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## Much Ado About Nothing? A Quantitative Analysis of Transatlantic Trade Liberalization

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# **Much Ado About Nothing? A Quantitative Analysis of Transatlantic Trade Liberalization<sup>♣</sup>**

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## **ABSTRACT**

This paper explores the quantitative consequences of transatlantic trade liberalization envisioned in a Transatlantic Trade and Investment Partnership (TTIP) between the United States and the European Union. Our key innovation is to base our estimate on a new quantitative trade model with an associated recent technique which is far more parsimonious and has a far tighter connection between theory and data than previous approaches. We make use of the recently established detailed World Input Output Database (WIOD). This allows us to take input-output linkages pertaining among industries into account. We also explore the consequences of labor mobility across the countries of the European Union.

JEL-Classification: F10, F11, F12, F16

Keywords: international trade and trade policy, factor mobility, intermediate inputs, sectoral interrelations

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# 1 Introduction

The liberalization of transatlantic trade envisioned in a Transatlantic Trade and Investment Partnership (TTIP) between the United States and the European Union is of paramount importance for the global economy as it involves economies accounting for almost one half of global value added and one third of world trade (Hamilton and Quinlan 2014). The tariffs prevailing in EU-US-trade are already very low (on average less than 3% for manufactures and slightly more for agricultural products). Hence, significant liberalization can only be achieved by tackling issues which go beyond the elimination of these tariffs and involve negotiations concerning frictional barriers, environmental regulation, health and safety, labor standards, cultural diversity and investor state dispute settlement procedures. The design and legitimacy of these frictions, regulations, standards and rules have proven to be delicate issues in past EU-US relations, and they have stirred considerable public controversies ever since the TTIP negotiations started in June 2013 (Bhagwati 2013; Economist 2014a, 2014b). Numerous economists also fear that bilateral agreements, of which TTIP is about to become the most outstanding example, foster regionalism and thereby undermine the global trading system (Bhagwati et al. 2014).

Against this backdrop it is important to know what is at stake. This paper explores the quantitative consequences of the reallocation of resources associated with the liberalization of transatlantic trade on incomes, prices and welfare for the United States and the members of the European Union and for the countries outside this bilateral agreement. Our key innovation is to base our estimate on *a new quantitative trade model with an associated recent technique* developed by Dekle et al. (2007) which is far more parsimonious and has a far tighter connection between theory and data than previous approaches.<sup>1</sup>

We consider a version of the Ricardian model developed in Redding (2014) which allows for trade and factor mobility. We extend this model to comprise an arbitrary number of heterogeneous industries similar to Caliendo and Parro (2014). Perfectly competitive industries use labor and land together with intermediates to produce their output. As in Eaton and Kortum (2002), productivities are drawn from country and industry specific distributions, leading to different marginal costs and prices. Consumers and firms source goods from the lowest cost supplier (after trade costs). The resulting international trade pattern follows the law of gravity. We consider both labor immobility and mobility between subgroups of locations. In the latter

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1 Costinot and Rodriguez-Claré (2014) provide a lucid recent survey of this literature.

case, real wages are equalized across a subgroup of locations. In both cases the equilibrium is characterized by a set of conditions involving market clearing, bilateral expenditure shares, price indices and population shares. Applying the Dekle et al. (2007) technique allows us to get rid of a number of parameters which will enter only indirectly through their effect on the observed ex-ante values of equilibrium variables. In particular, we neither need to estimate substitution elasticities nor the locations' technology levels. Most importantly, however, *we do not need the bilateral trade cost matrix and hence, we do not have to quantify tariff equivalents of non-tariff barriers*, a process that has led to widely differing results (cf. Fontagné et al. 2013). Instead, we can rely on the fact that these parameters are embedded in the observed ex-ante trade flows.

Our analysis innovates on previous analyses of transatlantic trade liberalization along two further lines. First, whereas previous quantitative analyses relied on the GTAP database, we make use of the recently established detailed *World Input Output Database* (WIOD), which provides information for 41 countries and 35 industries (Timmer et al. 2012). This is important and allows us to take *input-output linkages* pertaining among industries into account. Our disaggregated approach then also allows us to track down the reallocation effects to the level of industries. Second, in contrast to previous analyses, we also explore the consequences of *labor mobility across the countries of the European Union*. We start our quantitative analysis by looking at a pure trade regime where all factors are immobile across countries. We then look at the welfare effects in Europe when labor is mobile and a spatial equilibrium is established.

With the negotiations still going on it is hard to project the final trade liberalization measures. Therefore, we consider a range of conceivable trade cost reductions. The most ambitious scenario involves an across the board non-tariff barrier reduction by 25%. Our main findings are the following.

First, even in the most extreme scenario, where we consider a trade barrier reduction of 25%, real income gains are in the range of up to 2%, except for Ireland and Luxembourg which derive larger gains. The bilateral trade liberalization has negative welfare effects on third countries, but these are typically small. Russia, Canada and Mexico, being tightly integrated with Europe and the United States respectively but not involved in transatlantic trade liberalization, would experience the strongest negative welfare effects associated with trade diversion.

Second, both the strongest winners and strongest losers (except for Russia) exhibit the closest ex-ante connections with the US as measured by the initial shares of US goods in their total

spending. Even in our age of globalization, these spending shares are small and this accounts for the limited results that we obtain overall.

Third, the fabrics of real income changes in the pure trade regime (labor immobility within Europe) vary considerably across countries. The biggest winner, Ireland, for example, reaps overall welfare gains due to dramatic wage increases and despite higher prices. On the other hand, most Eastern European countries, benefit from falling prices despite reduced wages.

Fourth, long term effects of transatlantic trade liberalization associated with population mobility in the EU would lead to migration from eastern European countries into Ireland, Luxembourg and, to a lesser extent, into Great Britain. In the most extreme scenario real income gains among EU members would level at 1.3% as a result of labor mobility.

Finally, the consequences of the mix of industries in the countries of the European Union and in the United States are mild, in general, except in those countries (like Ireland) which experience the strongest real income effects.

**Relation to the previous literature.** Our analysis is related to the growing literature on new quantitative trade modelling. This literature has provided momentous stimuli to the research pertaining to the quantification of the gains from trade, and the consequences of the advancing globalization of economic activity, more generally. A hallmark of the new quantitative trade models is that they have solid, yet possibly different, micro-foundations, which give rise to common gravity-type macro-level predictions for bilateral trade flows as a function of bilateral trade costs.<sup>2</sup> We build on the Ricardian tradition established in the seminal work by Eaton and Kortum (2002). More specifically, we use a version of the model developed in Redding (2014) which allows for (costly) trade of final and intermediate goods between any number of locations and for factor mobility between a subgroup of locations (the EU). We extend his one-sector framework to comprise an arbitrary number of heterogeneous interlinked industries similar to Caliendo and Parro (2014). Each location is endowed with a stock of housing and labor. Perfectly competitive firms use labor and land together with intermediates to produce output that can be used for final consumption and as intermediate input. In the spirit of Eaton and Kortum (2002), each firm draws a productivity parameter from country and industry specific distributions, leading to different marginal costs and subsequent prices of their products. Consumers, who derive utility from the consumption of final products and housing, and firms,

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2 The spectrum of micro-foundations for the gravity equation spans from perfect competition to monopolistic competition with and without firm heterogeneity (see Costinot and Rodriguez-Claré 2014 and the more detailed references provided therein).

that need intermediate inputs, source each good from the lowest cost supplier (taking trade costs into account). The resulting international trade pattern follows the law of gravity. We consider both the case of labor immobility and of labor mobility between subgroups of locations where, in the latter case, real wages are equalized across a subgroup of locations (the EU countries) in spatial equilibrium. Only recently, these new quantitative trade models have been applied to trade policy and trade liberalization issues. The most recent examples of relevance for our analysis are Redding (2014), who looks at the trade integration between the United States and Canada, Costinot and Rodriguez-Claré (2014), who provide estimates of trade integration for OECD countries, and Caliendo and Parro (2014), who examine the trade integration between the United States in Mexico in the wake of the establishment of NAFTA. Our paper borrows the modelling of input-output linkages from Caliendo and Parro (2014). We apply such a model to an altogether different instance, transatlantic trade, rather than trade within America. Moreover, in contrast to their analysis, we take labor mobility into account.

Our paper also relates to a small literature which has provided estimates of the economic effects of a transatlantic trade and investment partnership. Francois et al. (2013) set up a multi-region, multi-sector global computable general equilibrium (CGE) model which, in most sectors, assumes perfect competition under the Armington assumption, but in some heavy manufacturing sectors allows for imperfect and monopolistic competition and thereby also accounts for gains from specialization. In addition to looking at static effects, their study also considers longer-run impacts of trade through investment effects on capital stocks. Data on non-tariff barriers are drawn from Ecorys (2009). Fontagné et al. (2013) proceed in a similar vein. Their computations are based on MIRAGE, another computable general equilibrium for the world economy developed by CEPII, which differs in some choices from Francois et al. (2013) but also features multiple industries and relies on the Armington assumption. Our analysis differs from these works both in our modelling approach, the reliance on a medium-sized new quantitative trade model with Ricardian micro-foundations rather than the Armington approach, and our different solution method, which is far less demanding in terms of the parameters needed. Given our far different choices, we consider our analysis to be complementary to these two studies.

