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Essays in International Economics: the Trade-Creation Effect of Migration

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Abstract

My thesis consists of three chapters relating to topics in International Economics. My first two chapters study the effects of migration flows on the economic outcomes of stayers for both receiving and sending countries. In both these chapters I develop and calibrate two distinct general equilibrium (GE) models to study the quantitative effect of migration on the real income of workers. The third chapter empirically investigates the relationship between firm export behaviour and their composition of foreign-born workers.

In my first chapter I develop a multi-country GE model where consumers choose where to reside, facing a trade-off between potentially earning a higher wage abroad but incurring a cost to migrating. The novel contribution in this paper is that estimating migration costs within a GE model allows me to quantify interesting policy experiments. In one experiment I consider the effects of an expansion of the European Economic Area (EEA), which allows free movement of labour for its member countries. I find that expanding the European Economic Area to include Turkey leads to a very small negative impact on the average wages in the rest of the member countries. I find the increase in migration from Turkey into the EEA is offset by a decrease in migration to EEA countries from other member countries.

The empirical trade-literature has shown that members of migrant networks can reduce the information frictions that exist in bilateral trade costs and help firms increase exports to their country of origin. In my second chapter I utilize insights from this literature and add a new channel, a trade-creation effect, by which migrants affect economic outcomes across countries in a GE multi-country model with trade. In this setting the decision of workers on where to reside and the decisions of firms on which countries to export to are linked because where firms choose to sell their goods affects real income in a location which in turn affects a consumers decision to migrate. My results show that the trade creation effects are strong. It is particularly important in mitigating welfare losses for countries with large outflows in their population. For example, the average real income of a stayer in a net-emigration country is 1.4% higher due to the trade-creation effect.

In my final chapter, which is joint work with Professor Ananth Ramanarayanan, we study the relationship between export behaviour and the foreign-born worker composition at Canadian manufacturing firms using unique Canadian administrative employer-employee tax data. We argue that if immigrants are lowering the informational, or language barriers to export to their home country, then we should see these effects at firms that employ these immigrants, and it should be evident at a country-specific level. Our results confirm this assertion; we find that firms have much higher export sales to a country if they employ immigrant workers from that country. The increase in export sales of these firms stems from the link between immigrant employment and a reduction in trade costs.

Keywords: international trade, international migration, firm-level analysis

Co-Authorship Statement

This thesis contains Chapter 4 co-authored with Ananth Ramanarayanan. Together we worked on the conception and empirical methodology of the paper, analysis and interpretation of data, and drafting of the manuscript.

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Contents

List of Tables

List of Figures

List of Appendices

Chapter 1

Introduction

My thesis consists of three chapters relating to topics in International Economics. My first two chapters study the effects of migration flows on the economic outcomes of stayers for both receiving and sending countries. In both these chapters I develop and calibrate two distinct general equilibrium (GE) models to study the quantitative effect of migration on the real income of workers. The third chapter empirically investigates the relationship between firm export behaviour and their composition of foreign-born workers.

Given that migration is widespread and affects the labour force of many countries, there has been a long history of researchers trying to evaluate the effects of international migration on native-born stayers. In my first chapter, I employ a multi-country GE model to analyze the determinants of international migration for a set of 83 countries plus a rest of the world (ROW) aggregator. In this model, consumers choose where to reside, facing a trade-off between potentially earning a higher wage abroad but incurring a cost to migrating. My model is characterized by a nested CES production function that incorporates worker heterogeneity in skill (high-skilled and low-skilled) and nativity (immigrants and natives). I calibrate the migration costs consumers face to match important features of international migration. These costs are skill specific and vary by source-destination pair. Calibrating the migration costs within a GE framework is the main contribution of this paper. This enables me to quantify a consumer's migration response to different policy experiments, e.g. the expansion or contraction of the European Economic Area (EEA), which allows free movement of labour for its member countries. I find that expanding the European Economic Area to include Turkey leads to negligible impact on the average wages in the rest of the member European countries. I find that the increase in migration from Turkey into the EEA is offset by a decrease in migration to EEA countries from other member countries as well as an increase in migration to Turkey from EEA member countries.

The empirical trade-literature has shown that members of migrant networks can reduce the information frictions that exist in bilateral trade costs and help firms increase exports to their country of origin. One can think of information frictions as the language barriers that exist across countries that stifle trade. In my second chapter I utilize insights from this literature and add a new channel, a trade-creation effect, by which migrants affect economic outcomes across countries in a GE multi-country model with trade. In this setting the decision of workers on where to reside and the decisions of firms on which countries to export to are linked because where firms choose to sell their goods affects real income in a location which in turn affects a consumer's decision to migrate. Similarly, firm export decisions are affected by consumer migration decisions because where consumers choose to settle lowers the costs for firms selling to their country of origin. I calibrate my model for a set of 43 countries and assess the welfare impact of migration by comparing welfare under the currently observed levels of migration to a counterfactual scenario with no migration. My results show that the trade creation effects are strong, and are particularly important in mitigating welfare losses for countries with large outflows in their population. For example, the average welfare of native-born stayers in Portugal improves from -3% to only -1.24% if we account for the role that migrants have on trade costs. For Ireland, the average welfare of the native born stayer goes from -.22% to having a 1.5% improvement from migration when we account for the trade-creation effect. Firms which would otherwise not find it profitable to export to Portugal and Ireland can now do so because of the migrants reducing bilateral trade costs and this has a considerable impact on welfare in these countries.

I use the calibrated model to model the response of consumers and firms to a regional trade cost reduction. Migration rates can decrease in regions with low trade barriers because there is less of a need to migrate to a neighboring country when consumers can import more goods at a lower price. The increase in imports decreases the price level in each country and increases consumers' real income. However, migration rates can also increase because the increases to real income can now entice new consumers to migrate. Thus the size and direction of this migration effect is a quantitative question. In the context of an experiment where trade costs between the United States and Mexico decrease I find Mexican immigration to the United States falls and real income in Mexico increases from the increased trade between the two countries.

In my final chapter, which is joint work with Professor Ananth Ramanarayanan, we study the relationship between firm export behaviour and the foreign-born worker composition at Canadian manufacturing firms using unique Canadian administrative tax data. The administrative dataset we use, the Canadian Employer-Employee Dynamics Database (CEEDD), has linked employer-employee data for all Canadian manufacturing firms between the years 2010 and 2014. These files contain detailed annual firm level statistics and comprehensive information for every Canadian tax-file, including additional information on immigrant tax-filers sourced from immigration landing records.

We use this data to support our claim that if immigrants lower the information and language barriers to export to their home country, we should see these effects at firms that employ these immigrants, and it should be evident at a country-specific level. Our results confirm these assertions; we find that firms have higher export sales to the home countries of their immigrant workforce. The increase in export sales stems from firms with higher immigrant employment facing lower trade costs. However, if firms hire immigrants from countries where they expect high demand for their goods there exists an endogeneity problem in the interpretation of our trade-creation results. One way to overcome this issue is to instrument for the country specific immigrant employment at a firm. This requires finding an exogenous source of firm immigrant employment that is uncorrelated with current period firm demand shocks. We use lagged immigrant employment and employment at other firms in the same industry as instruments. Acknowledging the potential exogeneity issues with these instruments we also model the firms' employment decisions to hire immigrants. Using the first order conditions from that problem we derive an equation relating elasticities of trade costs to export sales. The estimation results from this problem are consistent with our previous results: immigrant employment from country k assists with firms increasing their export sales to country k.

Chapter 2

A Study of International Migration: Looking Beyond OECD Countries

2.1 Introduction

From 2000-2010 the global migrant stock increased by an average of 4.6 million annually, more than double the average amount seen throughout the 1990s. This increase is not only in migration to advanced economies, but also to developing countries. For example, the immigrant population share in OECD member countries Canada and Australia exceeds 20%. Similarly, Saudi Arabia, a developing country, has a migrant stock of over 7 million, an amount that accounts for over 25% of their population. This rapid rise in international migration, which now stands at over 230 million worldwide, has solidified the importance of quantifying the economic consequences for source and destination countries from migration.

In this chapter I construct and calibrate a general equilibrium (GE) model of migration to estimate the economic impact of international migration at the country level. The decision of workers to migrate is driven primarily by differences in income and migration costs across countries. Using this model I uncover the effects of migration on the real wages of stayers in source and destination countries by estimating a counterfactual experiment that removes the possibility of migrating abroad; essentially sending migrants back to their country of birth. A world of no migration impacts the wages and welfare of OECD countries negatively. On average, workers in OECD countries see a drop of .55% in their wages. Similarly, an average worker in a non-OECD country also sees a modest decrease in their wages in a world of no migration. These results suggest that migration has had a positive economic outcome on the stayers of receiving countries.

I use my model to quantify the economic impact of international migration for a set of 83 countries plus a rest of the world (ROW) aggregator. My model is characterized by a nested CES production function that incorporates worker heterogeneity in skill (high-skilled and low-skilled) and nativity (immigrants and natives). I use this framework to estimate parameters in a migration cost function that varies by skill to match the compositional patterns of regional and worldwide migration. In my model, a consumer observes wages, prices, and migration costs for all possible destination countries. The cost of staying in their country of birth is zero. Taking all this information the consumer chooses to reside in the country that maximizes his utility; he faces a trade-off between earning a higher wage abroad and paying a migration cost. However, the wages and prices offered in a country will be affected by the labour supply choices of all other emigrants and immigrants in the world.

In addition to the no-migration counterfactual experiment I use the calibrated model to estimate the response of workers to changes in the expansion or reduction of countries that are members of the European Economic Area explicitly. In one experiment I simulate the response of workers in to Turkey joining the EEA. By studying this in a GE framework I can highlight the indirect effects of these types of policy scenarios. In addition to the migration decisions between European countries and Turkey being directly affected, there are also indirect effects stemming from the changes in the decision of workers outside these areas to migrate within EEA countries or to other countries. I find these indirect effects are considerable when evaluating the overall impact from such an experiment.

I contribute to the limited literature on quantifying the impact from migration by expanding the set of countries to include many non-OECD countries for which the effects of migration can be studied. The rise of highly skilled immigrants from developing countries settling in OECD countries has increased the need to measure the impact from migration for developing, non-OECD countries. Between 1990 and 2000 there was a 64% increase in highly skilled immigration to OECD countries against only a 14% increase in low skilled immigration (Beine, Docquier and Rapoport, 2008). I can measure the impact for a large set of countries because my calibration methodology is designed to utilize accessible country level information, such as immigrant and native-born populations. In addition to this standard country level data I also require a richer set of migration data, specifically the stock of bilateral migration decomposed by skill levels. There is now reliable data accessible from the OECD Database on Immigrants in OECD and non-OECD Countries (DIOC-E) that contains this information.

Additionally since I model and individual's migration decision, I am not restricted to only quantitative experiments with exogenous shifts in migration populations, the most popular being a comparison of a world with and without migration. This modelling decision allows for more interesting policy experiments, including an experiment where we are able to grant countries currently on the road to European Union(EU) membership, Albania, Montenegro, Serbia, the former Yugoslav Republic of Macedonia and Turkey, the right to work in the European Economic Area[1] (EEA) without a work permit. In my model this will correspond to a reduction in the costs an individual faces when choosing to migrate within the EEA.

This paper relates to the literature on analyzing the determinants and composition of international migration. Sjaastad (1962) explored the returns to migration in a human capital model and established the seminal economic framework to interpret migration patterns. The simple, yet profound assertion of this model is that migration is a response to differences in the return to labour supply. This model served as the groundwork for numerous models in the migration literature that followed; the Borjas (1987) model of human capital investment and international migration is the most popular of these subsequent works (Örn B. Bodvarsson and den Berg,

[1]The European Economic Area includes all countries in the EU plus Norway, Iceland and Liechtenstein

2013). My work relates to Borjas (1987) in that we both specify a model of migration that decomposes an individual's earnings into observed and unobserved portions. The separation of earnings into two parts is important when evaluating the decision to migrate or not. Work done by Grogger and Hanson (2011), Rosenzweig (2006) and Beine, Docquier and Özden (2011) use a similar structure to analyze the determinants of international migration. They find that a simple model of income maximization can account for both the positive sorting - immigrants will settle in destination countries with high rewards to skill and positive selection - higher skilled workers are more likely to emigrate. Another important strand of the immigration literature examines the wage and production impact from migration on destination and source countries. I adapt a nested CES production function framework similar in structure to work by Di Giovanni, Levchenko and Ortega (2015); Ottaviano and Peri (2012) who investigate the impact of immigration on source and destination country wages and welfare. The consensus in these papers is that immigration has had a small positive effect on the average wages of natives.

2.2 Model Framework

I adapt a framework most similar to Docquier, Machado and Sekkat (2015) and Grogger and Hanson (2011) to analyze the movements of worldwide migration using a nested CES production technology that incorporates worker heterogeneity in skill level: high and low skilled labour, and nativity: immigrant and native-born.

The model consists of N countries, indexed $n \in \{1, \ldots, N\}$. The starting population of workers of skill type s in country n is denoted by N_{ns}. There is a single consumption good in each country that is not internationally traded.

2.2.1 Preferences

Worker $i's$ decision to migrate is determined by maximizing their utility over moving to country n and consuming Q_{in} at a country specific price P_n. All workers of skill type s born in country j and working in country n inelastically supply 1 unit of labour and earn a wage w_{jns}. A worker is characterized by their skill type $s \in \{H, L\}$ and their country of birth and country of work pair. Worker i born in country j solves:

$$\underset{n}{max} U(Q_{ijns}) - c_{jns} + \varepsilon_{ijn}$$

subject to

$$P_n Q_{ijns} \leq I_{ijns}$$

where $I_{ijns} \in \{w_{js}, w_{j1s}, ..., w_{jns}\}$, c_{jns} is the cost of migrating from country j to n for a worker of skill type s, and ε_{ijn} is the idiosyncratic shock for worker i born in country j and migrating to country n.

Substituting in the budget constraint I can write the consumer problem as,

$$\underset{n}{max}\ U(\tfrac{I_{ijns}}{P_n}) - c_{jns} + \varepsilon_{ijn}$$
$$\underset{n}{max}\ \left\{U(\tfrac{w_{js}}{P_j}) + \varepsilon_{ijj}, U(\tfrac{w_{j1s}}{P_1}) - c_{j1s} + \varepsilon_{ij1}, \ldots, U(\tfrac{w_{jns}}{P_n}) - c_{jns} + \varepsilon_{ijn}\right\}$$

A worker can choose to reside and work in their country of birth (in this case country j) and earn w_{js} , allowing for the consumption $\frac{w_{js}}{P_j}$. A worker can also choose to reside in country n, pay a migration cost c_{jns} and earn wage w_{jns}, allowing for the consumption of $\frac{w_{jns}}{P_n}$.

Assuming a linear utility function, standard optimization steps yield the indirect utility from migrating to country n,

$$V_{ijns}(P_n, I_{ijns}) = \frac{w_{jns}}{P_n} - c_{jns} + \varepsilon_{ijn}$$

Finally, assuming ε_{ijn} follows a type 1 extreme value distribution I can apply the results of McFadden (1974) to uncover the probability of a worker of skill s born in country j choosing to migrate to country n.

$$\delta_{jns} = Pr\left[V_{jns} = \max_k V_{ijks}\right] = Pr\left[V_{ijns} > V_{ij-ns}\right] = \frac{\exp\left[\frac{w_{jns}}{P_n} - c_{jns}\right]}{\sum_{k \in n} exp\left[\frac{w_{jks}}{P_k} - c_{jks}\right]} \tag{2.1}$$

The intuition of equation (2.1) can be summarized as follows: each worker i born in country j of skill type s receives a draw from a type 1 extreme value distribution that affects their utility cost of migrating to country n. Given c_{jns}, a higher ε_{ijn} makes migration to country n more attractive, whereas a higher c_{jns} makes migration less attractive.

L_n denotes the population in country n after migration.

$$L_n = \sum_s \sum_j \delta_{jns} N_{js}$$

2.2.2 Production Technology

Each country produces a non-tradeable good. Countries' production technologies differ in productivity. Firms in each country n are competitive and produce using a combination of high and low skill labour, L_{nH} and L_{nL} respectively. Firms in country n produce using a nested CES production of the form,

$$Y_n = A_n(\theta_H L_{nH}^{\rho} + \theta_L L_{nL}^{\rho})^{\frac{1}{\rho}}$$

where $\rho = 1 - \frac{1}{\sigma_s}$, σ_s is the elasticity of substitution across skill types, $s \in \{H, L\}$, and the parameters θ_H, θ_L represent technology parameters that shift the relative productivity of high and low skill labour, with $\theta_H + \theta_L = 1$.

CES nests are ordered by skill levels: high skilled or low skilled, $s \in \{H, L\}$, and nativity: native-born working in his country of birth or an immigrant worker, $x \in \{N, M\}$.

High skilled workers working in country n are composed of native-born workers for whom it is optimal to remain in country n ($x = N$) and immigrant workers for which is it optimal to work in country n where their country of birth is $j \neq n$ ($x = M$). β_M and β_N captures the relative productivity of migrant and native high skilled labour, with $\beta_M + \beta_N = 1$.

$$\begin{aligned} L_{nH} &= \left[\sum_x \left(\beta_x L_{xnH}^{\gamma}\right)\right]^{\frac{1}{\gamma}} \\ L_{nH} &= \left[\beta_N L_{NnH}^{\gamma} + \beta_M L_{MnH}^{\gamma}\right]^{\frac{1}{\gamma}} \\ L_{nH} &= \left[\beta_N \left(\delta_{nnH} N_{nH}\right)^{\gamma} + \beta_M \left(\sum_{j \neq n} \delta_{jnH} N_{jH}\right)^{\gamma}\right]^{\frac{1}{\gamma}} \end{aligned} \tag{2.2}$$

where $\gamma = 1 - \frac{1}{\sigma_x}$ and σ_x is the elasticity of substitution between (un)skilled natives and (un)skilled migrants. The first component in the RHS of equation (2.2) corresponds to the high skilled labour supplied by natives in country n. The second component in the RHS of equation (2.2) corresponds to the high skilled labour supplied by all migrants in country n.

Similarly low skilled workers working in country n aggregates to the following

$$\begin{aligned} L_{nL} &= \left[\sum_x \left(\alpha_x L_{xnL}^{\gamma}\right)\right]^{\frac{1}{\gamma}} \\ L_{nL} &= \left[\alpha_N L_{NnL}^{\gamma} + \alpha_M L_{MnL}^{\gamma}\right]^{\frac{1}{\gamma}} \\ L_{nL} &= \left[\alpha_N \left(\delta_{nnL} N_{nL}\right)^{\gamma} + \alpha_M \left(\sum_{j \neq n} \delta_{jnL} N_{jL}\right)^{\gamma}\right]^{\frac{1}{\gamma}} \end{aligned} \tag{2.3}$$

where α_M and α_N captures the relative productivity of migrant and native low skilled labour, with $\alpha_M + \alpha_N = 1$.

The benefits of using a nested CES production function are that it allows for a simple implementation of imperfect substitution among worker types. Wages of workers will depend on the substitutability or complementarity among worker types, e.g. the downward pressure on the wages of high skilled native-born workers stemming from increases in high-skilled immigrant workers is more pronounced if the substitutability between the two groups is high. Profit maximization implies that workers will be paid their marginal product. Therefore a worker of skill s and nativity x in country n earns the following wage,

$$\frac{\partial Y_n}{\partial L_{xns}} = \frac{\partial Y_n}{\partial L_{ns}} \times \frac{\partial L_{ns}}{\partial L_{xns}}$$

The marginal product of low skilled workers of nativity x is equal to,

$$\begin{aligned} w_{xnl} = \frac{\partial Y_n}{\partial L_{xnL}} &= \frac{\partial Y_n}{\partial L_{nL}} \times \frac{\partial L_{nL}}{\partial L_{xnL}} \\ &= A_n \frac{1}{\rho}\left[\theta_H L_{nH}^{\rho} + \theta_L L_{nL}^{\rho}\right]^{\frac{1}{\rho}-1} \rho\theta_L L_{nL}^{\rho-1} \times \frac{1}{\gamma}\left[\sum_x (\alpha_x L_{xnL}^{\gamma})\right]^{\frac{1}{\gamma}-1} \gamma\alpha_x L_{xnL}^{\gamma-1} \end{aligned}$$

where $\left[\sum_x \left(\alpha_x L_{xnL}^{\gamma}\right)\right]^{\frac{1}{\gamma}-1} = L_{nL}^{1-\gamma}$ and the wages of low skilled workers equals,

$$w_{xnL} = A_n \left[\theta_{nH} L_{nH}^{\rho} + \theta_{nL} L_{nL}^{\rho}\right]^{\frac{1}{\rho}-1} \theta_L L_{nL}^{\rho-\gamma} \alpha_x L_{xnL}^{\gamma-1} \tag{2.4}$$

Similarly, the wages of high skilled workers of nativity x is equal to,

$$w_{xnH} = A_n \left[\theta_H L_{nH}^{\rho} + \theta_L L_{nL}^{\rho}\right]^{\frac{1}{\rho}-1} \theta_H L_{nH}^{\rho-\gamma} \beta_x L_{xnH}^{\gamma-1} \tag{2.5}$$

Empirical evidence shows migrant workers earn significantly less than their native-born counterparts even with similar observable characteristics (Green and Riddell, 2003; Sweetman, 2004). The evidence suggests that a portion of the productivity of a worker is lost when they migrate to a new country; there is an element of a migrant's human capital produced abroad that is specific to the source country, and that is not transferable to the source marketplace. Though it is important, for simplicity and tractability I do not model this aspect of migration. Instead it is assumed to be explicitly in the costs that migrants face when deciding which country to migrate to.

2.2.3 Equilibrium

Equilibrium is defined as a set of wages $\{w^*_{xns}\}$, prices $\{P^*_n\}$, and migration decisions $\{n^*_{ijs}\}$ such that

1. Every worker i maximizes their utility by choosing the optimal $n^*_{ijns} \in \{1, \ldots N\}$
2. Every firm j in country n chooses a production plan to maximize profits

$$max \; P^*_n Y_n - w^*_{nH} L_{nH} - w^*_{nL} L_{nL}$$

subject to

$$Y_n \leq A_n F(L_{nH}, L_{nL}), \; \forall n$$

with wages equaling the following as a result of optimization

$$\begin{aligned} w^*_{xnH} = &\quad A_n \left[\theta_H L^{\rho}_{nH} + \theta_L L^{\rho}_{nL}\right]^{\frac{1}{\rho}-1} \theta_H L^{\rho-\gamma}_{nH} \beta_x L^{\gamma-1}_{xnH} \\ w^*_{xnL} = &\quad A_n \left[\theta_{nH} L^{\rho}_{nH} + \theta_{nL} L^{\rho}_{nL}\right]^{\frac{1}{\rho}-1} \theta_L L^{\rho-\gamma}_{nL} \alpha_x L^{\gamma-1}_{xnL} \end{aligned}$$

3. Markets clear in all countries

$$Y_n = \sum_{i \in n} Q_{in}$$

and labour demand and labour supply of each worker type is equal in all countries

$$\begin{aligned} L_{Nns} = &\quad \delta_{nns} N_{ns} \\ L_{Mns} = &\quad \sum_{j \neq n} \delta_{jns} N_{js} \end{aligned}$$

2.3 Data

I calibrate the model using 2010 data from four major sources: the OECD, the World Bank, and datasets complied by Barro and Lee (2013) and Mayer and Zignago (2011). From the OECD

Database on Immigrants in OECD and non-OECD Countries (DOIC-E) I have information on bilateral stock of migrants at the country level decomposed by skill level. I use country population statistics from the World Bank populations dataset. The Barro and Lee (2013) dataset contains educational attainment statistics which I use to assign a high and low skilled proportion of the population for every country. Finally, the Mayer and Zignago (2011) dataset contains bilateral country information, such as the geodesic between countries[2], suitable to capture the costs of migration.

I construct the initial labour force for each country in my model for the year 2010.[3] I can ascertain the initial labour force in each country, consisting of the native-born working population divided into high and low skill types by combining data from three different sources. I begin with the OECD's DOIC-E database 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 determine the proportion of migrants in each country and subtract them to back out the native portion. Finally, I compute the proportion of high and low skilled natives in each country by using the educational attainment data found in Barro and Lee (2013). 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.

There are some issues that arise with using the Barro and Lee (2013) dataset. The ideal data reports the exact percentage of native-born individuals in a country that have tertiary education, this would be the proportion of high skilled labour in a country. The Barro and Lee (2013) dataset does not distinguish between native-born and immigrants when assigning their educational attainment statistics; it is not uncommon for the United Nations population data which they base their estimates on to include both immigrants and native-born individuals. Unfortunately, they do not detail for which countries this is the case. I assume that the educational attainment statistics assigned by Barro and Lee (2013) to each country are not affected in a significant way by the inclusion of immigrants. This could arise because the data used to assign

[2]Geodesic is the shortest possible line between two points on a sphere

[3]The most recent year possible with the data available

educational attainment in a country rarely includes immigrants or another alternative is that the distribution of educational attainment is the same for both immigrants and native-born.[4] It could also be that the inclusion of both immigrants and native-born individuals does occur frequently and in response one could calibrate the model to the high skilled native, migrant mix.

