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International Trade and Migration: A Quantitative Framework

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International Trade and Migration: A Quantitative Framework

Mario Larch* Steffen Sirries†

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Abstract

Goods trade and international mobility of labor are typically analyzed separately. While there is excellent research in both fields, far less is known about the interrelationships between international migration and international trade. This paper provides a first structurally estimable model of international trade with endogenous international migration choices of workers which can be used for model-based counterfactual predictions. Using bilateral trade and migration data for 33 OECD countries we find that quantitative welfare predictions vastly change: investigating reasonable changes in the costs of factor and goods mobility across borders in this unified framework almost doubles the predicted welfare effects compared to established models. Our results sensitize policy makers who seek ex-ante evaluations of international trade agreements and migration policies.

JEL-Codes: F14, F22, F13, O15.

Keywords: international trade, international migration, trade costs, migration costs, structural estimation, gravity equation.

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1 Introduction

The evaluation of the effect of trade costs and its consequences for other economic variables of interest has become eminently prominent amongst trade economists. Over the last decades it appears to be one of the major tasks in the literature. Beside the tremendous use of gravity models as the workhorse for applied researchers in this strand of literature, the pioneering work of Anderson and van Wincoop (2003) serves by now as the theoretical foundation for this approach; the starting point for a structural treatment of the empirical gravity model. Ever since the evaluation of trade costs in a globalizing world via structural models dominates the empirical trade literature. A prominent list of most recent publications which improved this evaluation tremendously includes for example Eaton and Kortum (2002), Anderson and van Wincoop (2003), Santos Silva and Tenreyro (2006), Anderson (2011), Waugh (2010), Fieler (2011) and Arkolakis, Costinot, and Rodríguez-Clare (2012). The estimation of counterfactual economic scenarios of highest political interest is not only a big issue for researchers, but for every politician dealing with foreign affairs. Especially the evaluation of preferential trade agreements is always considered by politics as well as by economists. These improvements make model-based counterfactual predictions of various trade policies and their consequences possible and might put advisers – ex-ante – in an well informed position.

Several (successful) attempts have been made to use the gravity approach for other economic flows as for example migration or FDI (see Grogger and Hanson (2011) and Beine, Docquier, and Özden (2011) as recent examples for migration). Even the first appearance of the idea of gravity in the social science has been on migration in Ravenstein's laws of migration from the 19th century (Ravenstein (1885)). In difference to the trade literature, the migration literature still lacks an established theoretical foundation for the use of the empirical gravity model. Anderson (2011) is the notable exception here. He

develops a framework – very similar to Anderson and van Wincoop (2003) – where the (conditional) multilateral resistance concepts of migration of an economy are as important as in the full general equilibrium trade models.¹ To learn about the effects of changes in migration barriers and to ex-ante inform decision makers who deal with migration policies, a structural and fully general equilibrium approach has yet to be established.

In a very recent survey paper Gaston and Nelson (2013) shed light on the literature which tries to link the trade and the migration literature. At least since Mundell (1957) in his Heckscher-Ohlin-Samuelson-type model, potential links between international trade and cross-border migration are of economist’s interest and still crucial for policy makers. Whereas the new trade literature often assumes labor to be the only production factor which is infinitely costly to trade, hence to be immobile, and the recent migration literature focuses more or less on labor market issues with respect to exogenous and differentiated labor supply shocks, this paper concentrates again on the interdependence of goods and factor flows across borders. To the best of our knowledge we are first in developing a new trade model which is structurally estimable where labor is internationally mobile including an individual costly migration decision.

Figure 1 shows the correlation of residuals of a standard trade gravity estimation à la Head, Mayer, and Ries (2010) and residuals of a standard migration gravity estimation à la Grogger and Hanson (2011) for bilateral country pairs of 33 OECD countries. We can see that even after controlling for common determinants of trade and migration, the residuals seem to be linked. To account for the residual pattern, our approach incorporates the general equilibrium nature of trade and migration.

¹The migration structure of our model builds on this attempt.

