

Migration and Unemployment: A Search Modeling Approach

by

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In my job market paper, I examine the role of migration in determining unemployment levels in a search model with migration. Search models have been used extensively to explain differences in unemployment rates, and are often used to compare labor markets across countries. However, much of what we know about labor markets in developed economies ignores who is moving for what reasons, and is largely limited to within-country studies, despite evidence that migration is increasing over time. I build a theoretical model to follow workers' employment status and location, and utilize differences in labor market institutions to show that capturing these worker flows across borders is an important aspect of migration and unemployment that has been largely ignored. This sheds light on the considerations workers take when moving and highlights the role labor market structures play in equilibrium unemployment across countries. An application of the model shows that the model is capable of generating large migration flows comparable to between US states, as well as smaller flows as observed between European countries.

In my second paper, I expand upon the model in my job market paper to add costs to migrants' decisions to move and be away from home. Migration across national borders is not a costless endeavor for workers to undertake. They face fixed costs to move, and flow costs while abroad. Workers report salience of language barriers, housing markets, and cultural distance in preventing them from making an otherwise desirable move across national borders. Incorporating these costs into a model of labor search with migration improves the model's performance relative to a similar model without costs when using European labor markets as an example. The model is also more realistic than models without migration involving meaningfully disparate origins and destinations, or without any migration. Under the context of costly migration, I provide evidence that at least one explanation for the insufficiency of a single labor market in the EU to ensure full convergence of labor market conditions lies in the costs workers face from living away from home, and not from a lack of

migration.

In my third paper, I eliminate restrictions on workers from the model in my first two papers and allow all workers to move freely. In this environment, all workers face competition from other groups, as well as costs to their movement. Labor search and migration allows for the study of the effect of labor market characteristics on equilibrium migration, unemployment, and wages. I provide a theoretical model to explain why countries have different unemployment rates despite similarities in other factors, and a mechanism for the differentiated wage impacts of immigrants on both sending and receiving labor markets.

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Contents

1	A Search Model of Migration & Unemployment	1
1.1	Introduction	1
1.2	Model	8
1.2.1	Model Environment	8
1.2.2	Equilibrium	12
1.2.3	Comparative Statics	16
1.2.4	Parameterization	19
1.2.5	A Numerical Experiment	20
1.3	Efficient Allocations	26
1.3.1	Comparative Statics	28
1.3.2	Parameterization	28
1.3.3	A Second Numerical Experiment	29
1.3.4	Comparison of the Market and Planner's Problem	32
1.4	An Application of the Model	34
1.5	Conclusion	37
2	Labor Market Search with Migration: Unbundling Cost Mechanisms	39
2.1	Introduction	39
2.2	Model	45
2.2.1	Discrimination	48

2.2.2	Non-Discrimination	61
2.2.3	Discrimination vs Non-Discrimination	71
2.2.4	Efficient Allocations	76
2.2.5	Planner vs Non-Discrimination	82
2.3	Approximating the Data	84
2.4	Conclusion	87
3	International Migration: Unemployment Differences and Costs to Move	90
3.1	Introduction	90
3.2	Related Literature	93
3.3	Model	95
3.3.1	Workers	97
3.3.2	Firms	97
3.3.3	Equilibrium	98
3.4	Parameterization and Numerical Exercises	100
3.4.1	Numerical Exercises	100
3.5	Conclusion	104
4	Appendix	110
4.0.1	Country Classifications	110
4.0.2	Other Figures	111
4.0.3	Discrimination	113
4.0.4	A Search Model of Migration & Unemployment Equilibrium Values .	134
4.0.5	Labor Market Search with Migration: Unbundling Cost Mechanisms Equilibrium Solutions	136
4.0.6	International Migration: Unemployment Differences and Costs to Move Equilibrium Solutions & Figures	140

List of Tables

1.1	Average Unemployment Variation Over Time	2
1.2	Worker Categorizations	15
1.3	Baseline Parameterization	19
1.4	Parameters	36
1.5	Outcomes	36
2.1	Baseline Parameterization	53
2.2	Approximation of Data Parameterization	85
2.3	Approximation of Equilibrium Values	86
3.1	Average Within Year Variation Unemployment Over Time	92
3.2	Worker Categorizations	96
3.3	Parameters	101
3.4	Parameters Cont.	101
3.5	Outcomes	102

List of Figures

1.1	Intra-Schengen Cross-Border Labor Migration, Percentage of Sending Population	3
1.2	Labor Supply and Demand	13
1.3	Worker Flows	14
1.4	Wage and Market Tightness Comparative Statics Example: Increase in Productivity	17
1.5	Non-Discrimination Changing Initial Population	21
1.6	Non-Discrimination Changing Productivity	22
1.7	Non-Discrimination Posting and Maintenance Costs Changing	23
1.8	Non-Discrimination Changing Unemployment Benefits	24
1.9	Non-Discrimination Changing Bargaining Power	25
1.10	Planner Changing Initial Population	29
1.11	Planner Changing Productivity	30
1.12	Planner Posting and Maintenance Costs Changing	30
1.13	Planner Changing Unemployment Benefits	31
1.14	Planner Changing Bargaining Power	31
2.1	Global Unemployment Rates and Variation	40
2.2	Intra-EU Labor Migration by Region	41
2.3	Source: Europa	41
2.4	Full Discrimination Move Costs (Leaving)	55

2.5	Full Discrimination Move Costs (Returning)	56
2.6	Full Discrimination Flow Costs	57
2.7	Full Discrimination Changing Productivity	58
2.8	Full Discrimination Posting and Maintenance Costs Changing	59
2.9	Full Discrimination Changing Unemployment Benefits	60
2.10	Full Discrimination Changing Bargaining Power	61
2.11	Non-Discrimination Move Costs (Leaving)	67
2.12	Non-Discrimination Move Costs (Returning)	68
2.13	Non-Discrimination Flow Costs	69
2.14	Non-Discrimination Changing Productivity	70
2.15	Non-Discrimination Posting and Maintenance Costs Changing	71
2.16	Non-Discrimination Changing Unemployment Benefits	72
2.17	Non-Discrimination Changing Bargaining Power	73
2.18	Planner Move Costs (Leaving)	78
2.19	Planner Move Costs (Returning)	79
2.20	Planner Flow Costs	79
2.21	Planner Changing Productivity	80
2.22	Planner Posting and Maintenance Costs Changing	81
2.23	Planner Changing Unemployment Benefits	81
2.24	Planner Changing Bargaining Power	82
3.1	Intra-EU Cross-Border Labor Migration	92
3.2	US-Canada Cross-Border Labor Migration	93
4.1	Unemployment Rates and Variation with Averages	111
4.2	Unemployment Rates and Variation Alternate Averages	111
4.3	EU Unemployment Rates and Variation	112
4.4	Euro Zone Unemployment Rates and Variation	112

4.5	Worker Flows	116
4.6	Full Discrimination Changing Initial Population	131
4.7	Full Discrimination Changing Productivity	132
4.8	Full Discrimination Posting and Maintenance Costs Changing	132
4.9	Full Discrimination Changing Unemployment Benefits	133
4.10	Full Discrimination Changing Bargaining Power	133

Chapter 1

A Search Model of Migration & Unemployment

1.1 Introduction

Search models have been used extensively to explain differences in unemployment rates, and are often used to compare structural differences across labor markets. These comparisons, however, ignore significant amounts of migration across national borders. Additionally, much of what we know about labor markets in developed economies at a theoretical level is largely limited to within country studies.

A frequent application of search and matching models is to generate cross-country differences in unemployment rates by calibration of a single-country model to match structural characteristics. These structural differences then result in differences in unemployment rates. Significant differences in labor market conditions across space are indeed present throughout the recent past. As an example, I use the context of US and European labor markets to illustrate a series of stylized facts. Shown in Table 1.1, unemployment across the US and between European countries varies over time, as measured by the variation across states/countries in a given year. Taking the average within-year variation over the last 36 years, the US

has much lower differences in unemployment rates across states than is seen across European countries. Importantly, this pattern remains regardless of the subset of time periods or countries chosen, and is not undermined by a core group of European economies (France, Germany, and Italy), or by the euro zone countries.¹

Table 1.1: Average Unemployment Variation Over Time

Geographic Area	1983-2015	1983-1995	1995-2008	2008-2015
US	2.282	3.137	1.176	2.653
Schengen	17.578	16.209	15.082	23.186
EU	21.091	23.741	16.706	22.858
Euro	20.342	22.669	14.149	25.883
France, Germany, Italy	22.661	23.386	21.551	22.618

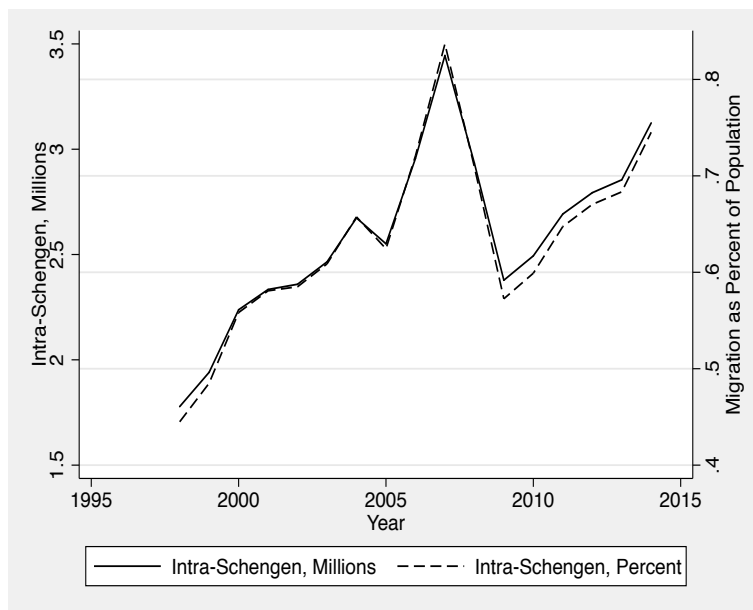
Source: FRED and Eurostat; Values are Within-Year Variation Averaged for the Given Spans

One explanation for this difference in unemployment rates is the structural similarities in labor markets across US states relative to European countries. If labor market characteristics are more similar, we would expect to see more similar labor market outcomes through time. Certainly fewer differences in labor market structures exist within the US than across European countries. During this time, however, European nations saw a dramatic increase in legislative changes pushing for convergence in labor market policies across national borders. For European Union (EU) countries, in particular, these changes were mandated and implemented quickly. Given that there is only a small decline in the variation in unemployment through time, regulatory unification doesn't seem to be the only driver of differences in unemployment rates.

A second common explanation for aggregate convergence in unemployment rates is migration. Perfectly mobile labor should work to equalize unemployment rates across space,

¹The Schengen countries are: Austria, Belgium, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Slovakia, Slovenia, Spain, Sweden, Switzerland, Lichtenstein. EU countries are: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, United Kingdom. Euro zone countries are: Austria, Belgium, Cyprus, Estonia, Finland, France, Germany, Greece, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Portugal, Slovakia, Slovenia, Spain.

Figure 1.1: Intra-Schengen Cross-Border Labor Migration, Percentage of Sending Population



Source: Eurostat

all else equal. Cross-state migration in the US is higher than across Europe: on average, about 5% of US workers move across a state border each year (Bonin et al. (2008)). Figure 1.1 shows that in Europe, migration has increased over time in terms of both total numbers moving, and the percentage of the population for Schengen Agreement countries.² Migration in the Schengen area goes from almost zero prior to 1998, to almost 1% of the population each year by 2015. The upward trend is reversed briefly during the financial and euro zone crises, but resumes following the resolution of the Greek debt crisis in 2010.

Despite the increased labor mobility across Europe since the late 20th century, unemployment variation persists. A small decline in unemployment variation can be seen in Table 1.1 as migration flows increased for the years following the Schengen Agreement in 1995 until the global financial crisis. There is a relationship between migration and unemployment rate variation as evidenced by relatively high-migration, low unemployment variation in the

²The Schengen Agreement opened up European countries to visa-free movement of labor for all member citizens, and eliminated almost all legal barriers to movement across much of Europe. A similar, more exaggerated pattern is evident for EU and euro zone countries shown in Appendix 4.0.2 Figures 4.3 and 4.4.

US and low migration, high unemployment variation in Europe. The lack of cross-border labor mobility in theoretical search and matching models limits understanding of labor market conditions in an increasingly globalized economy. Coupled with remaining differences in labor market characteristics like productivity, unemployment benefits, and labor market flexibility, migration in the context of search and matching provides an avenue for further analysis. There are also public policy implications from outlining factors to encourage (or discourage) migration, and potentially lower unemployment rates.

For this reason, I build a theoretical model that embeds the relationship between migration, unemployment, and labor market structures. This paper embeds both the ability and decision to migrate in the classical Diamond, Mortensen, and Pissarides search model of unemployment. I utilize differences in labor market institutions across countries to show that capturing the subsequent worker flows across borders is an important aspect of migration and unemployment that has been overlooked. The tradeoffs workers face in the search and migration decision in turn generate migration flows and unemployment rate differences across space in equilibrium. General equilibrium impacts of potential differences in labor market structures from migration on worker allocations and employment are also captured using this framework.

The contribution of this paper is to join the study of unemployment, migration incentives, and wage dispersion by providing a framework to evaluate competing empirical estimations. Additionally, the search and migration framework here is ideally suited to simultaneously examine the sending and receiving country outcomes while separating out general equilibrium employment and wage effects on both natives and migrants. Existing search and matching literature is limited in the scope of analysis of the role of migration, and focuses largely on intra-country migration across regions within a single country. As such it is unable to evaluate the role of structural differences across labor markets in catalyzing or diminishing the equalizing unemployment rates across space, and is limited in its ability to address the importance of real and/or perceived barriers to movement. Migration literature on the other

hand, focuses on the expected value of a job, the effects on wages of natives and migrants, or the selection of a particular type of migrant. This thread of the literature lacks a unified framework to address the probability and value of a particular match occurring, the wage dispersion effects in the origin and destination countries, and the general equilibrium effects of migration on firm and worker incentives in the presence of frictions. This paper seeks to fill this void in our understanding of the relationship between migration and unemployment at the national level.

In the theoretical model presented here I emphasize the role that even small differences in labor market structures like productivity, job posting and maintenance costs to firms, unemployment benefits, and workers' bargaining power play in determining variation in unemployment across countries. Workers face a tradeoff in searching; they are faced with a combination of the expected value of a job and the probability of matching with that job. These characteristics are inversely related: a high value job receives more interest from all workers, lowering the probability any given worker matches with that job. Workers do not internalize this externality when making search decisions. This is a key feature of my model, and search and matching models more generally.

Using a competitive equilibrium characterization and a planner's problem, I distinguish between market outcomes and the first-best outcome to compare model predictions. I also provide an example of parameterizations of the model to match a high-migration, low unemployment variation equilibrium and a low-migration, high unemployment variation equilibrium to demonstrate the model's predictive powers qualitatively.

I find that productivity and unemployment benefit differentials can be more important in driving the differences in labor market conditions than previous work has found.³ One reason I observe a larger impact is the ability to observe each workers' movements where other models focus only on market tightness, which changes differently from unemployment and worker allocation across countries. There are also large differences in which workers are impacted

³See Nickell (1997, 2006).

from structural differences in terms of the impact on migrant and native unemployment rates and wages. For this reason I pay particular attention to population distribution and unemployment across countries in addition to the standard emphasis on market tightness.

The study of migration follows a long line of research ranging from factor allocation models of trade to geographic gravity models and networks. A major focus of theoretical models has been on expected income, wages, or amenities in determining workers' movements. For examples, see Harris and Todaro (1970), Becker (1974), and Greenwood (1985). Much of this research has emphasized the influence of expected wages on migration, but I am unaware of any that utilizes labor market differences to explore unemployment in the context of labor migration between two countries.

Utilizing the search framework in the context of labor migration enables the study of cross-border labor market differences, and the impacts of an increasingly mobile labor force. A theoretical model that allows for many differences between labor markets is an important part of understanding differences in labor market conditions, particularly when conditions might be expected to be more similar. A first step for this analysis has been to document and explain migration within-countries.

Single-market matching can work fairly well empirically to predict within-country unemployment variation (Epstein (2012), Postel-Vinay and Robin (2002)), but European models focusing primarily on within-country and between-country comparisons miss the millions of EU citizens moving across European borders each year.⁴

Focusing instead on segmented labor markets, as seen in Albrecht and Vroman (2002) and Blázquez and Jansen (2003) and others, can be helpful as an additional intermediate step between a truly single labor market and a model of multiple countries with migration without the complication that multiple markets entails. Stavrunova (2007) and Gautier (2002) analyze the impact of job heterogeneity on labor market outcomes through search externalities

⁴For examples of within-country, European studies see Postel-Vinay and Robin (2002), Gautier (2002), Scarpetta (1996), Jolivet et al. (2006), Nickell (2006), Ridder and Berg (2003), Brücker et al. (2014), Bonthuis et al. (2015), or Hatton and Tani (2005).

and unemployment rates within a single labor market. Lkhagvasuren (2012) utilizes productivity shocks to generate migration between regions in equilibrium, but uses labor market structural parameters to calibrate a model to match US unemployment rates and correlation between unemployment rates across states rather than looking directly at the impacts from changes in those characteristics. Ridder and Berg (2003) and Schmutz and Sidibé (2015) estimate implied labor market search frictions for migration within individual countries, and across cities within a single country, to better understand the matching mechanism at work within countries' labor markets. Additionally, Ortega and Peri (2013) use OECD data to examine the effects of income and immigration policies on migration across OECD countries empirically, without emphasizing other institutional differences across boundaries or employment outcomes. The absence thus far of such a theoretical framework for international migration through labor market search limits our understanding of migrants' decisions, and their impacts on both origin and destination markets.

Search models are also useful to examine the existence of wage dispersion in economies, but have typically relied on either search costs or worker heterogeneity to generate different wages in equilibrium. For example, Gaumont et al. (2005) are able to generate no more than two wages in equilibrium in their models, while Albrecht and Vroman (2002) generates three equilibrium wages in the pooling equilibrium with heterogeneous workers. Existing work is typically limited to generating wages based on either worker or firm heterogeneity.

Empirically, Borjas (1985), Card (1990), Borjas (2003), and Card et al. (2012) capture part of an on-going discussion on the impact of migrants on wages in the receiving countries, but lack a unified theory explaining both disparate wage effects, and migration incentives.⁵ Empirical studies typically must differentiate across workers' skills in order to estimate any effects of migrants on native workers. Migrants are found to have very little impact on native wages as in Card (1990), to pull down native wages in the directly competing native population as in Borjas (2003), or to increase native wages as in Gerfin et al. (2010). Ottaviano and

⁵For selected others, see Butcher and Card (1991), Gerfin et al. (2010), and Ottaviano and Peri (2012).

Peri (2012) finds an important nuance to the wage effect on natives such that least skilled natives see wages fall while slightly higher skilled natives see wages rise following a migrant influx. New immigrants also have a negative effect on previous immigrants' wages.

1.2 Model

1.2.1 Model Environment

The model is in continuous time, and all values represent total flow value for the given agent. Both countries share a single time discount factor for agents, r , as well as job destruction rate, δ .⁶ All workers within a country, regardless of origin and unemployment location, have the same productivity or skill, y_k , based upon location of employment, k . Jobless benefits, b_k , worker bargaining power, β_k , and costs to posting a vacancy, c_k , also vary by country. Differences are determined by the current location of the worker or firm, so a migrant cannot transfer his origin jobless benefit or bargaining power by moving. Migration ability is limited to workers from the foreign country, F , and it is costless both to move and to be away from one's origin country.

Workers can be either employed or unemployed, and firms can have either filled or unfilled vacancies. There is no on-the-job search, and one job is offered by each firm. Firms post a vacancy based on the eventual firm hiring location, independent of the worker origin and unemployment location: They cannot target a particular worker type based on nationality or current location.

Each period, a fixed proportion of matches, δ , is destroyed, and the total unemployment pool begins to search in either the home or foreign market. Next, matches occur with a probability dependent on the number of vacancies offered by firms and the number of workers searching in that market. Newly matched workers move, if necessary. Finally production

⁶This is one margin I have not chosen to exploit in examining the margins of the migration decision, but that could easily be incorporated into the framework by making δ country- or match-specific.

occurs and unemployment benefits for remaining unemployed workers are collected and wages paid. The interdependence of the two labor markets through the unemployment pool builds in the concept of spillovers in the market tightnesses of each market while maintaining the externalities imposed by individuals failing to account for their impacts on each market. The impact of each market on the other through the overlap of market tightness helps to explain the persistence in differences in unemployment rates observed in the data (See Table 1.1). All variables are denoted with a triplet $\{i, j, k\} = H, F$ so that variable X is identified: X_{ij}^k ; where i denotes country of origin, j gives current location, and k gives the location of the job or benefit received.

Matching parameters can vary by worker origin, worker unemployed location, worker employed location, or remain uniform across countries. The probability of matching is independent of search effort, which is costless. The model presented here makes use of the den Haan, Ramey, and Watson form of matching.⁷ Matching brings together unemployed workers and open vacancies in the labor market, and places them randomly into a matched, filled job with an employed worker:

$$M(u_k, v_k) = m(1, \frac{v_k}{u_k})u_k = q_k(\theta_k)u_k. \quad (1.1)$$

Market tightness, $\theta = v/u$, is defined as the ratio of open vacancies to unemployed workers. The probability that an unemployed worker in country k matches with a firm in country k is given by $q_k(\theta_k)$, and the probability that an unfilled vacancy in country k becomes filled is given by $\theta_k q_k(\theta_k)$.

⁷The den Haan, Ramey, and Watson form of matching is chosen in order to utilize the probability limits built into the functional form without adding an additional parameter to the model as it requires only one rather than two as in more traditional Cobb-Douglas matching.

Matching is governed by Z_k , the elasticity of matching in the country of the match:

$$q_k(\theta_k) = (1 + \theta_k^{Z_k})^{-1/Z_k} \quad (1.2)$$

with $\partial q_i / \partial \theta_i < 0$ and $\partial q_i / \partial \theta_j < 0$. Where, i indicates the workers' origin country, j gives the workers' unemployment location, and k indicates the job matching location. Market tightness depends only on firm location, k .

Unemployed workers choose where to search, with the flow value of unemployment equal across searching in either country in equilibrium. This value is determined by workers' country of origin, country of unemployment, and the net value of finding a job in either country:

$$rU_{ij} = b_j + \max_k \{ \theta_k q_k(\theta_k) (N_{ij}^k - U_{ij}^k) \} \quad (1.3)$$

The trade off between job finding rates and the value of that job is seen in the second term. When the value of a job is high, more workers are likely to search in that market, thus offsetting overall value by lowering the job finding rate. These forces off-set one another in equilibrium so that workers become indifferent between markets.

The flow value of employment to the worker, rN , is given by the discounted value of the wage less the value of moving into unemployment in that country:

$$rN_{ij}^k = w_{ij}^k + \delta(U_{ik} - N_{ij}^k) \quad (1.4)$$

Upon loss of employment in country, k , workers gain unemployment benefits, b_k , and the value of unemployment, but lose the wage. These workers begin search in country k , and only move if they are matched in the other country.

Firms choose whether to post a vacancy based on the cost to post as well as the probability weighted value of filling the vacancy and moving into production without differentiating between workers of different location.

This gives the flow value of posting a vacancy, rV :

$$rV_i = -c_i + \frac{q^i(\theta^i)}{(u_{ii} + u_{ij})}[u_{ii}(J_{ii}^i - V_i) + u_{ij}(J_{ij}^i - V_i)] \quad (1.5)$$

in country i , and

$$rV_j = -c_j + \frac{q^j(\theta^j)}{(u_{ii} + u_{ij} + u_{jj})}[u_{ii}(J_{ii}^j - V_j) + u_{ij}(J_{ij}^j - V_j) + u_{jj}(J_{jj}^j - V_j)] \quad (1.6)$$

in country j .

The flow value of a filled vacancy, rJ , to the firm is again the discounted value of productivity less the cost to posting, the wage payment, and the probability weighted value of the match dissolving:

$$rJ_{ij}^k = y_k - w_{ij}^k - c_k + \delta(V_k - J_{ij}^k) \quad (1.7)$$

Wages are bargained based on production surplus for the type of match, S , bargaining power, β , in job location k , and costs to establishing a vacancy, c , in location k . Bargaining partially captures the large power of labor unions in many countries, and allows differences in outside options to migration to be reflected in wages through unemployment values.

Workers employed in country k always receive share β_k of the match surplus, S_{ij}^k , where $S_{ij}^k = J_{ij}^k + N_{ij}^k - U_{ij} - V_{ij}^k$. Thus wages increase whenever total surplus increases, or when β increases (holding the size of the surplus constant):

$$w_{ij}^k = \beta_k S_{ij}^k \quad (1.8)$$

Firms in country k receive share $(1 - \beta_k)$ of the match surplus: $(1 - \beta_k)S_{ij}^k$.

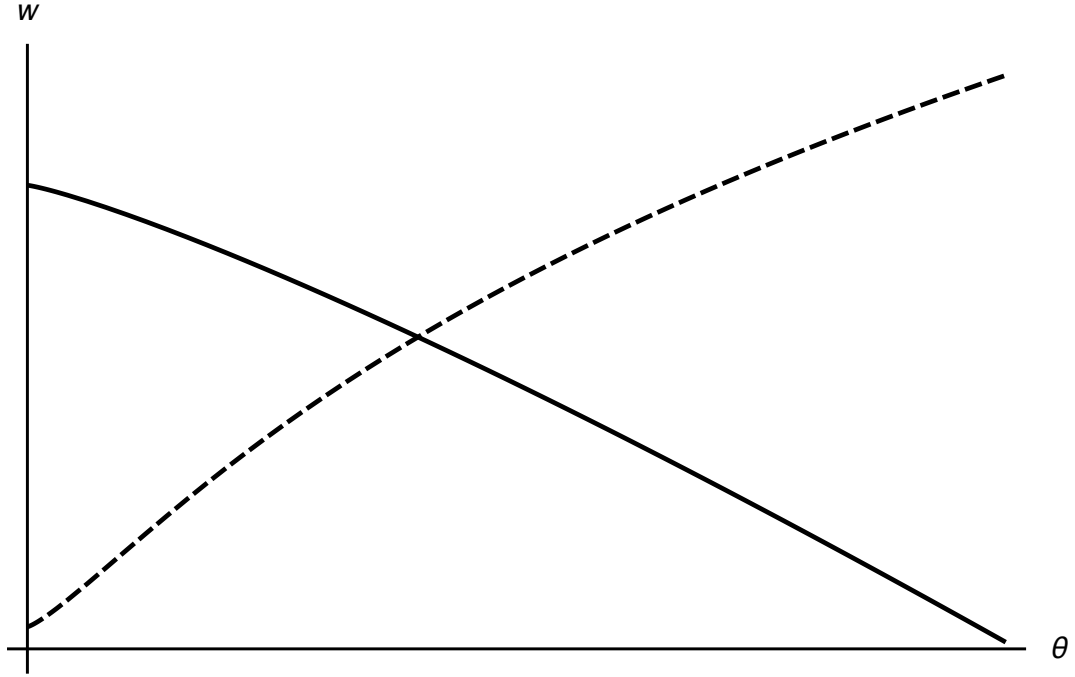
1.2.2 Equilibrium

The equilibrium concept employed here is a stationary equilibrium which is imposed by setting changes in unemployment and population allocations to zero. This means that in equilibrium, flows between countries off-set one another so that the net migration is zero. Gross migration varies based on the relative probabilities of finding a job and the structural differences of the labor markets. The stationary equilibrium can be characterized in terms of market tightness determined by the labor market bargaining for wages and the free-entry condition for firms, $rV = 0$.

Wages can now be described by labor supply and demand equations as functions of parameters and market tightness. Labor demand, $w_{ij}^k = y_k - c_k - \frac{c_k(r+\delta)}{q_k(\theta_k)}$, gives a negative relationship between wages and market tightness. A larger market tightness, θ , lowers the probability the open vacancy will match with a worker, so the wage required for the firm's zero profit condition is lower when θ is larger. For example, increases in productivity increase labor demand, holding other wages and market tightnesses constant. Labor supply for workers, $w_{ij}^k = \beta_k(y_k - c_k) + (1 - \beta_k)rU_{ij}$ given the appropriate rU , gives a positive relationship between wages and market tightness. A larger market tightness increases the probability an unemployed worker meets a vacancy, but also implies a larger value of unemployed workers for firms which increases the eventual wage paid.

The determination of the wages and market tightness for a typical market can be seen by plotting the labor supply and demand schedules as in Figure 1.2. In the stationary equilibrium, market tightness is determined by the firms' and workers' optimization, before accounting for particular migration conditions. The effects of changes in parameters on equilibrium wages and market tightness work through shifts in the labor supply or demand decision, and are shown in the comparative statics below.

Figure 1.2: Labor Supply and Demand



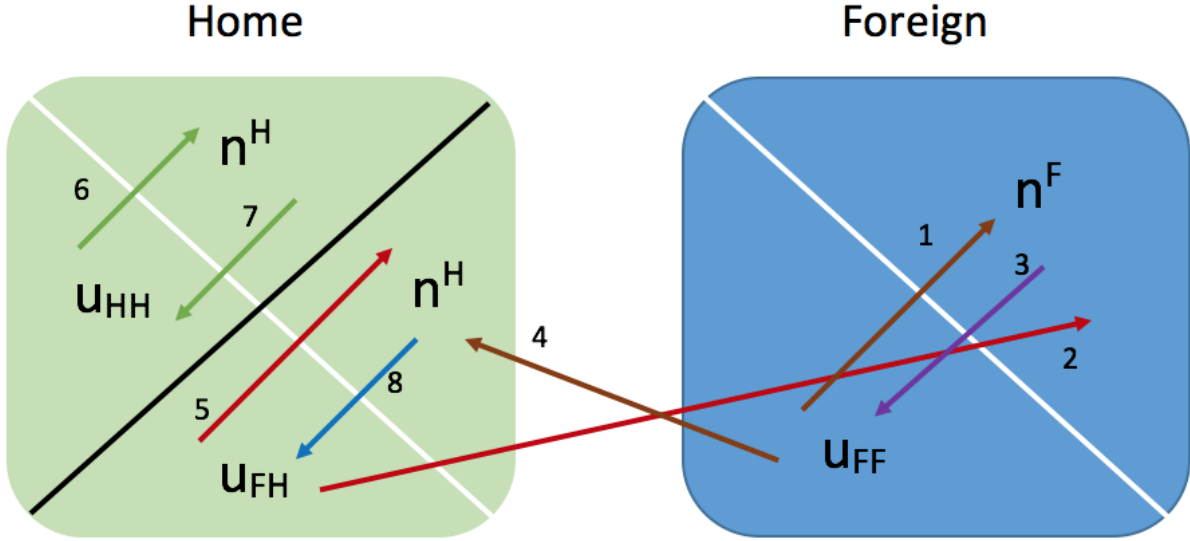
Market tightness is defined for each country as:

$$\theta_F = \frac{v_F}{u_{FF} + u_{FH}} \quad (1.9)$$

$$\theta_H = \frac{v_H}{u_{FF} + u_{FH} + u_H} \quad (1.10)$$

The market tightnesses depend on overlapping subsets of the unemployment pool. In search and matching models without migration, population is normalized to 1 so that v and u are both the vacancy (unemployment) level and rate. Here, migration means that equilibrium populations are not necessarily 1, and so v and u reflect the levels only. Figure 1.3 shows the flows of workers across employment status and migration patterns.

Figure 1.3: Worker Flows
Non-Discrimination



Equality of job creation and destruction at the country-level is given by two conditions. Equation 1.11 represents the flow out of employment for foreign workers into employment in the foreign country on the left hand side, and the flow out of foreign employment on the right hand side. The left hand side of Equation 1.11 is represented in Figure 1.3 by the summation of arrows 1 and 2. The right hand side is represented by arrow 3. Equation 1.12 equates the flow into and out of employment in the home country. The right hand side of Equation 1.12 is represented in Figure 1.3 by the summation of arrows 4, 5, and 6. The right hand side is represented by arrows 7 and 8.

$$\theta_F q^F(\theta_F)(u_{FF} + u_{FH}) = \delta n_F \quad (1.11)$$

$$\theta_H q^H(\theta_H)(u_{FF} + u_{FH} + u_H) = \delta n_H \quad (1.12)$$

The number of migrants into each country must equal the number of migrants out to keep population constant in equilibrium: Equation 1.13 is represented in the bottom panel

of Figure 1.3 by the equality of arrow 2 and 4.⁸

$$\theta_F q^F(\theta_F) u_{FH} = \theta_H q^H(\theta_H) u_{FF} \quad (1.13)$$

In the remainder of the paper, workers are categorized as either foreign stayers, prior foreign migrants, foreign returning migrants, new migrants, or home workers. A foreign stayer is a foreign national who spent his/her previous unemployment spell in the foreign country, and is subsequently matched in the foreign country. A prior foreign migrant is a foreign native who migrated to the home country prior to his most recent unemployment spell, and subsequently matches in the home country. A returning migrant is a worker who previously migrated to the home country, lost employment, and subsequently matches in the foreign country. A home worker is always employed and unemployed in the home country due to the migration constraint on those workers. Employed workers are characterized as foreign workers, foreign migrant workers, or home workers. Foreign workers are foreign nationals employed in the foreign country. Foreign migrants are foreign nationals employed in the home country. Home workers are home nationals employed in the home country. This is summarized in Table 1.2.

Table 1.2: Worker Categorizations

Category	Nationality	Most Recent Unemployment	Most Recent Employment	Next Employment	Migrating for Employment?
Foreign Stayer	F	F	F	F	No
Prior Foreign Migrant	F	H	H	H	No
Foreign Returning Migrant	F	H	H	F	Yes
New Migrant	F	F	F	H	Yes
Home Worker	H	H	H	H	No

Initial populations in each country are the number of staying employed and unemployed, plus the number who have moved and either remain employed or who have lost employment

⁸This does not imply that populations must be equal.

and are unemployed abroad. Initial populations are given by:

$$P_o^F = u_{FF} + u_{FH} + n_F + \frac{\theta_H q^H(\theta_H)(u_{FF} + u_{FH})}{\delta} \quad (1.14)$$

$$P_o^H = u_H + \frac{\theta_H q^H(\theta_H)u_{HH}}{\delta} \quad (1.15)$$

Given the overlap of the markets, it can be difficult to track workers' movements and employment status. Workers employed in the home country must be divided into the two origin groups by inference rather than explicitly.

1.2.3 Comparative Statics

The effects on labor market conditions from changes in parameter values filters through the firms' and workers' optimization problems. First, parameters determine the equilibrium wage and market tightness. Then, the migration and job creation and destruction conditions determine unemployment and worker allocations. The effect of parameter changes on labor supply and demand on market tightnesses and wages, and subsequent effects on unemployment and migration are shown in two steps. I separate across labor supply and demand effects on market tightness and wages, evaluate the overall effect, and follow with the impact on unemployment for workers from changes in market tightness.

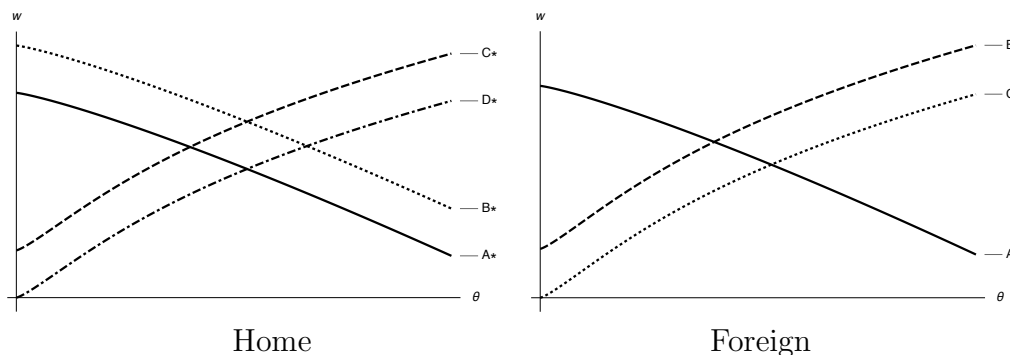
Increasing productivity or decreasing posting and maintenance costs increases the demand for labor for all types of workers. Specifically, increasing foreign productivity (decreasing posting and maintenance costs) increases demand for all matches in the foreign country, without changing the demand for home workers. Increasing home productivity (decreasing posting and maintenance costs) increases demand for all matches in the home country.

Increasing home productivity or decreasing posting and maintenance costs increases labor supply for all workers except foreign stayers. Increasing foreign productivity or decreasing posting and maintenance costs increases labor supply for all foreign workers except those

already in the home country.

Combining the supply and demand effects, increasing foreign productivity or decreasing posting and maintenance costs increases foreign market tightness, but has an indeterminate effect on wages. Increasing home productivity or decreasing posting and maintenance costs increases home tightness and also has an indeterminate effect on wages. Figure 1.4 shows this effect for the increase in home productivity on the home market on the left. The labor demand shifts from curve A to curve B while the labor supply shifts from curve C to D. Since both supply and demand have increased, the market tightness in the home market unambiguously increases, but the wage effects depend on which curve shifts more. In the figure, I have given the potential outcome where wages do not change, but this is not necessarily the case for any given change in productivity. In the foreign country, when the home productivity increases, only the labor supply increases. Supply moves from B^* to C^* and labor demand remains unchanged at A^* , thus increasing market tightness and wages in the foreign country, shown on the right of Figure 1.4.

Figure 1.4: Wage and Market Tightness Comparative Statics Example: Increase in Productivity



Increasing foreign unemployment benefits increases the supply of foreign stayers only. Increasing home unemployment benefits increases the supply of all workers except foreign stayers who are unaffected.

Increasing foreign unemployment benefits increases foreign market tightness and lowers wages. Increasing home unemployment benefits increases home market tightness and lowers wages.

Changes in bargaining power have a clear effect on foreign stayers, home workers, and prior migrants. New migrants experience indeterminate effects from changes in bargaining power. Increasing foreign bargaining power decreases labor supply for foreign stayers. Increasing home bargaining power decreases labor supply for home workers and prior migrants.

Increasing foreign bargaining power decreases foreign market tightness and increases wages. Increasing home bargaining power decreases home market tightness and increases wages.

Given the changes in market tightness from parameter changes, I now evaluate the changes in unemployment. When foreign productivity or unemployment benefits increase or posting and maintenance costs decrease, unemployment for foreign stayers decreases as long as home market tightness is sufficiently large. Unemployment for foreign migrants decreases and there is no change in unemployment for home workers. When home productivity or unemployment benefits increase or maintenance costs decrease, unemployment for foreign stayers and home workers decreases. Unemployment for foreign migrants decreases as long as foreign market tightness is sufficiently large.

When foreign bargaining power increases, unemployment for foreign stayers decreases if home market tightness is sufficiently large. Unemployment for foreign migrants increases and unemployment for home workers is unaffected. When home bargaining power increases, unemployment for foreign stayers and home workers increases. Unemployment for foreign migrants decreases if foreign market tightness is sufficiently large.

I now turn to a numerical exercise to give a potential result of these changes in parameters across otherwise symmetric countries.

1.2.4 Parameterization

Given the lack of analytical solution for market tightnesses and the indeterminate comparative statics above, a numerical parameterization of the model is performed. Parameters are chosen both for ease of comparability between the market outcome and the planner's outcome as well as to match data and search and matching literature more generally. In the following exercises, the two countries are given symmetric baseline parameterizations and one parameter in the foreign country is changed to follow the change in stationary equilibrium resulting from that particular asymmetry. This does not describe the transition between the equilibria, but only gives a snapshot of the equilibrium once it has been attained.

The baseline parameterization is chosen for comparability across all specifications of the model. Population, P_o , and productivity, y , are set to one; matching elasticity, Z , is 1.25 to match Petrosky-Nadeau and Zhang (2013); workers' bargaining power, β , and unemployment benefits, b , are 0.5. Costs to firms to posting vacancies, c , are set slightly below the value in Albrecht and Vroman (2002) and Beine et al. (2013) at 0.2, compared with 0.3. The discount rate, δ , is set at 0.05 and the job destruction rate, r , at 0.15 to match the literature. A summary can be found in Table 1.3.⁹

Table 1.3: Baseline Parameterization

Parameter	Value H, F
y	1
b	0.5
c	0.2
β	0.5
Z	1.25
r	0.05
δ	0.15
P	1

⁹Bounds and equilibrium values were found using a multiple complementarity solver in GAMS.

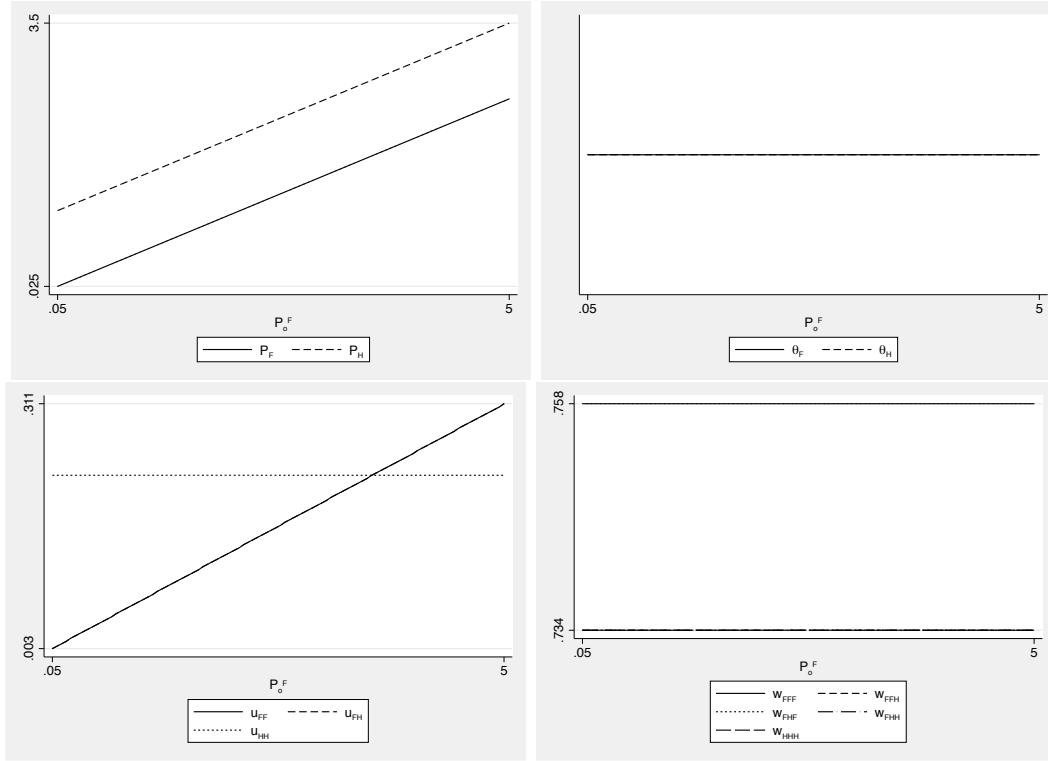
1.2.5 A Numerical Experiment

The home country is set to the baseline parameterization, with one parameter in the foreign country changing at a time. The remaining foreign country parameters are set to the baseline values.

Increasing the initial population in the foreign country doesn't change optimal behavior of firms or workers relatively, but does change allocations of workers (Figure 1.5). Workers from the foreign country migrate to offset greater competition with the increase in the population until the unemployment numbers for foreign workers are equalized across the two countries. Home workers' inability to move keeps them at home, and they are unaffected by the increase in foreign workers due to the increase in vacancies offered keeping the market tightness in the home country constant. Home workers have higher unemployment until the foreign population is triple that of the home population. Wages are unchanged by changes in initial population in the foreign country; however, not all workers receive the same wage. Foreign workers remaining in the foreign country receive a slightly higher wage than other workers.