The work by Felbermayr et al. (2014; 2013) is closest to our approach. They employ a structurally estimated general equilibrium model and a strategy that differs from the computable general equilibrium tradition in that the parameters of the model are estimated on those data that the model has to replicate in the baseline equilibrium. This is in line with the approach of

the new quantitative trade literature that we also pursue. However, our analysis differs in a number of important aspects. First, the analyses by Felbermayr et al. (2014; 2013) have their micro-foundations in a monopolistic competition model in the tradition of Helpman and Krugman (2005) whereas our analysis follows the Ricardian tradition of Eaton and Kortum (2002). Second, we allow for input-output linkages and trace down the effects to industries whereas they pursue an aggregate single-sector approach. Third, we allow for factor mobility. Finally, and most importantly, we draw on the Dekle et al. (2007) method, which ties the model and data tighter together than their approach. Given these very different choices we consider our analysis to be a complement rather than a substitute to theirs. Moreover, our analysis provides a robustness check on both their study as well as the two works in the computable general equilibrium tradition. We compare and discuss our findings in more detail below.

The structure of our paper is as follows. Chapter 2 sets up our model. Chapter 3 first takes up our methodology and data and then proceeds to our empirical analysis and results. Chapter 4 concludes.

## 2 The model

**The setup.** Our analysis builds on the research on quantitative trade models that evolved in the wake of Eaton and Kortum (2002).<sup>3</sup> More specifically, we consider a version of the model developed in Redding (2014) which allows for (costly) trade of final goods and of intermediate goods between all locations and for factor mobility between a subgroup of locations. We extend Redding’s one-sector framework to comprise an arbitrary number of heterogeneous industries (sectors) similar to Caliendo and Parro (2014).<sup>4</sup> The economy consists of  $M$  countries which we index by  $m$  and  $N$  regions indexed by  $s \in \{n, i\}$ . Each region is endowed with an exogenous quality-adjusted amount of land  $H_n$ . Countries  $m$  consist of a subset of regions  $N^m \subset N$  and are exogenously endowed with a measure of  $\bar{L}^m$  workers who supply 1 unit of labor each. Labor is used to produce a continuum of differentiated goods in each of  $K$  industries (sectors) indexed by  $k$  and  $j$ . Workers are immobile between countries but perfectly mobile between regions within a country, as well as between sectors. Hence, in a spatial equilibrium real wages are equalized across a country’s regions. Finally, we assume that all regions can trade with each other subject to iceberg trade costs so that  $d_{nik} \geq 1$  units of a good produced in industry  $k$  in

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3 Costinot and Rodriguez-Claré (2014) survey this research.

4 Michaels et al. (2012) consider an economy comprising a manufacturing sector and an agricultural sector.



region  $i$  have to be shipped in order for one unit of the good to arrive in  $n$ . We assume that goods trade within a region is costless,  $d_{nnk} = 1$ .

**Preferences.** Preferences of the representative consumer in region  $n$  are defined over the consumption of goods  $C_n$  and the residential use of land  $H_n^C$  and take the Cobb-Douglas form:

$$U_n = \left(\frac{C_n}{\alpha}\right)^\alpha \left(\frac{H_n^C}{1-\alpha}\right)^{1-\alpha}, \quad 0 < \alpha < 1 \quad (1)$$

The consumption aggregate  $C_n$  is defined over the consumption of the outputs of  $k = 1 \dots K$  industries ( $C_{nk}$ ) and is also assumed to be of Cobb-Douglas form

$$C_n = \prod_{k=1}^K C_{nk}^{\delta_{nC}^k}, \quad 0 \leq \delta_{nC}^k \leq 1, \quad \sum_{k=1}^K \delta_{nC}^k = 1 \quad (2)$$

where  $\delta_{nC}^k$  are the constant consumption shares on industries  $k$ . Each industry offers a continuum of varieties  $\omega \in [0,1]$  which enter preferences according to a constant elasticity of substitution function

$$C_{nk} = \left[ \int_0^1 q_{nk}(\omega)^{\frac{\sigma_k-1}{\sigma_k}} d\omega \right]^{\frac{\sigma_k}{\sigma_k-1}} \quad \sigma_k > 1 \quad (3)$$

where  $q_{nk}(\omega)$  is consumption of variety  $\omega$  produced in industry  $k$  in region  $n$  and  $\sigma_k$  denotes the (constant) within-industry elasticity of substitution between any two varieties. The assumption of a continuum of varieties within each sector ensures that each individual good and producer are of zero weight within the economy.

**Production.** Production of each variety  $\omega$  within any industry  $k$  and at any location  $n$  takes place with constant returns to scale and under perfect competition combining labor, land and all available varieties of outputs from a mix of industries as intermediate inputs. Regions and industries differ in terms of their input mix and their productivities  $z_{nk}(\omega)$ , however. We follow Eaton and Kortum (2002), Caliendo and Parro (2014) and Michaels et al. (2012) by assuming that productivities are drawn independently from region and industry specific Fréchet distributions with cumulative density functions given by

$$F_{nk}(z_{nk}) = e^{-T_{nk} z_{nk}^{-\theta_k}} \quad (4)$$

where  $T_{nk}$  is a scale parameter which determines average productivity and the shape parameter  $\theta_k$  controls the dispersion of productivities across goods within each sector  $k$ , with a higher  $\theta_k$  leading to a denser distribution. Taking iceberg costs  $d_{nik} \geq 1$  into account, the cost to a consumer in region  $n$  of buying one unit of  $\omega$  in sector  $k$  from a producer in region  $i$  is thus

$$p_{nik}(\omega) = \frac{d_{nik} c_{ik}}{z_{ik}(\omega)}, \quad 0 < \beta_{nk} < 1, \quad 0 < \eta_{nk} < 1 \quad (5)$$



where  $c_{ik}$  are the marginal costs given by

$$c_{ik} = w_i^{\beta_{ik}} r_i^{\eta_{ik}} \rho_{ik}^{1-\beta_{ik}-\eta_{ik}}, \quad 0 < \beta_{ik} < 1, \quad 0 < \eta_{ik} < 1 \quad (6)$$

with  $w_i$ ,  $r_i$  and  $\rho_{ik}$  being the wage rate, the rental rate of land, and the industry specific index of intermediate input prices in  $i$ , respectively, and where  $\beta_{ik}$  and  $\eta_{ik}$  are the exogenous cost shares of labor and land.

**Expenditure shares and price indices.** Consumers (and firms) treat goods as homogeneous and consequentially source each good from the region that provides it at the lowest price. Hence,

$$p_{nk}(\omega) = \min\{p_{nik}(\omega); i = 1 \dots N\} \quad k = 1 \dots K \quad (7)$$

Using equilibrium prices and the properties of the Fréchet distribution as in Eaton and Kortum (2002), the share of expenditure of region  $n$  in industry  $k$  on goods produced in region  $i$  is:

$$\pi_{nik} = \frac{T_{ik}(d_{nik}c_{ik})^{-\theta_k}}{\sum_{s=1}^N T_{sk}(d_{nsk}c_{sk})^{-\theta_k}} \quad (8)$$

The implied perfect CES price index  $P_{nk}$  for industry aggregates (subutility)  $C_{nk}$  is

$$P_{nk} = \gamma_k \left[ \sum_{i=1}^N T_{ik}(d_{nik}c_{ik})^{-\theta_k} \right]^{-\frac{1}{\theta_k}} \quad (9)$$

where  $\gamma_k \equiv \left[ \Gamma \left( \frac{\theta_k + 1 - \sigma_k}{\theta_k} \right) \right]^{\frac{1}{1-\sigma_k}}$  and  $\Gamma(\cdot)$  denotes the gamma function. The Cobb-Douglas price index for overall consumption is:

$$P_n = \prod_{k=1}^K P_{nk}^{\delta_{nk}^k} \quad (10)$$

Finally, we allowed for the intermediate goods mix used by firms to differ from the mix used in consumption and to vary across industries and regions. Hence, the intermediate goods price index  $\rho_{nj}$  of industry  $j$  in region  $n$  can be written as

$$\rho_{nj} = \prod_{k=1}^K P_{nk}^{\delta_{nk}^j}, \quad 0 \leq \delta_{nk}^j \leq 1, \quad \sum_{k=1}^K \delta_{nk}^j = 1 \quad (11)$$

where  $\delta_{nk}^j$  is the share of industry  $k$  in the input mix of industry  $j$  in country  $n$ .