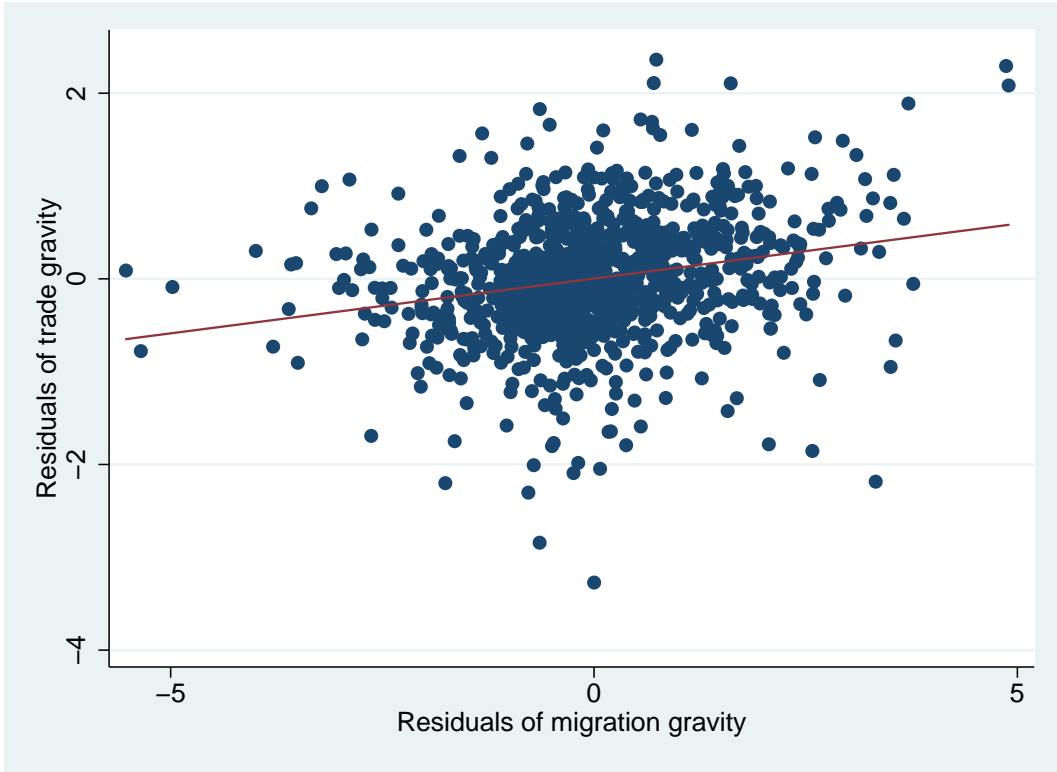


Figure 1: ($\text{corr}(\hat{e}_{\text{trade}}, \hat{e}_{\text{migr}}) = 0.2304$)

Therefore, we first set up a simple and standard trade system with Armington (1969) preferences and link it to the migration system of Anderson (2011) and thus to the migration decision.² We end up with a simple general equilibrium model of international trade and migration. Employing consistent estimation strategies to extract crucial structural parameters of the model, namely the trade and migration cost vectors, we can conduct several counterfactual scenarios of interest.

The counterfactual situation we analyze shows the difference in welfare effects of the evaluation of the planned Free Trade Agreement between the US and the European Union, once when we evaluate the hypothetical signing with a standard approach à la Anderson and van Wincoop (2003) and once with

²See Behrens, Mion, Murata, and Südekum (2011) p. 15 for a similar approach. Note here that they do not have *ij* dimension, thus, this model is not migration but a location decision model. This is exactly what they write, but might not obvious at first glance.

our framework, allowing for migration. The main result shows that welfare effects magnify on average when we account for factor flows. We also can quantitatively evaluate other counterfactual situations where for example a reduction of migration barriers – additionally to the reduction of trade barriers – is explicitly written into a contract of market integration between countries.³

Similar work has been done by Redding (2012) where migration is possible on a intra-national level and a second production factor is introduced which is immobile. Behrens, Mion, Murata, and Südekum (2011) offer a location choice model which sheds light on spatial frictions within and across regions and di Giovanni, Levchenko, and Ortega (2012) calibrate a model which also incorporates trade and migration on a cross-border level with remittances and their additional effects for originating economies.

