# The trade-creation effect of migrants: a multi-country general equilibrium analysis

Miguel Cardoso*

Department of Economics

University of Western Ontario

**Abstract**

I develop a general equilibrium multi-country model that allows for interaction between firm production and exporting decisions and individual migration decisions. Migrants lower trade costs and influence the number of firms that find it profitable to operate domestically or in foreign markets. The reduction in trade costs will impact consumer welfare by affecting the amount and range of differentiated products that can be purchased locally or imported for consumption. I use the model to evaluate the trade-inducing and labour market impact of migration on source and destination countries. For countries with a large diaspora distributed among many countries such as that of Portugal and Poland the welfare outcomes from international migration are between 0.9% - 1.76% worse relative to the benchmark case if I restrict the role that migrants have on affecting firm costs. For these countries the trade creation effect mitigates some of the loss in welfare stemming from the labour market effects of a loss in population from emigration.

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# 1 Introduction

The admission criteria for immigrants vary among countries: some emphasize family reunification, some are based on a points system, while others use a variety of other criteria. Likewise, the proportion of the population accounted for by immigrants differs considerably across countries, even across developed countries. For example, in Canada and Australia immigrants now account for more than 20% of the population, whereas in Finland and Argentina immigrants account for less than 5% of the population. For other countries migration has lead to decreases in their population; in Portugal and Mexico emigration has accounted for a 10% drop in population. Differences in the rates of migration across countries and in the rules governing who can enter, are dependent on whether migration is perceived to have a positive or negative impact on the welfare of native-born workers in those countries. This welfare impact will depend in part on how firm production and export decisions change in response to the scale and source-country composition of migrants in their country.

There are no estimates of the welfare effects of international migration that take into account the impact that migration has on determining bilateral trade flows. Lower trade costs due to migration influence export sales to a country by increasing the sales of existing exporting firms and influencing the number of firms that find it profitable to export, I will refer to these effects as the trade-creation effects of migration. In a series of papers on the literature of international trade and networks, Rauch (1999) and Rauch and Trindade (2002) show that inadequate information about international trading opportunities is a cost to international trade which members of migrant networks can play a key role in overcoming by acting as intermediaries between firms across countries. Studies on the determinants of trade flows conducted in the United States, Canada, Spain, France, and the United Kingdom have revealed consistent results; a 10% increase in immigrants from a particular source country is associated with a 1-3% increase in exports to that country (Gould, 1994; Head and Ries, 1998; Peri and Requena-Silvente, 2010). Thus, the extent to which migration reduces trade costs will impact consumer welfare by affecting the amount and range of differentiated products that can be purchased locally or imported for consumption. The main objective of this paper is to quantitatively assess the aggregate impact of migration via this transmission channel and gauge its relative importance in contributing to the overall welfare impact from the currently observed levels of migration. I find that the welfare contribution of the trade-creation effects of migration is important, particularly for countries with high rates of emigration and a diaspora spread among many countries.

To quantify the migration trade-creation mechanism, I develop a general equilibrium multi-country model where the decision of consumers on where to migrate and the decision of firms on which markets to serve interact. Firms sell goods in all markets that are profitable, and operate in a monopolistic competition market structure with heterogeneity in firm productivity as in Melitz (2003) and Chaney (2008). Consumers work where they will earn the highest real income net of migration costs. The wage they earn at a location will depend on their skill type, the degree of complementary between worker skill types, and changes in the labour supply coming from immigration and emigration[1]. The consumer migration decision and firm export decision interact because which locations a firm sells their product to will impact real income, and where immigrants choose to settle will lower the costs for firms selling to their country of origin. The importance of this interaction depends on the responsiveness of firm trade costs to migration flows. Using the model equation of bilateral trade flows, I estimate the elasticity of exports with respect to standard variables in the gravity trade literature augmented with migration variables. I use these estimates to construct bilateral trade costs, which are dependent on the number of immigrants and emigrants for each source-destination country pair.

In addition to the trade-creation effect, migration impacts consumer welfare in a country through a labour market effect on nominal wages and a market size effect on aggregate demand for goods. I assess the total welfare effects of migration by comparing welfare under the observed levels of migration to a counterfactual scenario with no migration. I compare the economic outcome of this no-migration scenario to the baseline scenario generated by the model to determine the winners and losers from international migration. Native-born stayers

[1]Common features in the nested CES models of labour demand and supply used in the literature that investigates the migration impact on the wages of native-born workers (Borjas, 2003; Ottaviano and Peri, 2012)

in attractive migration destinations such as Canada and the United States have had overall, positive welfare gains from international migration, 6% and 4.5% respectively. Whereas native-born stayers in traditional emigrant source countries such as Mexico, Poland, and Portugal have had welfare losses, with an overall decline in welfare of around 2% each.

The welfare changes to consumers from migration originate from three sources *i*) labour market effects due to changes in nominal wages *ii*) firm entry and exit stemming from market size effects, and *iii*) trade-creation effects due to changes in firm export behaviour. Labour market effects result from immigrants putting downward pressure on the wages of workers with similar characteristics and upward pressure on the wages of workers with different characteristics. For example, low skilled Mexican immigration into the United States will increase the wages of high skilled American workers but reduce the wages of low skilled American workers. Changes to the market size alters aggregate demand in a country which affects firm production decisions and therefore the varieties available for consumption. In the case of Canada, the increase in the population due to immigration induces firm entry in the domestic Canadian market which increases the set of varieties produced in Canada, resulting in a lower price level and higher real income for Canadian workers.

My focus in this paper is on the third channel; how changes to bilateral trade costs affects firm entry and exit decisions. Of the three transmission channels, this is the only one where the source country composition of the immigrants that settled in a country explicitly matters for how firms will respond. To isolate the impact of the trade-creation channel, I consider a counterfactual in which trade costs do not depend on migration and compare the results to the baseline results. For Canada, the United States, and Mexico the results are similar; this channel is not critically important because the behaviour of exporting firms to these set of countries stay relatively stable between the model with all three channels present and one where the trade creation effect of migration is shut down. Furthermore, for the United States and Canada, the welfare contribution of importing additional varieties at a lower cost is small compared to the labour market and market size welfare gains resulting from the large increase in population from immigration. However, for countries with large diasporas distributed among many countries such as Portugal and Poland this channel is more pronounced. Both countries experience a decline in welfare if the trade creation channel of migration is ignored, welfare losses worsen from -1.24% to -3.00% and -2.44% to -3.54%, for Portugal and Poland respectively. In contrast to Canada, the United States, and Mexico, the decisions of firms serving Portugal and Poland depends in a large way on the diaspora reducing the costs of foreign firms exporting there. The trade creation effect mitigates some of the loss in welfare stemming from the labour market and market size effects.

This paper relates to the labour literature that aims to evaluate the economic impact of migration. Ottaviano and Peri (2012); Aydemir and Borjas (2007); Borjas (2003); Card (2009) document the effects of large scale migration on the nominal wages of native workers in the United States. These studies use an aggregate production function that parameterizes the elasticity of substitution between types of workers where the labour input is CES composite of different types of labour (e.g. low skilled and high skilled). In this framework immigrants put downward pressure on the wages of workers with similar characteristics and upward pressure on the wages of workers with different characteristics. The effect of a particular labour supply shock on the wages of native-born workers will depend on the elasticity of substitution between worker types and the size of the inflow of each worker type.

In addition to the work cited above on the aggregate relationship between country level trade flows and migration flows, my paper also complements the empirical literature that uses firm-level data to investigate the importance of source-country immigrant composition on export outcomes. Using firm-level data from PortugalBastos and Silva (2012) find that larger levels of Portuguese emigrants in a particular destination increases firm export participation and export intensity to those locations.

This paper is most closely related to recent work that quantifies the impact of migration on consumer welfare using general equilibrium models with market size effects. Iranzo and Peri (2009) introduce endogenous product variety in a two-country model of migration to explore the welfare effects of a large movement of skilled migration from Eastern Europe to Western Europe. This increases total production of the differentiated consumption goods which the remaining workers in Eastern Europe can purchase via trade. di Giovanni, Levchenko and Ortega (2015) implement a similar framework and calibrate a general equilibrium model to match world income and trade patterns for a set of 60 countries that also features bilateral remittances and distinguishes between the short-run and long-run effects of migration. More recently Aubry, Burzynski and Docquier (2016) expanded the literature to also include the contribution that migrants make to national budgets and social transfers. In these studies, countries with higher stocks of migrants, such as Canada and Australia, benefit the most from migration while countries with high emigration rates, such as Poland and Mexico, on average, have welfare losses from migration. While my findings exhibit this general relationship, in my work I show that the source country composition of migrants matters when measuring the economic impact of the market size channel. The contribution of this paper is to highlight the importance of migration in determining bilateral trade flows, this introduces a new transmission channel by which migration affects welfare in a country. Additionally, compared to these papers, I endogenize the migration decision of individuals and estimate trade costs that are dependent on migration flows. This allows me to test the sensitivity of migration decisions to changes in trade costs. In a trade-cost reduction counterfactual I find that the benefits of lower trade costs for a country depends critically on whether the population increased or decreased following the policy.

# 2 Model Framework

There are $J$ countries, indexed $j = 1, ..., J$. The initial population of workers of skill type $s$ in country $j$ is denoted by $Z_{js}$. Consumers derive utility by consuming goods from two sectors; $N$ denotes the non-traded sector and $T$ the traded sector. Both are made of a continuum of differentiated goods. Consumer $c$ born in country $i$ makes a decision to migrate to country $j$ based on the real wage net the costs of migrating that they will receive. The bilateral costs of migration I estimate will depend on standard determinants of migration flows such as distance and language similarity between countries Borjas (1987); Mayda (2010).

## 2.1 Consumer Preferences

A consumer is characterized by his skill type $s \in \{H, L\}$ and country of origin $j$. Consumers of skill type $s$ residing in $j$ inelastically supply one unit of labour and earn wage $w_{js}$. Consumer preferences are Cobb-Douglas in the CES aggregates of sectors $h \epsilon \{N, T\}$, a consumer $c$ in country $j$ with income $w_{js}$ maximizes

$$\max_{q_j^T(\omega), q_j^N(\omega)} \left[ \int_{\omega \epsilon \Omega_j^T} q_j^T(\omega)^{\frac{\sigma^T-1}{\sigma^T}} d\omega_n^T \right]^{\frac{\sigma^T}{\sigma^T-1}\mu^T} \left[ \int_{\omega \epsilon \Omega_j^N} q_j^N(\omega)^{\frac{\sigma^T-1}{\sigma^T}} d\omega_n^N \right]^{\frac{\sigma^N}{\sigma^N-1}\mu^N} \tag{1}$$

$$s.t. \int_{\omega \epsilon \Omega_j^T} q_j^T(\omega) p_j^T(\omega) d\omega + \int_{\omega \epsilon \Omega_j^N} q_j^N(\omega) p_j^N(\omega) d\omega \leq w_{js}$$

$q_j^h(\omega)$ is the quantity consumed of good $\omega$ belonging to sector $h = N, T$ in country $j$, and $\Omega_j^h$ is the mass of varieties available in sector $h$. $\mu^T$and $\mu^N$ are the share of tradeables and non-tradeables in consumption and $\sigma^h$ is the elasticity of substitution between varieties in sectors $T$ and $N$.