Figure 1.6 illustrates the impact from an increase in productivity in the foreign country from parity with the home country to quadruple that of the home country. Workers still choose to move even when the foreign country is far more productive, though fewer move as the foreign country becomes increasingly productive. Higher productivity also results in many more vacancies opened in the foreign country as firms seek more workers (second panel). Unemployment for home workers increases in this case, as foreign workers migrate less and firms open fewer vacancies to entice workers due to the high opportunity cost to foreign workers to leave their home country (third panel). Again, home workers always have higher unemployment than foreign workers. Increasing foreign productivity increases wages for foreign workers remaining in the foreign country and new migrants, but decreases wages for home workers and foreign migrants who had their most recent unemployment spell in the home country. Increases are most dramatic for foreign workers who never move followed by

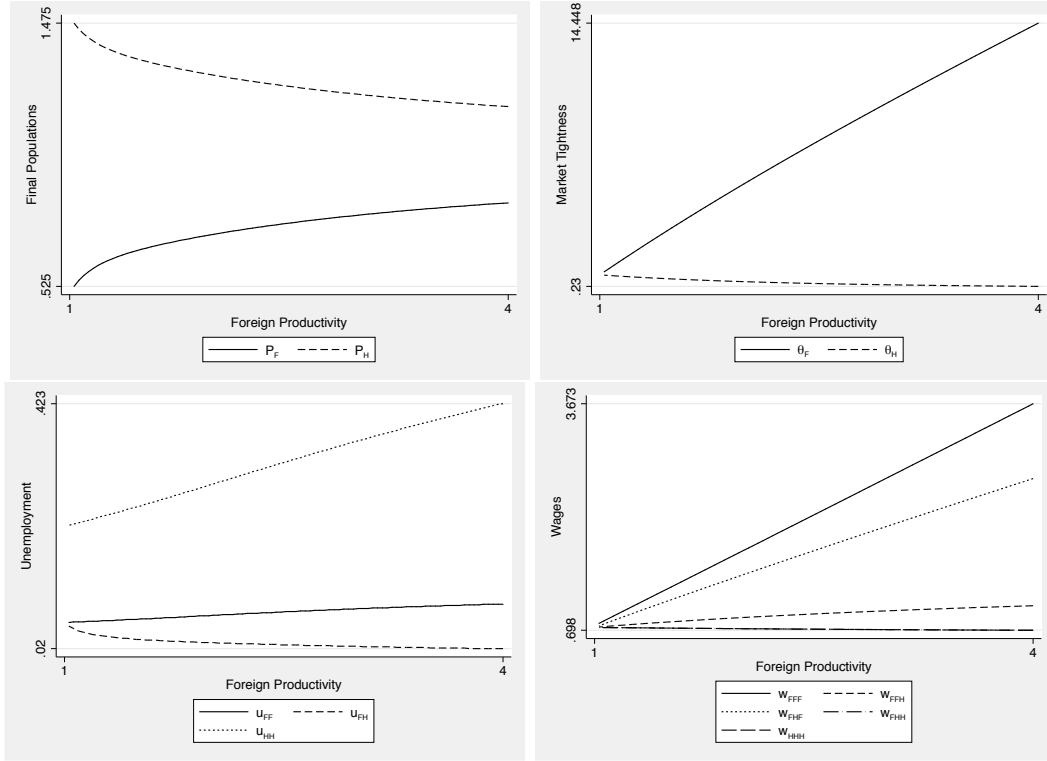
Figure 1.5: Non-Discrimination Changing Initial Population



foreign workers returning from the home country and foreign workers migrating to the home country for the first time.

Moving from costless to very costly (right to left) posting in the foreign country, fewer foreign workers are located in the foreign country until no workers remain when costs absorb approximately one third of the value of production to the firm (Figure 1.7). Market tightness in the home economy does not change since workers move from the foreign country as firms more than compensate by opening more vacancies (second panel). This is contrasted with the case in the foreign country where posting becomes prohibitively costly, and firms post increasingly fewer and fewer new vacancies as the available pool of workers becomes smaller and smaller (first and second panels). Unemployment in the foreign country drops to around 1% at the upper limit of costs, and the unemployment of foreign migrants converges up to meet that of home workers (third panel). Wages decrease with cost increases for foreign workers who never migrate, and for new migrants. The decrease is largest for foreigners who

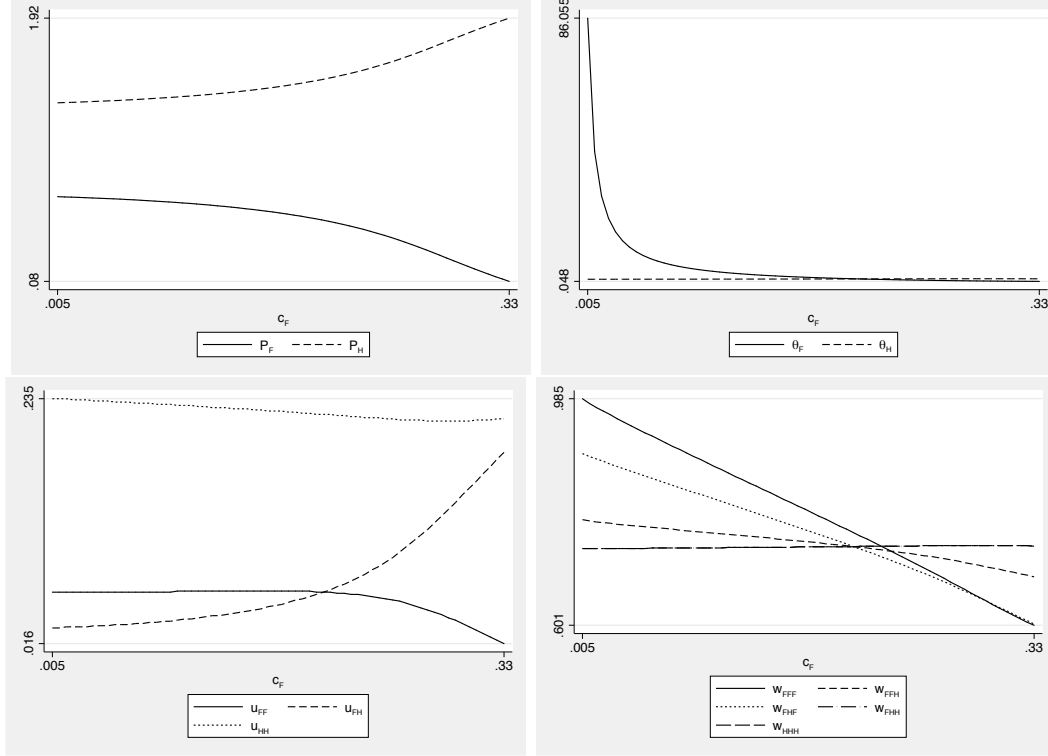
Figure 1.6: Non-Discrimination Changing Productivity



never move followed by returning migrants and then new migrants into the home country. Home workers and foreign workers who migrated prior to their most recent unemployment see a very slight increase in wages once the foreign posting cost is larger than in the home country.

Changes in unemployment benefits have relatively little impact on the equilibrium distribution of workers between countries. As the foreign country becomes more generous, more workers locate in the foreign country, but the change is small, as seen in Figure 1.8. Market tightness in the home country drops by about 25% as firms are less inclined to draw foreign workers who would have a higher outside option in bargaining from the increasingly generous benefits they receive in their native country (second panel). Firms in the foreign country offer relatively more vacancies as benefits increase, but the change is small, and seeks to induce workers to leave unemployment. Unemployment increases for home workers as the number of vacancies falls, increases slightly for foreign stayers as the total foreign population

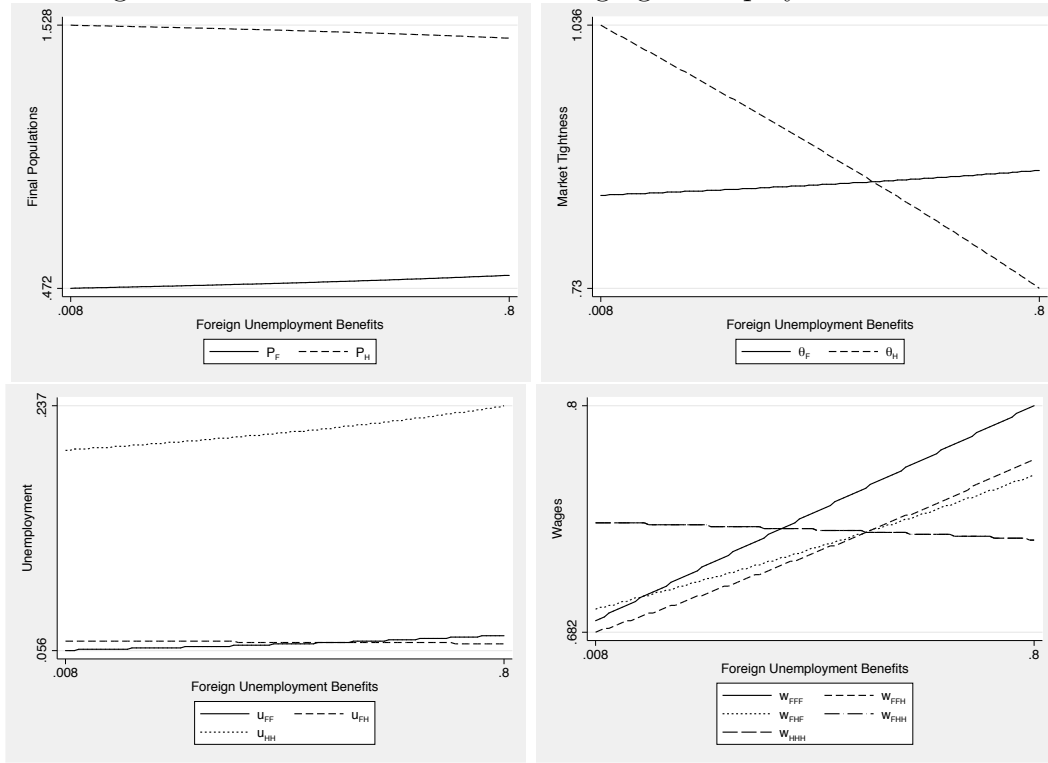
Figure 1.7: Non-Discrimination Posting and Maintenance Costs Changing



increases, and decreases for foreign workers due to lower migration rates from the generosity of foreign unemployment benefits. Foreign workers always have lower unemployment than home workers. This relatively small impact from changes in unemployment benefits supports the empirical evidence put forth in Nickell (1997, 2006). Increasing unemployment benefits results in higher wages for foreign stayers and new migrants with the largest increase accruing to stayers. Home workers and migrants who moved previous to the most recent period of unemployment see a decrease in wages as the foreign country becomes more generous to the unemployed.

When workers in the foreign country gain bargaining power, moving from receiving almost none of the surplus of the match to 86% of the surplus, fewer foreign workers choose to locate in the foreign country until no foreign workers remain (Figure 1.9). This is due to the erosion of firms' incentives to post vacancies where increases in workers' bargaining power in the foreign country mean that home firms have no incentive to maintain open vacancies

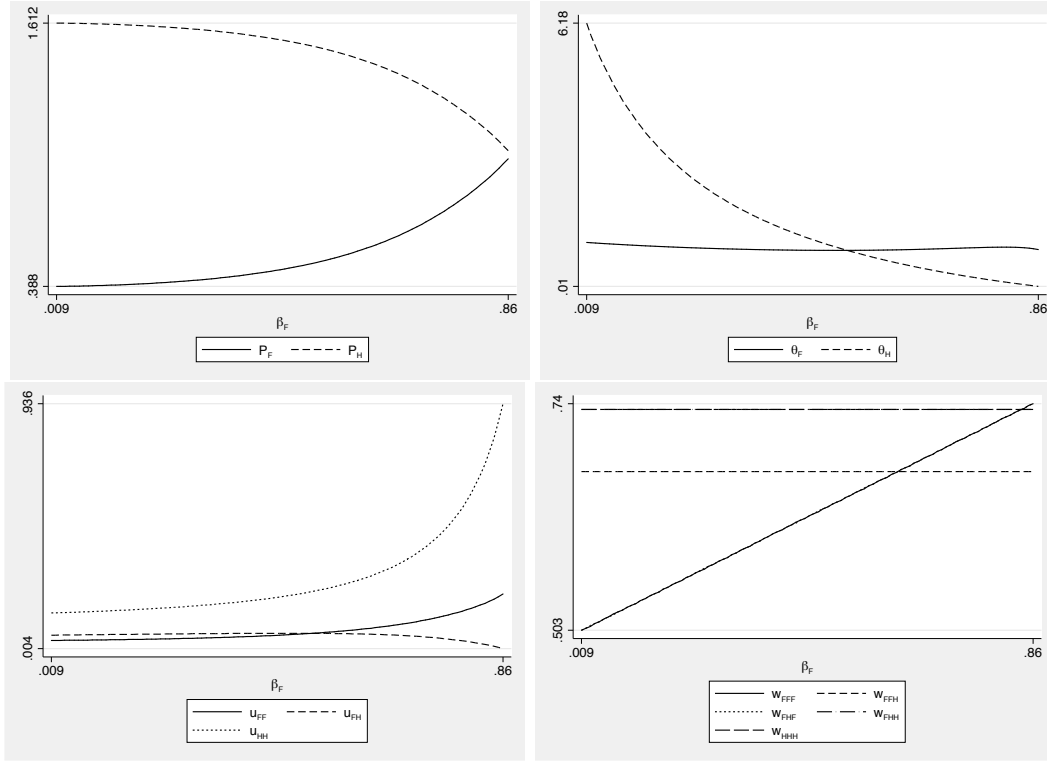
Figure 1.8: Non-Discrimination Changing Unemployment Benefits



when the demand for those positions drops significantly. Foreign firms change their posting behavior relatively little as vacancies increase in line with the larger foreign population. Unemployment is increasing in the home country as fewer vacancies are posted as well as for foreign stayers since the job market becomes more competitive with the population increase from the increased bargaining power. Foreign migrants face lower unemployment due to their dwindling numbers. Wages for foreign stayers and returning migrants increase with the increase in bargaining power while all other workers experience no change in wage. Home workers and foreign workers who migrated previous to the most recent episode of unemployment receive the highest wages until they are surpassed by foreign stayers when bargaining power is greatest. New migrants to the home country are better off than foreign stayers and returning migrants until foreign bargaining power surpasses the power in the home country.

Changes in unemployment benefits have the smallest overall impact on unemployment in

Figure 1.9: Non-Discrimination Changing Bargaining Power



both countries. Productivity, posting costs, and bargaining power can cause large differences in population allocation, unemployment and wages across groups of workers.

When firms are only permitted to post jobs according to the location of the firm, and not using workers' characteristics, home workers are affected by foreign workers' migration decisions. I interpret the increase in home workers' unemployment rates as arising from the crowding out of home workers by foreign workers when the home country is a more desirable place for workers to live. More workers are migrating to the home country on average than is observed in the data.¹⁰ The inability of home workers to leave the home market means that the unemployment predicted by the model is an upper bound on the negative effects on home workers' unemployment from migrants. While home workers and foreign migrants who were in the home country during the last unemployment experience are relatively unaffected

¹⁰Near the bounds of some parameterizations, fewer workers will migrate in the model than in the data, but these are often caused by unrealistic parameter values, i.e. workers are four times as productive in the foreign country as in the home country.

by changes in foreign country parameters. This is in contrast to other workers who are often compensated for disadvantages from lower surplus, bargaining power, or benefits.

A modification of the market equilibrium can be made to allow firms to target a particular subset of workers. I refer to this as discrimination. This is not meant to be discrimination in the idiomatic sense. Discrimination in this world is defined such that the employer chooses to open a position to workers based on worker country of origin and current unemployment location. This makes the equilibrium segmented, and is the most restricted version of the model. Discrimination in this sense is not completely unrealistic: firms looking to post a vacancy may want to search specifically for skills known to be possessed by a subset of the unemployed that would limit potential applicants to only foreign migrants. Even though the constrained nature of the discrimination set-up may not represent real world employment and migration decisions, it establishes a baseline model to describe a worker's migration decision based on varying labor market characteristics. For a full description of the model environment, comparative statics, and numerical experiments, see Appendix 4.0.3.

1.3 Efficient Allocations

Next, I consider the allocation of workers and their employment status, across the two countries by a benevolent social planner.

Typically in models of labor search and matching, it is possible to evaluate welfare and efficiency of the market outcome by comparing the workers' bargaining power in the market outcome to the elasticity of the matching function. When the two match, this is known as the Hosios condition for efficiency of the market equilibrium given the search frictions the planner faces.¹¹ There are a number reasons this is not possible here. The first reason is that the markets here are not symmetric. In contrast to Davis et al. (1996), the ex ante separation of markets via geography does not allow for a comparison due to the ability of workers to effectively change their type by migrating. It is also not possible to reach the

¹¹See Hosios (1990).

equivalent condition for each market individually due to market and worker heterogeneity, and worker ability to change type.¹²

The planner's objective is to maximize total social surplus shared between firms and workers without prioritizing how the surplus is divided. The planner is subject to the same matching frictions as in the competitive equilibrium, and faces the same costs to posting jobs.

The planner maximizes:

$$\int_0^\infty e^{-rt} [(y_F - c_F)n_{FF} + (y_H - c_H)(n_{FH} + n_{HH}) + b_F u_{FF} + b_H(u_{FF} + u_{FH}) - c_F \theta_F(u_{FF} + u_{FH}) - c_H \theta_H(u_{FF} + u_{FH} + u_{HH})] \quad (1.16)$$

The first four terms are the net benefits for workers from a given allocation across space and employment. The final two terms are the costs of unfilled vacancies to society.

The planner is subject to the laws of motion for unemployment:

$$\dot{u}_{FF} = \delta n_F - \theta_F q_F u_{FF} \quad (1.17)$$

$$\dot{u}_{FH} = \delta n_{FH} - \theta_F q_F u_{FH} - \theta_H q_H u_{FH} \quad (1.18)$$

$$\dot{u}_{HH} = \delta n_{HH} - \theta_H q_H u_{HH} \quad (1.19)$$

$$\dot{n}_{FF} = \theta_F q_F (u_{FF} + u_{FH}) - \delta n_{FF} \quad (1.20)$$

$$\dot{n}_{FH} = \theta_H q_H (u_{FF} + u_{FH}) - \delta n_{FH} \quad (1.21)$$

$$\dot{n}_{HH} = \theta_H q_H u_{HH} - \delta n_{HH} \quad (1.22)$$

¹²A second reason is that the den Haan, Ramey and Watson matching function employed does not yield a comparable functional statistic for the first derivative as in the commonly used Cobb-Douglas form for the Hosios condition. Even with a Cobb-Douglas matching function, it is not analytically possible to reduce the free-entry conditions for firms to compare across the planner's allocation and the market allocation in equilibrium as is typically done. If a Cobb-Douglas matching function were used in the context of this paper, the equality of workers' bargaining power and the elasticity of the matching function does not yield a first-best outcome because of the asymmetry of the markets.

These six constraints represent the same evolution of employment and unemployment as in the competitive equilibrium. The planner is also subject to the same equilibrium conditions as in the market equilibrium on population, market tightness definitions, and migration which ensure a stationary equilibrium Equations (1.9 - 1.15). These equations match the flow descriptions in the market outcome. The difference in the planner's allocations all work through the choice of market tightness before migration conditions are imposed.

Wages are determined exactly as in the competitive equilibrium models shown in equation (4.5), with firms and workers sharing the surplus of the match according to worker's bargaining productivity, β_k while firms in country k receive $(1 - \beta_k)$ of the match surplus, although the planner is indifferent to the sharing rule, β .

1.3.1 Comparative Statics

Comparative statics for changes in parameters under the planner are identical to those for the market equilibrium. The planner is subject to the same laws of motion for job turnover and migration conditions. The difference lies in that the planner will choose different market tightnesses from the competitive equilibrium outlined above.

Once again, a numerical experiment is used to show how the planner's allocations differ from those of the market behaviors.

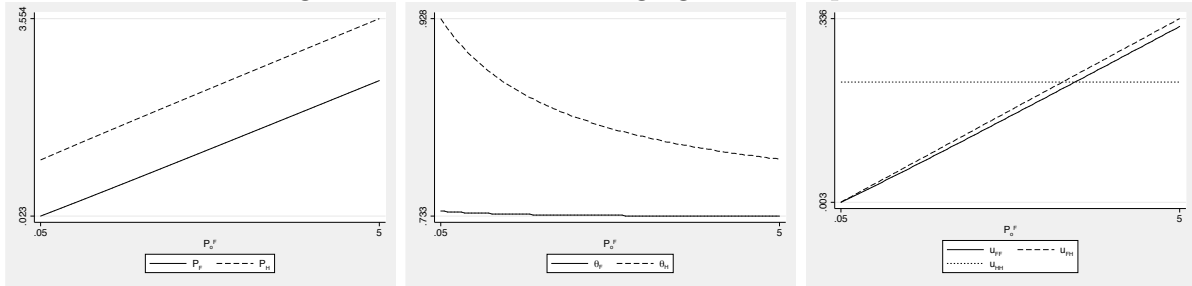
1.3.2 Parameterization

Again, I use the same baseline parameterization from the competitive equilibria to better understand how the planner allocates jobs, and employed and unemployed workers across countries.

1.3.3 A Second Numerical Experiment

Allocation of equilibrium population between countries is the same under the planner as in the competitive equilibrium when the initial population of the foreign country is increased (Figure 1.10). Since all other parameters between the countries are symmetric, the planner chooses the same equilibrium population allocation dynamic as both competitive markets. The planner chooses to open more vacancies in the home country when the foreign population is smaller than the home population, and adds fewer additional vacancies as the foreign population surpasses that of the home country (second panel). Migrant workers face slightly higher unemployment than the foreign workers who remain in the foreign country. This is due to the planner partially internalizing the extra crowding that happens when workers relocate to the home country. Foreign workers face increasing unemployment as they become less scarce; home workers' unemployment is not affected, but is higher than for foreign workers until there are three times as many foreign workers as home workers.

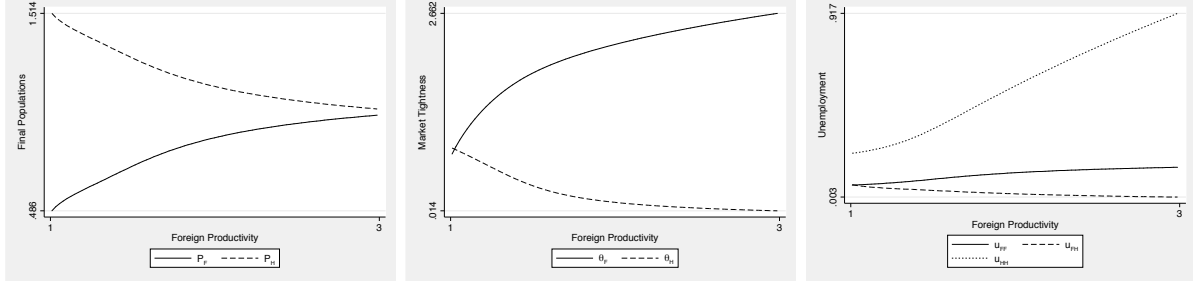
Figure 1.10: Planner Changing Initial Population



As foreign firms' productivity increases, the planner moves fewer workers to the home country. Once the foreign firms are three times as productive, the planner has equal numbers of workers in each country. This maximizes total match surplus since the foreign matches are significantly more productive than home matches. Figure 1.11 shows that workers are compensated for the comparatively larger population, with more open vacancies as more productive matches generate more social surplus from matching. Unemployment is increasing for home workers as the planner opens fewer vacancies in the less productive country, and

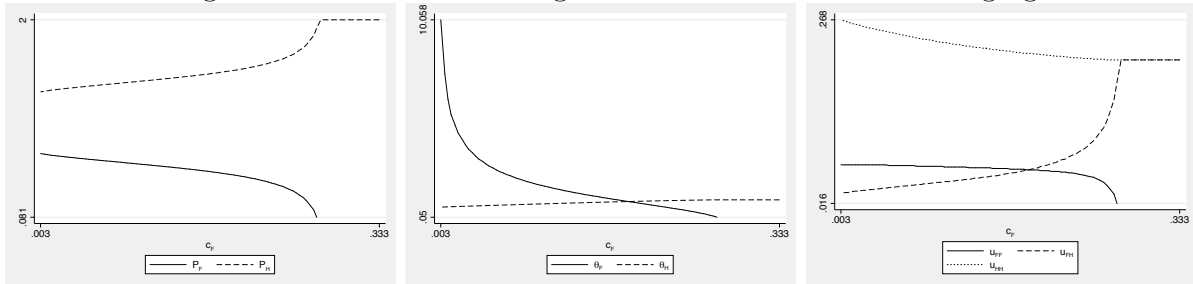
more vacancies in the foreign country from which home workers are excluded. Migrant workers experience falling unemployment due to the paucity of migrant workers under the planner under the planner's application of the most extreme productivity differential.

Figure 1.11: Planner Changing Productivity



The planner reacts to increases in vacancy posting and maintenance costs as in the competitive equilibria shown in Figure 1.12. As vacancies become more costly in the foreign country, fewer workers are allocated there until it is so costly that the planner chooses to put all workers in the home country. Market tightness in the foreign country decreases as costs increase until no open vacancies are maintained at all. The planner more than makes up for the increased population in the home country by posting more vacancies as the costs in the foreign country increase. Unemployment in the foreign country decreases as workers are moved into the home country, and unemployment rates for foreign migrants converges upward to that of home workers.

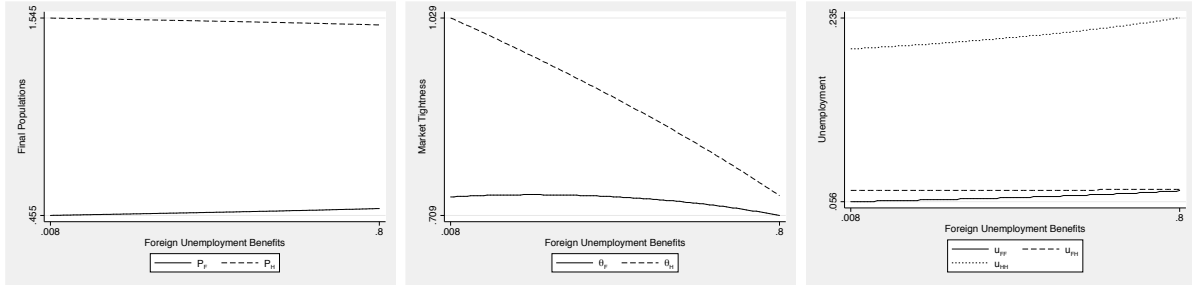
Figure 1.12: Planner Posting and Maintenance Costs Changing



As unemployment benefits increase in the foreign country, the planner allocates more workers there, but the change is small (Figure 1.13). The planner also decreases market

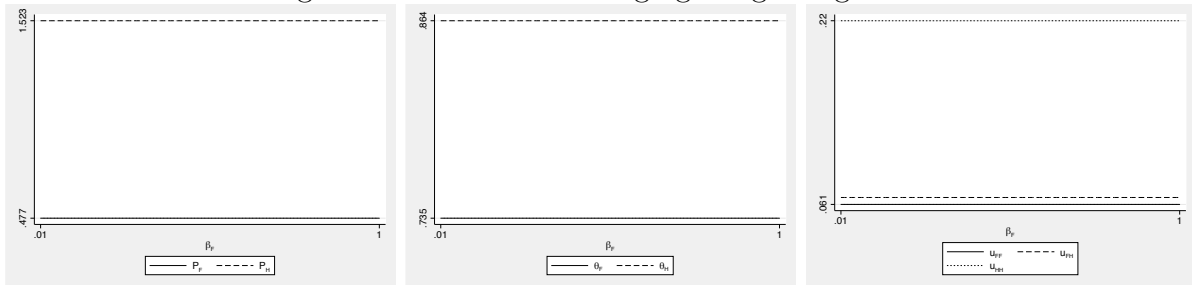
tightness in both countries as benefits increase because the planner is less concerned about drawing people out of unemployment when it is more generous: matches under high benefits in the foreign country generate less surplus. Unemployment for all workers increases due to the decrease in vacancies posted, though home workers see the largest increase, and always have higher unemployment.

Figure 1.13: Planner Changing Unemployment Benefits



Reassuringly, Figure 1.14 shows that the planner does not react to changes in workers' bargaining power as he is agnostic about the allocation of the match surplus, and only seeks to keep the total surplus as large as possible given the values of the other parameters. Populations, market tightness, and unemployment do not vary with bargaining power under the planner.

Figure 1.14: Planner Changing Bargaining Power



1.3.4 Comparison of the Market and Planner's Problem

Now, looking at how far from the planner's allocations the competitive equilibrium under non-discrimination falls, Figures 1.5 and 1.10 show the impact of increasing the foreign-born population. In terms of allocation of people, the planner always allocates more workers to the home country, and always keeps slightly more than half of the foreign-born workers in the home country. The planner keeps market tightness in the foreign country lower, and home country tightness higher than in the competitive equilibrium, but home market tightness decreases as the population increases. Unemployment for home workers is slightly less than 1% lower under the planner, and foreign migrants face slightly lower unemployment than foreign stayers even though the competitive equilibrium shows foreign workers kept equal. The planner more generously compensates migrants for the decreased probability of finding a job as the population becomes large in the home country.

When productivity increases in the foreign country, the planner increases the equality of worker allocation as in the competitive equilibrium (Figures 1.6 and 1.11), but begins with a less equal distribution and ends with a more equal distribution when foreign productivity is highest than in either market outcome. Market tightness also begins at parity under the planner when the countries are symmetric, but tightness diverges more dramatically under the planner (Figure 1.11 shows a large drop in the home country along with the increase in the foreign country). This is more extreme when the countries are more similar, and changes less as the populations equate and almost no foreign workers are moved to the home country. Unemployment increases in the home country as the planner employs many workers in the more productive country, and almost none in the less productive country. Unemployment drops for the few workers who are still moved to the home country, and foreign workers always experience lower unemployment under the planner.

The planner also mimics the competitive equilibria when posting costs increase in the foreign country, but reacts more aggressively. Workers are moved out of the foreign country more quickly as posting costs to firms increase, and all workers locate in the home country

under lower foreign posting cost than in the market outcomes. Figures 1.7 and 1.12 reflect this same desire to move foreign workers away from the increasing cost as market tightness begins lower in the foreign country, and more quickly moves toward zero as costs in the foreign country increase. The planner also compensates for the population changes by increasing market tightness in the home country. Unemployment for all workers follows the same pattern under the planner as in the market, but migrants' unemployment converges with that of home workers once all workers are located there whereas the market maintains foreign workers at lower unemployment levels than home workers, even when all workers are in the home country.

Qualitative changes in allocations under the planner when unemployment benefits in the foreign country change are very similar to changes under non-discrimination. The planner chooses a slightly less equal population distribution, shown in Figures 1.8 and 1.13. However, market tightness decreases in both countries as foreign benefits increase. The planner keeps more foreign workers in unemployment due to the high value of being unemployed, and opens fewer home vacancies due to lower rates of migration than in the market outcome. Figures 1.8 and 1.13 show relatively small changes for all workers under the planner, even when unemployment benefits increase. The planner employs more home workers than the market and similar numbers of foreign workers. Overall, for changes in unemployment benefits, the market outcomes are not far from those under the planner (with the exception of the number of unfilled vacancies maintained) as the planner keeps the non-profit generating activities to a minimum while the market cannot as easily allocate efficiently.

Although the planner does not make changes according to changes in bargaining power as the market does, I still examine the difference between the two. Compared to the market, the planner initially has a less unequal population distribution when foreign bargaining power is low, but has a more unequal distribution when power is high. Figures 1.9 and 1.14 show that while the planner chooses a slightly lower market tightness for the foreign country, the home market has a lower market tightness than under the market when bargaining

power is low, and higher levels when bargaining power is high. There are equal outcomes when workers bargaining power is equal in both countries. The planner chooses an unemployment level for home workers almost ten percentage points higher than the market when bargaining power is low, but home workers experience lower unemployment under the planner when bargaining power is greater in the foreign country. Foreign migrants experience lower unemployment under non-discrimination. Foreign stayers have lower unemployment under non-discrimination only when foreign workers receive less than 48% of the match surplus, and have lower unemployment under the planner otherwise.

Under the numerical example provided, we see that the market allocation frequently diverges from the efficient allocation. The lack of an analytical solution prevents a more careful construction of differences for a general choice of parameters.

1.4 An Application of the Model

This section presents two calibrations of the model to match with the high-migration, low difference in unemployment rates case (exemplified by the US) and the low-migration, large difference in unemployment rates case (exemplified by Europe) outlined in the Introduction.

I chose parameters for the model that are realistic in the sense that they represent economies which are relatively similar, but predict different stationary equilibria. Table 1.4 shows the different values for the two cases. The particular parameters here generate the different equilibria that are targeted, but are not the only parameterizations that generate the qualitative differences I target.

In the high-migration, low difference in unemployment rates case, parameters reflect very similar economies in the two countries. The case shown in Table 1.4 gives the model prediction from the case where both countries (or US states) are perfectly symmetric. In this scenario, workers still choose to migrate, though the model does not require non-zero migration flows. Table 1.5 shows that over 75% of workers in the foreign country leave for

the thicker market in the home country. Overall unemployment rates are high- at 37.5% and 41.1%, but reflect the similarities across the two markets. There is also significant wages dispersion across the different workers. Workers in the foreign country, whether they never left or are newly returning, receive the lowest wages followed by new migrants into the home country. Previous migrants and home workers receive the highest wages.

In the low-migration, large difference in unemployment rates case, parameters reflect fairly similar economies, but ones that vary in ways that create large differences in unemployment rates across the two countries. In this case, the foreign country is more attractive in some ways, but less attractive in other ways compared to the home country. The foreign country is more productive and has higher bargaining power, but lower unemployment benefits and higher costs to posting and maintaining a vacancy for firms. This trade-off results in much lower migration into the home country: now only 24% of foreign workers locate in the home country, and unemployment rates are much different from the US proxy scenario. Unemployment rates are 39.7% and 66.7% in the foreign and home country. Again, these overall rates are very high, but the levels were not the target moment for this parameterization.

Table 1.4: Parameters

	y_F	y_H	b_F	b_H	c_F	c_H	P_F^o	P_H^o	β_F	β_H	Z	r	δ
US proxy	1	1	0.5	0.5	0.2	0.2	1	1	0.75	0.75	1.25	0.05	0.15
Europe proxy	1.65	1	0.45	0.55	0.25	0.2	1	1	0.85	0.8	1.25	0.05	0.15

Table 1.5: Outcomes

	θ_F	θ_H	u_{FF}	u_{FH}	u_{HH}	u_F	u_H	P_F^f	P_H^f	w_{FFF}	w_{FFH}	w_{FHF}	w_{FHH}	w_{HHH}
US proxy	0.059	0.214	0.087	0.288	0.439	0.375	0.411	0.232	1.768	0.741	0.746	0.741	0.755	0.755
Europe proxy	0.190	0.056	0.301	0.096	0.732	0.397	0.667	0.759	1.241	1.32	0.758	1.297	0.759	0.759

This points to one avenue of policy that countries can employ to keep workers at home: increasing productivity decreases out migration and increases wages. Countries hoping to keep more of their most highly skilled workers would do well to institute national policy helping workers and firms to be more productive. Countries hoping to limit in-migration from other countries could provide FDI in common sending countries that works toward improving productivity abroad.¹³ Aside from efforts to improve productivity in common sending countries, the countries seeking to make unemployment rates more similar could also work to decrease labor market frictions for matching, and to open up all markets to be more flexible. Although not explored in great detail in this section, the role of unemployment benefits in generating unemployment could also be targeted. Lower, or shorter term unemployment benefits have been shown to decrease overall unemployment rates in the numerical exercises above, and in empirical literature.¹⁴ The role of workers' bargaining power is an additional mechanism put forth for explaining the differences between US and European labor markets. Perhaps since migration may not be enough for labor market conditions to converge, these other policy avenues would more efficiently use resources in improving the market equilibrium.

1.5 Conclusion

Despite the focus on the role of migration as a convergent factor for unemployment rates within the US, the model in this paper shows that migration alone may not be the driving force in keeping US unemployment rates more similar than those across European countries.

Workers choose to move not only based on productivity and expected wages in the receiving country, but also based on the likelihood of gaining employment upon migrating. While the model presented in this paper prevents a subset of workers from migrating, the equilibrium impact from some workers migrating is insufficient to generate equal (or near

¹³Many would argue that the Brexit vote was driven by anti-immigrant sympathies among lower skilled Brits.

¹⁴See Nickell (1997, 2006) for examples concerning the comparison between the US and Europe.

equal) unemployment rates across countries in all but a handful of special cases which are highly dependent on the particular parameters chosen.

Wage effects for home workers are highly dependent on the mechanism for generating migration. When productivity difference across countries generate the move, home workers suffer very little as in Card (1990), but when the mechanism is business environment as for posting costs, home workers suffer larger losses akin to those in Borjas (2003). Including worker heterogeneity in a model of search with migration would shed light on this debate.

In a model of matching with restricted migration, the movement of workers across asymmetric states has been shown to be insufficient to generate a convergence in unemployment rates across countries for a variety of parameterizations. For this reason, one potential extension to study unemployment rate variation at the country level should focus on those factors which are most salient to those moving: costs to move and be away from home.

Chapter 2

Labor Market Search with Migration: Unbundling Cost Mechanisms

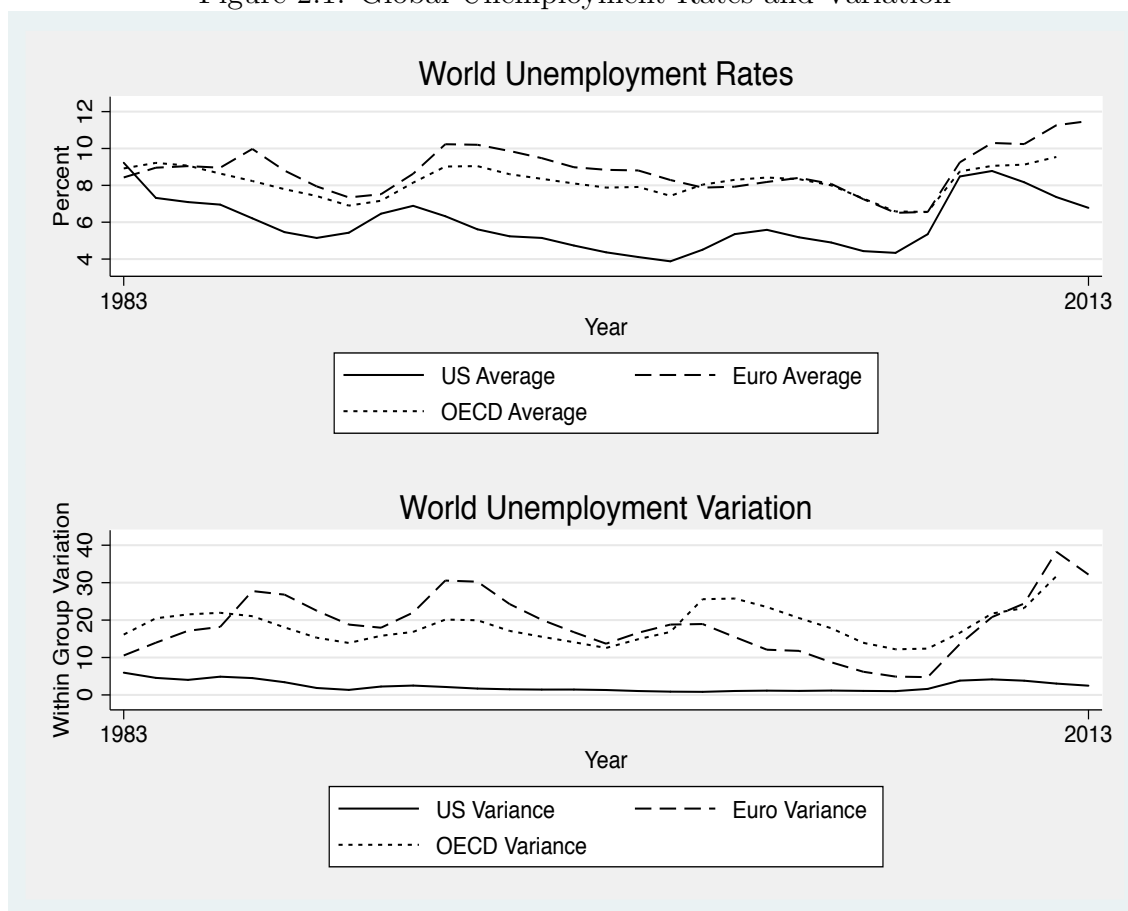
2.1 Introduction

The lack of cross-border labor mobility in many existing search models limits our understanding of labor markets in an increasingly globalized economy. I examine the migration decision of a worker by using a migration model of employment search which allows for costly migration and variation in unemployment and labor market characteristics in equilibrium. I build a theoretical model to follow workers' employment status and location, and utilize differences in labor market institutions across borders to show that capturing these worker flows across borders is an important aspect of search that has been largely assumed away. I then apply the model to data from the European Union (EU) to explore the effectiveness of the model in generating realistic outcomes. This sheds light on important considerations by workers to move away from home even when that move is costly, and highlights the tradeoffs that (potential) migrants face.

Large flows of intra-euro zone migration with persistent differences in unemployment rates further complicate our understanding of unemployment at the European Union level.

Figures 2.1 and 2.2 from Sargent (2017) show the increase in intra-EU mobility from 1998-2012 and the differences in unemployment across EU states since the introduction of the euro. The total numbers of labor migrants have consistently increased with migration from eastern countries providing a large proportion of flows, with only a short-lived decrease following the financial crisis of 2007/2008.

Figure 2.1: Global Unemployment Rates and Variation



I construct a benchmark search model with costly migration to explore the migration decision at the individual level through the lens of costs that workers face.¹ I build a model that describes the cross-border migration decision, and evaluate the unemployment

¹I focus specifically on the euro zone countries in order to abstract from the complications arising from the non-universal use of the euro throughout the EU and the rest of Europe. See Appendix A for a list of countries. This framework could also apply to post-Great Recession markets in the US where workers face a barrier to move from mortgage debts, and other costs associated with regional moves within the US.

Figure 2.2: Intra-EU Labor Migration by Region

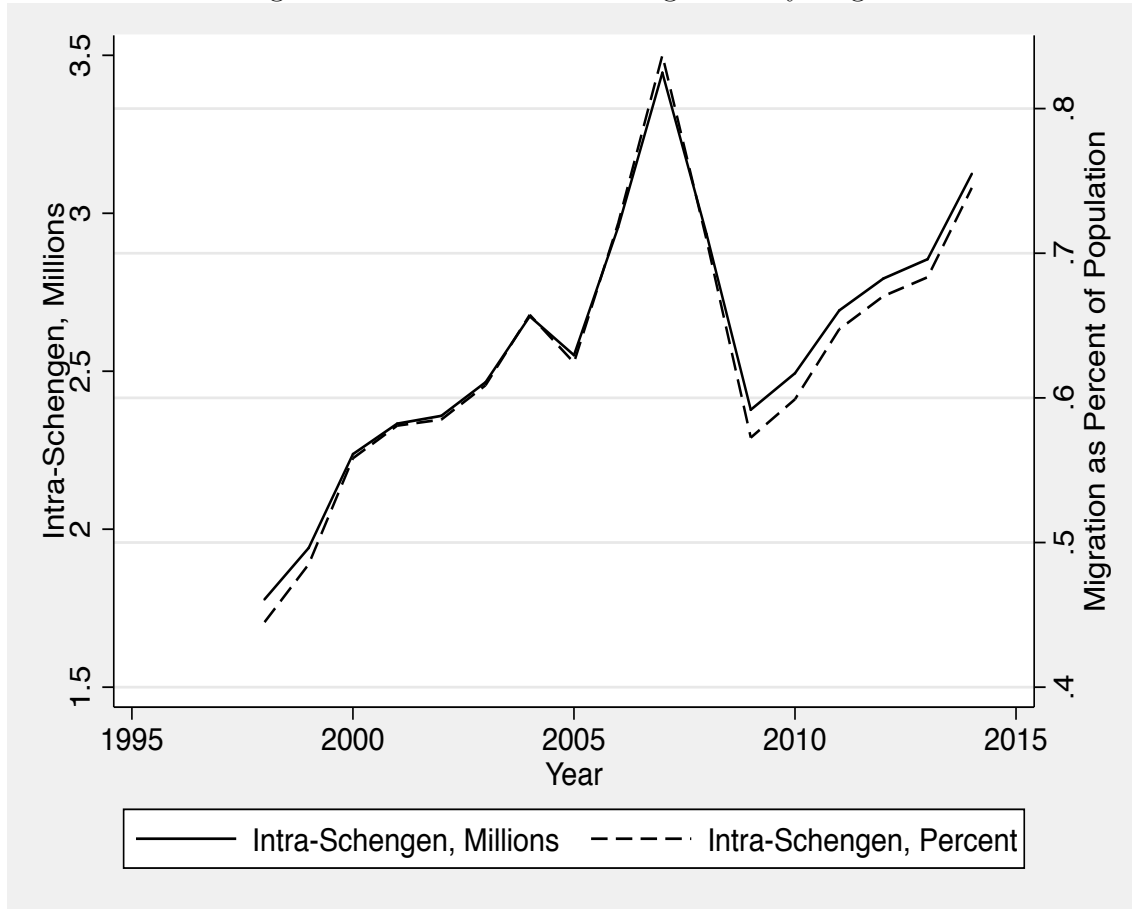


Figure 2.3: Source: Europa

and efficiency implications of the decentralized equilibrium. I further disaggregate between costs workers face from moving between two locations and costs faced from being away from one's country of origin. Results indicate that this distinction is important in determining equilibrium unemployment rates and population distribution across countries. The bundling, or ignoring, of the differences in these two types of costs to workers points to important policy implications for labor migration within the EU. The model predicts that making moves easier by eliminating legal barriers to movement, as most legislation has focused on, may be less important than making living abroad easier through language and cultural assimilation aid. I pay particular attention to population distributions across countries in addition to the

standard emphasis on market tightness and unemployment.

I differentiate between two competitive equilibria and a planner's allocation to explore different firm behaviors to distinguish between the impacts from firms targeting/not targeting particular worker types. I use the planner's allocation to evaluate the distance from a first best outcome both for the more realistic competitive equilibrium and current levels in EU data.