The remainder of the paper is structured as follows: Section 2 presents the structural gravity model including an individual, explicit and multilateral migration decision. The following section 3 derives two estimable gravity equations; one for trade and one for migration from which we extract structural parameters. The bilateral trade and migration data we employ are described in section 4 and section 5 presents the results and the design of the counterfactual analysis. Section 6 concludes.

2 The Model – Trade, Migration and the Link

2.1 Trade System

2.1.1 Aggregate Bilateral Trade Flows

We start with a mult-country perfect competition trade model. The representative consumer in country j is characterized by the utility function U_j . We assume that goods are differentiated by country of origin following Armington

³The most popular example for such an integration of labor markets or reduction of migration barriers respectively is the European Union single market project.

(1969). The quantity of purchased goods from country i is given by c_{ij} , leading to the following utility function

$$U_j = \left[\sum_{i=1}^N \beta_i^{\frac{1-\sigma}{\sigma}} c_{ij}^{\frac{\sigma-1}{\sigma}} \right]^{\frac{\sigma}{\sigma-1}}, \quad (1)$$

where N is the number of countries, σ is the elasticity of substitution in consumption, and β_i is a positive preference parameter measuring the product appeal for goods from country i .

International trade of goods from i to j imposes iceberg trade costs $t_{ij} > 1$ (Samuelson (1952)). Profit maximization then implies that $p_{ij} = p_i t_{ij}$, where p_i denotes the factory gate price of the good in country i .

The representative consumer maximizes Equation (1) subject to the budget constraint $Y_j = \sum_{i=1}^N p_i t_{ij} c_{ij}$. The value of aggregate sales of goods from country i to country j can then be expressed as

$$X_{ij} = p_i t_{ij} c_{ij} = \left(\frac{\beta_i p_i t_{ij}}{P_j} \right)^{1-\sigma} Y_j, \quad (2)$$

and P_j is the standard CES price index given by $P_j = [\sum_{i=1}^N (\beta_i p_i t_{ij})^{1-\sigma}]^{1/(1-\sigma)}$. In general equilibrium, total sales correspond to nominal income, i.e., $Y_i = \sum_{j=1}^N X_{ij}$. Assuming labor to be the only factor of production and full employment, GDP is given by total factor income, i.e., $Y_i = w_i L_i$.

2.2 The Trade Gravity Equation

Our quantitative framework implies a gravity equation for bilateral trade flows, which we derive in this section. We first use $Y_i = \sum_{j=1}^N X_{ij}$ which summarizes the general equilibrium nature of our model and implies market clearing, i.e.,

$$Y_i = \sum_{j=1}^N X_{ij} = \sum_{j=1}^N \left(\frac{\beta_i t_{ij} p_i}{P_j} \right)^{1-\sigma} Y_j = (\beta_i p_i)^{1-\sigma} \sum_{j=1}^N \left(\frac{t_{ij}}{P_j} \right)^{1-\sigma} y_j. \quad (3)$$

Solving for scaled prices $\beta_i p_i$ and defining $Y^W \equiv \sum_j Y_j$ and income shares $\theta_j \equiv Y_j/Y^W$, we can write bilateral trade flows as given in equation (2) as

$$X_{ij} = \frac{Y_i Y_j}{Y^W} \left(\frac{t_{ij}}{\Pi_i P_j} \right)^{1-\sigma}, \quad \text{where} \quad (4)$$

$$\Pi_i \equiv \left(\sum_{j=1}^N \left(\frac{t_{ij}}{P_j} \right)^{1-\sigma} \theta_j \right)^{1/(1-\sigma)}, \quad P_j \equiv \left(\sum_{i=1}^N \left(\frac{t_{ij}}{\Pi_i} \right)^{1-\sigma} \theta_i \right)^{1/(1-\sigma)}, \quad (5)$$

while we substituted equilibrium scaled prices into the definition of the price index to obtain the multilateral resistance terms P_j .

