. The same is true for the border effects between the EU and Turkey. In the FEs estimation EU's exports of agro-food products to itself are 62.59 times larger than EU's exports to Turkey. Turkey's agro-food exports to itself are 14.24 times larger than Turkey's exports to the EU. These numbers show that Turkey implies much higher border barriers on EU's export goods than EU on Turkey's exports. Regarding the results from the regressions with MRTs, EU's exports of agro-food products to itself are 140.43 times larger than EU's exports to Turkey and Turkey's exports to itself are 41.15 times larger than Turkey's exports to the EU. These numbers also show that Turkey implies much higher border barriers. However, the results from the regressions with MRTs reveal much higher border effects than from the fixed effects estimation. In all regressions the border effect is lower within the EU than between the EU and Turkey. Expectantly, there is a lower level of NTBs and more harmonization of regulations between EU member countries than between EU countries and a third country like Turkey. We obtain similar results for the disaggregated agricultural sectors

Figure 2 and 3 show the border effects for 17 agricultural sectors trade between EU and Turkey resulting from the two theoretical MR settings and compared to border effects from regressions without any accounting of multilateral resistance (nor MR) and from regressions with atheoretical remoteness variables (RV). The highest border effects on EU's export to Turkey are in the sectors cattle meat, other meat products, sugar, dairy products and oil seeds. In all these sectors the FEs border effect is the lowest. The lowest border effects are in the sectors wheat, other animal products, processed rice and wool. In the remaining sectors border effects resulting from the fixed effects estimation are the lowest, except in the sector plant-based fibres. Comparing with the border effects on Turkey's exports to the EU a different picture appears. The highest border effects are also in the sectors cattle meat, other meat products and dairy products, but contrary also

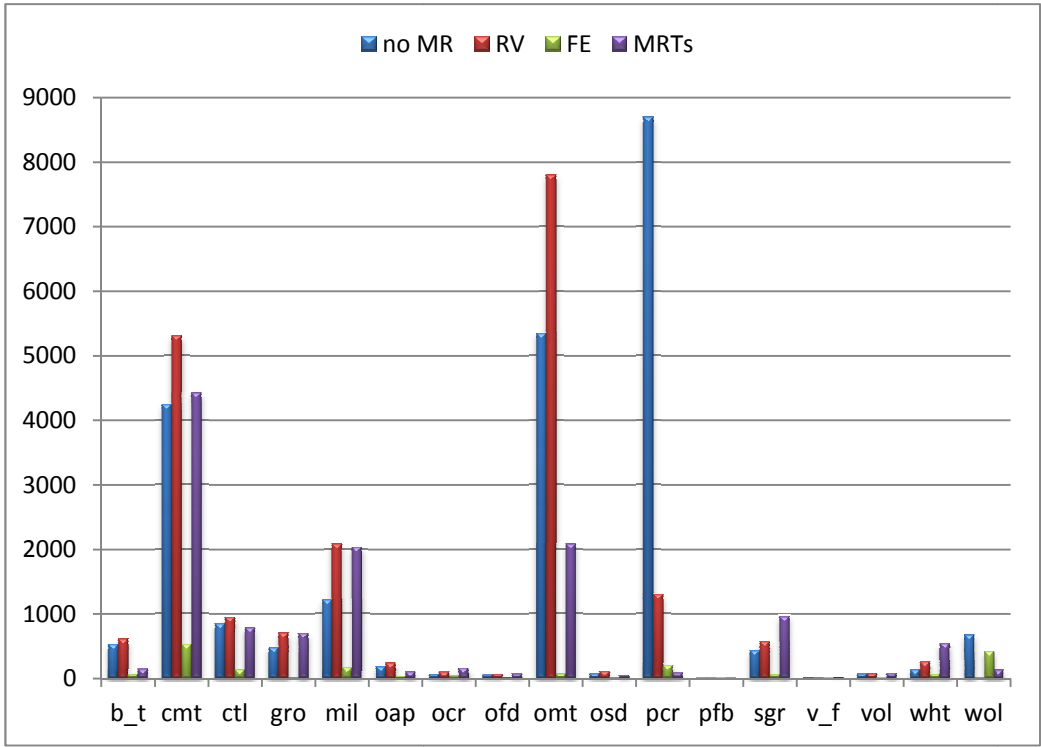
in processed rice, cattle and cereal grains. The lowest are in the sectors vegetables and fruits, plant-based fibres and in other food products. Here mostly the atheoretical border effects are the highest. Exceptions are the sugar sector and the wheat sector.