A specially commissioned Eurobarometer public opinion survey in 2009 highlights the main incentives for and deterrents of migration for work purposes. A majority of respondents, 60%, think free labor mobility within the EU is good. Respondents report that approximately 2% of EU citizens were actively working abroad in 2009 while about 10% have ever worked abroad, and having lived abroad in the past makes people more likely to consider living abroad in the future. Although this is a minority of EU and euro area citizens, it implies 10 million people were working in a country other than the one of their citizenship, and 50.2 million had ever worked abroad.² Additionally, 17% of European adults expect to work abroad in the future with newer EU members' citizens more likely than older EU members to say they expect to ever work abroad. Figure 2.2 also documents that this number is likely to continue to increase into the future.

Bonin et al. (2008) report that Cyprus, Malta, Romania, Bulgaria, Slovakia, and Belgium have the most out-migration into other EU countries with 2.6% to 13.3% of the sending country population living and working abroad in 2007/8.³ The average cross-border mobility rate for moves by EU citizens within the EU is about 0.2% per year (approximately 20% of all movers regardless of destination being in the EU or not). Each year, about one million EU citizens move across an EU border for work. Within-country moves average 1% of the population per year. This is much lower than regional mobility for non-EU migrants within the EU, indicating that EU citizens are less mobile than external migrants, and further emphasizing the importance of the cost of being away from home identified by the

²Based on a population of 502,090,235 for the euro area in 2009 according to Eurostat.

³Based on a labor force survey conducted from 2007-2008 in the EU.

Eurobarometer survey.

Migration flows are also not simply in one direction. Figure 2.1 shows that no single region dominates migrant flows across borders. People are willing and able to move back and forth across borders, and do so with some frequency. Of those who have worked abroad, 17.5% have moved more than 4 times, 35% have moved 2-4 times, 14.9% have moved once, while only 14.3% have never moved from home (choosing to commute rather than relocate). The relatively low mobility among EU citizens, and the hesitation to leave one's home, point to cultural barriers to a single Europe-wide labor market even though migrants are willing to move back and forth over time and legal barriers are small or non-existent.

Living and working abroad is not seen as costless: Being away from home is the single most important cost to deter someone from seeking employment outside of their home country. "*[L]anguage and cultural barriers are extremely important when explaining the limited level of geographic mobility in Europe*" (Bonin et al. (2008), 9). Two of the three factors determined to have significant explanatory power for the lack of migration are language and culture. The third is a more generic "job hurdles", which likely includes the other two. This contrasts with the absence of moving costs in responses to questions about the most important costs to living and working abroad.

Although one aim of the EU is to act as a single labor market, it remains disjointed (Pascouau 2013, Zimmermann 2013). Significant changes in labor market and institutional structures at the European level have drastically reduced the policy differences in labor markets across the EU since the introduction of the euro. While explicit legal barriers to mobility have been largely eliminated some, such as unemployment benefit requirements, have increased (Burda and Wyplosz (1994), Epstein (2012), Bertola and Rogerson (1997), Scarpetta (1996), Jolivet et al. (2006), Nickell (1997), Yashiv (2007)).⁴

In the theoretical model I emphasize differences in costs to moving away from origin, costs to move back after a previous move, and costs to being away from one's country of origin

⁴For example, the UK recently introduced a lag period for new migrants to receive benefits. It remains to be seen how immigration will be legislated following Brexit negotiations.

to examine the role that different costs play in influencing a move, as well as their relative importance in the decision. I also report results from differences in structural parameters. I find significant differences in the effects from these parameters across model specifications. In the competitive equilibrium specifications, I find that the impact on labor market outcomes from flow costs to being away and moving costs is less clear than commonly perceived both in driving the migration decision, and potentially resulting in welfare costs due to these inefficiencies. The bundling of these cost in the literature obscures important differences in the margins of the trade-offs of migrating for employment, and the focus on move costs ignores the most salient factors migrants consider when moving.

Empirical work on migration has focused on the role of expected income in the migration decision and the estimation of welfare impacts from migrants, but has not utilized other aspects of labor markets or workers to motivate movements (Beine et al. (2013), Kennan and Walker (2011)). For example, Ortega and Peri (2013) document international migration for OECD countries, and find that mobility is indeed higher between EU countries than with the remaining OECD countries, but does not investigate costs faced by workers. Welfare impacts also extend to wage effects from an influx of migrants. Card (1990), Borjas (1985), Gerfin et al. (2010), Ottaviano and Peri (2012), and Cadena and Kovak (2016) find varying impacts on natives' and migrants' wages from immigration. The variation in the estimation of the effects stems partially from the reliance on natural experiments, like the Mariel boat lift or the Great Recession, and the lack of a general equilibrium theory to explain effects not only on particular subsets of workers in the receiving country, but the effects on those left behind as well.

Theoretical models often explain only within-country moves, and neglect important barriers to movement such as language, culture, and immigrant requirements for unemployment benefits as well as institutional and productivity differences across national borders. Kawata et al. (2014) find large welfare effects from moving costs between prefectures in Japan with wage posting and move costs, but do not allow for flow costs. They find that costs to moving

have a significant, negative effect on welfare, but this may be due to the omission of flow costs in their model. Schmutz and Sidibé (2015) find similar effects in a search model based on the French labor market.⁵ In a related theoretical model, Kline and Moretti (2013) show that migration lowers unemployment and can increase welfare in equilibrium. Equilibrium is imposed using a costly housing market allocation and requires symmetry in other factors. Workers face no costs to moving, or living away from origin location. Finally, Lkhagvasuren (2012) utilizes an island model and US data to compare persistent differences in unemployment rates between US states across different age groups despite high mobility in a wage posting model with only move costs to workers.

This paper builds on existing search models to include migration across countries in equilibrium while allowing for detailed study of the impacts of labor market characteristics on labor market conditions such as unemployment, population allocations, and wages.

2.2 Model

The model characterizes the migration decision in a search model with labor mobility. Limiting migration to agents of one origin country or region allows for clearer exposition of the marginal migration decision, and the labor market characteristics that influence the decision. It also corresponds to the dominant migration pattern between the bigger economies of north-western Europe and the smaller, poorer economies of eastern and southern Europe documented in Bonin et al. (2008).

The model is in continuous time, and all values represent total flow value for a given agent. Each country shares a single interest rate and time discount factor for agents, r . All workers, regardless of country of origin and unemployment location, have the same productivity or skill, y , based upon location of employment. Productivity can be thought of as a measure of aggregate development, or predominant sector of comparative advantage of the economies

⁵See Molho (2001), Chassamboulli and Palivos (2014), Ortega (2000), and Zenou (2009) for a selection of others.

in addition to physical production. Each firm posts only one job. Both countries share the same exogenous job destruction rate, δ . The countries may have different jobless benefits, b , worker bargaining power, β , and costs to posting and maintaining a vacancy, c . These differences are job location-specific, not worker origin-specific, so a worker who migrates does not bring his bargaining power or jobless benefit with him.

Only workers from the foreign country, F , are allowed to migrate. Workers from the home country, H , can only search and work in the home country, and there is no on-the-job search. Migration can only happen when a worker is unemployed, but is not in only one direction: unemployed foreign workers may go back and forth between countries anytime they match with a firm in the country in which they do not currently collect unemployment benefits. They are not obligated to return after migration, and may stay in either country indefinitely. This allows a flow of foreign workers in both directions, which works to equilibrate the labor markets.

At the beginning of time, workers are either employed or unemployed, and firms have filled and unfilled vacancies. Some matches are destroyed, and the unemployed search in either market. Some matches occur, and workers move, if necessary. Once vacancies are filled, and workers have moved, production occurs and benefits are collected. Variables are denoted with a triplet $\{i, j, k\} = H, F$ so that variable X is identified: X_{ij}^k . Worker country of origin is denoted by i , j gives the workers' current location, and k gives the location of the job or benefit received.

I separate between competitive equilibrium models of “discrimination” and “non-discrimination” on the part of firms, though this should not be interpreted as discrimination in the idiomatic sense. Here, discrimination means that the employer chooses to open a position to workers based on worker origin country and current unemployment location. While the set-up may not fully capture real world employment and migration decisions, it establishes a benchmark model that is relatively simple while still capturing key characteristics of migration patterns in the data. The non-discrimination characterization further improves

upon the discrimination characterization in matching EU data.

Matching brings together unemployed workers and open vacancies in the labor market, and places them into a randomly matched, filled job with an employed worker. Matching parameters may differ between worker origin, worker unemployed location, worker employed location. The probability of matching is independent of search effort.

The functional form for matching matters greatly: Cobb-Douglas forms are common in search models due to the simplicity of solutions, and fit with data in individual economies. The den Haan et al. (1997) form has the benefit of probability bounds between zero and one, but never results in an analytical solution (den Haan et al. (1997) and Petrosky-Nadeau and Zhang (2013)).⁶ Petrosky-Nadeau and Zhang (2013) show the fit of this matching function using US data.

Matching is dependent on the stock of unfilled vacancies, v , and the stock of workers who are currently unemployed, u :

$$M(u, v) = m(1, \frac{v}{u})u = q(\theta)u \quad (2.1)$$

Where $\theta = v/u$. Market tightness, θ , gives the ratio of open vacancies to unemployed workers. The probability that an unemployed worker is matched with a firm is $q(\theta)$, and $\theta q(\theta)$ is the probability that an unfilled vacancy is filled. The den Haan, Ramey, and Watson form of matching is governed by Z_k , the elasticity of matching in the firm country, $k = i, j$. The probability that a worker meets with a vacancy is given by:

$$q_k(\theta^k) = (1 + \theta_k^{-Z_k})^{-1/Z_k} \quad (2.2)$$

with $\partial q_i / \partial \theta_i < 0$.

The segmented markets in the discrimination case means the relevant market tightness

⁶Migration and market overlap prevents an analytical solution even with the use of the Cobb-Douglas matching. The model presented here makes use of the den Haan, Ramey, and Watson form to utilize the probability limits built into the functional form without adding an additional restriction to the model as it requires only one parameter rather than two as with Cobb-Douglas matching.

and matching probability is governed by worker country of origin, worker unemployment location, and firm location. Under non-discrimination, workers' probability of matching with a vacancy is dependent only on conditions in the particular country of the job location. These are shown explicitly in the relevant sections below.

2.2.1 Discrimination

In the discrimination model, each job type is a separate labor market. This is because firms choose to post a vacancy targeting a particular portion of the unemployment pool. This is similar to the segmented equilibrium for a two-skill, one country model in Albrecht and Vroman (2002) and Blázquez and Jansen (2003).

Since markets are separate, market tightness in each sub-market, θ_{ij}^k , is independent of the others. Market tightness spillovers happen only due to a worker's change of status. For example, if a worker moves to another country for employment and then loses that employment, his relevant market tightness has changed twice: the first when he moved; the second when he became unemployed again. Importantly, he has not internalized his effect on his original or new market tightness when making the decision to search and migrate.

Jobs and workers are defined specifically by workers' country of origin, country of unemployment, and matched location. As such, market tightness in this setting is defined as:

$$\theta_{ij}^k = v_{ij}^k / u_{ij}^k \tag{2.3}$$

Through migration and subsequent job destruction, unemployment rates in each sub-market have impacts on other sub-markets. If no workers ever migrated, the model would simplify into two parallel markets that behaved like the one in Albrecht and Vroman (2002) and Blázquez and Jansen (2003).

Workers choose where to search based on the perceived return from search in each market.

In equilibrium, the flow value of search in each market is equalized, making workers indifferent between searching in either country. The flow value of unemployment to the worker, rU , depends on the unemployment benefit and the probability of finding a job in each market, as well as the net value of moving from unemployment into employment for a particular job. Not all workers have the same value of unemployment. The act of searching is itself costless, but workers face two other costs. The first, ϕ_{jk} , represents the cost to move from country j to country k . The second, τ_{ij} , is the flow cost to a worker from country i who currently lives in country j . τ_{ij} can be thought of as a language or other cultural barrier, or costs to commuting or phoning home to stay in touch with family left behind. The flow value of unemployment is thus:

$$rU_{ij} = b_j - \tau_{ij} + \max_k \{ \theta_{ij}^k q_{ij}^k (\theta_{ij}^k) (N_{ij}^k - U_{ij}^k - \phi_{jk}) \} \quad (2.4)$$

Where $\tau_{ij} = 0$ when $i = j$ and $\phi_{jk} = 0$ when $j = k$.

The flow value of employment to the worker, rN , is the value of the wage less the discounted value of moving into unemployment and flow cost to living away from home:

$$rN_{ij}^k = w_{ij}^k - \tau_{ij} + \delta(U_{ij} - N_{ij}^k) \quad (2.5)$$

Firms choose whether to post a vacancy based on the cost to post as well as the probability weighted value of filling the vacancy and moving into production. This gives the flow value of posting a vacancy, rV :

$$rV_{ij}^k = -c_k + q_{ij}^k (\theta_{ij}^k) (J_{ij}^k - V_{ij}^k) \quad (2.6)$$

The flow value of a filled vacancy to the firm, rJ , is the value of productivity less the cost to posting, the wage payment, and the probability weighted value of the match dissolving:

$$rJ_{ij}^k = y_k - w_{ij}^k - c_k + \delta(V_{ij}^k - J_{ij}^k) \quad (2.7)$$

Wages are bargained based on production surplus, bargaining power, and costs (establishing a vacancy for firms and movement or flow costs of migration to workers, if applicable). Bargaining captures the power of labor unions present in many developed countries and allows differences in outside options to migrate to be reflected in wages through unemployment values rather than as a result of an optimization done by firms as in wage posting models.

Workers receive share β_k of the match surplus, S_{ij}^k , where $S_{ij}^k = J_{ij}^k + N_{ij}^k - U_{ij} - V_{ij}^k$. Firms in country k receive $(1 - \beta_k)$ of the match surplus: $(1 - \beta_k)S_{ij}^k$.

Equilibrium

In equilibrium, workers are allowed to move only when gaining employment, but flows between countries off-set one another so that the net migration is zero. This allows for a characterization of the equilibrium in terms of market tightness determined by the labor market bargaining for wages and the free-entry condition for firms.

Market tightness is the number of open vacancies for each of the five types divided by the total population of "eligible" unemployed to fill those vacancies. Under discrimination, there are five separate markets:

$$\theta_{FF}^F = \frac{v_{FF}^F}{u_{FF}} \quad (2.8)$$

$$\theta_{HH}^H = \frac{v_{HH}^H}{u_{HH}} \quad (2.9)$$

$$\theta_{FF}^H = \frac{v_{FF}^H}{u_{FF}} \quad (2.10)$$

$$\theta_{FH}^F = \frac{v_{FH}^F}{u_{FH}} \quad (2.11)$$

$$\theta_{FH}^H = \frac{v_{FH}^H}{u_{FH}} \quad (2.12)$$

The first two give the market tightness for "stayers"; those workers who do not leave their country of origin. The third gives the market tightness for a new migrant; he has not

been employed abroad since his last unemployment spell, but may have lived abroad in the more distant past. The final two give market tightness for recent migrants. The fourth is a recent migrant who has lost his job and is now gaining employment back in the foreign country. The final is for a recent migrant who lost his job, but is staying in the home country with his new job match.

Wages can then be characterized from market tightness and parameters:

$$w_{ij}^k = \beta_k S_{ij}^k = \beta_k (y_k - c_k) + (1 - \beta_k) r U_{ij} = y_k - c_k - \frac{c_k}{q_k(\theta_{ij}^k)} \quad (2.13)$$

The first equality is from the worker's problem; the second from the firm's free entry condition. Together with market tightness, these determine wages for each type of worker.

Initial populations are the sum of all unemployed and employed workers from each country, regardless of current location:

$$P_o^F = u_{FF} + u_{FH} + n_{FF}^F + n_{FH}^F + n_{FF}^H + n_{FH}^H \quad (2.14)$$

$$P_o^H = u_{HH} + n_{HH}^H \quad (2.15)$$

Job creation and destruction conditions ensure that the total stock of employed and unemployed in each submarket remains constant in a stationary equilibrium. Workers move between these pools, but all flows offset in equilibrium:

$$\theta_{FF}^F q_{FF}^F(\theta_{FF}^F) u_{FF} = \delta n_{FF}^F \quad (2.16)$$

$$\theta_{FF}^H q_{FF}^H(\theta_{FF}^H) u_{FF} = \delta n_{FF}^H \quad (2.17)$$

$$\theta_{FH}^F q_{FH}^F(\theta_{FH}^F) u_{FH} = \delta n_{FH}^F \quad (2.18)$$

$$\theta_{FH}^H q_{FH}^H(\theta_{FH}^H) u_{FH} = \delta n_{FH}^H \quad (2.19)$$

$$\theta_{HH}^H q_{HH}^H(\theta_{HH}^H) u_{HH} = \delta n_{HH}^H \quad (2.20)$$

Finally, the migration condition ensures that overall populations at the country-level remain constant in equilibrium while allowing people to move in and out of each market. This does not require that populations are equal, or equal to initial values:

$$\theta_{FH}^F q_{FH}^F(\theta_{FH}^F) u_{FH} = \theta_{FF}^H q_{FF}^H(\theta_{FF}^H) u_{FF} \quad (2.21)$$

Parameterization

In order to ensure non-negative solutions for wages, market tightness, unemployment rates, vacancies and employment rates, productivity, y , is bounded below by the sum of cost to posting a vacancy, c , unemployment benefits, b , and costs to move or be away from home, ϕ and τ , when applicable: $y > c + b + \phi + \tau$.

Productivity is also bound below by the discounted value of the costs to posting a vacancy:

$$y > c(q(\theta) + \frac{r + \delta}{q(\theta)})$$

These two conditions ensure that firms' shares of production surplus are large enough to cover all the costs associated with posting and maintaining an open vacancy or a filled position. If productivity is not large enough, the value of a filled position, rV , falls below zero. Further limitations can be found on parameter values, but those listed above are sufficient to ensure reasonable equilibrium values for outcome variables.

Unemployment benefits, b , are bound between zero and one. Costs to being away from home, τ , and move costs, ϕ , are unbounded above, and I limit them to non-negative values.⁷ Initial populations, P_o , are also unlimited by the model, though I normalize initial populations to one in each country.

Workers' bargaining power, β , is definitionally restricted between zero and one. Productivity, y , is bounded below by the sum of unemployment benefits, b , costs to posting a

⁷A negative flow cost could be characterized as love of travel or adventure that outweighs any language or cultural barrier.

Table 2.1: Baseline Parameterization

Parameter	Value H, F
y	1
b	0.5
c	0.2
β	0.5
ϕ_{FH}	0.05
ϕ_{HF}	0.05
τ	0.05
Z	1.25
r	0.05
δ	0.15
P	1

vacancy, c , and move and flow costs, ϕ and τ , or one; whichever is larger. Matching elasticity, Z , must be above 0.3, but is unbounded above; this easily includes the estimated value of 1.25 in Petrosky-Nadeau and Zhang (2013). Costs to firms for posting and maintaining a vacancy, c , are bound below by zero, and above by worker productivity less unemployment benefits and costs to workers to move and be away from home.

Numerical Exercises

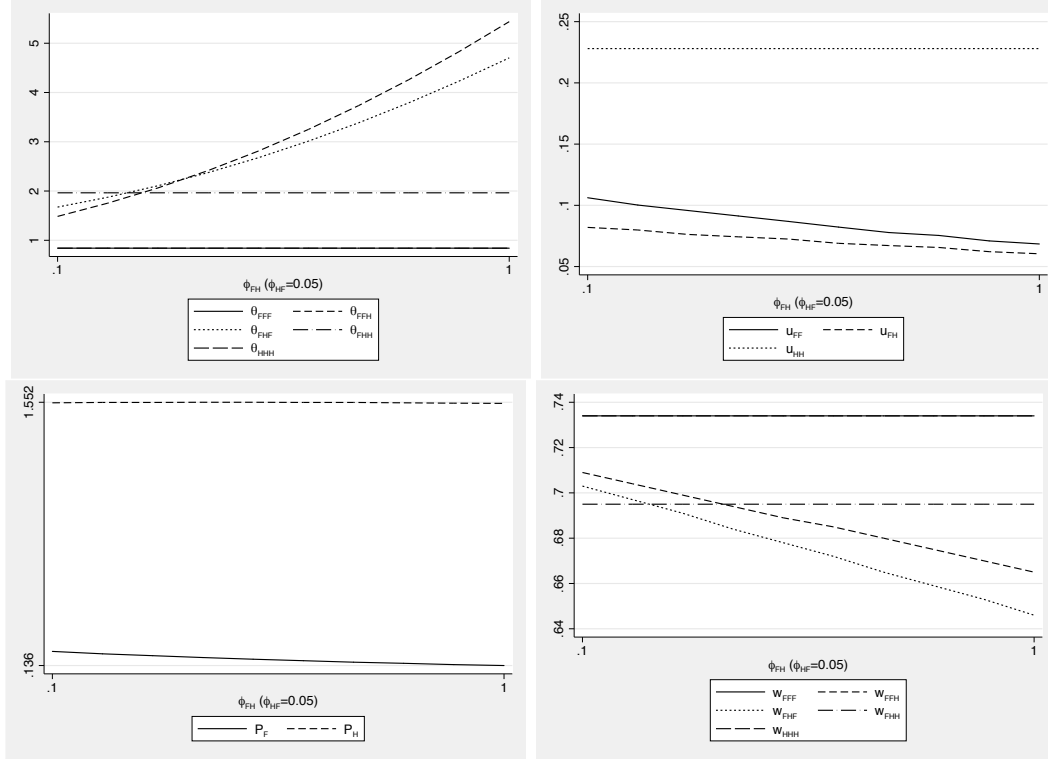
The baseline specification for numerical exercises is chosen for comparability with the non-discrimination and planner's allocations below. Population and productivity are set to one; matching elasticity is 1.25 to match Petrosky-Nadeau and Zhang (2013). All costs to workers are set at 0.05; workers' bargaining power and unemployment benefits are 0.5; these are within reasonable proximity to average values in EU countries used by Campolmi and Faia (2011). Costs to firms to posting vacancies are set slightly below the value in Albrecht and Vroman (2002) and Beine et al. (2013) at 0.2 compared with 0.3 in the others. Finally, the discount rate is set at 0.05 and the job destruction rate at 0.15 to match the literature. Numerical bounds and equilibrium values were determined using a multiple complementarity solver in GAMS. The baseline parameterization is summarized in Table 2.1.

In all three numerical exercises that follow, I set the home (receiving) country to the baseline calibration outlined above, and allow parameters in the foreign (sending) country to vary one at a time. The far left of the panels gives low values of the parameter, and increasing values moving left to right. The far right of each panel is the highest permitted value of the parameter. This shows the impact of policy changes in the sending country on the destination and origin country labor markets. Changing the parameters in this way allows for interpretations of the impacts on migration from relative changes in labor market characteristics in isolation.

Figures 2.4 and 2.5 show the effects of moves in and out of the foreign country becoming increasingly costly to foreign workers. Market tightness for new movers increases as unemployment for foreign workers decreases in both countries to compensate workers for the cost (first panel). Unemployed workers not currently facing a move see no change in the probability of finding a job as the move cost increases (second panel). Unemployment for home workers is unaffected by changes in the move cost faced by foreign workers since firms can distinguish between worker type, and need not compensate all workers to increase the available pool of workers as in non-discrimination below. Foreign workers in both countries face lower unemployment when moving becomes increasingly costly as firms compensate movers for the higher cost with a higher probability of matching. The distribution of workers, shown in the third panel, remains fairly constant, but becomes more unequal as costs increase. Wages for home workers, foreign workers who never move, and foreign workers who moved prior to their most recent spell of unemployment are unaffected by move costs. Though the movers face a lower wage after migration than never movers. Recent migrants experience decreasing wages as their costs to move (in either direction) increase.

When workers face no costs to living away from home, Figure 2.6 shows that all markets experience the same tightness (far left of each panel). As flow costs increase, tightness increases for all but the home natives and foreign never-movers. Tightness increases most for foreign workers who previously moved and are staying in the home country. New migrants

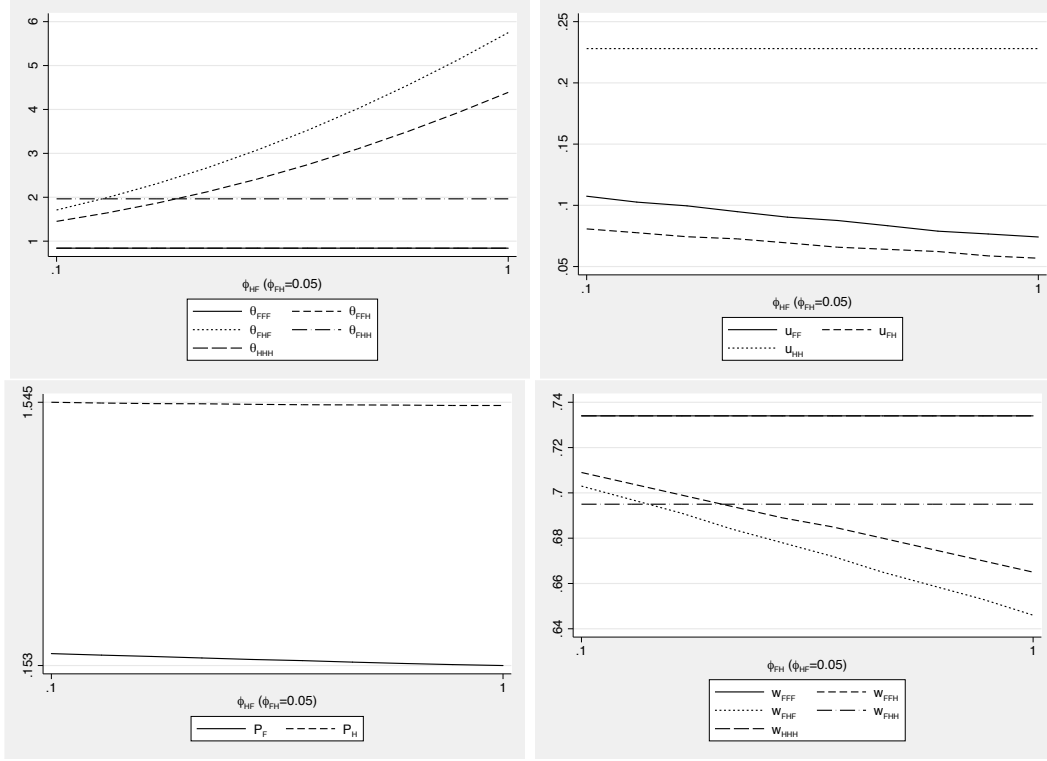
Figure 2.4: Full Discrimination Move Costs (Leaving)



and returning foreign workers see the next largest. There are large decreases in unemployment rates for stayers in both countries and a small increases for movers as flow costs move from zero to positive, but only small changes as costs become very large as shown in the middle panel. The increased flow cost faced by ever-movers is compensated with the increased probability of finding a job (larger $\theta q(\theta)$). When flow costs increase from zero, the population becomes less equally distributed quickly, but then the allocation changes become less dramatic after costs are approximately 15% of total productivity. Workers in either country who never move see no change in wages from a change in costs to living away from home. Ever movers all see decreases in wages with new migrants experiencing a smaller decline than workers who moved prior to their most recent spell of unemployment, who are the most affected since they have most likely been away from their country of origin longest.

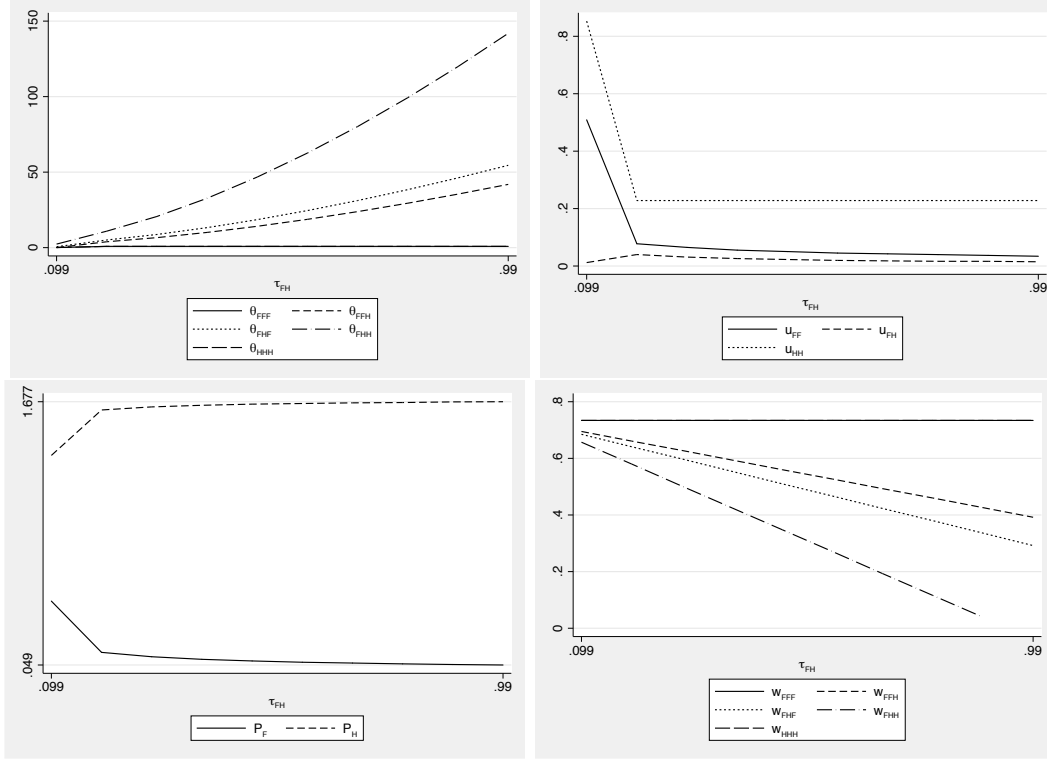
Figure 2.7 describes increasing productivity in the foreign country. Increasing foreign productivity decreases market tightness for all workers and unemployment for home natives.

Figure 2.5: Full Discrimination Move Costs (Returning)



Unemployment for foreign stayers and in the home country overall (first and second panel) increases. The foreign country sees an increase in unemployment as it catches up to the productivity in the home country, and then decreases as productivity there surpasses it. When foreign productivity is lower than in the home country, only 25% of foreign natives stay. As productivity increases, more workers stay/return, and few foreign workers migrate once productivity is twice as high in the foreign country. Even when productivity is twice that in the home country, workers migrate despite the increase in vacancies in the foreign country shown in the first panel. The fourth panel shows the impact on wages from increases in productivity in the foreign country. Home workers and foreign workers who moved prior to their most recent spell of unemployment see no change in wages from changes in foreign productivity. Foreign workers who never move have the largest increase in wages from increases in productivity followed by newly returning migrants and then new migrants into the home country.

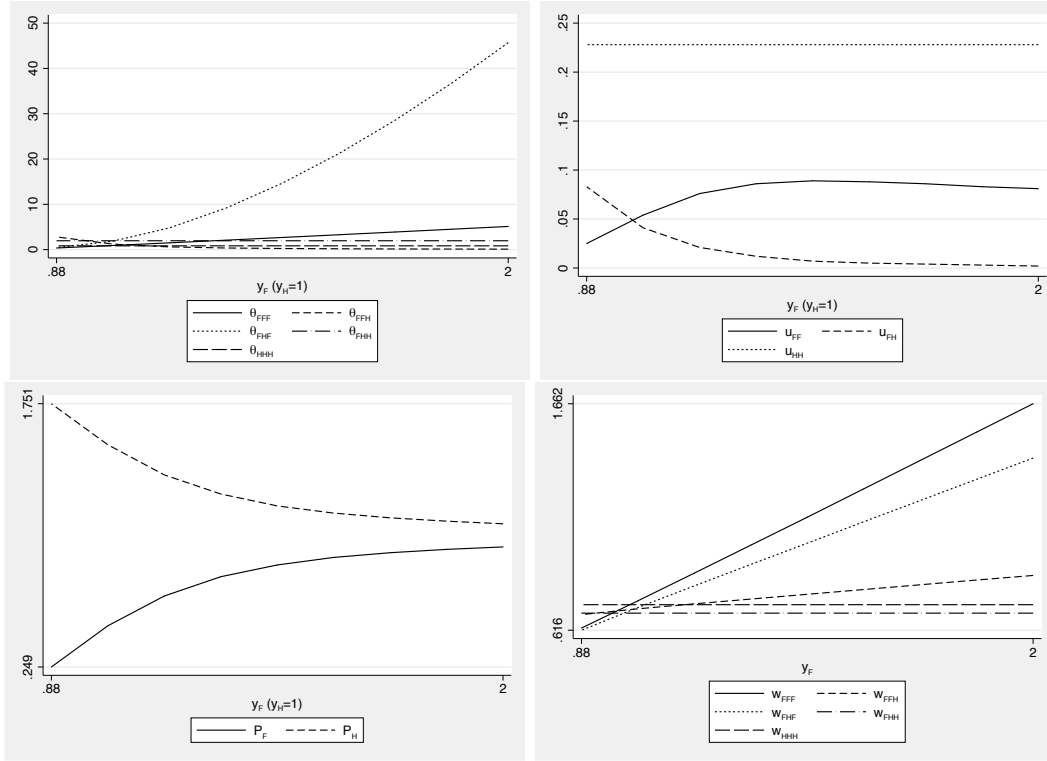
Figure 2.6: Full Discrimination Flow Costs



Increases in foreign posting and maintenance costs to firms are shown in Figure 2.8. The total surplus shared between workers and firms decreases as costs increase. When posting and maintenance costs to firms are high in the foreign country, fewer vacancies are offered (first panel), and unemployment increases for foreign migrants while it decreases for those left behind (second panel). Market tightness for all jobs in the foreign country decrease with the increased costs to firms. Workers become increasingly less equally distributed as the surplus falls to zero, and no workers remain in the foreign country. When posting costs in the foreign country increase, foreign workers who never move see a large decline in wages while home workers are unaffected. All migrants experience an initial decline in wages, but then wages stabilize for foreign workers who moved prior to their most recent spell of unemployment. Recent migrants in either direction see a continues decline that is larger for migrants returning to the foreign country than for those leaving.

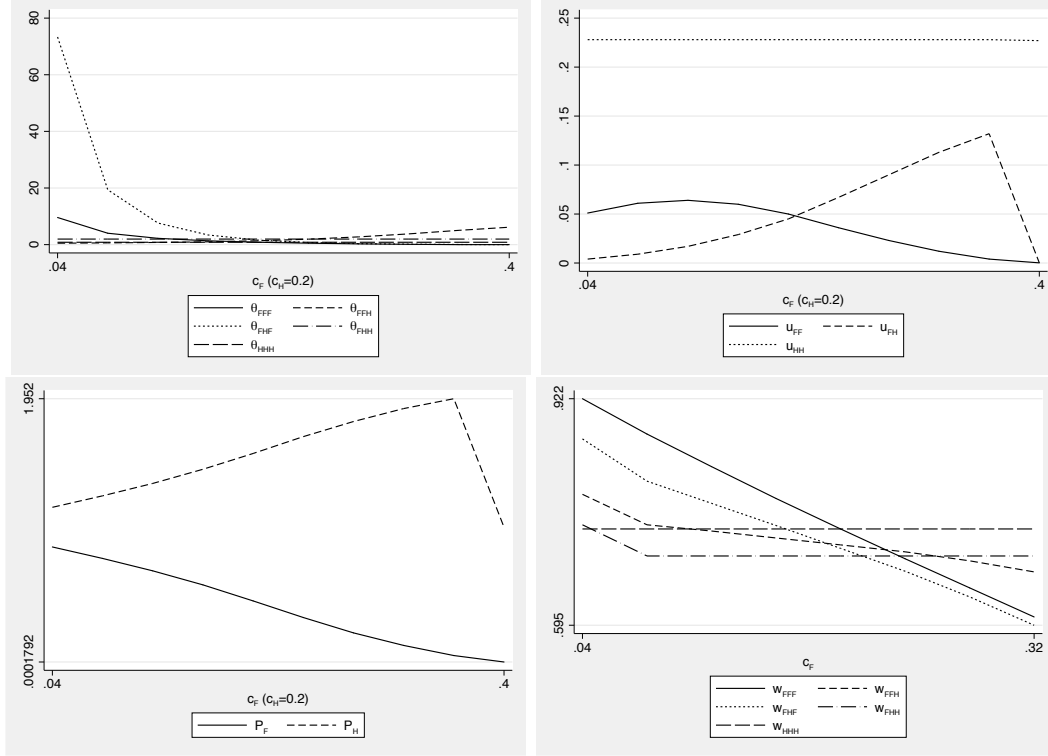
Increases in unemployment benefits in the foreign country shown in Figure 2.9 decrease

Figure 2.7: Full Discrimination Changing Productivity



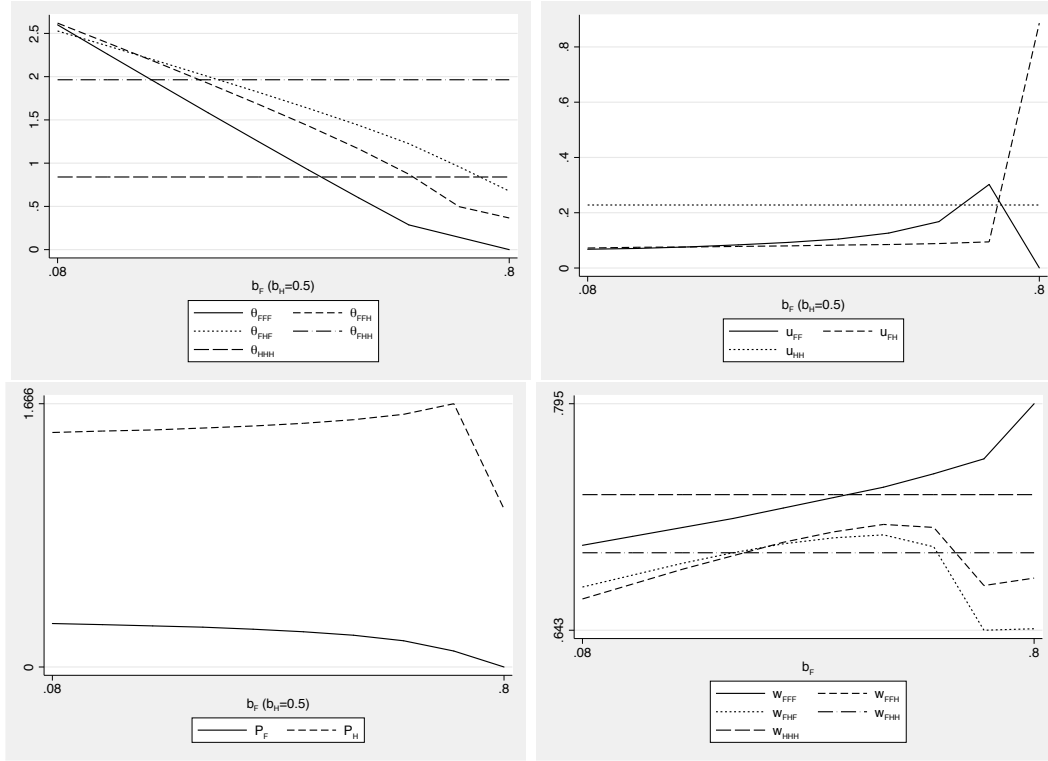
market tightness for foreign workers who will move for the next job or who never left the foreign country (first panel). Workers staying in the home country, including previous migrants experience no change in market tightness from the increase in unemployment benefits in the foreign country. Unemployment increases in the foreign country as employment becomes less desirable until firms stop opening vacancies and all workers leave the foreign country. While initial population distributions across the countries are quite imbalanced, increases in foreign unemployment benefits exacerbates the flight out of the foreign country; shown in the third panel of Figure 4.9. When unemployment benefits increase in the foreign country, foreign stayers experience an increase in wages, with an uptick as benefits approach the upper limit of allowed values. Home workers and foreign workers who moved prior to their most recent spell of unemployment see no change in wages from changes in foreign benefits. Recent migrants first benefit from the increase in unemployment benefits, but once benefits exceed those in the home country, wages decline.

Figure 2.8: Full Discrimination Posting and Maintenance Costs Changing



As workers in the foreign country gain more bargaining power, market tightness decreases for foreign nationals who have never moved, or who are returning from a previous move as seen in the first panel of Figure 2.10. Home workers and foreign workers staying in the home country after a previous move experience no effect on market tightness from foreign changes in bargaining power. Unemployment for all workers in the home country decreases with the increase in bargaining power, and increases for migrants. The foreign country first sees overall unemployment increase with the increase in bargaining power, and then decrease as workers flee to the home country, and a higher proportion of remaining workers are employed. The third panel of Figure 2.10 shows the out migration of foreign workers from the foreign country as bargaining power increases. Increasing foreign bargaining power increases wages for foreign stayers, foreign workers who moved prior to their most recent spell of unemployment, and foreign workers who are new migrants into the home country. New migrants experience a smaller increase than the others. Home workers and returning

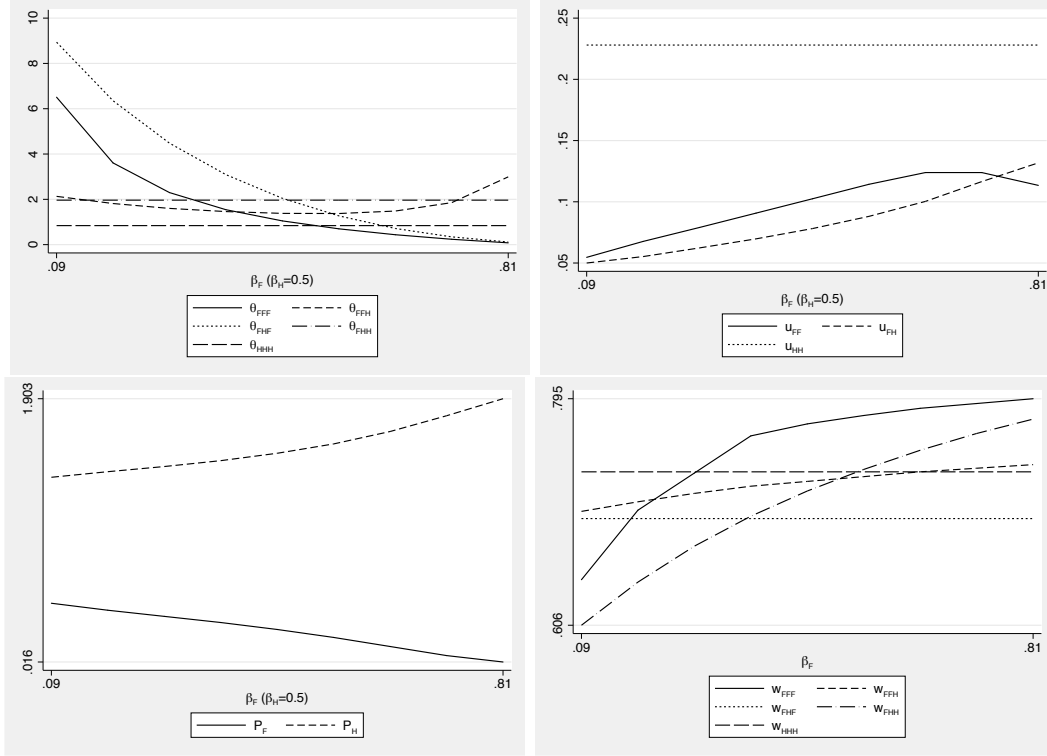
Figure 2.9: Full Discrimination Changing Unemployment Benefits



migrants experience no change in wages with changes in bargaining power in the foreign country.

Overall, home workers, who are not allowed to migrate, experience higher unemployment under most of the conditions observed. This can be attributed largely to their inability to move to seek out better, or at the least different, opportunities elsewhere. They are subject to the choices of foreign country nationals who are able to weigh the varying differences between the two countries. Home workers are adversely affected when the home country is more attractive to workers and firms, but the direction of parameter changes matter: When the foreign country becomes better (worse) by some measure, home workers benefit (suffer) in terms of falling (rising) unemployment. The ability of firms to discriminate across worker types also disproportionately impacts home workers as they are a captive labor pool incapable of arbitraging away opportunities. In general, wages are negatively correlated with costs to workers and firms and positively correlated with productivity, unemployment

Figure 2.10: Full Discrimination Changing Bargaining Power



benefits (for low and middling values), and bargaining power in the foreign country. Home workers' wages are never affected by changes in parameters in the foreign country since firms observe worker types, and can compensate only those workers affected by changes. Wages for foreign workers regardless of country of residence are more responsive to changes in parameter values.

2.2.2 Non-Discrimination

In the non-discrimination model, firms post a vacancy solely based on firm location independent of worker origin or unemployment location, and randomly meet with all unemployed workers in that market.

There are two distinct labor markets: one for each country. The main difference between the non-discrimination and the discrimination versions is that under non-discrimination the labor markets, through market tightnesses, θ_k 's, are explicitly interdependent (See Equations

2.28 and 2.29). This is due to the fact that firms in either country can hire foreign country workers, regardless of their unemployment location, and firms cannot choose between workers.

The impact of each market on the other helps to explain the persistence in differences in unemployment rates observed in the data (See Figures 1 and 2). Even with freedom of movement and convergence in labor market policies documented by Bonin et al. (2008), the model mimics qualitative patterns seen in the data, and large differences in labor market conditions persist even when labor market characteristics converge.⁸

In the discrimination models, firms hire only one type of worker. Where type is determined by worker origin, unemployment location, and (eventual) hiring firm location. In the non-discrimination models, firms choose a vacancy based on the eventual firm hiring location that is independent of the worker origin and unemployment location. The interdependence of the two labor markets builds-in the concept of spillovers in the market tightnesses of each market, while maintaining the externalities imposed by individuals failing to account for their impacts on each market. Firms are also able to access a much larger pool of workers. Home firms are able to hire any unemployed worker in either country. Foreign firms can hire any unemployed foreign worker, regardless of unemployment location. The only restriction is that foreign firms may not hire home workers since their migration is blocked.