**Income and land rents.** We follow Redding (2014) by assuming that a region's land rent is evenly distributed among that region's consumers. Hence, with  $v_n$  denoting income per capita in region  $n$ , that region's total expenditure is

$$v_n L_n = w_n L_n + (1 - \alpha) v_n L_n + \sum_{k=1}^K \eta_{nk} R_{nk} + D_n \quad (12)$$

where  $R_{nk}$  is the total revenue of industry  $k$  firms in region  $n$  and  $D_n$  a fixed transfer accounting for the country's trade deficit (surplus if negative). The first term on the right hand side (RHS) is labor income from production and the two following terms are the incomes from expenditures on residential land use and from commercial land use, respectively. Since labor costs are a constant share  $\beta_{nk}$  of revenue in each industry,

$$w_n L_n = \sum_{k=1}^K \beta_{nk} R_{nk}, \quad (13)$$

we can rewrite total expenditure as:

$$v_n L_n = \frac{\sum_{k=1}^K (\beta_{nk} + \eta_{nk}) R_{nk} + D_n}{\alpha} \quad (14)$$

Goods market clearing commands that the sum of spending from all regions on goods produced in region  $i$  and industry  $k$  must equal that industry's revenue. Using eq. (14) this yields:

$$R_{ik} = \sum_{n=1}^N \pi_{nik} \{ \sum_{j=1}^K [\delta_{nc}^k (\beta_{nj} + \eta_{nj}) + \delta_{nj}^k (1 - \beta_{nj} - \eta_{nj})] R_{nj} + \delta_{nc}^k D_n \} \quad (15)$$

where the term in parenthesis represents the combined consumption and intermediate demand of country  $n$  for industry  $k$  goods.

Land market clearing requires that total rent income must equal total spending on land:

$$r_n H_n = (1 - \alpha) v_n L_n + \sum_{k=1}^K \eta_{nk} R_{nk}$$

This together with eq. (14) allows to write a region's rental rate of land in terms of its endogenously determined revenues, as well as its exogenously given trade deficit and supply of land:

$$r_n = \frac{\sum_{k=1}^K ((1 - \alpha) \beta_{nk} + \eta_{nk}) R_{nk} + (1 - \alpha) D_n}{\alpha H_n} \quad (16)$$

**Labor mobility.** Corresponding to utility function (1), the welfare of a worker residing in region  $n$ , is given by her real income

$$V_n = \frac{v_n}{p_n^\alpha r_n^{1-\alpha}} \quad (17)$$

The mobility of labor across regions within a country  $m$  ensures that real incomes are equalized (whilst the international immobility of workers implies that real incomes can differ across countries). Hence, there is a common utility level  $\bar{V}^m$  which pertains across regions within country  $m$ . Using income per capita from eq. (14) and the rental rate of land from eq. (16) we can solve for the population in region  $n$  in terms of the endogenously determined revenues,

price indices, and common utility level, as well as the exogenously given trade deficit and housing supply:

$$L_n = \frac{\sum_{k=1}^K (\beta_{nk} + \eta_{nk}) R_{nk} + D_n}{\alpha^\alpha P_n^\alpha \left( \frac{\sum_{k=1}^K ((1-\alpha)\beta_{nk} + \eta_{nk}) R_{nk} + (1-\alpha)D_n}{H_n} \right)^{1-\alpha}}, \quad \forall n \in N^m \quad (18)$$

**General equilibrium.** The general equilibrium of the model can be represented by the following system of four equations which jointly determines for all locations  $n$  the set of industry revenues  $\mathbf{R}_{nk}$ , price indices  $\mathbf{P}_{nk}$ , each locations region-sector trade shares  $\pi_{nik}$ , and the population shares in each region,  $\lambda_n^m \equiv L_n / \bar{L}^m$ :

$$\begin{aligned} \pi_{nik} &= \frac{T_{ik}(d_{nik}c_{ik})^{-\theta_k}}{\sum_{s=1}^N T_{sk}(d_{nsk}c_{sk})^{-\theta_k}} \\ P_{nk} &= \gamma_k \left[ \sum_{i=1}^N T_{ik}(d_{nik}c_{ik})^{-\theta_k} \right]^{-\frac{1}{\theta_k}} \\ R_{ik} &= \sum_{n=1}^N \pi_{nik} \{ \sum_{j=1}^K [\delta_{nc}^k (\beta_{nj} + \eta_{nj}) + \delta_{nj}^k (1 - \beta_{nj} - \eta_{nj})] R_{nj} + \delta_{nc}^k D_n \} \\ \lambda_n^m &= \frac{\frac{\sum_{k=1}^K (\beta_{nk} + \eta_{nk}) R_{nk} + D_n}{P_n^\alpha \left( \frac{\sum_{k=1}^K ((1-\alpha)\beta_{nk} + \eta_{nk}) R_{nk} + (1-\alpha)D_n}{H_n} \right)^{1-\alpha}}}{\sum_{i \in N^m} \left[ \frac{\sum_{k=1}^K (\beta_{ik} + \eta_{ik}) R_{ik} + D_i}{P_i^\alpha \left( \frac{\sum_{k=1}^K ((1-\alpha)\beta_{ik} + \eta_{ik}) R_{ik} + (1-\alpha)D_i}{H_i} \right)^{1-\alpha}} \right]} \end{aligned} \quad (19)$$

$$\text{where } c_{ik} = \left( \frac{\sum_{k=1}^K \beta_{ik} R_{ik}}{L_i} \right)^{\beta_{ik}} \left( \frac{\sum_{k=1}^K ((1-\alpha)\beta_{ik} + \eta_{ik}) R_{ik} + (1-\alpha)D_i}{\alpha H_i} \right)^{\eta_{ik}} \left( \prod_{k=1}^K P_{nk}^{\delta_{nk}^k} \right)^{1-\beta_{ik}-\eta_{ik}} \quad (20)$$

This equation system involves the bilateral industry trade shares, eq. (8), price indices, eq. (9), and goods market clearing, eq. (15). The shares of country  $m$ 's population living in region  $n$ , eq. (19), follow from applying  $\lambda_n^m \equiv L_n / \bar{L}^m$  together with  $\bar{L}^m = \sum_{n \in N^m} L_n$  to eq. (18). Finally, the marginal costs  $c_{ik}$  are calculated by using the input price indices, eq. (11), wages, eq. (13), and rental rates of land, eq. (16), to replace the corresponding values in eq. (6).

### 3 The liberalization of transatlantic trade

#### 3.1 Methodology

We apply the method introduced by Dekle, Eaton and Kortum (2007) to study the effects of a counterfactual change in inter-regional trade costs  $\mathbf{d}_{nik}$ . We denote the value that an endogenous variable  $\mathbf{x}$  takes in the counterfactual equilibrium with a prime ( $\mathbf{x}'$ ) and its relative value in the counterfactual and initial equilibria by a hat ( $\hat{\mathbf{x}} \equiv \mathbf{x}'/\mathbf{x}$ ). Starting from the equilibrium system specified in the previous section and defining total expenditure  $\mathbf{Y}_n \equiv \mathbf{v}_n \mathbf{L}_n$ , and total wage income  $\mathbf{W}_n = \mathbf{w}_n \mathbf{L}_n$  the counterfactual equilibrium values must satisfy:

$$\pi'_{nik} = \frac{\pi_{nik}(\hat{d}_{nik}\hat{c}_{ik})^{-\theta_k}}{\sum_{s \in N} \pi_{nsk}(\hat{d}_{nsk}\hat{c}_{sk})^{-\theta_k}} \quad (21)$$

$$\hat{P}_{nk} = \left[ \sum_{i=1}^N \pi_{nik}(\hat{d}_{nik}\hat{c}_{ik})^{-\theta_k} \right]^{-\frac{1}{\theta_k}} \quad (22)$$

$$R'_{ik} = \sum_{n=1}^N \pi'_{nik} \{ \sum_{j=1}^K [\delta_{nc}^k(\beta_{nj} + \eta_{nj}) + \delta_{nj}^k(1 - \beta_{nj} - \eta_{nj})] R'_{nj} + \delta_{nc}^k S_n \} \quad (23)$$

$$\lambda_n^m = \frac{\lambda_n^m \frac{\hat{Y}_n}{\hat{P}_n^\alpha \hat{r}_n^{1-\alpha}}}{\sum_{i \in N^m} \lambda_i^m \frac{\hat{Y}_i}{\hat{P}_i^\alpha \hat{r}_i^{1-\alpha}}} \quad (24)$$

$$\text{with } \hat{c}_{ik} = \left( \frac{\hat{W}_i}{\hat{\lambda}_i^m} \right)^{\beta_{ik}} \hat{r}_i^{\eta_{ik}} \left( \prod_{j=1}^K \hat{P}_{ij}^{\delta_{ij}^j} \right)^{1-\beta_{ik}-\eta_{ik}}, \hat{r}_n = \frac{\sum_{k=1}^K ((1-\alpha)\beta_{nk} + \eta_{nk}) R'_{nk} + (1-\alpha)D_n}{\sum_{k=1}^K ((1-\alpha)\beta_{nk} + \eta_{nk}) R_{nk} + (1-\alpha)D_n},$$

$$\hat{W}_n = \frac{\sum_{k=1}^K \beta_{ik} R'_{ik}}{\sum_{k=1}^K \beta_{ik} R_{ik}} \text{ and } \hat{Y}_n = \frac{\sum_{k=1}^K (\beta_{nk} + \eta_{nk}) R'_{nk} + D_n}{\sum_{k=1}^K (\beta_{nk} + \eta_{nk}) R_{nk} + D_n}.$$

The implied change in real income ( $\hat{V}_n \equiv V'_n/V_n$ ) for a consumer living in region  $n$  in country  $j$  is then, under labor mobility:

$$\hat{V}_n = \frac{\hat{Y}_n}{\hat{r}_n^{1-\alpha}} \prod_k \hat{r}_{nk}^{-\alpha \frac{\delta_{nc}^k}{\theta_k}} \hat{c}_{nk}^{-\alpha \delta_{nc}^k} \quad (25)$$

An inspection of the equation system characterizing the counterfactual, eq. (21) - (24) and of the implied change in the real income (25) reveals the parsimony of our method. In order to numerically solve this equation system we only need information concerning a small number of exogenous variables, the share of goods in consumption ( $\alpha$ ), the cost shares of labor and land (or intermediates), ( $\beta_{nk}, \eta_{nk}$  or  $1 - \beta_{nk} - \eta_{nk}$ ), sectoral expenditure and cost shares ( $\delta_{nc}^k, \delta_{nj}^k$ ) for which data are readily available, and estimates for the sectoral productivity dispersion ( $\theta_k$ ). Neither does our method require information concerning the elasticity of substitution ( $\sigma_k$ ), nor

on the region- and sector specific scale parameters of technology ( $T_{nk}$ ) or the factor supplies (except for population shares of regions within countries). Most importantly, however, no information is needed concerning the multidimensional matrix of trade frictions ( $d_{nik}$ ), the key advantage of this method established by Dekle, Eaton and Kortum (2007).