Figure 1: Border Effects on EU's Exports to Turkey



Source: Author’s own calculations.

Figure 2: Border Effects on Turkey's Exports to the EU



Source: Author’s own calculations.

2.5 Calculation of Tariff Equivalents

The theoretical foundation of the gravity model enables us to transform the effects of border barriers into border trade costs using the elasticity of substitution and the coefficient of the border dummy. To calculate tariff equivalents of non-tariff trade barriers we use $AVE_{bij} = \exp[\beta_{ij}/1-\sigma] - 1$, where AVE_{bij} is the AVE of border barriers, e.g., $AVE_{EU/TUR}$ indicates the complexities faced by the EU when exporting its products to Turkey concerning the implied effect on price. β_{ij} is the coefficient applying to the border dummy b_{ij} and σ is the elasticity of substitution between goods. The main problem is to choose the correct elasticity of substitution. In the literature it is common to use the values 3, 5 and 7. It is also possible to use the elasticity of substitution from the GTAP database according to our sector aggregation. It offers two different elasticities: ESUBM and ESUBD, where ESUBM is equal to ESUBD multiplied by two. We employ all these option for the elasticity of substitution and also add the double of ESUBM (ESUBM2). The rationale for the latter one is that some authors show that the elasticity of substitution in the GTAP database is significantly low (Hummels, 2001; Heasd and Ries, 2001). AVEs of border barriers cover the average level of importing country protection (tariffs and non-tariffs trade barriers) and further non-policy factors (network differences, information related costs, preferences in national goods, etc.) not captured by the proxies in the gravity equation. By controlling for transport costs and other trade costs in the gravity equation it is assumed that border trade costs mainly reflect the effects of NTBs.

Following the approach of Winchester (2009) we use the existing border barriers between EU members as a benchmark assuming that the effects of NTBs between member countries is low and that a successful enlargement would involve a similar low level of NTBs between EU and Turkey¹⁰. We calculate AVEs of NTBs facing EU's exports to Turkey by subtracting AVE_{EU} from $AVE_{EU/TUR}$, if AVE_{EU} is lower than $AVE_{EU/TUR}$. In the same way we calculate AVEs of NTBs facing Turkey's exports to the EU by subtracting AVE_{EU} from $AVE_{TUR/EU}$, if AVE_{EU} is lower than $AVE_{TUR/EU}$. In cases when AVE_{EU} is greater than $AVE_{EU/TUR}$ and/or greater than $AVE_{TUR/EU}$, we assume that the accession of Turkey into the EU would not change the level of NTBs. In cases when the coefficient of the border dummy is insignificant, we assume that no border barriers exist. By setting those insignificant coefficients to zero we get border effects of 1. This means that intra-national trade is not larger than international trade resulting in zero NTBs.

Table 2 reports the benchmarked AVEs of NTBs between the EU and Turkey calculated using ESUBM2. In terms of FE (MRTs) results AVEs of NTBs imposed by Turkey on EU's exports range between 3.81% (5.61%) in light manufacture to 57.49% (61.76%) in services. In the disaggregated agricultural sectors they range between 2.74% in wheat (5.54% in wool) to 161.62% (254.14%) in beverages and tobacco in the FE (MRTs) estimations. According to the FE estimation Turkey imposes no AVEs of NTBs on the exports of crops and wool. However, as a result of the MRTs regressions there are no NTBs on processed rice exported from the EU. AVEs imposed by EU on Turkey's exports range between 7.11% (7.91%) in heavy manufacture to 27.74% (32.79%) in services. In the disaggregated agricultural sectors they range between 10.77% in other crops (1.99% in oil seeds) to 107.16% in beverages and tobacco (257.57% in cereal grains) in FE (MRTs) estimations. Following the fixed effect results EU imposes no NTBs on Turkey's export in the sectors light manufacturing, oil seeds and plant based fibres. However, according to the results of the MRTs regressions