In this framework, the welfare of workers in $j$ are affected by migration is via the impact that migrants have on on equilibrium prices nominal wages $w_{js}$, and the set of goods $\Omega_j$. The set of goods available in $j$, $\Omega_j$ will also change due to trade costs. Markets easily accessible to other countries will have a larger set of goods available for consumption. Standard optimization leads to an expression of indirect utility for a consumer with wage $w_{js}$

$$V_{js} = \frac{w_{js}}{(P_j^T)^{\mu_T} (P_j^N)^{\mu_N}} \tag{2}$$

Welfare increases with a fall in the price level $(P_j^T)^{\mu_T} (P_j^N)^{\mu_N}$, which is decreasing in the number of varieties available for consumption in $j$. Where $P_j^h$ is the ideal price index in sector $s = N, T$ in country $j$,

$$P_j^h = \left[ \int_{\omega \epsilon \Omega_n^h} p_n^h(\omega)^{1-\sigma_h} d(\omega) \right]^{\frac{1}{1-\sigma_h}} \tag{3}$$

## 2.2 Consumer Migration Decision

A consumer $c$ residing in country $i$ makes a decision on which country $j$ to reside in by solving,

$$\underset{j}{max}\ V^*_{cijs} = ln\,(V_{js}) - ln\,(t_{ijs}) + \varepsilon_{cij} \tag{4}$$

where $\varepsilon_{cij}$ is an idiosyncratic shock for consumer $c$ born in $i$ migrating to $j$ and $t_{ijs}$ is the cost of migrating between countries $i$ and $j$ for a consumer of skill type $s$. Following McFadden (1974), I assume $\varepsilon_{cij}$ is i.i.d across i and $j$ and follows a type 1 extreme value distribution. This yields the following expression for the probability a consumer born in $i$ resides in $j$:

$$\delta_{ijs} = Pr[V^*_{cijs} = \underset{k}{max} V^*_{ciks}] = Pr[V^*_{cijs} > V^*_{ci-js}] = \frac{\frac{V_{js}}{t_{ijs}}}{\sum\limits_k \left(\frac{V_{ks}}{t_{iks}}\right)}$$

$t_{ijs}$ is meant to capture the barriers that individuals face in migrating. Using standard proxies from the migration literature (Mayda, 2010; Clark, Hatton and Williamson, 2007), distance, language similarity, past colonial relationships and contiguity between countries will form the determinants of migration costs $t_{ijs}$. Everything else being equal a lower $t_{ijs}$ between countries $i$ and $j$ for a worker of skill $s$ leads to a higher probability of migrating, $\delta_{ijs}$.

Let $m_{ijs}$ denote the number of workers of skill type $s$ in country $j$ originating from country $i$ after migration and $Z_{is}$ denote the starting population of each worker skill type in country $i$.

$$m_{ijs} = \delta_{ijs} Z_{is} \tag{5}$$

Summing over all source countries $i$ gives the total amount of labour available in $j$ of skill type $s$.

$$L_{js} = \underset{i}{\Sigma} m_{ijs}$$

The effective labour force in $j$ is given by a CES aggregate of high and low skilled labour.

$$L_j = \left(\theta_H L_{jH}^{\frac{\eta-1}{\sigma}} + \theta_L L_{jL}^{\frac{\eta-1}{\sigma}}\right)^{\frac{\eta}{\eta-1}} \tag{6}$$

$\theta_H$ and $\theta_L$ capture the relative importance of skilled and low skilled labour in production. Skilled and unskilled workers are imperfect substitutes in production, where $\eta$ is the elasticity of substitution across skill types. Katz and Murphy (1992) first showed the importance of modeling skilled and unskilled labour as imperfect substitutes in production to properly understand the impact of changes in labour supply on the wages of workers. In my setting high skilled migrants will put downward pressure on wages of high skilled native-born workers and upward pressure on the wages of low skilled native-born workers. I assume that immigrant and native workers are perfect substitutes within skill groups meaning there are no differences in productivity between immigrants and native-born workers of the same skill level. There is mixed evidence on the substitutability between immigrant and native-born workers. Using U.S., Canadian, and Mexican data Aydemir and Borjas (2007) show that immigrant and native-born workers are perfect substitutes in production. Whereas Ottaviano and Peri (2012) find a less than perfect substitutability between immigrant and native workers, be it a small one. di Giovanni, Levchenko and Ortega (2015) compare the welfare outcomes from migration under scenarios where immigrant and native labor are both perfect substitutes and imperfect substitutes in production and find that the results are robust to either specification. Nonetheless, in both cases aggregate labour supply in $j$ will still be affected by the skill composition of immigrant workers residing in $j$. Differences in aggregate labour supply across countries form from differences in the proportion of high and low skilled native labour *and* the skill composition of immigrants residing in $j$.

The composite wage in country $j$, $\widetilde{w}_j$, represents the minimized cost of one unit of effective labour in country $j$ is given by,

$$\widetilde{w}_j = \left(\theta_H^{\sigma} w_{jH}^{1-\sigma} + \theta_L^{\sigma} w_{jL}^{1-\sigma}\right)^{\frac{1}{1-\sigma}}$$

Changes in the nominal wage from migration affect native-stayers directly by increasing or decreasing their nominal wage but also in the variety of goods available goods for consumption. Changes in high and low skilled wages will transfer to the composite wage and affect firm production decisions. For example, higher production costs aboard stemming from increases in $\widetilde{w}_n$ leads to less varieties available to import in $j$, increasing the domestic price level and lowering real income.

## 2.3 Firm Technology

Firms operate in a monopolistic competition market structure as in Melitz (2003) and Chaney (2008). Firms are heterogeneous in their productivity and incur a fixed cost when they enter the domestic or tradeable sector. For each country $j$ and sector $h$ the mass of entrants, $e_j^h$ is endogenous. Potential firms must pay a cost $f_e$ to obtain a productivity draw $\varphi$ from the productivity distribution. $f_{jj}^N$ is the fixed cost of producing the non-tradeable good in country $j$ and $f_{ji}^T$ is the fixed cost of selling the tradeable good in country $i$ for a firm operating in country $j$. If a firm in $j$ is exporting goods in sector $T$ to consumers in $i$ they also incur an iceberg per-unit cost that is dependent on the number of immigrants and emigrants between countries $j$ and $i$, $\tau_{ji}^T(L_{ji}, L_{ij})$. $L_{ji}$ and $L_{ij}$ are endogenous objects of the model that reflect the the optimal migration decisions of consumers.

Firms produce using skilled and low-skilled labour. A firm located in country $j$ with productivity $\varphi$ in sector $T$ for $i \neq j$ and facing demand for its good from consumers in country $i$, $q_{ji}^h(\varphi)$, solves,

$$\overset{min}{L_{jH}(\varphi) + L_{jL}(\varphi)} \qquad w_{jH}L_{jH}(\varphi) + w_{jH}L_{jL}(\varphi) - f_{ji}^h$$

$$s.t \qquad . \; A_j\varphi\left(\theta_H L_{jH}^{\frac{\sigma-1}{\sigma}}(\varphi) + \theta_L L_{jL}^{\frac{\sigma-1}{\sigma}}(\varphi)\right)^{\frac{\sigma}{\sigma-1}} = q_{ji}^h(\varphi)$$

The solution to this firm problem shows that the cost of a firm located in $j$ faces in selling

$q$ goods to destination $i$ is divided into two components: a variable cost and a fixed cost,

$$c_{ji}^{h}(q) = \underbrace{\frac{\widetilde{w}_j \tau_{ji}^{T}\left(L_{ji},\, L_{ij}\right)}{A_j \varphi} q}_{\text{Variable Cost}} + \overbrace{f_{ji}^{h}}^{\text{Fixed Cost}}$$

Changes to the skill distribution in $j$ as a result of migration will alter the wages of workers in $j$ and subsequently the cost of production for firms located in $j$. The variable cost component also includes $\tau_{ji}^{T}\left(L_{ji},\, L_{ij}\right)$, where $\tau_{ji}^{T}\left(L_{ji},\, L_{ij}\right) > 1$ for any $j \neq i$ and $\tau_{ji}^{T}\left(L_{ji},\, L_{ij}\right) = 1 \,\forall\, j$ [2]. $f_{ji}^{T}$ is the fixed cost a firm faces when entering market $i$ from $j$. Firm specific productivity $\varphi$ is drawn from a Pareto distribution with shape parameter $\gamma$, the corresponding CDF of $\varphi$ is $G(\varphi) = 1 - \left(\frac{1}{\varphi}\right)^{\gamma}$ and the PDF is $g(\varphi) = \gamma \varphi^{-1-\gamma}$. As a consequence of the heterogeneity in productivity and the presence of fixed costs of production and exporting not all firms will find it profitable to sell to all markets. There will be different productivity requirements to enter different markets and given that firm productivity is constant, only changes in the variable or fixed costs can alter a firm's decision to enter a market. For example, lower production costs in $j$ due to a decrease in $\widetilde{w}_j$ leads to more varieties available to export, lowering the foreign price level of importers of these goods and increasing real income.

The marginal cost for a firm located in country $j$ with productivity $\varphi$ to serve market $i$ is $\frac{\widetilde{w}_j \tau_{ji}^{T}(L_{ji},\, L_{ij})}{A_j \varphi}$. The trade inducing effect that I estimate in the model will manifest in the variable costs that firm face when exporting.

Firms are price setters and charge a constant mark-up over marginal cost equal to:

$$p_{ji}^{h}(\varphi) = \frac{\sigma_h}{\sigma_h - 1} \frac{\widetilde{w}_j \tau_{ji}^{T}\left(L_{ji},\, L_{ij}\right)}{\varphi} \tag{7}$$

Given the optimal pricing decision of firms and consumer demand, the total sales for a firm in sector $h$ with productivity $\varphi$ is given by,

$$x_{ji}^{h}(\varphi) = p_{ji}^{h}(\varphi) q_{ji}^{h}(\varphi)$$

[2] In the non-tradeable sector $\tau_{jj}^{N} = 1$ and $\tau_{ji}^{N} = \infty$ for any $j \neq i$

$$x_{ji}^{h} = \mu^{h} Y_i \left( \frac{p_{ji}^{T}(\varphi)}{P_i^{T}} \right)^{1-\sigma_h} \tag{8}$$

where $Y_i^h = \mu^h Y_i$ is the total income in country $i$ spent on sector $h$. Given prices, total income, and wages across countries there is a solution for the productivity cutoff for firms in country $j$ must meet to find it profitable to serve sector $h$ in market $i$. This cutoff can be solved by obtaining minimum level of productivity that a firm needs to earn zero profits from serving market $i$.

Profits for a firm in country $j$ with productivity $\varphi$ serving market $i$ is equal to:

$$\pi_{ji}^{h}(\varphi) = p_{ji}^{h}(\varphi) q_{ji}^{h}(\varphi) - c_{ji}^{h}(\varphi) q_{ju}^{h}(\varphi) - f_{ji}^{h}$$

$$\pi_{ji}^{h}(\varphi) = \frac{x_{ji}^{h}(\varphi)}{\sigma_h} - f_{nj}^{T} \tag{9}$$

Setting $\pi_{ji}^{h}(\varphi) = 0$ I can solve or the productivity cutoff $\bar{\varphi}_{ji}^{h}$

$$\bar{\varphi}_{ji}^{h} = \frac{\widetilde{w}_j \tau_{ji}^{T}\left(L_{ji},\, L_{ij}\right)}{A_j P_j^{h}} \left( \frac{f_{ji}^{h} \widetilde{w}_j}{Y_j A_j} \right)^{\frac{1}{\sigma_h - 1}} \left( \frac{\sigma_h}{\mu_h} \right)^{\frac{1}{\sigma_h - 1}} \frac{\sigma_h}{\sigma_h - 1} \tag{10}$$

Equation (10) shows that the productivity needed to serve sector $h$ in market $i$ is increasing in both iceberg and fixed costs, as well as the composite wage. The extent to which migration adjusts these costs that firms face will matter when I conduct my counterfactual experiments to evaluate the impact of migration on welfare. For example, a higher number of immigrants residing in country $j$ from $i$ lowers the cost of exporting for firms located in country $j$ to $i$. This will lower the marginal costs that a firm in country $j$ faces to serve market $i$ and leads to reduction in the productivity requirement to enter market $i$ and an increase in the number of firms exporting from $j$ to $i$.