Table (2.1) lists the top 10 destination countries for migrants in my sample and provides statistics on the share of immigrants, emigrants for each country. Table (2.1) also contains descriptive statistics on the distance traveled by immigrants and emigrants. Several interesting patterns arise from these simple summary statistics. Perhaps unsurprisingly for a list of the top 10 migrant destination countries, there are several countries where the immigrant *share* of the population is large; foreign-born in Australia and Canada make up over 20% of the population. Several countries exhibit large immigrant and emigrant shares as a percentage of population. Russia's stock of 13,677,467 immigrants accounts for 9.57% of the population, but once the stock of emigrants is accounted for the net population gain from migration is less than 7%. A similar pattern exists for the United Kingdom, with an immigrant share of 11.75% and an emigrant share of 6.51%, in a world where there was no migration in the United Kingdom their population would be change by less than 5%. The impact of immigration on the labour market outcomes of countries that exhibit both high immigration and emigration will be different from countries with only high immigration or emigration rates. The labour market outcomes will also be different depending on whether the emigrants leaving a country and immigrants entering that country are similar in skills.

[4]This seems unlikely, there is a lot of documented evidence on positive selection

Table 2.1: Migration Statistics: Top 10 Destination Countries

Country	Stock of Immigrants	Immigrant Share of Population	Emigrant Share of Population	Avg. Dist.(km) Immigrant Traveled	Avg. Dist.(km) Emigrant Traveled
United States	41,307,385	13.35%	0.55%	4791	5297
Russian Federation	13,677,467	9.57%	2.83%	1646	2534
Germany	10,350,815	12.66%	4.85%	1674	3540
United Kingdom	7,373,907	11.75%	6.51%	3809	8478
Canada	6,859,385	20.17%	4.08%	6920	2247
France	6,818,647	10.49%	2.37%	2369	2666
Australia	6,013,093	27.29%	2.37%	12,934	13,769
Spain	5,113,275	10.98%	2.07%	5129	3724
Italy	4,489,457	7.57%	4.18%	2779	4900
South Africa	2,846,897	5.58%	1.25%	3897	10,017

Notes: Using 2010 data sourced from the OECD DOIC-E Migration Database

Table 2.2: Migration Statistics: Top 10 Source Countries

Country	Stock of Emigrants	Immigrant Share of Population	Emigrant Share of Population	Avg. Dist.(km) Immigrant Traveled	Avg. Dist.(km) Emigrant Traveled
Mexico	11,343,114	0.52%	9.67%	4557	3419
United Kingdom	3,855,045	11.75%	6.14%	3809	8478
Russian Federation	3,758,557	9.57%	2.63%	1646	2534
Germany	3,639,715	12.66%	4.45%	1674	3540
Poland	3,277,180	1.55%	8.61%	1066	2533
Romania	2,644,179	0.52%	13.06%	1138	2284
Turkey	2,585,281	2.13%	3.57%	1193	2492
Italy	2,387,429	7.57%	4.03%	2779	4900
Portugal	1,599,694	7.66%	15.13%	5089	3172
United States	1,488,050	13.35%	0.48%	4791	5297

Notes: Using 2010 data sourced from the OECD DOIC-E Migration Database

The statistics on distance traveled in Table (2.1) also yield some interesting points. In some countries immigrants and emigrants traveled similar distances, the United States and France being two examples. In other countries the distance traveled by immigrants and emigrants is radically different. For example, Canadians emigrating abroad traveled an average of 2247km whereas immigrants traveling into Canada traveled an average of 6920km; a distance three times as far. I measure distance between countries using the geodesic distance between countries as a proxy for establishing the cost of migrating between countries. Simple intuition suggests that the larger the distance between countries the larger the cost of migrating.

Table (2.2) lists the top 10 source countries for migrants in my sample and provides statistics on the share of immigrants, emigrants for each country. Five countries, the United Kingdom, Russian Federation, Germany, Italy and the United States appear on both top 10 lists. Mexico has the largest emigrant population in the world and over three times the number of emigrants as the second largest source country, the United Kingdom. Mexican emigration is concentrated heavily in the United States; 99% of Mexican emigrants reside in the United states. High skilled Mexican emigrants are more dispersed but are still highly concentrated in the U.S., 89% reside in the United States compared to 99% for low skilled workers. Combined, immigration from Mexico accounts for 27% of the total stock of U.S. immigrants.

There exists strong regional migration patterns in the migration data: 61% of European emigrants choose to reside in another European country and 94% of OECD emigrants reside in another OECD country. Non-OECD to non-OECD migration is less common. Only 22% of immigrants originating from a non-OECD country reside in another non-OECD country.

To estimate the model I require information on the migration costs potential migrants face when deciding which country to reside in. Mayer and Zignago (2011) compile a dataset that is useful for trying to capture the costs of migrating. Their dataset contains the geodesic distance in kilometers between capital cities, information on linguistic similarity between countries,[5] and whether two countries share a border. The bilateral differences across countries in these characteristics will form migration costs that consumers face. Details for this procedure are found in the next section.

[5]Languages spoken by at least 20% of the population in both countries

One of the major differences between my analysis and work done by others is the inclusion of many non-OECD countries as possible migration destinations.[6] It is therefore important to understand the criteria we used to include or exclude countries from our sample to arrive at the 83 countries I use in my model. There were some limiting factors that affected the inclusion of countries in our model. First, I restrict the sample to those countries with a meaningful presence of either emigration or immigration. For a country to be included in my model it had to have at least 0.025% of the combined worldwide immigrant or emigrant stock, which was roughly 60,000 in 2010. For example, Palau, an island nation with a stock of immigrants totaling 5,776 and a stock of emigrants totaling 7,971 was not included in my sample. Countries removed under this fashion tended to be very small in size; there would be little to gain by including these countries and would only serve to add more computational burden to the estimation process. Secondly, I removed countries for which the OECD DIOC-E had no data on bilateral migration.

2.4 Calibration

Before going over my estimation procedure it is valuable to discuss the parameters that I take from the literature and how the sensitivity of my results can be affected by these parameters. The elasticity of substitution parameters needed in the production function, σ_s and σ_x, are taken as given from the labour literature. These parameters are important for understanding the effects of migration because they determine the degree of substitutability between different groups of workers, which in turn affects their wages. By choosing well established parameters found in the literature I am able to focus on the main crux of this paper, solving for the migration decisions of consumers in a general equilibrium environment.

For the elasticity of substitution across skill types, σ_s, I use a value of 3. This is the value estimated by Katz and Murphy (1992), and more recently by Ottaviano and Peri (2012). The

[6] See Örn B. Bodvarsson and den Berg (2013) Section 3.2.7 Evidence on Worldwide Migration

value I assign for σ_x, the substitutability between natives and migrants is 10, a value taken from Manacorda, Manning and Wadsworth (2012). These parameters influence the strength of the wage impact that migration has on native-born stayers. For example, following an increase in the labour supply of immigrant workers, a higher substitutability, represented by a higher σ_s, between immigrant and native-born workers in production leads to a *larger* negative impact on the wages of native-born workers.

It should be noted that these elasticities of substitution are estimated using mostly U.S. data, and it can be debated whether it is appropriate to assign these same values to immigrants from all 82 other countries. One possible solution to lessen this problem would be to estimate a small number of region specific elasticities. For example, immigration into south Asian countries is mostly from other south Asian countries and therefore the substitutability between natives and immigrants, σ_x, of this region could potentially be higher than the elasticity of substitution used between migrants and natives in the U.S.

2.4.1 Calibration Procedure

The model is estimated following a four step procedure. The first step is to assign the bilateral cost of migrating to every country in my model. To estimate this NxN system I make an initial guess of the migration costs that workers face and construct $\hat{c}_{jns}$. In the second step I assign a TFP value for each country where the TFP values for each country are adjusted such that in equilibrium the differences between the ratio of GDP/Capita relative to the U.S. in the model and the ratio of GDP/Capita relative to the U.S. found in the data are minimized. The counterfactual experiment that I conduct will use the TFP values that satisfy this condition. The third step is to solve an individuals maximization problem by choosing n over the set of all possible destination countries, given the migration costs from step 1, TFP values for each country as well an initial vector of wages and prices. I solve this system of non-linear equations by adjusting prices in each country until the goods and labour markets clear. Finally I compare the moments from our model with the moments in the data and adjust the vector of migration costs until I minimize the squared distance between the model and data moments.

The migration costs that workers face to be contingent on the source-destination country pair and the skill level of the prospective migrant,

$$c_{jns} = \alpha_0^s + \alpha_1^s d_{jn} + \alpha_2^s L_{jn} + \alpha_3^s EEA_{jn} + \alpha_4^s B_{jn}$$

where, d_{nj} is the geodisc distance between country j and country n, L_{nj} is a dummy variable indicating whether the two countries share a similar language,[7] EEA_{nj} is a dummy variable indicating whether the two countries are in the European Economic Area, and B_{jn} is a dummy variable indicating whether the two countries share a land border.

I calibrate the migration cost parameters, $\{\alpha^s\}$, via Simulated Method of Moments matching the following moments: migrants as a percentage of the world population, average distance travelled, proportion of language similarity migration, proportion of EEA migration, and proportion of contiguous migration; calculated separately by skill level.

2.4.2 Model Fit

Table (2.3) shows the calibrated migration cost parameters results from the Simulated Method of Moments procedure outlined in Section (2.4.1). My findings on the determinants of migration are consistent with the literature: the cost of migrating increases with the distance between the two countries and migrating to a country of a similar language reduces the cost of migrating. Furthermore, migrating to the EEA is less costly for EEA member country migrants, more so if the source and destination country share a land border. I use these estimates to construct the costs that workers face in migrating abroad.

The model does a very good job at matching the targeted moments in the data. For example, the model's predictions for the number of migrants, average distance travelled by migrants, and the proportion of migration between countries of similar language match the observed data

[7] 20% of the population in both countries speak the same language

quite well. Table (2.4) contains the goodness of fit for all 10 matched moments.

Table 2.3: Model Parameters

	High Skilled	Low Skilled
α_0 (Fixed Cost)	4.8002	2.3747
α_1 (d_{jn})	0.3622	0.7568
α_2 (L_{jn})	-1.2874	-1.5287
α_3 (EEA_{jn})	-0.4199	-0.1536
α_4 (B_{jn})	-0.3150	-0.8809

Notes: Migration parameters estimated using the Simulated Method of Moments procedure outlined in this section.

Table 2.4: Model Fit

	High Skilled		Low Skilled	
	Data	Model	Data	Model
Migrants as % of Population	4.01%	4.00%	1.75%	1.74%
Average Distance Traveled (km)	6239	6279	5325	5451
Proportion of Language Similarity Migration	33.64%	35.10%	32.43%	34.06%
Proportion of EEA Migration	13.62%	15.45%	12.91%	11.93%
Proportion of Contiguous Migration	11.31%	12.57%	20.72%	23.04%

2.5 Results

The main counterfactual experiment is one where I undo world migration and study the consequences on wages and output in a world where all immigrants are sent back to their country of origin. Now the population in country n will be the individuals in country n where it was optimal to stay plus all individuals born in n but where it was optimal to move to some country j.

$$N_n = \sum_s \sum_j \mathbf{1}_{\{n^*_{jns}=n\}} + \sum_s \sum_j \mathbf{1}_{\{n^*_{ins}\neq n\}})$$

What makes my analysis unique is that I am able to go beyond the traditional examination of undoing migration into only OECD countries and examine the consequences of undoing migration into non-OECD countries as well. Table (2.5) shows the effect on the average wages of natives who stayed in their country of origin compared with the no migration case. Where average wages in a country is equal to,

$$\bar{w}_n = \frac{\sum_j \sum_s \sum_x \delta_{jns} * N_{js} * w_{xjns}}{\sum_j \delta_{jns} * N_{js}}$$

A negative value indicates that native stayers are worse off in the counterfactual world of no migration. We see from Table (2.5) that there is a differential wage effect for high and low skilled workers in both OECD and non-OECD countries from migration. In a world of no migration, high skilled workers see a larger decrease in their wages relative to low skilled workers in non-OECD countries. This is due to the large proportion of high skilled workers in non-OECD countries being constrained to stay in their country of origin. In a world with migration, the high skilled workers that remained benefited from the large outflow of high skilled workers. High skilled emigration, often to OECD destinations, placed upward pressure on the wages of high skilled native workers that remained. The wages of low skilled workers in non-OECD were negligibly affected by the no migration counterfactual.

The only group to see relatively large gains to their wages in a world with no migration are low skilled workers in OECD countries. The large inflow, in absolute terms, of low skilled workers from non-OECD countries put downward pressure on the wages of low skilled workers in OECD countries. In our no-migration counterfactual, the low skilled OECD workers benefit from having less compeititon from foreign, low skilled labour.

In a study of the consequences of undoing world migration into OECD countries, authors Di Giovanni, Levchenko and Ortega (2015) find an average loss of 2.38% in welfare for OECD countries, an amount similar to ours. They also find an average loss of 2.0% for non-OECD countries, whereas I find a much smaller change on average. This could be explained by the fact that in their model there is *never* migration into non-OECD countries, and their inclusion of remittances. For both OECD and non-OECD countries there is a negative effect on GDP/Capita, in the range of 2-7%.

Table 2.5: Worldwide Migration Counterfactual

	% Δ High Skill Wages	% Δ Low Skill Wages	% Δ GDP per Capita
OECD	-0.92%	0.35%	-6.74%
Non-OECD	-0.50%	0.06%	-2.28%

Notes: A negative number means that the average wage of a high skilled native stayer in an OECD country was 0.92% higher in a world with migration

Table 2.6: European Union Membership Expansion Counterfactual

	% Δ High Skill Wages	% Δ Low Skill Wages	% Δ GDP per Capita
Europe with Turkey	-2.10%	-6.51%	-5.60%
Europe without Turkey*	-0.01%	0.01%	-0.01%

Notes: A negative number means that the average wage of a high skilled native stayer in an European country was 2.10% higher in * For this row of calculations I do not include Turkey. I do still account for Turkish migrants in the rest of the EU

My second counterfactual experiment is one where I grant Turkey,[8] a country currently on track for European Union membership, the full benefits of being a member state of the EU. Turkey has a population of over 70 million, 10% of which are considered high skilled. This is comparable to the United Kingdom or Germany in population size and Portugal in skill composition. In our model the benefits of being a member state of the EU takes the form of a cost reducing parameter for citizens migrating within the European Economic Area. Following Turkey's accession into the EEA, the model predicts that migration into other EEA countries from Turkey increases by 22%. The impact of this increased immigration is shown in Table (2.6). The results show that the wages of native European stayers are negatively affected by

[8]Turkey was chosen because it has the largest economy and population of all EU candidate countries

Turkey joining the EU; the average wage of a native European stayer falls between 2-7%. This is primarily due to Turkey having a large population who on average are earning a wage below the EU average. When we compare wages of workers in Europe accounting for this compositional effect we see very little changes in average wages across both skill groups; European workers react to the increase in Turkish migrants by sorting to other European countries, including Turkey. Immigration into Turkey from the rest of Europe increases by 29%, migration into other European countries from European workers and migration into Europe from the rest of the world falls slightly. The multi-country general equilibrium framework is central to this result. Consumers' in Europe and abroad react to the changing EEA landscape and mitigate much of the wage impact following Turkey's inclusion into the EEA. A model that only allowed for exogenous movements in migration has the potential to overstate the negative effects of Turkey's inclusion into the EU.

In my last counterfactual I simulate the migration response of consumers in Europe and the rest of the world to the United Kingdom leaving the EU and no longer being part of the EEA, commonly referred to as Brexit. The economic fallout for the United Kingdom and the rest of Europe following Brexit has been discussed extensively in the popular media and in academic journals and the likely fall in immigration to the UK is seen as a large, if not the largest, economic cost of Brexit (Economist, 2017; Wadsworth et al., 2016; Breinlich et al., 2016). In contrast to these papers, the structure of my model allows me to model the migration decision of workers in response to Brexit and measure the impact on the real wages and GDP of the UK. I find that the impact on wages is relatively small, as shown in Table (2.7), wages of native-born stayers are barely affected. Additionally, the wages of high-skilled workers in the United Kingdom fall by 0.12% and the wages of low-skilled workers increase by 0.08%. Similar to the previous counterfactual, in the steady state, workers from across Europe react to the United Kingdom leaving the EEA and mitigate the wage impact from Brexit in the rest Europe. The loss in migration from the rest of Europe is offset by less Britons leaving; migration into Europe from the United Kingdom falls by 22% and migration from the rest of

Europe, particularly from Central and Eastern Europe, into the United Kingdom falls by 20%. Conversely, migration into the United Kingdom from outside the EEA and migration within the remaining EEA countries increases slightly.

Table 2.7: Brexit: European Union Membership Contraction

	% Δ High Skill Wages	% Δ Low-Skill Wages	% Δ GDP per Capita
European Economic Area*	0.01%	-0.01%	-0.02%

Notes: *Comparing average wages in all EEA countries following the United Kingdom's departure from the EU not including the UK.

2.6 Conclusion

As international migration increases, understanding the labour market consequences becomes more important. I assessed the impact from migration and analyzed the determinants of migration using a simple model of income maximization embedded in a general equilibrium model. The model framework incorporates many of the important features of the world economy and empirical studies of international migration. There exists labour productivity differences across countries, worker heterogeneity in productivity across skill types, and between working in your country of birth or abroad, as well as country-pair and skill specific costs of migration. Though I try and account for all the important features of the world economy and international migration, this model is still only a simplification of an incredibly complex decision making process of individuals deciding to relocate to another part of the world, oftentimes thousands of miles away, with little or no guarantee on what the outcome might be. However, the complexity of the problem should not dissuade us from pursuing it, especially when the number of international migrants now number some 232 million.

My analysis suggests that, on average, individuals in both OECD and non-OECD countries are better off due to international migration. Additional research on the robustness of this result are avenues for future study. For example, remittances sent home by migrants provides a substantial boost to the income of those in the source country. The Philippines, a country with 4 million emigrants, sees remittance inflows equivalent to 15% of their GDP. Since I only look at the change in real wages due to migration and not income; I may have underestimated the benefits of migration, especially for countries that have high levels of remittances. My analysis also does not take into account any possible effects migrants have on a countrys productivity; the labour market outcomes from migration may be different if we endogenize TFP. Lastly, my analysis of the determinants of migration ignores the social, political, and cultural factors that undoubtedly enter into the decision making process of a potential migrant. As more data becomes available in this literature the inclusion of these components becomes possible.

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Chapter 3

The Trade-Creation Effect of Migrants: a Multi-country General Equilibrium Analysis

3.1 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. 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.

In a series of papers on international trade and migration networks, Rauch (1999) and Rauch and Trindade (2002) show migrant networks can play a key role in overcoming informational barriers to international trade by acting as intermediaries between firms across countries. Lower trade costs due to migration influence export sales to a country by *i*) increasing the sales of existing exporting firms and *ii*) influencing the number of firms that find it profitable to export, I will refer to these effects as the trade-creation effects of migration.

Empirical studies on the trade-creation effects 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, 1999; 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 trade-creation channel and gauge its relative importance in contributing to the overall welfare impact from the currently observed levels of migration. To the best of my knowledge, I provide the first set of quantitative results showing that the welfare contribution of the trade-creation effect 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 multi-country general equilibrium 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 can earn the highest real income net of migration costs. The wage they earn at a location depends on their skill type, the degree of complementary between worker skill types, and changes in the labor supply coming from immigration and emigration[9]. These decisions are integrated because where firms choose to sell their goods affects real income in a location which in turn affects a consumer's decision to migrate. Similarly, firm export decisions are affected by consumer migration decisions be-

[9]These are common features in the nested constant elasticity of substitution models of labor 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).

cause where consumers choose to settle lowers 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 labor 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 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. 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*) labor 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. Labor 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 entry decisions and therefore the varieties available for consumption. In the case of United States, the increase in the population due to immigration induces firm entry in the domestic American market which increases the set of varieties produced in the United States, resulting in a lower price level and higher real income for American consumers.

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 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 quantitatively small because the behaviour of exporting firms in this set of countries, is roughly the same in the model with all three channels present and one with the trade-creation effect of migration 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 labor market and market size welfare gains resulting from the large increase in population from immigration.

For countries with large diasporas distributed among many countries such as Portugal and Poland this channel is more pronounced. Welfare losses under the current levels of migration compared to the no-migration counterfactual worsen from -1.24% to -3.00% and -2.44% to -3.54%, for Portugal and Poland respectively, if the trade-creation channel of migration is ignored. 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 labor market and market size effects.

This paper relates to the large literature that evaluates the economic impact of migration. Ottaviano and Peri (2012), Card (2009), Aydemir and Borjas (2007), and Borjas (2003) 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 different types of workers where the labor input is a constant elasticity of substitution composite of different types of labor (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. Similar to these papers, the effect of a particular labor supply shock on the nominal wages of native-born workers in my model will depend on the elasticity of substitution between worker types and the size of the inflow of each worker type.

In addition to Gould (1994), Head and Ries (1999), and Peri and Requena-Silvente (2010) that study 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 Portugal Bastos 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, Burzyński 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.

The rest of the paper is organized as follows. In Section (3.2), I develop the model. Section (3.3) discusses the quantitative construction of the model. In Section (3.4), I present my data sources and the estimation results. Section (3.5) presents the counterfactual experiments for the main welfare results. Finally, Section (3.6) concludes.

3.2 Model Framework

There are J countries, indexed $j = 1, ..., J$. The starting 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.

3.2.1 Consumer Preferences

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

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

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

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

In this framework, the welfare of workers in j are affected by migration via the impact that migrants have on prices p_j^g, nominal wages w_{js}, and the set of goods Ω_j^g. The set of goods available in j, Ω_j^T will also change due to trade costs; higher trade costs between countries results in less goods being traded and less varieties of goods available for consumers. Whereas, 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} that equals,

$$V_{js} = \frac{w_{js}}{\left(P_j^T\right)^{\mu^T} \left(P_j^N\right)^{\mu^N}} \tag{3.1}$$

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

$$P_j^g = \left[\int_{\omega \epsilon \Omega_j^g} p_j^g(\omega)^{1-\sigma_g} d(\omega) \right]^{\frac{1}{1-\sigma_g}} \tag{3.2}$$

3.2.2 Consumer Migration Decision

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

$$\max_j \; V^*_{cijs} = ln\left(V_{js}\right) - ln\left(t_{ijs}\right) + \varepsilon_{cij} \tag{3.3}$$

where ε_{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 ε_{cij} is i.i.d across countries i and j and follows a type 1 extreme value distribution. This yields the following expression for the probability a consumer born in i of skill s chooses to reside in j:

$$\delta_{ijs} = Pr\left[V^*_{cijs} = \max_k V^*_{ciks}\right] = Pr\left[V^*_{cijs} > V^*_{ci-js}\right] = \frac{\frac{V_{js}}{t_{ijs}}}{\sum\limits_k \left(\frac{V_{ks}}{t_{iks}}\right)} \tag{3.4}$$

t_{ijs} is meant to capture the barriers that individuals face in migrating. Using standard proxies from the migration literature: distance, language similarity, membership in a free movement of persons agreement, and contiguity between countries will form the determinants of migration costs t_{ijs} (Mayda, 2010; Clark, Hatton and Williamson, 2007; Borjas, 1987). 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, δ_{ijs}.

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

$$M_{ijs} = \delta_{ijs} Z_{is} \tag{3.5}$$

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

$$L_{js} = \sum_i M_{ijs} \tag{3.6}$$

where L_{js} is also the labour supplied in country j of skill s that is usable by firms in production.

3.2.3 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 g the mass of entrants, e_j^g is endogenous. Potential firms must pay a cost f_e to obtain a productivity draw φ 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, $\tau_{ji}^T\left(M_{jis},\, M_{ij}\right)$. M_{jis} and M_{ijs} are endogenous objects of the model that reflect the the optimal migration decisions of consumers.

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

$$\begin{aligned} \overset{min}{L_{jH}(\varphi),\, L_{jL}(\varphi)} \qquad & w_{jH}L_{jH}(\varphi) + w_{jL}L_{jL}(\varphi) + f_{ji}^T \\ s.t \qquad & A_j\varphi\left(\theta_H L_{jH}^{\frac{\eta-1}{\eta}}(\varphi) + \theta_L L_{jL}^{\frac{\eta-1}{\eta}}(\varphi)\right)^{\frac{\eta}{\eta-1}} = \tau_{ji}^T\left(M_{jis},\, M_{ijs}\right) q_{ji}^T(\varphi) \end{aligned}$$

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

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

θ_H and θ_L capture the relative importance of skilled and low skilled labor in production. Skilled and unskilled workers are imperfect substitutes in production, where η is the elasticity of substitution across skill types.