Note that this system of equations exactly corresponds to the system given in Equations (9)-(11) in Anderson and van Wincoop (2003) or Equations (5.32) and (5.35) in Feenstra (2004). Note that migration will change the number of people working in country i . Migration therefore influences trade flows X_{ij} via changes in GDPs.

For the migration system we need the indirect utility function of one representative consumer, given by

$$\begin{aligned} U_j^* &= \frac{1}{L_j} \left[\sum_{i=1}^N \beta_i^{\frac{1-\sigma}{\sigma}} \left(\left(\frac{\beta_i}{P_j} \right)^{1-\sigma} (p_i t_{ij})^{-\sigma} Y_j \right)^{\frac{\sigma-1}{\sigma}} \right]^{\frac{\sigma}{\sigma-1}} \\ &= \frac{Y_j P_j^{\sigma-1}}{L_j} \left[\sum_{i=1}^N (\beta_i p_i t_{ij})^{1-\sigma} \right]^{\frac{\sigma}{\sigma-1}} = \frac{Y_j P_j^{\sigma-1}}{L_j} [P_j^{1-\sigma}]^{\frac{\sigma}{\sigma-1}} \\ &= \frac{Y_j}{L_j P_j} = \frac{w_j}{P_j}. \end{aligned} \quad (6)$$

Up to here we just follow the existing trade literature with respect to the model. We next describe the migration system of the quantitative framework, where the migration decision depends on real wages and therefore will be linked to the trade system.

2.3 Migration System and the Link

From the perspective of a single worker, the migration decision is a discrete choice from a set of locations. Hence we can start with the utility from migration from j to i for a worker h

$$V_{ji} = \ln(U_i^*) - \ln(U_j^*) - \ln(\delta_{ji}) + \ln(\varepsilon_{jih}), \quad (7)$$

where U_i^* and U_j^* are the indirect utility functions taken from the trade system (equation (6)), ε_{jih} captures idiosyncratic, individual specific utility from migration and δ_{ji} are migration costs.⁴ Thus, we can decompose the utility of migration into a common part for migrants from country i to j , δ_{ij} and an individual specific part, ε_{jih} .

Inserting U_i^* and U_j^* leads to

$$V_{ji} = \ln\left(\frac{w_i}{P_i}\right) - \ln\left(\frac{w_j}{P_j}\right) - \ln(\delta_{ji}) + \ln(\varepsilon_{jih}). \quad (8)$$

The migration flow from j to i is given by

$$M_{ji} = G(V_{ji})N_j, \quad (9)$$

where N_j is the number of natives in j and $G(V_{ji})$ gives the proportion of migrants from j to i . When ε_{jih} is assumed to be i.i.d. this proportion is given by the probability as in McFadden (1974)

$$G(V_{ji}) = \frac{\exp(V_{ji})}{\sum_k \exp V_{jk}}. \quad (10)$$

Note that this discrete choice setting has also been recently used by Grogger and Hanson (2011) and Beine, Docquier, and Özden (2011).

Now, inserting (8) in (9) and using (10), we can write the migration flows

⁴ ε_{jih} does not serve here as an error term of an estimated model!

as

$$M_{ji} = \frac{\frac{w_i}{w_j} \frac{P_j}{P_i} \frac{1}{\delta_{ji}}}{\sum_k \left(\frac{w_k}{w_j} \frac{P_j}{P_k} \frac{1}{\delta_{ji}} \right)} N_j \quad (11)$$

$$= \frac{\frac{w_i}{P_i} \frac{1}{\delta_{ji}}}{\sum_k \left(\frac{w_k}{P_k} \frac{1}{\delta_{jk}} \right)} N_j, \quad (12)$$

where (12) equals eq. (15) from Anderson (2011) except for the price index which expresses the wages in real terms here.

Remember also that $\sum_i M_{ji} = N_j$, i.e., all natives from country j are split up over all N countries, including the home country. $\sum_j M_{ji} = L_i$ is the number of all migrants coming to i , including natives that stay in i , M_{ii} . This is then the labor force available in country i .