Notice before proceeding that a regime of pure trade but without factor mobility among a subset of locations is simply represented by imposing  $\hat{\lambda}_n^m = \lambda_n^m / \lambda_n^m = 1$  in the above system. We will make use of this in our ensuing empirical analysis in order to identify and distinguish the (medium-run) pure trade effects from the longer-run effects of labor mobility within the European Union.

### 3.2 Data

In addition to the data requirements concerning exogenous parameters in our model ( $\alpha, \beta_{nk}, \eta_{nk}, \delta_{nC}^k, \delta_{nJ}^k, \theta_k$ ) we simply need a matrix of bilateral industry trade shares  $\pi_{nik}$  which includes own-trade. We use the World Input Output database (WIOD) as our main data source. This data set provides a time-series of world input-output tables compiled on the basis of officially published input-output tables in combination with national accounts and international trade statistics. We take the data for the year 2011 as it is the most current year available in the database at the time of writing. The world input-output table for this year covers data from 35 industries in 41 countries, including one artificial “rest of the world” (ROW) country. However, due to differences in sector classifications across countries, some countries have zero output and consumption in some of these 35 sectors. For example, there is zero production in China and Indonesia in ‘sale, maintenance and repair of motor vehicles and motorcycles; retail sale of fuel’ and in Sweden and Luxembourg in ‘leather, leather and footwear’<sup>5</sup>. To avoid the problems associated with zero output and consumption we aggregate the data to 29 industries according to table 1 in the appendix. The available countries include all current members of the European Union, except for Croatia which has not been a part of the Union in 2011, as well as the US and all major trading partners of the EU and the US. The complete list is provided in table 2 in the appendix. We can use this input-output table to derive the consumption and intermediate good shares ( $\delta_{nC}^k$  and  $\delta_{nJ}^k$ ), the share of value added ( $\beta_{nk} + \eta_{nk}$ ) and the bilateral industry trade shares ( $\pi_{nik}$ ). Appendix A1 explains this process in detail, including how we thereby handle

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5 There is also zero production in Cyprus, Luxembourg, Latvia and Malta in ‘coke, refined petroleum and nuclear fuel’ and for several countries in the sector ‘private households with employed persons’ and zero consumption in Latvia and Cyprus in ‘water transport’, in Luxembourg in ‘air transport’ and, again in several countries in the sector ‘private households with employed persons’.

inventory changes and zeros in bilateral trade flows. In line with values from previous literature we set the share of goods in consumption  $\alpha$  equal to 75% and assign 20% of total value added to land.

For data on the labor force we rely on the WIOD Socio Economic Accounts (SEA). We use the value of ‘people engaged’, which includes self-employed and family-workers, for the year 2011 which is consistent with the data above.<sup>6</sup> Since, there is no value for ROW we use the International Labor Associations estimate of the worldwide work force of 3 billion people and subtract the work force of all other countries in our model.

### 3.3 Results

With the negotiations still going on it is hard to project the trade liberalizations that will finally be undertaken. In response to this uncertainty we consider a range of conceivable reductions of non-tariff barrier between the EU and the US. We keep this range within the lines hypothesized in previous studies so that the most ambitious scenario that we consider involves a non-tariff barrier reduction by 25%.

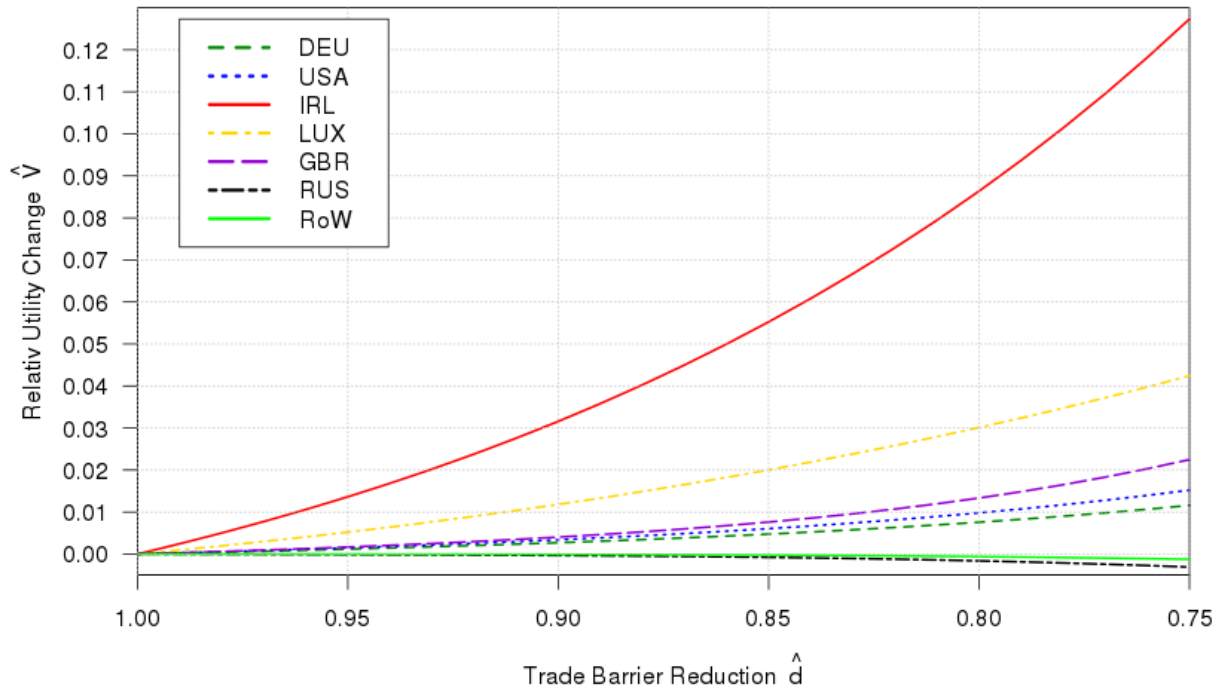


Figure 1: Welfare effects of trade barrier reduction; pure trade regime

**Real income changes - pure trade regime.** Figure 1 reports our findings for the change in real incomes,  $\hat{V}_n \equiv V'_n/V_n$  from eq. (25) for what we have previously termed the pure trade regime,  $\hat{\lambda}_n^j = \lambda_n^j/\lambda_n^j = 1$  (no labor mobility in Europe). As can be seen, there are two very strong winners in Europe, Ireland and Luxembourg. In the most ambitious scenario of a trade barrier

<sup>6</sup> See Timmer (2012) and Timmer et al. (2007) for details on the work force data.

reduction of 25%, Ireland would reap a real income gain of more than 12% and Luxembourg of slightly more than 4%. In the selection of countries shown,<sup>7</sup> Great Britain and the United States follow with real income gains at around 2% and 1.5% in this scenario. In the full sample only the Netherlands and Belgium show similar effects. For the rest of the countries the quantitative effects are much milder, even in this most ambitious scenario. Germany would obtain a real income gain of about 1%. Figure 1 also reveals that there is trade diversion: Russia and the ROW-countries experience negative welfare effects. Trade diversion is similarly strong for Mexico and Canada, as these countries are very tightly integrated with the United States but would not be involved in transatlantic trade liberalization.

Figure 2 provides complementary information concerning the initial spending shares on US goods and services for our country sample. We have ordered the countries from the strongest losers of transatlantic trade liberalization (Russia, Canada, Taiwan, Mexico) to the strongest winners, the Netherlands, Great Britain, Luxembourg and Ireland. It becomes apparent that both the strongest winners and the strongest losers exhibit the closest ex-ante connections with the United States (except for Russia which has such ties with the EU): the spending shares on US goods and services from Luxembourg and Ireland are in the range of 9% to 10% and the spending shares of Canada and Mexico are only slightly lower, at around 8%. Figure 2 reveals also that the limited overall welfare results, that we have diagnosed, stem from the small share that US goods have in overall spending in most of the countries: for most countries apart from the mentioned ones, these shares are well below 2%.