¹⁰ The existing border effects between EU member countries are assumed to be the result of fundamental components (infrastructure, networks, natural geography) and taste biases which are endogenous and not entirely to eliminate (Nitsch and Wolf, 2009). Through benchmarking the AVEs of border barriers between the EU and Turkey to the EU level we assume to eliminate at least the remaining policy measures.

there are no NTBs in the sectors light manufacturing and also plant-based fibres. Partly there are very high differences between the AVEs of NTBs coming from the alternative theoretical MR settings, especially in the sectors beverages and tobacco, grains, fruits and vegetables and plant-based fibres. In sum, comparing to other studies the results for AVEs of NTBs seem to be reasonable for most sectors. Especially, our estimated AVEs of NTBs for agriculture and manufacturing within the EU are in line with recent studies. However, we estimated strikingly higher AVEs of NTBs for services and beverages and tobacco which are much lower in Park (2002) as well as in Philippidis and Sanjuan (2007a, 2007b).

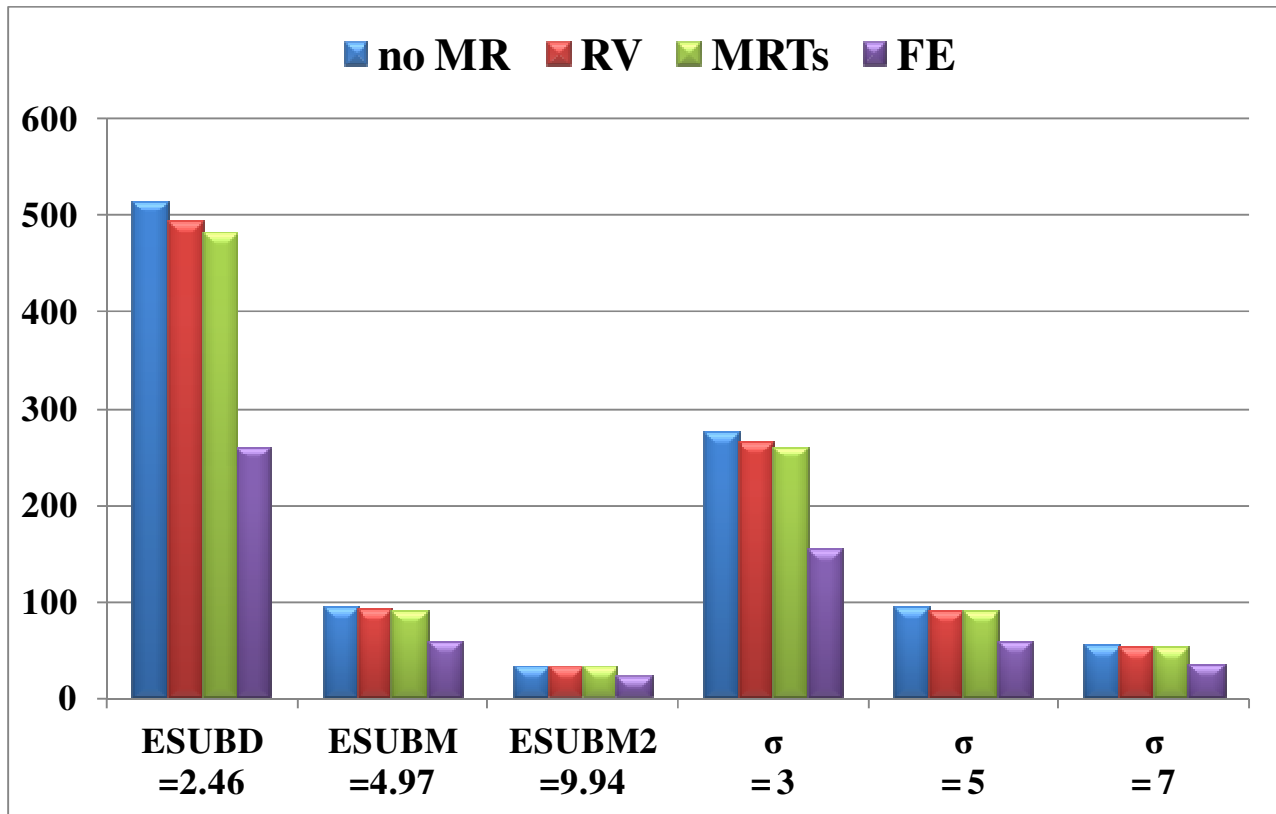
Table 2: Implied AVEs of NTBs (%)