Using the assumption that the number of firms in the each sector $h$ is proportional to a country's total income $\mu^h Y_j$ I can combine (3) and (10) to solve an expression of the price index across sectors and countries.

$$P_j^h = \left( \sum_{k=1}^{N} e_k^h \int_{\underline{\varphi}_{kj}^h}^{\infty} \left( \frac{\sigma_h}{\sigma_h - 1} \frac{\widetilde{w}_k \tau_{ki}^T (L_{jk},\, L_{kj})}{\varphi A_k} \right)^{1-\sigma_h} dG_h(\varphi) \right)^{\frac{1}{1-\sigma_h}}$$

$$P_j^h = \lambda_2^{-\frac{1}{\gamma}} Y_j^{-\frac{1}{\gamma}\frac{(\gamma+1-\sigma_h)}{\sigma_h - 1}} \Theta_j \tag{11}$$

where $\Theta_j^{-\gamma} = \sum_{k=1}^{N} \frac{Y_k}{Y} (\widetilde{w}_k \tau_{kj}^h)^{-\gamma} \left( f_{kj}^h \widetilde{w}_k \right)^{\frac{-1+\sigma_h - \gamma}{\sigma_h - 1}}$ and $\lambda_2 = \frac{\left(\frac{\sigma_h}{\sigma_h - 1}\right)^{1-\sigma_h} \gamma}{\gamma + 1 - \sigma_h} \lambda_1^{-1+\sigma_h-\gamma}$

### 2.4 Competitive Equilibrium

A competitive equilibrium is a set of migration decisions $\{m_{ijs}\}_{j=1}^{J}\ \forall i$, prices $\left\{P_j^N,\, P_j^T\right\}_{j=1}^{J}$, wages $\{w_{jH},\, w_{jL}\}_{j=1}^{J}$, and mass of firms $\left\{e_j^N,\, e_j^T\right\}_{j=1}^{J}$ such that consumers maximize their utility, firms maximize profits, the goods and labour markets clear and expected profits from firm entry in the economy are equal to zero. The mass of firms is pinned down by the standard free entry condition, the cost $f_e$ , that a firm pays discover their productivity is equal to the expected profits from doing so.

## 3 Constructing costs using model predictions

In this section I outline the predictions of the model that guide my empirical estimation in section 4. My strategy is to construct model equations that I can bring to the data to get estimates of $t_{jis}$, $\tau_{ji}^T$, $f_{ji}^T$, and $f_{nn}^h$. I can then use the fitted values of these estimates as inputs when solving the model.

### 3.1 Migration costs $t$

An issue with bringing equation (5), the predicted level of bilateral migration to the data is the limited accurate data on the counterpart $V_{js}$, real wages of workers in country $j$ of skill

$s$. Particularly comparable wage data by skill level for every source and destination country in my sample. However, following Anderson (2011) I can use the labour market clearing equations to solve for and substitute out the equilibrium wages,

$$L_{js} = V_{js} \sum_i \frac{\frac{1}{t_{ijs}}}{\sum_k \left( \frac{V_{ks}}{t_{iks}} \right)} Z_{is}$$

$$V_{js} = \frac{L_{js}}{\Phi_{js} \sum_i L_{is}}$$

This yields an expression for bilateral migration,

$$\frac{m_{ijs}}{L_{js}} = \frac{Z_{is}}{\sum_i L_{is}} \left( \frac{1}{t_{ijs}} \right) \left( \frac{1}{\Phi_{js} \kappa_{is}} \right) \tag{12}$$

where $\Phi_{js} = \left( \sum_i \frac{\frac{1}{t_{ijs}}}{\kappa_i} \frac{Z_{is}}{\sum_i L_{is}} \right)$ measures how easy it is to enter $j$ for workers with skill $s$, and $\kappa_{is} = \sum_k \left( \frac{V_{ks}}{t_{iks}} \right)$ measures how easy is it leave $i$ for workers with skill $s$. (12) implies that in a friction-less world, immigrant populations found in $j$ would be found in equal proportion to their share of the world population: $\frac{m_{ijs}}{L_{js}} = \frac{Z_{is}}{\sum_i L_{is}}$. The degree to which a distortion to this proportion exists will provide insight on the importance of bilateral migration costs in our estimation.

Following the literature on the determinants of migration Mayda (2010); Borjas (1987); Grogger and Hanson (2011) I parameterize migration costs as,

$$(t_{ijs})^{-1} = D_{ij}^{\alpha_1^s} e^{\alpha_2^s LANG\_SIM_{ij} + \alpha_3^s CONNECTED_{ij} + \alpha_4^s COLONY_{ij}}$$

letting $\frac{Z_{is}}{\kappa_{is}} = exp^{S_{is}}$, and $\frac{M_{js}}{\sum_{i \neq j} L_{is} \Phi_{js}} = exp^{S_{js}}$ I can express migration flows from $i$ to $j$ in a log-linear form as,

$$ln\left(m_{ijs}\right) = \alpha_1^s ln\left(D_{ij}\right) + \alpha_2^s LANG\_SIM_{ij} + \alpha_3^s CONNECTED_{ij} + \alpha_4^s COLONY_{ij} + S_{is} + S_{js} \tag{13}$$

With data on the stocks of bilateral migration by skill level I can estimate equation (13) and use the estimates of $\{\hat{\alpha}^s\}$ to construct the migration costs $\hat{t}_{ijs}$ that consumers face when migrating between countries.

## 3.2 Firm costs $\tau$ and $f$

The first prediction that I highlight from the model is the total export sales by firms in country $j$ to country $i$. I can solve for total sales in sector $T$ by firms in country $j$ to country $i$ by summing over the sales of firms in country $j$ that meet the productivity threshold requirement to serve market $i$, $\bar{\varphi}^{T}_{ji}$. Total export sales between countries depends negatively on both the variable and fixed costs that firms face.

$$X^T_{ji} = \frac{X^T_i \left(\frac{\tilde{w_j}\tau^T_{ji}}{A_j}\right)^{-\gamma} n^T_j \left(f^T_{ji}\right)^{1-\frac{\gamma}{\sigma_T - 1}}}{\Theta_i^{-\gamma}} \tag{14}$$

Letting,

$$\left(\tau^T_{ji}\right)^{-\gamma} = D^{\beta_1}_{ji} e^{\beta_2 l_{ji} + \beta_3 SB_{ji} + \beta_4 colony_{ji} + \beta_5 landlock_{ji} + \beta_6 RTA_{ji}} L^{\beta_7}_{ij} L^{\beta_8}_{ji}, \tag{15}$$

and $\mu_T Y_j \left(\frac{\tilde{w_j}}{A_j}\right)^{-\gamma} = e^{\lambda_j}$, and $\mu_T Y_i \Theta_i^{-\gamma} = e^{\lambda_i}$ I can now express export sales from $j$ to $i$ in a log-linear form as

$$ln\ \left(X^T_{ji}\right) = \underbrace{ln\left(\left(\tau^T_{ji}\right)^{-\gamma}\right)}_{\text{Parameterisation of Variabe Cost}} + \lambda_j + \lambda_i + \left(1 - \frac{\gamma}{\sigma_T - 1}\right) ln\left(f^T_{ji}\right) \tag{16}$$

where (15) is a parameterisation of the bilateral variable cost, $\lambda_j$ is the fixed effect of the exporting country, and $\lambda_i$ is the fixed effect of the importing country. My formulation of variable fixed costs will be important for my counterfactual experiments. It is important to highlight that if I were to estimate (16) in it's current form I could not attribute the same variable to both variable and fixed cost and uniquely identify the impact it has on export sales. However, using the model prediction on the average level of sales of exporting firms from $j$ to $i$, equation (17), I can identify $f_{ji}^T$ separately from $\tau_{ji}^T$. Without this step variable selection would be ad hoc; I have no guidelines to follow to tell us which should be included in variable cost and not fixed cost.

The average sales of exporting firms from $j$ to $i$ can be written as the total sales from country $j$ to $i$ divided by the number of exporting firms, where the number of exporting firms is equal to total number of of firms in $j$ that meet the productivity cutoff of exporting to $i$, $\bar{\varphi}_{ji}^T$.[3]

$$\frac{X_{ji}^T}{N_{ji}^T} = \frac{\left[\mu_T \frac{Y_i}{Y} \frac{\left(\tilde{w}_j \tau_{ji}^T\right)^{-\gamma} \left(f_{ji}^T\right)^{1-\frac{\gamma}{\sigma_T - 1}} e_j^T}{\Theta_i^{-\gamma}}\right]}{\left(\frac{1}{\bar{\varphi}_{ji}^T}\right)^{\gamma} e_j^T}$$

$$\frac{X_{ji}^T}{N_{ji}^T} = \frac{\left(f_{ji}^T\right)}{\frac{1}{\sigma_T}\left(\frac{\gamma}{\gamma+1-\sigma_T}\right)^{-1}} \tag{17}$$

The difficulty in using equation (17) to learn about bilateral fixed costs is that there seldom exists bilateral trade data on the number of exporting firms for a reasonably large set of countries. To overcome this limitation I use use a recent database, the OECD Eurostat Trade by Enterprise Characteristics Database (OECD-TEC), that reports the number of exporting and importing enterprises for 43 countries. I infer my estimates of the bilateral fixed costs values $f_{ji}^T$ by calculating them directly from equation (18) given values of $\gamma$ and $\sigma_T$.

$$\hat{f}_{ji}^T = \frac{X_{ji}^T}{N_{ji}^T} \frac{1}{\sigma_T} \left(\frac{\gamma}{\gamma + 1 - \sigma_T}\right)^{-1} \tag{18}$$

High fixed costs between destination $i$ and source country $j$, results in less productive firms being unable to export to $i$, the firms that do find it profitable to export to $i$, even in the face of high fixed costs, are more productive and have higher sales than the marginal firm

[3]The percentage of firms that will meet the cutoff is calculated as $Pr\left(\varphi > \bar{\varphi}_{nj}^T\right) = \left(\frac{1}{\bar{\varphi}_{nj}^T}\right)^{\gamma}$

that drops out of exporting.

I can now re-specify equation (16) as,

$$ln\left(X_{ji}^{T}\right)-\left(1-\frac{\gamma}{\sigma_{T}-1}\right)ln\left(\hat{f}_{ji}^{T}\right) = \alpha_{1}ln\left(d_{ji}\right)+\alpha_{2}l_{ji}+\alpha_{3}SB_{ji}+\alpha_{4}colony_{ji}+\alpha_{5}landlock_{ji} +\alpha_{6}RTA_{ji}+\alpha_{7}ln\left(IMM_{ji}\right)+\alpha_{8}ln\left(EMI_{ji}\right)+\lambda_{j}+\lambda_{i}$$

Similarly, using the average sales of domestic firms operating in $j$: total domestic sales of firms in $j$ $X_{jj}^{h}$ divided by the number of domestic firms operating in country $j$, $N_{jj}^{h}$, yields a formula for $f_{jj}^{h}$.

$$\hat{f}_{jj}^{h}=\frac{X_{jj}^{h}}{N_{jj}^{h}}\frac{1}{\sigma_{T}}\left(\frac{\gamma}{\gamma+1-\sigma_{T}}\right)^{-1} \tag{19}$$

# 4 Data and Estimation

In this section I provide details on the migration and trade data sources I use to estimate the model equations presented in section 3. Using the estimates of $\hat{t}_{jis}$, $\hat{\tau}_{ji}^{T}$, $\hat{f}_{ji}^{T}$, and $\hat{f}_{nn}^{h}$ as inputs, I can solve the model and quantitatively assess the aggregate impact of migration via the three transmission channels and gauge their relative importance in contributing to the overall welfare impact from the currently observed levels of migration.

## 4.1 Migration Data

My bilateral migration data decomposed by skill level comes from the OECD Database on Immigrants in OECD and non-OECD Countries (DIOC-E ). The dataset includes over 100 destination countries and more than 200 countries of origin. I use this database along with education attainment data from Barro and Lee (2013) and population data from the World Bank to construct each country's initial labour force composition in 2010. I begin with the OECD-DIOC-E where I have information on the bilateral stock of migrants across countries. Merging this information with data on country populations from the World Bank I can determine the proportion of migrants in each country and subtract them to back out the native portion. Lastly, I assign the high skilled proportion of the native labour force in each country as the percentage of individuals in a country aged 25 or older that have tertiary education using the educational attainment statistics found in Barro and Lee (2013). Table (1) presents data on the proportion of population that are immigrants for my set of 43 countries and the skill distribution of these immigrants. International migration has had major influences on the labour composition for many countries, for example, Canada and Australia the population is 20% foreign-born, and these foreign-born are predominantly high skilled. Several countries exhibit large immigrant and emigrant shares as a percentage of population. In the United Kingdom and Greece immigrants account for over 10% of the population, however because they also have a high emigration rate, their net population gain from migration falls by half. There also exists large discrepancies in the skill distribution of immigrants and emigration in a country. Argentina has a modest 4.5% immigration population share but over 95% of those immigrants are low skilled, whereas the high skilled portion of those that emigrate from Argentina is over 65%. The impact of migration on the labour market outcomes and trade-creation effects for countries will depend critically on the pattern of immigration and emigration, both the amount and skill composition of who enters and leaves.