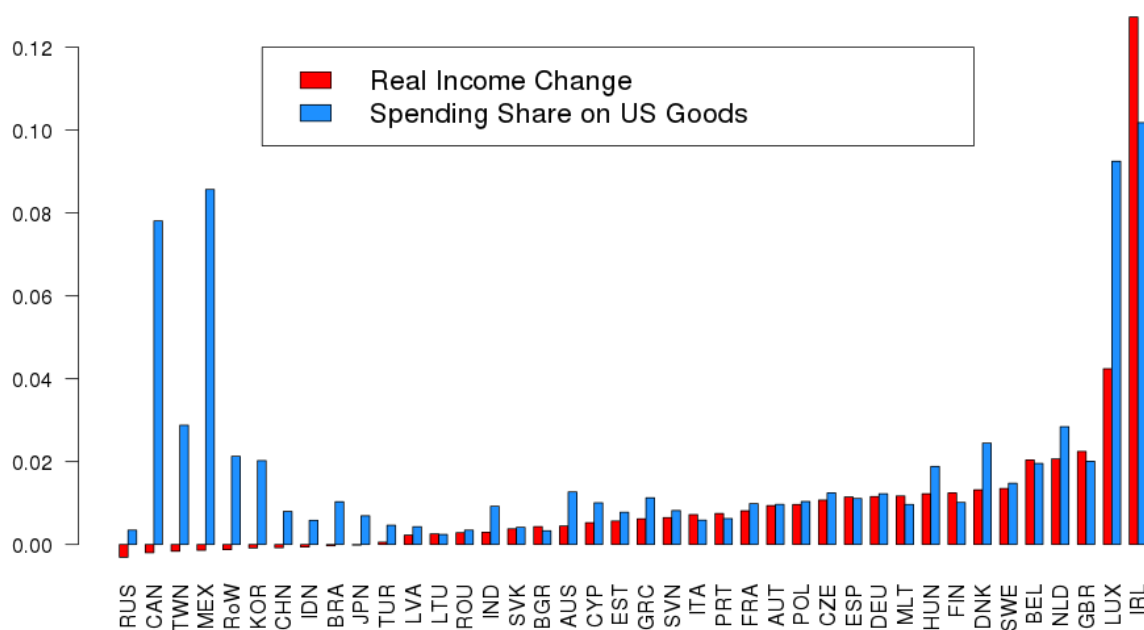


Figure 2: Welfare effects and initial spending shares

<sup>7</sup>See table 3 in the appendix for a full list.



Figure 3 provides a more detailed look into the fabrics of the real income changes. As is clear from eq. (17), real income is composed of nominal income, goods prices and land prices. A breakdown of the overall welfare change into the changes in goods prices and incomes is provided in that figure. The numbers reported are for the most ambitious trade liberalization scenario. It is interesting to note that the overall welfare effects have very heterogeneous roots.

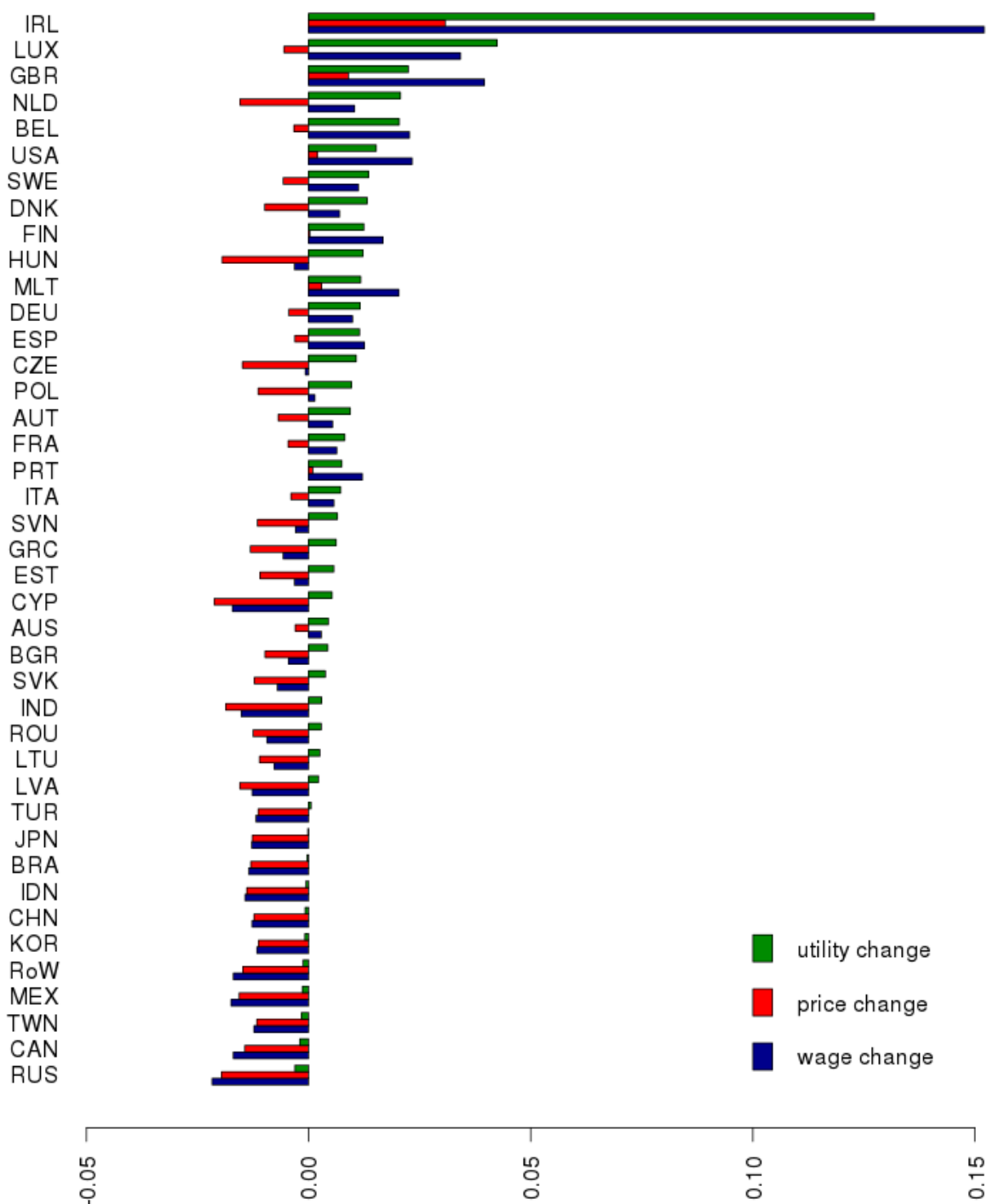


Figure 3: The components of welfare changes

In the case of Ireland, Great Britain and the US the overall welfare gain is due to a strong increase in wages which overcompensates rising prices. The positive real income effects in

most Northern and Western EU countries, such as Luxembourg, the Netherlands, Belgium, Germany, France and Spain is driven by both wage gains and falling goods prices. Eastern and Southeastern European countries, on the other hand, experience falling wages that are overcompensated by drastic price reductions. Finally, falling prices also buffer the negative effects of trade diversion in third party countries, resulting in only minimal welfare losses. In the case of India and Australia, who compensate trade losses by increasing their bilateral ties, falling prices even lead to overall real income gains despite reduced wages.