σ (ESUBM)*2	sector	no MR		RV		FE		MRTs	
		EUTUR	TUREU	EUTUR	TUREU	EUTUR	TUREU	EUTUR	TUREU
13.6	lightmnfc	2.53	0.00	2.46	0.00	3.81	0.00	5.61	0.00
14.5	heavymnfc	2.76	8.68	5.70	0.00	5.82	7.11	6.89	7.91
7.7	serv	63.51	28.47	64.43	28.60	57.49	27.74	61.76	32.79
23.3	extraction	10.14	4.68	10.02	4.53	4.51	7.13	7.31	9.69
4.6	b_t	150.09	329.10	164.24	342.87	161.62	107.16	254.14	137.27
15.4	cmt	69.52	59.39	66.08	60.56	55.15	41.19	62.52	57.32
8.0	ctl	69.23	106.33	70.32	107.01	49.16	68.76	77.03	90.49
5.2	gro	124.41	244.46	134.20	265.62	106.35	49.04	118.40	257.57
14.6	mil	42.09	44.23	45.48	46.35	33.31	29.36	45.14	43.58
5.2	oap	28.81	135.78	29.83	144.39	5.52	48.73	30.50	71.15
13.0	ocr	22.82	12.42	24.34	13.40	0.00	10.77	7.81	18.84
8.0	ofd	63.03	30.15	64.81	30.65	46.65	18.31	54.87	30.78
17.6	omt	54.84	51.21	58.31	52.40	43.07	23.45	51.46	37.11
9.8	osd	63.74	23.66	65.24	23.88	63.43	0.00	62.84	1.99
10.4	pcr	20.41	105.71	11.96	83.32	26.20	75.76	0.00	59.78
10.0	pfb	0.00	0.00	0.00	0.00	56.82	0.00	16.33	0.00
10.8	sgr	83.59	51.31	85.90	53.11	72.55	37.80	102.20	66.81
7.4	v_f	105.84	0.32	96.18	0.86	65.85	29.74	111.34	26.52
13.2	vol	32.80	25.05	33.79	25.26	50.16	13.77	44.85	27.53
17.8	wht	10.70	21.07	11.36	22.47	2.74	20.53	14.02	27.87
25.8	wol	7.75	6.88	0.00	0.00	0.00	27.55	5.54	9.69

Source: Authors' own calculation.

Figure 3 shows the AVEs of border barriers in the aggregated agro-food sector existing between EU member countries using different MR settings in the gravity equation and different elasticities of substitution. Calculating the AVEs of NTBs with varying elasticity of substitution it is evident that the size of the AVEs and thus the deviations between different MR settings increase disproportionately with lower elasticity of substitution. The highest AVEs are obtained using ESUBD from the GTAP database and the lowest with ESUBM2. Concluding the choice of the elasticity of substitution can have a much higher effect on the sizes and differences in the AVEs of NTBs than the choice of the MR setting in the gravity framework.

Figure 3: AVEs of border barriers in aggregated agro-food sector within the EU (%)



3 Simulations with Global Trade Analysis Project (GTAP) Framework

The CGE simulations in this paper utilize the comparative static multi regional general equilibrium GTAP model. This model provides a detailed representation of the economy including the linkages between farming, agribusiness, industrial and service sectors of the economy. The use of the non-homothetic constant difference of elasticity (CDE) functional form to handle private household preferences, the explicit treatment of international trade and transport margins and a global banking sector which links global savings and consumption are innovative in GTAP. Trade is represented by bilateral matrices based on the Armington assumption. Further features of the standard model are perfect competition in all markets as well as a profit and utility maximizing behavior of producers and consumers. All policy interventions are represented by price wedges. The framework of the standard GTAP model is well documented in Hertel (1997) and available on the internet.¹¹