Katz and Murphy (1992) first showed the importance of modeling skilled and unskilled labor as imperfect substitutes in production to understand the impact of changes in labor supply on the wages of workers. In my setting high skilled migrants 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. Perfect substitutability between immigrant and native workers within skill groups results in a *larger* negative impact on the wages of high skilled native-born workers compared to a setting where the two groups are not perfectly substitutable.

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, albeit 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 labor supply in j will still be affected by the skill composition of immigrant workers residing in j. Differences in aggregate labor supply across countries form from differences in the proportion of high and low skilled native labor *and* the skill composition of immigrants residing in j.

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

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

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 for consumption.

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. For example, higher production costs abroad stemming from increases in $\tilde{w}_j$ leads to less varieties available to import in j, increasing the domestic price level and lowering real income.

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,

$$c_{ji}^T(q) = \underbrace{\frac{\tilde{w}_j \tau_{ji}^T \left(M_{jis}, M_{ijs}\right)}{A_j \varphi}}_{\text{Variable Cost}} q + \overbrace{f_{ji}^T}^{\text{Fixed Cost}} \tag{3.7}$$

In addition to the composite wage, the variable cost component also includes $\tau_{ji}^T \left(M_{jis}, M_{ijs}\right)$, where $\tau_{ji}^T \left(M_{jis}, M_{ijs}\right) > 1$ for any $j \neq i$ and $\tau_{ji}^T \left(M_{jis}, M_{ijs}\right) = 1 \, \forall \, j$.[10] f_{ji}^T is the fixed cost a firm faces when entering market i from j. Firm specific productivity φ is drawn from a Pareto distribution with shape parameter γ, the corresponding CDF of φ 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 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 $\tilde{w}_j$ leads to, everything else equal, more varieties available to export from country j. Countries that receive these new goods see a decrease in the price level of their tradeable sector and an increase in real income. The trade inducing immigrant effect that I estimate in the model will manifest in the variable costs that firms face when exporting, specifically in $\tau_{ji}^T \left(M_{jis}, M_{ijs}\right)$.

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

$$p_{ji}^g(\varphi) = \frac{\sigma_g}{\sigma_g - 1} \frac{\widetilde{w}_j \tau_{ji}^g \left(M_{jis}, M_{ijs}\right)}{\varphi}$$

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

Given the optimal pricing decision of firms and consumer demand, the total sales for a firm in sector g with productivity φ is given by,

$$x_{ji}^{g}(\varphi) = p_{ji}^{g}(\varphi)q_{ji}^{g}(\varphi)$$
$$x_{ji}^{g}(\varphi) = \mu^{g}Y_{i}\left(\frac{p_{ji}^{g}(\varphi)}{P_{i}^{g}}\right)^{1-\sigma^{g}}$$

where $Y_{i}^{g} = \mu^{g}Y_{i}$ is the total income in country i spent on sector g.

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 g in market i. This cutoff can be obtained by finding the 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 φ serving market i is equal to,

$$\pi_{ji}^{g}(\varphi) = p_{ji}^{g}(\varphi)\, q_{ji}^{g}(\varphi) - c_{ji}^{g}(\varphi)\, q_{ju}^{g}(\varphi) - f_{ji}^{g}$$
$$\pi_{ji}^{g}(\varphi) = \frac{x_{ji}^{g}(\varphi)}{\sigma_{g}} - f_{ji}^{g}$$

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

$$\bar{\varphi}_{ji}^{g} = \frac{\tilde{w}_{j}\tau_{ji}^{g}\left(M_{jis},\, M_{ijs}\right)}{A_{j}P_{j}^{g}}\left(\frac{f_{ji}^{g}\tilde{w}_{j}}{Y_{j}A_{j}}\right)^{\frac{1}{\sigma_{h}-1}}\left(\frac{\sigma_{g}}{\mu_{g}}\right)^{\frac{1}{\sigma_{g}-1}}\frac{\sigma_{g}}{\sigma_{g}-1} \tag{3.8}$$

Equation (3.8) shows that the productivity needed to serve sector g in market i is increasing in both iceberg and fixed costs, as well as the composite wage. The extent to which migration adjusts the 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 a reduction in the productivity requirement to enter market i and an increase in the number of firms exporting from j to i.

Using the standard assumption that the number of firms in each sector g is proportional to a country's total income $\mu^g Y_j$ [11] I can combine (3.2) and (3.8) to solve an expression of the price index across sectors and countries.

$$P_j^g = \left(\sum_k e_k^g \int_{\bar{\varphi}_{kj}^g}^{\infty} \left(\frac{\sigma_g}{\sigma_g - 1} \frac{\tilde{w}_k \tau_{kj}^g \left(M_{jks}, M_{kjs} \right)}{\varphi A_k} \right)^{1-\sigma_g} dG(\varphi) \right)^{\frac{1}{1-\sigma_g}}$$

$$P_j^g = \lambda_2^{-\frac{1}{\gamma}} Y_j^{-\frac{1}{\gamma} \frac{(\gamma+1-\sigma_g)}{\sigma_g - 1}} \Theta_j \tag{3.9}$$

where $\Theta_j^{-\gamma} = \sum_k \frac{Y_k}{Y} \left(\tilde{w}_k \tau_{kj}^g \left(M_{jks}, M_{kjs} \right) \right)^{-\gamma} \left(f_{kj}^g \tilde{w}_k \right)^{\frac{-1+\sigma_g-\gamma}{\sigma_g - 1}}$ and $\lambda_2 = \frac{\left(\frac{\sigma_g}{\sigma_g - 1} \right)^{1-\sigma_g} \gamma}{\gamma + 1 - \sigma_g} \lambda_1^{-1+\sigma_g-\gamma}$

3.2.4 Competitive Equilibrium

A competitive equilibrium is a set of migration decisions $\left\{ M_{ijs} \right\}_{j=1}^{J}$ $\forall i$, prices $\left\{ P_j^N, P_j^T \right\}_{j=1}^{J}$, wages $\left\{ w_{jH}, w_{jL} \right\}_{j=1}^{J}$, 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 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.

3.3 Constructing Costs Using Model Predictions

In this section I outline the model predictions that guide my empirical estimation in Section (3.4). My strategy is to construct model equations that I can bring to the data to get estimates of t_{jis}, τ_{ji}^T, f_{ji}^T, and f_{jj}^g. I then use the fitted values of these estimates as inputs when solving the model.

[11] See Chaney (2008)

3.3.1 Migration costs t

A challenge with bringing equation (3.5), the predicted level of bilateral migration, to the data is the limited data on the counterpart V_{js}, real wages of workers in country j of skill s. Particularly difficult is gathering 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 as follows,

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

$$V_{js} = \frac{L_{js}}{\Phi_{js} \sum\limits_i L_{is}}$$

This yields an expression for bilateral migration,

$$\frac{M_{ijs}}{L_{js}} = \frac{Z_{is}}{\sum\limits_i L_{is}} \left(\frac{1}{t_{ijs}}\right) \left(\frac{1}{\Phi_{js} \kappa_{is}}\right) \tag{3.10}$$

where $\Phi_{js} = \left(\sum\limits_i \frac{\frac{1}{t_{ijs}}}{\kappa_i} \frac{Z_{is}}{\sum\limits_i L_{is}} \right)$ measures how easy it is to enter j for workers with skill s, and $\kappa_{is} = \sum\limits_k \left(\frac{V_{ks}}{t_{iks}}\right)$ measures how easy is it leave i for workers with skill s. (3.10) implies that in a frictionless world, immigrant populations found in j would be found in equal proportion to their share of the world population: $\frac{M_{ijs}}{L_{js}} = \frac{Z_{is}}{\sum\limits_i L_{is}}$. The degree to which a distortion to this proportion exists will provide insight on the importance of bilateral migration costs in the consumer's migration decision. Following the literature on the determinants of migration (Borjas, 1987; Grogger and Hanson, 2011; Mayda, 2010) I parameterize migration costs as a function of the distance between two countries (D_{ij}), and dummy variables for whether the two countries share a common language ($Lang_{ij}$), a land border (SB_{ij}), or historical colonial ties ($Colony_{ij}$),

$$\left(t_{ijs}\right)^{-1} = D_{ij}^{\alpha_1^s} e^{\alpha_2^s Lang_{ij} + \alpha_3^s SB_{ij} + \alpha_4^s Colony_{ij}}$$

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

$$\ln\left(M_{ijs}\right) = \alpha_1^s ln\left(D_{ij}\right) + \alpha_2^s Lang_{ij} + \alpha_3^s SB_{ij} + \alpha_4^s Colony_{ij} + SD_{is} + DD_{js} \tag{3.11}$$

With data on the stocks of bilateral migration by skill level I can estimate equation (3.11) and use the estimates $\{\hat{\alpha}^s\}$ to construct the migration costs, $\hat{t}_{ijs}$ that consumers face when migrating between countries. Details on the estimation procedure for migration costs follows in Section (3.4).

3.3.2 Firm costs τ and f

The first prediction that I highlight from the firms' problem is the solution for total export sales from all firms in country j to country i. Summing over the sales of all firms in country j that meet the productivity threshold requirement to serve market i, $\bar{\varphi}_{ji}^{T}$, yields equation (3.12). From this result, we can see that total export sales between countries depends negatively on both the variable and fixed costs that firms face.

$$X_{ji}^T = \frac{X_i^T \left(\frac{\tilde{w}_j \tau_{ji}^T\left(M_{jis}, M_{ijs}\right)}{A_j}\right)^{-\gamma} e_j^T \left(f_{ji}^T\right)^{1-\frac{\gamma}{\sigma_T - 1}}}{\Theta_i^{-\gamma}} \tag{3.12}$$

Letting,

$$\left(\tau_{ji}^T\right)^{-\gamma} = D_{ji}^{\beta_1} e^{\beta_2 Lang_{ji} + \beta_3 SB_{ji} + \beta_4 Colony_{ji} + \beta_5 Landlock_{ji} + \beta_6 RTA_{ji}} M_{ijH}^{\beta_7} M_{ijL}^{\beta_8} M_{jiH}^{\beta_9} M_{jiL}^{\beta_{10}} \tag{3.13}$$

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 express export sales from j to i in a log-linear form as

$$ln\left(X_{ji}^T\right) = \underbrace{\ln\left(\left(\tau_{ji}^T\left(M_{jis}, M_{ijs}\right)\right)^{-\gamma}\right)}_{\text{Parametrization of Variable Cost}} + \lambda_j + \lambda_i + \left(1 - \frac{\gamma}{\sigma_T - 1}\right) ln\left(f_{ji}^T\right) \tag{3.14}$$

where (3.13) is a parametrization of the bilateral variable cost, λ_j is the fixed effect of the exporting country, and λ_i is the fixed effect of the importing country.The variable costs are parameterized to include the standard variables in the gravity literature augmented with migration variables.

If I were to estimate (3.14) via OLS in its 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. Next, I will show that using the model prediction on the average level of sales of exporting firms from j to i, I can identify f_{ji}^T separately from τ_{ji}^T. Without this additional 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, $\bar{\varphi}_{ji}^T$.[12]

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

which simplifies to,

$$\frac{X_{ji}^T}{N_{ji}^T} = \frac{\left(f_{ji}^T\right)}{\frac{1}{\sigma_T}\left(\frac{\gamma}{\gamma+1-\sigma_T}\right)^{-1}} \tag{3.15}$$

The difficulty in using equation (3.15) 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 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.

The empirical literature on the positive relationship between immigration and exporting

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

argues that this relationship exists, in part, due to the impact that immigrants have on reducing the *fixed cost* of exporting. However, the Meltiz-type framework I use has a notable implication for the relationship between fixed costs and average sales, a relationship that is not always compatible with what is observed in the data. In these types of models, average sales between countries i and j is increasing in the fixed costs between destination i and source country j. With higher fixed costs lower productivity firms are unable to profitably export to i. The firms that do find it profitable to export to i, even in the presence of higher fixed costs, are more productive and have higher sales than the marginal firm that drops out of exporting. For example, if following the introduction of a Free Trade Agreement (FTA) between two countries, average exports between those two countries increase, the model would incorrectly rationalize that outcome as the FTA *increasing* the fixed costs of exporting between those two countries. Due to this inconsistency, I do not parameterize the fixed costs of exporting. Instead, I infer my estimates of the bilateral fixed costs values f_{ji}^{T} by calculating them directly from equation (3.16) given values of γ and σ_T.

$$\hat{f}_{ji}^{T} = \frac{X_{ji}^{T}}{N_{ji}^{T}} \frac{1}{\sigma_T} \left(\frac{\gamma}{\gamma + 1 - \sigma_T} \right)^{-1} \tag{3.16}$$

With these estimates I can now re-specify equation (3.14) as,

$$\begin{aligned} ln\left(X_{ji}^{T}\right) - \left(1 - \frac{\gamma}{\sigma_T - 1}\right) ln\left(\hat{f}_{ji}^{T}\right) \quad = \quad & \beta_1 ln\left(D_{ji}\right) + \beta_2 Lang_{ji} + \beta_3 SB_{ji} + \beta_4 Colony_{ji} + \beta_5 Landlock_{ji} \\ & + \beta_6 RTA_{ji} + \beta_7 ln\left(M_{ijH}\right) + \beta_8 ln\left(M_{ijL}\right) \\ & + \beta_9 ln\left(M_{jiH}\right) + \beta_{10} ln\left(M_{jiL}\right) + \lambda_j + \lambda_i \end{aligned} \tag{3.17}$$

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

$$\hat{f}^{g}_{jj} = \frac{X^{g}_{jj}}{N^{g}_{jj}}\frac{1}{\sigma_g}\left(\frac{\gamma}{\gamma + 1 - \sigma_g}\right)^{-1} \tag{3.18}$$

3.4 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 (3.3). Using the estimates of $\hat{t}_{jis}$, $\hat{\tau}^{T}_{ji}$, $\hat{f}^{T}_{ji}$, and $\hat{f}^{g}_{jj}$ 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.

3.4.1 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 80 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 (3.1) 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. In Canada and Australia the population is 20% foreign-born, and these foreign-born are predominantly high skilled. Several countries exhibit both 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 number and skill composition of who enters and leaves.

3.4.2 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. Theis 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 (3.3). 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 (3.2) shows values of average sales from a sample of countries in my dataset where rows correspond to the exporting country.[13] Conditional on a firm exporting to a destination, the market structure I use predicts that fixed costs have no impact on sales to that destination. Fixed costs only affect 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, due to their large differences in the number of firms that export to the United States.

There exists strong regional patterns in the trade data, both in the value of exports and

[13]For example, a Canadian firm's average value of exports to the United States was $8,781,714 in 2010

number of exporting firms. In North America, trade among Canada, Mexico, and the United States is highly concentrated among each other.The United States is both Canada and Mexico's largest trading partner and the United States exports more to Canada than they do to any other country. Furthermore, the signing of NAFTA by all three countries in 1993 solidified their trading relationship. Caliendo and Parro (2015) finds that intra-bloc trade increased by 118% for Mexico, 11% for Canada, and 41% for the U.S. following the introduction of NAFTA's tariff reductions. This translated to a 1.13% increase in welfare for Mexico, a 0.08% increase for the U.S., and a welfare decline of 0.06% for Canada. In Section (3.5) I model the response of consumers and firms to further decreases in bilateral trade costs between the three countries.

Table 3.1: 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 3.2: 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	-

3.4.3 Estimating Migration Costs

I estimate equation (3.19) using pseudo maximum likelihood estimation techniques proposed by Silva and Tenreyro (2006) to retrieve the determinants of international migration flows for low and high skilled migrants. This method helps address the issue that comes from estimating a log specification when there are occurrences of zero values in the dependent variable.

$$ln\left(M_{ijs}\right) = \alpha_0^s + \alpha_1^s ln\left(D_{ij}\right) + \alpha_2^s Lang_{ij} + \alpha_3^s SB_{ij} + \alpha_4^s Colony_{ij} + SD_{is} + DD_{js} + \epsilon_{ijs} \quad (3.19)$$

The estimates presented in Table (3.3) 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 similar, 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 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.

Table 3.3: Barriers to Migration by Skill Level

Dependant Variable		$ln\left(m_{ijH}\right)$	$ln\left(m_{ijL}\right)$
Distance	$ln\left(D_{ji}\right)$	-0.218	-0.229
		(0.095)**	(0.114)**
Language Similarity	$Lang_{ji}$	1.392	1.879
		(0.187)***	(0.310)***
Shared Border	SB_{ji}	1.247	1.743
		(0.219)***	(0.286)***
Colonial Ties	$Colony_{ji}$	0.536	0.012
		(0.190)***	(0.328)
R^2		0.903	0.962
Observations		1806	1806

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

3.4.4 Estimating Trade Costs

The estimates of $\hat{f}^T_{ij}$ and $\hat{f}^g_{jj}$ are fitted directly from the data using equations (3.18) and (3.16). Using the fitted values of $\hat{f}^T_{ij}$ I estimate equation (3.20) via OLS to retrieve the components of the variable cost in $\left(\tau^T_{ij}\right)^{-\gamma}$ that firms face when serving foreign markets.

The results in Table (3.4) show that my estimated elasticities of exports to the standard gravity variables are consistent with the trade literature: export sales decrease with the distance between two countries, whereas countries that share a common language, a land border, or colonial ties have higher export sales between them. The results pertaining to migration show that the estimated elasticity of exports to migrants are all 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. My results fall in the range of the estimated elasticities reported by Peri and Requena-Silvente (2010) who find the majority of literature estimate elasticities between 0.01 and 0.40. 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 the trade-creation effect to the same extent if there exists large differences in the skill distribution of their emigrants.

$$\begin{aligned} ln\left(X_{ji}^{T}\right)-\left(1-\frac{\gamma}{\sigma_{T}-1}\right)ln\left(\hat{f}_{ji}^{T}\right) &= \beta_1 ln\left(D_{ji}\right)+\beta_2 Lang_{ji}+\beta_3 SB_{ji}+\beta_4 Colony_{ji}+\beta_5 Landlock_{ji} \\ &+\beta_6 RTA_{ji}+\beta_7 ln\left(M_{ijH}\right)+\beta_8 ln\left(M_{ijL}\right) \\ &+\beta_9 ln\left(M_{jiH}\right)+\beta_{10} ln\left(M_{jiL}\right)+\lambda_j+\lambda_i+\epsilon_{ji} \end{aligned} \quad (3.20)$$

Table 3.4: Barriers to Trade

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 Similarity	$Lang_{ji}$	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	$ln\left(M_{ij}^{H}\right)$	0.061
		(0.016)***
Unskilled Immigrants	$ln\left(M_{ij}^{L}\right)$	0.022
		(0.016)
Skilled Emigrants	$ln\left(M_{ji}^{H}\right)$	0.066
		(0.016)***
Unskilled Emigrants	$ln\left(M_{ji}^{LS}\right)$	0.032
		(0.016)**
Adjusted R^2		0.895
Observations		1806

Notes: *** p¡0.01, ** p¡0.05, * p¡0.1

3.4.5 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, $\left\{M_{ijs}\right\}_{j=1}^{J}\ \forall i$, prices $\left\{P_j^N,\ P_j^T\right\}_{j=1}^{J}$, wages $\left\{w_{jH},\ w_{jL}\right\}_{j=1}^{J}$, 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.

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

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 η, 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, σ^g, is set to 6 for both sectors, the middle of the range of estimates reported by Anderson and van Wincoop (2004) and Feenstra (1994). The parameter governing the distribution of firm productivity, γ, is set equal to 5.3 following Axtell (2001). For each country μ^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).

The variable and fixed cost values, $\hat{\tau}_{ji}^T$ and $\hat{f}_{ji}^T$ help determine overall trade volumes in the model. Following Di Giovanni, Levchenko and Ortega (2015), to assess the model fit on overall trade I compare the mean value of bilateral trade as a share of total income, $\pi_{ji} = \frac{X_{ji}^T}{w_j L_j}$, in the model to the data. The mean values are similar, in the data the value is 0.0055 and in the model it is 0.0064; the gravity coefficients I use to generate bilateral trade in the model fit the observed trade volumes quite well. Similarly, the migration cost values, $\hat{t}_{ijs}$ along with equilibrium wages and price levels determine individual migration decisions. To assess the model fit on overall migration I compare the mean value of emigration as a share of a country's starting population, $\chi_{ij} = \frac{\sum_s M_{ijs}}{\sum_s Z_{is}}$, in the model to the data. The value in the data is 0.0016 and in my model it is 0.0018; the determinants of migration cost I use to generate bilateral migration in the model fit the observed migration levels quite well.

3.5 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 compare real income in a no-migration counterfactual to the level of real income from the currently observed levels of migration to assess the impact of migration and measure the relative importance of the trade-creation effects in contributing to the overall welfare impact.

3.5.1 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 (3.1) 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. In all my experiments the average real wages of native-born stayers in a country j, are 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 real wage is roughly monotonic: in countries where the population fell (rose), real wages decreases (increases). Figure (3.2) shows the effects of the drop in trade costs to changes in the emigration rate and the tradeable price 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 tradeable price sector, this is caused by the labour market and market size effects of having a smaller population from less immigration. Consumers benefit from both new firms finding it profitable to export for the first time and existing exporters increasing their sales to their location. Figure (3.3) 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 one has to emigrate. 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 document the response of consumers and firms to a regional trade cost reduction. Migration rates should be lower 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 study the quantitative importance of this mechanism because I can observe changes to migration after lowering trade costs and quantitatively study which effect is stronger in equilibrium. Figure (3.4) 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. These results are large compared to what has been estimated by Caliendo and Parro (2015) but are qualitatively similar in that Mexico gains the most from a reduction in trade costs. Quantitative differences result, in part, from the migration response in my model that serves to amplify the gains in Mexico.

In contrast to my second counterfactual scenario, and more inline with present day policy[14], I use the model to study the effects on firm decisions and consumer migration decisions following an *increase* in trade costs between Canada and the United States. I simulate the effects of increasing both the variable and fixed trade costs in 10% increments on the tradeable price level in each country and level of migration to the United States from Canada. Figure (3.5) shows the results of these increments. Following the increase in trade costs, Canadian imports from the United States fall and the price level in the Canadian tradeable sector increases. Canada's dependence on the U.S. as a tradeable partner is reflected in this increase. In contrast, the U.S. tradeable price sector changes are marginal compared to Canada's; in relative terms, Canada is a much smaller trading partner for the U.S. We also see a modest decrease in migration to the United States from Canada, however the net-population in Canada stays relatively stable as consumers increase their migration rates to other countries. U.S. emigration rates increase slightly following this trade increase, this increase coupled with the trade-creation effect of migrants helps to marginally lower the price level in the U.S.