3 Parameter Estimation

To conduct a counterfactual analysis we describe in this section which structural parameters we extract from the data and how. Therefore we start with the derivation of an estimable version of the gravity equation of trade flows, followed by a gravity equation for the migration flows. The trade gravity equation is fairly standard in the literature (Anderson and van Wincoop (2003), Feenstra (2004)), whereas the migration gravity has not yet derived in the same structural manner as the trade gravity. There are only a few exceptions including Anderson (2011) which we follow closely here. The structural parameters we want to extract from the data are namely the trade cost t_{ij} and the migration costs δ_{ij}

3.1 Trade Gravity Estimation

Deriving an estimable gravity equation starting from the system of equations (4) and (5) is standard and follows Anderson and van Wincoop (2003).

We estimate the following gravity model:

$$z_{ij} \equiv \frac{x_{ij}}{y_i y_j} = \exp \left(k - (1 - \sigma) \ln t_{ij} - \ln \Pi_i^{1-\sigma} - \ln P_j^{1-\sigma} + \varepsilon_{ij} \right), \quad (13)$$

where z_{ij} are normalized trade flows. Trade costs are specified as

$$t_{ij}^{1-\sigma} = \exp(\beta_1 PTA_{ij} + \beta_2 \ln DIST_{ij} + \beta_3 CONTIG_{ij} + \beta_4 LANG_{ij}), \quad (14)$$

and control for Π_i and P_j using importer and exporter fixed-effects.

3.2 Migration Gravity Estimation

Remember equation (12)

$$M_{ji} = \frac{\frac{w_i}{P_i} \frac{1}{\delta_{ji}}}{\sum_k \left(\frac{w_k}{P_k} \frac{1}{\delta_{jk}} \right)} N_j,$$

and replace $\frac{w_i}{p_i} \equiv \omega_i$ and we get the same expression as in Anderson (2011)

$$M_{ji} = \frac{\frac{\omega_i}{\delta_{ji}}}{\sum_k \left(\frac{\omega_k}{\delta_{jk}} \right)} N_j. \quad (15)$$

Denote $W_j \equiv \sum_k \omega_k / \delta_{jk}$ and define the labor force supplied to i from all origins

$$L_i \equiv \sum_j M_{ji}. \quad (16)$$

Also, $N \equiv \sum_j N_j = \sum_i L_i$, the world labor supply N . The labor market clearance equation is

$$L_i = \omega_i \sum_j \left((1/\delta_{ji}) / W_j \right) N_j. \quad (17)$$

Then

$$\omega_i = \frac{L_i}{\Omega_i N}, \quad \text{with} \quad (18)$$

$$\Omega_i = \sum_j \frac{1/\delta_{ji}}{W_j} \frac{N_j}{N}. \quad (19)$$

Using the one before the last equation, we can write W_j as

$$W_j = \sum_k \frac{\omega_k}{\delta_{jk}} = \sum_k \frac{L_k}{\Omega_k \delta_{jk} N}. \quad (20)$$

Substituting the same equation into M_j we can write

$$M_{ji} = \frac{\omega_i/\delta_{ji}}{\sum_k \omega_k/\delta_{jk}} N_j = \frac{L_i N_j 1/\delta_{ji}}{N \Omega_i W_j}. \quad (21)$$

Replace $1/\delta_{ji}$ by $\delta_{ji}^{1-\theta}$ to end up with the following system:

$$M_{ji} = \frac{L_i N_j}{N} \left(\frac{\delta_{ji}}{\Omega_i W_j} \right)^{1-\theta}, \quad \text{with} \quad (22)$$

$$\Omega_i = \left[\sum_j \left(\frac{\delta_{ji}}{W_j} \right)^{1-\theta} \frac{N_j}{N} \right]^{\frac{1}{1-\theta}}, \quad W_j = \left[\sum_i \left(\frac{\delta_{ji}}{\Omega_i} \right)^{1-\theta} \frac{L_i}{N} \right]^{\frac{1}{1-\theta}}. \quad (23)$$

This structure equals the standard gravity system from Anderson and van Wincoop (2003) which is the one we derived before in section 3.1. Ω_i and W_j indicate analogously the multilateral resistance terms for the migration gravity.