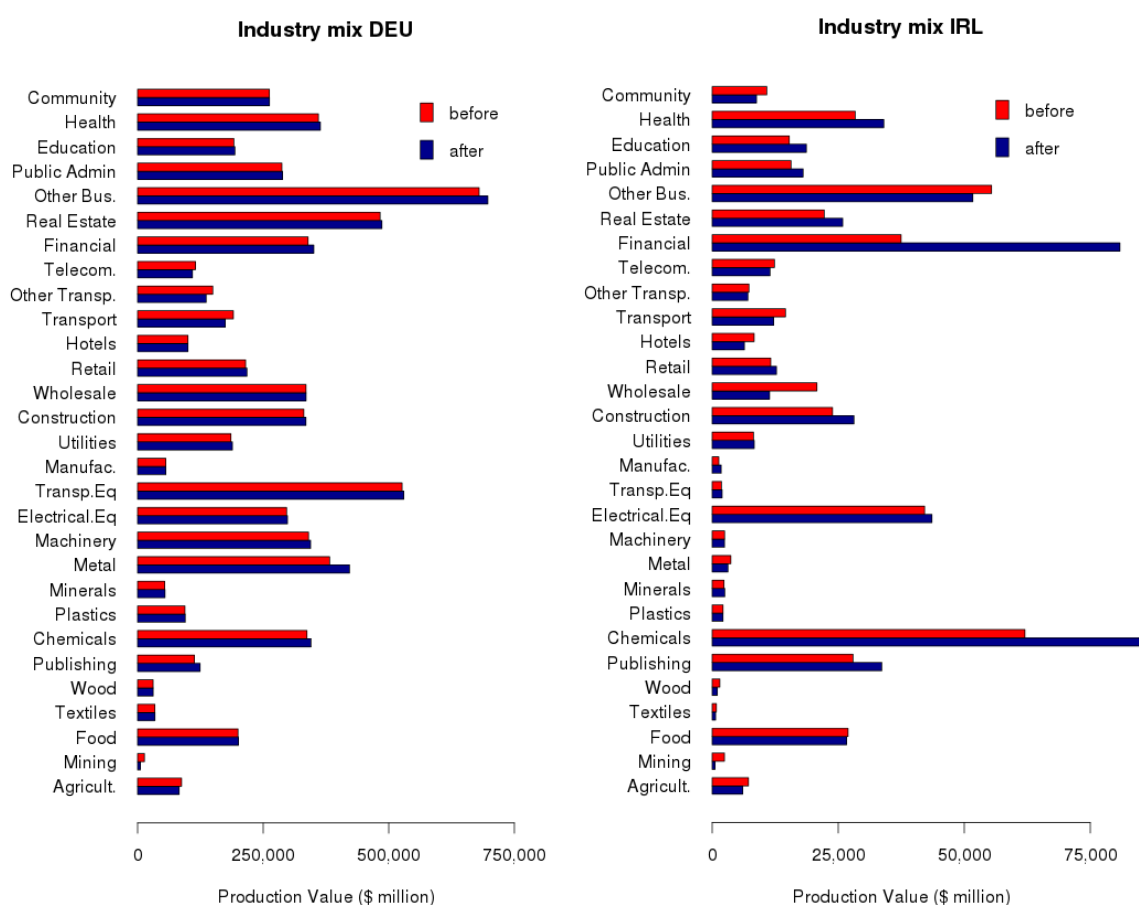


Figure 4: Effects on the industry mix: Germany vs. Ireland

We have also looked at the changes in the industry mix that is implied by transatlantic trade liberalization. Figure 4 reports the results on industry mix, again under the assumption of the most ambitious liberalization path for two countries. Germany is representative for many other countries in that there is only little effect on the industry mix. As can be seen, there are only very small effects, if any, in most of the industries. An exception is metal which would thrive under transatlantic trade liberalization whilst telecommunications, transport, other transport activities and mining shrink. Ireland, which would be the overall winner in welfare terms,

experiences strong effects, in some industries, however. Both financial and chemical products (including pharmaceuticals) would experience a strong boost.

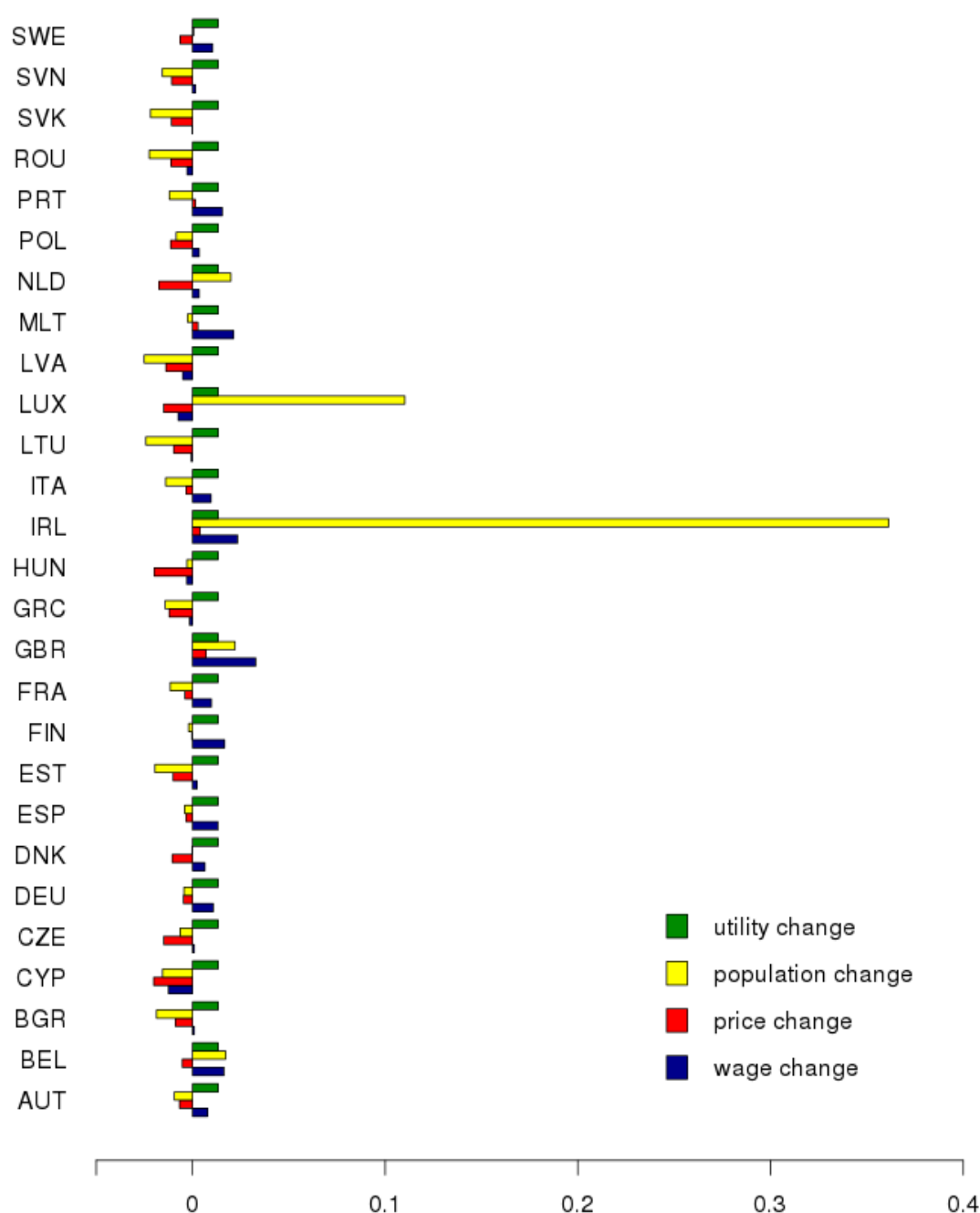


Figure 5: Welfare effects in European countries, with labor mobility

**Population mobility in Europe.** Figure 4 portrays our findings under the assumption of full labor mobility in Europe. It should be noted that we have integrated only one strong dispersion force in our model, land prices. Clearly, there are further forces which reduce labor mobility in Europe, in particular heterogeneous location preferences and a plethora of mobility costs. The results in this section should therefore be seen as an extreme scenario, just as the no mobility

case (depicted in figure 1) goes to the other extreme. The establishment of a spatial equilibrium in the mentioned extreme case would level all income gains at 1.3% in all EU members. Ireland and Luxembourg would experience a strong inflow of labor followed, with an already much weaker inflow, by Great Britain, the Netherlands and Belgium. This inflow immensely reduces wages in these countries, but thereby also lowers production costs and consequently leads to much lower price increases as compared to the no-mobility case in figure 1.

### **3.4 Discussion**

Both our model and our empirical strategy differ from both from the previous computable general equilibrium evaluations of transatlantic trade liberalization as well as from the approach pursued in Felbermayr (2014; 2013). Hence, in addition to being interesting on their own, our results provide an important robustness check for these earlier studies.

Our overall welfare results are in the range of the results reported in Francois (2013) and slightly higher than those reported in Fontagné (2013), all methodological differences notwithstanding. The more recent study by Felbermayr (2014), in contrast, reports significantly higher welfare effects. According to that study, the EU 28 would achieve a welfare gain of 3.9 % and the United States of 4.9 %. The welfare loss that they compute for the rest of the world (-0,9%) is in the ballpark of our results, however.

Like Felbermayr et al. (2014) we find a substantial degree of heterogeneity within the EU and between the EU and the US. However, this masks stark differences at a finer level. Felbermayr et al. (2003) report that it is in particular the member states of the EU with peripheral geographic positions that benefit most. This corresponds to our finding with respect to Ireland. However, we also find that a country at the geographic center, Luxembourg, would derive extremely strong benefits. Felbermayr et al. (2013), on the other hand, find that Spain would derive strong gains in the range of 5.6 % which is dramatically at odds with our findings and which is also hard to understand given the small share of spending that Spain devotes to US goods and services (cf. figure 2.).

There are some further differences. Whereas trade diversion effects appear to play little role in Fontagné (2013), they are clearly visible in other studies and, for very good reasons, very prominent for Russia, Canada and Mexico in our analysis.

The different empirical strategies make it impossible to trace the exact sources of these differences. Given the transparency of our model and empirical strategy, and the plausible

explanations that we could give for our results, it would be good to know what underlies the differences.

## 4 Conclusion

This paper is the first to set up a new quantitative trade model and to employ the method of Dekle et al. (2007) to evaluate the quantitative consequences of the liberalization of transatlantic trade associated with the envisioned EU-US trade and investment partnership. The advantage of this approach is that we do not need information on the initial trade cost matrix to perform our numerical analysis. The trade costs are extremely hard to quantify since the most important outstanding trade barriers are of the non-tariff nature. Previous analyses have obtained widely differing results for the tariff equivalents of these barriers and hence, are plagued by considerable uncertainties. Our approach allows us to circumvent this problem since these parameters are already embedded in the baseline specification. With our method it is easy to establish the real income effects for a whole range of trade cost reductions. Our welfare results are similar to earlier estimates drawing on computable general equilibrium models but significantly lower than another more recent study.