Once again, unemployed workers choose to search in either market (if foreign), with the flow value of unemployment equal across search in either country in equilibrium. The flow value of unemployment depends on workers' country of origin, country of unemployment, and the net value of finding a job in either country:

$$rU_{ij} = b_j - \tau_{ij} + \max_k \{ \theta^k q^k(\theta^k)(N_{ij}^k - U_{ij}^k - \phi_{jk}) \} \quad (2.22)$$

Again, $\tau_{ij} = 0$ when $i = j$ and $\phi_{jk} = 0$ when $j = k$.

⁸See Figure 2.1, and Section 4 for more detailed discussion.

Home workers face a similar value of unemployment without choosing over k , and face no costs.

The flow value of employment to the worker, rN , remains the discounted value of the wage less the value of moving into unemployment:

$$rN_{ij}^k = w_{ij}^k - \tau_{ij} + \delta(U_{ik} - N_{ij}^k) \quad (2.23)$$

$\tau_{ij} = 0$ when $i = j$.

Firms choose whether to post a vacancy based on the cost to post as well as the probability weighted value of filling the vacancy and moving into production without differentiating between workers of different location. This gives the flow value of posting a vacancy, rV :

$$rV_i = -c_i + \frac{q^i(\theta^i)}{(u_{ii} + u_{ij})} [u_{ii}(J_{ii}^i - V_i) + u_{ij}(J_{ij}^i - V_i)] \quad (2.24)$$

in country i , and

$$rV_j = -c_j + \frac{q^j(\theta^j)}{(u_{ii} + u_{ij} + u_{jj})} [u_{ii}(J_{ii}^j - V_j) + u_{ij}(J_{ij}^j - V_j) + u_{jj}(J_{jj}^j - V_j)] \quad (2.25)$$

in country j .

The flow value of a filled vacancy, rJ , to the firm is again the discounted value of productivity less the cost to posting, the wage payment, and the probability weighted value of the match dissolving:

$$rJ_{ij}^k = y_k - w_{ij}^k - c_k + \delta(V_k - J_{ij}^k) \quad (2.26)$$

Wages are determined exactly as in the discrimination model from Equation (2.13). Firms in country k receive $(1 - \beta_k)$ of the match surplus as in the discrimination model.

The consolidated markets in the non-discrimination case means that the relevant matching probability and market tightness are indexed by firm location only:

$$q_k(\theta_k) = (1 + (\theta_k)^{Z_k})^{-1/Z_k} \quad (2.27)$$

Equilibrium

Equilibrium in the non-discrimination model is determined as in the discrimination model. Free-entry for firms again means that new vacancies are posted until the flow value of an empty vacancy is zero.

Market tightness is defined for each country as:

$$\theta_F = \frac{v_F}{u_{FF} + u_{FH}} \quad (2.28)$$

$$\theta_H = \frac{v_H}{u_{FF} + u_{FH} + u_{HH}} \quad (2.29)$$

Market tightness spillovers can now be seen explicitly in the overlap of the unemployment pool that is relevant to each market. The home workers' migration restriction is also reflected here.

Equality of job creation and destruction at the country-level is given by:

$$\theta_F q^F(\theta_F)(u_{FF} + u_{FH}) = \delta n_F \quad (2.30)$$

$$\theta_H q^H(\theta_H)(u_{FF} + u_{FH} + u_H) = \delta n_H \quad (2.31)$$

The number of migrants into each country must equal the number of migrants in to keep population constant, but not necessarily equal, in equilibrium:

$$\theta_F q^F(\theta_F) u_{FH} = \theta_H q^H(\theta_H) u_{FF} \quad (2.32)$$

Populations in each country are the number of staying employed and unemployed, plus the number who have moved and either remain employed, or who have lost employment and are unemployed abroad. Initial populations are given by:

$$P_o^F = u_{FF} + u_{FH} + n_F + \frac{\theta_H q^H(\theta_H)(u_{FF} + u_{FH})}{\delta} \quad (2.33)$$

$$P_o^H = u_H + \frac{\theta_H q^H(\theta_H) u_{HH}}{\delta} \quad (2.34)$$

Parameterization

Bounds on parameters for the non-discrimination characterization are not sensitive to cases where the two countries are symmetric, but are sensitive to asymmetric labor markets. Numerical bounds and equilibrium values were determined using a multiple complementarity solver in GAMS. The bounds presented here are sufficient conditions that ensure reasonable values for unemployment, vacancies and employment, given the values of the other parameters.

Initial population, P_o , in the country not allowed to migrate is bounded above: it cannot be more than 5.7 times the size of the country that is allowed to migrate. Productivity, y , and posting and maintenance costs, c , bounds are unchanged from the discrimination characterization. Costs to firms for posting and maintaining a vacancy are bound below by zero, and above by worker productivity less unemployment benefits, b , and costs to workers to move, ϕ , and be away from home, τ , when productivity is adjusted to be sufficiently large to satisfy analytical bounds.

Costs to moving and being away from home as well as the job destruction rate are limited

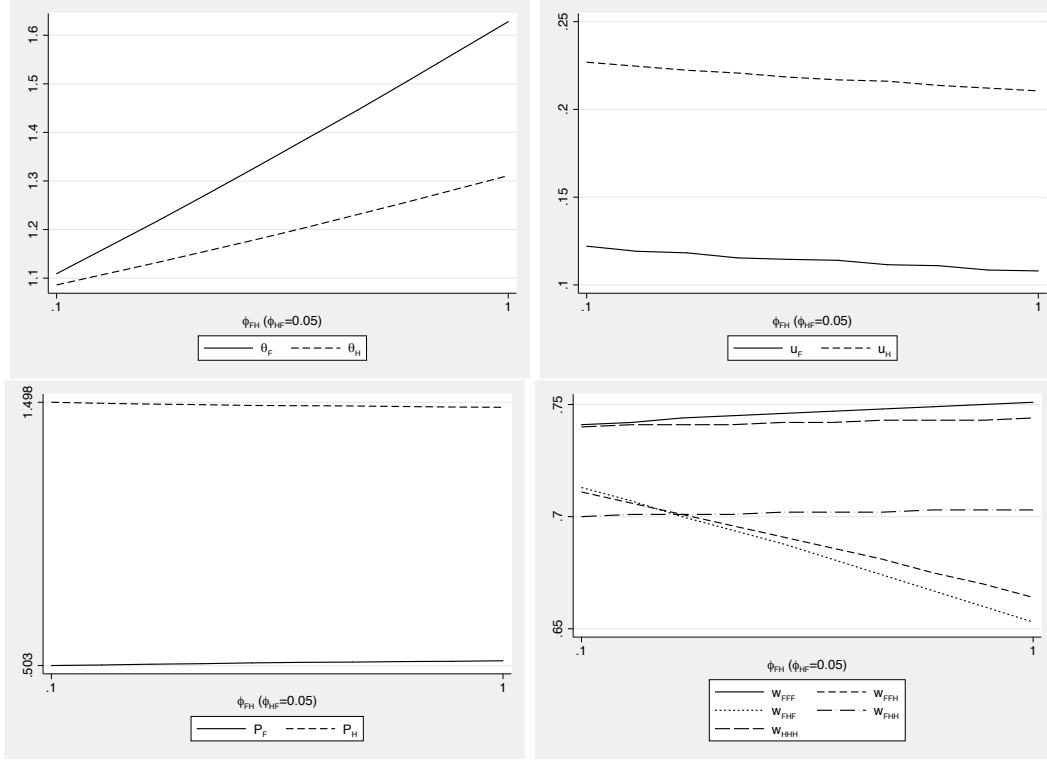
from zero to one. The discount rate must be below 0.6. Unemployment benefits must be below one, and above 0.5 or 0.75 in the symmetric and asymmetric cases. These bounds provide a large range around calibration values used in Albrecht and Vroman (2002) as well as Beine et al. (2013), Petrosky-Nadeau and Zhang (2013), and others.

Numerical Exercises

Figures 2.11 and 2.12 show the impact from increasing move costs to workers. As it becomes increasingly costly for foreign workers to move in either direction (to or from the foreign country), market tightness and employment increase everywhere. Firms choose to compensate all workers for the costs foreign migrants face by increasing the probability of finding a job in both countries. Foreign workers are not equally distributed across countries even when the move cost in one direction is low, but fewer workers move out of, and into, the foreign country as those costs increase. Even in the case of symmetric costs, the two countries have differing levels of unemployment, with the levels identical (not shown in the figure) when the costs are zero and decreasing as the costs to leave the foreign country increase. The relative differences between the levels across worker types and countries remains constant for all values of the cost to leave. Wages for home workers, foreign workers who moved prior to their most recent spell of unemployment, and foreign stayers increases slightly as move costs increase, though migrants always have lower wages than stayers. New migrants experience decreasing wages as move costs increase, and returning migrants see the largest decrease as they move twice rather than once.

Increasing flow costs to workers living away from country of origin has a similar, if more nuanced, effect as the move costs: Market tightness and employment increase in the home country with little change in the foreign country due to the asymmetry of the cost faced based on location. Figure 2.13 shows this effect. Firms only compensate workers who are away from home, rather than compensating those foreign natives who have stayed behind as in the case of increasing costs to move. Changes in flow costs for the given parameterization

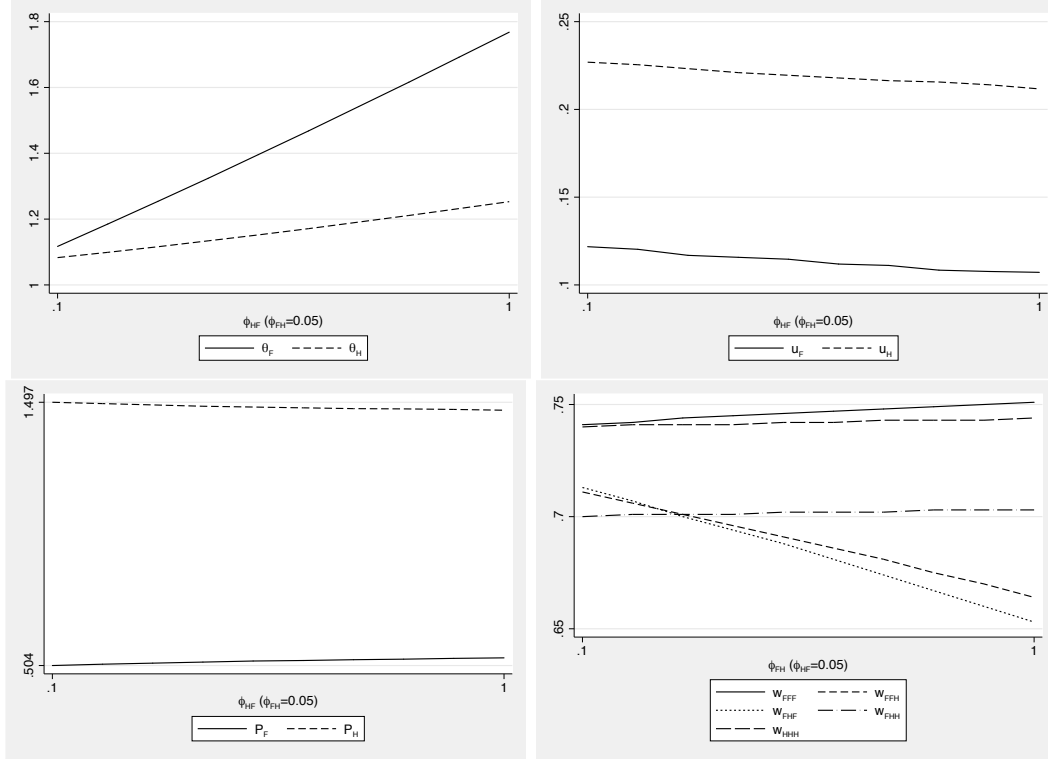
Figure 2.11: Non-Discrimination Move Costs (Leaving)



have very little impact on workers' allocation across countries: the first and third panels of Figure 2.13 indicates that flow costs are compensated by an increased probability of finding a job in the home country. Foreign workers benefit disproportionately, though not uniquely, in all three cost scenarios (Figures 2.11, 2.12 and 2.13). Wages for foreign stayers and home workers are unaffected by costs to living away from worker origin. New migrants face decreasing wages as flow costs increase as do workers who moved prior to their most recent spell of unemployment. Prior movers experience the largest decrease in wages.

Productivity differences are shown in Figure 2.14. As productivity in the foreign country increases, market tightness in the foreign country increases while tightness decreases slightly in the home country. Unemployment for foreign migrants decreases as productivity increases, and migrants return home. Unemployment for stayers in both countries increases as the foreign country becomes more productive since in the foreign country, there are more people searching for jobs, and in the home country job matches are relatively less productive. As

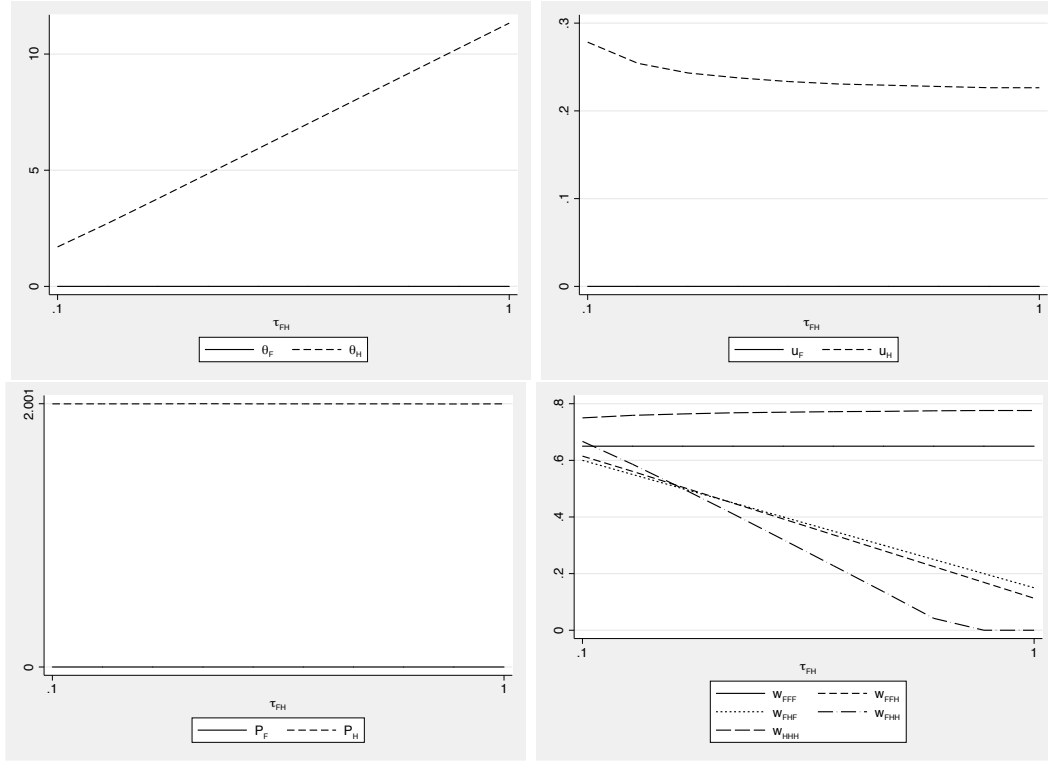
Figure 2.12: Non-Discrimination Move Costs (Returning)



the foreign country becomes more productive, more foreign workers remain in the foreign country. Further increases in foreign productivity beyond levels shown in the third panel of Figure 2.14 eventually result in no migration to the home country. Home workers and foreign workers who migrated before their most recent unemployment period see a small decrease in wages when foreign productivity increases. Foreign stayers see the biggest increase in wages with productivity, followed by returning migrants and newly leaving migrants. Newly leaving migrants see only a small increase relative to the others.

Figure 2.15 shows that increasing the job posting cost in the foreign country decreases market tightness in the foreign country, and slightly increases tightness in the home country. Posting cost increases increase unemployment for foreign migrants and decrease unemployment for home workers. Foreign stayers experience decreasing unemployment as costs increase due to the exodus of foreign workers into the home market with larger match surplus and higher probability of finding a job. When costs in the foreign country are about one

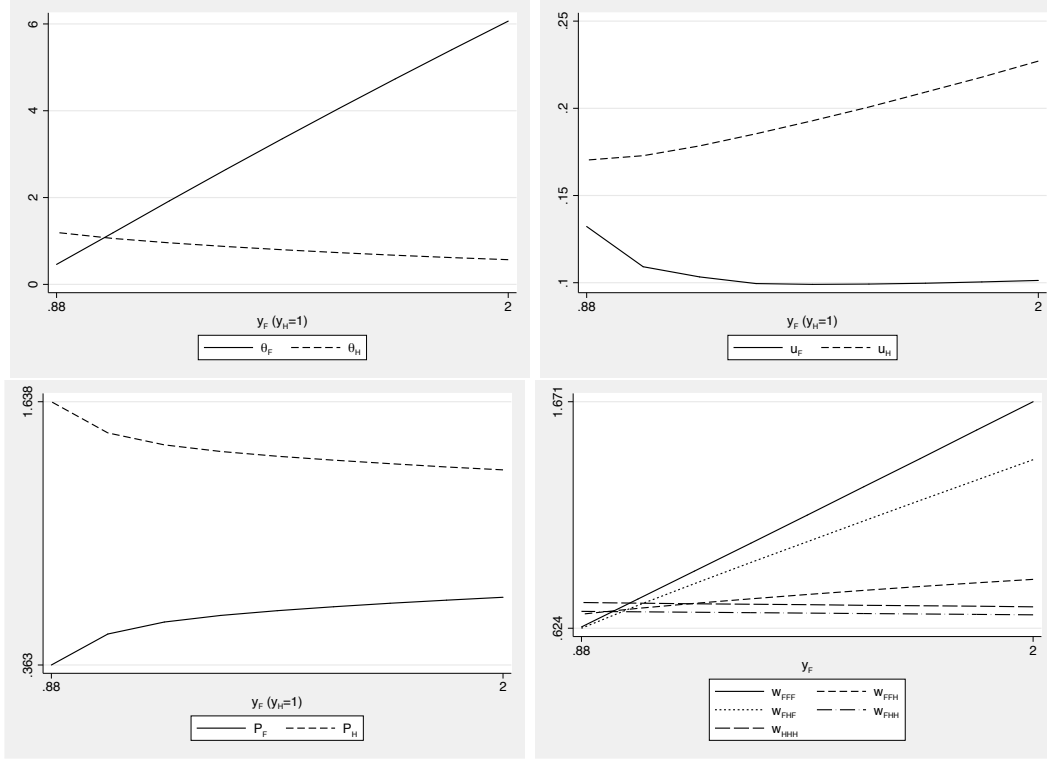
Figure 2.13: Non-Discrimination Flow Costs



and a half times those in the home country, no workers remain in the foreign country. Home workers and migrants in the home country who moved before the most recent unemployment spell see a small increase in wages when posting costs increase in the foreign country. Foreign stayers and new migrants experience a decrease in wages with foreign stayers seeing the largest decline as costs increase, followed by newly returning migrants. Newly leaving migrants see only a small decline relative to the others.

Changes in foreign unemployment benefits are shown in Figure 2.16. Increasing unemployment benefits in the foreign country decreases market tightness in the home country. Unemployment for all workers increases. Home workers experience the biggest increase in unemployment while foreign movers the least. Employment decreases by about 2% in the home country, and is stable in the foreign country. Fewer foreign workers migrate as benefits becomes more generous. Wages for home workers and foreign workers who migrated before their most recent unemployment period see a small decrease in wages as unemployment ben-

Figure 2.14: Non-Discrimination Changing Productivity

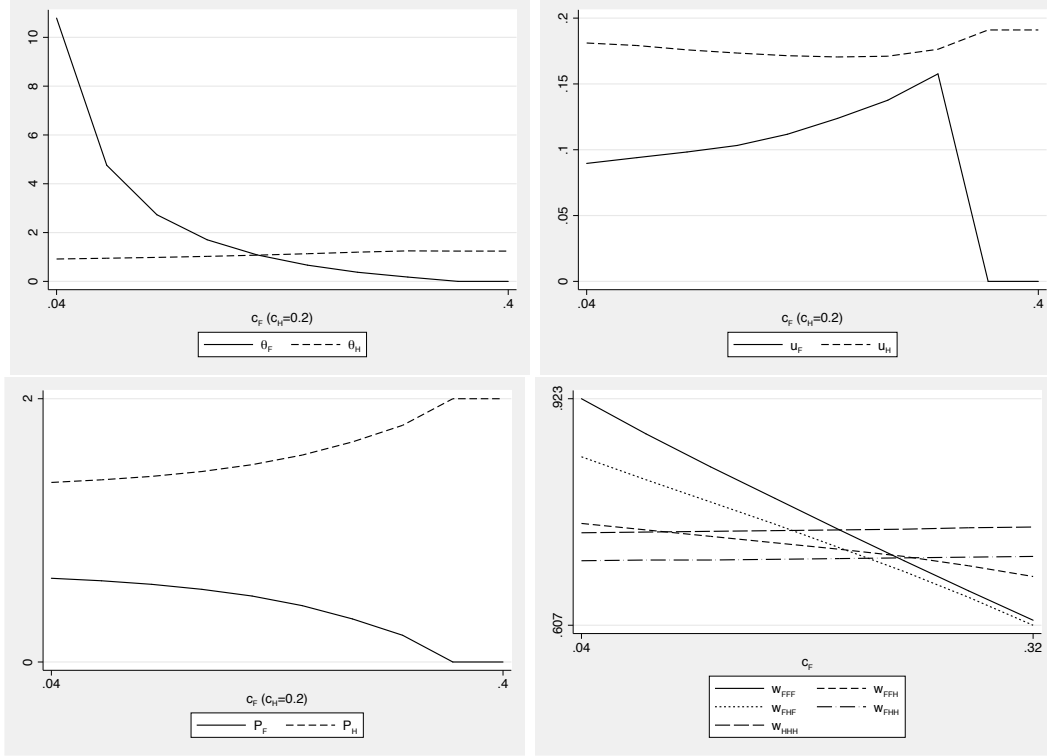


efits increase in the foreign country. Foreign stayers and new migrants experience an increase in wages. Foreign stayers benefit the most followed by newly returning migrants and then newly leaving migrants.

Bargaining power changes in the foreign country have no impact in either market in terms of market tightness, unemployment, and population distributions, as shown in 2.17.⁹ Under different parameterizations, changes in bargaining power do have an impact that is qualitatively similar to the effect shown in Figure 4.10 under full discrimination. Wages for some workers are impacted from the changes in bargaining power under the baseline parameterization. All workers located in the home country see no change in wages from the change in bargaining power in the foreign country, but all workers in the foreign country see an increase in wages as their power increases. Foreign stayers see a smaller percentage increase than newly returning migrants, but foreign stayers always have higher wages than

⁹This is due to the particular calibration with the home country. Different baseline parameterizations can generate changes in market tightness, unemployment and migration from changes in bargaining power.

Figure 2.15: Non-Discrimination Posting and Maintenance Costs Changing



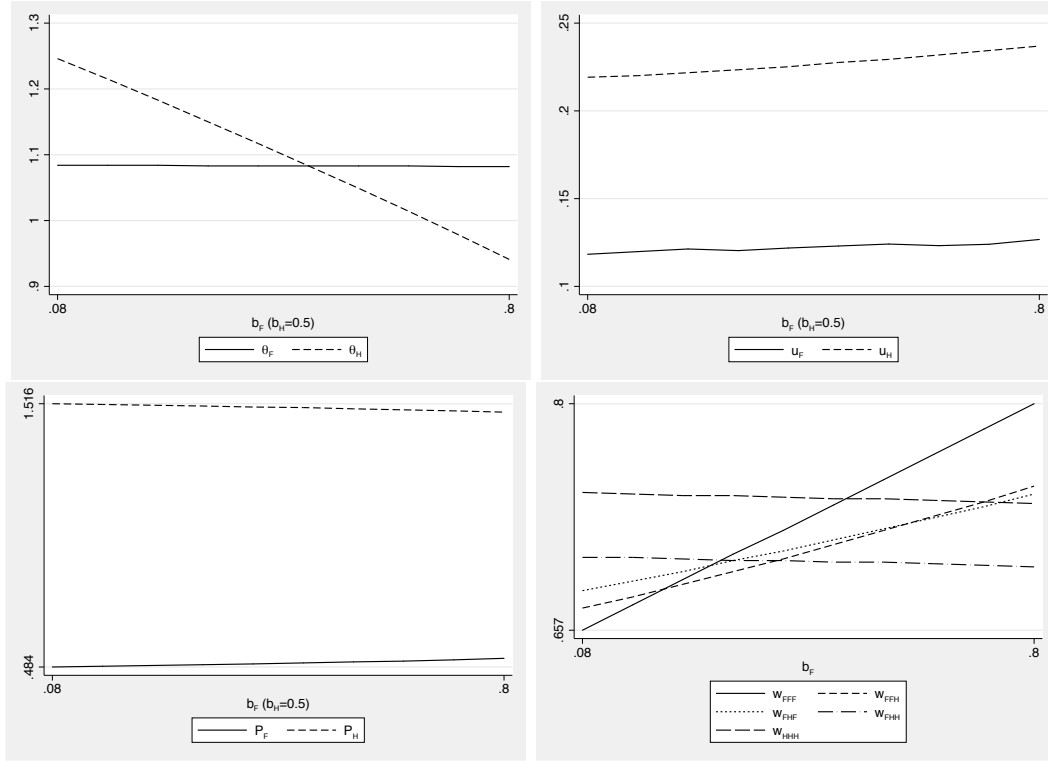
the returning migrants.

When foreign workers face costs to move to and from the home country, home workers see wage increases whenever the population in the home country decreases. When migration is due to changes in foreign productivity, vacancy costs or unemployment benefits, home workers have higher wages when more foreign workers are in the home country. Separating out migrants' incentives to move between these two groups of effects can help explain whether migration should be expected to increase or decrease natives' and prior migrants' wages. This can provide a theoretical justification of the results in Ottaviano and Peri (2012).

2.2.3 Discrimination vs Non-Discrimination

Firms post more vacancies under discrimination as costs to move to the home country increase, and home workers see lower unemployment (Figures 2.4 and 2.11). As migration into the home country becomes costly, migrants have lower unemployment under

Figure 2.16: Non-Discrimination Changing Unemployment Benefits

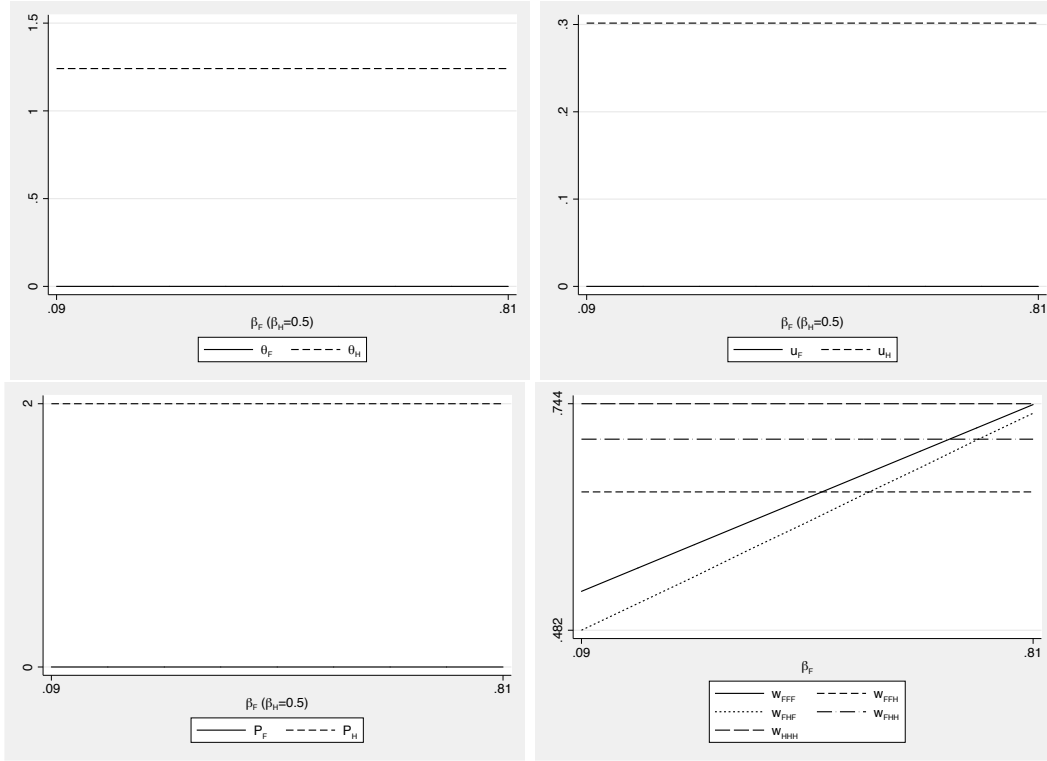


non-discrimination; foreign stayers have lower unemployment under discrimination, but by less than the foreign migrants and home workers benefit. Wages for foreign stayers, home workers, and foreign migrants who migrated before their most recent unemployment period are higher under discrimination by firms. New migrants are equally well-off in terms of wages under either type of firm behavior.

The qualitative results for market tightness and unemployment are the same when workers instead face an increasing cost to return home rather than to leave; shown in Figures 2.5 and 2.12. Quantitative differences are hidden by the imprecise scale on the figures. Move costs seem to matter more in their existence rather than the direction of the move in which workers face them. Wages for all workers are higher under non-discrimination by firms, though the differences between firm behaviors are small.

In the case of flow costs shown in Figures 2.6 and 2.13, market tightness under discrimination is much higher than under non-discrimination. Increases in the flow costs migrants

Figure 2.17: Non-Discrimination Changing Bargaining Power



face increases tightness under both regimes in the home country, and in the foreign country under discrimination but not under non-discrimination. Initial increases from zero flow costs decrease unemployment, foreign workers always have lower unemployment than home workers, particularly under non-discrimination. Home workers fare better under discrimination. Wages for home workers and foreign migrants who migrated before their most recent unemployment period are higher under non-discrimination by firms. Foreign stayers and new migrants have higher wages when firms cannot discriminate.

When productivity in the foreign country increases (Figures 2.7 and 2.14), firms post more vacancies per unemployed worker in both countries when allowed to discriminate between workers. This keeps unemployment lower for home workers and overall in the home country lower than when firms are unable to discriminate. In this case, firms are able to respond to the increase in productivity in the foreign country by increasing postings for workers currently living there, and also to lure foreign migrants back home. The return migration of

foreign workers alleviates some of the disadvantage now facing the home firms by making the unemployment pool in the home country smaller. Workers there are indirectly compensated for their lower productivity with increased probability of finding a job. Wages for new migrants and foreign migrants who migrated before their most recent unemployment period are higher under discrimination by firms. Foreign stayers have higher wages under non-discrimination by firms. Home workers are better off with discrimination when the countries are symmetric, but worse off with discrimination when the foreign country is more productive.

While the qualitative impacts of changes in posting costs in the foreign country are the same across regimes (Figures 2.8 and 2.15), there are many more vacancies in the discrimination regime in the home country. Foreign stayers are again indifferent between regimes in terms of unemployment, but home workers have lower unemployment under non-discrimination and foreign migrants prefer discrimination. Wages for home workers are higher when firms cannot discriminate. All foreign workers who have ever lived in the home country receive higher wages when firms can discriminate. Foreign stayers receive higher wages when firms can discriminate, and posting costs in the foreign country are low, but higher wages when firms cannot discriminate and posting costs in the foreign country are high.

Differences in unemployment benefits across countries are arbitrated away by migration except for when the foreign country is exceptionally generous in the full discrimination model as seen in Figure 2.9. When firms cannot discriminate, market tightness in the home country decreases as the foreign country becomes more generous, seen in Figure 2.16. Firms at home open fewer vacancies when the foreign country is more generous because the outside option of foreign workers becomes so high that more vacancies are less effective in luring more workers. In line with the literature, in the non-discrimination model, unemployment rises with unemployment benefits, but the increase is across all workers, not just those able to benefit from the increase. Under full discrimination, unemployment for workers in the home country is constant until benefits in the foreign country are very high, and then increases

for migrants only. Foreign stayers experience increased unemployment with the increase in benefits. Home workers and migrants have lower unemployment under non-discrimination whereas foreign stayers are indifferent between the two regimes. Home country job seekers are rewarded with a higher probability of finding a job under discrimination. All workers except for foreign stayers always receive higher wages when firms cannot discriminate. Foreign stayers receive higher wages when benefits are low when firms discriminate, but higher wages when benefits are high when firms cannot discriminate.

Under the baseline parameterization, changes in bargaining power have no impact on most outcomes in the non-discrimination model (Figure 2.17). When firms are allowed to discriminate (Figure 2.10), they choose to open more vacancies in the country where workers take less of the share of the match surplus. Unemployment is higher with discrimination for foreign workers and under non-discrimination for home workers, though few workers choose to stay in the foreign country when facing worse bargaining power at home. Home workers receive higher wages when firms cannot discriminate. Foreign stayers and new migrants into the home country receive higher wages when firms discriminate. Newly returning migrants receive higher wages when foreign bargaining power is low and firms discriminate, but higher wages when foreign bargaining power is high when firms cannot discriminate. Migrants who moved prior to their most recent unemployment spell receive higher wages when firms discriminate when foreign bargaining power is high, but higher wages when firms cannot discriminate and foreign bargaining power is low.

Home workers are expected to prefer the discrimination regime since firms are able to separate out the migrants from the home workers in unemployment, and take advantage of the differential opportunity costs faced by the different workers as well as the inability of home workers to move. Typically, this separation generates higher wages and lower unemployment for home workers. Under non-discrimination, firms cannot separate these effects from the costs and the mobility restriction, and so make vacancies available based only on the number of unemployed rather than taking into account their outside options explicitly as when they

discriminate. The impact on wages is mixed, such that workers do not always prefer one firm behavior over another. Their exact preference will depend on particular parameterizations.

2.2.4 Efficient Allocations

I examine how a benevolent planner would allocate workers across the two countries and between employment status in order to compare it to the decentralized equilibrium without discrimination. It is common in models of labor search and matching to evaluate welfare and efficiency of the market outcome by comparing the workers' bargaining power in the market outcome to the elasticity of the matching function. As discussed in Sargent (2017), there are a number reasons this is not possible in this model. Particularly, with migration, the free entry conditions for firms cannot be compared across the planner's allocation and the market allocation in equilibrium as is typically done. Instead, I look at the difference between labor market outcomes and worker allocation between the non-discrimination and planner's problems. Comparing the two gives an estimate of how far away from a first-best equilibrium the market allocation lies.

The planner seeks to maximize joint well-being of the firms and workers. The planner is subject to the same matching frictions as the workers and firms, and faces the same costs to posting jobs and movement of workers, where applicable. Equilibrium variables of interest remain the same as in the market equilibrium.

The planner maximizes:

$$\begin{aligned} \int_0^\infty e^{-rt} & [(y_F - c_F)n_{FF} + (y_H - c_H)(n_{FH} + n_{HH}) + b_F u_{FF} + b_H(u_{FF} + u_{FH}) \\ & - c_F \theta_F(u_{FF} + u_{FH}) - c_H \theta_H(u_{FF} + u_{FH} + u_{HH}) \\ & - \phi_{FH} \theta_H q_H u_{FF} - \phi_{HF} \theta_F q_F u_{FH} - \tau_{FH}(u_{FH} + n_{FH})] \end{aligned} \quad (2.35)$$

The first four terms are the net benefits of workers from a given allocation across space and employment status. The next two terms are the costs of open vacancies to society. The

final three terms are the costs to workers from moving from one location to another upon matching with an open vacancy, and the costs to workers who are living abroad.

The planner remains subject to the laws of motion for unemployment:

$$\dot{u}_{FF} = \delta n_F - \theta_F q_F u_{FF} \quad (2.36)$$

$$\dot{u}_{FH} = \delta n_{FH} - \theta_F q_F u_{FH} - \theta_H q_H u_{FH} \quad (2.37)$$

$$\dot{u}_{HH} = \delta n_{HH} - \theta_H q_H u_{HH} \quad (2.38)$$

$$\dot{n}_{FF} = \theta_F q_F (u_{FF} + u_{FH}) - \delta n_{FF} \quad (2.39)$$

$$\dot{n}_{FH} = \theta_H q_H (u_{FF} + u_{FH}) - \delta n_{FH} \quad (2.40)$$

$$\dot{n}_{HH} = \theta_H q_H u_{HH} - \delta n_{HH} \quad (2.41)$$

These six constraints represent the same evolution of employment and unemployment as in the non-discrimination competitive equilibrium. The planner is also subject to the equilibrium conditions (2.28), (2.29), (2.30), (2.31), (2.32), (??) and (2.34) as in the non-discrimination case on population, market tightness definitions and migration which ensure a stationary equilibrium.

Wages are determined exactly as in the competitive equilibrium models shown in Equation (2.13), with firms and workers sharing the surplus of the match according to worker's bargaining productivity, β_k while firms in country k receive $(1 - \beta_k)$ of the match surplus. The planner is indifferent to the sharing rule between firms and workers.

Parameterization

The elasticity of the matching function, Z_k may range from 0.3 to 10 in the case of country symmetry, or from 0.3 to 3.8 in the case of asymmetry. The common discount rate, r , and job destruction rate, δ , may range from 0 to 0.33. P_o^H cannot be more than 60 times P_o^F in the case of asymmetry. In the case of asymmetry, y_H can be no more than 20% larger

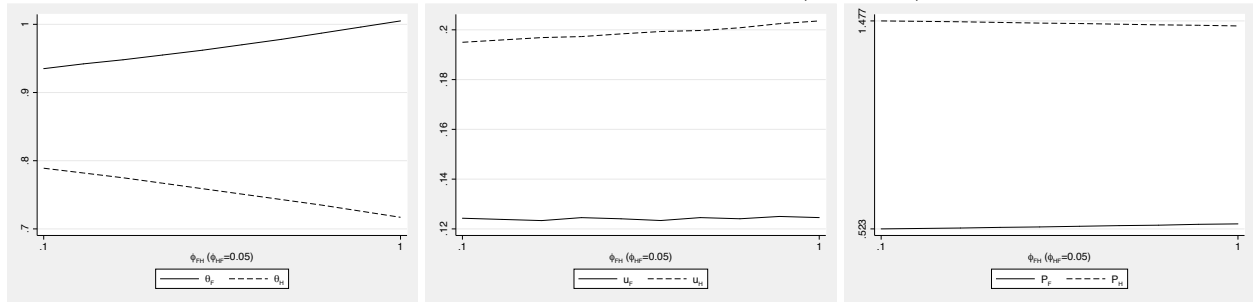
than y_F if the planner is to keep people in both countries.

When y_H is sufficiently large, the benefits of the thicker market outweigh both the moving costs and the flow costs to being away that keeps a population in both countries. When y_F is larger than y_H , the difference in productivity cannot exceed y_F being more than 188% the productivity in the home country to form a non-degenerate equilibrium. Flow costs to living away from one's country of origin, τ_{ij} , may range from 0 to 0.41. Move costs, ϕ_{jk} , may range from 0 to 1.34 in the case of country symmetry, and 0 to 2.29 in the case of asymmetry.

Numerical Exercises

Figure 2.18 shows that increasing costs to foreign workers of an out migration from the foreign country increases market tightness in the foreign country and unemployment in the home country (first panel). Market tightness in the home country decreases as more workers move in from the foreign country. Unemployment for foreign workers is relatively constant as the planner keeps migrants' unemployment low to compensate for the move cost. As move costs increase for foreign workers leaving the foreign country, the planner allocates around 2% more workers to the foreign country when move costs are high compared to when they are low. Even the planner has a muted response to moving costs to workers.

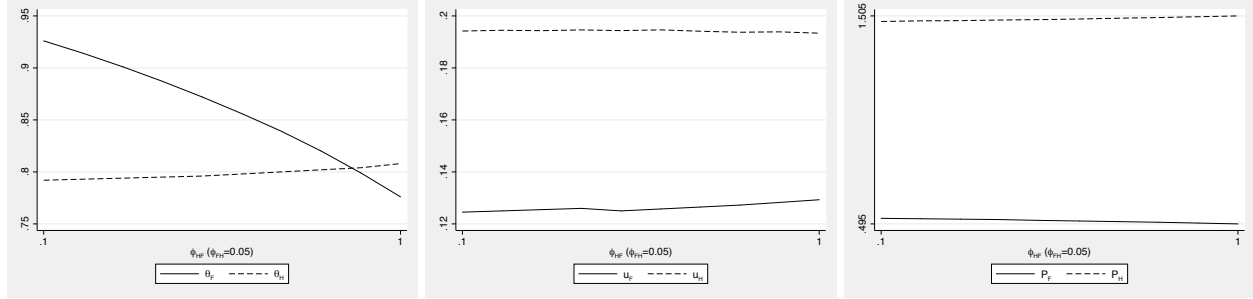
Figure 2.18: Planner Move Costs (Leaving)



When the cost of return migration for foreign workers increases, shown in Figure 2.19, market tightness and employment in the foreign country decrease. Market tightness in the home country increases slightly as it is costly for existing migrants to return, and firms do not

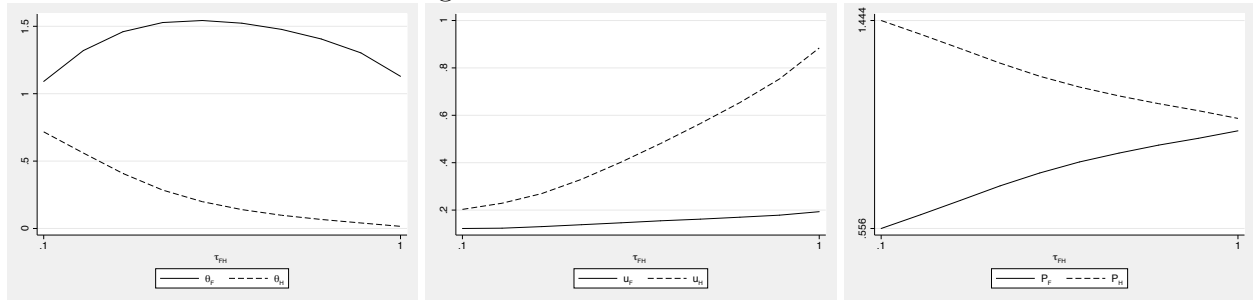
increase openings in the home country to compensate for the influx of workers. The planner chooses to keep fewer workers in the foreign country, preferring to allocate all workers in the home country when costs to return to the foreign country are high.

Figure 2.19: Planner Move Costs (Returning)



Flow costs have a much larger impact on the planner's allocations than move costs, shown in Figure 2.20. Increasing flow costs to foreign migrants first increases market tightness and then decreases it as it becomes prohibitively costly for foreign workers to live away from home. Home tightness decreases as the planner decreases vacancies more than proportionately with the movement of foreign workers out of the home country. Unemployment in the home country increases as it becomes increasingly unattractive to foreign workers and the planner partially compensates the foreign migrants at the expense of home workers. When costs are low, the planner moves just under half of foreign workers to the home country, but as costs to be away from home increase, the planner keeps more foreign workers in the foreign country, eventually choosing to keep all workers from migrating.

Figure 2.20: Planner Flow Costs



Qualitative impacts from changes in foreign productivity mimic those from changes in flow costs, and are shown in Figure 2.21. Increasing foreign country match productivity leads the planner to increase the supply of vacancies in the foreign country while keeping some foreign workers unemployed even as productivity is twice the level in the home country. The home country experiences a decrease in market tightness and a large increase in unemployment as matches there are increasingly unproductive. The planner keeps more foreign workers in the foreign country as productivity there increases, but for the ranges shown, foreign productivity is never high enough to prompt the planner to evenly allocate workers across the two countries.