We estimate the following gravity model:

$$m_{ij} \equiv \frac{x_{ij}}{y_i y_j} = \exp \left(k - (1 - \sigma) \ln \delta_{ij} - \ln \Omega_i^{1-\sigma} - \ln W_j^{1-\sigma} + \varepsilon_{ij} \right), \quad (24)$$

where m_{ij} are normalized migration flows. Migration costs are specified as

$$\delta_{ij}^{1-\sigma} = \exp(\gamma_1 PTA_{ij} + \gamma_2 \ln DIST_{ij} + \gamma_3 CONTIG_{ij} + \gamma_4 LANG_{ij}), \quad (25)$$

and control for Ω_i and W_j using importer and exporter fixed-effects as we control for the multilateral resistance terms in the trade gravity.

3.3 Estimators

Santos Silva and Tenreyro (2006) argue that the standard approach of estimating the above multiplicative models (equations 13 and 24) by simply taking logarithms and estimate the resulting linear model with OLS yields inconsistent parameter estimates. In addition, log-linearization would drop all zero observations from the trade and migration matrices, which is clearly not theoretically justified and will in general lead to biased estimates. Thus, we do not rely on OLS estimates for the bilateral trade and migration costs respectively and chose the Poisson pseudo-maximum-likelihood estimator.⁵ By now this approach is standard for trade gravity estimation and we conduct the empirical investigation for the migration gravity as well by estimating equation 24 via PPML for the same reasons.

4 Data

We use two bilateral data sets in a cross section for the year 2000. Firstly, we use the well known CEPII bilateral trade data from Head, Mayer, and Ries (2010) with many geographical information. Secondly, we use the “Where on Earth is everybody”-data from Özden, Parsons, Schiff, and Walmsley (2011).

⁵As argued by Santos Silva and Tenreyro (2006), PPML is also likely to be a more sensible choice than other consistent non-linear estimators (such as non-linear least squares or Gamma PML), because it gives equal weight to all observations. They additionally demonstrate that the PPML estimator is generally well behaved in the context of constant elasticity models by conducting Monte Carlo simulations (see Santos Silva and Tenreyro, 2011).

This data set provides information on international bilateral migration stocks (censuses and official registers). We keep the OECD sample to account for the sparsity of the bilateral dimension of the migration data, so we concentrate on north-north migration.⁶

5 Results

5.1 Model Fit and Other Parameters

Before we provide the results and the design of the counterfactual analysis, we compare the estimates of our structural model to the observed economic variables of interest. Therefore we plug the estimated parameters from the trade and migration gravity respectively into our model and compare the predictions of that procedure with the observed trade and migration flows. Figure 2 shows the scatterplot of the trade system and figure 3 shows the respective scatterplot of the migration system. A 45 degree line would as usual indicate a perfect fit. The figures indicate a very well fit of our model to the observed trade and migration data simultaneously.

⁶Notably our framework fits very well for the two-way migration pattern within the OECD and our counterfactual analysis provides results for changes of the trade and migration cost within this group of countries.