## 4.2 Trade Data

I use 2010 data from the OECD-TEC on bilateral export sales and the number of exporting enterprises in the manufacturing industry to construct bilateral average sales and export sales for each pair of countries in my sample. These data is combined with United Nations Industrial Development Organization(UNIDO) data on domestic manufacturing production and the number of domestic enterprises to estimate the trade equations specified in the section 3. A unique characteristic of the data is the bilateral information it provides on the number of exporting enterprises, enabling the construction of average export sales for country pairs. Table (2) shows values of average sales from a sample of countries in my dataset where rows correspond to the exporting country[4]. Conditional on a firm exporting to a destination fixed cost has no impact on sales to that destination. Fixed cost effects average sales by affecting the number of firms exporting to that market. I will pick up the variation in average sales that comes from the number of firms, for example, Canada and Mexico have similar levels of export sales to the United States but large differences in averages sales, stemming from the significant differences in the *number of firms* that export to the United States.

## 4.3 Estimating Migration Costs

I estimate equation (20) using pseudo maximum likelihood estimation techniques proposed by Santos Silva and Tenreyro (2006) to get the determinants of the important characteristics of international migration flows for low and high skilled migrants. This method helps address the issue that comes from estimating models when there are occurrences of zero values in the dependent variable. The use of a log specification drops the zero observations which would likely result in biased estimates.

$$ln\left(m_{ijs}\right) = \alpha_0^s + \alpha_1^s ln\left(D_{ij}\right) + \alpha_2^s LANG\_SIM_{ij} + \alpha_3^s CONNECTED_{ij} + \alpha_4^s COLONY_{ij} + S_i^s + S_j^s + \epsilon_{ijs} \tag{20}$$

The estimates presented in Table (3) allow me to construct $\hat{t}_{ijs}$, the costs of migration, for individuals of skill $s$ migrating from country $i$ to country $j$. These costs along with equilibrium wages and prices factor into the decision that individuals make on whether to migrate, and if so where. The results show migration between countries is decreasing in bilateral log distance but increasing in the presence of language similarity, having a past colonial relationship and having a shared border between countries. The results across skill types are generally consistent except for the impact of sharing a colonial relationship which only matters for high skilled migration. Language similarity and sharing a border exude more influence for low skilled migration but both variables are also significant for high skilled migration. Using a similar structure, Grogger and Hanson (2011) and Beine, Docquier and

[4]For example, Canadian firm's average export value to the United States was $8,781,714 in 2010

Özden (2011) also find that migration costs as captured by bilateral distance, linguistic and cultural variables exert significant effects on migration flows. My estimates are in line with theirs, for example, the effect of distance on migration sits in the range they estimate of -0.139 to -0.613.

### 4.4 Estimating Trade Costs

The estimates of $\hat{f}_{ij}^{T}$ and $\hat{f}_{ij}^{h}$ are fitted directly from the data using equations (18) and (19). Using the fitted values of $\hat{f}_{ij}^{T}$ and equation (21) I can estimate $\left(\tau_{ij}^{T}\right)^{-\gamma}$ to retrieve the determinants of the variable costs that firms face when serving foreign markets. The results in table (4) show that the estimated elasticity of exports to migrants falls in the range of 0.02-0.07, which translates to a 10% increase in migrants being associated with a 0.2% to 0.7% increase in bilateral trade. The majority of the estimated elasticities for migrants in the literature fall between 0.01 and 0.40, as reported by Peri and Requena-Silvente (2010). My results show that the importance of the migrant effect depends strongly on the skill of the migrants. The elasticity for skilled immigrants is three times as large as the one estimated for unskilled immigrants, which is also estimated to be not significant. This result will be important in the quantitative assessment of migration on welfare; countries with similar levels of emigrants will not benefit from accessing imports in the same way if there are large exists differences in the skill distribution between them of those leaving.

The estimated elasticities on the other determinants have the expected signs and are generally significant; a greater distance between countries reduces trade, and sharing a common language or being members of a regional trade agreement increases trade.

$$\begin{aligned} ln\left(X_{ji}^{T}\right)-\left(1-\frac{\gamma}{\sigma_T-1}\right)ln\left(\hat{f}_{ji}^{T}\right) &= \alpha_1 ln\left(d_{ji}\right)+\alpha_2 l_{ji}+\alpha_3 SB_{ji}+\alpha_4 colony_{ji} \\ &\quad +\alpha_5 landlock_{ji}+\alpha_6 RTA_{ji}+\alpha_7 ln\left(IMM_{ji}^{S}\right)+\alpha_8 ln\left(EMI_{ji}^{S}\right) \\ &\quad +\lambda_j+\lambda_i+\epsilon_{ji} \quad (21) \end{aligned}$$

### 4.5 Labour Productivity and Parameter Values

To complete the numerical implementation of the model requires values of labour productivity, $A_j$ for every country in the model. I generate values of $A_j$ such that when I solve for the model equilibrium, $\{m_{ijs}\}_{j=1}^{J}\ \forall i$ , prices $\left\{P_j^N,\ P_j^T\right\}_{j=1}^{J}$ , wages $\{w_{jH},\ w_{jL}\}_{j=1}^{J}$, and mass of firms $\left\{e_j^N,\ e_j^T\right\}_{j=1}^{J}$ the PPP-adjusted GDP per capita for each country $j$ in my model relative to the U.S. matches the PPP-adjust per capita GDP relative to the U.S. using data from 2010.

$$\frac{\frac{w_j L_j}{\left(P_j^N\right)^{\alpha N}\left(P_j^T\right)^{\alpha T}\left(L_{jL}+L_{jH}\right)}}{\frac{w_{US} L_{US}}{\left(P_{US}^N\right)^{\alpha N}\left(P_{US}^T\right)^{\alpha T}\left(L_{US\,L}+L_{US\,H}\right)}} = R_j/R_{US}\ \ \forall j$$

where $R_j = GDP\_PPP\_Capita_j$ in the data.

Lastly, I specify the parameter values found in the production function and effective labour endowment. In the effective labour endowment $L_j$ I must choose a value for $\eta$, the elasticity of substitution between skilled and unskilled workers. Following Ottaviano and Peri (2012) I set $\eta = 3$. The elasticity of substitution between varieties of goods, $\sigma^h$, is set to 6 for both sectors, the middle of the range of estimates reported by Anderson and Wincoop (2004) and Feenstra (1994). The parameter governing the distribution of firm productivity, $\gamma$ is set equal to 5.3 following Axtell (2001). For each country $\mu^N$ is set to 0.65 with $\mu^T = 0.35$ which reflects the share of non-tradeable and tradeable in consumption used by Alvarez and Lucas (2007).

## 5 Quantitative Assessment

In this section I highlight the importance of the interaction between firm export decisions and consumer migration decisions. Consumers can benefit from trade by importing foreign varieties. However, consumers always benefit more from increases in domestic product variety compared to foreign product varieties because of trade costs. The benefits of foreign varieties decrease with trade barriers and in the extreme case where trade costs are infinitely large there is no benefit to increases in foreign variety. In the second half of this section I assess the aggregate impact of migration and gauge measure the relative importance of the trade-creation effects in contributing to the overall welfare impact.

## 5.1 The Responsiveness of Migration to Changes in Trade Costs

To see the responsiveness of migration to changes in trade costs I resolve the baseline model with an exogenous decrease in trade costs of 20% for all country pairs. Figure (1) shows this policy has a positive effect on the average real wages of native-born stayers in countries that exhibit population growth after a reduction in trade costs. Average real wages of native-born stayers in a country $j$, is calculated as,

$$\frac{m_{jjH}\frac{w_{jH}}{\left(P_j^N\right)^{\alpha_N}\left(P_j^T\right)^{\alpha_T}}+m_{jjL}\frac{w_{jL}}{\left(P_j^N\right)^{\alpha_N}\left(P_j^T\right)^{\alpha_T}}}{m_{jjH}+m_{jjL}}$$

The relationship between population and welfare is roughly monotonic: in countries where the population fell (rose), welfare decreases (increases). Figure (2) shows the effects of the drop in trade costs to changes in the emigration rate and the price level in the tradeable sector relative to the baseline model. As shown by the dashed line, representing the line of best fit, there is a positive relationship between the emigration rate in a country and $P^T$, the price level in the tradeable sector. The increase in real wages coming from increased imports and a lower $P^T$ leads to, on average, a lower emigration rate in a country. A few countries see a small increase in their $P^T$, this is caused by the labour market and market size effects of having a smaller population from less immigration. Consumers benefit from new firms finding it profitable to export for the first time and existing exporters increasing their sales to their location. Figure (3) shows the effects of a drop in trade costs on the emigration rate and shows that there is a strong negative relationship between the emigration rate in a country and changes in average real wages of native-born stayers. As we would expect the better off a country is after a reduction in trade costs, the less incentive I have to emigrate away. The small losses that many countries exhibit is caused by the drop in immigration to these countries from countries located in the $4^{th}$ quadrant of the figure.

In my second counterfactual scenario I observe the response of consumers and firms to a regional trade cost reduction. Migration rates should be lower in a in regions with low trade barriers; there is less need to migrate to a neighboring country when I can import a variety of products from that neighboring country, thereby decreasing the price level I face in my domestic country and increasing my real income. For example, If after joining NAFTA, Mexico saw increases to their real wages, Mexicans would have less incentive to migrate to the United States. However, the extent to which having easier access to goods from Mexico increases real wages in the United States will incentivise migration to the United States from Mexico. My model is flexible enough to allow for the study the quantitative importance of this mechanism; I can observe changes to migration after lowering trade costs and quantitatively study which effect is stronger in equilibrium. Figure (4) shows the effects of reducing both the variable and fixed trade costs in 10% increments on the tradeable price level in each country and the level of Mexican immigration to the United States. As the trade costs between the two countries decrease the price level in both countries decreases; imports become cheaper and consumers benefit. Changes in Mexican immigration to the United States only become notable once trade costs are reduced by more than 40%. At that point the benefits of working in the United States and earning a higher nominal wage decreases in importance because Mexican stayers can now enjoy the benefits of importing USA produced goods at a lower cost and do not have to incur the migration cost to consume them in the United States.

## 5.2 No-Migration Counterfactual

My main counterfactual experiment involves evaluating the welfare effects of sending all foreign-born individuals back to their country of origin. The source of the welfare changes will be traced to changes in labour market conditions - responses in wages, and changes in firm production decisions - responses in firm export behaviour. The welfare measure used in the analysis is simply real wages of stayers. Table (5) shows the changes in population ordered by magnitude of population change from the counterfactual experiment. Table 6 shows my main results - the percentage change in average real wages for native stayers between the no migration scenario relative to the observed levels of migration generated by the benchmark model. The results show that for some countries the main channel by which migration effects welfare is by changes in labour market conditions. The first column of table (6) shows the overall change in average welfare. Countries with large immigrant populations benefit the most; average welfare in Canada and the United States is 6% and 4.5% higher in a world with migration relative to the counterfactual experiment. Countries that have had a net loss in population due to high emigration are worse off; in Portugal and Poland average welfare is 1.25% and 2.5% lower in a world with migration.