Three important caveats are important to keep in mind. First, for Europe we study a scenario both with no labor mobility and one with labor mobility hindered only by changing land prices. Both these scenarios are to be thought of as the extreme limiting cases. Second, our analysis sheds only light on static gains from trade liberalization but not on the likely follow-up effects associated with induced capital accumulation and dynamic growth effects. Third, our approach, like the previous attempts, does not embrace welfare effects associated with FDI. Hence, from these two latter constraints, our results have to be viewed as lower bounds for the welfare effects. Future research is needed to embed FDI in the new quantitative trade models to obtain more accurate overall welfare effects for the investment part of this (and any other) agreement.

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## Appendix

**Table 1: List of sectors**

WIOD Sector	Label	New Sector	Label
1	Agriculture, Hunting, Forestry and Fishing	1	Agricult.
2	Mining and Quarrying	2	Mining
3	Food, Beverages and Tobacco	3	Food
4	Textiles and Textile Products	4	Textiles
5	Leather, Leather and Footwear	5	Wood
6	Wood and Products of Wood and Cork	6	Publishing
7	Pulp, Paper, Paper , Printing and Publishing	7	Chemicals
8	Coke, Refined Petroleum and Nuclear Fuel	8	Plastics
9	Chemicals and Chemical Products	9	Minerals
10	Rubber and Plastics	10	Metal
11	Other Non-Metallic Mineral	11	Machinery
12	Basic Metals and Fabricated Metal	12	Electrical Eq
13	Machinery, Nec	13	Transp. Eq
14	Electrical and Optical Equipment	14	Manufac.
15	Transport Equipment	15	Utilities
16	Manufacturing, Nec; Recycling	16	Construction
17	Electricity, Gas and Water Supply	17	Wholesale
18	Construction	18	Retail
19	Sale, Maintenance and Repair of Motor Vehicles and Motorcycles; Retail Sale of Fuel	19	Hotels
20	Wholesale Trade and Commission Trade, Except of Motor Vehicles and Motorcycles	20	Transport
21	Retail Trade, Except of Motor Vehicles and Motorcycles; Repair of Household Goods	21	Other Transp.
22	Hotels and Restaurants	22	Telecom.
23	Inland Transport	23	Financial
24	Water Transport	24	Real Estate
25	Air Transport	25	Other Bus.
26	Other Supporting and Auxiliary Transport Activities; Activities of Travel Agencies	26	Public Admin
27	Post and Telecommunications	27	Education
28	Financial Intermediation	28	Health
29	Real Estate Activities	29	Community
30	Renting of M&Eq and Other Business Activities		
31	Public Admin and Defence; Compulsory Social Security		
32	Education		
33	Health and Social Work		
34	Other Community, Social and Personal Services		
35	Private Households with Employed Persons		

Source: WIOD Database



**Table 2: Country sample**

<b>Code</b>	<b>Country</b>	<b>Code</b>	<b>Country</b>	<b>Code</b>	<b>Country</b>
AUS	Australia	FRA	France	MLT	Malta
AUT	Austria	GBR	Great Britain	NLD	Netherlands
BEL	Belgium	GRC	Greece	POL	Poland
BGR	Bulgaria	HUN	Hungary	PRT	Portugal
BRA	Brazil	IDN	Indonesia	ROU	Romania
CAN	Canada	IND	India	RUS	Russia
CHN	China	IRL	Ireland	SVK	Slovakia
CYP	Cyprus	ITA	Italy	SVN	Slovenia
CZE	Czech Republic	JPN	Japan	SWE	Sweden
DEU	Germany	KOR	Korea	TUR	Turkey
DNK	Denmark	LTU	Lithuania	TWN	Taiwan
ESP	Spain	LUX	Luxemburg	USA	United States of America
EST	Estonia	LVA	Latvia	ROW	Rest of World
FIN	Finland	MEX	Mexico		

Source: WIOD Database

**Table 3: Detailed effects of different scenarios**

	25% Trade Barrier Reduction						Autarky		
	<u>real income</u>		<u>prices</u>		<u>wages</u>		<u>real income</u>	<u>prices</u>	<u>wages</u>
	immobile	mobile	immobile	mobile	immobile	mobile	Immobile & no deficits		
AUS	0,45%	0,45%	-0,30%	-0,37%	0,29%	0,22%	-16,01%	22,37%	-3,02%
AUT	0,94%	1,33%	-0,68%	-0,67%	0,54%	0,78%	-42,50%	109,69%	0,27%
BEL	2,04%	1,33%	-0,33%	-0,53%	2,27%	1,64%	-50,37%	161,03%	2,57%
BGR	0,43%	1,33%	-0,98%	-0,89%	-0,45%	0,09%	-36,46%	79,97%	-1,69%
BRA	-0,03%	-0,03%	-1,30%	-1,37%	-1,35%	-1,41%	-8,04%	11,76%	-0,06%
CAN	-0,20%	-0,20%	-1,44%	-1,51%	-1,69%	-1,76%	-24,50%	42,80%	-1,82%
CHN	-0,08%	-0,08%	-1,23%	-1,29%	-1,27%	-1,33%	-12,45%	22,40%	2,51%
CYP	0,53%	1,33%	-2,12%	-2,01%	-1,71%	-1,25%	-31,41%	62,72%	-1,56%
CZE	1,07%	1,33%	-1,49%	-1,50%	-0,07%	0,09%	-47,92%	146,35%	3,21%
DEU	1,16%	1,33%	-0,45%	-0,47%	0,99%	1,08%	-24,86%	50,58%	2,87%
DNK	1,32%	1,33%	-0,99%	-1,05%	0,70%	0,64%	-30,67%	68,65%	3,49%
ESP	1,15%	1,33%	-0,31%	-0,34%	1,26%	1,32%	-17,98%	29,77%	-0,36%
EST	0,57%	1,33%	-1,09%	-1,01%	-0,32%	0,24%	-33,41%	76,07%	2,39%
FIN	1,24%	1,33%	0,03%	-0,03%	1,67%	1,66%	-19,68%	37,90%	2,96%
FRA	0,81%	1,33%	-0,46%	-0,40%	0,63%	0,98%	-20,44%	34,88%	-0,57%
GBR	2,25%	1,33%	0,90%	0,71%	3,96%	3,28%	-26,59%	49,87%	-0,75%
GRC	0,62%	1,33%	-1,31%	-1,21%	-0,57%	-0,15%	-19,58%	30,51%	-2,39%
HUN	1,22%	1,33%	-1,95%	-1,99%	-0,32%	-0,30%	-53,73%	186,93%	2,70%
IDN	-0,06%	-0,06%	-1,39%	-1,46%	-1,43%	-1,50%	-13,75%	19,08%	-2,24%
IND	0,29%	0,30%	-1,86%	-1,92%	-1,51%	-1,57%	-8,12%	9,89%	-1,85%
IRL	12,73%	1,33%	3,08%	0,39%	15,21%	2,34%	-31,49%	75,90%	6,24%
ITA	0,72%	1,33%	-0,40%	-0,33%	0,57%	0,96%	-15,03%	26,61%	1,89%
JPN	-0,02%	-0,02%	-1,27%	-1,33%	-1,28%	-1,35%	-5,16%	8,36%	0,98%
KOR	-0,09%	-0,09%	-1,13%	-1,19%	-1,16%	-1,23%	-16,05%	39,41%	10,40%
LTU	0,26%	1,33%	-1,10%	-0,98%	-0,78%	-0,07%	-23,63%	45,45%	1,52%
LUX	4,24%	1,33%	-0,55%	-1,50%	3,42%	-0,74%	-95,79%	9212,24%	36,48%
LVA	0,22%	1,33%	-1,55%	-1,38%	-1,27%	-0,51%	-34,81%	74,02%	-1,63%
MEX	-0,14%	-0,14%	-1,56%	-1,64%	-1,75%	-1,82%	-30,29%	57,33%	-2,75%
MLT	1,17%	1,33%	0,29%	0,28%	2,03%	2,13%	-72,65%	471,28%	1,40%
NLD	2,07%	1,33%	-1,54%	-1,74%	1,03%	0,34%	-33,69%	81,74%	5,08%
POL	0,97%	1,33%	-1,13%	-1,13%	0,14%	0,34%	-33,43%	74,77%	1,58%
PRT	0,75%	1,33%	0,09%	0,15%	1,21%	1,55%	-26,77%	47,77%	-2,46%
ROU	0,28%	1,33%	-1,25%	-1,11%	-0,94%	-0,28%	-22,92%	37,54%	-2,80%
RUS	-0,31%	-0,32%	-1,96%	-2,03%	-2,17%	-2,25%	-22,61%	33,00%	-5,51%
SVK	0,38%	1,33%	-1,22%	-1,09%	-0,71%	-0,02%	-45,64%	132,02%	2,92%
SVN	0,65%	1,33%	-1,15%	-1,08%	-0,30%	0,15%	-44,05%	118,36%	0,66%
SWE	1,35%	1,33%	-0,57%	-0,65%	1,12%	1,04%	-24,89%	50,60%	2,83%
TUR	0,06%	0,06%	-1,13%	-1,19%	-1,18%	-1,24%	-23,00%	38,21%	-2,45%
TWN	-0,16%	-0,17%	-1,17%	-1,24%	-1,23%	-1,30%	-28,96%	80,66%	14,52%
USA	1,52%	1,55%	0,20%	0,15%	2,33%	2,31%	-10,64%	15,36%	-0,71%
RoW	-0,12%	-0,12%	-1,48%	-1,57%	-1,69%	-1,77%	-24,51%	42,03%	-2,37%

## A1: Derivation of trade shares from the WIOD database

For each combination of countries and sectors the WIOD contains an entry  $X_{ni,jk}$  of flows from industry  $k$  in country  $i$  to industry  $j$  in country  $n$ , including within country flows  $X_{ii,jk}$ . Moreover, it also provides values for flows from industry  $k$  in country  $i$  to country  $n$  that end up as final consumption by households  $X_{ni,Ck}$ , final consumption by non-profit organizations  $X_{ni,Pk}$ , government spending  $X_{ni,Gk}$ , investments  $X_{ni,Ik}$  and inventory changes  $X_{ni,Qk}$ .