Francois (1999, 2001) developed an approach where NTBs are modeled as iceberg or dead-weight trade to study the Doha Round of the WTO negotiation. This approach has been extended by Hertel et al. (2001a, 2001b) who also aimed at the connection between NTBs and CGE modeling treating NTBs as unobserved trade costs which are not explicitly in the GTAP data base. The authors introduce an additional “effective” import price that is a function of the observed import price and an exogenous unobserved technical coefficient (Hertel et al., 2001a, p. 13):

$$pms_{irs}^* = pms_{irs} - ams_{irs} \quad (5)$$

¹¹ See www.gtap.org.

where: pms_{irs}^* percentage change of effective import price of i supplied from region r to region s
 pms_{irs} percentage change of domestic price for i supplied from r to region s
 ams_{irs} import i from region r augmenting tech change in region s

Removal of trade costs from a particular exporter are reflected in an increase of ams_{irs} under the assumption that ams_{irs} is equal to one in the initial equilibrium. The effective domestic price of good i exported from region r to s falls and thereby mirrors a reduction of real resource costs. This approach of modeling a removal of NTBs as a reduction in trade costs draws on the iceberg transport costs theory as it is originally introduced by Samuelson (1954). Other authors (e.g., Fugazza and Maur, 2008) also name this the “sand in the wheel” approach.

An increase of ams_{irs} and the corresponding efficiency enhancement furthermore implies that the effective imported quantity of good i from region r to region s is increased ($qxs_{irs}^* = qxs_{irs} + ams_{irs}$) which leads to the following import demand and composite import price equation (Hertel et al., 2001a, p. 13):

$$qxs_{irs} = -ams_{irs} + qim_{is} - \sigma^i \cdot (pms_{irs} - ams_{irs} - pim_{irs}) \quad (6)$$

$$pim_{is} = \sum_k \theta_{iks} \cdot (pms_{iks} - ams_{iks}) \quad (7)$$

where: qxs_{irs} percentage change in bilateral exports of i supplied from r to region s
 qim_{is} percentage change in average imports of i supplied from region r to region s
 pim_{is} percentage change in average import price of i supplied from region r to region s
 σ^i elasticity of substitution among imports of i
 θ_{irs} share of imports from r in imports of s at market prices

According to equations (6) and (7) an increase of ams_{irs} implies that imports of i from region r to s are more competitive and substitute imports from other regions. Additionally to this cost raising effects, NTBs also generate a protection effect which might be captured via import tariffs. Andriamananjara et al. (2003, 2004) as well as Fugazza and Maur (2008) offer a thorough study of the impacts of NTBs in regional and global CGE models, respectively. The authors emphasize that the use of the import tariffs approach to model NTBs and the corresponding rent creating mechanism needs very careful interpretation of the resulting welfare effects. This is of diminishing importance, but also given in the GTAP model where all additional tariff revenues are collected by the regional house and are being kept inside the tariff revenue collecting country.

Andriamananjara et al. (2003, 2004) comprehensively compare these two approaches of CGE modeling of NTBs. Fugazza and Maur (2008) offer the first analysis that is doing this on a global basis by utilizing AVEs of NTBs estimates, which are provided by Kee et al. (2006) for a 26-country 27-sector version of the GTAP data base version 6. The result of both papers shows that there are surprising large differences in the results of the experiments when NTBs are modeled with the help of import tariffs and technological change variables, respectively, although both approaches tend to affect the terms of trade in a similar manner. In particular the authors conclude that the efficiency type modeling of NTBs tends to weigh heavily in the overall large positive welfare gain results. This is also found by Philippidis and Carrington (2005), Philippidis and Sanjuán (2007a, 2007b), Winchester (2009) as well as Chang and Hayakawa (2010) who used estimated AVEs and implement them in a CGE model via the “iceberg cost approach”. Particularly Fugazza and Maur (2008) also state that “the use of efficiency gains seems only realistic for small value shocks, as generally has been assumed in the literature. We tend to have “sand in the wheels”, not rocks.”

In the following quantitative GTAP analysis we employ the newly available version 8 GTAP data base. We combine the original 119 countries and regions and 57 sectors into a 24 by 10 aggregated version. With the

sector aggregation we match the sectors predefined in the gravity model approach. Countries, regions and sectors are highlighted in more detail in Table A1 and A2 in the Appendix.