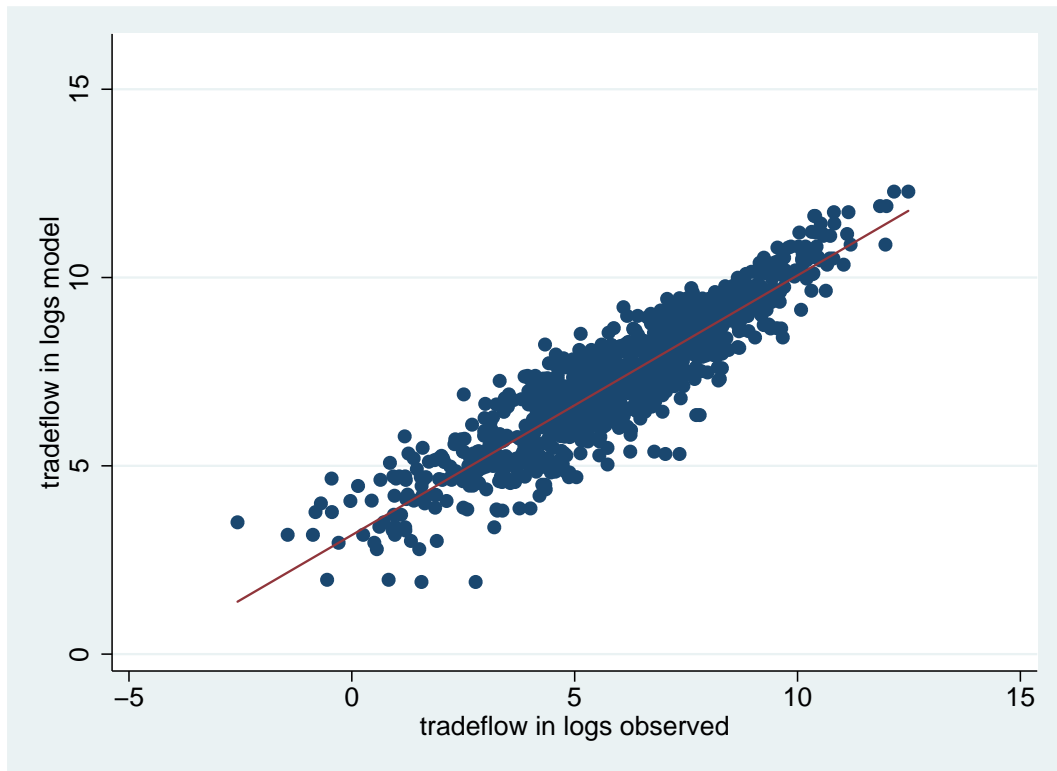


Figure 2: Fit of Trade

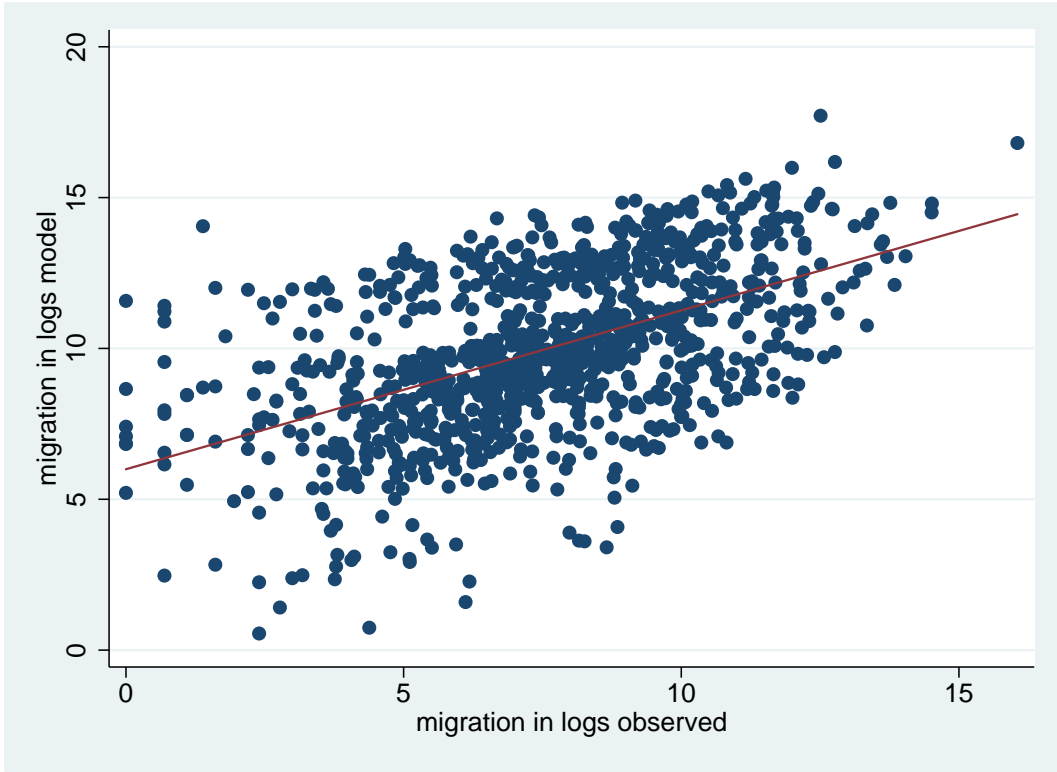


Figure 3: Fit of Migration

5.2 Counterfactual Analysis

Our quantitative framework now allows us to conduct several counterfactual analysis that means we hypothetically may change for example the trade and/or migration costs and reestimate the model for such changes. Thereby we account for the general equilibrium nature of our framework, providing third country effects and allowing migration and trade to be influenced by each other. The first counterfactual analysis we provide asks the following: “What would happen if TTIP would be signed?” That means, we will hypothetically change the true PTA vector to one where an agreement would be signed between the USA and the EU in addition to existing PTAs in 2000. The recently debated TTIP serves here as an example for potential trade and

migration cost reduction at the same time.⁷ Then we compare our results to results from evaluating the same change in the PTA vector within a model which does include the explicit migration decision and thus assumes labor to be immobile, comparable to Anderson and van Wincoop (2003).⁸ In anticipation of our results this comparison shows how important migration is in welfare analysis with new quantitative trade frameworks. Tables 1 and 2 show results at the world level. Table 3 shows selected results at the country level. All tables show the welfare (defined as the real GDP per capital in our model) to be higher in a world where TTIP would be signed, especially for signers as expected. The positive welfare changes are higher for the model which includes migration. Table 3 shows that the difference between the evaluation of TTIP with and without migration by country is on average around 30 percent and for some countries above 100 percent. Non signers loose out from TTIP.

Table 1: Inception of FTA between US and European Union

world GDP change (%)	world trade change (%)	world migration change (%)
.0056011	.096451	.0464708

Table 2: Inception of FTA between US and European Union Without Migration

world GDP change (%)	world trade change (%)	world migration change (%)
0	.0733666	no migration at all