The results in the second column are generated by running the experiment while not allowing for immigrants and emigrants to influence the trade costs that firms face. In this counterfactual the only channels by which migration effects welfare is via changes in labour market conditions and domestic aggregate demand. The results suggest that there exists heterogeneity in the importance of the firm export behaviour across countries. For Canada and the United States there is little change in welfare. For these countries the marginal firm that no longer finds it profitable to begin domestic production because of reduction in international profits is on average quite small and does not have much of an impact on average welfare. Furthermore, the welfare contribution of importing additional varieties at a lower cost is small compared to the labour market and market size welfare gains resulting from the large increase in population from immigration. Whereas for countries like Portugal and Poland the inability of foreign firms to access these markets at a lower cost has a much large impact. This suggests that in these countries the marginal firm that no longer finds it profitable to export is on average large relative the the firms ceasing production in Canada and the United States. For Cyprus and Ireland the affects are strong enough that the benefits of international migration go from positively affecting average welfare to negatively effecting it. For these countries the trade creation effect mitigates some of the loss in welfare stemming from the labour market and market size effects the loss in population from emigration.

I also decompose the overall change in welfare for the two skill groups by country. Figure

(5) shows that for all countries at least one skill group has gained from migration. For example, in Mexico, low skilled workers have suffered losses to their average welfare but high skilled Mexicans are better off. This may come as a surprise given the large levels of low skilled Mexican emigration to the U.S., one would surmise that the low skilled labour remaining in Mexico would be better off. However, the emigration rate for high school graduates and college educated Mexicans is actually higher than those of low skilled high school dropouts Aydemir and Borjas (2007).[5] In Canada both high and low-skilled workers have benefited from migration but due to Canada's immigration policy that target high-skilled immigrants, high-skilled native-born Canadians have had smaller gains in their real income compared to low-skilled Canadian workers.

## 6 Conclusion

In this paper I have developed a model that is able to assess the impact that global migration has had on country level welfare. I find that the impact from the observed levels of migration has had a positive welfare impact for the majority of countries in my sample, even some that have had net losses in population from migration such as Ireland and Chile. My main finding is that the importance of the transmission channel by which migration effects welfare varies. For countries such as Canada and the United States the main impact from international migration is from changes in labour market and market size effects whereas for countries such as Portugal and Poland the trade-creation channel is equally important. Furthermore, because I endogenize the consumer migration decision I can observe the welfare effects of a trade-reduction policy accounting for the interaction between firm export and individual migration decisions. The migration response of consumers following a trade-reduction policy can make some countries worse off. The more gains to real income a previously high emigrant country accrues from a reduction in trade costs, the less incentive consumers in that country have to emigrate. Countries that see decreases to their population following a trade-reduction

[5] In absolute terms the number of low-skill workers emigrating from Mexico is higher than that of high-skilled workers.

policy are worse off.

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Table 1: Migration Descriptive Statistics

| Country Name | % Immigrant share of population | % High skilled immigrant share | % Emigrant share of population | % High skilled emigrant share |
|---|---|---|---|---|
| Argentina | 4.4% | 4.3% | 2.0% | 65.5% |
| Australia | 22.6% | 71.1% | 2.2% | 80.6% |
| Austria | 14.0% | 66.3% | 5.1% | 76.5% |
| Belgium | 13.7% | 31.1% | 4.1% | 71.2% |
| Bulgaria | 0.2% | 89.0% | 9.4% | 57.8% |
| Brazil | 0.3% | 24.0% | 0.5% | 60.5% |
| Canada | 19.9% | 82.3% | 3.7% | 85.6% |
| Switzerland | 23.8% | 67.7% | 7.5% | 69.1% |
| Chile | 1.2% | 89.4% | 2.9% | 47.9% |
| Cyprus | 13.0% | 71.2% | 12.0% | 60.3% |
| Czech Republic | 2.5% | 76.6% | 3.4% | 73.8% |
| Germany | 12.7% | 60.1% | 4.3% | 75.4% |
| Denmark | 8.2% | 48.7% | 3.4% | 74.9% |
| Spain | 11.0% | 52.7% | 2.1% | 47.8% |
| Estonia | 14.6% | 80.4% | 13.5% | 76.8% |
| Finland | 4.2% | 48.9% | 4.7% | 69.6% |
| France | 10.5% | 52.5% | 2.3% | 69.6% |
| United Kingdom | 11.7% | 71.5% | 6.3% | 75.0% |
| Greece | 10.9% | 58.9% | 6.3% | 46.7% |
| Hungary | 3.8% | 75.5% | 4.2% | 77.6% |
| Indonesia | 0.1% | 15.1% | 0.7% | 16.5% |
| Ireland | 14.8% | 75.9% | 15.8% | 65.3% |
| Iceland | 6.0% | 62.0% | 19.4% | 80.6% |
| Israel | 22.6% | 76.4% | 3.5% | 83.1% |
| Italy | 7.5% | 52.3% | 4.2% | 43.4% |
| Lithuania | 9.7% | 50.4% | 11.6% | 67.9% |
| Luxembourg | 37.6% | 46.0% | 9.0% | 62.3% |
| Latvia | 28.5% | 47.1% | 14.3% | 76.2% |
| Mexico | 0.4% | 57.5% | 8.7% | 41.0% |
| Malta | 4.0% | 48.8% | 17.1% | 46.7% |
| Netherlands | 9.8% | 57.2% | 4.5% | 71.7% |
| Norway | 10.5% | 55.1% | 3.0% | 71.2% |
| New Zealand | 25.8% | 67.2% | 14.6% | 75.5% |
| Poland | 0.7% | 61.5% | 7.9% | 76.6% |
| Portugal | 6.3% | 50.4% | 13.9% | 34.4% |
| Romania | 0.6% | 36.7% | 11.7% | 66.6% |
| Russian Federation | 10.3% | 66.2% | 3.1% | 55.6% |
| Slovak Republic | 2.5% | 48.5% | 5.9% | 76.9% |
| Slovenia | 10.7% | 59.7% | 6.2% | 49.1% |
| Sweden | 13.7% | 65.5% | 3.0% | 77.3% |
| Turkey | 2.7% | 37.0% | 3.6% | 34.1% |
| United States | 12.1% | 67.1% | 0.6% | 62.6% |
| South Africa | 6.2% | 5.6% | 1.3% | 78.2% |

Table 2: Average Sales Summary Statistics

| Value of Exports (thousands) | | | | | | |
|---|---|---|---|---|---|---|
| | CAN | DEU | GBR | MEX | PRT | USA |
| CAN | - | $3,676,691 | $15,899,871 | $4,865,217 | $289,612 | $289,418,959 |
| DEU | $8,528,851 | - | $78,355,783 | $9,194,962 | $10,343,578 | $86,847,475 |
| GBR | $6,674,983 | $44,119,716 | - | $1,411,185 | $2,748,700 | $57,846,613 |
| MEX | $10,663,920 | $3,556,249 | $1,732,810 | - | $183,112 | $238,858,913 |
| PRT | $230,949 | $6,239,533 | $2,650,412 | $533,405 | - | $1,737,085 |
| USA | $248,186,864 | $48,040,817 | $48,414,446 | $163,320,693 | $1,064,963 | - |

| Number of Exporting Firms | | | | | | |
|---|---|---|---|---|---|---|
| | CAN | DEU | GBR | MEX | PRT | USA |
| CAN | - | 2,887 | 3,715 | 1,831 | 429 | 32,957 |
| DEU | 8,437 | - | 22,337 | 6,408 | 13,765 | 20,795 |
| GBR | 10,476 | 12,735 | - | 2,804 | 6,316 | 29,554 |
| MEX | 15,833 | 4,512 | 1,180 | - | 323 | 13,598 |
| PRT | 1,152 | 2,142 | 1,883 | 435 | - | 2,236 |
| USA | 94,443 | 34,731 | 42,188 | 51,466 | 3,559 | - |

| Average Sales | | | | | | |
|---|---|---|---|---|---|---|
| | CAN | DEU | GBR | MEX | PRT | USA |
| CAN | - | $1,273,534 | $4,279,911 | $2,657,137 | $675,085 | $8,781,714 |
| DEU | $1,010,887 | - | $3,507,892 | $1,434,919 | $751,440 | $4,176,363 |
| GBR | $637,169 | $3,464,446 | - | $503,276 | $435,196 | $1,957,319 |
| MEX | $673,525 | $788,176 | $1,468,483 | - | $566,911 | $17,565,739 |
| PRT | $200,477 | $2,912,947 | $1,407,548 | $1,226,219 | - | $776,872 |
| USA | $2,627,901 | $1,383,226 | $1,147,588 | $3,173,371 | $299,231 | - |

Table 3: Barriers to migrant flows by skill level

| Dependant Variable | | |
|---|---|---|
| | $ln\,(m_{ijH})$ | $ln\,(m_{ijL})$ |
| ln distance | -0.218 | -0.229 |
| | (0.095)** | (0.114)** |
| Language Similarity | 1.392 | 1.879 |
| | (0.187)*** | (0.310)*** |
| Shared Borders | 1.247 | 1.743 |
| | (0.219)*** | (0.286)*** |
| Colonial Relationship | 0.536 | 0.012 |
| | (0.190)*** | (0.328) |
| $R^2$ | 0.903 | 0.962 |
| Observations | 1849 | 1849 |

note: *** p<0.01, ** p<0.05, * p<0.1

Table 4: Export Sales Regression

| Dependant Variable | | $ln\left(X_{ji}^{T}\right)-\left(1-\frac{\gamma}{\sigma_T-1}\right)ln\left(\hat{f}_{ji}^{T}\right)$ |
|---|---|---|
| Distance | $ln\left(d_{ji}\right)$ | -0.988 |
| | | (0.046)*** |
| Language | $l_{ji}$ | 0.361 |
| | | (0.100)*** |
| Shared Border | $SB_{ji}$ | 0.025 |
| | | (0.119) |
| Colonial Ties | $colony_{ji}$ | 0.227 |
| | | (0.133)* |
| Landlocked | $landlock_{ji}$ | 0.008 |
| | | (0.194) |
| RTA | $RTA_{ji}$ | 0.382 |
| | | (0.105)*** |
| Skilled Immigrants | $ln\left(Imm_{ji}^{HS}\right)$ | 0.061 |
| | | (0.016)*** |
| Unskilled Immigrants | $ln\left(Imm_{ji}^{LS}\right)$ | 0.022 |
| | | (0.016) |
| Skilled Emigrants | $ln\left(Emi_{ji}^{HS}\right)$ | 0.066 |
| | | (0.016)*** |
| Unskilled Emigrants | $ln\left(Emi_{ji}^{LS}\right)$ | 0.032 |
| | | (0.016)** |
| Adjusted $R^2$ | | 0.895 |
| Observations | | 1806 |

Includes country origin and destination dummies

note: *** p<0.01, ** p<0.05, * p<0.1

Table 5: No Migration Counterfactual: Impact on Population

| Country | Change in Population | Country | Change in Population |
|---|---|---|---|
| Luxembourg | 45.90% | Italy | 3.60% |
| Australia | 26.30% | Argentina | 2.40% |
| Israel | 24.70% | Estonia | 1.40% |
| Switzerland | 21.50% | Cyprus | 1.20% |
| Canada | 20.20% | Brazil | -0.20% |
| Latvia | 19.90% | Hungary | -0.50% |
| New Zealand | 15.10% | Finland | -0.60% |
| United States | 13.00% | Indonesia | -0.60% |
| Sweden | 12.50% | Czech Republic | -0.90% |
| Belgium | 11.20% | Turkey | -0.90% |
| Austria | 10.40% | Ireland | -1.30% |
| Spain | 10.00% | Chile | -1.70% |
| Germany | 9.60% | Lithuania | -2.10% |
| France | 9.10% | Slovak Republic | -3.50% |
| Norway | 8.30% | Poland | -7.30% |
| Russian Federation | 8.00% | Portugal | -8.20% |
| United Kingdom | 6.00% | Mexico | -8.40% |
| Netherlands | 5.80% | Bulgaria | -9.20% |
| Denmark | 5.30% | Romania | -11.20% |
| Greece | 5.20% | Malta | -13.60% |
| South Africa | 5.20% | Iceland | -14.20% |
| Slovenia | 5.10% | | |