3.1 Experiment Design

In this section, the results of a possible EU enlargement to include Turkey are discussed. In doing so, not only tariffs, but also NTBs are considered. Here, we focus on the welfare effects of the EU and Turkey in case of a removal of NTBs coming from different MR settings in the gravity approach to calculate AVEs. The results are discussed on the basis of the equivalent variation (EV) in different experiments. Results are presented in millions of US\$ for the year 2007 of the GTAP data base. The calculations are based on GEMPACK (Version 11.0) and RunGTAP (Harrison and Pearson, 1996). A fixed trade balance is adopted as macroeconomic closure in all trade policy experiments.¹²

The base year of the newest GTAP version 8 data base is 2007. Advantageously, this very recent base year 2007 of a global data base implicates that the political environment is fairly up to date. Thus, the MFA quota is already phased out (2005), the EU enlargement of 2004 and 2007 is taken care of and China is by 2007 a member of the WTO fulfilling its scheduled obligations.¹³

Besides changes in the political environment of an economy, macroeconomic developments such as technical progress are of great importance for the growth of an economy. In order to take these changes into account, corresponding trends are incorporated in the analysis. We include exogenous projections of the global and regional GDP and factor endowment into the extended GTAP model. In the simulations, technical progress is generated endogenously by the model, enabling the projected growth pattern. Data for the corresponding shocks are taken from the CEPII, the United Nation and the World Bank.

Implementing the latest changes and updating the macroeconomic environment we move the GTAP framework to the year 2020. Within this timeframe we assume that Turkey-EU enlargement will be concluded. Since the aim of the study is to compare the effects of different gravity model specification to estimate AVEs of NTBs, to be able to see the pure effects coming from the alternative specifications, first the EU enlargement is held by considering the removal of NTBs and then estimated AVEs are implemented into GTAP.

3.2 Simulation Results

Table 3 displays the welfare results of the experiments in millions of US\$ utilizing the EV. The upper part of the table exhibits the results of the fixed effects specification whereas the lower part is considering the results of MRTs specification. The first column of the table displays the total EV, the second displays the effects of bilateral tariff reductions, while subsequent ones decomposed this result to the sectoral level. Thus, columns 3 to 7 show the effects of NTBs' removal by the EU, while columns 8 to 11 represents the effects that are related to the removal of NTBs by Turkey.

From a first glance to Table 3, it is clear that the results of MRTs estimation are significantly higher than the ones calculated with the fixed effects estimation. In both experiments, Turkey is unambiguously gaining

12 We also assumed the top level nest Armington elasticities between domestic goods, and the import composite to be equal to lower-level nest Armington elasticities between imports from different countries.

13 While the implementation period extends to 2010, almost all of the reduction will have been completed by 2005 (Martin et al., 2003).

from the EU enlargement by reduction of NTBs. For our first experiment with fixed effect estimation, total welfare gain of Turkey amounts to 167 billion US\$ whereas the EU's welfare gain is less than Turkey, which amounts to 75 billion US\$. That Turkey experiences higher welfare gains than the EU is also in accordance with Lejour and Mooij (2004), Zahariadis (2005) and Acar et al. (2007). In our analysis, these results can be traced back to the NTBs' removal in the service sectors in both regions. However, the elimination of NTBs in the Turkish service sectors is leading to much higher welfare increase of 120 billion US\$ which makes more than 70% of the total gain of Turkey. Beside the service sector, the removals of NTBs in the Turkish food and agriculture sector leads to a significant increase in Turkish welfare level (12.7 billion US\$) whereas the gains for the EU is lower (2.3 billion US\$). Conversely, when EU eliminates the NTBs in the food and agriculture sector, both regions face almost same level of welfare gain (around 4-6 billion US\$). Also, the effect of the NTBs' removals in the European manufacture sector leads to gains for Turkey of 6.3 billion US\$ and elimination of NTBs in the same sector by Turkey delivers a gain of 2.6 billion US\$ for the EU.