⁷Heid and Larch (2012) already evaluated TTIP in a structural gravity framework without full employment. Hence, they capture a different link between dimensions of the economies. Here we focus on how migration would change the results to shed light on the interdependencies between trade and migration and these change the evaluation of such agreements ex-ante.

⁸The difference between Anderson and van Wincoop (2003) and our framework for the latter case only lies in the estimation stage, where we estimated the structural parameters of the trade costs via PPML.

Table 3: Selected results of welfare changes by country

Country	rel. welfare change	Model without migration	abs. difference	Percent difference
MEX	-.0022877	-.0012785	-.0010092	.7894172
TUR	-.0011883	-.0029055	.0017172	-.5910235
CHL	-.0011581	-.0010562	-.0001019	.0965121
:	:	:	:	:
JPN	-.000161	-.0004006	.0002396	-.5980565
:	:	:	:	:
DEU	.0078152	.0033957	.0044195	1.301525
:	:	:	:	:
USA	.0103697	.0046371	.0057326	1.236233
:	:	:	:	:
AUT	.0138356	.0077528	.0060827	.7845843
:	:	:	:	:
PRT	.0208332	.0129	.0079331	.6149693
SVK	.0208737	.0123877	.008486	.6850356
EST	.0593799	.0446894	.0146905	.3287251
averages	.0108304	.0060021	.0048283	.3080928

6 Conclusion

Recent quantitative trade frameworks do not allow labor to be mobile. We build in these framework's vein a structurally estimable trade model where we include an explicit discrete choice like migration decision at the individual level. This framework thus accounts for the potential complementarity of trade and migration. We are able to improve the evaluation of trade cost reductions like signing a preferential trade agreement. Our framework enables policy evaluations to be differentiated by separate reductions of trade and migration costs. Our first results show that accounting for migration almost doubles the welfare effects from signing a preferential trade agreement between the US and the European Union. Several other counterfactual analysis of highest political interest are possible with our framework. At least we can say that migration

matters a lot for welfare analysis within new quantitative trade frameworks.

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