[14]See appendix for a brief background on the tariff measures enacted by the United States and the tariff countermeasures enacted by Canada in response

Figure 3.1: Changes in Welfare and Population Following a Reduction in Trade-Costs

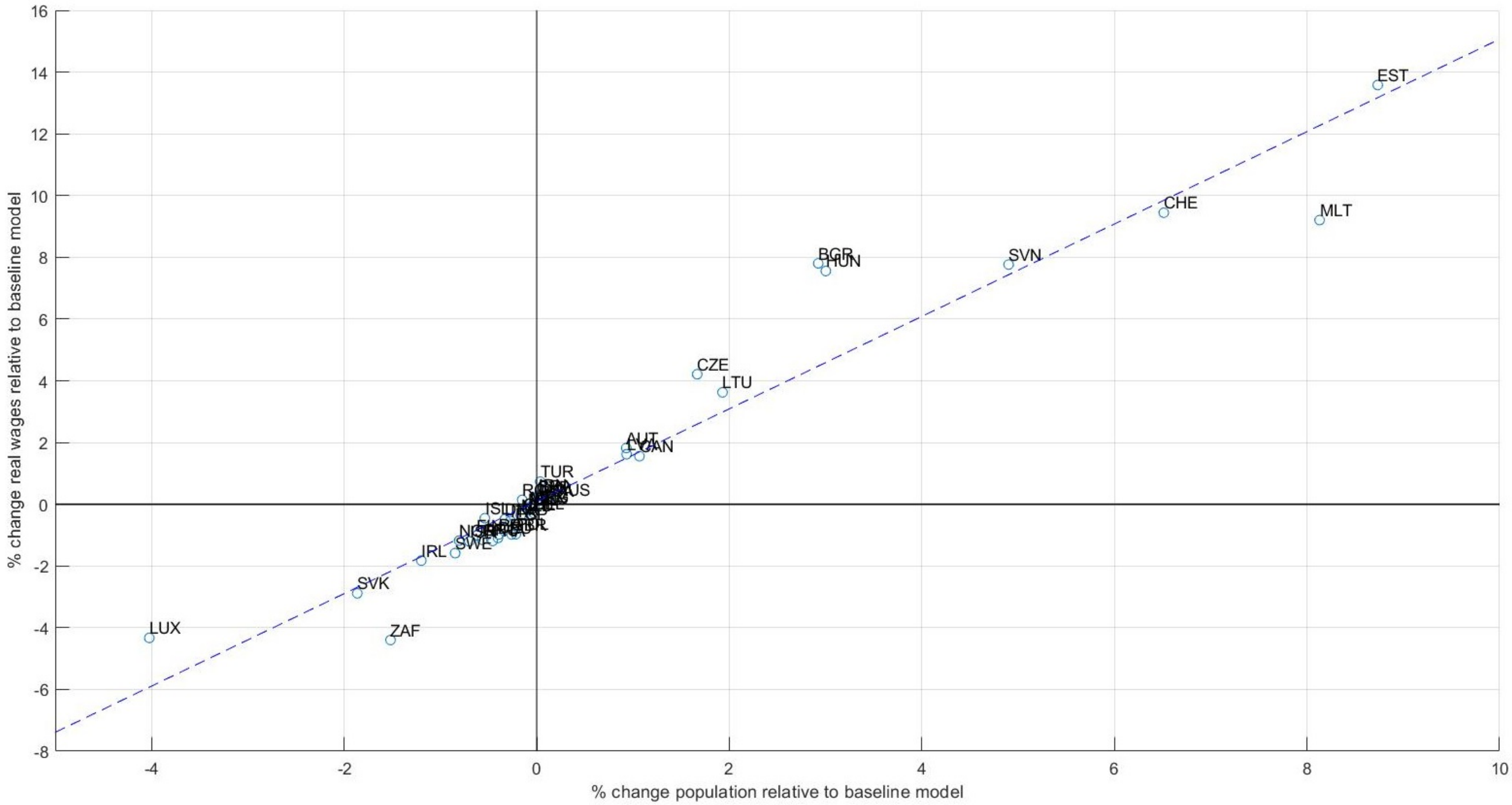


Figure 3.2: Tradeable price level and the emigration rate Following a Reduction in Trade-Costs

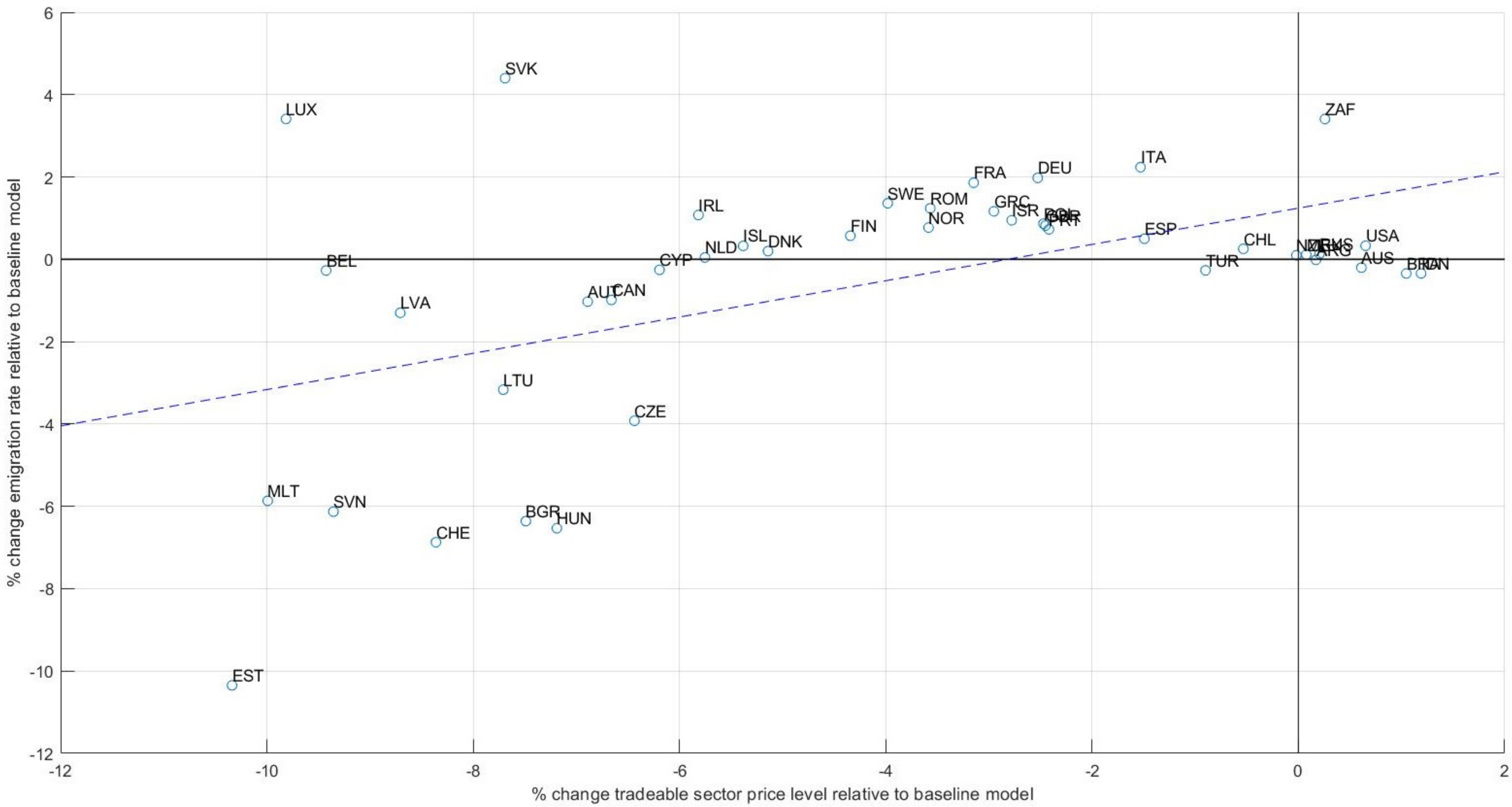


Figure 3.3: Real wages and the emigration rate Following a Reduction in Trade-Costs

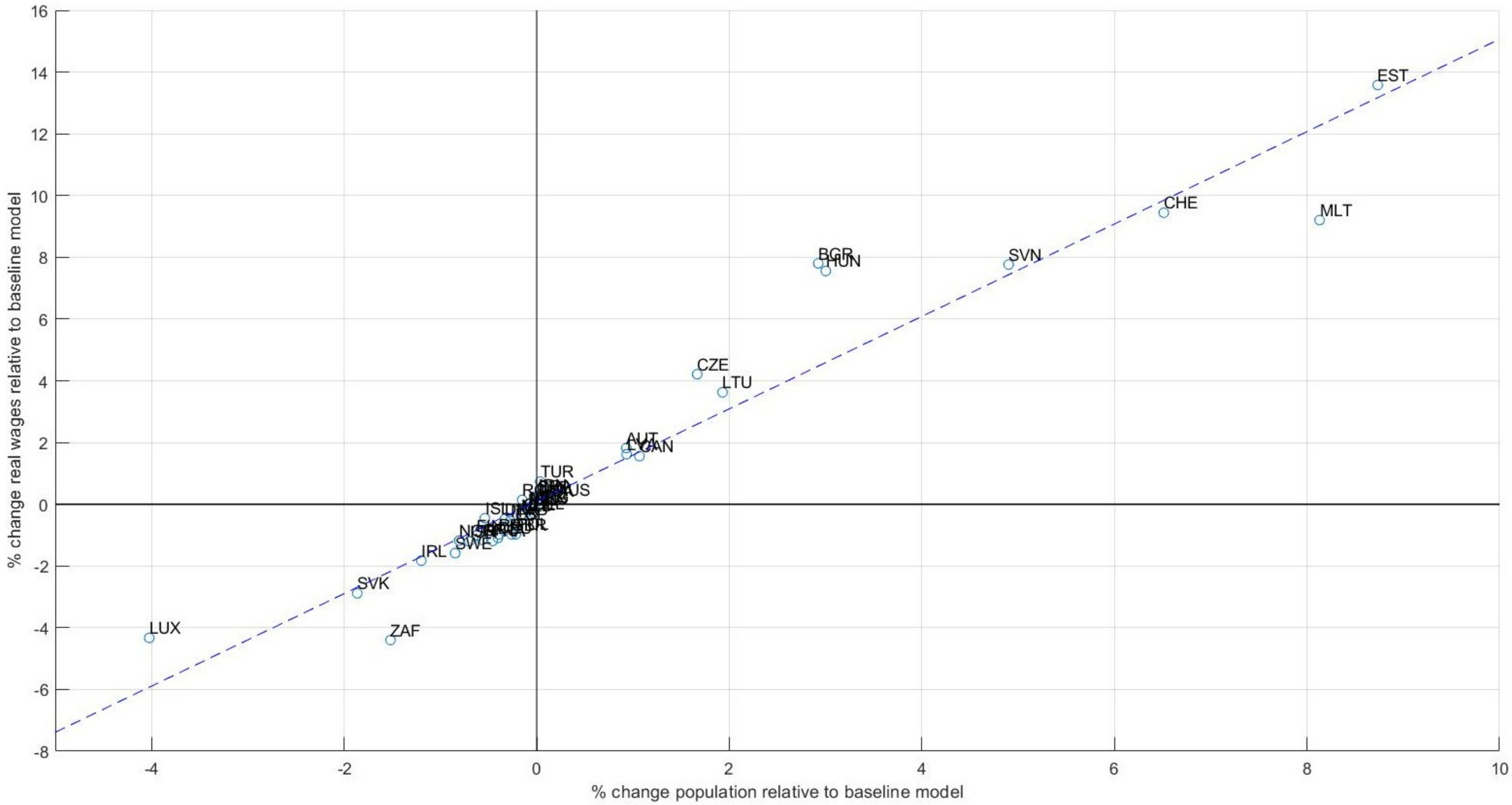


Figure 3.4: United States and Mexico Trade Cost Reduction

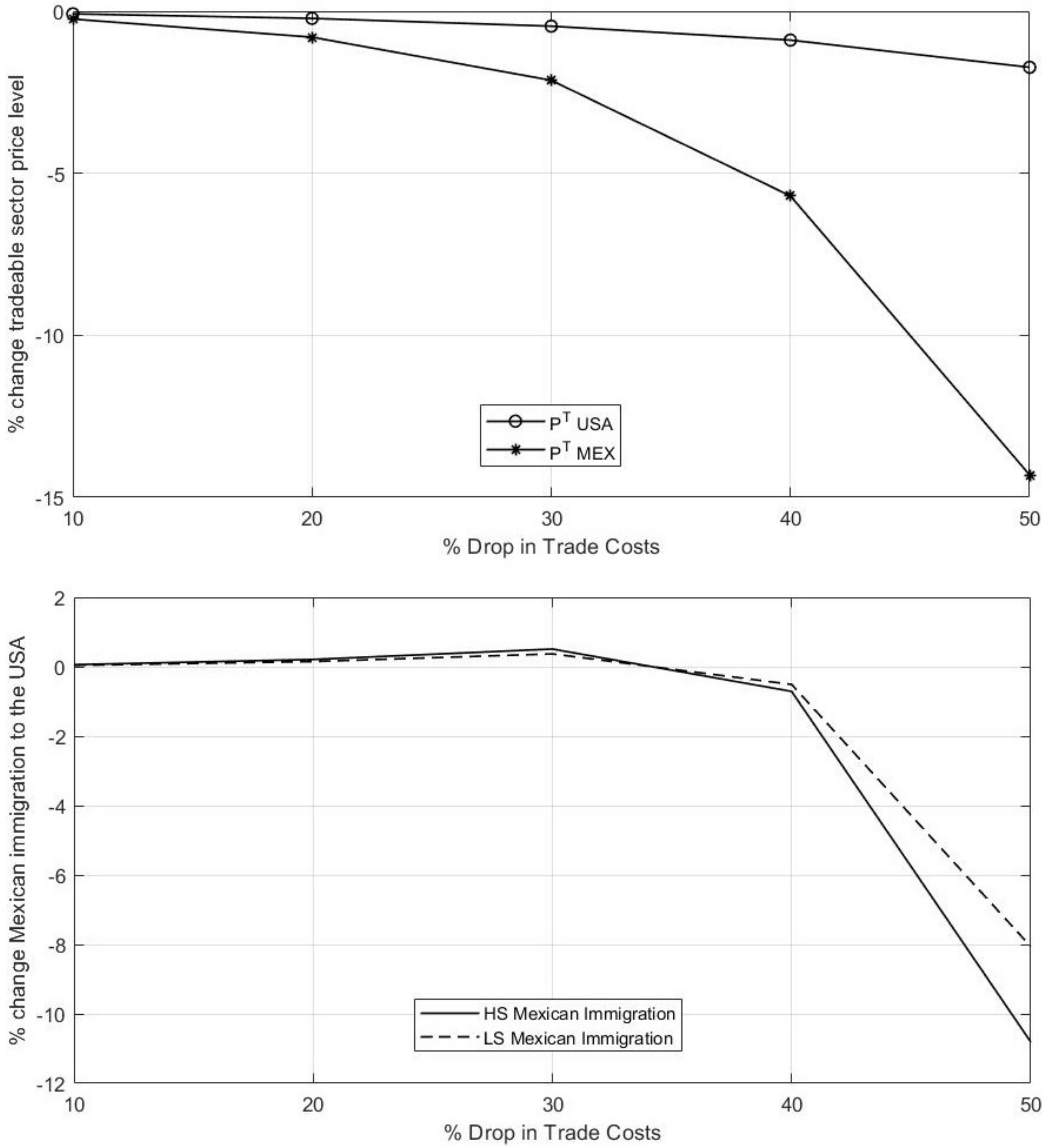
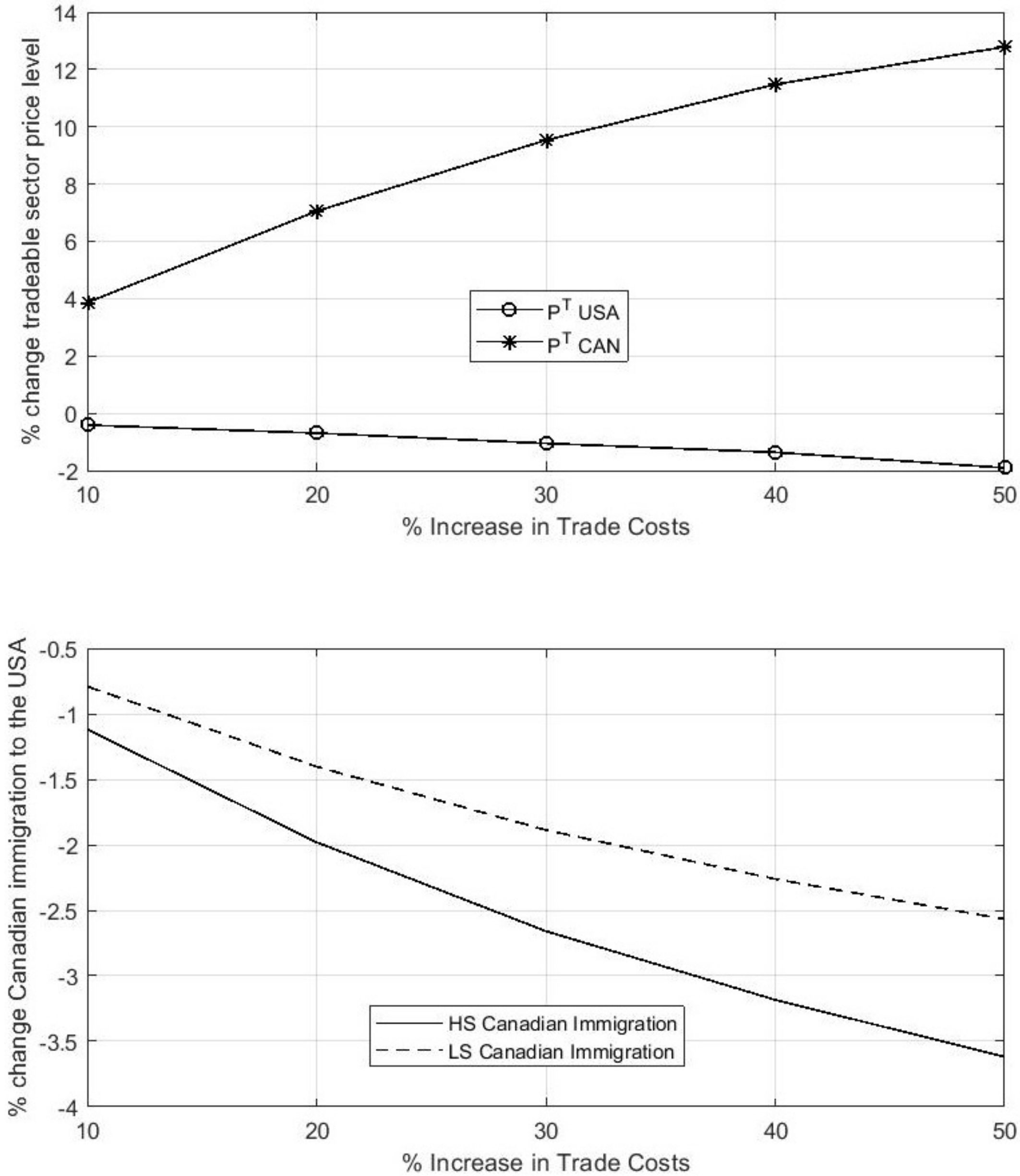


Figure 3.5: United States and Canada Trade Cost Increase



3.5.2 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 can be traced to changes in labour market conditions - responses in wages, *and* to changes in firm production decisions - responses in firm export behaviour. The welfare comparison measure used in the analysis is the real wages of native-born stayers.

Table (3.5) shows the changes in population ordered by magnitude of population change from the counterfactual experiment. For example, Australia and Canada have a decrease in population of over 15%, whereas Malta and Iceland have their population rise by over 15%, when all foreign-born individuals return to their country of origin.

Table (3.6) 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 affects welfare is by changes in labour market conditions. The first column of Table (3.6) 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 affects welfare is via changes in labour market and market size effects. 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 a 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 larger impact. This suggests that in these countries the marginal firm that no longer finds it profitable to export is on average large, relative to 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 affecting it. For these countries the trade-creation effect mitigates some of the loss in welfare stemming from the labour market and market size effects of emigration lowering their overall population.

I also decompose the overall change in welfare for the two skill groups by country. Figure (3.6) 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[15] (Aydemir and Borjas, 2007). In Canada both high and low-skilled workers have benefited from migration, however, due to Canada's immigration policy that target high-skilled immigrants, low-skilled native-born Canadians have had much larger gains in real income.

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

Table 3.5: No Migration Counterfactual: Impact on Population

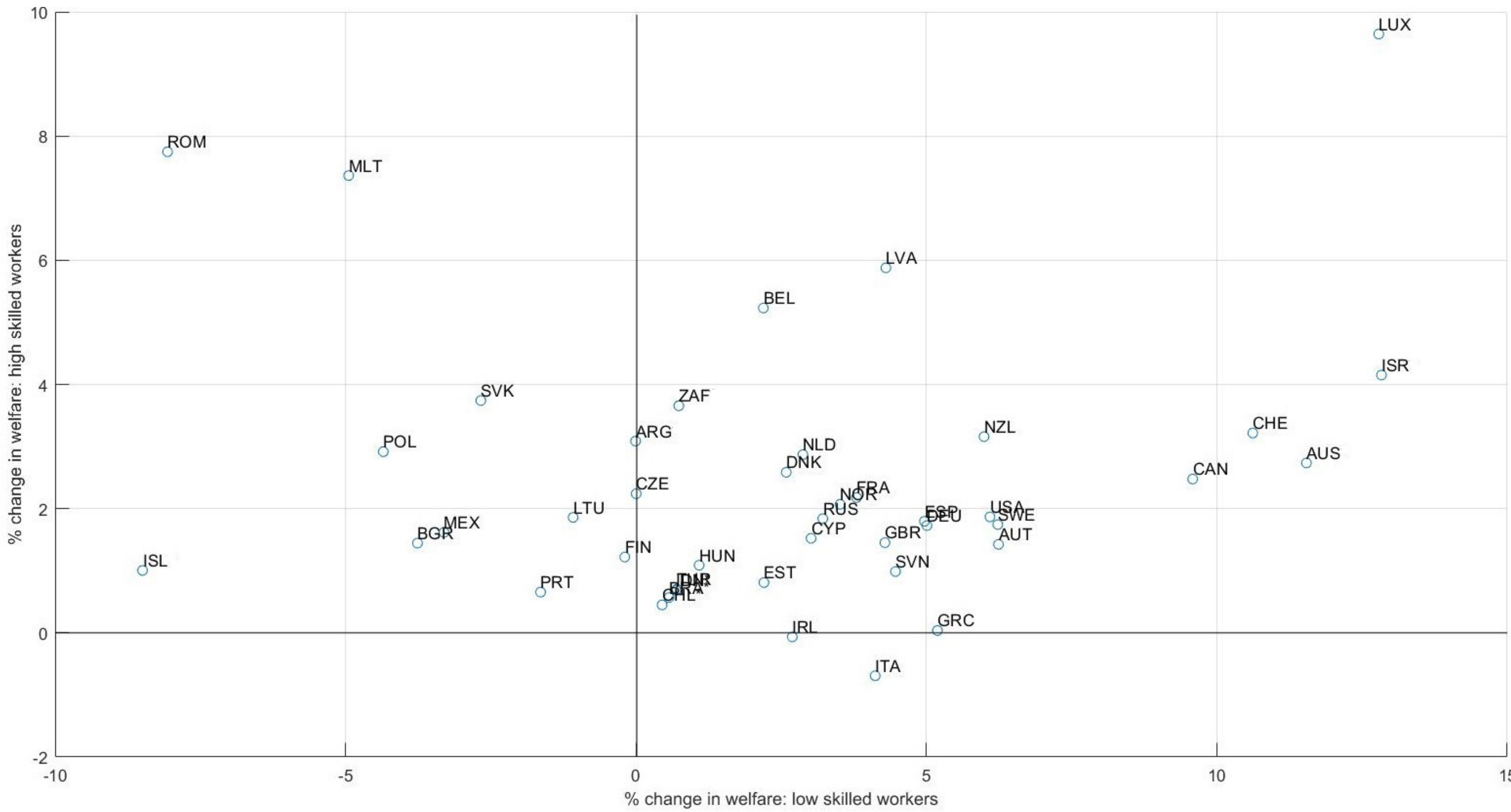
Country	Change in Population	Country	Change in Population
Luxembourg	-31.46%	Italy	-3.44%
Australia	-20.84%	Argentina	-2.39%
Israel	-19.79%	Estonia	-1.34%
Switzerland	-17.67%	Cyprus	-1.19%
Canada	-16.80%	Brazil	0.19%
Latvia	-16.60%	Hungary	0.52%
New Zealand	-13.13%	Finland	0.57%
United States	-11.53%	Indonesia	0.57%
Sweden	-11.10%	Czech Republic	0.90%
Belgium	-10.09%	Turkey	0.91%
Austria	-9.45%	Ireland	1.27%
Spain	-9.09%	Chile	1.76%
Germany	-8.74%	Lithuania	2.16%
France	-8.34%	Slovak Republic	3.63%
Norway	-7.70%	Poland	7.83%
Russian Federation	-7.42%	Portugal	8.89%
United Kingdom	-5.69%	Mexico	9.11%
Netherlands	-5.50%	Bulgaria	10.09%
Denmark	-4.99%	Romania	12.55%
Greece	-4.96%	Malta	15.72%
South Africa	-4.91%	Iceland	16.59%
Slovenia	-4.84%		

Notes: Change in population using 2010 data

Table 3.6: Model Predictions on Welfare Changes

Country	Overall Change	No Trade-Creation Effect	Country	Overall Change	No Trade-Creation Effect
Argentina	0.40%	0.41%	Iceland	-4.48%	-5.08%
Australia	8.11%	8.51%	Israel	8.73%	5.31%
Austria	4.77%	3.05%	Italy	3.34%	2.04%
Belgium	3.30%	0.59%	Lithuania	-0.02%	-1.63%
Bulgaria	-2.35%	-3.76%	Luxembourg	11.61%	7.83%
Brazil	0.57%	0.81%	Latvia	4.84%	3.33%
Canada	5.94%	6.40%	Mexico	-2.46%	-2.72%
Switzerland	7.84%	5.34%	Malta	-2.64%	-9.04%
Chile	0.45%	-0.04%	Netherlands	2.87%	0.23%
Cyprus	2.50%	-0.80%	Norway	2.97%	2.31%
Czech Republic	0.43%	-1.38%	New Zealand	4.79%	3.82%
Germany	4.05%	2.81%	Poland	-2.44%	-3.54%
Denmark	2.59%	0.31%	Portugal	-1.24%	-3.00%
Spain	3.97%	3.05%	Romania	-5.16%	-6.24%
Estonia	1.64%	0.10%	Russia	2.47%	2.93%
Finland	0.37%	-0.26%	Slovak Republic	-1.35%	-3.16%
France	3.31%	2.53%	Slovenia	3.58%	1.09%
United Kingdom	3.14%	1.64%	Sweden	4.65%	4.01%
Greece	3.83%	2.26%	Turkey	0.71%	0.03%
Hungary	1.09%	-0.58%	United States	4.54%	4.31%
Indonesia	0.69%	0.32%	South Africa	1.14%	0.75%
Ireland	1.52%	-0.22%			

Figure 3.6: Model Predictions on Welfare Changes by Skill Level



3.6 Conclusion

In this chapter I 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 channels by which migration affects native-born stayers' welfare in a country varies. For countries such as Canada and the United States the main impact from international migration is from labour market and market size effects whereas for countries such as Portugal and Poland the trade-creation channel is equally important. For net-emigration countries like Portugal and Poland, the trade-creation effect mitigates some of the loss in welfare stemming from the labour market and market size effects. Furthermore, because I endogenize the consumer migration decision I can observe the welfare effects of a trade-reduction policy that accounts for the interaction between firm export decisions 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. In the context of an experiment where trade costs between the United States and Mexico decrease I find Mexican immigration to the United States falls and real income in Mexico increases from the increased trade between the two countries. Overall, countries that see decreases to their population following a trade-reduction policy are worse off.