Figure 1: Changes in welfare and population

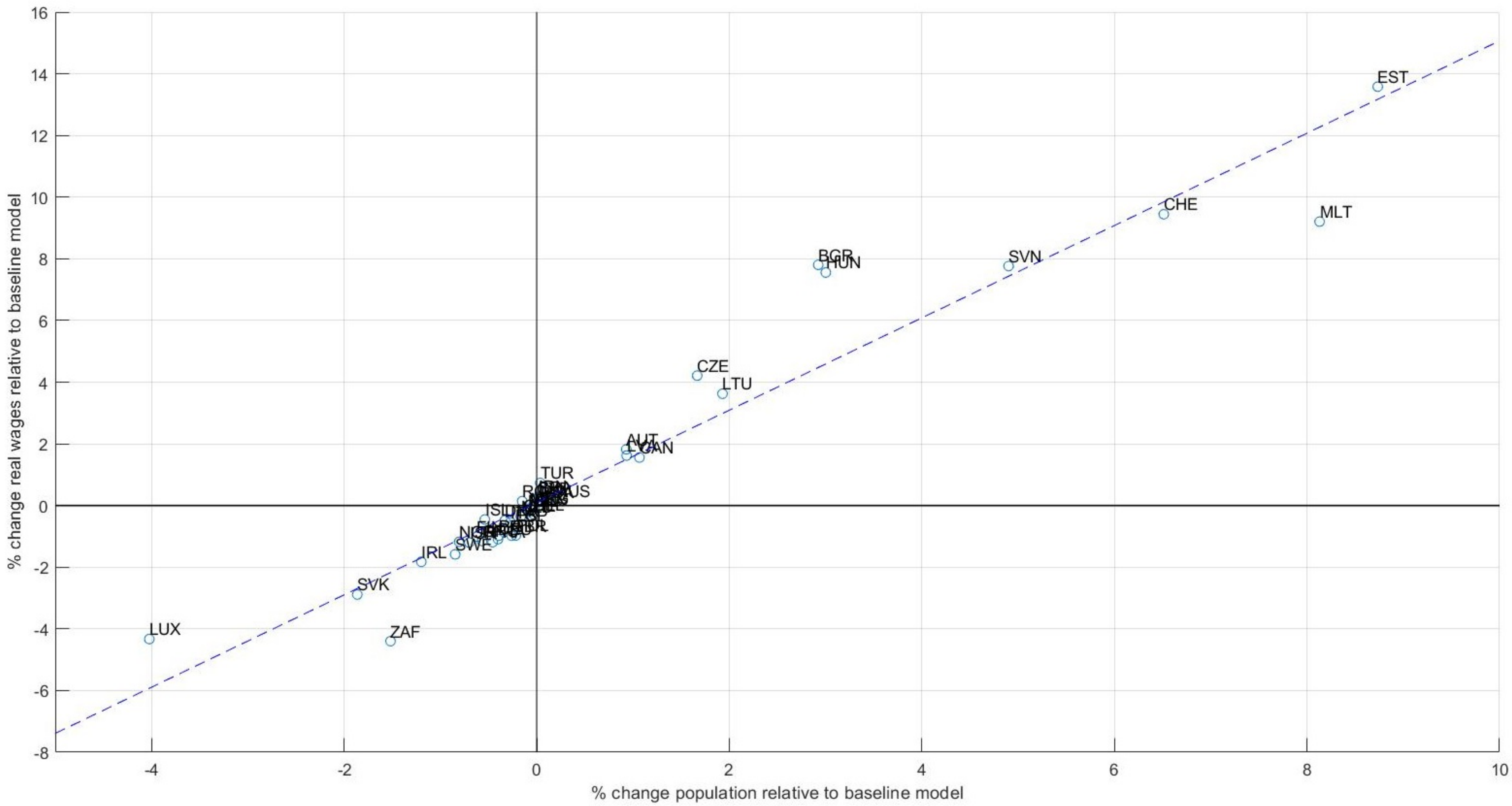


Figure 2: Tradeable price level and the emigration rate

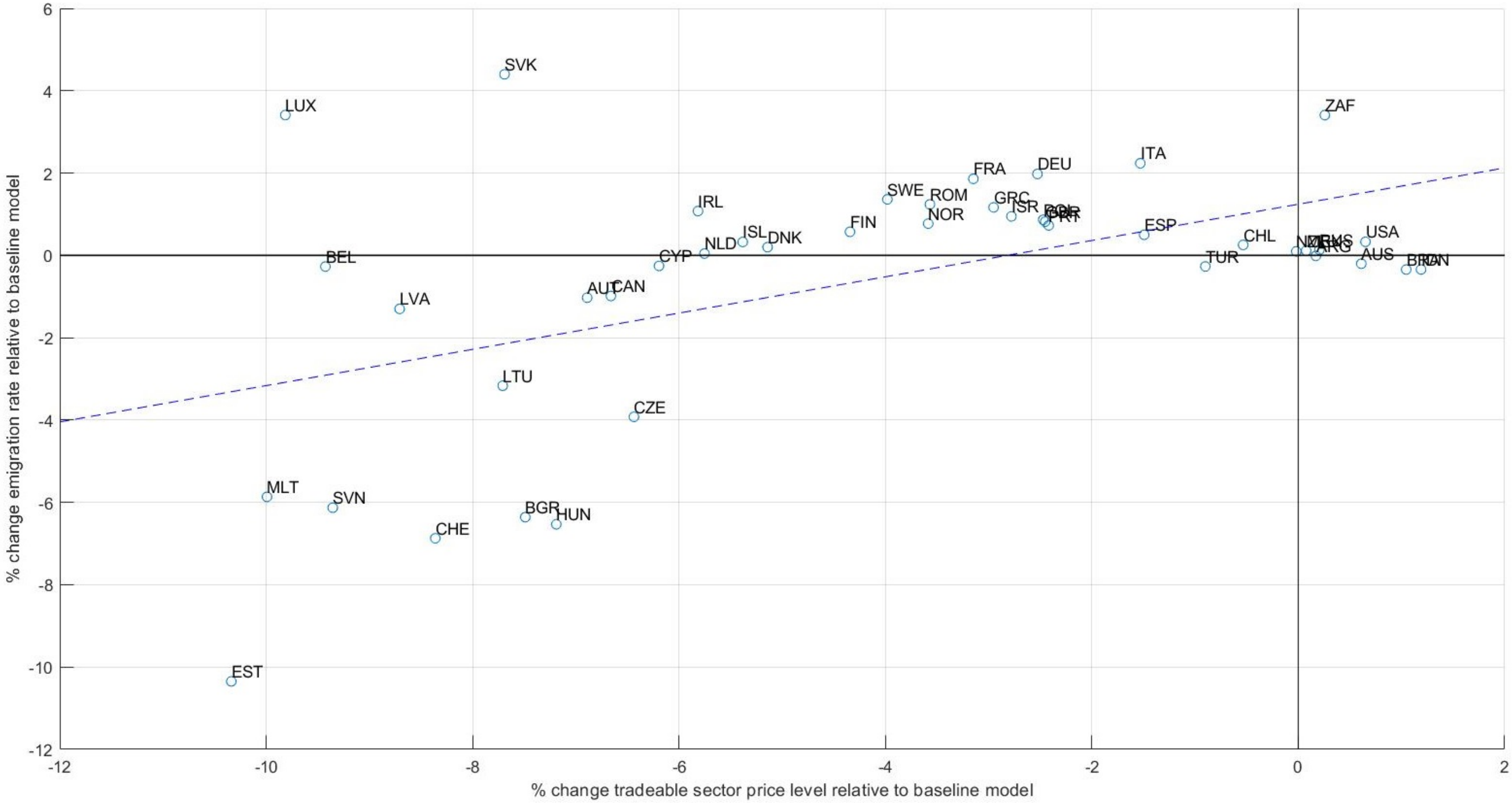


Figure 3: Real wages and the emigration rate

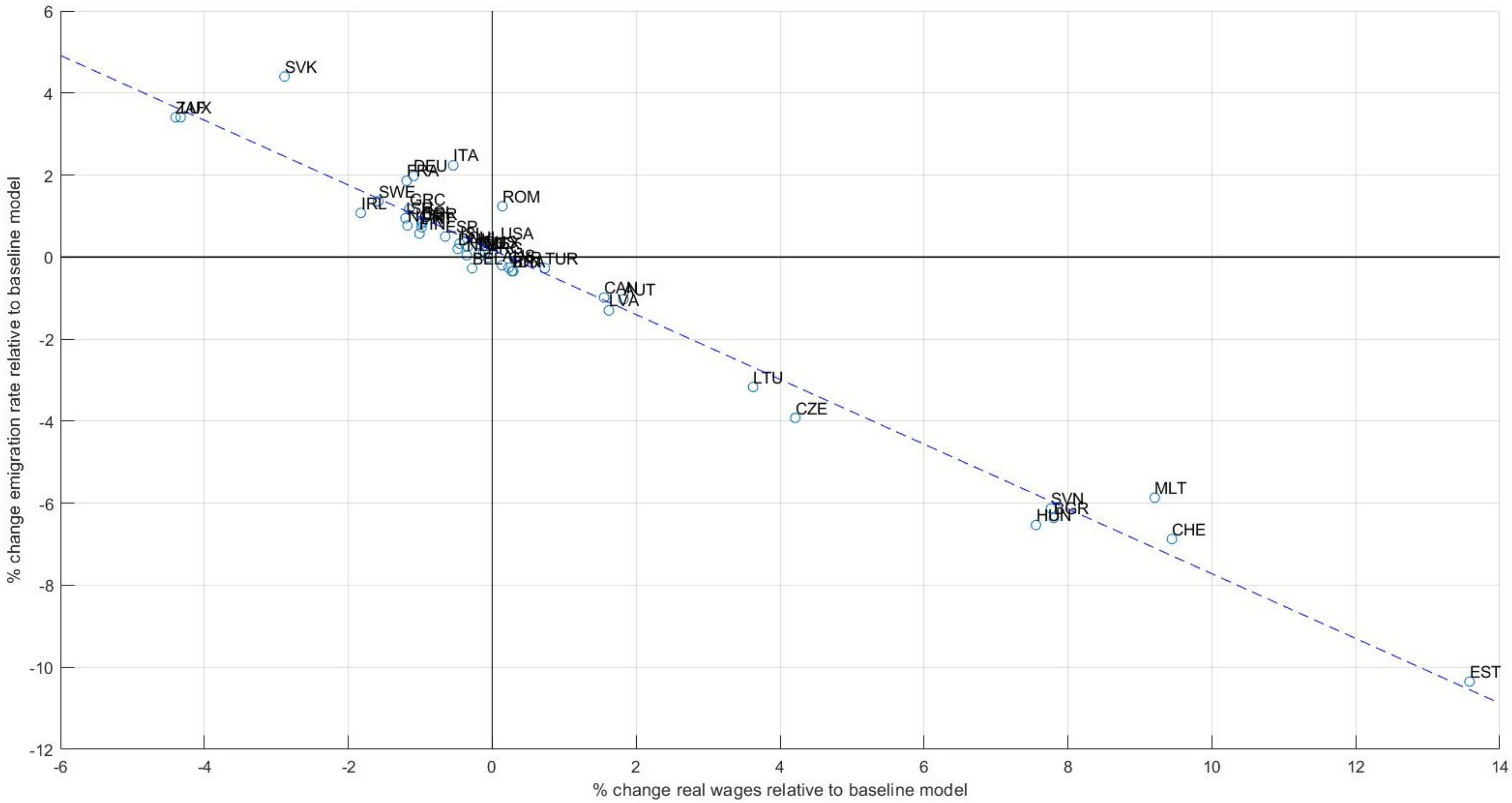


Figure 4: United States and Mexico Trade Cost Reduction

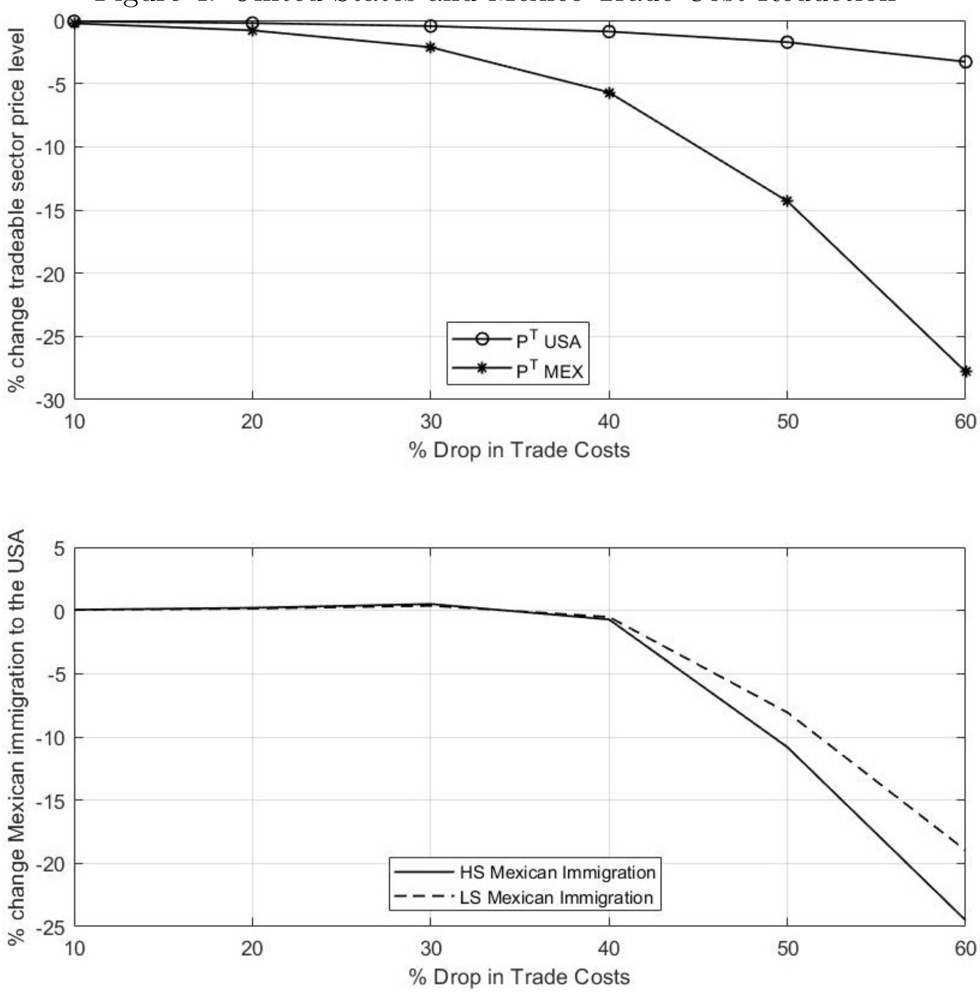
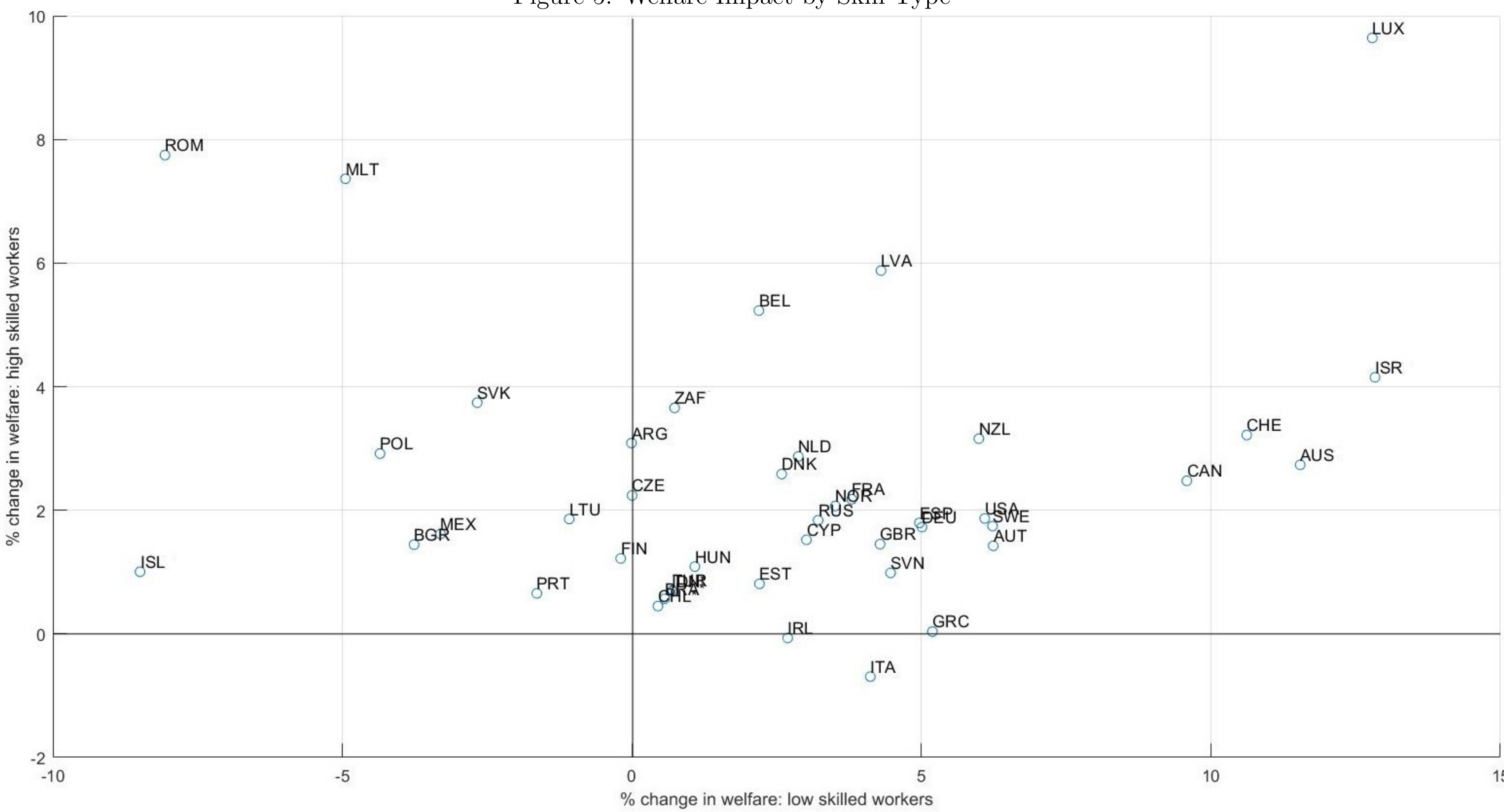


Table 6: Model Predictions on Welfare Changes

| Country | Overall Change | Only Migration | Country | Overall Change | Only Migration |
|---|---|---|---|---|---|
| Luxembourg | 11.61% | 7.83% | Russian Federation | 2.47% | 2.93% |
| Israel | 8.73% | 5.31% | Estonia | 1.64% | 0.10% |
| Australia | 8.11% | 8.51% | Ireland | 1.52% | -0.22% |
| Switzerland | 7.84% | 5.34% | South Africa | 1.14% | 0.75% |
| Canada | 5.94% | 6.40% | Hungary | 1.09% | -0.58% |
| Latvia | 4.84% | 3.33% | Turkey | 0.71% | 0.03% |
| New Zealand | 4.79% | 3.82% | Indonesia | 0.69% | 0.32% |
| Austria | 4.77% | 3.05% | Brazil | 0.57% | 0.81% |
| Sweden | 4.65% | 4.01% | Chile | 0.45% | -0.04% |
| United States | 4.54% | 4.31% | Czech Republic | 0.43% | -1.38% |
| Germany | 4.05% | 2.81% | Argentina | 0.40% | 0.41% |
| Spain | 3.97% | 3.05% | Finland | 0.37% | -0.26% |
| Greece | 3.83% | 2.26% | Lithuania | -0.02% | -1.63% |
| Slovenia | 3.58% | 1.09% | Portugal | -1.24% | -3.00% |
| Italy | 3.34% | 2.04% | Slovak Republic | -1.35% | -3.16% |
| France | 3.31% | 2.53% | Bulgaria | -2.35% | -3.76% |
| Belgium | 3.30% | 0.59% | Poland | -2.44% | -3.54% |
| United Kingdom | 3.14% | 1.64% | Mexico | -2.46% | -2.72% |
| Norway | 2.97% | 2.31% | Malta | -2.64% | -9.04% |
| Netherlands | 2.87% | 0.23% | Iceland | -4.48% | -5.08% |
| Denmark | 2.59% | 0.31% | Romania | -5.16% | -6.24% |
| Cyprus | 2.50% | -0.80% | | | |

Figure 5: Welfare Impact by Skill Type



# A Appendix

## A.1 Solving for total sales from country n to j $X_{nj}$

Total sales from all firms in country $n$ to country $j$ that meet the input requirement $\bar{\varphi}$ can be written down as

$$X_{nj}^{T} = \int\limits_{\bar{\varphi}_{nj}^{T}} p_{nj}^{T}(\varphi)\, q_{nj}^{T}(\varphi)\, n_n dG(\varphi)$$

$$X_{nj}^{T} = \int\limits_{\bar{\varphi}_{jn}^{T}} p_{nj}^{T}(\varphi)\, p_{nj}^{T}(\varphi)^{-\sigma_T} \left(P_j^T\right)^{\sigma_T - 1} \mu_T Y_j n_n dG(\varphi)$$