The lower parts of Table 4 display the results of our second experiment. As already mentioned above the MRTs estimation results are delivering higher gains than the ones that are estimated with fixed effects. Although the results are going in the same direction, high discrepancies are seen between the two estimation methods, especially in some sectors. Differences are highly pronounced in the service sector when they are removed by Turkey. The gain for Turkey which amounts to 247 billion US\$, is 47% higher than the one that is estimated with fixed effects. Furthermore, the reduction of NTBs in the food and agriculture sector by the EU is leading to changes in the welfare level for both regions that are highly different than the ones in the first experiment. Hence, the gain for Turkey amounts to 15.3 billion US\$, while it is 4.2 billion US\$ when fixed effects is employed. Also for the EU, the overall welfare gain is three times higher when the AVEs of NTBs are estimated with the MRTs gravity specification

Table 3: Welfare Results in Experiments (million US\$ relative to the baseline)

Experiment 1: Fixed effects

		Bilateral Tariff Reduction	Removal of NTBs									
		Total	EU					Turkey				
	Total EV		Food&Ag	Mnfc	Serv	Extrac	Total	Food&Ag	Mnfc	Serv	Extrac	Total
Turkey	167943	4651	4166	6307	19825	61	30359	12717	146	119960	110	132932
EU	75263	65	6438	1929	19910	99	28377	2320	2568	41886	47	46821
ROW	3338	582	-750	-2400	-421	-83	-3654	129	-318	6685	-85	6411

Experiment 2: MRTs

		Bilateral Tariff Reduction	Removal of NTBs									
		Total	EU					Turkey				
	Total EV		Food&Ag	Mnfc	Serv	Extr	Total	Food&Ag	Mnfc	Serv	Extr	Total
Turkey	247013	6085	15269	8230	32669	132	56300	26510	181	157648	289	184629
EU	111646	636	19801	2210	29680	198	51888	3721	3826	51459	116	59122
ROW	2042	150	-2197	-2904	-104	-169	-5373	279	-458	7656	-211	7266

Source: Authors' own calculation.

4 Conclusion

Policy analysis in CGE applications concentrated on tariff cuts and neglected the importance of non-tariff trade barriers. The main reason is the difficulty in measurement and the agreement on a standard estimation method. There are several approaches how to estimate the effects of NTBs. We base our study on the gravity border effect approach that is most commonly used in the research agenda. A theory-based specification to account for multilateral resistance is of great importance to obtain reliable results. However, there are different options how to correctly specify the gravity model and to avoid biased estimates for border effects. While there are a lot of papers explaining the causes of border effects and comparing different estimation techniques there is no study on comparing border effects resulting from different MR specifications and analyzing the corresponding implications for CGE simulations. This paper tries to close this gap.

In the first step this paper analyzes alternative gravity border effect model specifications to estimate the effects of NTBs between the EU and Turkey using the GTAP data base. To derive a theory-based gravity model it is necessary to account for multilateral price resistance. We compare two approaches which are used more commonly in practical research. On the one hand it is possible to consider MRTs by specifying exporter and importer fixed effects and on the other hand to calculate them following the approach by Baier and Bergstrand (2009). Comparing the border effects for four aggregated sectors and 20 disaggregated agricultural sectors we observe partly huge differences, especially in the sectors beverages and tobacco, cereal grains, animal products, and plant-based fibres. By trend the border effects resulting from regressions with MRTs specification are greater. The deviations in the aggregated sectors are minimal leading us to the conclusion that the results are only comparable for aggregated sectors. Furthermore, it is possible to get significant border effects with the one MR setting but insignificant effects with the other MR setting for the same sector. Depending on the sector this can enormously influence the corresponding welfare implications. The next step involved the conversion of the quantity effects into AVEs of NTBs. For this we applied different elasticities of substitutions. Results reveal great importance of the choice of the elasticity of substitution. With lower elasticity of substitution the size of AVEs of NTBs increases disproportionately. The differences in AVEs coming from different MR settings behave in the same manner.