Of course, inventory changes can be negative and sometimes they are significantly large. If we were to calculate final demand by simply summing over consumption, investment, government spending and inventory changes we would end up with a negative final demand in some instances. Hence, to reconcile the real world data with our static model that has no room for inventories we follow Costinot and Rodriguez-Claré (2014) and split the vector of inventory changes into a vector with all positive changes  $X_{ni,Qk+}$  and one with all negative changes  $X_{ni,Qk-}$  and treat them differently. Positive inventory changes are directly included in the final demand in the same way that final consumption, government spending and investments are, i.e. we treat the build up of inventory as if it were consumed in the current period. Formally final demand in country  $n$  for goods from industry  $k$  in country  $i$ ,  $X_{ni,Fk}$ , is defined as the sum  $X_{ni,Fk} = X_{ni,Ck} + X_{ni,Pk} + X_{ni,Gk} + X_{ni,Ik} + X_{ni,Qk+}$ .

On the other hand, negative inventory changes are treated as if they were produced (and consumed) in the current period. To do this, we can not simply increase our output vector by the respective (absolute) value of inventory changes because the production of the inventory in the last period also required intermediates and, thus, had a larger overall effect. To see how to calculate the necessary changes consider an example with  $N$  countries and  $J$  sectors in matrix notation, where  $X$  is the original total output vector (of size  $N \times J \times 1$ ),  $A$  the matrix of input coefficients (of size  $N \times J \times N \times J$ ),  $F$  the final demand vector (of size  $N \times J \times 1$ ) including positive inventory changes and  $Inv$  the vector of negative inventory changes (of size  $N \times J \times 1$ ). Then the total output can be calculated as the sum of intermediate flows, final demand, and inventory changes as  $X = AX + F + Inv$ . We want to calculate the new level  $X_{new}$  for which the final demand vector is unchanged but inventory changes  $Inv$  are set to 0, i.e. the total output if the negative inventory changes had been produced in the current period. Rearranging terms we get  $X_{new} = (E - A)^{-1}F$  where  $E$  is the unit matrix. We then obtain the new input output matrix by combining intermediate good flows  $AX_{new}$  and the unchanged final demand vector  $F$ .

This final input-output table allows us derive to important parameters of the model. Firstly we can calculate the share that industry  $k$  has in the consumption demand of country  $n$  by dividing demand for industry  $k$  goods by total demand to get  $\delta_{nC}^k = \sum_i X_{ni,Fk} / \sum_k \sum_i X_{ni,Fk}$ . Similarly,

we can derive the share that industry  $k$  has in the intermediate demand of industry  $j$  in country  $n$  as  $\delta_{nj}^k = \sum_i X_{ni,jk} / \sum_k \sum_i X_{ni,jk}$ .

Moreover, we can now use the adjusted input output matrix to calculate bilateral trade flows in each industry  $X_{nik}$  by summing over all usages (intermediate use in all industries and final demand) of  $k$  in its destination country. Hence,  $X_{nik} = \sum_j X_{ni,jk} + X_{ni,Fk}$  gives the total flows of industry  $k$  goods from  $i$  to  $n$ . Our bilateral trade flows can be thought of as a set of  $k$  matrices, one for each industry, as shown in figure A1.

$X_{nik}$	Importer 1	Importer 2	...	$\sum$
Exporter 1	$X_{11k}$	$X_{12k}$	...	$X_{1k}$
Exporter 2	$X_{21k}$	$X_{22k}$	...	$X_{2k}$
...	...	...	...	...
$\sum$	$E_{1k}$	$E_{2k}$	...	

Figure A1: Industry specific bilateral trade matrix

When looking at the data, several of these bilateral trade flows will be equal to 0 due to the high level of sectoral and geographical disaggregation. However, while trade between any two countries in any industry can become arbitrarily small in the Eaton-Kortum model, it can only become 0 if trade costs between those two countries were infinitely high. However, in this case it could no longer hold true that direct trade between those countries would be cheaper than trade via some partner country (with non-infinite trade costs). To avoid these problems, we set all zero trade flows equal to a value of 1 US Dollar. Note that after our industry aggregation process each country produces output in each industry. Since this output will be in the millions, setting some values to 1 Dollar has no real influence on the other countries' trade *shares*, which will be used in our final calculations.

Given this data, we can sum over all exporters to get country  $n$ 's total spending in industry  $k$ , i.e.  $E_{nk} = \sum_i X_{nik}$ . Summing over the spending in each individual industry gives country  $n$ 's total spending as  $E_n = \sum_k E_{nk}$ .

Also, summing over all Importers, we can calculate country  $i$ 's total production in industry  $k$ , i.e. firm revenue in industry  $k$ , as  $X_{ik} = \sum_n X_{nik}$ . Total production or revenue in country  $i$  is, hence, given by  $R_i = \sum_k X_{ik}$ .

Finally, we can also derive the share that country  $i$  has in country  $n$ 's spending in industry  $k$ ,  $\pi_{nik}$ , by dividing industry  $k$  flows from  $i$  to  $n$ ,  $X_{nik}$ , by country  $n$ 's total industry spending  $E_{nk}$ .

Again, these shares can be represented by  $k$  bilateral trade share matrices as shown in figure A2.

$\pi_{nik}$	Importer 1	Importer 2	...
Exporter 1	$\pi_{11k} = \frac{X_{11k}}{E_{1k}}$	$\pi_{21k} = \frac{X_{12k}}{E_{2k}}$	...
Exporter 2	$\pi_{12k} = \frac{X_{21k}}{E_{1k}}$	$\pi_{22k} = \frac{X_{22k}}{E_{2k}}$	...
...	...	...	...
$\sum$	<b>1</b>	<b>1</b>	<b>1</b>

Figure A2: Industry specific bilateral trade share matrix

## Appendix not for publication

### A2: Symbols

$\alpha$	share of housing in consumption
$\beta_{nk}$	cost share of labor
$C_n$	goods and services consumption index in n
$C_{nk}$	consumption index of industry k goods in n
$c_{nk}$	cost of an input bundle in industry k in country n
$D_n$	trade deficit of country n
$d_{nik}$	iceberg trade costs for shipping an industry k good from country i to n
$\delta_{nC}^k$	share of industry k in consumption of individuals from n
$\delta_{nj}^k$	share of industry k in intermediate demand of firms from industry j and country n
$\eta_{nk}$	cost share of land
$F_{nk}(z_{nk})$	country and industry specific Frechet distribution function for productivity draws
$\gamma_k$	calculatory constant
$H_n$	housing stock in n
$H_n^C$	private housing consumption
$i$	index for locations/countries
$j$	index for industries/sectors
$k$	index for industries/sectors
$K$	number of sectors
$L_n$	number of workers in n
$\bar{L}^m$	worker endowment of m
$\lambda_n^m$	share of workers of country group m living in location n
$m$	index for country group
$N$	number of locations/countries
$N^m$	country group = set of locations/countries
$n$	index for locations/countries
$\omega$	index for varieties
$P_n$	price index for consumption in country n
$P_{nk}$	price index for industry k goods in country n
$p_{nik}(\omega)$	price for variety $\omega$ of industry k offered to consumers in n by a country i firm
$\pi_{nik}$	share of country i in the expenditure of country n on industry k goods
$q_{nk}(\omega)$	consumption of variety $\omega$ from industry k by an individual from n
$R_{nk}$	revenue of industry k in country n
$r_n$	rental rates of land in n
$\rho_{nk}$	price index for intermediate demand of an industry k firm in country n
$\sigma_k$	elasticity of substitution between varieties in industry k
$T_{nk}$	measure of the average productivity in industry k in country n
$\theta_k$	measure of the density of productivities
$U_n$	utility of a consumer in n
$V_n$	indirect utility = real income of a worker in n
$v_n$	total income of one worker in n
$W_n$	total labor income of country n
$w_n$	wages in n
$Y_n$	total income of country n
$z_{nk}(\omega)$	productivity draw of a firm in country n and industry k producing variety $\omega$