Figure 2.21: Planner Changing Productivity

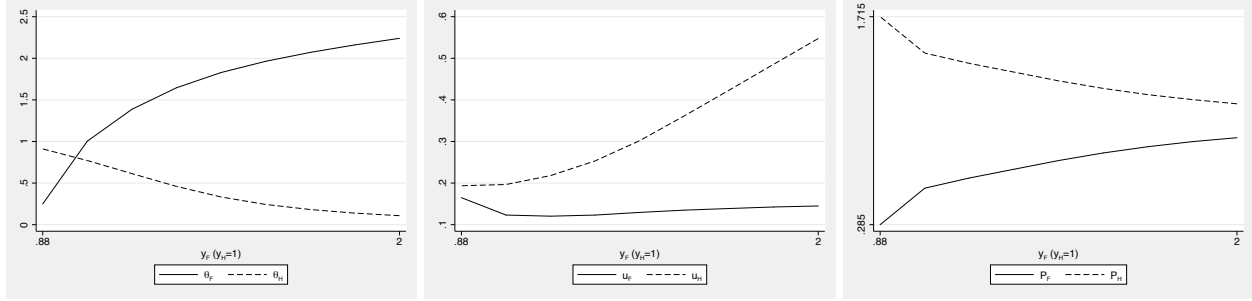
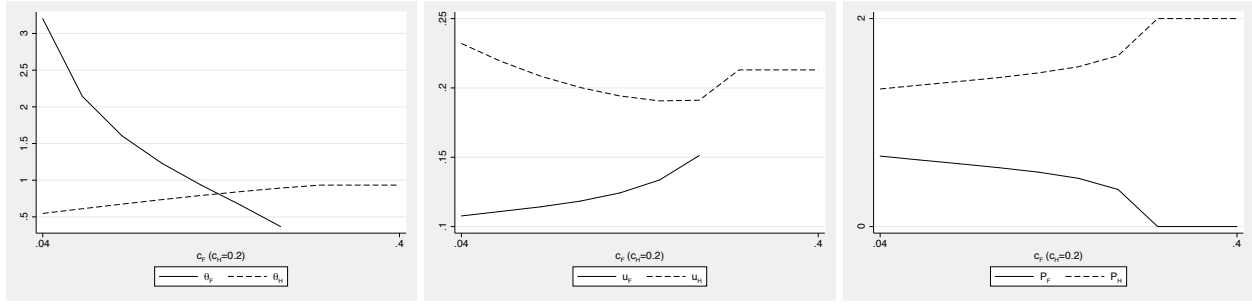


Figure 2.22 shows the planner's reaction to changing foreign firms' costs to posting and maintaining a vacancy. Making job posting and maintenance more costly in the foreign country decreases tightness in the foreign country and unemployment for both home and foreign natives. Market tightness in the home country and unemployment for foreign migrants and in the foreign country increases. Increases in job posting and maintenance costs make the foreign market very unattractive to the planner for postings. Once costs exceed about a third of production value, the planner ceases to keep any foreign workers in the foreign country.

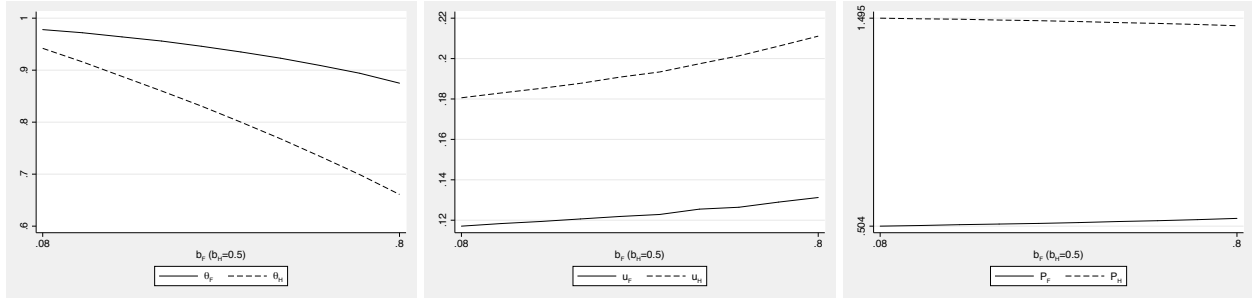
As shown in Figure 2.23, more generous unemployment benefits in the foreign country decrease market tightness everywhere as employment decreases due to its decreased value relative to unemployment. The home country sees a larger fall in tightness than the foreign

Figure 2.22: Planner Posting and Maintenance Costs Changing



country. More generous foreign benefits induces the planner to keep slightly more foreign workers in the foreign country, but generous unemployment benefits are not sufficient to keep workers from migrating.

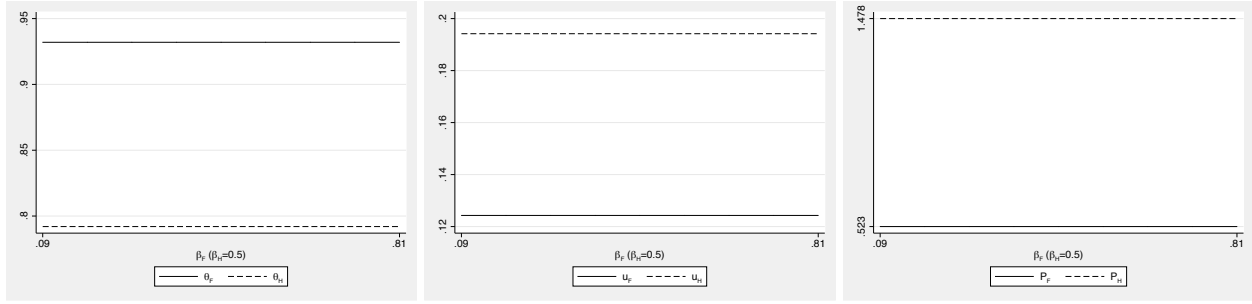
Figure 2.23: Planner Changing Unemployment Benefits



Changes in bargaining power have no impact on the planner's allocation as shown in Figure 2.24. This is to be expected as the planner is not concerned with the way in which the surplus from matching is shared between the workers and the firms. The planner is only concerned with making the surplus as large as possible, given the constraints and frictions he faces.

Unlike the competitive equilibrium, home workers do not systematically lose out to their mobile competitors. The planner sometimes alleviates some of the disadvantage they face from lack of mobility.

Figure 2.24: Planner Changing Bargaining Power



2.2.5 Planner vs Non-Discrimination

When out migration costs for foreign workers increase, the planner keeps market tightness in both countries and overall unemployment lower than the market allocation (See Figures 2.11 and 2.18). Home workers have a higher unemployment rate, and more people overall live in the home country than in the market equilibrium. This contrasts with the scenario of increasing return migration costs in which the planner moves many workers out of the foreign country and keeps them there with little probability of returning, so there are fewer jobs in the foreign country.

When workers experience flow costs to being away from the foreign country, the planner maintains fewer open vacancies in both countries than the market as shown in Figures 2.13 and 2.20. Unemployment for foreign stayers and home workers is higher, and overall home country unemployment is higher than the market allocation. The increase in costs to migrants increases unemployment overall under the planner, and the planner distinguishes less between the type of costs workers face than the competitive equilibrium does.

Changes in foreign productivity display qualitatively similar impacts under non-discrimination (Figure 2.14) and with the planner (Figure 2.21). When the foreign country is more productive, the planner again maintains fewer open vacancies and higher unemployment, especially for all workers in the home (less productive) country.

When posting and maintenance costs in the foreign country are increasing (Figures 2.15 and 2.22), the planner maintains a slightly lower market tightness there while keeping tight-

ness in the home country similar to the market allocation. The planner also keeps unemployment lower everywhere than the market.

The planner (Figure 2.23) maintains fewer open vacancies and unemployment in both countries than the market (Figure 2.16) when unemployment benefits increase in the foreign country. This prevents too many costly and unproductive open vacancies and as many workers matched as possible. Some of the externality from migration is off-set by the planner in comparison to the market.

Despite the lack of impact from changes in bargaining power on either the non-discrimination market outcome (Figure 2.17) or the planner's allocation (Figure 2.24), both generate very different equilibrium allocations. The planner maintains more open vacancies in the foreign country, and fewer open vacancies in the home country than the market outcome. Home workers thus face lower unemployment under the planner since all workers are located in the home country under the competitive equilibrium whereas the planner keeps some workers in the foreign country, definitionally making foreign unemployment higher under the planner. Workers are also more unequally distributed under the market outcome than under the planner.

Under the planner, home workers generally suffer more from the changes in relative values of parameters, and are seldom compensated for costs unlike the foreign workers. Home workers still bear the costs of their migration restriction without the planner compensating them in the same way the foreign workers experience. Since the cost of the migration restriction is not explicitly faced by the market or the planner, this aspect is eliminated from consideration. Without directly accounting for this cost, search models miss a major welfare consideration for those workers in equilibrium.

2.3 Approximating the Data

Calibrating the model to representative values of parameters allows assessment of the performance of the model in predicting the data. For identical parameterizations, we can also see how differently each model allocates workers and jobs between the two asymmetric countries, and how equilibrium variables differ from the data.

Parameters were chosen to reflect the group average of the most common sending and receiving countries indicated by the Eurobarometer Special Labor Mobility Survey (2009) and the Geographic Mobility of the EU Special Report for the Commission (Bonin et al. (2008)).¹⁰

The top sending countries for within EU migration, foreign country in the model, are Cyprus, Malta, Romania, Bulgaria and Slovakia. These countries have the highest rate of out migrants per population. Parameters for these countries are taken as the simple average of individual country values to create an estimate for the group as the foreign country, or region. The top receiving countries are Germany, the United Kingdom, Spain, Austria, Italy and the Netherlands. Parameter values for these countries are also averaged to give an estimate for the group as the home country, or region. Data for all parameters are taken as the most recent available value as reported from the OECD, Eurostat, Eurobarometer, Campolmi and Faia (2011), and Nickell and Nunziata (2000). The home country value is normalized to ease comparisons across the two groups where appropriate.

Productivity is the normalized real labor production per hour worked from the Eurostat database, 2013. The foreign value is set to approximately one third the value of that in the home country based on group averages. Unemployment benefits are taken from Campolmi and Faia (2011), and Nickell and Nunziata (2000). Vacancy costs are assigned the baseline value of the parameterizations above in line with Albrecht and Vroman (2002). Workers bargaining power is taken as the labor cost as a proportion of total costs of production from Eurostat.

¹⁰Additional details on parameter computation can be found in Sargent (2017).

Table 2.2: Approximation of Data Parameterization

Parameter	Value H, F
y	2, 0.7
b	0.5
c	0.2
β	0.75, 0.82
ϕ_{FH}	0.3
ϕ_{HF}	0.2
τ	0.9
Z	1.25
r	0.05
δ	0.15
P	1, 0.14

Wages are taken as the group average of median annual earnings of full-time workers divided by GDP per capita in 2014 from Eurostat. This gives the normalized home country wage of 1.255, and the normalized foreign country wage of 1.041. Wage information is only available at the country level, not by immigration status from Eurostat, so within-country variation for wages is unknown. The home country group wage is more uniform within group than the foreign country group wage. Cyprus and Malta have similar normalized wages to the home country group than to the remaining foreign country group countries.

The matching elasticity is set to match Petrosky-Nadeau and Zhang (2013). Populations are taken as the group average in 2015 from Eurostat of each region with the home country normalized to 1. The discount rate and job destruction rate are set to match the parameterizations in line with the literature. Move costs and flow costs are chosen to target group average unemployment rates. The full parameterization is shown in Table 2.2.

Table 2.3 shows the results from the calibration from each of the three characterizations explored above. Move costs under the parameterization which more closely matches the data have very little impact on migrant flows. This is consistent with survey results from the Eurobarometer as well as anecdotal evidence from Mexican migrants into the United States. One time move costs to migrants, even when very large, act as an ineffectual deterrent.

Table 2.3: Approximation of Equilibrium Values

Model	θ_F	θ_H	u_F	u_H
FD	10.715	0.278	1	0.254
ND	0.503	2.352	0.111	0.156
PP	1.662	1.917	0.088	0.162
Data	0.0607	0.181	0.0882	0.0906

Flow costs play a larger role in allocations of workers across the two countries. In order to generate unemployment rates close to those observed, workers in this framework must face large flow costs to living away from home. This is in line with reports of being away from one's home and family playing the largest role in deterring labor migration in the EU. If the EU is to fully integrate labor markets, the best policy arena to spur movement would be to lower the perceived costs of being away from home. Changes in unemployment benefit policies and worker's bargaining power are likely to have less of an effect as further changes to these national level policies must be relatively small compared to past changes.

All three models generate more vacancies per unemployed worker than is observed. The full discrimination regime never employs any workers in the foreign country, though not all workers leave. Full discrimination also generates significantly fewer jobs in the home country. The planner allocates the same proportion of unemployed workers in the foreign country, but too many workers are unemployed in the home country. Perhaps unemployment is too low in the EU given the labor market frictions and estimated costs faced by firms and workers. The non-discrimination regime gets fairly close to the observed outcomes for unemployment. Qualitatively, relative unemployment levels between the two countries is closer than under full discrimination or the planner.

Wages for workers in the home country are always higher than in the foreign country. This is expected given the difference in productivity across countries. Even when they face high costs, migrants receive a significantly higher wage when leaving the foreign country than if they remain. However, returning migrants are not compensated for the move and

flow costs they face by moving back and forth: wages for foreign workers who always stay in the foreign country are higher. In comparison to the data, the model predicted wages for the foreign country are too low while home country wages are too high. Compared to the model without costs in Sargent (2017), the model with costs is farther from the data in the foreign country, but closer for the home country. The model makes the sending countries seem worse than they truly are, but makes the receiving countries seem better.

The search model with migration presented here improves upon existing work that tries to explain why workers may or may not choose to migrate abroad, and generates different unemployment rates across markets in equilibrium. While the restrictions imposed on the workers in the home country prevent fully matching with data, it is a first step to using search labor market frictions to improve our understanding of labor market variation within otherwise very similar groups of countries. Compared to Sargent (2017), the model with costs to workers predicts higher market tightness in both countries from non-discrimination and similar market tightness in the home country under the planner. Importantly, all unemployment rates from the model with costs predicts unemployment values much closer to those in the data.

2.4 Conclusion

While the use of single market analysis in search models has performed moderately well in individual country studies, it fails to explain key aspects of life in an increasingly international labor market. I show that equilibrium migration is an important aspect of search with labor mobility that is currently missing from analyses which can be used to illustrate observed trends. Even in the limiting case of one country migration with symmetric countries, the model generates variation in unemployment rates across the two countries. When data-based asymmetries are introduced, model predictions more closely match behavior, and illuminate potential margins of parameters on the migration decision and show the effects of different

types of costs faced by workers. Move costs are relatively unimportant in determining a workers' decision to migrate; flow costs to being away play a much larger role. The focus on move costs in existing literature masks this nuance, and skews the appropriate policy focus. As seen in the non-discrimination section, parsing the specific reason for a move would aid in predictions of wage effects on natives, prior migrants, and new migrants. This can also help in determining impacts on those left behind. Some migration may have a net-zero welfare impact from the perspective of wages, while other migration flow may be pareto-improving. Accounting for changes in the sending country as in the model here explicitly allows for that comparison.

Given the workers' lack of incentives to internalize his own impact on the labor market, without policy intervention it is unlikely that the market and planner's equilibria will coincide. Not only do we see the impact of search externalities on the labor market allocations, but there is also an important role played by costly moves and costs to being away from home as noted in the Eurobarometer survey from 2009.

The numerical experiments show that labor market structures such as flow costs and unemployment benefits play a large role in the potential migrants' decision whereas the costs associated with the move play a relatively minor role in comparison based on the impact on unemployment rates in sending and receiving countries. Additionally, I have shown how the competitive equilibrium departs from the efficient allocation in the presence of costly migration and search externalities.

The theoretical model in this paper provides a framework for examining the margins upon which workers rely to generate a migration decision. Tracking workers allows for a deeper understanding of those characteristics of labor markets which may have a large impact on the decision to move. Firms react to productivity and posting costs as expected even in the limiting case of one country migration for homogeneous workers.¹¹ Currently popular modifications of the DMP search framework such as heterogeneous workers may not be

¹¹See Nickell (2006) for a detailed analysis of important determinants of labor market equilibria.

necessary to generate the observed data implying that firms see immigrant and native workers much more like substitutes than popular opinion might seem to indicate, and skill mismatch or stratification plays a relatively smaller role in determining equilibrium unemployment rate.

Chapter 3

International Migration: Unemployment Differences and Costs to Move

3.1 Introduction

When making the decision to move to another country for work, people take into consideration the likelihood of obtaining work, the value of that work (often relative to work at home), and the costs they face when moving and living away from home. There is much research on the labor market outcomes of workers after they have moved, the effects of that move on the native population, and the fiscal cost to government from migrants. What is not well-documented is the effect that different costs to workers has on the migration decision and the labor market outcomes that follow. This is an important omission given the dominance of these costs in surveys of migrants and potential migrants (Bonin et al. (2008)). Respondents cited the difficulty in living away from friends and family as well as the cost to secure housing and physically move. Existing work aggregates the fixed and marginal costs together which distorts analysis of the different ways costs enter into a (potential) migrant's

decision-making process.

In order to more fully understand the effects of costs to workers, I build a two country search and matching model with costs of migration for workers. I focus on fixed move costs as well as a flow cost faced anytime a worker is away from his/her country of origin. In the model the two countries may differ according to characteristics such as productivity, unemployment benefit generosity, union power, cost to open and maintain a vacancy, and the efficiency of the labor market in matching unemployed workers with open vacancies. This captures the most frequently cited factors in determining labor market conditions in empirical literature (Nickell (1997, 2006)). Workers from either country may choose to search for work domestically or abroad, and face costs to move and be away from home when they become employed abroad. They face an additional cost to return home if they subsequently match back in the country of origin.

Migration and unemployment rates vary greatly over time and space. Take for example the different cases of the European Union (EU) and the US and Canada. Citizens of the EU have been steadily increasing the rate at which they cross a national border for work, yet there are persistent differences in unemployment rates across member countries. This increase in migration rates has lowered the within-year variation in unemployment rates across countries somewhat, but large differences remain. On the other hand, migration across the US-Canada border has remained relatively consistent but low over the last 20 years, and unemployment rates do not display any particular pattern of becoming more or less similar over time.¹

Since the characteristics of the labor markets between EU countries and the US and Canada differ along separate characteristics, they can be used to illuminate the importance of costs in a worker's migration decision, and the labor market condition effects of that migration. I use this to explore the role of costs to workers in choosing to migrate, and ask: What must the structure of costs to workers be to generate the observed amount of migration

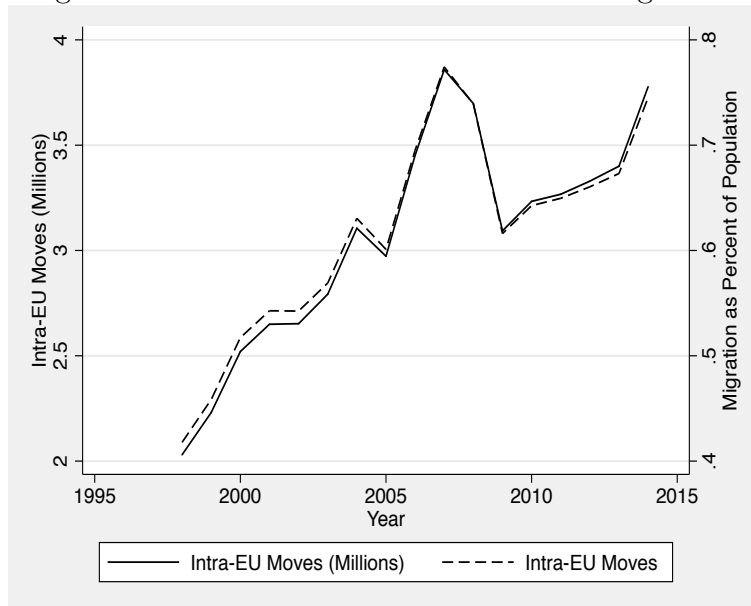
¹See Table 3.1 and Figures 3.1 and 3.2.

Table 3.1: Average Within Year Variation Unemployment Over Time

Geographic Area	1983-2015	1983-1995	1995-2008	2008-2015
US-Canada	3.661	5.528	3.814	0.767
EU	21.091	23.741	16.706	22.858
W/in US	2.282	3.137	1.176	2.653
W/in Canada	9.732	11.848	10.384	5.407
Schengen	17.578	16.209	15.082	23.186

Source: FRED, Eurostat, OECD, and Statistics Canada; Values are Average Within-Year Variation of Unemployment Rates for the Given Geographic Spaces and Time Spans.

Figure 3.1: Intra-EU Cross-Border Labor Migration

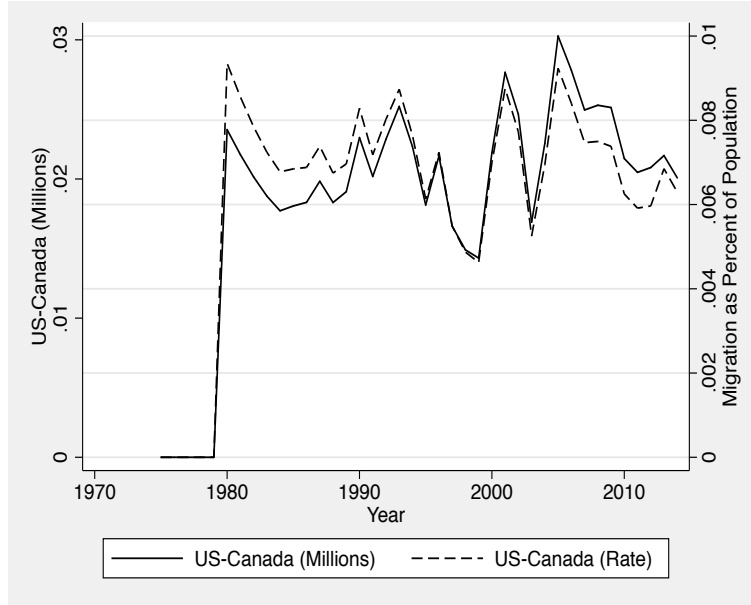


Source: Eurostat

in the developed world, and can they account for the observed differences in unemployment rates?

First, I look at the EU, and approximate the unemployment and migration rate data by adjusting the costs to workers after parameterizing labor market characteristics in line with data and related literature. Next, I do the same for the case of the US and Canada. Both exercises show the capability of the model to generate realistic differences in unemployment and migration, even when countries are quite similar in productivity, social welfare generosity, and worker's bargaining power. The model tends to over-predict migration rates in both case

Figure 3.2: US-Canada Cross-Border Labor Migration



Source: FRED and Statistics Canada

studies, and implies that costs to workers moving between EU countries are higher than costs for workers moving between the US and Canada. This second result is in contrast with the higher observed migration in the EU, and highlights important general equilibrium effects and the need for better understanding the migration decision.

3.2 Related Literature

This paper bridges a gap between theoretical search and matching and (largely) empirical microeconomic literature on the welfare and wage effects of immigration.

I build upon the standard DMP search framework by adding in costly, two-way migration. This makes it close to some search and matching internal migration papers like Kawata et al. (2014), Chassamboulli and Palivos (2014), Zenou (2009), and Schmutz and Sidibé (2015). These focus on cross-regional moves and urban-rural commuting, but don't capture the significant labor market differences across national borders we observe. The model here is also similar to Ortega (2000) and Lkhagvasuren (2012) in terms of allowing unrestricted

migration for workers, but doesn't rely on symmetry conditions for solutions, and again, is able to capture differences in labor market characteristics which are absent in other work.

The model is additionally capable of analyzing wage impacts from migration, which are not discussed in the present form.²

One restriction in the model is that the solution relies on perfect substitutability of foreign and native workers; Grossman (1982) finds empirically that this is not an egregious assumption. Some studies find that costly migration can result in skill-level selection of workers, though the type of selection which dominates is unclear.³ This skill-based selection of workers happens both through worker self-selection and through institutional and legalistic barriers, and so require careful theoretical considerations before including such a mechanism in a model like the one in this paper.

There is general agreement that existing migration rates, both internally and internationally, are sub-optimal and an increase in migration would result in net welfare increases globally (Kennan and Walker (2011), Moses and Letnes (2004)), Borjas (2001), Sjaastad (1962), and Klein et al. (2007), but the welfare loss estimated varies in magnitude.

Analyses of the costs and benefits of migration explore a range of outcomes. Most closely relating to the costs explored in this paper are Lazear (1999), Docquier et al. (2015), Barrett and Mosca (2013), Borjas (2001), and Bartolucci et al. (2014). Each attempts to incorporate monetary and non-monetary costs into the migration decision, though most do not separate between fixed and marginal costs. I show below how this matters in allocating workers across space, and in determining equilibrium unemployment rates.

The model below outlines both the workers' and firms' decision making, and defines a stationary equilibrium before moving to a test of the model's ability to replicate the unemployment and migration rates presented in the introduction.

²See Card (1990), Borjas (1985), Borjas (1994), Gerfin et al. (2010), Ottaviano and Peri (2012), Cadena and Kovak (2016), and Kennan (2016) for details.

³See Chiquiar and Hanson (2005) and Belot and Hatton (2012) for examples.

3.3 Model

The model is in continuous time, and agents and firms have the same time discount factor, r . A match is when an unemployed worker and firm meet, and an empty vacancy becomes filled. Once a match is formed, production with value, y , takes place. The value of production depends only on the location of the match. Any given match has a probability, δ , of dissolving. If a match is dissolved, the worker becomes unemployed in that country, and the vacancy becomes open. Matches are one firm, one worker.

Workers can be either employed or unemployed, and search only when unemployed. Workers may only migrate upon matching with a firm in the country other than the one in which they are unemployed. Unemployed workers choose to search in either country based on the expected value of matching in that country, taking into account the wage, costs to moving and living there, and, importantly, the probability of matching. When unemployed, workers receive unemployment benefits, b , depending on the location of unemployment. Employed workers receive wage, w , which is the result of Nash bargaining over the joint firm-worker surplus of a match. Workers receive a share, β , of the match surplus depending on where the match is formed. Workers from either country can move back and forth between countries as many times as desired. There are no formal restrictions to moving across borders. Workers do face costs to undertaking a move (a one-time fixed cost, ϕ) that is direction- and worker origin-specific, as well as a flow cost to living away from home (a marginal cost faced each period as long as the worker lives out of his country of origin, τ) that is worker origin-specific.

There are 8 types of worker in the model based on their origin country, current country, and next employment country. Table 3.2 shows these types.

Firms post vacancies until the flow value of posting an additional vacancy is at or below zero. A vacancy, regardless of status, costs the firm, c , which depends on the location of the match, but not on the nationality of the worker. This covers hiring and firing costs as well as training and recruitment costs. When matched, firms receive $1 - \beta$ of the match surplus.

Matching occurs randomly between unemployed workers, u , and open vacancies from

Table 3.2: Worker Categorizations

Category	Nationality	Most Recent Unemployment	Most Recent Employment	Next Employment	Migrating for Employment?
Foreign Stayer	F	F	F	F	No
Prior Foreign Migrant	F	H	H	H	No
Foreign Returning Migrant	F	H	H	F	Yes
New Foreign Migrant	F	F	F	H	Yes
Home Stayer	H	H	H	H	No
Prior Home Migrant	H	F	F	F	No
Home Returning Migrant	H	F	F	H	Yes
New Home Migrant	H	H	H	F	Yes

firms, v . The matching function is CRS to match with literature for the US and Western Europe, and can be characterized by the ratio of unfilled vacancies to unemployed workers. This ratio is known as market tightness, $\theta = v/u$. Market tightness is commonly used in search and matching to pin down equilibrium values of unemployment, vacancies, and wages.

$$M(u, v) = \frac{uv}{(u^Z + v^Z)^{1/Z}} \quad (3.1)$$

The particular matching function employed here is from den Haan et al. (1997), and has been shown to match data from the US in Petrosky-Nadeau and Zhang (2013). One feature of this particular matching function is that it automatically generates matching probabilities in $[0,1]$.

Matching probabilities for workers and firms are not necessarily symmetric since there is no requirement on a static number of firms. The probability that a worker meets with a vacancy is given by:

$$\frac{M(u, v)}{u} = f_k(\theta_k) = (1 + \theta_k^{-Z_k})^{-1/Z_k} \quad (3.2)$$

The probability that a vacancy meets a worker is given by:

$$\frac{M(u, v)}{v} = q_k(\theta_k) = (1 + \theta_k^{Z_k})^{-1/Z_k} \quad (3.3)$$

3.3.1 Workers

When a worker is unemployed, s/he receives unemployment benefit, pays a cost to living away from home (if applicable), and chooses to search based on the relative value and probability of matching in each location. The flow value of unemployment to the worker is given by:

$$rU_{ij} = b_j - \tau_{ij} + \max_k \{f_k(\theta_k)(N_{ij}^k - U_{ij}^k - \phi_{jk})\} \quad (3.4)$$

Where $\tau_{ij} = 0$ when $i = j$ and $\phi_{jk} = 0$ when $j = k$.

When a worker is employed, s/he receives a wage based on the negotiated value of the surplus from the match with the firm less the cost to living away from home (if applicable). The flow value of the match to the worker which takes into account the probability of match destruction is given by:

$$rN_{ij}^k = w_{ij}^k - \tau_{ij} + \delta(U_{ik} - N_{ij}^k) \quad (3.5)$$

Again, $\tau_{ij} = 0$ when $i = j$.

When making search and migration decisions, workers take the market tightness as given, and do not take into account their impact on the market. This leads to potentially counter-intuitive general equilibrium effects.

3.3.2 Firms

When firms have posted a vacancy, but have not yet met with a worker, they pay a maintenance and posting cost, and face a weighted probability of matching with one of the

four types of unemployed worker. Each worker match has a different value to the firm due to differences in unemployment benefits and costs to those workers. The flow value of posting a vacancy to the firm is given by:

$$rV_k = -c_k + \frac{f_k(\theta_k)}{(u_{ii} + u_{ij} + u_{ji} + u_{jj})} [u_{ii}(J_{ii}^k - V_k) + u_{ij}(J_{ij}^k - V_k) + u_{ji}(J_{ji}^k - V_k) + u_{jj}(J_{jj}^k - V_k)] \quad (3.6)$$

Once the firm has matched with a worker, production occurs, and the firm pays the posting and maintenance cost and the worker the bargained wage. The flow value of a match to the firm also takes into account the probability that the match may one day dissolve:

$$rJ_{ij}^k = y_k - w_{ij}^k - c_k + \delta(V_k - J_{ij}^k) \quad (3.7)$$

When making the decision to post vacancies, firms are also basing decisions taking the existing market tightness as given.

3.3.3 Equilibrium

An equilibrium consists of flow values to firms and workers, market tightnesses, wages, unemployment, employment, population (initial and final), and open vacancies.

Market tightness is defined for each country as:

$$\theta_F = \frac{v_F}{u_{FF} + u_{FH} + u_{HF} + u_{HH}} \quad (3.8)$$

$$\theta_H = \frac{v_H}{u_{FF} + u_{FH} + u_{HF} + u_{HH}} \quad (3.9)$$

Job creation and destruction in each country must be equal to ensure constant unemployment rates:

$$f_F(\theta_F)(u_{FF} + u_{FH} + u_{HF} + u_{HH}) = \delta(n_F) \quad (3.10)$$

$$f_H(\theta_H)(u_{FF} + u_{FH} + u_{HF} + u_{HH}) = \delta(n_H) \quad (3.11)$$

Net migration must be zero, so that each migrant leaving a country is replaced by another coming in:

$$f_F(\theta_F)(u_{FH} + u_{HH}) = f_H(\theta_H)(u_{FF} + u_{HF}) \quad (3.12)$$

This ensures that the total population in each country is constant, but does not require that they are equal in equilibrium.

Populations in each country are the number of staying employed and unemployed, plus the number who have moved and either remain employed, or who have lost employment and are unemployed abroad.

Initial populations are given by:

$$P_o^F = u_{FF} + u_{FH} + f_F(\theta_F)(u_{FF} + u_{FH})/\delta + f_H(\theta_H)(u_{FF} + u_{FH})/\delta \quad (3.13)$$

$$P_o^H = u_{HH} + u_{HF} + f_H(\theta_H)(u_{HF} + u_{HH})/\delta + f_F(\theta_F)(u_{HF} + u_{HH})/\delta \quad (3.14)$$

Final populations are given by:

$$P^F = u_{FF} + u_{FH} + n_F \quad (3.15)$$

$$P^H = u_{HH} + u_{HF} + n_H \quad (3.16)$$

Worker's indifference between searching in either country and population accounting completes the equilibrium conditions required to solve for the stationary equilibrium.

3.4 Parameterization and Numerical Exercises

Since the model does not have an analytical solution, I next perform a series of numerical exercises with the model parameterized to coincide with the conditions described in the introduction. A sensitivity check of the model for parameter bounds shows that existence of a solution does not depend on any parameters taking values that are unrealistic or limited within a narrow bound.⁴

The matching elasticity, Z , in must be larger than 0.1. The time discount, r , must be larger than 0, but smaller than 0.5. The job destruction probability, δ , must be larger than 0. The initial populations must be positive. The productivity, y , must be larger than the sum of the posting and maintenance costs, c , and the unemployment benefits, b , in the same country ($y_k > c_k + b_k$). The posting and maintenance costs, c , unemployment benefits, b , and worker's bargaining power, β , must all lie between 0 and 1. The flow costs to workers, τ , and the move costs to workers, ϕ , have no bounds. Positive values for the costs reflect a negative welfare to the worker while a negative value reflects a positive welfare impact- this may come in the form of a love of adventure where living abroad yields a positive effect on worker's flow value through the flow cost. A negative value for the move cost could be due to a subsidy from the government to encourage more movement by workers.

3.4.1 Numerical Exercises

For the numerical exercises, I show the equilibrium solutions for market tightness, unemployment rates, populations, and migration rate under two separate characterizations of the model. The first considers the case of the EU. The second shows the model predictions

⁴All parameter bounds and numerical exercises use a multiple complementarity solver in GAMS.

for the US and Canada. Continuing with the notation above, for the EU proxy “Home” and “Foreign” were assigned as groupings of member states along the most common destination and origin countries in the EU. Productivity is the main difference across these groups. For the US-Canada proxy, the US is taken as “Home”.

Tables 3.3 and 3.4 show the parameterization for both the EU and US-Canada exercises. The parameters are chosen to reflect productivity differentials, ease of doing business, unemployment benefit generosity, and the presence of unions in the two groups. The costs are chosen to target differences in unemployment rates and migration rates. The parameterization shown here is one of multiple potential characterizations that was chosen to approximate the data. The exact parameters are not critical for the results, but parameters should be close to those used.⁵

Table 3.3: Parameters

	y_F	y_H	b_F	b_H	c_F	c_H	P_F^o	P_H^o	β_F	β_H	Z	r	δ
Europe proxy	1.65	1	0.45	0.55	0.25	0.2	1	1	0.85	0.8	1.25	0.05	0.15
US-Canada proxy	1	1	0.5	0.65	0.2	0.25	1	0.1	0.7	0.85	1.25	0.05	0.15

Table 3.4: Parameters Cont.

	ϕ_{FF}^H	ϕ_{FH}^F	ϕ_{HF}^H	ϕ_{HH}^F	τ_F^H	τ_H^F
Europe proxy	0.429	0.449	0.459	0.439	1.47	1.38
US-Canada proxy	0.007	0.006	0.006	0.007	0.01	0.01

Table 3.5 shows the outcome from the exercises. In general, the model performs well in targeting differences in unemployment rates, but over-predicts migration for the given parameterization.⁶

For the EU proxy, the move costs (both to leave and return) are slightly higher for the “Home” country, and it is marginally less costly to leave the origin country than to return.

⁵Various other parameterizations yield qualitatively similar results for values near those shown in the table.

⁶If the two groups are parameterized differently in terms of the values in Table 3.3, the migration rate can be forced closer to the rates shown in Figures 3.1 and ??, but less-closely matches the data for those values.

Table 3.5: Outcomes

	θ_F	θ_H	u_F	u_H	P_F^f	P_H^f	Migration Rate
Europe proxy	58.792	66.044	0.042	0.100	1.001	0.999	0.07
US-Canada proxy	11.486	0.719	0.072	0.135	1.304	0.696	0.091

Flow costs are higher for the Foreign country than for the Home country. This choice of values for costs targets the unemployment and migration rates shown in Table 3.1 and Figure 3.1. Overall, market tightness is very high. Generally, this indicates that firms would like to hire many more employees than that are able to. Home market tightness is higher than Foreign market tightness. Part of the reason for the higher market tightness in the Home country is that unemployment benefits are higher there. Higher unemployment benefits means that workers require a larger incentive to leave unemployment. The difference in unemployment rates between the two countries closely approximates the data. This is unsurprising given that unemployment rates were targeted in choosing parameter values. The unemployment rate is lower in the Foreign country, and can be attributed to the higher productivity in that country. The final population allocations are close to equality. The population in the Foreign country is slightly higher because the greater productivity increases the value of living there for all workers. The rate of migration between the two countries is approximately three percentage points higher than shown in the data.⁷

For the US-Canada proxy, move and flow costs are symmetric for workers from both countries, but it is less costly for workers to return to their country of origin. Flow costs are also much larger than move costs. This choice of values for costs again targets the unemployment and migration rates shown in Table 3.1 and Figure 3.2. As in the case of the EU proxy, market tightness is high in the US, but low in Canada. Unemployment rates, and the difference in the unemployment rates matches the data. Again, this is unsurprising since these values were targeted. The final population allocation shows more Americans in Canada than in the data. This partially explains the migration rate being higher in the

⁷This could potentially indicate that there is something mitigating migration that is not included in the model at present.

model's prediction than in the data. Migration rates in the model are much higher than the data which I attribute to the fact that the costs here do not include the work visa requirement in effect for Americans in Canada and Canadians in the US.⁸

Information on the results from changing one cost parameter at a time, and from changing all three (leave, return, and flow) together are shown for the baseline parameterizations for the EU and US-Canada cases in the appendix. These figures show the movement of the equilibrium outcomes as the parameters increase from zero.

In the EU proxy, costs to leave and return have identical effects. Increasing either move cost has little effect on market tightness, but increases Foreign unemployment and decreases home unemployment and the migration rate. Increasing flow costs increases market tightnesses after a threshold is reached. Unemployment in the Home country decreases while unemployment in the Foreign country decreases until the same threshold, after which unemployment rates cease changing. Migration decreases until the threshold value, and then stays the same. When all three costs increase simultaneously, market tightness increases after a lower threshold value is reached while Home unemployment decreases and Foreign unemployment increases until reaching that same threshold. The migration rate decreases until the threshold cost value and then stays the same.

In the US-Canada proxy, leave and return move costs have slightly differing effects on the equilibrium. Increasing the cost to leave increases market tightness and decreases unemployment and the migration rate. Increasing the cost to return increases market tightness in the Foreign country, but has no effect on the market tightness in the Home country. Unemployment in the Home country and migration decreases and then increases while unemployment in the Foreign country stays constant and then decreases. Increasing the flow costs to living away from home increases all market tightness, but has a larger effect in the Foreign country. Unemployment in the Home country decreases and then levels-off. Unemployment in the

⁸The costs of obtaining a visa could potentially be included in the model, but given the timing in the world it does not clearly translate into the model's timing, and could require further richness in the model. Inclusion of the visa requirement as an increase in the cost to leave one's country of origin is possible, but this moves the predicted unemployment and migration rates away from observed values.

Foreign country increases, and the migration rate decreases. When all three costs are increased together, market tightness increases, unemployment in the Home country decreases, unemployment in the Foreign country stays constant, and the migration rate decreases.

Overall, the model implies that move costs are small relative to flow costs. This is consistent with self-reported attitudes about their relative importance in making the migration decision in the EU survey (Bonin et al. (2008)), as well as with intuition. The results shown here also suggest that in the long-run costs are much lower for US-Canada migrants than for the EU, but that another factor not captured in the framework here has a non-negligible effect on migration rates separate from the determination of unemployment for current data to reflect an equilibrium.

If the model is taken as the true long-run equilibrium for the two groupings, we should expect that migration rates will increase beyond those seen today in both cases (again assuming that we are not already in equilibrium). We should also expect to see many more Americans moving to Canada than are observed in the data to balance out the net flows, and final populations predicted in the model.⁹ Additionally, unless visa restrictions between the US and Canada are relaxed, we may continue to observe lower migration than the model predicts. For the EU, workers will continue to move across borders at an increasing rate.

3.5 Conclusion

The importance of immigration in influencing labor market outcomes has been increasing steadily in the last few decades. While empirical studies are important to understand the particular cases and drivers, a theoretical model upon which to assess those empirical studies has been lacking. In this paper, I have briefly outlined the basic framework upon which I believe future work should build.

The model in this paper incorporates frictional labor markets and cross-border migration decisions to more fully understand the forces which lead workers to migrate, and how that

⁹Almost twice as many Canadians move to the US than vice versa each year.

migration decision might impact unemployment for natives and migrants in both sending and receiving countries. Though I have not discussed it here, wage dispersion effects from migration are also fully incorporated into the general equilibrium model. This allows us to understand the kind of wage shock workers might face under a world of fully free labor migration.

Additionally, this paper should not be seen as an explanation for the current rates of migration and unemployment seen in the world. This model explores the long-run equilibrium that is expected if country-level characteristics persist while workers continue to move back and forth across borders. It is unlikely that the current state of migration in the developed world is at an equilibrium.

I have shown that the model is capable of near replication of some stylized facts for the EU and the US and Canada. With more precise estimates of parameters, and further study, the model will improve our understanding of the role that costs to workers- both fixed and marginal- play in determining international migration flows and unemployment rates.

It is important to emphasize that current empirical work places great weight on skill heterogeneity of workers in evaluating the impacts of migration on sending and receiving countries, and future versions of the model presented in this paper would do well to include this characteristic. However, the model shown here approximates the data reasonably well in consideration that the empirical literature so heavily emphasizes the need to account for such heterogeneity in evaluation.

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Chapter 4

Appendix

4.0.1 Country Classifications

Schengen: Austria, Belgium, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Slovakia, Slovenia, Spain, Sweden, Switzerland, Lichtenstein

EU: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, United Kingdom

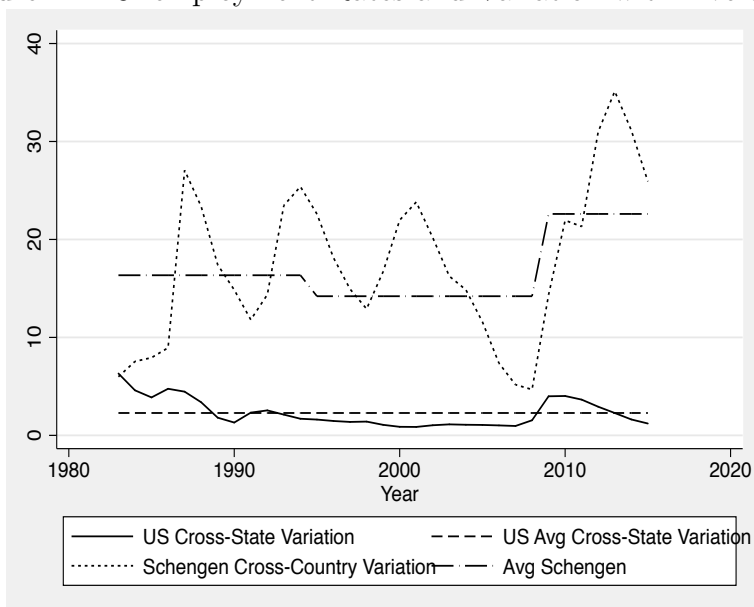
Euro: Austria, Belgium, Cyprus, Estonia, Finland, France, Germany, Greece, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Portugal, Slovakia, Slovenia, Spain

EU not Euro: Bulgaria, Croatia, Czech Republic, Denmark, Hungary, Poland, Romania, Sweden, and the United Kingdom

4.0.2 Other Figures

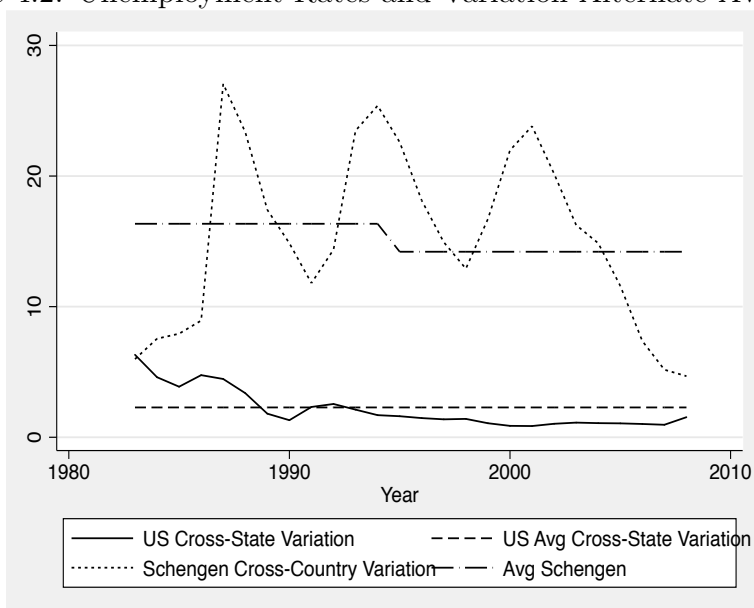
Unemployment Variation Figures (with and without euro crisis)

Figure 4.1: Unemployment Rates and Variation with Averages



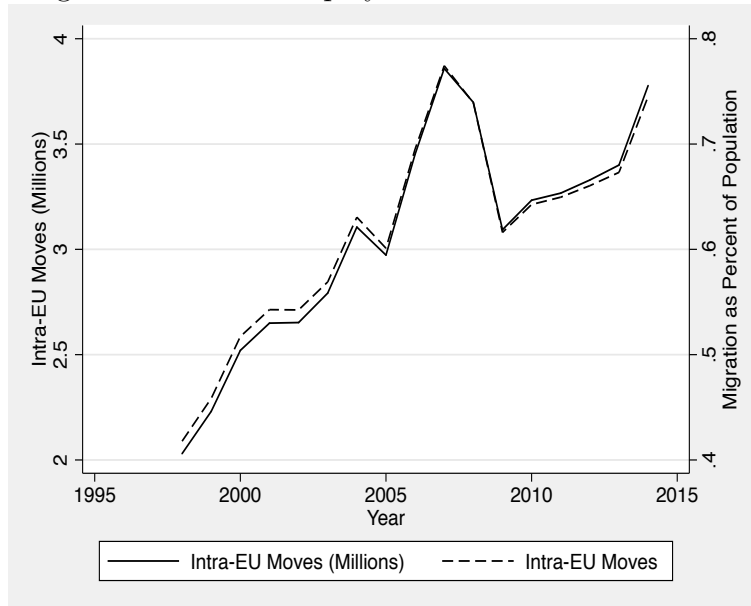
Source: Eurostat

Figure 4.2: Unemployment Rates and Variation Alternate Averages



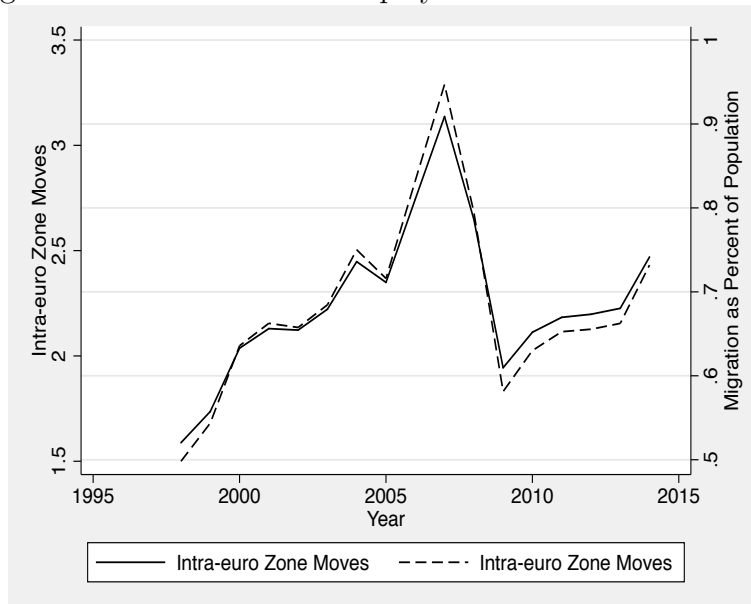
Source: Eurostat

Figure 4.3: EU Unemployment Rates and Variation



Source: Eurostat

Figure 4.4: Euro Zone Unemployment Rates and Variation



Source: Eurostat

4.0.3 Discrimination

Since firms post vacancies according to unemployed workers' origin and current location under discrimination, each job acts as a segmented labor market. This is similar to the segmented equilibrium for a two-skill, one-country model in Albrecht and Vroman (2002) and Blázquez and Jansen (2003).