$$X_{nj}^{T} = \int\limits_{\bar{\varphi}_{jn}^{T}} \left(\frac{\sigma_T}{\sigma_T - 1} \frac{\tilde{w}_n \tau_{nj}^{T}}{\varphi}\right)^{1-\sigma_T} \left(P_j^T\right)^{\sigma_T - 1} \mu_T Y_j n_n dG(\varphi)$$

$$X_{nj}^{T} = \left(\frac{\sigma_T}{\sigma_T - 1} \tilde{w}_n \tau_{nj}^{T}\right)^{1-\sigma_T} \left(P_j^T\right)^{\sigma_T - 1} \mu_T Y_j n_n \int\limits_{\bar{\varphi}_{nj}^{T}} \varphi^{\sigma_T - 1} \gamma \varphi^{-1-\gamma} d\varphi$$

$$X_{nj}^{T} = X_j^T \left(\frac{\sigma_T}{\sigma_T - 1} \tilde{w}_n \tau_{nj}^{T}\right)^{1-\sigma_T} \left(P_j^T\right)^{\sigma_T - 1} n_n \gamma \frac{\left(\bar{\varphi}_{jn}^{T}\right)^{-1+\sigma_s-\gamma}}{\gamma + 1 - \sigma_s}$$

$$X_{nj}^{T} = X_j^T \left(\frac{\sigma_T}{\sigma_T - 1} \tilde{w}_n \tau_{nj}^{T}\right)^{1-\sigma_T} \left(P_j^T\right)^{\sigma_T - 1} n_n \gamma \frac{\left(\frac{\tilde{w}_n \tau_{nj}^{T}}{P_j^T} \times \frac{\sigma_T}{\sigma_T - 1} \left(f_{nj}^{T}\right)^{\frac{1}{\sigma_T - 1}} \left(\sigma_T^{-1} \mu_T Y_j\right)^{\frac{-1}{\sigma_T - 1}}\right)^{-1+\sigma_T-\gamma}}{\gamma + 1 - \sigma_T}$$

$$X_{nj}^{T} = \frac{X_j^T \left(\frac{\sigma_T}{\sigma_T - 1}\right)^{-\gamma} \left(\tilde{w}_n \tau_{nj}^{T}\right)^{-\gamma} \left(P_j^T\right)^{\gamma} e_n \gamma \left[\left(f_{nj}^{T}\right)^{\frac{1}{\sigma_T - 1}} \left(\sigma_T^{-1} \mu_T Y_j\right)^{\frac{-1}{\sigma_T - 1}}\right]^{-1+\sigma_T-\gamma}}{\gamma + 1 - \sigma_T}$$

where $\left(P_j^T\right)^{\gamma} = \left[\Theta_j Y_j^{\frac{1}{\gamma} - \frac{1}{\sigma_T - 1}} \left(\left(\frac{\sigma_T}{\sigma_T - 1}\right) \left(\sigma_T^{-1} \mu_T\right)^{\frac{1}{\gamma} - \frac{1}{\sigma_T - 1}} \left(\frac{\gamma}{\gamma + 1 - \sigma_T}\right)^{\frac{-1}{\gamma}}\right)\right]^{\gamma}$ and $\Theta_j^{-\gamma} = \sum_{k=1}^{N} \frac{n_k}{Y} \left(\widetilde{w_k} \tau_{kj}^{T}\right)^{-\gamma} \left(f_{kj}^{T}\right)^{\frac{\sigma_T - 1 - \gamma}{\sigma_T - 1}}$

$$X_{nj}^T = \frac{X_j^T \left(\tilde{w}_n \tau_{nj}^T\right)^{-\gamma} e_n^T \left(f_{nj}^T\right)^{1-\frac{\gamma}{\sigma_T - 1}}}{\Theta_j^{-\gamma}}$$

where I assume that $e_n^T$, the total mass of potential entrants in sector $T$ is country $n$ is proportional to total income in $n$, $Y_n$ as in Chaney (2008).