Ignored in my study are the effects of remittance inflows on the real income of consumers. Similar to the trade-creation effect, remittances should help to partially offset the negative impact on real wages from the market size effect in net-emigration countries. For countries such as the Philippines, a country with 4 million emigrants and remittance inflows equivalent to 15% of GDP this effect can be considerable.

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Chapter 4

Immigrants and Exports: Firm-level evidence from Canada

4.1 Introduction

In contemporary models of trade the ability of a firm to export is largely driven by exogenous differences in firm productivity; the more productive firms will export and the less productive firms will only sell domestically or exit the market entirely (Melitz, 2003). However, on its own, differences in productivity are not enough to explain a firm's decision to export to new markets (Eaton, Kortum and Kramarz, 2011). Firms must exhibit other differences that vary their ability to overcome the frictions of international trade and participate in what would otherwise be advantageous trading opportunities.

An important friction that firms face is information based: information about trading opportunities (Allen, 2014), trading terms (Steinwender, 2018), or a lack of assurance that trading terms will be honored (Head and Mayer, 2013). Members of migrant networks can play a key role in overcoming these information barriers by acting as intermediaries between firms and inducing trade (Rauch, 1999, 2001; Rauch and Trindade, 2002). In this paper, we use a matched Canadian employer-employee dataset to analyze how firms' immigrant employment affects exporting behavior to the home countries of their immigrant workforce.

Our main contributions in this paper are to: *i*) add to the limited firm level evidence on the pro-trade effect of immigrant employment at firms using matched employee-employer Canadian data; *ii*) adapt index number methods from the Industrial Organization production function estimation literature to deal with the endogeneity concern present in these types of studies (Doraszelski and Jaumandreu, 2013; Gandhi, Navarro and Rivers, 2018); and *iii*) provide causal estimates of the immigrant trade-creation effect that overcomes *both* the unit of observation and endogeneity bias concerns of earlier studies.

To estimate the pro-trade relationship of immigration on firm export sales we specify a model where firms make labor input choices from different source countries. From this problem we derive an equation where we can infer the effects of immigrants on firm trade costs from observed employment and both domestic and foreign sales. Prior attempts at evaluating the causal effect of a firm's migrant worker composition on firm exports using firm level data have relied solely on instrumental variables (IV) techniques. However, the lack of a convincing natural experiment to supplement the use of an IV strategy results in instruments that are likely correlated with a firm's immigrant source-country composition and exports. Our estimation results do not suffer from these issues and enable us to estimate the causal pro-trade effect of immigrant employment on firm export behaviour. We find that an increase in immigrant employment from a particular source country is associated with an increase in the probability of exporting to that destination *and* an increase in export sales to that destination.

Gould (1994) and Head and Ries (1999) provided the first empirical evidence showing immigrants have a positive effect on bilateral trade flows. Subsequent research showed that these results are robust to different specifications, countries and time periods (e.g. Dunlevy (2006); Peri and Requena-Silvente (2010)). These studies typically find that a 10 per cent increase in immigrants from a particular source country is associated with a one to three percent increase in exports to that immigrants source country.

The mechanism by which these researchers frame the immigrant pro-trade effect occurs at the firm level: firms with access to immigrant workers with the foreign expertise of an intended export destination can increase exports to a destination, or export to a destination that they would otherwise not have found profitable. However, the unit of observation used in these studies is aggregate country level exports. Another limitation in these earlier papers is interpreting their pro-trade immigrant results as a causal effect. Two major concerns are i) spurious correlation due to unobserved favorable conditions between two countries, simultaneously promoting both trade and migration, and ii) reversal causality due to the possibility of immigrants settling in countries with strong trade-links to their home country because of their preference for home goods. Recent work has tried to address these two concerns.

Papers by Hiller (2013) and Hatzigeorgiou and Lodefalk (2016) overcome the data limitation of earlier studies and find that firms benefit from immigrant employment by facing lower trade costs of exporting to the home country of their immigrant workers. The lower trade costs that these firms face leads to an increase in export sales to existing markets and an expansion to new markets. These authors recognize that unobserved factors can confound simple OLS estimates and attempt to identify the causal impact of immigration on firm exports using IV strategies. To instrument for immigrant employment at firm i, Hiller (2013) uses the number of migrants born in country k employed at all other firms. However, if two firms are linked via the supply chain (e.g. intermediate input suppliers), the decision of one firm to hire immigrants from country k to facilitate exporting to country k is potentially correlated with the other firm's immigrant hiring decisions and export flows. Hiller (2013) and Hatzigeorgiou and Lodefalk (2016) also use lagged immigrant employment as an instrument for current employment at a firm. While past immigrant employment is likely to be correlated with current immigrant employment, as noted by these authors, this instrument likely violates the exclusion restriction because firms make trade decisions many years in advance.

In regards to the causality concerns, Cohen, Gurun and Malloy (2017) and Parsons and Vzina (2018) use plausible exogenous immigrant settlements in the United States of Japanese disbursement to internment camps during the 1940s and Vietnamese refugees arriving during the 1970s to explore the pro-trade immigrant effect. They confirm the previous results and find an elasticity of trade to immigrants in the range of 0.1-0.3 using aggregate export sales as their unit of observation.

The rest of the paper is structured as follows. In Section (4.2) we describe the data sources and document several stylized facts regarding the relationship between immigrant employment and firm-exporting. In addition to the minimum necessary information such as firm export sales by destination, and firm source country worker composition we have additional information on immigrant workers from their Canadian landing record files. With this data we study potential mechanisms by which immigrants reduce the information frictions that exist in bilateral trade. For example, by comparing the pro-trade effect of foreign-born workers that only speak the destination language, versus those that speak the destination language and originate from that country as well we find that the language spoken of immigrants has a significant impact on increasing firm exports.

Motivated by these findings, in Section (4.3), we analyze the relationship between immigrant employment and firm exporting through the lens of a model in which firms have idiosyncratic productivity and destination-specific demand, and face destination-specific fixed and variable costs to export. These costs depend on the number of immigrants the firm hires from each destination. We derive equations for firm-level export entry and sales by destination as functions of observable firm and destination characteristics and the unobservable destination-specific demand. Recognizing the probable bias in the pro-trade estimates of this model we extend the basic model to deal with the endogeneity concerns by specifying the firm's problem in terms of labor input choices from different source countries. The estimating equation we derive from this problem enables us to estimate the causal pro-trade immigrant effect. As noted above, prior attempts at evaluating the causal effect of a firm's migrant worker composition on firm exports have relied solely on IV techniques.

The estimation results in Section (4.4) show that there exists a strong, robust pro-trade effect for firms that employ immigrant workers. We find that *i*) both the extensive and intensive margin of export sales are positively affected; *ii*) this effect is strongest for export sales in the differentiated goods market. Finally we conclude and provide discussion on future research in this topic in Section (4.5).

4.2 Data

We use the Canadian Employer-Employee Dynamics Database-Trade by Enterprise Characteristics, a unique longitudinal dataset with linkages of multiple individual and firm files from several federal Canadian departments.

4.2.1 Data Sources

We draw on four major Canadian administration data sources for our estimation. From the National Accounts Longitudinal Microdata File (NALMF) we have information for all incorporated firms operating in Canada between the years 2005-2013. This longitudinal administrative database is complied from data in the Business Register (BR), employer payroll deduction remittance forms (PD7), corporate income tax accounts (T2), and business income on personal tax forms (T1). This data includes, but is not limited to, information on a firm's employee payroll, profits, number of employees, and four-digit NAICS industry code.[16]

We link export information to each firm in the NALMF from data in the Trade by Exporter Characteristics (TEC). The TEC files contain annual firm-level information on the value of export sales by country, decomposed at the six-digit Harmonized Sales goods classification level. We have four years of export data beginning in 2010. The level of detail in export sales allows us to decompose the value of exports into differentiated products and homogeneous products using the Rauch (1999) classification and test the assertion that the immigrant pro-trade effect is stronger for the sales of differentiated products compared to homogeneous ones.

At the individual level, we have comprehensive information for every Canadian tax-filer

[16] See appendix for a full list of variables and their sources.

(native and immigrant) on items as diverse as employment income, industry of employment, and geographical location sourced from personal income tax forms that collectively is referred to as the Canadian Employer-Employee Dynamics Database (CEEDD).

For an immigrant tax-filer, there is additional information sourced from the Longitudinal Immigration Database (IMDB), which includes the landing records of all persons that obtained permanent resident status in Canada since 1980 and filed at least one tax return since 1982. From the IMDB we have information on immigrant workers that includes, but is not limited to, their country of birth, last country of residence, primary language spoken, and Canadian official language ability. Table (4.1) shows the top 15 source countries for immigrant employment during the 2010-2013 time period. India, the Philippines and China make up the top three source countries for employment in the manufacturing industry. These countries also top the list of countries of birth for recent immigrants.[17]

4.2.2 Sample of Interest

We restrict our analysis to an unbalanced panel of manufacturing firms that operated between 2010 to 2013 and link employee data to these firms going back to 2007. The data contains 52,421 unique firms of which 18,151 have positive export sales to at least one country during the four year period. Exporting firms are on average larger than non-exporting firms; average employment in exporting firms is 104 workers whereas for non-exporting firms it is only 14. This employment disparity also exists for immigrant employment; on average exporting firms employ 24 foreign-born workers whereas non-exporting firms only employ 3. The most likely export destination for a Canadian manufacturing firm is, unsurprisingly, the Untied States, over 30% of exporting firms [18] exported to the US.

[17] Statistics Canada, Immigrant population in Canada, 2016 Census of Population

[18] We refer to exporting firms as firms that exported to at least one country during the four year period

Table 4.1: Immigrant Source Countries

Country	Immigrants Employed
India	194,328
Philippines	174,688
China	135,669
Vietnam	105,657
Sri Lanka	52,330
Poland	51,396
Romania	34,714
Guyana	34,359
Hong Kong	33,280
United Kingdom	32,684
Pakistan	26,648
Jamaica	26,181
El Salvador	22,037
Russia	19,352
Haiti	19,219

Notes: Employment numbers for manufacturing firms using the sample pooled from 2010-2013

4.2.3 Trends in immigrant employment and firm export behavior

Using this data we document several new data facts on the relationship between immigrant employment and Canadian manufacturing firms' exporting behaviour. From Figure (4.1) we see that conditional on employing an immigrant from a particular country a firm is more likely to export there. For example, the fraction of manufacturing firms that export to Denmark is only 0.009 but if we only look at firms that have Danish employees the fraction increases to 0.182. Figure (4.2) shows that firm export sales relative to domestic sales increases substantially to country k for firms with immigrant employment from country k. For example, overall average relative export sales to China are only 1.3% for Canadian manufacturing firms but if we focus in on firms that have Chinese employees the average increases to 3.8%. From Table (4.2) we see that the pro-trade immigration effect holds across the firm-size distribution. This suggests that it is neither just small, privately owned immigrant enterprises exporting to their origin country, nor only large multinational firms trading between its international subsidiaries that is driving the pro-trade immigration effect. Taken together, these findings suggest that the source-country composition of workers at a firm is important in explaining the differences in firm export behaviour. In Section (4.3) we outline the theoretical framework that relates the the source composition of workers at a firm to a firm's decision to sell to a country, and conditional on entering, how much to sell.

Figure 4.1: Firm Exporting and Immigrant Composition

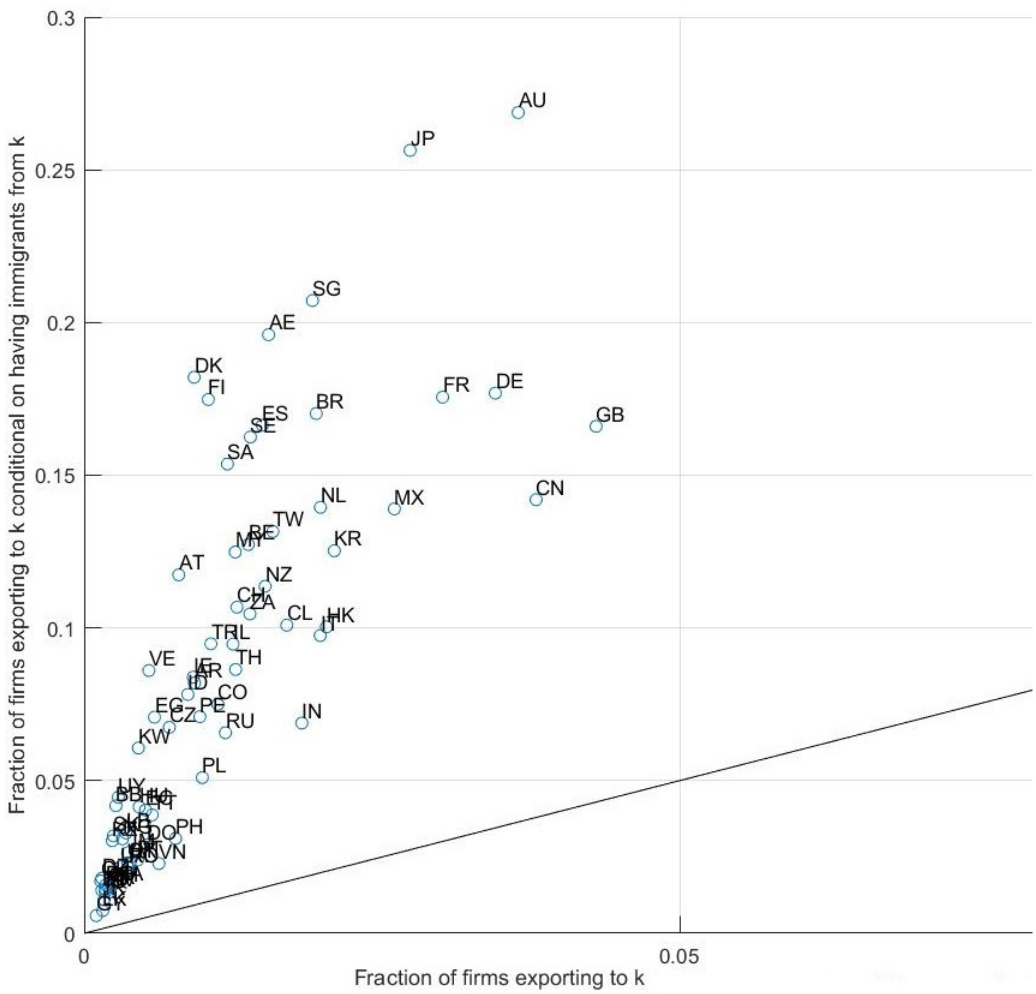

Figure 4.2: Relative Export Sales and Immigrant Composition

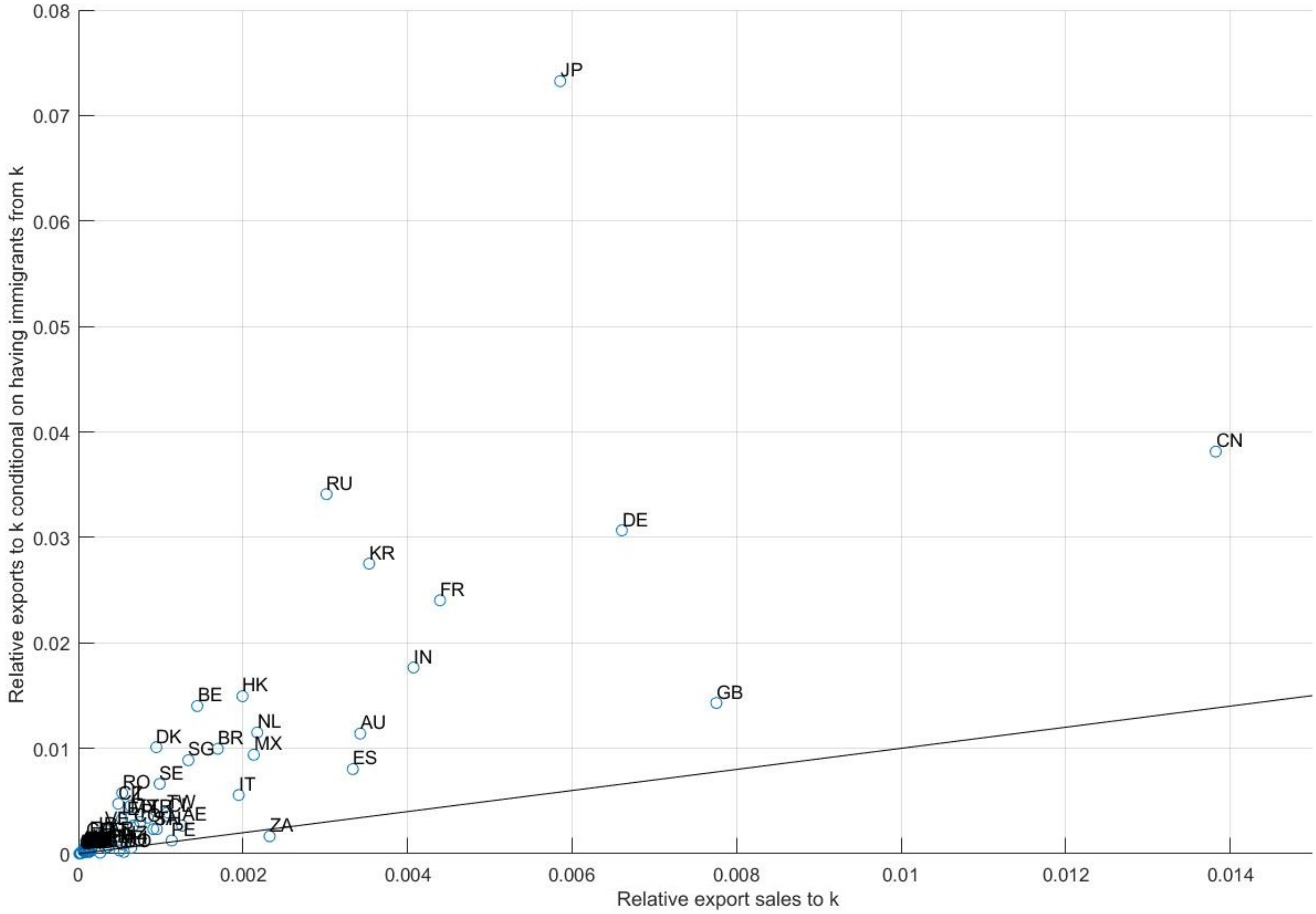

Table 4.2: Firm Exports by Revenue Quartile

	With Immigrant Employment	Without Immigrant Employment
Revenue Quartile	Positive Exports Flows	Positive Exports Flows
1	0.57%	0.04%
2	1.01%	0.14%
3	2.26%	0.38%
4	8.61%	1.45%

Notes: An observation is a firm-country pair pooled over the time period 2010-2013. The *with* immigrant employment column shows the percentage of exporting firms that export to country k conditional on having immigrant employment from country k.

4.3 Theoretical framework

Firms are indexed by i and countries are indexed by $j, k = 1, \ldots, K$. We label Canada as country 1. Firms decide on whether to sell to each country, and conditional on entering, how much to sell. A firm has to pay a fixed cost $f_k(N_{ik})$ to sell to country k and there is an iceberg cost $\tau_k(N_{ik})$ per unit of goods shipped. N_{ik} is the number of immigrants from country k employed at firm i. We assume that the fixed and iceberg exporting costs take the forms:

$$\tau_k(N_{ik}) = \exp(\beta_\tau' D_k) \times g_\tau(N_{ik}) \tag{4.1}$$

$$f_k(N_{ik}) = \exp(\beta_f' D_k) \times g_f(N_{ik}) \tag{4.2}$$

where $\beta_\tau' D_k$ and $\beta_f' D_k$ are linear combinations of a set of country k's characteristics, D_k, that proxy for how distance from Canada affects each cost function, as in the gravity literature, and the functions g_τ and g_f are common across countries.

There is a representative consumer in each country with preferences given by the CES aggregator,

$$Q_k = \left(\int_{\Omega_k} \alpha_{ik}^{\frac{1}{\sigma}} q_{ik}^{\frac{\sigma-1}{\sigma}} di \right)^{\frac{\sigma}{\sigma-1}}$$

where the elasticity of substitution is $\sigma > 1$. α_{ik} is a firm- and country-specific demand shock that is lognormally distributed i.i.d. across firms and countries. Let total income in country k be Y_k.

Demand for good i in country k is given by

$$q_{ik} = \alpha_{ik} Q_k \left(\frac{p_{ik}}{P_k} \right)^{-\sigma}$$

Or in terms of expenditures,

$$x_{ik} = p_{ik} q_{ik} = p_{ik}^{1-\sigma} \alpha_{ik} E_k$$

where the price index P_k is given by $P_k = \left(\int_{\Omega_k} p_{ik}^{1-\sigma} \alpha_{ik} di \right)^{1/(1-\sigma)}$ and $E_k = \frac{Y_k}{P_k^{1-\sigma}}$.

4.3.1 Export sales and export entry

For now we assume that a firm cannot choose its composition of workers. Firm i's productivity is ϕ_i, and the wage is w. Firm i has to produce $\tau_k(N_{ik})$ units to sell one unit to country k, so the per-unit cost of selling to k is $\frac{w\tau_k(N_{ik})}{\phi_i}$. If firm i sells to country k, the variable profits from doing so are given by:

$$\left(p_{ik} - \frac{w\tau_k(N_{ik})}{\phi_i}\right) q_{ik}$$

Plugging in country k's demand and maximizing leads firm i to set its price as a constant markup over its marginal cost,

$$p_{ik} = \frac{\sigma}{\sigma - 1} \frac{w\tau_k(N_{ik})}{\phi_i}$$

So firm i's export sales are given by

$$x_{ik} = \left(\frac{\sigma}{\sigma - 1} \frac{w\tau_k(N_{ik})}{\phi_i}\right)^{1-\sigma} \alpha_{ik} E_k$$

We can substitute out for $\frac{\sigma}{\sigma-1}\frac{w}{\phi_i}$ using the analogous expression for domestic sales. Letting Canada be denoted country 1, firm i's domestic sales are $x_{i1} = \left(\frac{\sigma}{\sigma-1}\frac{w}{\phi_i}\right)^{1-\sigma} \alpha_{i1} E_1$, so

$$x_{ik} = x_{i1} \tau_k(N_{ik})^{1-\sigma} \frac{\alpha_{ik}}{\alpha_{i1}} \frac{E_k}{E_1}$$

Taking logs and using the form of τ_k in equation (4.1),

$$\log x_{ik} = \log x_{i1} + (1-\sigma)\beta'_\tau D_k + (1-\sigma)\log g_\tau(N_{ik}) + \log \tilde{\alpha}_{ik} + \log \tilde{E}_k \tag{4.3}$$

where $\tilde{\alpha}_{ik} = \log\left(\frac{\alpha_{ik}}{\alpha_{i1}}\right)$ and $\tilde{E}_k = \log\left(\frac{E_k}{E_1}\right)$.

Equation (4.3) forms the basis of our first method for estimating the effect of immigrant employment on export sales conditional on exporting.