Separate markets mean that the market tightness in each sub-market, θ_{ij}^k , is nominally independent: Spillovers happen only due to a worker's change of employment or location status. For example, if a worker moves to another country for employment and then loses that employment, the relevant market tightness has changed. Importantly in the search framework, his effect on his original, and his new, market tightness is not considered when making the decision to migrate or search. Migration can only happen when moving out of unemployment.¹

For workers, the flow value of search across markets must be the same in equilibrium. This makes workers indifferent between the perceived return from searching in any particular market. The flow value of unemployment to the worker, rU , depends on the unemployment benefit and the expected value of matching in that market. The expected value is given by the product of the probability of finding a job in each market and the net value of moving from unemployment into employment. While unemployed in country j , the worker receives unemployment benefit, b_j , and chooses to search in either country based on the expected probability of matching with a job, $\theta_{ij}^k q_{ij}^k(\theta_{ij}^k)$, and the net gain from employment in that market, $(N_{ij}^k - U_{ij}^k)$. Search is costless, and all workers share the same work effort. This gives the flow value of unemployment as:

$$rU_{ij} = b_j + \max_k \{ \theta_{ij}^k q_{ij}^k(\theta_{ij}^k) (N_{ij}^k - U_{ij}^k) \} \quad (4.1)$$

The flow value of employment to the worker, rN , is the discounted value of the wage less

¹I make this assumption for simplification, but Kawata et al. (2014) show that in equilibrium this holds, regardless of moving costs, in a similar framework.

the value of moving into unemployment:

$$rN_{ij}^k = w_{ij}^k + \delta(U_{ik} - N_{ij}^k) \quad (4.2)$$

Firms choose whether to post a vacancy based on the cost to post, c_k , as well as the probability weighted value to the firm of filling the vacancy and moving into production, $q(\theta)(J - V)$. This gives the flow value of posting a vacancy, rV , in country k for a worker from country i living in country j :

$$rV_{ij}^k = -c_k + q_{ij}^k(\theta_{ij}^k)(J_{ij}^k - V_{ij}^k) \quad (4.3)$$

The flow value of a filled vacancy, rJ , to the firm is the value of production less the cost to posting in country k , the wage payment to a worker from i unemployed in j matching in k , and the probability weighted value to the firm of the match dissolving, $\delta(V - J)$:

$$rJ_{ij}^k = y_k - w_{ij}^k - c_k + \delta(V_{ij}^k - J_{ij}^k) \quad (4.4)$$

Wages are bargained based on production surplus for the type of match, S , bargaining power, β , in job location k , and costs to establishing a vacancy in location k . Bargaining partially captures the large power of labor unions in many countries, and allows differences in outside options to migration to be reflected in wages through unemployment values.

Workers employed in country k always receive share β_k of the match surplus, S_{ij}^k , where $S_{ij}^k = J_{ij}^k + N_{ij}^k - U_{ij} - V_{ij}^k$:

$$w_{ij}^k = \beta_k S_{ij}^k \quad (4.5)$$

Firms in country k receive share $(1 - \beta_k)$ of the match surplus: $(1 - \beta_k)S_{ij}^k$.

Equilibrium

Market tightness is the number of open vacancies, v , of each of the five types divided by the total population of "eligible" unemployed, u , to fill those vacancies:

$$\theta_{FF}^F = \frac{v_{FF}^F}{u_{FF}} \quad (4.6)$$

$$\theta_{FF}^H = \frac{v_{FF}^H}{u_{FF}} \quad (4.7)$$

$$\theta_{FH}^F = \frac{v_{FH}^F}{u_{FH}} \quad (4.8)$$

$$\theta_{FH}^H = \frac{v_{FH}^H}{u_{FH}} \quad (4.9)$$

$$\theta_{HH}^H = \frac{v_{HH}^H}{u_{HH}} \quad (4.10)$$

Initial populations are the sum of all unemployed and employed workers from each country, regardless of current location:

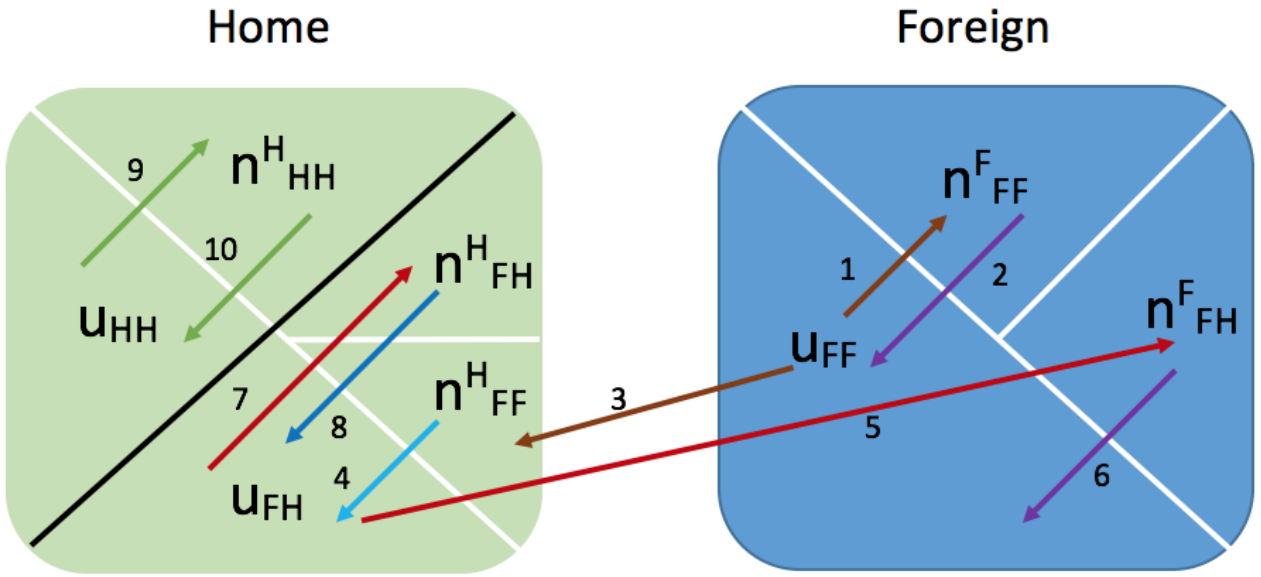
$$P_o^F = u_{FF} + u_{FH} + n_{FF}^F + n_{FH}^F + n_{FF}^H + n_{FH}^H \quad (4.11)$$

$$P_o^H = u_{HH} + n_{HH}^H \quad (4.12)$$

The Figure 4.5 summarizes the next group of conditions which ensures a stationary equilibrium.

Job creation and destruction conditions ensure that the total stock of employed and unemployed in each submarket remains constant in equilibrium. For example, Equation (4.13) describes the number of foreign unemployed workers who are in the foreign country and match with a firm in the foreign country on the left hand side, and are represented by arrow 1 in the diagram. The right hand side is the number of foreign workers employed in the foreign country who lose their job, and are represented by arrow 2 in the diagram. Equation 4.14

Figure 4.5: Worker Flows
Discrimination



equates the flow of foreign unemployed into the home country with the destruction of those jobs, and is represented by arrows 3 and 4 in the diagram. Equation 4.15 equates previous foreign migrants returning to the foreign country for employment and the subsequent loss of those jobs by prior workers, and is represented by arrows 5 and 6 in the diagram. Equation 4.16 equates newly matched unemployed foreign migrants with the destruction of their jobs in the home country, and is represented by arrows 7 and 8 in the diagram. Equation 4.17 represents the flow into and out of unemployment for home workers, and is given by arrows 9 and 10 in the diagram.

Equations (4.13) through (4.17) ensure that every job sub-market is in equilibrium:

$$\theta_{FF}^F q_{FF}^F(\theta_{FF}^F) u_{FF} = \delta n_{FF}^F \quad (4.13)$$

$$\theta_{FF}^H q_{FF}^H(\theta_{FF}^H) u_{FF} = \delta n_{FF}^H \quad (4.14)$$

$$\theta_{FH}^F q_{FH}^F(\theta_{FH}^F) u_{FH} = \delta n_{FH}^F \quad (4.15)$$

$$\theta_{FH}^H q_{FH}^H(\theta_{FH}^H) u_{FH} = \delta n_{FH}^H \quad (4.16)$$

$$\theta_{HH}^H q_{HH}^H(\theta_{HH}^H) u_{HH} = \delta n_{HH}^H \quad (4.17)$$

The migration condition ensures that populations at the country-level remain constant in equilibrium while allowing people to move in and out of each market. Equation 4.18 is represented by the equality of arrows 3 and 5 in the diagram.

$$\theta_{FH}^F q_{FH}^F(\theta_{FH}^F) u_{FH} = \theta_{FF}^H q_{FF}^H(\theta_{FF}^H) u_{FF} \quad (4.18)$$

Together with wage bargaining and the zero profit condition on firms, the market tightness definitions, the population definitions, the creation-destruction conditions, and zero net migration conditions fully define a stationary equilibrium.

Parameter Bounds

Productivity is bounded below by the sum of the cost to posting a vacancy and unemployment benefits: $y > c + b$, or by the discounted value of the costs to posting a vacancy: $y > c(q(\theta) + (r + \delta)/q(\theta))$, whichever is larger.

Costs to posting and maintaining a vacancy are restricted by the same inequality as productivity: $c < y - b$ or 0.335, whichever is smaller, and is kept to positive values.²

Unemployment benefits are kept strictly positive, and face the same constraint as pro-

²Negative cost parameters could be used to identify government subsidies to firms wishing to stimulate job growth, but is left out of this paper.

ductivity and posting costs: $b < y - c$. Workers' bargaining power is also kept positive, and must remain below 0.9 (indicating that no equilibrium exists under the baseline specification when workers receive a share of match surplus that is 90%, or larger).

The job destruction rate is bound between zero and 0.7. While the discount rate must be positive and no larger than 0.55. Matching elasticity must be larger than 0.33, but is unbounded above. Initial population may take any non-negative value. The numerical bounds on all parameters vary somewhat depending on particular parameter values for the baseline, but are locally insensitive.

Comparative Statics

The equilibrium impact of changes in parameters on wage and market tightness in a particular sub-market can be evaluated using the changes to labor supply and demand from changes in parameters. The effects on labor supply are straightforward for foreign stayers, home natives, and prior foreign migrants in the home country. The impacts on new migrants' supply decisions are less clear. Labor demand effects are also straightforward. I separate equilibrium impacts into the effects on market tightness and wages, and then taking those changes as given, evaluate the impact on equilibrium unemployment.

Increasing productivity or decreasing posting and maintenance costs increases the demand for labor for all types of workers. Specifically, increasing foreign productivity (decreasing posting and maintenance costs) increases demand for all matches in the foreign country, without changing the demand for home workers. Increasing home productivity (decreasing posting and maintenance costs) increases demand for all matches in the home country.

On the supply side, increasing foreign productivity increases labor supply for all foreign workers except migrants remaining in the home country, without changing the supply of home workers and foreign migrants already in the home country. Increasing home productivity increases supply for all workers except foreign stayers. Increasing foreign posting

and maintenance costs decreases the supply of labor for all foreign workers except migrants remaining in the home country, and has no impact on the supply of home workers and foreign migrants already in the home country. Increasing home posting and maintenance costs decreases the supply of labor for all workers except foreign stayers who are unaffected. Increasing foreign unemployment benefits increases the supply of foreign stayers only.

Increasing home unemployment benefits increases the supply of all workers except foreign stayers who are unaffected. Increasing foreign bargaining power increases the supply of new foreign migrants into the home country, unclear effects on all other foreign workers except prior migrants who are unaffected along with home workers. Increases in home bargaining power have no impact on foreign stayers and unclear effects on the supply of all other workers.

Combining the supply and demand effects, increasing foreign productivity increases market tightness for all foreign workers except those who migrated prior to their previous unemployment. Home workers' and prior foreign migrants' market tightnesses are unaffected by changes in foreign productivity. Increasing home productivity increases market tightness for all workers except foreign stayers who are unaffected. Decreasing posting and maintenance costs has the same effect on market tightnesses as increases in productivity. The effect on wages is unclear for each of the changes in productivity and posting and maintenance costs.

Increasing foreign unemployment benefits increases market tightness for foreign stayers, and has no effect on any other workers' market tightness. Foreign stayers also experience a decrease in wages. Increasing home unemployment benefits increases the market tightness for all workers except foreign stayers. Wages decrease for all workers except foreign stayers.

Changes in both foreign and home bargaining power have an indeterminate effect on market tightness for all workers except foreign migrants newly moving to the home country in the case of changes to foreign bargaining power. For these workers, market tightness increases and wages decrease when foreign bargaining power increases.

Given the changes on market tightness, it is possible to analyze the effect on unemployment, employment and vacancies in both countries for changes in parameters except when

changes to market tightness are unclear.

When foreign productivity increases or posting and maintenance costs decrease, the impact on unemployment levels in both countries is unclear. If the effect on market tightness for foreign migrants returning to the foreign country is large enough, this will outweigh the negative effects of market tightness for foreign stayers and foreign workers newly migrating to the home country to yield a net increase in unemployment for foreign stayers. Otherwise, increasing foreign productivity or decreasing posting and maintenance costs will decrease unemployment for foreign stayers. Changes to unemployment for foreign migrants similarly depends on whether the effect of market tightness for returning migrants is larger than that of newly leaving migrants. If this is the case, unemployment for foreign workers living in the home country will decrease. Home workers see no change in unemployment from changes in foreign productivity or posting and maintenance costs.

When home productivity increases or home posting and maintenance costs decrease, it is similarly unclear what happens to unemployment for workers. Foreign stayers' unemployment levels will decrease if the effect from prior foreign migrants and new migrants outweighs the effect from returning migrants. Foreign migrants' unemployment will decrease if the effect from prior migrants and returning migrants outweighs the effect from new migrants. Home workers see a decrease in unemployment levels from the increase in home productivity or the decrease in home posting and maintenance costs.

Increasing foreign unemployment benefits decreases unemployment levels for foreign stayers, and has no impact on any workers in the home country. Increasing home unemployment benefits has an indeterminate effect on unemployment for foreign workers in both countries. For foreign stayers, unemployment will increase if the effect of returning migrants outweighs the effect of prior and newly leaving migrants. For foreign workers living in the home country, unemployment will increase if the effect of new migrants outweighs the effect of returning migrants and prior migrants. Home workers experience an increase in unemployment when home unemployment benefits increase. Changes in bargaining power in either country have

an indeterminate effect on unemployment for all workers.

Given the frequently unclear effects from changes in parameters on unemployment in either country, I pursue a numerical experiment to evaluate in a more concrete way what happens to workers in either country when parameters change.

A Numerical Experiment

In order to give a clear example of how the parameter choices impact the equilibrium, I employ a numerical comparative statics exercise for each characterization of the model. This captures the general equilibrium impacts on labor markets not captured in the comparative statics on wage and market tightness conditions from labor supply and demand, and on employment conditions from changes in market tightness alone. The home (usually receiving) country is always at the baseline calibration outlined above, and parameters for the foreign (usually sending) country are varied one at a time. This allows us to study the impact of policy changes in the sending country on the destination country.³ Changing the parameters in this way allows for clearer interpretations of the impacts on migration from changes in structural labor market characteristics. Figures 4.6-1.14 show the impact from changing parameters one at a time with equilibrium outcomes plotted as the parameter of interest increases on the horizontal axis moving right to left from the lower to upper bound of allowable values given the baseline parameterization. In all figures, home values and all but the parameter of interest in the foreign country are kept at the baseline calibration in Table 1.3.

Figure 4.6 shows the effect of increasing the initial population of foreign workers from zero to five times the value in the home country. Increasing the initial foreign population increases the final population in both countries, maintaining the absolute difference between the two countries (first panel). Since all other parameters are the same across countries, this population differential is constant with absolute levels increasing proportionately according

³Values in the home country could also be toggled. Results vary due to the asymmetry of the migration restriction on home workers.

to the additional workers in the economy. The home country is always more populated due to the equalization of unemployment rates for foreign workers at home (in the foreign country) and abroad (in the home country). Foreign workers' migration decisions equalize their unemployment in either country since other parameters are symmetric, making equal populations across markets the only way workers equalize the expected value of search across markets. Market tightness is unchanged as the initial population is increased since structurally the two countries are identical (second panel), and firm trade-offs haven't changed in the structural dimension. This also means wages are unaffected by changes in initial population. Unemployment for home workers remains unchanged while foreign workers experience increased unemployment (third panel) as their scarcity decreases. Home workers also experience higher unemployment until foreign population is about three times as large as the home population. Foreign workers are disproportionately impacted from the population increase since it is their country getting more crowded. Vacancies for home natives are not affected due to the targeting of particular worker types by firms. Changing the initial population value in the foreign country has the expected effect of increasing unemployment for foreign workers, increasing populations in both countries, and has relatively minimal effects on home workers.

Increases in foreign country productivity are shown in Figure 4.7. Starting from parity, the figure shows the impact from the foreign country becoming increasingly more productive until it is four times as productive in the foreign country as in the home country. Fewer workers choose to migrate as the foreign country becomes more and more productive relative to the home country (first panel). Regardless of how much more productive the foreign country becomes; however, the population is never evenly split between the two countries when all other parameters are equal. This is due to the crowding out in the foreign country of too many workers seeking too few jobs. Foreign workers do not anticipate their impact on the origin and destination markets from an individual migration decision, and so foreign workers remain in the home country even when the foreign country is much more productive.

Their probability of finding a job increases when productivity increases, though the effect is larger in the foreign country. Home workers experience no change in unemployment from the productivity change in the foreign country since the markets for each worker type are segmented. Foreign workers, regardless of location, see a decrease in unemployment when their home country gains productivity (third panel). Home workers always face higher unemployment than any foreign workers. Firms in the foreign country open more vacancies since each filled vacancy is more productive. Wages for all workers in the foreign country increase, with never-movers seeing the largest gain from the gain in productivity. Newly arrived foreign workers in the home country also see a small increase in wages since their outside option of unemployment in their home country has increased. Workers who have previously moved and remained in the home country along with home workers see no change in wages with increased foreign productivity.

When foreign firms face an increase in vacancy posting and maintenance costs, the size of the total surplus from any given match is decreased. Figure 4.8 shows the outcome from rising costs in the foreign country, beginning with costless posting and ending with costs taking up around a third of all production value at approximately 50% larger than in the home country. When posting is costless in the foreign country, very few foreign workers migrate to the home country (where costs are larger than zero), and unemployment for foreign workers at home and abroad is near zero. As costs in the foreign country increase, more workers move to the home country seeking the larger surplus values there. Market tightness for all positions in the home country is unaffected, while those in the foreign country see a large decrease. More costly posting means fewer vacancies posted. Home workers see no change in unemployment, while foreign workers who stay in the foreign country first see an increase due to the higher cost of vacancies to firms, and then a decrease in unemployment as more workers leave and those remaining become relatively scarce. Unemployment is always larger for home workers. On the other hand, migrant workers experience increased unemployment as their continual migration increases the available worker pool in the home country for firms

while profitability remains constant in the home country. At the point where posting and maintenance costs are equal between the two countries, all wages are equal. When costs are lower in the foreign country, wages are higher for all workers except foreign stayers, who see no change in wages regardless of changes in costs to firms. When costs are higher in the foreign country, wages everywhere drop. In the foreign country this is due to the lower surplus of matches due to the high costs while in the home country, firms no longer have to pay high wages to entice workers to search in the home country.

Making unemployment benefits more generous in the foreign country has qualitatively similar effects on population, market tightness, and unemployment as increases in posting costs (Figure 4.9). As the foreign country becomes more generous, so few jobs are posted in the foreign country that eventually all workers migrate to the home country. This is reflected in the market tightness decreasing to zero as the number of open vacancies maintained is zero when benefits are as large as is allowable for this parameterization. Unemployment increases slightly for foreign stayers as benefits become more generous, and then tends to zero as workers vacate the foreign country in favor of the higher probability of job finding rates in the home country. Foreign migrants see their unemployment rates converge up to those for home workers as the entire population moves into the home country seeking employment. The less restrictive environment for firms from the relatively lower unemployment benefit there leads them to post more vacancies and increases the probability that workers will match with a firm. Wages for foreign workers in the home country who moved prior to the most recent unemployment spell and home workers are unaffected by changes in unemployment benefits in the foreign country. Wages for workers in the foreign country and new migrants in the home country increase as unemployment benefits increase to compensate for the higher value of unemployment. As benefits in the foreign country increase beyond the level in the home country, wages drop for new migrants in both countries, coinciding with the movement of the entire population moving into the home country, and their crowding of the home market for foreign workers.

Changes in the bargaining power of workers in the foreign country again has qualitatively similar effects as posting costs and unemployment benefits. Each of these three parameters impacts the size and/or division of the match surplus, and incentivizes workers and/or firms to try to increase the probability of a match from the other side of the market. Figure 4.10 illustrates the impact when workers have very little bargaining power through the opposite extreme of having almost all the bargaining power in wage negotiations. Equilibrium population is most evenly split across the two countries when the foreign country's workers have no bargaining power. Then, as worker's share of the match surplus increases in the foreign country, more workers migrate until only 12% of the original workforce remains when their share is as large as possible. Market tightness in the foreign country also decreases in tandem with the increase in worker's bargaining power as firms find it less attractive to offer vacancies when their share of the surplus is low. Home workers again see no change in their unemployment levels from the changes in the foreign country, but migrants face increasing unemployment as they overcrowd the home market. Again, home workers always face higher unemployment. Foreign stayers, on the other hand, first see an increase in unemployment as firms open fewer vacancies, but then benefit from the exodus of workers into the home market, thereby lowering foreign country unemployment levels. Changes in productivity have relatively small effects on unemployment compared to posting costs, unemployment benefits, and bargaining power, but large differences in unemployment persist across all parameter variations. Wages for foreign stayers as well as new migrants in both countries see wages increase with the increase in bargaining power. The rise is most dramatic for foreign stayers. Home workers, and foreign workers who moved prior to their last unemployment spell see no change in wages with changes in foreign bargaining power.

Under discriminating behavior of firms, home workers' unemployment doesn't change even when foreign workers move in and out of the home country. They are relatively insulated from foreign worker's impacts on market tightness and population levels through the targeting of particular workers by firms. More workers migrate under discrimination condi-

tions, typically around 50%, than in the data, close to around 10%. If firms were to behave as they do under discrimination, there would be no support for the argument that immigrants hurt native workers' job prospects through competition for jobs. Given that most firms are unlikely to behave this way, we must examine what happens not only to home workers, but to all workers under more realistic firm hiring conditions. Wages are positively related with changes in market tightness for changes in initial populations, productivity, and posting costs, but negatively related with market tightness for changes in unemployment benefits and bargaining power.

Discrimination vs Non-Discrimination

I now compare how the two firm restrictions result in different equilibrium outcomes. Firm behavior, migration patterns, and unemployment values vary across parameter changes depending on the restrictions imposed on vacancy posting. The discrimination and non-discrimination characterizations are qualitatively similar for most of the comparative statics exercises. Both market equilibria provide important insights into the effects of changes in the structural characteristics of labor markets, while differences highlight ways in which labor markets may not work as expected when migration is limited to one nationality, but not for another.

When the initial population in the foreign country size is varied, the equilibrium distribution of workers is the same. Foreign workers are split evenly between the two countries (Figures 4.6 and 1.5). Firms under the two regimes behave differently: firms allowed to discriminate between worker types maintain slightly fewer unfilled vacancies than firms not allowed to discriminate. The second panels of Figures 4.6 and 1.5 show that discriminating firms post fewer vacancies per unemployed worker likely because their postings can be more targeted, but the third panels show that unemployment for home workers is higher as a result while foreign workers' unemployment in both countries are unaffected by the differing firm behavior. Wages for all workers are the same under both firm behaviors except for foreign

stayers without discrimination. In that case, foreign stayers benefit from the inability of firms to discriminate by targeting those workers who are not moving.

Figures 4.7 and 1.6 show how the discrimination and non-discrimination outcomes vary for changes in productivity in the foreign country. The population is less evenly distributed between countries for all values of productivity under discrimination. Firms recruit less equally when allowed to discriminate. Vacancies per unemployed worker increase in the foreign country under both firm behaviors, but home firms are not required to alter behavior under discrimination as the foreign productivity varies in order to retain an acceptable workforce. Under non-discrimination, firms begin to offer fewer vacancies as the foreign country becomes more productive, since those firms must compete with foreign firms to attract workers. Foreign workers who migrate experience the same unemployment under either firm behavior, but workers choosing to stay in the foreign country and home workers have very different unemployment conditions. Home workers are not affected under discrimination, but their competition for jobs without discrimination means they suffer disproportionately from the decrease in vacancies in the home country, and have large increases in unemployment as the foreign country becomes more productive. Foreign stayers benefit from the increase in vacancies under discrimination, but suffer from the increase in population (due to a decrease in migration) following the increase in productivity. When the countries are symmetric, all workers receive higher wages with discrimination. As the foreign country becomes more productive, foreign stayers more than overcome the initial lower wages under non-discrimination, and receive higher wages when firms cannot target particular workers. All other workers always receive higher wages when firms can discriminate.

When posting costs in the foreign country approach zero, almost no workers migrate to the home country under discrimination, but without firm discrimination, foreign workers continue to migrate at a rate of about 33% of the original population, shown in Figures 4.8 and 1.7. When firms cannot target particular workers, workers choose to search in the home country despite the larger surplus from remaining in the foreign country. As costs to firms

in the foreign country increase, more workers leave the foreign country until no one lives there under both discrimination and non-discrimination. Given the more equal distribution initially under discrimination, this transition occurs more quickly with the cost increase than under non-discrimination. Overall market tightness is lower under non-discrimination for all workers given firms' inability to target workers in the same way as when they are permitted to discriminate, but changes as foreign posting costs increase is qualitatively similar across the two scenarios (second panel). Home tightness increases slightly as firms open more vacancies, potentially in response to their relative advantage in a higher surplus once foreign costs surpass home costs. This increase in the home country benefits all workers under non-discrimination by decreasing unemployment despite the increase in population, but the decrease in unemployment benefits only foreign migrant workers under discrimination since home firms need not increase postings for home workers who are trapped there. Foreign workers experience decreased unemployment as fewer workers remain in the home country, but the overall foreign unemployment rate increases as eventually no jobs are filled, and all workers are unemployed when costs are highest. Foreign stayers and returning migrants receive higher wages under non-discrimination when costs are lower in the foreign country, but receive lower wages when costs are higher in the foreign country. New migrants to the home country, home workers and migrants who spent their most recent period of unemployment in the home country receive higher wages under discrimination when costs are lower in the foreign country, but lower wages when costs are higher.

Population distributions across discrimination and non-discrimination vary dramatically when unemployment benefits vary in the foreign country. Figures 4.9 and 1.8 show that discriminating firms result in workers always being less equally distributed, beginning with almost 70% of the original foreign population in the home country when there are almost no benefits in the foreign country, and inequality increasing as the foreign country becomes so generous that no match surplus remains after accounting for the opportunity cost to employment in the foreign country. This contrasts with the case in which firms cannot

discriminate where population distribution changes relatively little when benefits increase in the foreign country, and results in a more equal (though not close to equal) distribution when benefits are very generous in the foreign country. Market tightness also displays large differences from firm behavior under the two regimes: the second panels show tightness increasing slightly in the home country under discrimination and the foreign country under non-discrimination while tightness decreases in the foreign country under discrimination and in the home country under non-discrimination. I attribute this to the complete erosion of surplus under discrimination resulting in a marked decrease in vacancies by firms. When firms cannot discriminate, they decrease all postings in the home country due to the high opportunity cost of hiring a foreign migrant and being forced to pay those workers higher wages under equal bargaining rules due to foreign workers' higher opportunity cost of employment. This is reflected in the differences in unemployment patterns. Under discrimination, home workers are unaffected by the changes in foreign unemployment benefits while foreign migrants face increasing unemployment due to their increased migration and cost to the home country. Without discrimination, foreign workers in either country face little change in unemployment due to firms' inability to choose their worker pool. Home workers experience higher unemployment since firms unable to choose to hire home workers post fewer vacancies to avoid the higher wages foreign workers demand. Wages are higher without discrimination for newly leaving and returning migrants. Wages are higher without discrimination for home workers and migrants who spent their most recent period of unemployment in the home country when foreign unemployment benefits are low, but lower for those workers when foreign benefits are at their maximum allowable level. Wages are higher with discrimination for foreign stayers when foreign benefits are low, but higher when foreign benefits are high.

Changes in workers' bargaining power in the foreign country have markedly different effects across discrimination and non-discrimination. This is likely due to the differential impact on firms of decreasing the surplus they receive from matching when they are able to

target home workers under discrimination in the home country without risking matching with foreign migrants demanding higher wages from their outside bargaining power in the foreign country. Figures 4.10 and 1.9 show the effects from increasing workers' bargaining power from very small shares to very large shares of surplus. When firms are allowed to discriminate, the population is initially more equally distributed between the countries since firms are better able to target workers. Under discrimination, workers increasingly begin to locate in the home country as bargaining power in the foreign country increases. Without discrimination, foreign workers cease to migrate as the foreign country employment becomes more attractive. Firms have opposing incentives for maintaining open vacancies depending on their ability to discriminate. Discriminating firms in the home country maintain a fairly constant market tightness even as the foreign workers become less attractive, while foreign firms maintain fewer open vacancies as the foreign worker absorbs more of the match surplus. Home tightness is lower under discrimination than without discrimination until foreign workers absorb more than 80% of the match surplus. Foreign tightness is lower without discrimination until foreign workers' receive more than 46% of the match surplus. Workers also face very different unemployment conditions under the two regimes. When firms can discriminate, home workers are unaffected by changes in foreign bargaining power, and have lower unemployment rates than when firms cannot discriminate except when foreign workers receive less than half of the match surplus. Foreign migrants are worse off (in terms of unemployment) when foreign bargaining is low and firms cannot discriminate, but are better off when firms can discriminate and their bargaining power is high; this is partially attributable to the high value of employment in their native country, and the falling rates of migration as bargaining power increases. Foreign stayers always have higher unemployment when firms cannot discriminate: Foreign firms know the only workers available to match are foreign workers, and always know the unemployment pool's uniformity. As firms receive less of the match surplus, they hire fewer workers despite the increasing demand for foreign employment. Foreign stayers, new migrants, and returning migrants receive higher

wages when firms discriminate. Home workers and migrants who spent their most recent period of unemployment in the home country receive the same wages regardless of changes in bargaining power under both types of firm behavior.

Firms in the home country offer slightly more vacancies as the population increases, and there are always more vacancies in the home country when firms cannot discriminate. This makes home workers better off in the sense of experiencing in lower unemployment when firms cannot discriminate, and this decreases as more foreign workers join them in the unemployment pool in the home country. Wages vary significantly across firm behaviors, and depending on parameter values. Workers' wages are not systematically higher or lower under either regime.

Restrictions on firm recruiting behavior matters for equilibrium population allocations, unemployment, wages, and other labor market conditions more broadly.

Discrimination Figures

Figure 4.6: Full Discrimination Changing Initial Population

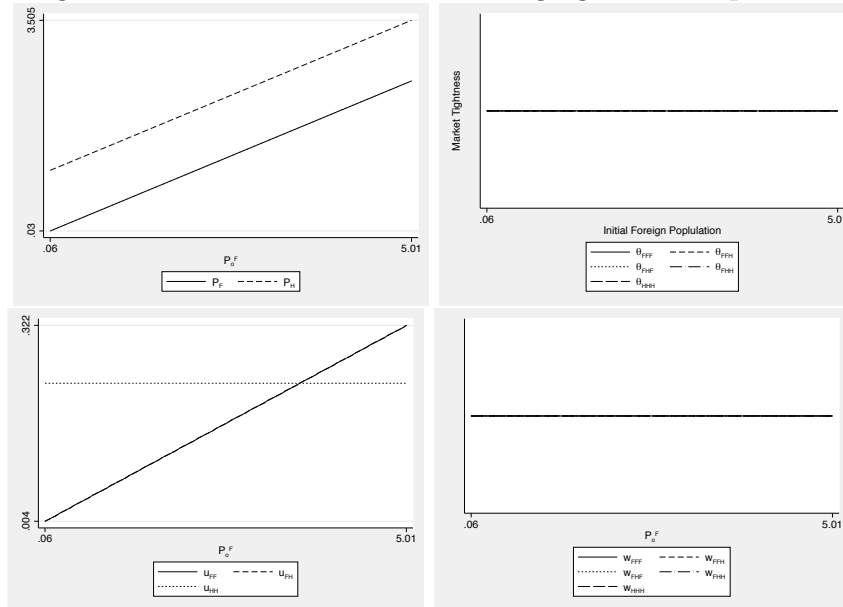


Figure 4.7: Full Discrimination Changing Productivity

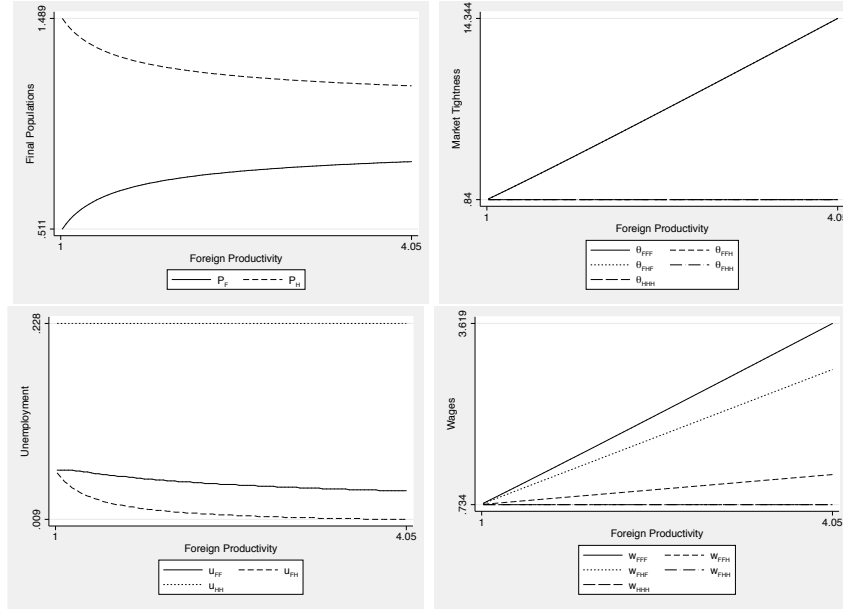


Figure 4.8: Full Discrimination Posting and Maintenance Costs Changing

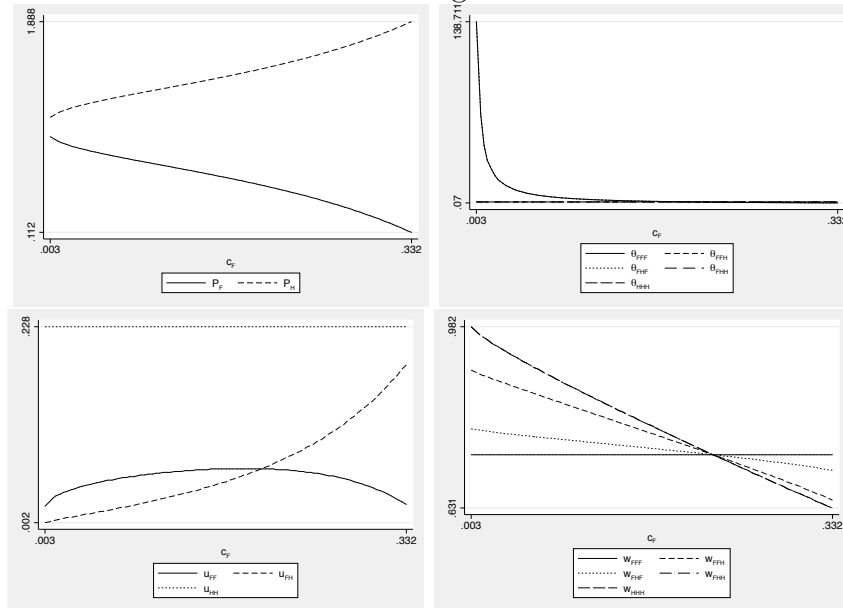


Figure 4.9: Full Discrimination Changing Unemployment Benefits

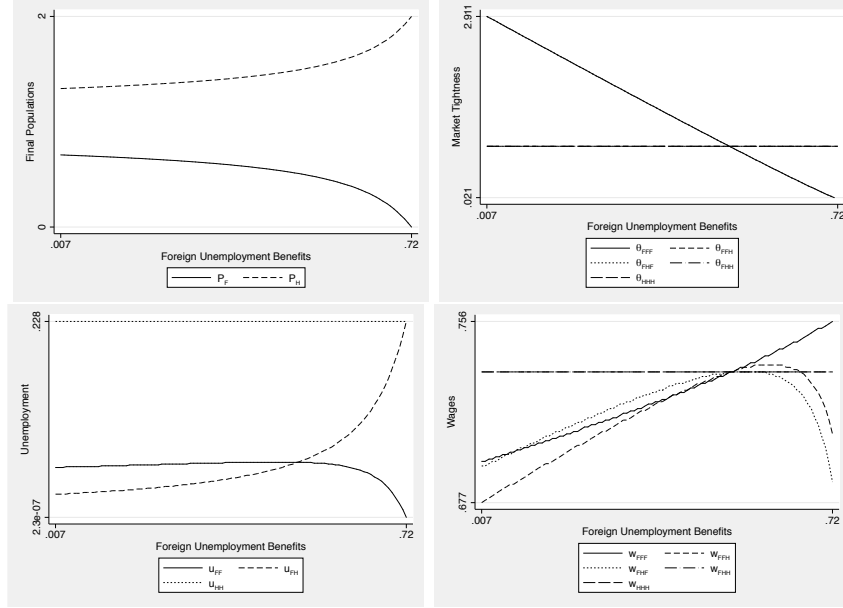
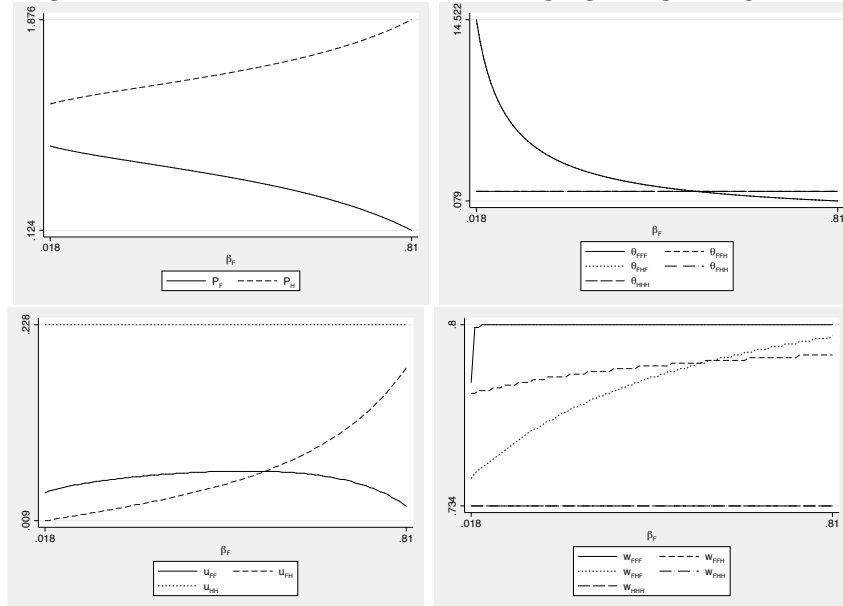


Figure 4.10: Full Discrimination Changing Bargaining Power



4.0.4 A Search Model of Migration & Unemployment Equilibrium Values

Wages

Discrimination (Labor Supply)

$$w_{11}^1 = \frac{\beta_1(y_1 - c_1)(r + \delta + \theta_{11}^1 q_{11}^1(\theta_{11}^1)) + (1 - \beta_1)b_1}{r + \delta + \beta_1 \theta_{11}^1 q_{11}^1(\theta_{11}^1)}$$

$$w_{12}^2 = \frac{\beta_2(y_2 - c_2)(r + \delta + \theta_{12}^2 q_{12}^2(\theta_{12}^2)) + (1 - \beta_2)b_2}{r + \delta + \beta_2 \theta_{12}^2 q_{12}^2(\theta_{12}^2)}$$

$$w_{22}^2 = \frac{\beta_2(y_2 - c_2)(r + \delta + \theta_{22}^2 q_{22}^2(\theta_{22}^2)) + (1 - \beta_2)b_2}{r + \delta + \beta_2 \theta_{22}^2 q_{22}^2(\theta_{22}^2)}$$

$$w_{11}^2 = -(((c_2 - y_2)\beta_2(r + \delta)(r(r + \delta) + q_{12}^1 \theta_{12}^1(r\beta_1 + \delta)) + q_{11}^2((c_2 - y_2)\beta_2(r + \delta)^2 + q_{12}^1(-ry_2\beta_1\beta_2 - (y_2\beta_2 + \beta_1(-c_1 + y_1 + (c_1 - y_1 + y_2)\beta_2))\delta + c_2\beta_2(\delta + \beta_1(r + \delta)))\theta_{12}^1)\theta_{11}^2 + b_2(-1 + \beta_2)(r + \delta)(r^2 + r\delta + q_{12}^1 r\beta_1\theta_{12}^1 + q_{12}^1 \delta \theta_{12}^1 + q_{11}^2 \delta \theta_{11}^2))/((r + \delta)(r(r + \delta) + q_{12}^1(r\beta_1 + \delta)\theta_{12}^1) + q_{11}^2((r + \delta)(r\beta_2 + \delta) + q_{12}^1(r\beta_1\beta_2 + (\beta_1 + \beta_2)\delta)\theta_{12}^1)\theta_{11}^2))$$

$$w_{12}^1 = (- (c_1 - y_1)\beta_1(r + \delta)^2(r + q_{12}^1 \theta_{12}^1) + q_{11}^2(-(c_1 - y_1)\beta_1(r + \delta)(r\beta_2 + \delta) + q_{12}^1(ry_1\beta_1\beta_2 + ((c_2 - y_2)(-1 + \beta_1)\beta_2 + y_1\beta_1(1 + \beta_2))\delta - c_1\beta_1(\delta + \beta_2(r + \delta))\theta_{12}^1)\theta_{11}^2 - b_2(-1 + \beta_1)(r + \delta)(r^2 + r\delta + q_{12}^1 \delta \theta_{12}^1 + q_{11}^2(r\beta_2 + \delta)\theta_{11}^2))/((r + \delta)(r(r + \delta) + q_{12}^1(r\beta_1 + \delta)\theta_{12}^1) + q_{11}^2((r + \delta)(r\beta_2 + \delta) + q_{12}^1(r\beta_1\beta_2 + (\beta_1 + \beta_2)\delta)\theta_{12}^1)\theta_{11}^2))$$