## A.2 Solving for average sales from country n to j $\frac{X_{nj}^T}{N_{nk}^T}$

$$\frac{X_{nj}^T}{N_{nj}^T} = \frac{\left[\mu_T Y_j \frac{\left(\tilde{w}_n \tau_{nj}^T\right)^{-\gamma} \left(f_{nj}^T\right)^{1-\frac{\gamma}{\sigma_T - 1}} n_n^T}{\Theta_j^{-\gamma}}\right]}{\left(\frac{1}{\bar{\varphi}_{nj}^T}\right)^{\gamma} n_n^T}$$

I sub in for $\bar{\varphi}_{nj}^T$ to get,

$$\frac{X_{nj}^T}{N_{nj}^T} = \frac{\mu_T Y_j \left(\tilde{w}_n \tau_{nj}^T\right)^{-\gamma} \left(f_{nj}^T\right)^{1-\frac{\gamma}{\sigma_T - 1}} n_n^T \Theta_j^{\gamma}}{\left(\frac{\tilde{w}_n \tau_{nj}^T}{P_j^T} \times \frac{\sigma_T}{\sigma_{T-1}} \left(f_{nj}^T\right)^{\frac{1}{\sigma_T - 1}} \times \left(\sigma_T^{-1} \mu_T Y_j\right)^{\frac{-1}{\sigma_T - 1}}\right)^{-\gamma} n_n^T}$$

$$\frac{X_{nj}^T}{N_{nj}^T} = \frac{\mu_T Y_j \left(\tilde{w}_n \tau_{nj}^T\right)^{-\gamma} \left(f_{nj}^T\right)^{1-\frac{\gamma}{\sigma_T - 1}} \Theta_j^{\gamma}}{\left(\tilde{w}_n \tau_{nj}^T\right)^{-\gamma} \left(P_j^T\right)^{\gamma} \left(f_{nj}^T\right)^{\frac{-\gamma}{\sigma_T - 1}} \left(\frac{\sigma_T}{\sigma_T - 1}\right)^{-\gamma} \left(\frac{1}{\sigma_T}\right)^{\frac{\gamma}{\sigma^T - 1}} \left(\mu_T Y_j\right)^{\frac{\gamma}{\sigma^T - 1}}}$$

$$\frac{X_{nj}^T}{N_{nj}^T} = \frac{\left(\mu_T Y_j\right)^{1-\frac{\gamma}{\sigma_T - 1}} \left(f_{nj}^T\right) \Theta_j^{\gamma}}{\left(P_j^T\right)^{\gamma} \left(\frac{\sigma_T}{\sigma_T - 1}\right)^{-\gamma} \left(\frac{1}{\sigma_T}\right)^{\frac{\gamma}{\sigma^T - 1}}}$$

I sub in for $P_j^T$ to get,

$$\frac{X_{nj}^T}{N_{nj}^T} = \frac{\left(\mu_T Y_j\right)^{1-\frac{\gamma}{\sigma_T - 1}} \left(f_{nj}^T\right) \Theta_j^{\gamma}}{\left(\Theta_j Y_j^{\frac{1}{\gamma} - \frac{1}{\sigma_T - 1}} \left(\frac{\sigma_T}{\sigma_T - 1}\right) \left(\sigma_T^{-1} \mu_T\right)^{\frac{1}{\gamma} - \frac{1}{\sigma_T - 1}} \left(\frac{\gamma}{\gamma + 1 - \sigma_T}\right)^{\frac{-1}{\gamma}}\right)^{\gamma} \left(\frac{\sigma_T}{\sigma_T - 1}\right)^{-\gamma} \left(\frac{1}{\sigma_T}\right)^{\frac{\gamma}{\sigma^T - 1}}}$$

$$\frac{X_{nj}^T}{N_{nj}^T} = \frac{\left(\mu_T Y_j\right)^{1-\frac{\gamma}{\sigma_T-1}} \left(f_{nj}^T\right) \Theta_j^{\gamma}}{\Theta_j^{\gamma} Y_j^{\frac{\gamma}{\gamma}-\frac{\gamma}{\sigma_T-1}} \left(\frac{\sigma_T}{\sigma_T-1}\right)^{\gamma} \left(\sigma_T^{-1}\mu_T\right)^{\frac{\gamma}{\gamma}-\frac{\gamma}{\sigma_T-1}} \left(\frac{\gamma}{\gamma+1-\sigma_T}\right)^{\frac{-\gamma}{\gamma}} \left(\frac{\sigma_T}{\sigma_T-1}\right)^{-\gamma} \left(\frac{1}{\sigma_T}\right)^{\frac{\gamma}{\sigma_T-1}}}$$

$$\frac{X_{nj}^T}{N_{nj}^T} = \frac{\left(\mu_T Y_j\right)^{1-\frac{\gamma}{\sigma_T-1}} \left(f_{nj}^T\right)}{\left(Y_j \mu_T\right)^{1-\frac{\gamma}{\sigma_T-1}} \left(\frac{1}{\sigma_T}\right)^{1-\frac{\gamma}{\sigma_T-1}} \left(\frac{\gamma}{\gamma+1-\sigma_T}\right)^{\frac{-\gamma}{\gamma}} \left(\frac{1}{\sigma_T}\right)^{\frac{\gamma}{\sigma_T-1}}}$$

$$\frac{X_{nj}^T}{N_{nj}^T} = \frac{\left(f_{nj}^T\right)}{\frac{1}{\sigma_T}\left(\frac{\gamma}{\gamma+1-\sigma_T}\right)^{-1}}$$

## A.3 Equations to Solve the Model

### A.3.1 Output and Sales across countries

$Y_j^h$ denotes the value of output in sector $h$ in country $j$ and $X_j^h$ denotes the value of sales or expenditure in sector $h$ in country $j$. Total spending in a country by consumers. $X_j^N + X_j^T$ has to be equal to total production in a country $Y_j^N + Y_j^T$.

Total sales from all firms in country $j$ to country $i$ that meet the input requirement $\bar{\varphi}$ can be written down as

$$X_{ji}^T = \frac{X_i^T \left(\tilde{w}_j \tau_{ji}^T\right)^{-\gamma} e_j \left(\tilde{w}_j f_{ji}^T\right)^{1-\frac{\gamma}{\sigma_T-1}}}{\Theta_i^{-\gamma}}$$

Total output in the trade sector in country $j$, $Y_j^T$, is equal to the sum of exports from country $j$ to the rest of the world

$$Y_j^T = \sum_{i=1}^{N} \frac{\left(\tilde{w}_j \tau_{ji}^T\right)^{-\gamma} e_j \left(\tilde{w}_j f_{ji}^T\right)^{1-\frac{\gamma}{\sigma_T-1}}}{\sum_{k=1}^{N} e_k^T \left(\tilde{w}_k \tau_{ki}^T\right)^{-\gamma} \left(\tilde{w}_k f_{ki}^T\right)^{\frac{\sigma_T-1-\gamma}{\sigma_T-1}}} X_i^T \tag{21}$$

### A.3.2 Free Entry Condition

$$E\left[\sum_{j=1}^{J}\mathbf{1}_{ji}\left[\varphi\right]\left(\pi_{ji}^{V,h}(\varphi)-\tilde{w}_j f_{ji}^{h}\right)\right]=\tilde{w}_j f_e$$

where $\mathbf{1}_{ji}\left[\varphi\right]$ indicates whether firm $\varphi$ in $j$ finds it profitable to sell in country $i$ and $\pi_{ji}^{V,h}(\varphi)$ are variable profits from selling there. With free entry firms will continue to pay $f_e$ to get a productivity draw until expected profits from doing so are zero.

### A.3.3 Equilibrium Steps

(a) Make guesses of wages, price vectors and mass of entrepreneurs for each country and each sector $\left\{w_{jH},\, w_{jL};\, P_j^N,\, P_j^T; e_j^N,\, e_j^T\right\}_{j=1}^{J}$

(b) Construct the composite cost of labour cost using $w_{jH},\, w_{jL}$; $\widetilde{w}_j=\left(\theta_H^{\sigma}w_{jH}^{1-\sigma}+\theta_L^{\sigma}w_{jL}^{1-\sigma}\right)^{\frac{1}{1-\sigma}}$

(c) Solve for the productivity cutoffs $\overset{-h}{\varphi}_{ji}=\frac{\widetilde{w}_j\tau_{ji}^{T}}{A_jP_j^h}\left(\frac{f_{ji}^{h}\widetilde{w}_j}{Y_jA_j}\right)^{\frac{1}{\sigma_h-1}}\left(\frac{\sigma_h}{\mu_h}\right)^{\frac{1}{\sigma_h-1}}\frac{\sigma_h}{\sigma_h-1}$ using our guesses of $P_j^h$ and that $Y_j=\widetilde{w}_jL_j$

(d) With $\overset{-h}{\varphi}_{ji}$ and our guesses of $P_j^h$, $e_j^h$, and $\widetilde{w}_j$ I can solve for total profits across all firms in sector $h$ in country $j$, $FE_{\pi_j}^{h}=\sum_i\frac{1}{\sigma_h}\left(\left(\frac{\sigma_h}{\sigma_h-1}\frac{\widetilde{w}_j\tau_{ji}^{h}}{A_j}\right)^{1-\sigma_h}\left(P_i^h\right)^{\sigma_h-1}\mu_hY_i\gamma\right)\frac{\left(\overset{-h}{\varphi}_{ji}\right)^{-1+\sigma_h-\gamma}}{\gamma+1-\sigma_h}-\widetilde{w}_jf_{ji}^{h}\left(\overset{-h}{\varphi}_{ji}\right)^{-\gamma}$

(e) Using $\overset{-h}{\varphi}_{ji}$ I can compute a new set of the price indices $\bar{P}_j^h$

(f) Iterate until for both sectors $h$ in all countries $j$

  (a) $\bar{P}_j^h-P_j^h=0$

  (b) $FE_{\pi_j}^{h}-\widetilde{w}_jf_E=0$

  (c) $\sum_{i=1}^{N}\frac{\left(\frac{\tilde{w}_j\tau_{ji}^{T}}{A_j}\right)^{-\gamma}e_j\left(\tilde{w}_jf_{ji}^{T}\right)^{1-\frac{\gamma}{\sigma_T-1}}}{\sum\limits_{k=1}^{N}e_k^T\left(\widetilde{w}_k\tau_{ki}^{T}\right)^{-\gamma}\left(\tilde{w}_kf_{ki}^{T}\right)^{\frac{\sigma_T-1-\gamma}{\sigma_T-1}}}X_i^T-\widetilde{w}_jL_j\mu_T=0$

  (d) $(w_{jH}L_{jH}+w_{jL}L_{jL})-\widetilde{w}_jL_j=0$