Next, we derive an equation to estimate the effect of immigrant employment on the extensive margin of export sales. Firm i's decision of whether to export is characterized by an inequality: profits from exporting to k are a constant fraction of sales, $\pi_{ik} = x_{ik}/\sigma$, and exporting requires paying a fixed cost $f_k(N_{ik})$. We use the indicator $\Xi_{ik} = 1$ if firm i exports to country k, which is the case if $x_{ik} \geq \sigma f_k(N_{ik})$. Substituting for domestic sales again,

$$\Xi_{ik} = \begin{cases} 1 & \text{if } x_{i1}\tau_k(N_{ik})^{1-\sigma}\tilde{\alpha}_{ik}\tilde{E}_k \geq \sigma f_k(N_{ik}) \\ 0 & \text{otherwise} \end{cases} \tag{4.4}$$

We can transform equation (4.4) into a probabilistic statement:

$$\begin{aligned} \Pr(\Xi_{ik} = 1) &= \Pr\left(\frac{\alpha_{ik}}{\alpha_{i1}} \geq \frac{E_1}{E_k}\frac{1}{x_{i1}\tau_k(N_{ik})^{1-\sigma}}\sigma f_k(N_{ik})\right) \\ &= \Pr\left(\log\tilde{\alpha}_{ik} \leq \log\tilde{E}_k + \log x_{i1} + (1-\sigma)\log\tau_k(N_{ik}) - \log(\sigma f_k(N_{ik}))\right) \end{aligned} \tag{4.5}$$

where the second line uses the symmetry of the normal distribution of $\log\tilde{\alpha}_{ik}$ to invert the inequality. Equation (4.5) forms the basis for estimating the effect of immigrant employment on export entry into a market.

If the firm observes part of α_{ik} before making decisions, then all these methods have endogeneity problems: if the firm knows that hiring more immigrants from k lowers the cost of selling there, then N_{ik} is positively correlated with α_{ik}, and OLS estimates of the sales equation and linear probability model estimates of the export entry equation will be biased upwards.

One option to deal with the endogeneity of N_{ik} is to instrument with lags of N_{ik}, because presumably, past immigrant employment is correlated with current immigrant employment, but uncorrelated (or less correlated) with current (transitory) shocks to demand.

Another option for an instrument is something other papers have used: the number of migrants from k minus the migrants employed by firm i—denoted say, by N_{-ik}. The logic is that the prevalence of migrants from k available for hiring increases the likelihood that firm i will hire a migrant from k independent of its propensity to export to k. A refinement of this method is to consider migrants from k employed by all other firms *in i's industry only*.

4.3.2 Export sales and export entry with multiple sectors

We can easily extend the theoretical framework in the previous section to also account for how the effect of immigrant employment on export sales can adjust to exports of different classes of goods. We adjust our model such that consumers now have preferences over homogeneous and differentiated goods and the fixed and iceberg exporting costs are also sector specific.

To distinguish between different classes of goods we follow the Rauch (1999) goods classification and split our data on firm export sales into either homogeneous or differentiated export sales. The belief is that the higher costs associated with trade in the differentiated goods sector should lead to a stronger pro-trade immigrant impact in that sector. For example, lower information costs arise in the homogeneous products sector due to the availability of a standardized reference price, quoted on organized exchanges, for prospective buyers and sellers. Following similar steps that we outlined previously in Section (4.3) firm i's export sales of homogeneous and differentiated export sales are given by,

$$x_{ik}^{H} = x_{i1}^{H}\tau_{k}^{H}\left(N_{ik}\right)^{1-\sigma_{H}}\frac{\alpha_{ik}^{H}}{\alpha_{i1}^{H}}\frac{E_{k}^{H}}{E_{1}^{H}} \tag{4.6}$$

$$x_{ik}^{D} = x_{i1}^{D}\tau_{k}^{D}\left(N_{ik}\right)^{1-\sigma_{D}}\frac{\alpha_{ik}^{D}}{\alpha_{i1}^{D}}\frac{E_{k}^{D}}{E_{1}} \tag{4.7}$$

Taking logs of equations (4.6) and equation (4.7) and using the same form of the iceberg exporting costs we outlined in equation (4.1) we can study the effects of immigrant employment on homogeneous and differentiated export sales conditional on exporting.

$$\log x_{ik}^{H} = \log x_{i1}^{H} + (1-\sigma_{H})\beta_{\tau}' D_{k}^{H} + (1-\sigma_{H})\log g_{\tau}^{H}(N_{ik}) + \log\tilde{\alpha}_{ik}^{H} + \log\tilde{E}_{k}^{H} \tag{4.8}$$

$$\log x_{ik}^{D} = \log x_{i1}^{D} + (1-\sigma_{D})\beta_{\tau}' D_{k}^{D} + (1-\sigma_{D})\log g_{\tau}^{D}(N_{ik}) + \log\tilde{\alpha}_{ik}^{D} + \log\tilde{E}_{k}^{D} \tag{4.9}$$

4.3.3 Firms' hiring decisions

An alternative method for dealing with the endogeneity concerns is by specifying the firm's problem of choosing N_{ik} and using the first order conditions of this problem to derive an equation that we estimate.

To write the firm's problem in terms of labor input choices, we start from output: for each destination k to which firm i sells, to satisfy demand it must produce $q_{ik} = \tau_k(N_{ik}) p_{ik}^{-\sigma} \alpha_{ik} E_k$, which can be inverted to:

$$\left(\frac{q_{ik}}{\tau_k(N_{ik})}\right)^{-1/\sigma} (\alpha_{ik} E_k)^{1/\sigma} = p_{ik}$$

So revenues for firm i from selling to k are:

$$\begin{aligned} r_{ik} &= p_{ik} \frac{q_{ik}}{\tau_k(N_{ik})} \\ &= \left(\frac{q_{ik}}{\tau_k(N_{ik})}\right)^{\frac{\sigma-1}{\sigma}} (\alpha_{ik} E_k)^{\frac{1}{\sigma}} \end{aligned}$$

To write the profit maximization problem in terms of labor inputs $\{N_{ik}\}_{k=1,...,K}$, first take as given firm i's total output y_i, and solve for the quantities exported to each country k, q_{ik}. Firm i allocates its sales to maximize revenues, taking as given the α_{ik}'s:

$$\begin{aligned} &\max_{\{q_{ik}\}} \sum_k \Xi_{ik} q_{ik}^{\frac{\sigma-1}{\sigma}} (\tau_k(N_{ik}))^{\frac{1-\sigma}{\sigma}} (\alpha_{ik} E_k)^{\frac{1}{\sigma}} \\ &\text{s.t.} \ \sum_k \Xi_{ik} q_{ik} \leq y_i \end{aligned}$$

The first order conditions for output produced for sale to k, q_{ik}, and output produced for domestic sale, q_{i1}, conditional on $\Xi_{ik} = 1$, yield:

$$q_{i1} \frac{\alpha_{ik} E_k}{\alpha_{i1} E_1} \tau_k(N_{ik})^{1-\sigma} = q_{ik} \tag{4.10}$$

Summing equation (4.10) across k and rearranging gives:

$$\frac{q_{id}}{\alpha_{id}E_d} = \frac{y_i}{\sum_k \Xi_{ik}\alpha_{ik}E_k\tau_k(N_{ik})^{1-\sigma}} \tag{4.11}$$

Using (4.10) and (4.11), we can write total revenues as:

$$\sum_k \Xi_{ik} q_{ik}^{\frac{\sigma-1}{\sigma}} (\tau_k(N_{ik}))^{\frac{1-\sigma}{\sigma}} (\alpha_{ik}E_k)^{\frac{1}{\sigma}} = y_i^{\frac{\sigma-1}{\sigma}} \left(\sum_k \Xi_{ik}\alpha_{ik}E_k\tau_k(N_{ik})^{1-\sigma} \right)^{\frac{1}{\sigma}} \tag{4.12}$$

Firm i's production technology is $y_i = \phi_i \sum_k N_{ik}$, so with total revenues given by (4.12), the profit maximization problem is:

$$\max_{\{N_{ik}\}_k} \left(\phi_i \sum_k N_{ik} \right)^{\frac{\sigma-1}{\sigma}} \left(\sum_k \Xi_{ik}\alpha_{ik}E_k\tau_k(N_{ik})^{1-\sigma} \right)^{\frac{1}{\sigma}} - w\sum_k N_{ij} - \sum_k \Xi_{ik} f_k(N_{ik})$$

Conditional on $\Xi_{ik} = 1$, the first-order condition for N_{ik} is:

$$\begin{aligned}
0 = &\frac{\sigma-1}{\sigma} \left(\phi_i \sum_j N_{ij} \right)^{\frac{\sigma-1}{\sigma}-1} \phi_i \left(\sum_j \Xi_{ij}\alpha_{ij}E_j\tau_j\left(N_{ij}\right)^{1-\sigma} \right)^{\frac{1}{\sigma}} \\
&+ \left(\phi_i \sum_j N_{ij} \right)^{\frac{\sigma-1}{\sigma}} \frac{1}{\sigma} \left(\sum_j \Xi_{ij}\alpha_{ij}E_j\tau_j\left(N_{ij}\right)^{1-\sigma} \right)^{\frac{1}{\sigma}-1} \alpha_{ik}E_k(1-\sigma)\tau_k(N_{ik})^{-\sigma} \frac{\partial \tau_k(N_{ik})}{\partial N_{ik}} \\
&- \frac{\partial f_k(N_{ik})}{\partial N_{ik}} - w
\end{aligned}$$

Using the fact that revenue shares are given by

$$\frac{r_{ik}}{r_i} = \frac{r_{ik}}{\sum_j \Xi_{ij} r_{ij}} = \frac{\tau_k(N_{ik})^{1-\sigma}\alpha_{ik}E_k}{\sum_j \Xi_{ij}\tau_j\left(N_{ij}\right)^{1-\sigma}\alpha_{ij}E_j}$$

we can simplify the first order condition to:

$$wN_{ik} = \frac{\sigma-1}{\sigma} r_i \frac{N_{ik}}{\sum_j N_{ij}} + r_{ik}\frac{1-\sigma}{\sigma}\frac{\partial \log \tau_k(N_{ik})}{\partial \log N_{ik}} - \frac{\partial f_k(N_{ik})}{\partial N_{ik}} N_{ik} \tag{4.13}$$

Equation (4.13) shows how we can infer the effects of immigrants on trade costs from observed employment and sales. In the absence of effects of immigrants on τ and f, (i.e. if $\frac{\partial \log \tau_k(N_{ik})}{\partial \log N_{ik}} = 0$ and $\frac{\partial f_k(N_{ik})}{\partial N_{ik}} = 0$), equation (4.13) states that payments to workers from country k as a fraction of firm i's revenues would equal the product of labor compensation's total share of revenues, $\frac{\sigma-1}{\sigma}$, times the fraction of employees from country k, $\frac{N_{ik}}{\sum_j N_{ij}}$. So, the wage payments firm i makes to immigrants from country k above this amount is compensation for the marginal increase in revenues associated with reduced trade costs for exporting to country k. This additional compensation comes in the form of two components, corresponding to the reductions in variable and fixed trade costs. The first part of this reduction, $\frac{\partial \log \tau_k(N_{ik})}{\partial \log N_{ik}}$, raises payments to migrants from k proportional to firm i's sales to country k, r_{ik}, since each additional unit of sales benefits from the variable trade cost reduction. The second term, which is just the marginal reduction in the fixed costs of selling to k, scaled by the number of workers from k, N_{ik}, corresponds to the increased profit firm i receives, independent of how much firm i sells to country k.

4.4 Empirical Findings

In this section, we report estimates of the firm-level effects of immigrant employment on exporting where the functional form of the functions $g_\tau(N_{ik})$ and $g_f(N_{ik})$ in $\tau_k(N_{ik}) = \exp(\beta_\tau' D_k) \times g_\tau(N_{ik})$ and $f_k(N_{ik}) = \exp(\beta_f' D_k) \times g_f(N_{ik})$ take the form of,

$$(1)\ \ g_\tau(N_{ik}) = (1 + N_{ik})^{\varepsilon_\tau}$$

$$(2)\ \ g_f(N_{ik}) = (1 + N_{ik})^{\varepsilon_f}$$

With this functional form all firms for which immigrant employment from country k equals zero, $N_{ik} = 0$, the variable and fixed costs of exporting to country k will be identical and only depend on the linear combinations of a set of country $k's$ characteristics D_k. We take the standard proxies for distance from the gravity literature for D_k: geodesic distance between countries, and dummy variables that specify whether country k is landlocked, shares a Free Trade Agreement (FTA) with Canada, or has English as their official language.

From our OLS estimates of equation (4.3) in Table (4.3) we can see there is a significant role for immigrant employment to increase export sales to their source country. Conditional on a firm having positive export flows to country k, a 10% increase in immigrant employment at a firm from country k is correlated with 2.7% higher export sales. This result is similar to the results found by Hatzigeorgiou and Lodefalk (2016): an increase in 1.2[19] immigrant workers at a firm from country k is correlated with a 4.4% higher export sales to country k. We also find that the language spoken of immigrant employees is linked to increased export sales for a firm; a 10% increase in immigrants that only speak the language of the destination country k is correlated with 0.5% higher export sales to k. These results provide new evidence on the mechanisms by which immigrants promote trade; immigrants reduce the language frictions that make up a segment of the information frictions that exist in international trade. The coefficients on our other variables are as expected. We find a positive relationship between a firm's domestic sales[20] and export sales; a 10% increase in domestic sales increases firm exports to *all* destinations by 3.3%. Similarly, destination GDP, destination GDP per capita, and indicators for the presence of a FTA and an English speaking country are all associated with higher export sales. In contrast, firm export sales are decreasing in the distance between Canada and the destination as well as the destination being a landlocked country.

[19] 1.2 additional immigrant workers is a 10% increase in the average immigrant employment of a firm in the data used by Hatzigeorgiou and Lodefalk (2016)

[20] Domestic sales is indicative of firm productivity and firm size in our model

Table 4.3: OLS estimates of export sales equation

Dependent variable	Log exports	
	(1)	(2)
ln immigrant employees from *k*	0.2716***	0.2819***
	(0.0169)	(0.0206)
ln immigrant speaking language from *k*		0.0472***
		(0.0090)
ln domestic sales	0.3488***	0.2533***
	(0.0044)	(0.0052)
ln distance	-0.4006***	-0.0221
	(0.0113)	(0.0256)
English dummy	0.2310***	-0.3606***
	(0.0166)	(0.0497)
Landlocked	-0.0523	-0.1328***
	(0.0325)	(0.0327)
FTA	0.1959***	0.1348***
	(0.0244)	(0.0267)
ln GDP	0.2484***	0.1918***
	(0.0045)	(0.0063)
ln GDP per capita	0.0067	-0.0134
	(0.0072)	(0.0089)
Industry and year fixed-effects	Yes	Yes
Firm-destination observations	190,155	107,843
Adjusted R^2	0.272	0.175

Notes: Robust standard errors clustered by firm-country. * significant at 10%; ** significant at 5%; *** significant at 1%. Regression (2) restricts the sample to countries where the first official language is not english.

We expect the networks employers gain access to from hiring immigrant employees are more important for exporting when it is more costly to obtain information about a profitable sales interaction. As argued by Rauch and Trindade (2002), such sales are more likely to involve differentiated goods, goods where, there is no reference price quoted on an exchange and prices do not convey all relevant information to the buyer. The estimates reported in Table (4.4) show that the immigrant effect for export sales decomposed into homogeneous and differentiated goods using the Rauch (1999) classification. We confirm that the immigrant employment effect on firm export sales is driven almost solely through the increase in exports of differentiated goods. A 10% increase in immigrants employed from country k is correlated with a 2.8% increase in *differentiated* goods exports sales to country k but only a 0.8% increase in *homogeneous* goods export sales. Additionally, the language effect that we discussed earlier is only present in the sale of differentiated goods.

Table 4.4: OLS estimates of homogeneous and differentiated sales equation

Dependent variable	Log homogenous exports		Log differentiated exports	
	(1)	(2)	(3)	(4)
ln immigrant employees from *k*	0.0855**	0.0456	0.2860***	0.2876***
	(0.0364)	(0.0481)	(0.0182)	(0.0222)
ln immigrant speaking language from *k*		-0.0078		0.0560***
		(0.0090)		(0.0097)
ln domestic sales	0.2879***	0.1957***	0.3316***	0.2436***
	(0.0118)	(0.0155)	(0.0047)	(0.0056)
ln distance	-0.3593***	-0.1541**	-0.3776***	0.0120
	(0.0351)	(0.0775)	(0.0121)	(0.0276)
English dummy	0.1192**	-0.2038	0.2188***	-0.3721***
	(0.0527)	(0.1720)	(0.0176)	(0.0526)
Landlocked	-0.5455***	-0.5635***	-0.0055	-0.0804**
	(0.1214)	(0.1247)	(0.0341)	(0.0343)
FTA	0.3037***	0.2674***	0.1808***	0.1157***
	(0.0810)	(0.0875)	(0.0260)	(0.0285)
ln GDP	0.2277***	0.1961***	0.2400***	0.1864***
	(0.0143)	(0.0210)	(0.0048)	(0.0067)
ln GDP per capita	-0.1307***	-0.1452***	0.0163**	-0.0061
	(0.0229)	(0.0288)	(0.0077)	(0.0094)
Industry and year fixed-effects	Yes	Yes	Yes	Yes
Firm-destination observations	33,011	16,315	171,741	96,199
Adjusted R^2	0.396	0.404	0.237	0.140

Notes: Robust standard errors clustered by firm-country. * significant at 10%; ** significant at 5%; *** significant at 1%. Regressions (2) & (4) restricts the sample to countries where the first official language is not english.

Table (4.5) reports estimates of the pro-trade effect generated by a linear probability estimation of equation (4.5). The coefficient of immigrant employment on the probability of exporting is positive and significant at the 1% level. Doubling the number of immigrants employed from country k increases the probability of exporting there by 1.2%. The other estimates are inline with our expectations, for example, there is a is 1.9% higher probability of exporting to a country that shares a FTA with Canada. Is a Portuguese speaking Brazilian immigrant valuable in promoting new trade links between Canadian firms and Portugal? Our estimate of the immigrant language effect in column (2) suggests that is also true. Doubling the number of language speakers from country k increases the probability of exporting to country k by a .05%.

Next, acknowledging the potential endogeneity concerns of the previous results we estimate versions of our sales equations adopting different instruments for immigrant employment. From Tables (4.6) and (4.7) we see that the results are mixed. Using three year lagged employment we find a strong positive effect of immigrant employment on firm export sales across all specifications. The elasticity of trade to immigrants is in the same range as our OLS estimates, 0.08-.30, corresponding to a 0.8% to 3% increase in exports to destination k following a 10% increase in immigrant employment from country k. However, when we use employment by all other firms in $i's$ industry and province we find the opposite results. However, the results in column (2), using our constructed exogenous immigrant labor supply measure should be taken with some caution given that we reject the Hansen J test null of the instrument exclusion restriction of exogeneity. A possible reason for this result is that two or more firms are linked via the supply chain (e.g. intermediate input suppliers), and the decision of one firm to hire immigrants from country k to facilitate exporting to country k is sufficiently correlated other firm's immigrant hiring decisions and export flows in the supply chain. If this correlation between firms is present and widespread in our data, the assumption of exogeneity of our second instrument will be rejected - which is has.

Table 4.5: LPM estimates of export participation equation

Dependent variable	Export Participation	
	(1)	(2)
ln immigrant employees from *k*	0.0387***	0.0346***
	(0.0006)	(0.0006)
ln immigrant speaking language from *k*		0.0015***
		(0.0000)
ln domestic sales	0.0034***	0.0028***
	(0.0000)	(0.0000)
ln distance	-0.0149***	0.0000
	(0.0001)	(0.0001
English dummy	0.0131***	-0.0009***
	(0.0000)	(0.0001)
Landlocked	0.0019**	-0.0007***
	(0.0000)	(0.0000)
FTA	0.0192***	0.0028***
	(0.0002)	(0.0001)
ln GDP	0.0045***	0.0022***
	(0.0000)	(0.0000)
ln GDP per capita	-0.0009***	0.0007***
	(0.0000)	(0.0000)
Industry and year fixed-effects	Yes	Yes
Firm-destination observations	30,149,595	22,651,906
Adjusted R^2	0.048	0.022

Notes: Robust standard errors clustered by firm-country. * significant at 10%; ** significant at 5%; *** significant at 1%. Regression (2) restricts the sample to countries where the first official language is not english.

Table 4.6: IV estimates of export sales equation

Dependent variable	Log exports	
	(1)	(2)
ln immigrant employees from k	0.2775***	-0.3190***
	(0.0184)	(0.0546)
ln domestic sales	0.3452***	0.4105***
	(0.0046)	(0.0072)
ln distance	-0.4088***	-0.3720***
	(0.0116)	(0.0117)
English dummy	0.2342***	0.2985***
	(0.0169)	(0.0177)
Landlocked	-0.0393	-0.0648**
	(0.0333)	(0.0327)
FTA	0.1944***	0.1428***
	(0.0249)	(0.0250)
ln GDP	0.2491***	0.2962***
	(0.0046)	(0.0062)
ln GDP per capita	0.0051	-0.0728***
	(0.0074)	(0.0101)
Instrument	Lagged Employment	Province NAICS
Industry and year fixed-effects	Yes	Yes
Firm-destination observations	181,082	190,155
Kleibergen-Paap rk LM (p)	0.0000	0.0000
Hansen J (p)	0.1451	0.0000
Adjusted R^2	0.272	0.257

Notes: Robust standard errors clustered by firm-country. * significant at 10%; ** significant at 5%; *** significant at 1%. Instruments in regression are: (1) lagged employment of workers from k employed at firm i going back three years, (2) supply of workers in the same province and industry of firm i excluding their own employment

Table 4.7: IV estimates of homogeneous and differentiated sales equation

Dependent variable	Log homogenous exports		Log differentiated exports	
	(1)	(2)	(3)	(4)
ln immigrant employees from k	0.0854**	-0.2871**	0.2954***	-0.2449***
	(0.0238)	(0.0307)	(0.0198)	(0.0585)
ln domestic sales	0.2919***	0.3373***	0.3263***	0.3873***
	(0.0831)	(0.0823)	(0.0049)	(0.0077)
ln distance	-0.3618***	-0.3365**	-0.3843***	-0.3515
	(0.0398)	(0.1279)	(0.0123)	(0.0124)
English dummy	0.1380***	0.1829***	0.2210***	0.2752***
	(0.0527)	(0.1720)	(0.0176)	(0.0526)
Landlocked	-0.5148***	-0.5597***	0.0072	-0.0158
	(0.0542)	(0.0568)	(0.0349)	(0.0343)
FTA	0.3140***	0.2597***	0.1791***	0.1325***
	(0.1257)	(0.1217)	(0.0265)	(0.0266)
ln GDP	0.2278***	0.2642***	0.2406***	0.2835***
	(0.0123)	(0.0049)	(0.0204)	(0.0067)
ln GDP per capita	-0.1424***	-0.1926***	0.0158**	-0.0551***
	(0.0148)	(0.0190)	(0.0079)	(0.0107)
Instrument	Lags	Prov NAICS	Lags	Prov NAICS
Industry and year fixed-effects	Yes	Yes	Yes	Yes
Firm-destination observations	31,314	33,011	163,796	171,741
Adjusted R^2	0.398	0.394	0.237	0.225

Notes: Robust standard errors clustered by firm-country. * significant at 10%; ** significant at 5%; *** significant at 1%. Instruments in regression are: (1) & (3) lagged employment of workers from k employed at firm i going back three years, (2) & (4) supply of workers in the same province and industry of firm i excluding their own employment english.

4.4.1 Estimates of the hiring first order condition

Our non-linear estimation of equation (4.13) is completed under the same specifications of the variable and fixed cost functions, $\tau_k(N_{ik})$ and $f_k(N_{ik})$ as in our linear case. When the costs follow a power function of the form, $\tau_k(N_{ik}) = \psi_k^\tau (1 + N_{ik})^{-\varepsilon_\tau}$ and $f_k(N_{ik}) = \psi_k^f (1 + N_{ik})^{-\varepsilon_f}$ the effects of immigrants on τ and f are,

$$
\begin{aligned}
\frac{\partial \log \tau_k (N_{ik})}{\partial \log N_{ik}} &= \frac{-\varepsilon_\tau}{1 + N_{ik}} \\
\frac{\partial f_k (N_{ik})}{\partial N_{ik}} &= -\varepsilon_f \psi_k^f \left(\frac{1}{1 + N_{ik}} \right)^{\varepsilon_f + 1}
\end{aligned}
$$

and our estimating equation (4.13) now becomes,

$$
wN_{ik} = \frac{\sigma - 1}{\sigma} r_i \frac{N_{ik}}{\sum_j N_{ij}} + r_{ik} \frac{\sigma - 1}{\sigma} \left(\frac{\varepsilon_\tau}{1 + N_{ik}} \right) + \varepsilon_f \psi_k^f \left(\frac{1}{1 + N_{ik}} \right)^{\varepsilon_f + 1} N_{ik} \tag{4.14}
$$

The results in Table (4.8) correspond to the non-linear estimation of equation (4.14). The results are consistent with the results outlined in the OLS results from Tables (4.3): immigrant employment from country k assists with firms increasing their export sales to country k. Additional confirmation of the consistency of the pro-trade effect is present when we compare the results from Table (4.4) with columns (2) and (3) of Table (4.8); immigrant employment increases export sales for differentiated goods. Less conclusive are the results on firm entry, corresponding to the estimates in the components on fixed costs.