Non-Discrimination (Labor Supply)

$$w_{11}^1 = \frac{(r + \delta)(b_1(1 - \beta_1) + (y_1 - c_1)(1 + \theta_1 q_1))}{r + \delta + (r + \delta + \beta_1 - 1)\theta_1 q_1}$$

$$w_{12}^2 = \frac{(r + \delta)(b_2(1 - \beta_2) + (y_2 - c_2)(1 + \theta_2 q_2))}{r + \delta + (r + \delta + \beta_2 - 1)\theta_2 q_2}$$

$$w_{22}^2 = \frac{(r + \delta)(b_2(1 - \beta_2) + (y_2 - c_2)(1 + \theta_2 q_2))}{r + \delta + (r + \delta + \beta_2 - 1)\theta_2 q_2}$$

$$w_{11}^2 = -(((c_2 - y_2)\beta_2(r + \delta)(r(r + \delta) + q_1(r\beta_1 + \delta)\theta_1) + q_2((c_2 - y_2)\beta_2(r + \delta)^2 + q_1(-ry_2\beta_1\beta_2 - (y_2\beta_2 + \beta_1(-c_1 + y_1 + (c_1 - y_1 + y_2)\beta_2))\delta + c_2\beta_2(\delta + \beta_1(r + \delta)))\theta_1)\theta_2 + b_2(-1 + \beta_2)(r + \delta)(r^2 + r\delta + q_1 r\beta_1\theta_1 + q_1 \delta \theta_1 + q_2 \delta \theta_2))/((r + \delta)(r(r + \delta) + q_1(r\beta_1 + \delta)\theta_1) + q_2((r + \delta)(r\beta_2 + \delta) + q_1(r\beta_1\beta_2 +$$

$$(\beta_1 + \beta_2)\delta)\theta_1)\theta_2))$$

$$w_{12}^1 = -(c_1 - y_1)\beta_1(r + \delta)^2(r + q_1\theta_1) + q_2(-(c_1 - y_1)\beta_1(r + \delta)(r\beta_2 + \delta) + q_1(ry_1\beta_1\beta_2 + ((c_2 - y_2)(-1 + \beta_1)\beta_2 + y_1\beta_1(1 + \beta_2))\delta - c_1\beta_1(\delta + \beta_2(r + \delta))\theta_1)\theta_2 - b_2(-1 + \beta_1)(r + \delta)(r^2 + r\delta + q_1\delta\theta_1 + q_2(r\beta_2 + \delta)\theta_2))/((r + \delta)(r(r + \delta) + q_1(r\beta_1 + \delta)\theta_1) + q_2((r + \delta)(r\beta_2 + \delta) + q_1(r\beta_1\beta_2 + (\beta_1 + \beta_2)\delta)\theta_1)\theta_2)$$

Discrimination (Labor Demand)

$$w_{ij}^k = y_k - c_k - \frac{c_k(r+\delta)}{q_{ij}^k(\theta_{ij}^k)}$$

Non-Discrimination (Labor Demand)

$$w_{ij}^k = y_k - c_k - \frac{c_k(r+\delta)}{q_k(\theta_k)}$$

Equilibrium Values

Discrimination

$$\begin{aligned} u_{FF} &= (P_o^F \delta q_{FH}^F \theta_{FH}^F) / (q_{FH}^F (\delta + q_{FF}^F \theta_{FF}^F) \theta_{FH}^F + q_{FF}^H \theta_{FF}^H (\delta + 2q_{FH}^F \theta_{FH}^F + q_{FH}^H \theta_{FH}^H)) \\ u_{FH} &= (P_o^F \delta q_{FF}^H \theta_{FF}^H) / (q_{FH}^F (\delta + q_{FF}^F \theta_{FF}^F) \theta_{FH}^F + q_{FF}^H \theta_{FF}^H (\delta + 2q_{FH}^F \theta_{FH}^F + q_{FH}^H \theta_{FH}^H)) \\ u_{HH} &= (P_o^H \delta) / (\delta + q_H \theta_{HH}^H) \\ v_{FF}^F &= (P_o^F q_{FH}^F \delta \theta_{FF}^F \theta_{FH}^F) / (q_{FH}^F (\delta + q_{FF}^F \theta_{FF}^F) \theta_{FH}^F + q_{FF}^H \theta_{FF}^H (\delta + 2q_{FH}^F \theta_{FH}^F + q_{FH}^H \theta_{FH}^H)) \\ v_{FF}^H &= (P_o^F q_{FH}^F \delta \theta_{FF}^H \theta_{FH}^F) / (q_{FH}^F (\delta + q_{FF}^F \theta_{FF}^F) \theta_{FH}^F + q_{FF}^H \theta_{FF}^H (\delta + 2q_{FH}^F \theta_{FH}^F + q_{FH}^H \theta_{FH}^H)) \\ v_{FH}^F &= (P_o^F q_{FF}^H \delta \theta_{FF}^H \theta_{FH}^F) / (q_{FH}^F (\delta + q_{FF}^F \theta_{FF}^F) \theta_{FH}^F + q_{FF}^H \theta_{FF}^H (\delta + 2q_{FH}^F \theta_{FH}^F + q_{FH}^H \theta_{FH}^H)) \\ v_{FH}^H &= (P_o^F q_{FF}^H \delta \theta_{FF}^H \theta_{FH}^H) / (q_{FH}^F (\delta + q_{FF}^F \theta_{FF}^F) \theta_{FH}^F + q_{FF}^H \theta_{FF}^H (\delta + 2q_{FH}^F \theta_{FH}^F + q_{FH}^H \theta_{FH}^H)) \\ v_{HH}^H &= (P_o^H \delta \theta_{HH}^H) / (\delta + q_H \theta_{HH}^H) \\ n_{FF}^F &= (P_o^F q_{FF}^F q_{FH}^F \theta_{FF}^F \theta_{FH}^F) / (q_{FH}^F (\delta + q_{FF}^F \theta_{FF}^F) \theta_{FH}^F + q_{FF}^H \theta_{FF}^H (\delta + 2q_{FH}^F \theta_{FH}^F + q_{FH}^H \theta_{FH}^H)) \\ n_{FF}^H &= (P_o^F q_{FF}^H q_{FH}^F \theta_{FF}^H \theta_{FH}^F) / (q_{FH}^F (\delta + q_{FF}^F \theta_{FF}^F) \theta_{FH}^F + q_{FF}^H \theta_{FF}^H (\delta + 2q_{FH}^F \theta_{FH}^F + q_{FH}^H \theta_{FH}^H)) \\ n_{FH}^F &= (P_o^F q_{FF}^H q_{FH}^F \theta_{FF}^H \theta_{FH}^F) / (q_{FH}^F (\delta + q_{FF}^F \theta_{FF}^F) \theta_{FH}^F + q_{FF}^H \theta_{FF}^H (\delta + 2q_{FH}^F \theta_{FH}^F + q_{FH}^H \theta_{FH}^H)) \end{aligned}$$

$$n_{FH}^H = (P_o^F q_{FF}^H q_{FH}^H \theta_{FF}^H \theta_{FH}^H) / (q_{FH}^F (\delta + q_{FF}^F \theta_{FF}^F) \theta_{FH}^F + q_{FF}^H \theta_{FF}^H (\delta + 2q_{FH}^F \theta_{FH}^F + q_{FH}^H \theta_{FH}^H))$$

$$n_{HH}^H = (P_o^H q_H \theta_{HH}^H) / (\delta + q_H \theta_{HH}^H)$$

Non-Discrimination

$$u_{FF} = (P_o^F q_F \delta \theta_F) / ((q_F \theta_F + q_H \theta_H) (\delta + q_F \theta_F + q_H \theta_H))$$

$$u_{FH} = (P_o^F q_H \delta \theta_H) / ((q_F \theta_F + q_H \theta_H) (\delta + q_F \theta_F + q_H \theta_H))$$

$$u_{HH} = (P_o^H \delta) / (\delta + q_H \theta_H)$$

$$n_F = (P_o^F q_F \theta_F) / (\delta + q_F \theta_F + q_H \theta_H)$$

$$n_H = (q_H \theta_H (P_o^F \delta + P_o^H \delta + P_o^H q_F \theta_F + (P_o^F + P_o^H) q_H \theta_H)) / ((\delta + q_H \theta_H) (\delta + q_F \theta_F + q_H \theta_H))$$

$$v_F = (P_o^F \delta \theta_F) / (\delta + q_F \theta_F + q_H \theta_H)$$

$$v_H = (\delta \theta_H (P_o^F \delta + P_o^H \delta + P_o^H q_F \theta_F + (P_o^F + P_o^H) q_H \theta_H)) / ((\delta + q_H \theta_H) (\delta + q_F \theta_F + q_H \theta_H))$$

4.0.5 Labor Market Search with Migration: Unbundling Cost Mechanisms Equilibrium Solutions

Equilibrium Solutions

Labor Supply:

Non-Discrimination

$$w_{11}^1 = -((b_F(-1 + \beta_F)(\delta + r) + \beta_F(\delta + r + q_F \Theta_F)(c_F - y_F)) / (\delta + r + \beta_F q_F \Theta_F))$$

$$w_{22}^2 = -((b_H(-1 + \beta_H)(\delta + r) + \beta_H(\delta + r + q_H \Theta_H)(c_H - y_H)) / (\delta + r + \beta_H q_H \Theta_H))$$

$$w_{12}^2 = (-b_H(-1 + \beta_H)(\delta + r) + (\delta + r + q_H \Theta_H)(-\tau_{FH} + \beta_H(-c_H + \tau_{FH} + y_H))) / (\delta + r + \beta_H q_H \Theta_H)$$

$$w_{12}^1 = -((-b_F \delta^2 q_F \Theta_F - b_F \delta q_F r \Theta_F + \beta_H c_H \delta q_F q_H \Theta_F \Theta_H + \delta^2 q_F q_H \Theta_F \phi_{FH} \Theta_H + \delta q_F q_H r \Theta_F \phi_{FH} \Theta_H + (-1 + \beta_F) b_H (\delta + r) (r(\delta + r) + q_H (\delta + \beta_H r) \Theta_H) + \delta^2 q_F r \Theta_F \phi_{HF} + 2\delta q_F r^2 \Theta_F \phi_{HF} + q_F r^3 \Theta_F \phi_{HF} + \delta^2 q_F q_H \Theta_F \Theta_H \phi_{HF} + \delta q_F q_H r \Theta_F \Theta_H \phi_{HF} + \beta_H \delta q_F q_H r \Theta_F \Theta_H \phi_{HF} + \beta_H q_F q_H r^2 \Theta_F \Theta_H \phi_{HF} + \delta^2 r \tau_{FH} +$$

$$\begin{aligned}
& 2\delta r^2\tau_{FH} + r^3\tau_{FH} + \delta^2 q_H \Theta_H \tau_{FH} + \delta q_H r \Theta_H \tau_{FH} + \beta_H \delta q_H r \Theta_H \tau_{FH} + \beta_H q_H r^2 \Theta_H \tau_{FH} + \delta q_F q_H \Theta_F \Theta_H \tau_{FH} - \\
& \beta_H \delta q_F q_H \Theta_F \Theta_H y_H - \beta_F (-b_F \delta q_F (\delta + r) \Theta_F - c_F (\delta + r)^2 (r + q_F \Theta_F) + \beta_H c_H \delta q_F q_H \Theta_F \Theta_H - \\
& c_F q_H ((\delta + r)(\delta + \beta_H r) + q_F (\delta + \beta_H \delta + \beta_H r) \Theta_F) \Theta_H + \delta^2 q_F q_H \Theta_F \phi_{FH} \Theta_H + \delta q_F q_H r \Theta_F \phi_{FH} \Theta_H + \\
& \delta^2 q_F r \Theta_F \phi_{HF} + 2\delta q_F r^2 \Theta_F \phi_{HF} + q_F r^3 \Theta_F \phi_{HF} + \delta^2 q_F q_H \Theta_F \Theta_H \phi_{HF} + \delta q_F q_H r \Theta_F \Theta_H \phi_{HF} + \beta_H \delta q_F q_H r \Theta_F \Theta_H \phi_{HF} + \\
& \beta_H q_F q_H r^2 \Theta_F \Theta_H \phi_{HF} + \delta^2 r \tau_{FH} + 2\delta r^2 \tau_{FH} + r^3 \tau_{FH} + \delta^2 q_H \Theta_H \tau_{FH} + \delta q_H r \Theta_H \tau_{FH} + \beta_H \delta q_H r \Theta_H \tau_{FH} + \\
& \beta_H q_H r^2 \Theta_H \tau_{FH} + \delta q_F q_H \Theta_F \Theta_H \tau_{FH} + \delta^2 r y_F + 2\delta r^2 y_F + r^3 y_F + \delta^2 q_F \Theta_F y_F + 2\delta q_F r \Theta_F y_F + \\
& q_F r^2 \Theta_F y_F + \delta^2 q_H \Theta_H y_F + \delta q_H r \Theta_H y_F + \beta_H \delta q_H r \Theta_H y_F + \beta_H q_H r^2 \Theta_H y_F + \delta q_F q_H \Theta_F \Theta_H y_F + \\
& \beta_H \delta q_F q_H \Theta_F \Theta_H y_F + \beta_H q_F q_H r \Theta_F \Theta_H y_F - \beta_H \delta q_F q_H \Theta_F \Theta_H y_H) / ((\delta + r)(r(\delta + r) + q_F (\delta + \beta_F r) \Theta_F) + q_H ((\delta + r)(\delta + \beta_H r) + q_F ((\beta_F + \beta_H) \delta + \beta_F \beta_H r) \Theta_F) \Theta_H))
\end{aligned}$$

$$\begin{aligned}
w_{11}^2 = & (-b_F (-1 + \beta_H) (\delta + r) (r(\delta + r) + q_F (\delta + \beta_F r) \Theta_F) + q_H \Theta_H (b_H \delta (\delta + r) - (\delta + r) ((r(\delta + r) + \\
& \delta q_F \Theta_F) \phi_{FH} + \delta q_F \Theta_F \phi_{HF}) - ((\delta + r)^2 + \delta q_F \Theta_F) \tau_{FH} - \beta_F q_F \Theta_F (c_F \delta + r ((\delta + r) \phi_{FH} + \tau_{FH}) - \delta y_F)) + \\
& \beta_H (-c_H (\delta + r) (r(\delta + r) + q_F (\delta + \beta_F r) \Theta_F) - b_H \delta q_H (\delta + r) \Theta_H + \beta_F c_F \delta q_F q_H \Theta_F \Theta_H - c_H q_H ((\delta + r)^2 + \\
& q_F (\delta + \beta_F \delta + \beta_F r) \Theta_F) \Theta_H + \delta^2 q_H r \phi_{FH} \Theta_H + 2\delta q_H r^2 \phi_{FH} \Theta_H + q_H r^3 \phi_{FH} \Theta_H + \delta^2 q_F q_H \Theta_F \phi_{FH} \Theta_H + \\
& \delta q_F q_H r \Theta_F \phi_{FH} \Theta_H + \beta_F \delta q_F q_H r \Theta_F \phi_{FH} \Theta_H + \beta_F q_F q_H r^2 \Theta_F \phi_{FH} \Theta_H + \delta^2 q_F q_H \Theta_F \Theta_H \phi_{HF} + \delta q_F q_H r \Theta_F \Theta_H \phi_{HF} + \\
& \delta^2 q_H \Theta_H \tau_{FH} + 2\delta q_H r \Theta_H \tau_{FH} + q_H r^2 \Theta_H \tau_{FH} + \delta q_F q_H \Theta_F \Theta_H \tau_{FH} + \beta_F q_F q_H r \Theta_F \Theta_H \tau_{FH} - \beta_F \delta q_F q_H \Theta_F \Theta_H y_F + \\
& ((\delta + r)(r(\delta + r) + q_F (\delta + \beta_F r) \Theta_F) + q_H ((\delta + r)^2 + q_F (\delta + \beta_F \delta + \beta_F r) \Theta_F) \Theta_H) y_H) / ((\delta + r)(r(\delta + r) + q_F (\delta + \beta_F r) \Theta_F) + q_H ((\delta + r)(\delta + \beta_H r) + q_F ((\beta_F + \beta_H) \delta + \beta_F \beta_H r) \Theta_F) \Theta_H)
\end{aligned}$$

Discrimination

$$\begin{aligned}
w_{11}^1 = & -((b_F (-1 + \beta_F) (\delta + r) + \beta_F (\delta + r + q_{FF}^F \Theta_{FF}^F) (c_F - y_F)) / (\delta + r + \beta_F q_{FF}^F \Theta_{FF}^F)) \\
w_{22}^2 = & -((b_H (-1 + \beta_H) (\delta + r) + \beta_H (\delta + r + q_{HH}^H \Theta_{HH}^H) (c_H - y_H)) / (\delta + r + \beta_H q_{HH}^H \Theta_{HH}^H)) \\
w_{12}^2 = & (-b_H (-1 + \beta_H) (\delta + r) + (\delta + r + q_{FH}^H \Theta_{FH}^H) (-\tau_{FH} + \beta_H (-c_H + \tau_{FH} + y_H))) / (\delta + r + \beta_H q_{FH}^H \Theta_{FH}^H)
\end{aligned}$$

$$\begin{aligned}
w_{12}^1 = & -(((-1 + \beta_F) b_H (\delta + r) (r(\delta + r) + q_{FF}^H (\delta + \beta_H r) \Theta_{FF}^H) - b_F \delta^2 q_{FH}^F \Theta_{FH}^F - b_F \delta q_{FH}^F r \Theta_{FH}^F + \\
& \beta_H c_H \delta q_{FF}^H q_{FH}^F \Theta_{FF}^H \Theta_{FH}^F + \delta^2 q_{FF}^H q_{FH}^F \Theta_{FF}^H \phi_{FH} \Theta_{FH}^F + \delta q_{FF}^H q_{FH}^F r \Theta_{FF}^H \phi_{FH} \Theta_{FH}^F + \delta^2 q_{FH}^F r \Theta_{FH}^F \phi_{HF} + \\
& 2\delta q_{FH}^F r^2 \Theta_{FH}^F \phi_{HF} + q_{FH}^F r^3 \Theta_{FH}^F \phi_{HF} + \delta^2 q_{FF}^H q_{FH}^F \Theta_{FF}^H \Theta_{FH}^F \phi_{HF} + \delta q_{FF}^H q_{FH}^F r \Theta_{FF}^H \Theta_{FH}^F \phi_{HF} + \beta_H \delta q_{FF}^H q_{FH}^F r \Theta_{FF}^H \Theta_{FH}^F \\
& \beta_H q_{FF}^H q_{FH}^F r^2 \Theta_{FF}^H \Theta_{FH}^F \phi_{HF} + \delta^2 r \tau_{FH} + 2\delta r^2 \tau_{FH} + r^3 \tau_{FH} + \delta^2 q_{FF}^H \Theta_{FF}^H \tau_{FH} + \delta q_{FF}^H r \Theta_{FF}^H \tau_{FH} + \\
& \beta_H \delta q_{FF}^H r \Theta_{FF}^H \tau_{FH} + \beta_H q_{FF}^H r^2 \Theta_{FF}^H \tau_{FH} + \delta q_{FF}^H q_{FH}^F \Theta_{FF}^H \Theta_{FH}^F \tau_{FH} - \beta_H \delta q_{FF}^H q_{FH}^F \Theta_{FF}^H \Theta_{FH}^F y_H -
\end{aligned}$$

$$\begin{aligned}
& \beta_F(-c_F(\delta+r)(r(\delta+r)+q_{FF}^H(\delta+\beta_H r)\Theta_{FF}^H)-b_F\delta q_{FH}^F(\delta+r)\Theta_{FH}^F+\beta_H c_H\delta q_{FF}^H q_{FH}^F\Theta_{FF}^H\Theta_{FH}^F- \\
& c_F q_{FH}^F((\delta+r)^2+q_{FF}^H(\delta+\beta_H\delta+\beta_H r)\Theta_{FF}^H)\Theta_{FH}^F+\delta^2 q_{FF}^H q_{FH}^F\Theta_{FF}^H\phi_{FH}\Theta_{FH}^F+\delta q_{FF}^H q_{FH}^F r\Theta_{FF}^H\phi_{FH}\Theta_{FH}^F+ \\
& \delta^2 q_{FH}^F r\Theta_{FH}^F\phi_{HF}+2\delta q_{FH}^F r^2\Theta_{FH}^F\phi_{HF}+q_{FH}^F r^3\Theta_{FH}^F\phi_{HF}+\delta^2 q_{FF}^H q_{FH}^F\Theta_{FF}^H\Theta_{FH}^F\phi_{HF}+\delta q_{FF}^H q_{FH}^F r\Theta_{FF}^H\Theta_{FH}^F\phi_{HF}+ \\
& \beta_H\delta q_{FF}^H q_{FH}^F r\Theta_{FF}^H\Theta_{FH}^F\phi_{HF}+\beta_H q_{FF}^H q_{FH}^F r^2\Theta_{FF}^H\Theta_{FH}^F\phi_{HF}+\delta^2 r\tau_{FH}+2\delta r^2\tau_{FH}+r^3\tau_{FH}+\delta^2 q_{FF}^H\Theta_{FF}^H\tau_{FH}+ \\
& \delta q_{FF}^H r\Theta_{FF}^H\tau_{FH}+\beta_H\delta q_{FF}^H r\Theta_{FF}^H\tau_{FH}+\beta_H q_{FF}^H r^2\Theta_{FF}^H\tau_{FH}+\delta q_{FF}^H q_{FH}^F\Theta_{FF}^H\Theta_{FH}^F\tau_{FH}+\delta^2 r y_F+ \\
& 2\delta r^2 y_F+r^3 y_F+\delta^2 q_{FF}^H\Theta_{FF}^H y_F+\delta q_{FF}^H r\Theta_{FF}^H y_F+\beta_H\delta q_{FF}^H r\Theta_{FF}^H y_F+\beta_H q_{FF}^H r^2\Theta_{FF}^H y_F+\delta^2 q_{FH}^F\Theta_{FH}^F y_F+ \\
& 2\delta q_{FH}^F r\Theta_{FH}^F y_F+q_{FH}^F r^2\Theta_{FH}^F y_F+\delta q_{FF}^H q_{FH}^F\Theta_{FF}^H\Theta_{FH}^F y_F+\beta_H\delta q_{FF}^H q_{FH}^F\Theta_{FF}^H\Theta_{FH}^F y_F+\beta_H q_{FF}^H q_{FH}^F r\Theta_{FF}^H\Theta_{FH}^F y_F- \\
& \beta_H\delta q_{FF}^H q_{FH}^F\Theta_{FF}^H\Theta_{FH}^F y_H)/((\delta+r)(r(\delta+r)+q_{FF}^H(\delta+\beta_H r)\Theta_{FF}^H)+q_{FH}^F((\delta+r)(\delta+\beta_F r)+ \\
& q_{FF}^H((\beta_F+\beta_H)\delta+\beta_F\beta_H r)\Theta_{FF}^H)\Theta_{FH}^F))
\end{aligned}$$

$$\begin{aligned}
w_{11}^2 = & (-b_F(-1+\beta_H)(\delta+r)(r(\delta+r)+q_{FH}^F(\delta+\beta_F r)\Theta_{FH}^F)+q_{FF}^H\Theta_{FF}^H(b_H\delta(\delta+r)- \\
& r(r+\beta_F q_{FH}^F\Theta_{FH}^F)(r\phi_{FH}+\tau_{FH})-\delta^2(r\phi_{FH}+q_{FH}^F\Theta_{FH}^F(\phi_{FH}+\phi_{HF})+\tau_{FH})-\delta(2r^2\phi_{FH}+ \\
& q_{FH}^F r\Theta_{FH}^F(\phi_{FH}+\beta_F\phi_{FH}+\phi_{HF}))+2r\tau_{FH}+q_{FH}^F\Theta_{FH}^F(\beta_F c_F+\tau_{FH}-\beta_F y_F)))+\beta_H(-b_H\delta q_{FF}^H(\delta+ \\
& r)\Theta_{FF}^H-c_H(\delta+r)^2(r+q_{FF}^H\Theta_{FF}^H)+\delta^2 q_{FF}^H r\Theta_{FF}^H\phi_{FH}+2\delta q_{FF}^H r^2\Theta_{FF}^H\phi_{FH}+q_{FF}^H r^3\Theta_{FF}^H\phi_{FH}+ \\
& \beta_F c_F\delta q_{FF}^H q_{FH}^F\Theta_{FF}^H\Theta_{FH}^F-c_H q_{FH}^F((\delta+r)(\delta+\beta_F r)+q_{FF}^H(\delta+\beta_F\delta+\beta_F r)\Theta_{FF}^H)\Theta_{FH}^F+\delta^2 q_{FF}^H q_{FH}^F\Theta_{FF}^H\phi_{FH}\Theta_{FH}^F+ \\
& \delta q_{FF}^H q_{FH}^F r\Theta_{FF}^H\phi_{FH}\Theta_{FH}^F+\beta_F\delta q_{FF}^H q_{FH}^F r\Theta_{FF}^H\phi_{FH}\Theta_{FH}^F+\beta_F q_{FF}^H q_{FH}^F r^2\Theta_{FF}^H\phi_{FH}\Theta_{FH}^F+\delta^2 q_{FF}^H q_{FH}^F\Theta_{FF}^H\Theta_{FH}^F\phi_{HF}+ \\
& \delta q_{FF}^H q_{FH}^F r\Theta_{FF}^H\Theta_{FH}^F\phi_{HF}+\delta^2 q_{FF}^H\Theta_{FF}^H\tau_{FH}+2\delta q_{FF}^H r\Theta_{FF}^H\tau_{FH}+q_{FF}^H r^2\Theta_{FF}^H\tau_{FH}+\delta q_{FF}^H q_{FH}^F\Theta_{FF}^H\Theta_{FH}^F\tau_{FH}+ \\
& \beta_F q_{FF}^H q_{FH}^F r\Theta_{FF}^H\Theta_{FH}^F\tau_{FH}-\beta_F\delta q_{FF}^H q_{FH}^F\Theta_{FF}^H\Theta_{FH}^F y_F+((\delta+r)^2(r+q_{FF}^H\Theta_{FF}^H)+q_{FH}^F((\delta+r)(\delta+ \\
& \beta_F r)+q_{FF}^H(\delta+\beta_F\delta+\beta_F r)\Theta_{FF}^H)\Theta_{FH}^F)y_H)/((\delta+r)(r(\delta+r)+q_{FF}^H(\delta+\beta_H r)\Theta_{FF}^H)+q_{FH}^F((\delta+ \\
& r)(\delta+\beta_F r)+q_{FF}^H((\beta_F+\beta_H)\delta+\beta_F\beta_H r)\Theta_{FF}^H)\Theta_{FH}^F))
\end{aligned}$$

Labor Demand:

Discrimination (Labor Demand)

$$w_{ij}^k = y_k - c_k - \frac{c_k(r+\delta)}{q_{ij}^k(\theta_{ij}^k)}$$

Non-Discrimination (Labor Demand)

$$w_{ij}^k = y_k - c_k - \frac{c_k(r+\delta)}{q_k(\theta_k)}$$

Equilibrium Values

Discrimination

$$\begin{aligned}
u_{FF} &= (P_o^F \delta q_{FH}^F \theta_{FH}^F) / (q_{FH}^F (\delta + q_{FF}^F \theta_{FF}^F) \theta_{FH}^F + q_{FF}^H \theta_{FF}^H (\delta + 2q_{FH}^F \theta_{FH}^F + q_{FH}^H \theta_{FH}^H)) \\
u_{FH} &= (P_o^F \delta q_{FF}^H \theta_{FF}^H) / (q_{FH}^F (\delta + q_{FF}^F \theta_{FF}^F) \theta_{FH}^F + q_{FF}^H \theta_{FF}^H (\delta + 2q_{FH}^F \theta_{FH}^F + q_{FH}^H \theta_{FH}^H)) \\
u_{HH} &= (P_o^H \delta) / (\delta + q_H \theta_{HH}^H) \\
v_{FF}^F &= (P_o^F q_{FH}^F \delta \theta_{FF}^F \theta_{FH}^F) / (q_{FH}^F (\delta + q_{FF}^F \theta_{FF}^F) \theta_{FH}^F + q_{FF}^H \theta_{FF}^H (\delta + 2q_{FH}^F \theta_{FH}^F + q_{FH}^H \theta_{FH}^H)) \\
v_{FF}^H &= (P_o^F q_{FH}^F \delta \theta_{FF}^H \theta_{FH}^F) / (q_{FH}^F (\delta + q_{FF}^F \theta_{FF}^F) \theta_{FH}^F + q_{FF}^H \theta_{FF}^H (\delta + 2q_{FH}^F \theta_{FH}^F + q_{FH}^H \theta_{FH}^H)) \\
v_{FH}^F &= (P_o^F q_{FF}^H \delta \theta_{FF}^H \theta_{FH}^F) / (q_{FH}^F (\delta + q_{FF}^F \theta_{FF}^F) \theta_{FH}^F + q_{FF}^H \theta_{FF}^H (\delta + 2q_{FH}^F \theta_{FH}^F + q_{FH}^H \theta_{FH}^H)) \\
v_{FH}^H &= (P_o^F q_{FF}^H \delta \theta_{FF}^H \theta_{FH}^H) / (q_{FH}^F (\delta + q_{FF}^F \theta_{FF}^F) \theta_{FH}^F + q_{FF}^H \theta_{FF}^H (\delta + 2q_{FH}^F \theta_{FH}^F + q_{FH}^H \theta_{FH}^H)) \\
v_{HH}^H &= (P_o^H \delta \theta_{HH}^H) / (\delta + q_H \theta_{HH}^H) \\
n_{FF}^F &= (P_o^F q_{FF}^F q_{FH}^F \theta_{FF}^F \theta_{FH}^F) / (q_{FH}^F (\delta + q_{FF}^F \theta_{FF}^F) \theta_{FH}^F + q_{FF}^H \theta_{FF}^H (\delta + 2q_{FH}^F \theta_{FH}^F + q_{FH}^H \theta_{FH}^H)) \\
n_{FF}^H &= (P_o^F q_{FF}^H q_{FH}^F \theta_{FF}^H \theta_{FH}^F) / (q_{FH}^F (\delta + q_{FF}^F \theta_{FF}^F) \theta_{FH}^F + q_{FF}^H \theta_{FF}^H (\delta + 2q_{FH}^F \theta_{FH}^F + q_{FH}^H \theta_{FH}^H)) \\
n_{FH}^F &= (P_o^F q_{FF}^H q_{FH}^F \theta_{FF}^H \theta_{FH}^F) / (q_{FH}^F (\delta + q_{FF}^F \theta_{FF}^F) \theta_{FH}^F + q_{FF}^H \theta_{FF}^H (\delta + 2q_{FH}^F \theta_{FH}^F + q_{FH}^H \theta_{FH}^H)) \\
n_{FH}^H &= (P_o^F q_{FF}^H q_{FH}^H \theta_{FF}^H \theta_{FH}^H) / (q_{FH}^F (\delta + q_{FF}^F \theta_{FF}^F) \theta_{FH}^F + q_{FF}^H \theta_{FF}^H (\delta + 2q_{FH}^F \theta_{FH}^F + q_{FH}^H \theta_{FH}^H)) \\
n_{HH}^H &= (P_o^H q_H \theta_{HH}^H) / (\delta + q_H \theta_{HH}^H)
\end{aligned}$$

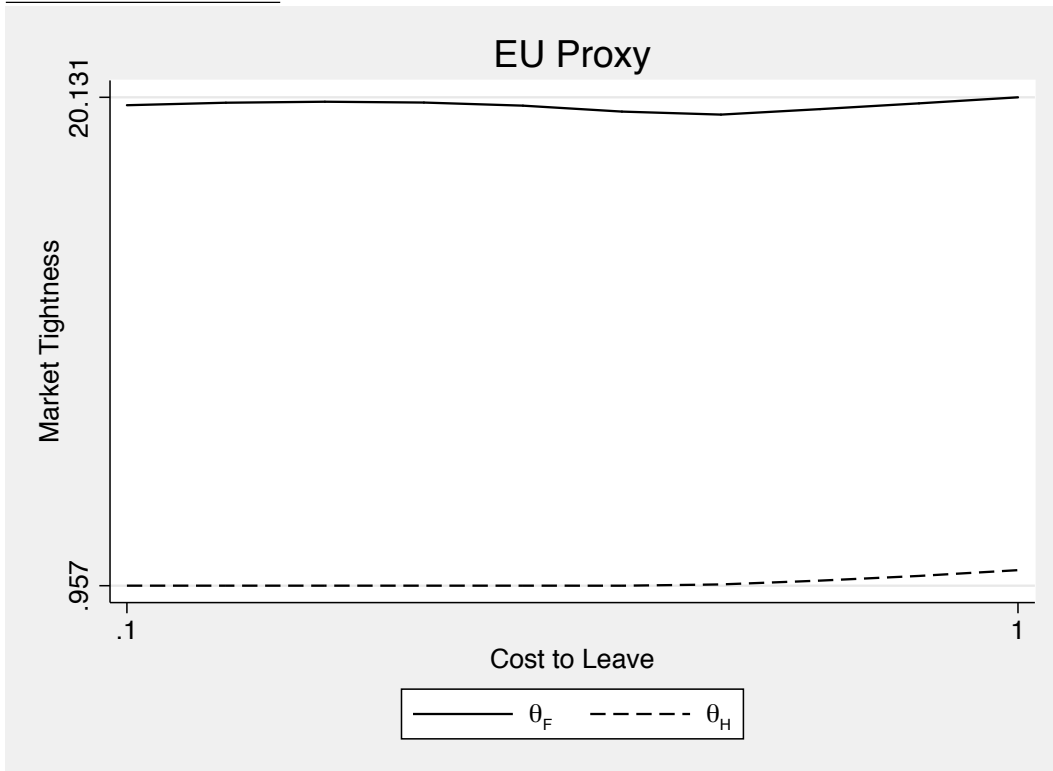
Non-Discrimination

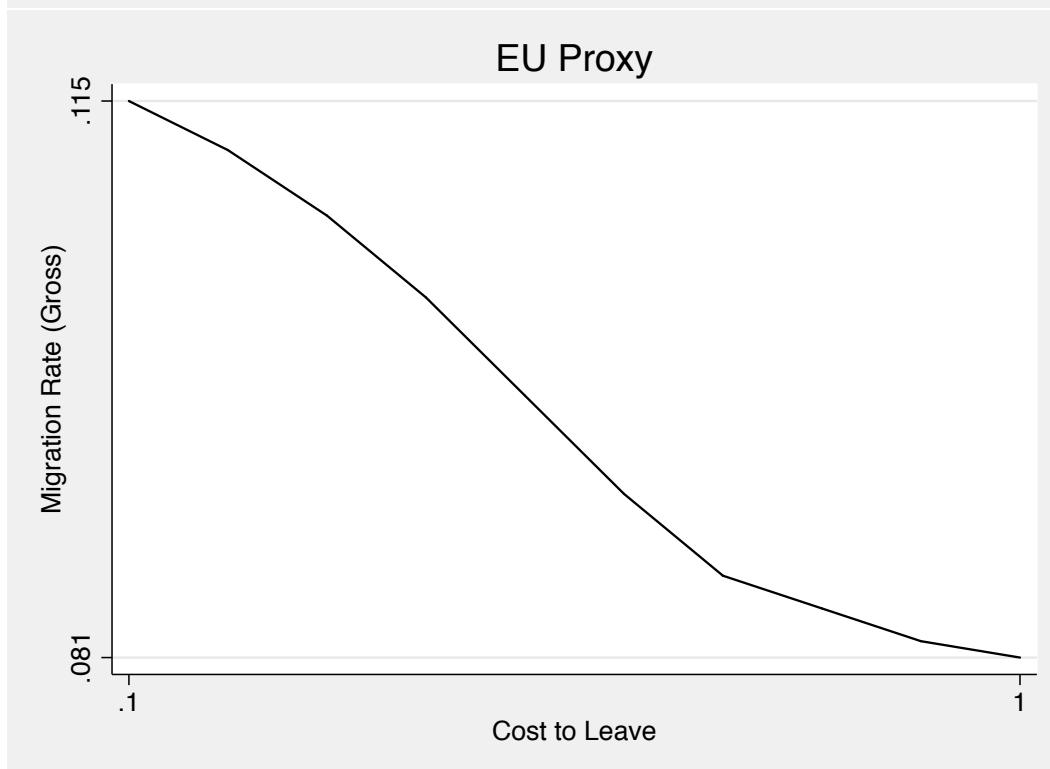
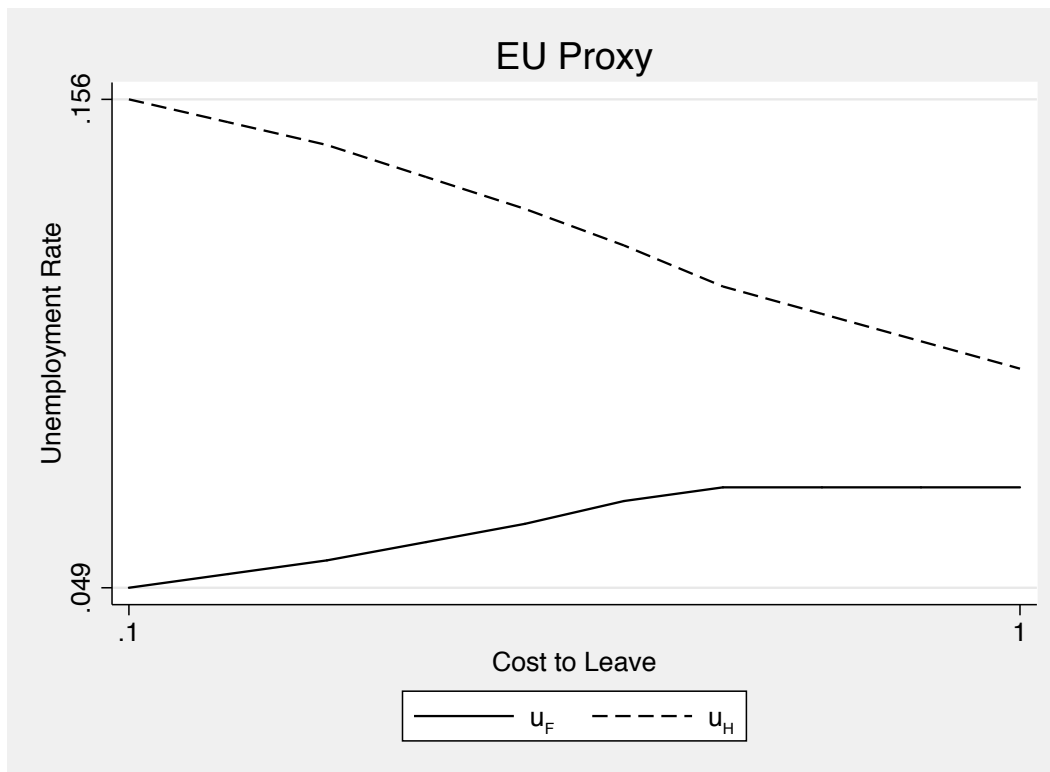
$$\begin{aligned}
u_{FF} &= (P_o^F q_F \delta \theta_F) / ((q_F \theta_F + q_H \theta_H) (\delta + q_F \theta_F + q_H \theta_H)) \\
u_{FH} &= (P_o^F q_H \delta \theta_H) / ((q_F \theta_F + q_H \theta_H) (\delta + q_F \theta_F + q_H \theta_H)) \\
u_{HH} &= (P_o^H \delta) / (\delta + q_H \theta_H) \\
n_F &= (P_o^F q_F \theta_F) / (\delta + q_F \theta_F + q_H \theta_H) \\
n_H &= (q_H \theta_H (P_o^F \delta + P_o^H \delta + P_o^H q_F \theta_F + (P_o^F + P_o^H) q_H \theta_H)) / ((\delta + q_H \theta_H) (\delta + q_F \theta_F + q_H \theta_H)) \\
v_F &= (P_o^F \delta \theta_F) / (\delta + q_F \theta_F + q_H \theta_H) \\
v_H &= (\delta \theta_H (P_o^F \delta + P_o^H \delta + P_o^H q_F \theta_F + (P_o^F + P_o^H) q_H \theta_H)) / ((\delta + q_H \theta_H) (\delta + q_F \theta_F + q_H \theta_H))
\end{aligned}$$