After converting the quantity effects into AVEs of NTBs we implement in the second step these AVEs into the GTAP model to simulate an EU enlargement till 2020. In so doing, we benchmark the AVEs of NTBs between the EU and Turkey to the NTB level existing between EU member countries. The experiments show that the welfare results relating to MRTs specification are significantly higher than the ones calculated with AVEs of NTBs coming from the fixed effects specification. The highest differences are pronounced in the service sector for Turkey and agro-food sector for both regions. Thus, depending on the specification of the gravity model to estimate the effects of NTBs we can get very different outcomes in terms of welfare results stemming from the removal of NTBs. Though Baier and Bergstrand (2009) show similar results for border effects resulting from fixed effects specification and their approximation method our results reveal partly huge deviations, especially when GTAP simulation results are considered in the comparison.

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6 Appendix

Table A1: Regional Aggregation of version 8 of the GTAP data base

Regions	Abbreviation
1. Turkey	TUR
2. European Union Austria, Belgium, Denmark, Finland, France, Germany, Ireland, United Kingdom, Greece, Italy, Luxembourg, Netherlands, Portugal, Spain, Sweden, Czech Republic, Hungary, Malta, Poland, Slovakia, Slovenia, Estonia, Latvia, Lithuania, Cyprus, Romania, Bulgaria	EU
3. Middle East and North Africa Bahrain, Kuwait, Oman, Qatar, Saudi Arabia, United Arab Emirates, Egypt, Morocco, Tunisia, Israel, Islamic Republic of Iran, Rest of North Africa, Rest of Western Asia	MENA
4. Former Soviet Union Belarus, Romania, Russian Federation, Ukraine, Kazakhstan, Kyrgyzstan, Georgia, Armenia, Azerbaijan, Rest of Former Soviet Union	XSU
5. Asia China, Hong Kong, Japan, Korea, Mongolia, Taiwan, Cambodia, Indonesia, People's Democratic Republic of Lao, Malaysia, Philippines, Singapore, Thailand, Viet Nam, Bangladesh, India, Nepal, Pakistan, Sri Lanka, Rest of South Asia, Rest of Southeast Asia	ASIA
6. North America Canada, United States of America, Mexico, Rest of North America	NORTH AM
7. Latin America Argentina, Bolivia, Brazil, Chile, Colombia, Ecuador, Paraguay, Peru, Uruguay, Venezuela, Costa Rica, Guatemala, Honduras, Nicaragua, Panama, El Salvador, Caribbean, Rest of Central America, Rest of South America	LATIN AM
8. Oceania Australia, New Zealand, Rest of Oceania	OCEANIA
9. Sub-Saharan Africa Cameroon, Cote d'Ivoire, Ghana, Nigeria, Senegal, Ethiopia, Kenya, Madagascar, Malawi, Mauritius, Mozambique, Tanzania, Uganda, Zambia, Zimbabwe, Botswana, Namibia, South Africa, Rest of African Customs Union, South Central Africa, Rest of Eastern Africa, Rest of Western Africa, Central Africa	SSA
10. Rest of the World Switzerland, Norway, Albania, Croatia, Rest of EFTA, Rest of Eastern Europe, Rest of Europe, Rest of the World	ROW

Table A2: Sectoral Aggregation of the GTAP data base

Sectors
1. Paddy rice
2. Wheat
3. Cereal grains nec
4. Vegetables, fruits, nuts
5. Oil seeds
6. Sugar cane, sugar beet
7. Plant-based fibres
8. Crops nec
9. Cattle, sheep, goats, horses
10. Animal products nec
11. Raw milk
12. Sugar
13. Processed rice
14. Dairy products
15. Meat: cattle, sheep, goats, horses
16. Meat products nec
17. Vegetable oils and fats
18. Food Products nec
19. Beverages and tobacco products
20. Extraction
Wool, forestry, fishing, coal, oil, gas, minerals nec
21. Light Manufacture
Textiles, wearing apparel, leather products, wood products, paper products, publishing, metal products, motor vehicles and parts, transport equipment nec
22. Heavy Manufacture
Petroleum, coal products, chemical, rubber, plastic products, mineral products nec, ferrous metals, metals nec., electronic equipment, machinery and equipment nec
23. Services
Electricity, gas manufacture, distribution, water, construction, trade, transport nec, sea transport, air transport, communication, financial services nec, insurance, business services nec, recreation and other services, PubAdmin/Defence/Health/Educat, dwellings