Table 4.8: NLS estimates of the employment and export sales equation

Dependent variable: wN_{ik}			
	(1)	(2)	(3)
Export goods type:	all	homogeneous	differentiated
Components in the variable cost			
Immigrant employees from k	0.0061***	-0.0039***	0.0082***
	(0.0004)	(0.0012)	(0.0005)
Components in the fixed cost			
Immigrant employees from k	-1.0009***	-0.8438***	-1.0966***
	(0.0032)	(0.0071)	(0.0033)
ln distance	-0.6982***	-0.5734***	-0.9242***
	(0.0124)	(0.0284)	(0.0148)
English Dummy	0.4628***	0.5445***	0.2842***
	(0.0070)	(0.0170)	(0.0081)
Landlocked	0.6987***	1.4760***	0.7687***
	(0.0248)	(0.1298)	(0.0240)
FTA	-2.3391***	-2.1869***	-2.6923***
	(0.0374)	(0.0904)	(0.0431)
Firm-destination observations	137,383	26,038	124,681
Adjusted R^2	0.657	0.640	0.663
RMSE	0.0068	0.0065	0.0064

Notes: Robust standard errors clustered by firm-destination. * significant at 10%; ** significant at 5%; *** significant at 1%

4.5 Conclusion

In this study, we have added to the limited literature on the relationship between firm export sales and their foreign-born employment using a novel administrative dataset from Canada. Our results suggest that there exists a strong pro-trade immigrant employment effect on firm export sales; both the intensive and extensive margin of firm exports are positively affected by immigrant employment. Exploiting the level of detail in linked employer-employee data to gain a better sense of the heterogeneity of the pro-trade immigrant effect is an important avenue to explore for future research. For example, do higher educated immigrants have a larger impact on increasing firm export sales relative to low skilled immigrants? Where in the firms' employee organizational chain are immigrants most effective in promoting exports? We suspect that foreign-born sales managers would be more effective in increasing exports sales to their country of origin compared to foreign-born production line workers. Or how has Canada's immigration policy, one that encourages and emphasizes skilled immigrants, aided the pro-trade relationship that we see? Exploring these questions will give us a better sense of how firms utilize their immigrant work-force to engage in profitable trade. This is particularly relevant for the literature that aims to accurately measure the aggregate impact of migration on the welfare of native-born workers.

Lastly, given that firms are likely making hiring decisions with future export decisions in mind (Molina and Muendler, 2013) a future theoretical contribution would be extending our framework to a dynamic setting.

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Chapter 5

Conclusion

Each of the three chapters of my thesis relate to topics in International Economics. The first two chapters study the effects of migration on the economic outcomes of stayers for both receiving and sending countries. In both these chapters I develop and calibrate two distinct general equilibrium (GE) models to study the quantitative effect of migration on the real income of workers. In my final chapter, which is joint work with Professor Ananth Ramanarayanan, we study the relationship between firm export behaviour and the foreign-born worker composition at Canadian manufacturing firms using unique Canadian administrative tax data.

In Chapter 2, I calibrate a multi-country GE model of migration to quantify the economic impact of international migration to OECD and non-OECD countries. In my model consumers observe wages, prices, and migration costs for all possible destination countries and choose to reside in the country that maximizes their utility. Using this model I quantify the effects of migration for high and low skilled native-born stayers. My main experiment is to quantify the wage impact from sending all migrants back to their country of birth, i.e. undoing worldwide migration. In a world of no migration, high skilled workers see a larger decrease in their wages relative to low skilled workers in non-OECD countries. I also find that low skilled workers in OECD countries are slightly better off from migration. These findings are qualitatively consistent with country-level analysis for large OECD countries, the United States and

Canada (Aydemir and Borjas, 2007; Ottaviano and Peri, 2012). In addition to the no-migration counterfactual I also use the calibrated model to estimate the migration response of workers to the expansion or reduction of member countries in the European Union (EU). In one experiment, I model the response of workers to the United Kingdom leaving the European Union - commonly referred to as Brexit. I find a limited wage impact from Brexit. In the steady state, workers across Europe alter their migration decisions and mitigate the wage impact observed in Europe and in the UK stemming from Brexit. The loss in migration from the rest of Europe is offset by a drop in British emigration to the rest of Europe, reducing a significant portion of the potential wage losses. Future research in this area would benefit from incorporating additional features of international migration in a GE framework with endogenous migration. For example, introducing a fiscal environment to study how the contribution of migrants to countries' national budgets e.g. their collection of social benefits, impacts large destination countries. As well as adding income from remittances into the budget constraint of native-born stayers. Remittances provide a substantial boost to consumer income for some source countries. For example remittances sent home constitute over 15% of GDP for Jamaica, El Salvador and the Philippines.

In a series of papers on international trade and migration networks, Rauch (2001) and Rauch and Trindade (2002) show migrant networks can play a key role in overcoming informational barriers to international trade by acting as intermediaries between firms across countries. In Chapter 3, I quantitatively assess the welfare impact of migration accounting for this trade-creation channel, and gauge its relative importance in contributing to the overall welfare impact from migration. To measure the trade-creation effect I develop a multi-country GE 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 "Melitz-style" monopolistic competition market environment. In addition to the trade-creation effect of migrants, migration also affects consumers through: *i*) labor market effects due to changes in nominal wages and *ii*) firm entry and exit decisions stemming from market size effects. I calibrate my model for a set of 43 countries and assess the welfare impact of migration by comparing welfare under the currently observed levels of migration to a counterfactual scenario with no migration. My quantitative results show that the welfare contribution of the trade-creation effects of migration are important, particularly for countries with high levels of emigration and a diaspora spread among many countries. I find the average consumer in a net-emigration country gains 1.4% from the trade-creation effect of migration. Overall, my analysis provides a positive view of the welfare effects of migration, particularly for popular destination countries like the United States and Canada. Additional investigation on the robustness of this result are avenues for future study. Some promising areas include, but are not limited to, adding fiscal channels: immigrant contributions to national budgets, and social equity channels: immigrant impact on the overall level of income redistribution and inequality.

In Chapter 4 we investigated how firms' immigrant employment affects their exporting behavior to the home countries of their immigrant workforce using a unique employer-employee manufacturing dataset. Given the limited success in replicating trade patterns using primarily differences in productivity across firms (Eaton, Kortum and Kramarz, 2011), firms must exhibit other differences that vary their ability to overcome the frictions of international trade. Immigrant employment is theorized to play a key role in overcoming information frictions for firms by acting as intermediaries between firms and inducing trade (Rauch, 1999, 2001; Rauch and Trindade, 2002). However, the limited availability of matched employer-employee data has limited progression in this line of research. We add to the limited firm level evidence on the pro-trade effect of immigrant employment at firms using matched employer-employee Canadian data and provide causal estimates of the immigrant trade-creation effect that overcomes *both* the unit of observation and endogeneity bias concerns of earlier studies. We find that an increase in immigrant employment from a particular source country is associated with an increase in the probability of exporting to that destination *and* an increase in export sales to that destination. Using the detail of our unique data to gain a better sense of the heterogeneity of the pro-trade effect across different immigrant groups is an important avenue to explore for future research. For example, do higher educated immigrants have a larger impact on increasing firm export sales relative to low skilled immigrants? Fully understanding the relationship between immigrant employment and firm export behaviour will be crucial for future research evaluating the impact of migration on the Canadian economy.

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Appendix A

Chapter 2 Appendix

A.1 Data

A.1.1 Missing Data

For several countries for which we have detailed bilateral migration data I am missing their education attainment numbers. For these countries I assign the average of their region, determined by Barro and Lee (2013).

Table A.1: Education Attainment

Country	Region
Burkina Faso	Sub-Suharan Africa
Hong Kong	Advanced Economies
Iran, Islamic Rep.	Middle East and North Africa
Puerto Rico	Latin America and the Caribbean

Notes: Using 2010 education attainment data sourced from Barro and Lee (2013)

A.1.2 Country Descriptive Statistics

Table (A.2) lists all 83 countries used in my sample as well as some basic country level statistics such as total population, and immigrant population.

Table A.2: Country Statistics

Country	Population	High Skilled Fraction	GDP per Capita (USD)	Immigrants	Emigrants
Albania	2,913,021	0.015	$4,094	16,138	916,374
Argentina	41,223,889	0.117	$10,276	1,620,210	768,899
Armenia	2,877,311	0.214	$3,218	185,626	618,251
Australia	22,031,750	0.380	$51,874	6,013,093	389,156
Austria	8,363,404	0.174	$46,858	1,012,776	374,203
Belarus	9,490,583	0.220	$6,029	1,075,291	1,007,133
Belgium	10,895,586	0.300	$44,380	1,464,709	403,497
Botswana	2,014,866	0.041	$6,346	91,222	26,590
Brazil	196,796,269	0.113	$11,224	543,961	1,107,849
Bulgaria	7,395,599	0.235	$6,843	14,260	724,880
Burkina Faso	15,605,217	0.028	$575	420,850	70,776
Cambodia	14,308,740	0.020	$786	76,761	465,387
Cameroon	19,970,495	0.025	$1,309	340,540	165,575
Canada	34,005,274	0.477	$47,447	6,859,385	1,154,001
Chile	16,993,354	0.181	$12,860	211,202	505,394
Colombia	45,918,097	0.198	$6,251	75,589	1,340,341
Costa Rica	4,545,280	0.188	$8,199	351,546	110,790
Croatia	4,417,781	0.183	$13,506	529,850	542,432
Cyprus	1,112,607	0.309	$30,818	134,538	159,829
Czech Republic	10,474,410	0.165	$19,808	727,368	366,952
Denmark	5,547,683	0.286	$58,041	450,615	179,754
Dominican Republic	9,897,985	0.103	$5,451	349,900	1,059,564
Ecuador	14,934,690	0.116	$4,657	153,360	921,630
Egypt	84,107,606	0.101	$2,602	157,130	437,163
El Salvador	6,164,626	0.068	$3,474	32,110	1,241,115
Estonia	1,331,475	0.348	$14,639	194,796	132,683
Fiji	859,950	0.131	$3,652	11,340	176,389
Finland	5,363,352	0.316	$46,202	220,610	256,319
France	65,027,512	0.244	$40,703	6,818,647	1,410,597
Germany	81,776,930	0.243	$41,786	10,350,815	3,639,715
Greece	11,121,341	0.268	$26,918	1,229,537	655,366
Hong Kong	7,024,200	0.294	$32,550	530,333	520,155
Hungary	10,000,023	0.194	$13,092	376,691	425,472
Iceland	318,041	0.277	$41,676	29,135	32,390
Indonesia	242,524,123	0.075	$3,113	169,620	1,299,802
Iran	74,567,511	0.151	$6,532	1,197,239	897,489
Ireland	4,560,155	0.443	$48,672	683,133	739,147
Israel	7,623,600	0.433	$30,643	1,741,065	224,278
Italy	59,277,417	0.121	$35,849	4,489,457	2,387,429

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Table A.2 – continued from previous page

Country	Population	High Skilled Fraction	GDP per Capita (USD)	Immigrants	Emigrants
Japan	128,070,000	0.301	$44,508	1,421,127	773,604
Kenya	41,350,152	0.079	$967	271,290	283,922
Latvia	2,097,555	0.180	$11,326	477,320	246,948
Liberia	3,948,125	0.053	$327	61,520	87,812
Lithuania	3,097,282	0.293	$11,985	255,877	398,708
Luxembourg	506,953	0.319	$104,965	190,598	36,423
Malawi	15,167,095	0.004	$459	177,330	243,227
Malaysia	28,112,289	0.164	$9,071	1,424,668	304,502
Mali	15,075,085	0.019	$708	223,970	146,190
Malta	414,508 0	.135	$21,088	14,934	95,668
Mauritius	1,250,400	0.053	$8,000	24,784	139,687
Mexico	117,318,941	0.177	$8,960	607,803	11,343,114
Mozambique	24,221,405	0.005	$419	230,001	503,497
Namibia	2,173,170	0.022	$5,192	83,529	49,250
Netherlands	16,615,394	0.288	$50,338	1,617,710	720,170
New Zealand	4,350,700	0.368	$33,691	1,132,848	552,873
Nicaragua	5,737,723	0.112	$1,526	40,060	555,476
Niger	16,425,578	0.011	$370	68,737	69,504
Norway	4,889,252	0.294	$87,770	518,236	137,805
Panama	3,643,222	0.236	$7,937	140,120	171,241
Paraguay	6,209,877	0.104	$3,226	164,017	620,208
Peru	29,373,646	0.209	$5,022	61,402	1,049,786
Poland	38,042,794	0.211	$12,598	589,820	3,277,180
Portugal	10,573,100	0.127	$22,539	810,416	1,599,694
Puerto Rico	3,721,525	0.116	$26,436	451,968	1,422,878
Romania	20,246,871	0.119	$8,297	105,266	2,644,179
Russian Federation	142,849,449	0.620	$10,675	13,677,467	3,758,557
Rwanda	10,246,842	0.014	$563	31,183	45,221
Slovak Republic	5,391,428	0.173	$16,601	136,122	482,061
Slovenia	2,048,583	0.223	$23,437	219,494	90,204
South Africa	50,979,432	0.061	$7,275	2,846,897	610,608
Spain	46,576,897	0.257	$30,737	5,113,275	878,198
Sudan	34,385,963	0.028	$1,476	91,116	122,811
Sweden	9,378,126	0.282	$52,076	1,229,285	248,352
Switzerland	7,824,909	0.332	$74,606	1,586,396	492,184
Tajikistan	7,641,630	0.087	$738	48,861	428,857
Thailand	67,208,808	0.125	$5,075	2,358,560	587,741
Togo	6,502,952	0.026	$488	267,694	63,654
Trinidad and Tobago	1,328,100	0.096	$16,684	41,738	319,009
Turkey	72,326,914	0.107	$10,672	1,537,287	2,585,281

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Table A.2 – continued from previous page

Country	Population	High Skilled Fraction	GDP per Capita (USD)	Immigrants	Emigrants
United Kingdom	62,766,365	0.283	$38,893	7,373,907	3,855,045
United States	309,348,193	0.573	$48,374	41,307,385	1,488,050
Uruguay	3,374,415	0.094	$11,938	161,355	303,625
Zambia	13,850,033	0.015	$1,463	597,640	152,587

Appendix B

Chapter 3 Appendix

B.1 Solving for total firm sales between countries

Total sales from all firms in country j to country i is equal to the sum of all sales of all firms that meet the input requirement $\bar{\varphi}_{ji}^{T}$,

$$X_{ji}^{T} = \int\limits_{\bar{\varphi}_{ji}^{T}} p_{ji}^{T}(\varphi)\, q_{ji}^{T}(\varphi)\, e_{j}^{T} dG(\varphi)$$

Taking this ratio and substituting in the demand that country i has for country j's tradeable goods, q_{ji}^{T},

$$X_{ji}^{T} = \int\limits_{\bar{\varphi}_{ji}^{T}} p_{ji}^{T}(\varphi)\, p_{ji}^{T}(\varphi)^{-\sigma_T} \left(P_{i}^{T}\right)^{\sigma_T - 1} \mu_T Y_i e_{j}^{T} dG(\varphi)$$

Substituting in the for price, p_{ji}^{T}, between j and i in the tradeable sector,

$$X_{ji}^{T} = \int\limits_{\bar{\varphi}_{ji}^{T}} \left(\frac{\sigma_T}{\sigma_T - 1}\frac{\tilde{w}_j \tau_{ji}^{T}}{\varphi}\right)^{1-\sigma_T} \left(P_{i}^{T}\right)^{\sigma_T - 1} \mu_T Y_i e_{j}^{T} dG(\varphi)$$

Rearrange and integrating over the firms that find it profitable to export results in,

$$X_{ji}^T = \left(\frac{\sigma_T}{\sigma_T - 1}\tilde{w}_n \tau_{nj}^T\right)^{1-\sigma_T} \left(P_i^T\right)^{\sigma_T - 1} \mu_T Y_i e_j^T \int_{\bar{\varphi}_{ji}^T} \varphi^{\sigma_T - 1}\gamma\varphi^{-1-\gamma} d\varphi$$

$$X_{ji}^T = X_i^T \left(\frac{\sigma_T}{\sigma_T - 1}\tilde{w}_j \tau_{ji}^T\right)^{1-\sigma_T} \left(P_i^T\right)^{\sigma_T - 1} e_j^T \gamma \frac{\left(\bar{\varphi}_{ji}^T\right)^{-1+\sigma_s-\gamma}}{\gamma + 1 - \sigma_s}$$

Substituting in for the productivity cutoff φ_{ji}^T,

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

Which can be simplified to,

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

with $\Theta_i^{-\gamma} = \sum_k \frac{n_k}{Y} \left(\tilde{w}_k \tau_{ki}^T\right)^{-\gamma} \left(f_{ki}^T\right)^{\frac{\sigma_T - 1 - \gamma}{\sigma_T - 1}}$ and where I have assumed that e_j^T, the total mass of potential entrants in sector T is country j is proportional to total income in j, Y_j as in Chaney, 2008.

B.2 Solving for average firm sales between countries

Taking total firm sales (B.1) and dividing by the number of firms that find it optimal to export, denoted by, N_{ji}^T, gives an equation for average firm sales between countries j and i.

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

The denominator of equation (B.2) represents the probability of any firm in j exporting to country i multiplied by the number of potential exporting firms in j, e_j^T

Substituting in for the productivity threshold gives,

$$\frac{X_{ji}^T}{N_{ji}^T} = \frac{\mu_T Y_i \left(\tilde{w}_j \tau_{ji}^T\right)^{-\gamma} \left(f_{ji}^T\right)^{1-\frac{\gamma}{\sigma_T - 1}} e_j^T \Theta_i^\gamma}{\left(\frac{\tilde{w}_j \tau_{ji}^T}{P_i^T} \times \frac{\sigma_T}{\sigma_{T-1}} \left(f_{ji}^T\right)^{\frac{1}{\sigma_T - 1}} \times \left(\sigma_T^{-1} \mu_T Y_i\right)^{\frac{-1}{\sigma_T - 1}}\right)^{-\gamma} e_j^T}$$

Which can be simplified to,

$$\frac{X_{ji}^T}{N_{ji}^T} = \frac{\mu_T Y_j \left(\tilde{w}_j \tau_{ji}^T\right)^{-\gamma} \left(f_{ji}^T\right)^{1-\frac{\gamma}{\sigma_T - 1}} \Theta_j^\gamma}{\left(\tilde{w}_j \tau_{ji}^T\right)^{-\gamma} \left(P_i^T\right)^\gamma \left(f_{ji}^T\right)^{\frac{-\gamma}{\sigma_T - 1}} \left(\frac{\sigma_T}{\sigma_{T-1}}\right)^{-\gamma} \left(\frac{1}{\sigma_T}\right)^{\frac{\gamma}{\sigma^T - 1}} \left(\mu_T Y_i\right)^{\frac{\gamma}{\sigma^T - 1}}}$$

$$\frac{X_{ji}^T}{N_{ji}^T} = \frac{\left(\mu_T Y_i\right)^{1-\frac{\gamma}{\sigma_T - 1}} \left(f_{ji}^T\right) \Theta_i^\gamma}{\left(P_i^T\right)^\gamma \left(\frac{\sigma_T}{\sigma_T - 1}\right)^{-\gamma} \left(\frac{1}{\sigma_T}\right)^{\frac{\gamma}{\sigma^T - 1}}}$$

Finally substituting in for the price level, P_i^T, and simplifying over several steps produces the desired average sales equation, $\frac{X_{ji}^T}{N_{ji}^T}$

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

$$\frac{X_{ji}^T}{N_{ji}^T} = \frac{(\mu_T Y_i)^{1-\frac{\gamma}{\sigma_T-1}} \left(f_{ji}^T\right) \Theta_i^\gamma}{\Theta_i^\gamma Y_i^{\frac{\gamma}{\gamma}-\frac{\gamma}{\sigma_T-1}} \left(\frac{\sigma_T}{\sigma_T-1}\right)^\gamma \left(\sigma_T^{-1}\mu_T\right)^{\frac{\gamma}{\gamma}-\frac{\gamma}{\sigma_T-1}} \left(\frac{\gamma}{\gamma+1-\sigma_T}\right)^{\frac{-\gamma}{\gamma}} \left(\frac{\sigma_T}{\sigma_T-1}\right)^{-\gamma} \left(\frac{1}{\sigma_T}\right)^{\frac{\gamma}{\sigma^T-1}}}$$

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

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

B.2.1 Equations and steps to solve the model

Sales across countries

Y_j^g denotes the value of output in sector g in country j and X_j^g 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 $Y_j^N + Y_j^T$.

As shown above, total sales from all firms in country j to country i that meet the input requirement $\bar{\varphi}_{ji}^T$ can be written down as,

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

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

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

Free entry condition

The free entry condition pins down the number of firms that find it profitable to enter the market.

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

where $\mathbf{1}_{ji}[\varphi]$ indicates whether firm φ in j finds it profitable to sell in country i and $\pi_{ji}^{V,g}(\varphi)$ 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.

Numerical solution steps

1. Make guesses of wages, price vectors and mass of firms for each country and each sector $\left\{w_{jH}, w_{jL}; P_j^N, P_j^T; e_j^N, e_j^T\right\}_{j=1}^J$
2. Construct the composite cost of labour cost using w_{jH}, w_{jL}; $\widetilde{w}_j = \left(\theta_H^{\sigma} w_{jH}^{1-\sigma} + \theta_L^{\sigma} w_{jL}^{1-\sigma}\right)^{\frac{1}{1-\sigma}}$
3. Solve for the productivity cutoffs $\bar{\varphi}_{ji}^{g} = \frac{\tilde{w}_j \tau_{ji}^T}{A_j P_j^h}\left(\frac{f_{ji}^h \tilde{w}_j}{Y_j A_j}\right)^{\frac{1}{\sigma_h - 1}} \left(\frac{\sigma_g}{\mu_g}\right)^{\frac{1}{\sigma_g - 1}} \frac{\sigma_g}{\sigma_g - 1}$ using our guesses of P_j^g and that $Y_j = \widetilde{w}_j L_j$
4. With $\bar{\varphi}_{ji}^{g}$ and the guesses of P_j^g, e_j^g, and $\widetilde{w}_j$ I can solve for total profits across all firms in sector g in country j, $FE_{\pi_j}^g = \sum_i \frac{1}{\sigma_g}\left(\left(\frac{\sigma_g}{\sigma_g - 1}\frac{\tilde{w}_j \tau_{ji}^g}{A_j}\right)^{1-\sigma_g}\left(P_i^g\right)^{\sigma_g - 1} \mu_g Y_i \gamma\right) \frac{\left(\bar{\varphi}_{ji}^{g}\right)^{-1+\sigma_g-\gamma}}{\gamma + 1 - \sigma_g} - \widetilde{w}_j f_{ji}^g \left(\bar{\varphi}_{ji}^{g}\right)^{-\gamma}$
5. Using $\bar{\varphi}_{ji}^{g}$ I can compute a new set of the price indices $\bar{P}_j^g$
6. Iterate until for both sectors g in all countries j

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

(b) $FE^{g}_{\pi_j} - \tilde{w}_j f_E = 0$

(c) $\sum_{i=1}^{N} \frac{\left(\frac{\tilde{w}_j \tau^T_{ji}}{A_j}\right)^{-\gamma} e_j \left(\tilde{w}_j f^T_{ji}\right)^{1-\frac{\gamma}{\sigma_T - 1}}}{[k=1]N \sum e^T_k \left(\tilde{w}_k \tau^T_{ki}\right)^{-\gamma} \left(\tilde{w}_k f^T_{ki}\right)^{\frac{\sigma_T - 1 - \gamma}{\sigma_T - 1}}} X^T_i - \widetilde{w}_j L_j \mu_T = 0$

(d) $\left(w_{jH} L_{jH} + w_{jL} L_{jL}\right) - \widetilde{w}_j L_j = 0$

B.3 United States and Canada Trade Relations

On May 31, 2018, the United States(U.S.), announced tariffs on imports of steel products from Canada at the rate of 25% and tariffs on the imports of aluminum products at the rate of 10%. Canadian exports of steel and aluminum subject to the tariffs in 2017 was valued at C$7.2 and C$9.2 billion for steel and aluminum products, respectively.

In response to these tariffs, on July 1, 2018 the Canada imposed countermeasure tariffs against C$16.6 billion on U.S. imports of Canadian goods. Steel and aluminum products account for C$8.2 billion, the remaining C$8.4 billion in tariffs are on a variety of goods that include maple syrup, whiskies, and inflatable boats[21]. The tariffs range from 10% to 25% and the Canadian government has announced they will remain in place until the U.S. eliminates their trade-restrictive measures against Canadian steel and aluminum products[22].

Table (B.1) shows a complete list, aggregated at the product level, of goods subject to tariffs and the level of tariffs imposed.

[21] Canadian International Merchandise Trade: Table (2201)

[22] Department of Finance publication entitled "Countermeasures in Response to Unjustified Tariffs on Canadian Steel and Aluminum Products"

Table B.1: Trade values of products subject to tariffs, customs basis, 2017

Product	Tariff %	Canadian 2017 trade value (C$ millions)
Steel products	25	5,590
Aluminum products	10	2,658
Sauces and condiments	10	818
Tissue products	10	731
Motorboats	10	610
Coffee	10	525
Chocolate and candy	10	519
Household appliances and parts	10	515
Plastic bags	10	447
Personal care products	10	381
Paper products	10	377
Furniture	10	363
Plastic household articles	10	343
Lawnmowers	10	301
Soft drinks and flavoured water	10	253
Beef	10	212
Soups	10	204
Water heaters	10	175
Orange juice	10	165
Plywood	10	152
Mattresses	10	147
Chicken	10	124
Detergents	10	121
Room deodorizers	10	121
Pizza and quiche	10	119
Others	10	592

Canadian International Merchandise Trade (customs basis) (2201).

Appendix C

Chapter 4 Appendix

C.1 Variable List and Sources

Tables C.1 and C.2 provide a detailed breakdown of the variables names, sources and description of the data we use in our empirical study of the relationship between immigrant employment and firm export behaviour. This data is accessible at the Canadian Centre for Data Development and Economic Research (CDER) located within Statistics Canada in Ottawa, Canada.

Table C.1: Employee Data

Variable Name	Source	Description
country_birth	IMDB	Immigrant's country of birth
country_citizenship	IMDB	Immigrant's country of citizenship
country_residence	IMDB	Immigrant's country of last permanent residence
d_t1_pc	T1	Postal code of residence (scrambled)
destination_cma	IMDB	The Census Metropolitan Area (CMA) of destination of the immigrant at landing in Canada (2011 SGC)
education_qualification	IMDB	Education qualification
eid	T2	Identification number of the enterprise employing the individual (scrambled)
emp_inc	T4	T4 earnings from a particular business number associated with the enterprise denoted by eid
immigration_category	IMDB	Immigration category
landing_age	IMDB	Age at admission
landing_year	IMDB	The year in which the permanent resident was admitted
level_of_education	IMDB	Level of education
LM_intention	IMDB	Intended skill level of the immigrant at the time of admission
mother_tongue	IMDB	Immigrants primary or native language
NOC5_CD11	IMDB	Intended Occupation at the 5 digit level (2011 ESDC classification)
official_language	IMDB	Self-declared indicators of an immigrants knowledge of an official language at admission
pid	T1	Personal ID, based on the SIN (scrambled)
skill_level_cd11	IMDB	Skill level of the immigrant at the time of admission
prov_emp	T4	Province of employment
prov_res	T4	Province of residence
t1h_commission_gross	T1	Gross commission income
t1h_DV_age	T1	Age (on December 31 of the reference year)
t1h_earn_t4	T1	Total employment earnings from T4
T1h_marst	T1	Marital status
T1h_net_inc_calc	T1	Calculated net income
t1h_prov_of_res	T1	Province of residence
t1h_tot_inc_calc	T1	Calculated total income
t1h_ui_ben	T1	Contains the amount of income from unemployment insurance during the tax year in question
T1h_yob	T1	Year of birth
tax_yr	T1	Reference year (calendar)
years_of_schooling	IMDB	Number of years of schooling for permanent residents

Business Register (BR); Income Tax and Benefit Return (T1); Statement of Remuneration (T4); Immigration Database (IMDB); Corporate Income Tax Accounts (T2)

Table C.2: Enterprise Data

Variable Name	Source	Description
d_opaddress_pc	BR	This field is used to register the Postal Code associated with the civic address of the operating entity (scrambled)
eid	T2	Identification number of the enterprise employing the individual (scrambled)
entmultiestablishmentflag	BR	This field is used to register that there are more than 1 establishment in the enterprise
entmultilocationflag	BR	This field is used to register that there are more than 1 location in the enterprise
gross_profits	T2	This item represents the net amount of Item 8089, Total sales of goods and services, less Item 8518, Cost of sales
naics4	BR	Four-digits NAICS for incorporated businesses
total_assets	T2	This item represents the total of all current, capital, long-term assets, and assets held in trust and must be reported line 2599
total_expenses	T2	Any amount reported under this item should be equal to the amount reported under Item 8518, Cost of sales, plus the amount reported under Item 9367, Total operating expenses. line 9368
total_liabilities	T2	This item represents the total of all current and long-term liabilities and must be reported
total_revenue	T2	This item represents the sum of all revenue amounts
country_edesc	TEC	Country English description
country_iso_code	TEC	Country ISO code. This code is defined by the International Standards Organization
hs8	TEC	Eight digit commodity code. For each establishment, there can be multiple HS8
us_relationship_code	TEC	US Import Attribute) Related and non-related code used as a means of identifying economic activity
value	TEC	Contains all the value for duty amounts of the shipment

Business Register (BR); Immigration Database (IMDB); Corporate Income Tax Accounts (T2); Trade-by-Enterprise Characteristics (TEC)

C.2 Derivation of firm sales equations

C.2.1 Firms' export sales decisions

Preferences of the representative consumer in country k for goods from firm i are

$$U\left(q_{1k}, q_{2k}, q_{3k}, \ldots, q_{ik}\right) = \left(\int_{i\in\Omega_k} \alpha_{ik}^{\frac{1}{\sigma}} q_{ik}^{\frac{\sigma-1}{\sigma}} d_i\right)^{\frac{\sigma}{\sigma-1}}$$

where Ω_k are the set of goods available in country k. α_{ik} is a firm-country specific demand shock that is lognormally distributed i.i.d across firms and countries, q_{ik} is demand for firm i goods in country k and $\sigma > 1$ is the elasticity of substitution across goods.

Country $k's$ demand for any good i is given by solving the maximization problem:

$$\max_{\{q_{ik}\}} = \left(\int_{i\in\Omega_k} \alpha_{ik}^{\frac{1}{\sigma}} q_{ik}^{\frac{\sigma-1}{\sigma}} d_i\right)^{\frac{\sigma}{\sigma-1}}$$

$$s.t. \int_{i\in\Omega_k} p_{ik} q_{ik} di = Y_k$$

where Y_k is total income in country k.

To solve for demand q_{ik}, take a ratio of the first order conditions with respect to goods i and j and substitute this ratio into the representative consumer's budget constraint in country k.

$$\mathcal{L}_{q_{ik},q_{jk}} = \left(\int_{i\in\Omega_k} \alpha_{ik}^{\frac{1}{\sigma}} q_{ik}^{\frac{\sigma-1}{\sigma}} d_i\right)^{\frac{\sigma}{\sigma-1}} + \lambda_k \left(Y_k - \int_{i\in\Omega_k} p_{ik} q_{ik} di\right)$$

First order condition w.r.t q_{ik}

$$\frac{\sigma}{\sigma-1}\left(\int_{i\in\Omega_k} \alpha_{ik}^{\frac{1}{\sigma}} q_{ik}^{\frac{\sigma-1}{\sigma}} d_i\right)^{\frac{1}{\sigma-1}} \alpha_{ik}^{\frac{1}{\sigma}} \frac{\sigma-1}{\sigma} q_{ik}^{\frac{-1}{\sigma}} = \lambda_k p_{ik} \tag{C.1}$$

First order condition w.r.t q_{jk}

$$\frac{\sigma}{\sigma-1}\left(\int_{i\in\Omega_k}\alpha_{jk}^{\frac{1}{\sigma}}q_{jk}^{\frac{\sigma-1}{\sigma}}d_j\right)^{\frac{1}{\sigma-1}}\alpha_{jk}^{\frac{1}{\sigma}}\frac{\sigma-1}{\sigma}q_{jk}^{\frac{-1}{\sigma}}=\lambda_k p_{jk} \tag{C.2}$$

Ratio of (C.1) and (C.2)

$$\left(\frac{\alpha_{ik}}{\alpha_{jk}}\right)^{\frac{1}{\sigma}}\left(\frac{q_{ik}}{q_{jk}}\right)^{\frac{-1}{\sigma}}=\frac{p_{ik}}{p_{jk}}$$
$$\left(\frac{q_{ik}}{q_{jk}}\right)^{\frac{-1}{\sigma}}=\left(\frac{p_{ik}}{p_{jk}}\right)\left(\frac{\alpha_{ik}}{\alpha_{jk}}\right)^{\frac{-1}{\sigma}}$$

$$q_{ik}=\left(\frac{p_{ik}}{p_{jk}}\right)^{-\sigma}\left(\frac{\alpha_{ik}}{\alpha_{jk}}\right)q_{jk} \tag{C.3}$$

Use (C.3) to sub it into our budget constraint

$$\int_{i\in\Omega_k}p_{ik}\left(\left(\frac{p_{ik}}{p_{jk}}\right)^{-\sigma}\left(\frac{\alpha_{ik}}{\alpha_{jk}}\right)q_{jk}\right)di=Y_k$$
$$p_{jk}^{\sigma}q_{jk}\frac{1}{\alpha_{jk}}\int_{i\in\Omega_k}p_{ik}^{1-\sigma}\alpha_{ik}di=Y_k$$
$$q_{jk}=Y_k\alpha_{jk}p_{jk}^{-\sigma}\frac{1}{\int_{i\in\Omega_k}p_{ik}^{1-\sigma}\alpha_{ik}di}$$

Sub q_{jk} into (C.3) and solve for the demand function q_{ik}

$$q_{ik}=\left(\frac{p_{ik}}{p_{jk}}\right)^{-\sigma}\left(\frac{\alpha_{ik}}{\alpha_{jk}}\right)\left(Y_k\alpha_{jk}p_{jk}^{-\sigma}\frac{1}{\int_{i\in\Omega_k}p_{ik}^{1-\sigma}\alpha_{ik}di}\right)$$
$$q_{ik}=(p_{ik})^{-\sigma}\alpha_{ik}\frac{Y_k}{\int_{i\in\Omega_k}p_{ik}^{1-\sigma}\alpha_{ik}di}$$

Where the price index $P_k=\left(\int_{i\in\Omega_k}p_{ik}^{1-\sigma}\alpha_{ik}di\right)^{\frac{1}{1-\sigma}}$. We can now write demand for any good i in country k as,

$$q_{ik} = Y_k \alpha_{ik} p_{ik}^{-\sigma} \frac{1}{P_k^{1-\sigma}} \tag{C.4}$$

Or in terms of expenditures,

$$x_{ik} = Y_k \alpha_{ik} \left(\frac{p_{ik}}{P_k} \right)^{1-\sigma} \tag{C.5}$$

C.2.2 Firms' export sales decisions with multiple sectors

The representative consumer in country k now has preferences for differentiated goods (D) and homogenous goods (H) goods from firm i in each respective sector:

$$U\left(q_{1k}^D, \ldots, q_{ik}^D, q_{1k}^H, \ldots, q_{ik}^H\right) = \left(\int_{i \in \Omega_k^D} \left(\alpha_{ik}^D\right)^{\frac{1}{\sigma_D}} \left(q_{ik}^D\right)^{\frac{\sigma_D - 1}{\sigma_D}} d_i \right)^{\frac{\sigma_D}{\sigma_D - 1}\mu_D} \left(\int_{i \in \Omega_k^H} \left(\alpha_{ik}^H\right)^{\frac{1}{\sigma_H}} \left(q_{ik}^H\right)^{\frac{\sigma_H - 1}{\sigma_H}} d_i \right)^{\frac{\sigma_H}{\sigma_H - 1}\mu_H}$$

where Ω_k^D, Ω_k^H are the set of goods available in country k in the differentiated and homogenous goods sectors. α_{ik}^D, α_{ik}^H are firm-sector-country specific demand shock that is lognormally distributed i.i.d across firms, sectors, and countries, q_{ik}^D, q_{ik}^H are the demand for firm $i's$ goods in each sector in country k and $\sigma_D > 1$, $\sigma_H > 1$ are the elasticity of substitution across goods in each sector.

Country $k's$ demand for any good i from either sector is given by solving the maximization problem:

$$\max_{q_{ik}^D, q_{ik}^H} = \left(\int_{i \in \Omega_k^D} \left(\alpha_{ik}^D\right)^{\frac{1}{\sigma_D}} \left(q_{ik}^D\right)^{\frac{\sigma_D - 1}{\sigma_D}} d_i \right)^{\frac{\sigma_D}{\sigma_D - 1}\mu_D} \left(\int_{i \in \Omega_k^H} \left(\alpha_{ik}^H\right)^{\frac{1}{\sigma_H}} \left(q_{ik}^H\right)^{\frac{\sigma_H - 1}{\sigma_H}} d_i \right)^{\frac{\sigma_H}{\sigma_H - 1}\mu_H}$$

$$s.t. \int_{i \in \Omega_k^D} p_{ik}^D q_{ik}^D di + \int_{i \in \Omega_k^H} p_{ik}^H q_{ik}^H di = Y_k$$

where Y_k is total income in country k.

Following the same sequence of steps as outlined in the 1 sector problem we solve for demand for any good i from each sector in country k as,

$$q_{ik}^D = Y_k^D \alpha_{ik}^D \left(p_{ik}^D\right)^{-\sigma_D} \frac{1}{\left(P_k^D\right)^{1-\sigma_D}} \tag{C.6}$$

$$q_{ik}^H = Y_k^D \alpha_{ik}^H \left(p_{ik}^H\right)^{-\sigma_H} \frac{1}{\left(P_k^H\right)^{1-\sigma_H}} \tag{C.7}$$

Or in terms of expenditures,

$$x_{ik}^D = Y_k^D \alpha_{ik}^D \left(\frac{p_{ik}^D}{P_k^D}\right)^{1-\sigma_D} \tag{C.8}$$

$$x_{ik}^H = Y_k^H \alpha_{ik}^H \left(\frac{p_{ik}^H}{P_k^H}\right)^{1-\sigma_H} \tag{C.9}$$

taking the prices indicies as $P_k^D = \left(\int\limits_{i\in\Omega_k^D} \left(p_{ik}^D\right)^{1-\sigma} \alpha_{ik}^D di\right)^{\frac{1}{1-\sigma_D}}$ and $P_k^H = \left(\int\limits_{i\in\Omega_k^H} \left(p_{ik}^H\right)^{1-\sigma} \alpha_{ik}^H di\right)^{\frac{1}{1-\sigma_H}}$

C.2.3 Firms' hiring decisions

To write the firm's problem in terms of labor input choices, we start from output: for each destination k to which firm i sells, to satisfy demand it must produce $q_{ik} = \tau_k(N_{ik})\, p_{ik}^{-\sigma} \alpha_{ik} E_k$, which can be inverted to:

$$\left(\frac{q_{ik}}{\tau_k(N_{ik})}\right)^{-1/\sigma} (\alpha_{ik}E_k)^{1/\sigma} = p_{ik}$$

So revenues for firm i from selling to k are:

$$\begin{aligned} r_{ik} &= p_{ik}\frac{q_{ik}}{\tau_k(N_{ik})} \\ &= \left(\frac{q_{ik}}{\tau_k(N_{ik})}\right)^{\frac{\sigma-1}{\sigma}} (\alpha_{ik}E_k)^{\frac{1}{\sigma}} \end{aligned}$$

To write the profit maximization problem in terms of labor inputs $\{N_{ik}\}_{k=1,\ldots,K}$, first take as given firm i's total output y_i, and solve for the quantities exported to each country k, q_{ik}. Firm i

allocates its sales to maximize revenues, taking as given the α_{ik}'s:

$$\max_{\{q_{ik}\}} \sum_k \Xi_{ik} q_{ik}^{\frac{\sigma-1}{\sigma}} \left(\tau_k \left(N_{ik}\right)\right)^{\frac{1-\sigma}{\sigma}} \left(\alpha_{ik} E_k\right)^{\frac{1}{\sigma}}$$

$$\text{s.t.} \sum_k \Xi_{ik} q_{ik} \leq y_i$$

The first order conditions for output produced for sale to k, q_{ik}, and output produced for domestic sale, q_{i1}, conditional on $\Xi_{ik} = 1$, yield:

$$\frac{\sigma-1}{\sigma} q_{ik}^{\frac{-1}{\sigma}} \left(\tau_k \left(N_{ik}\right)\right)^{\frac{1-\sigma}{\sigma}} \left(\alpha_{ik} E_k\right)^{\frac{1}{\sigma}} = \lambda_i$$

and for domestic output:

$$\frac{\sigma-1}{\sigma} q_{id}^{\frac{-1}{\sigma}} \left(\alpha_{id} E_d\right)^{\frac{1}{\sigma}} = \lambda_i$$

So taking the ratio of these two,

$$q_{i1} \frac{\alpha_{ik} E_k}{\alpha_{i1} E_1} \tau_k \left(N_{ik}\right)^{1-\sigma} = q_{ik} \tag{C.10}$$

Summing equation (C.10) across k and rearranging gives:

$$\frac{q_{id}}{\alpha_{id} E_d} = \frac{y_i}{\sum_k \Xi_{ik} \alpha_{ik} E_k \tau_k \left(N_{ik}\right)^{1-\sigma}} \tag{C.11}$$

Using (C.10) and (C.11), we can write total revenues as:

$$
\begin{aligned}
\sum_k \Xi_{ik} q_{ik}^{\frac{\sigma-1}{\sigma}} \left(\tau_k\left(N_{ik}\right)\right)^{\frac{1-\sigma}{\sigma}} \left(\alpha_{ik} E_k\right)^{\frac{1}{\sigma}} &= \sum_k \Xi_{ik} q_{id}^{\frac{\sigma-1}{\sigma}} \left(\frac{\alpha_{ik} E_k}{\alpha_{id} E_d} \tau_k\left(N_{ik}\right)^{1-\sigma}\right)^{\frac{\sigma-1}{\sigma}} \left(\tau_k\left(N_{ik}\right)\right)^{\frac{1-\sigma}{\sigma}} \left(\alpha_{ik} E_k\right)^{\frac{1}{\sigma}} \\
&= \left(\frac{q_{id}}{\alpha_{id} E_d}\right)^{\frac{\sigma-1}{\sigma}} \sum_k \Xi_{ik} \alpha_{ik} E_k \tau_k\left(N_{ik}\right)^{1-\sigma} \\
&= y_i^{\frac{\sigma-1}{\sigma}} \left(\sum_k \Xi_{ik} \alpha_{ik} E_k \tau_k\left(N_{ik}\right)^{1-\sigma}\right)^{\frac{1-\sigma}{\sigma}} \sum_k \Xi_{ik} \alpha_{ik} E_k \tau_k\left(N_{ik}\right)^{1-\sigma} \\
&= y_i^{\frac{\sigma-1}{\sigma}} \left(\sum_k \Xi_{ik} \alpha_{ik} E_k \tau_k\left(N_{ik}\right)^{1-\sigma}\right)^{\frac{1}{\sigma}}
\end{aligned}
$$

Firm i's production technology is $y_i = \phi_i \sum_k N_{ik}$, so with total revenues given by (4.12), the profit maximization problem is:

$$
\max_{\{N_{ik}\}_k} \left(\phi_i \sum_k N_{ik}\right)^{\frac{\sigma-1}{\sigma}} \left(\sum_k \Xi_{ik} \alpha_{ik} E_k \tau_k\left(N_{ik}\right)^{1-\sigma}\right)^{\frac{1}{\sigma}} - w \sum_k N_{ij} - \sum_k \Xi_{ik} f_k\left(N_{ik}\right)
$$

Conditional on $\Xi_{ik} = 1$, the first order condition for N_{ik} is:

$$
\begin{aligned}
0 = &\frac{\sigma-1}{\sigma} \left(\phi_i \sum_j N_{ij}\right)^{\frac{\sigma-1}{\sigma}-1} \phi_i \left(\sum_j \Xi_{ij} \alpha_{ij} E_j \tau_j\left(N_{ij}\right)^{1-\sigma}\right)^{\frac{1}{\sigma}} \\
&+ \left(\phi_i \sum_j N_{ij}\right)^{\frac{\sigma-1}{\sigma}} \frac{1}{\sigma} \left(\sum_j \Xi_{ij} \alpha_{ij} E_j \tau_j\left(N_{ij}\right)^{1-\sigma}\right)^{\frac{1}{\sigma}-1} \alpha_{ik} E_k \left(1-\sigma\right) \tau_k\left(N_{ik}\right)^{-\sigma} \frac{\partial \tau_k\left(N_{ik}\right)}{\partial N_{ik}} \\
&- \frac{\partial f_k\left(N_{ik}\right)}{\partial N_{ik}} - w
\end{aligned}
$$

Using the fact that revenue shares are given by

$$
\begin{aligned}
\frac{r_{ik}}{r_i} &= \frac{r_{ik}}{\sum_j \Xi_{ij} r_{ij}} \\
&= \frac{\tau_k\left(N_{ik}\right)^{1-\sigma} \alpha_{ik} E_k}{\sum_j \Xi_{ij} \tau_j\left(N_{ij}\right)^{1-\sigma} \alpha_{ij} E_j}
\end{aligned}
$$

We can substitute in y_i and multiply by N_{ik} throughout and simplify the first order condition to:

$$\begin{aligned} & \frac{\sigma-1}{\sigma}(y_i)^{\frac{\sigma-1}{\sigma}} \frac{N_{ik}}{\sum_j N_{ij}} \left(\sum_j \Xi_{ij} \alpha_{ij} E_j \tau_j \left(N_{ij}\right)^{1-\sigma} \right)^{\frac{1}{\sigma}} \\ & + (y_i)^{\frac{\sigma-1}{\sigma}} \left(\sum_j \Xi_{ij} \alpha_{ij} E_j \tau_j \left(N_{ij}\right)^{1-\sigma} \right)^{\frac{1}{\sigma}} \frac{\alpha_{ik} E_k \tau_k (N_{ik})^{1-\sigma}}{\sum_j \Xi_{ij} a_{ij} E_j \tau_j \left(N_{ij}\right)^{1-\sigma}} \frac{1-\sigma}{\sigma} \frac{\partial \tau_k (N_{ik})}{\partial N_{ik}} \frac{N_{ik}}{\tau_{kl} (N_{ik})} \\ & - \frac{\partial f_k (N_{ik})}{\partial N_{ik}} N_{ik} \\ = \; & w N_{ik} \end{aligned}$$

Now, the factor $\frac{\alpha_{ik} E_k \tau_k (N_{ik})^{1-\sigma}}{\sum_j \Xi_{ij} \alpha_{ij} E_j \tau_j \left(N_{ij}\right)^{1-\sigma}}$ is the share of sales to k, since the first order condition from above for any j, k give:

$$q_{ij} \tau_k (N_{ik})^{1-\sigma} \alpha_{ik} E_k = q_{ik} \tau_j \left(N_{ij}\right)^{1-\sigma} \alpha_{ij} E_j$$

So we can write revenue share as:

$$\begin{aligned} \frac{r_{ik}}{\sum_j \Xi_{ij} r_j} &= \frac{\left(\frac{q_{ik}}{\tau_k (N_{ik})}\right)^{\frac{\sigma-1}{\sigma}} (\alpha_{ik} E_k)^{\frac{1}{\sigma}}}{\sum_j \Xi_{ij} \left(\frac{q_{ij}}{\tau_j (N_{ij})}\right)^{\frac{\sigma-1}{\sigma}} \left(\alpha_{ij} E_j\right)^{\frac{1}{\sigma}}} \\ &= \frac{\tau_k (N_{ik})^{1-\sigma} \alpha_{ik} E_k}{\sum_j \Xi_{ij} \tau_j \left(N_{ij}\right)^{1-\sigma} \alpha_{ij} E_j} \end{aligned}$$

So substitute in for revenues r_i and r_{ik} to write:

$$\frac{w N_{ik}}{r_i} = \frac{\sigma-1}{\sigma} \frac{N_{ik}}{\sum_j N_{ij}} + \frac{r_{ik}}{r_i} \frac{1-\sigma}{\sigma} \frac{\partial \log \tau_k (N_{ik})}{\partial \log N_{ik}} - \frac{\partial f_k (N_{ik})}{\partial N_{ik}} \frac{N_{ik}}{r_i}$$

And assuming a value for σ, we can move the first term to the left hand side,

$$\frac{w N_{ik}}{r_i} - \frac{\sigma-1}{\sigma} \frac{N_{ik}}{\sum_j N_{ij}} = \frac{r_{ik}}{r_i} \frac{1-\sigma}{\sigma} \frac{\partial \log \tau_k (N_{ik})}{\partial \log N_{ik}} - \frac{\partial f_k (N_{ik})}{\partial N_{ik}} \frac{N_{ik}}{r_i} \tag{C.12}$$

Equation (C.12) forms the basis for estimating the causal effect of immigrant employment on a firm's export sales to destination *k*.

Curriculum Vitae

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