4.0.6 International Migration: Unemployment Differences and Costs to Move Equilibrium Solutions & Figures

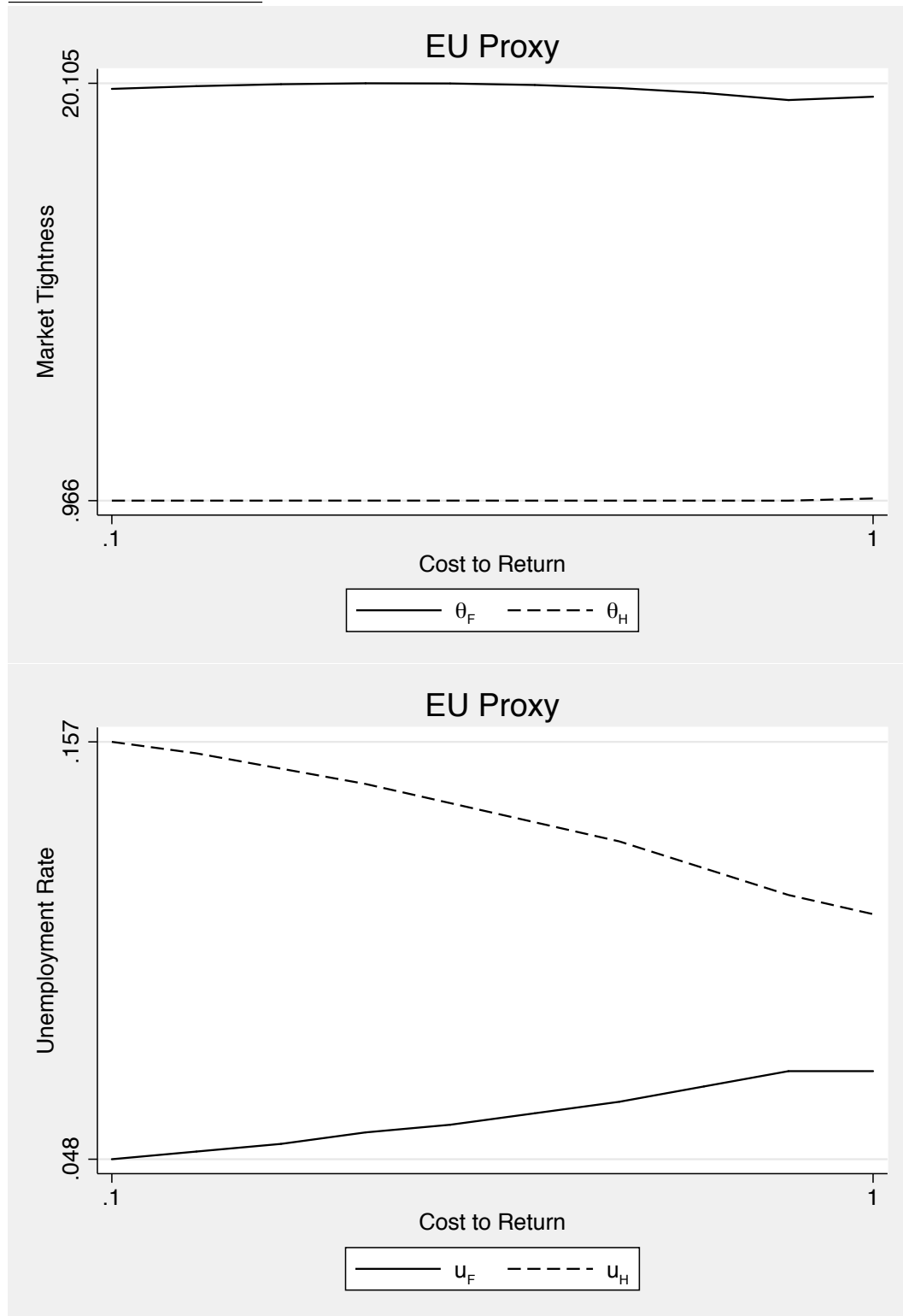
Cost Changes Details

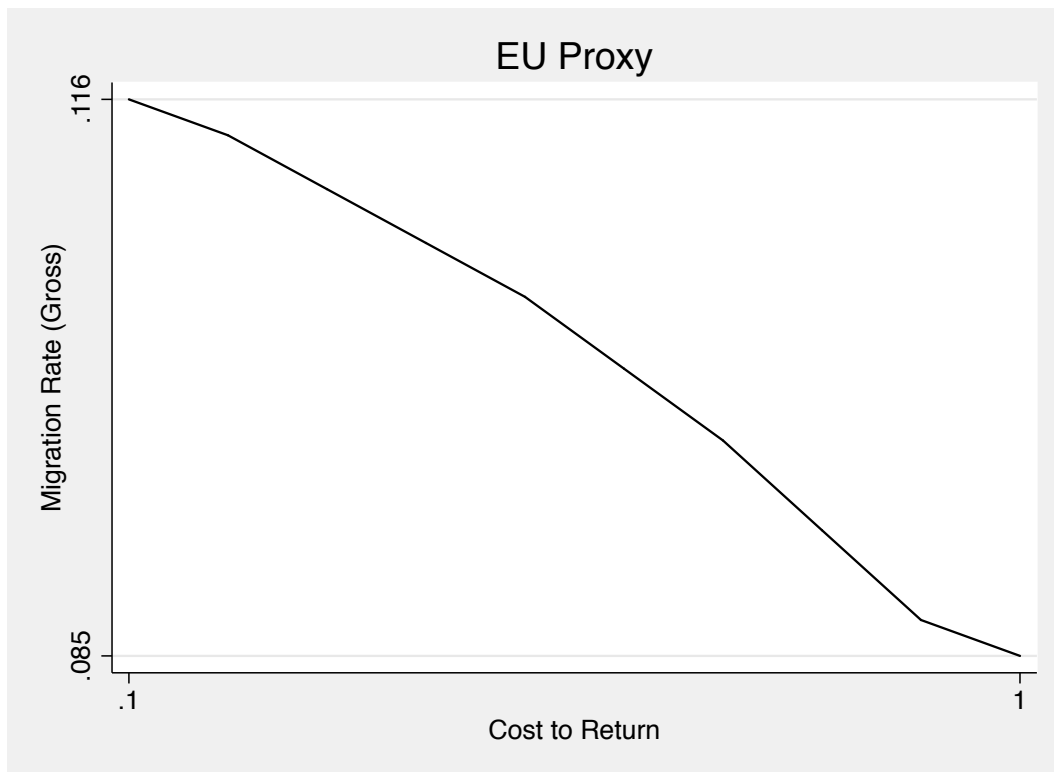
Leave Costs Only



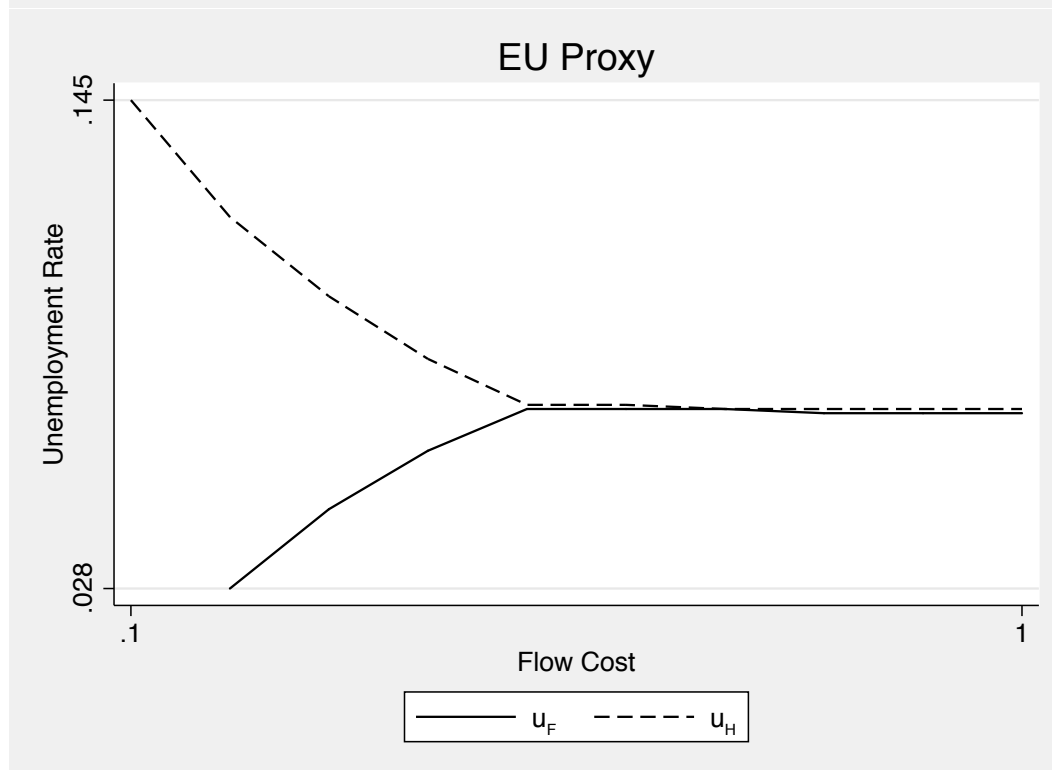
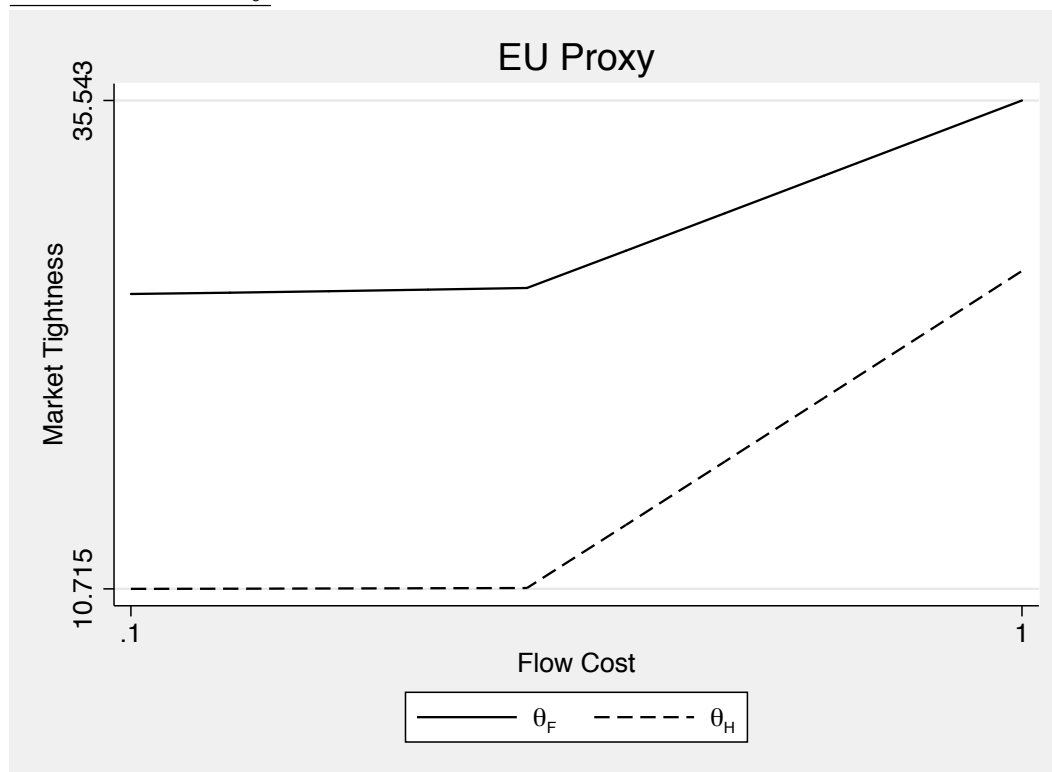


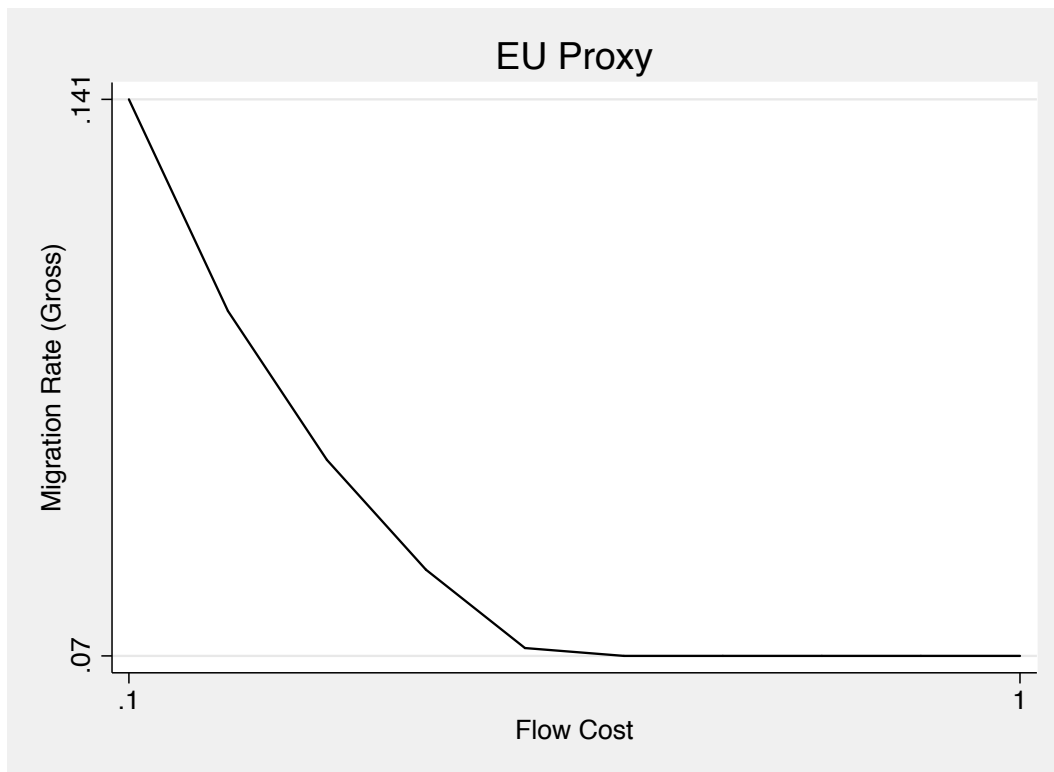
Return Costs Only



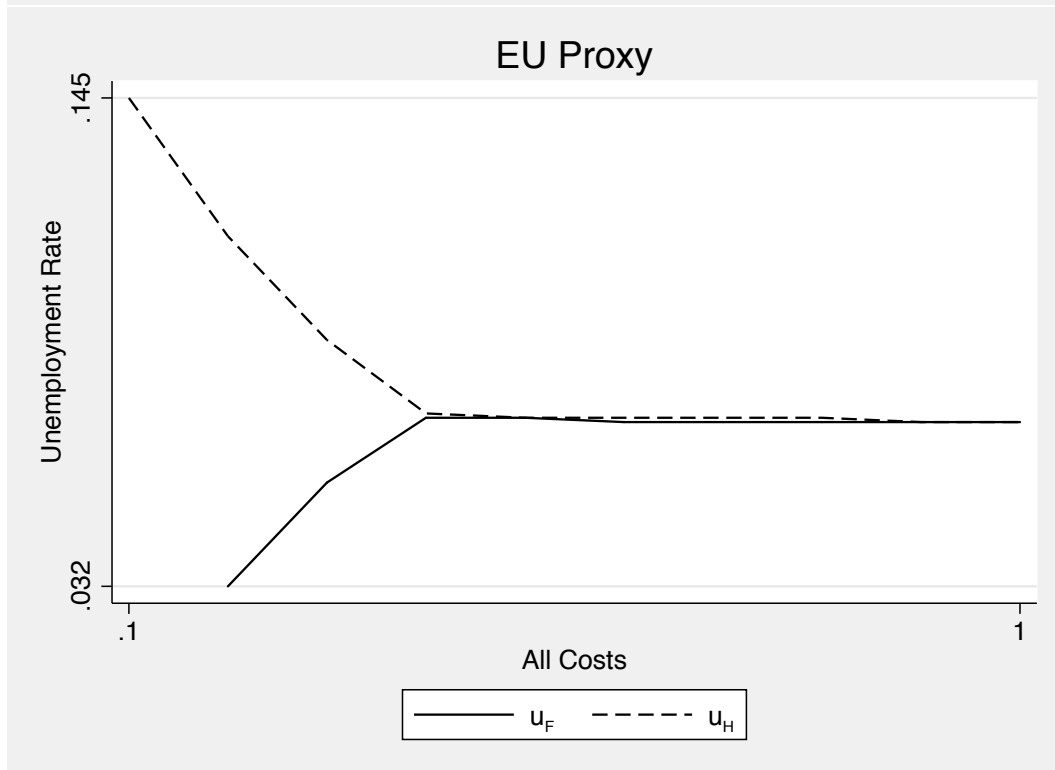
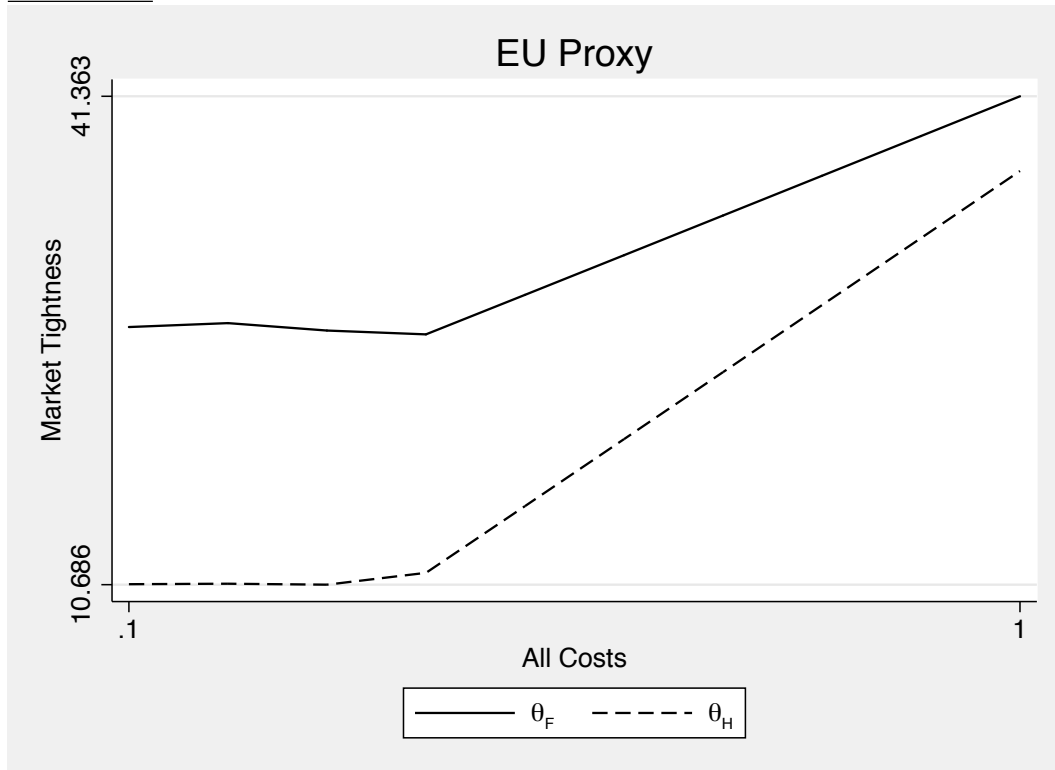


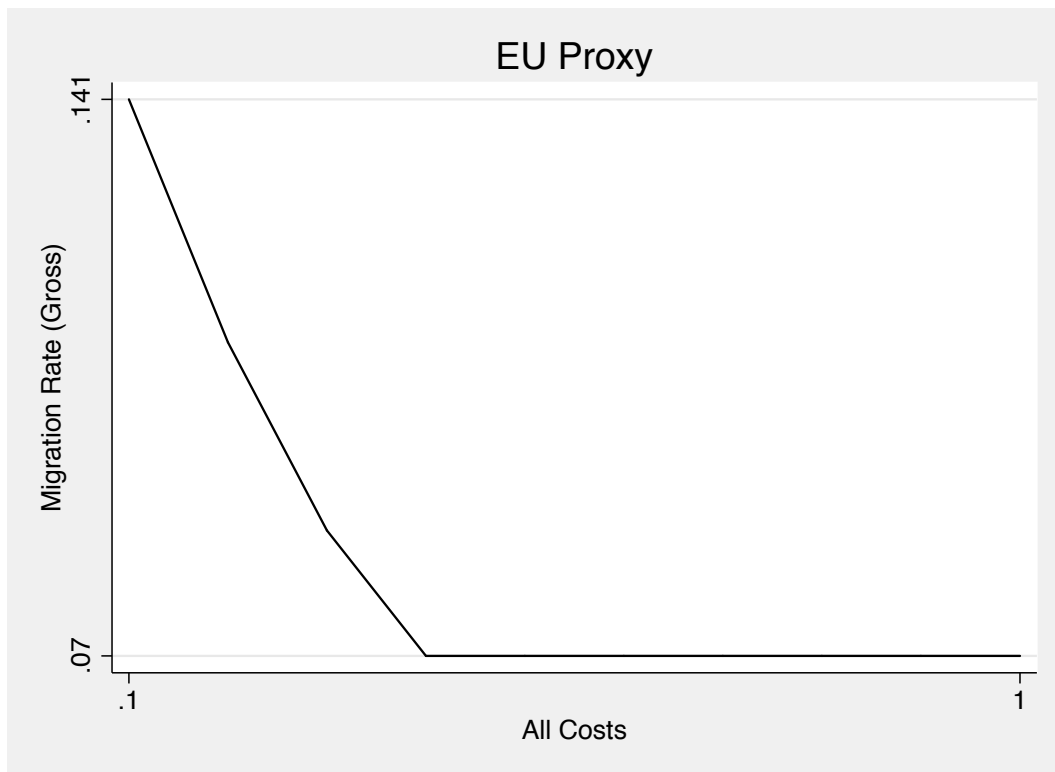
Flow Costs Only



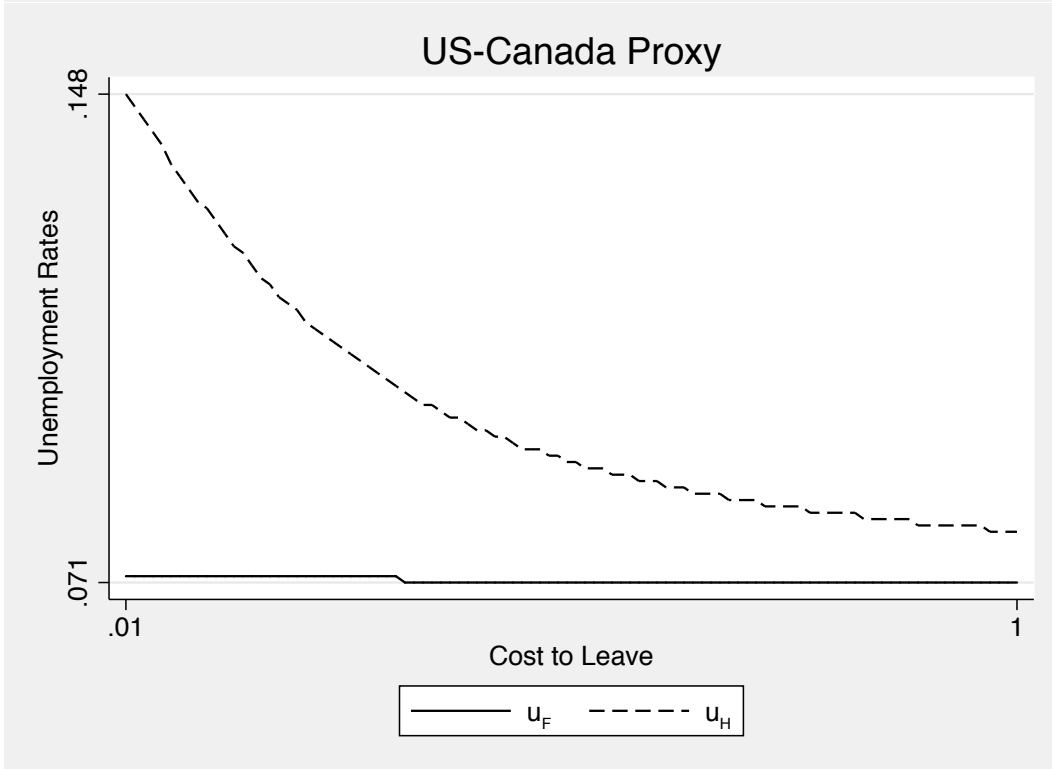
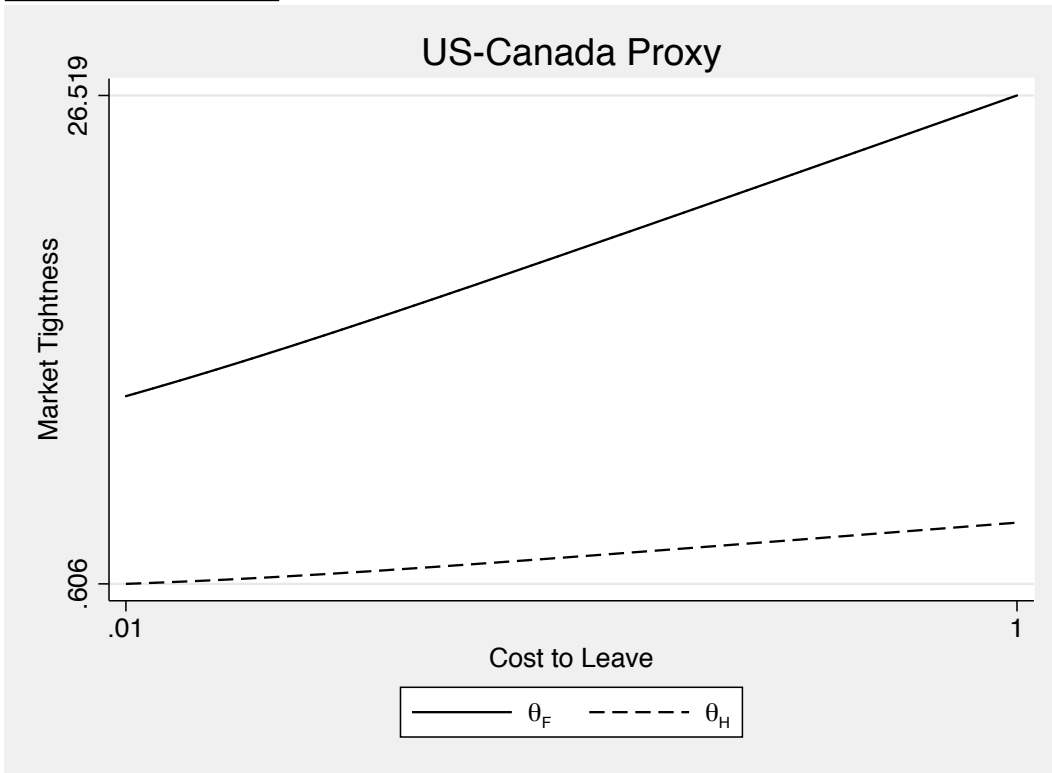


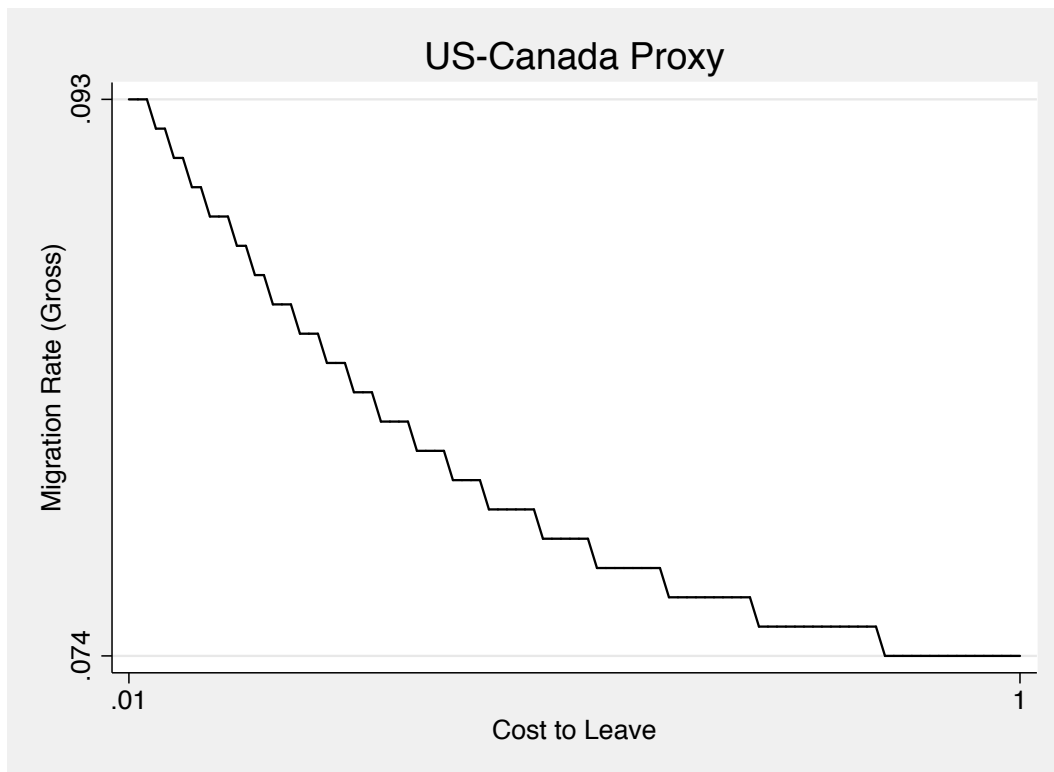
All Costs



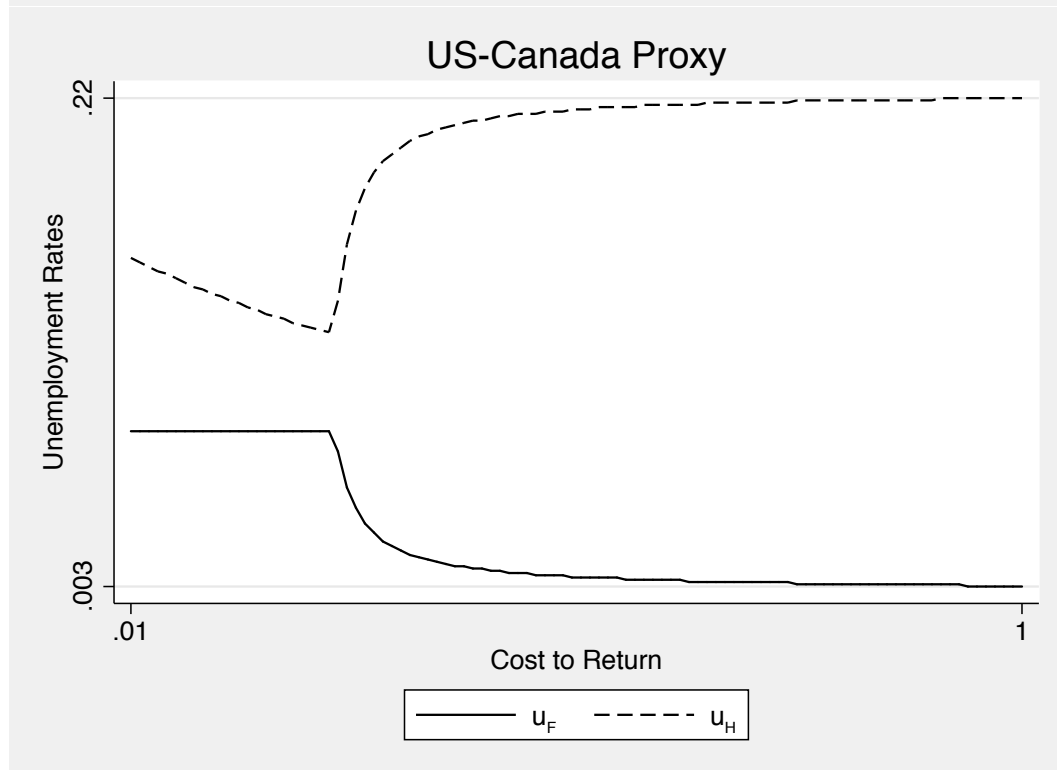
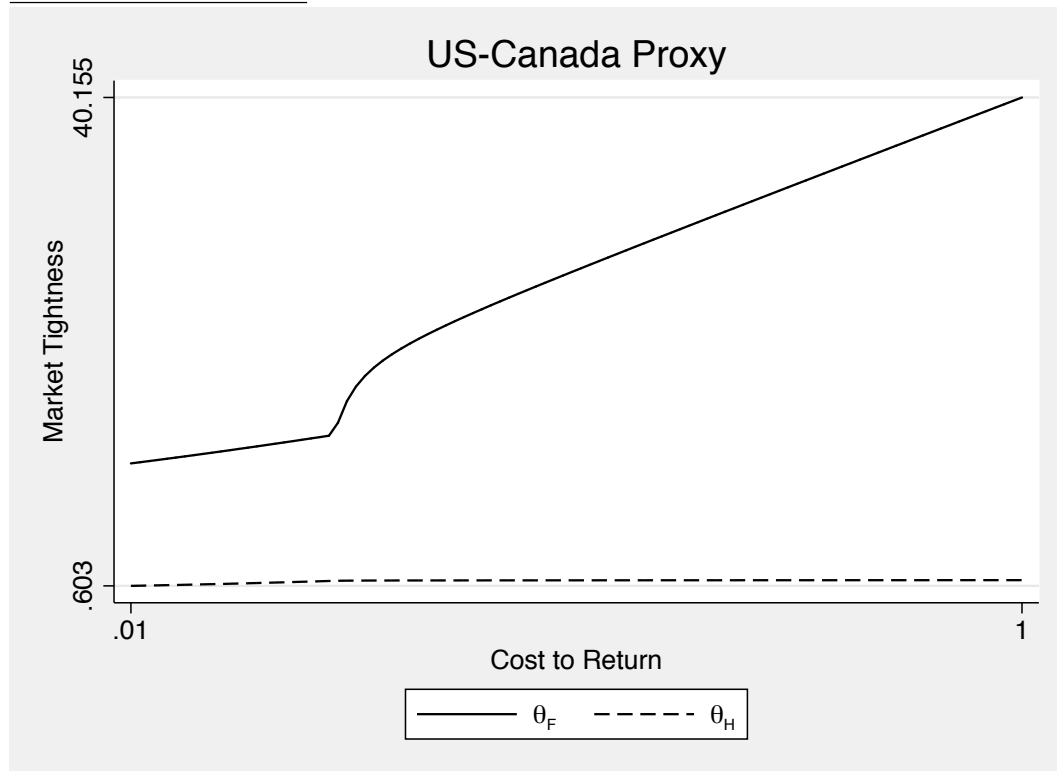


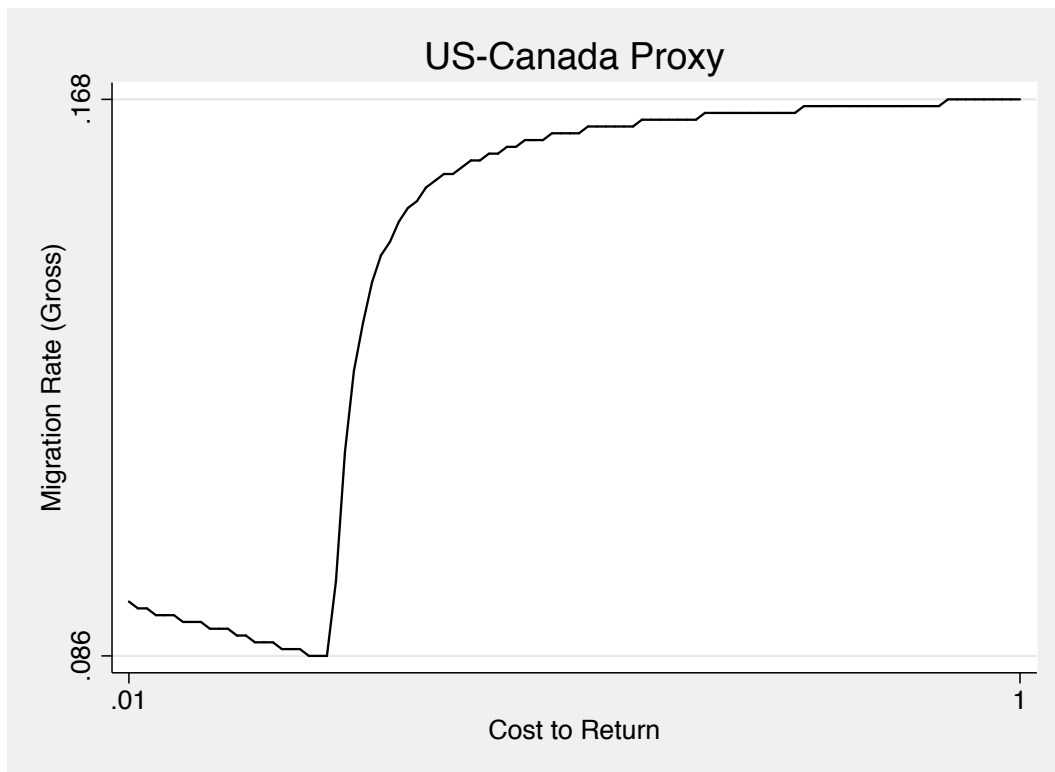
Leave Costs Only



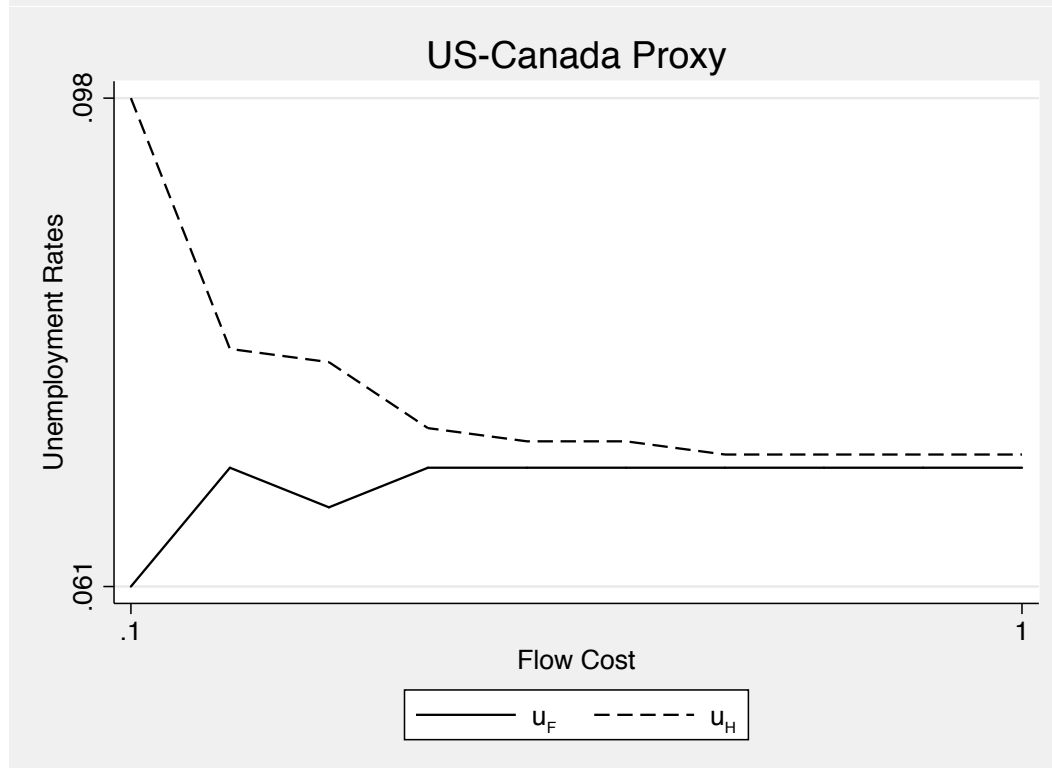
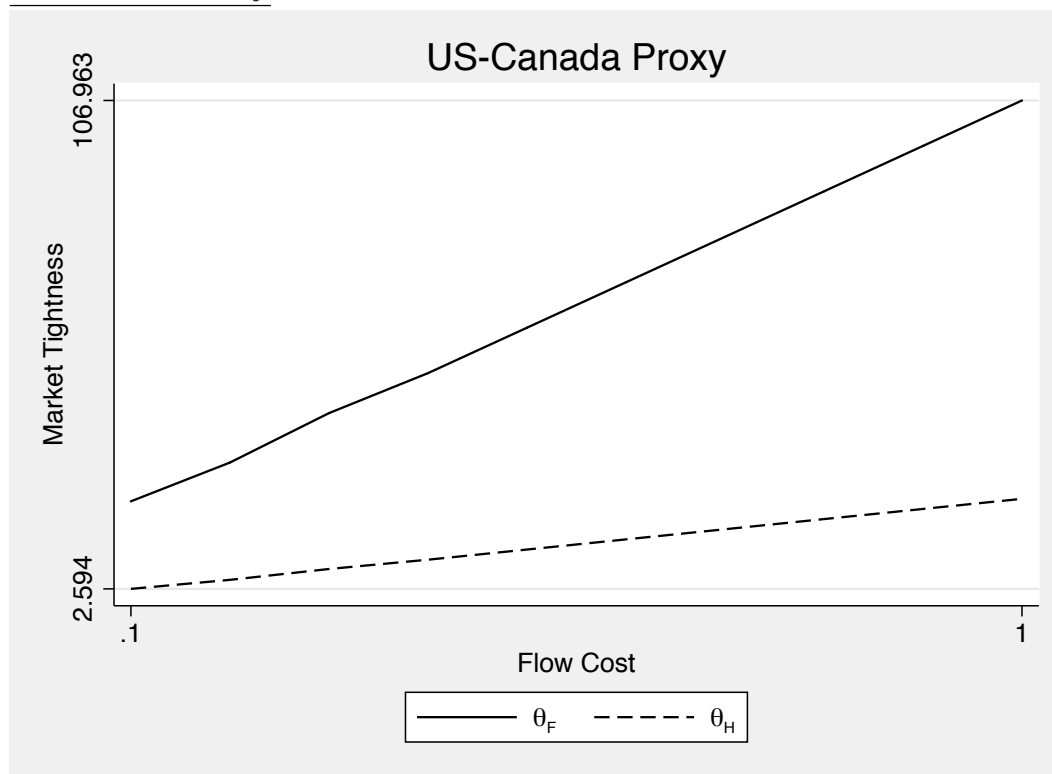


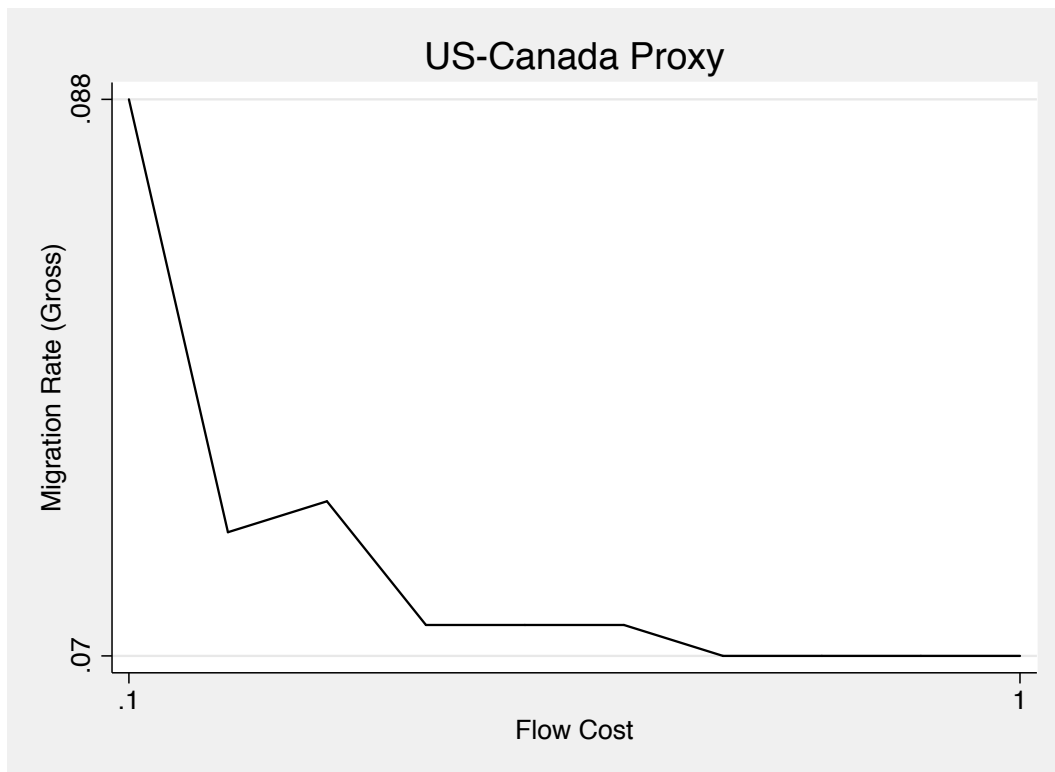
Return Costs Only



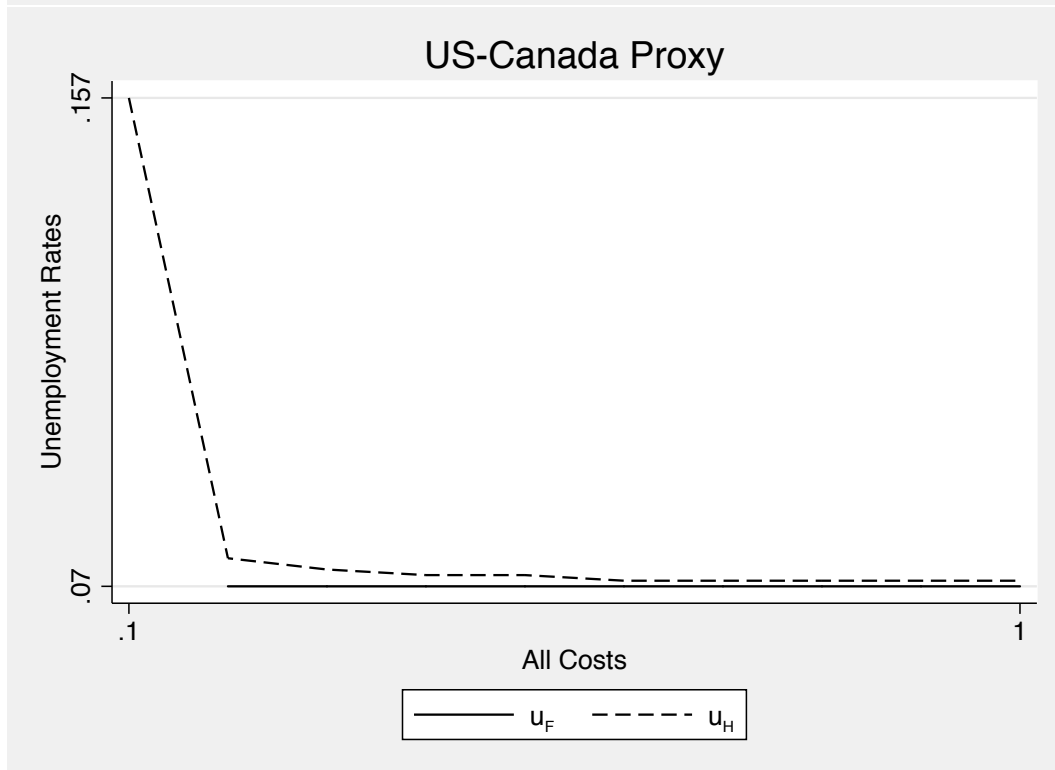
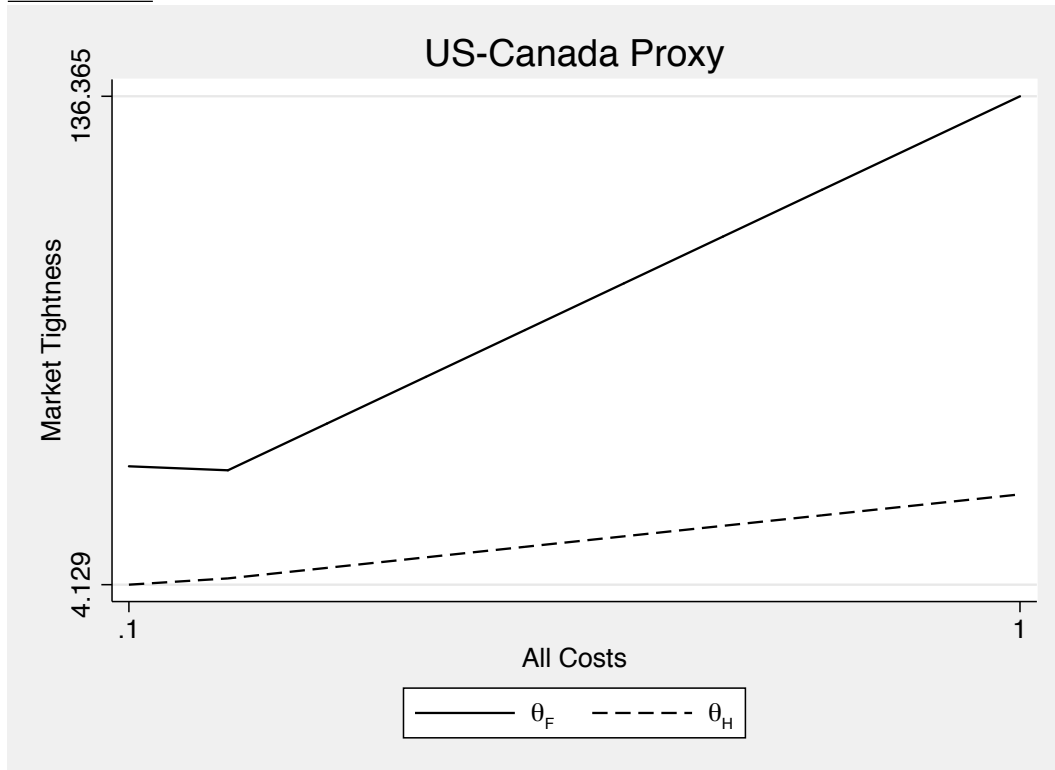


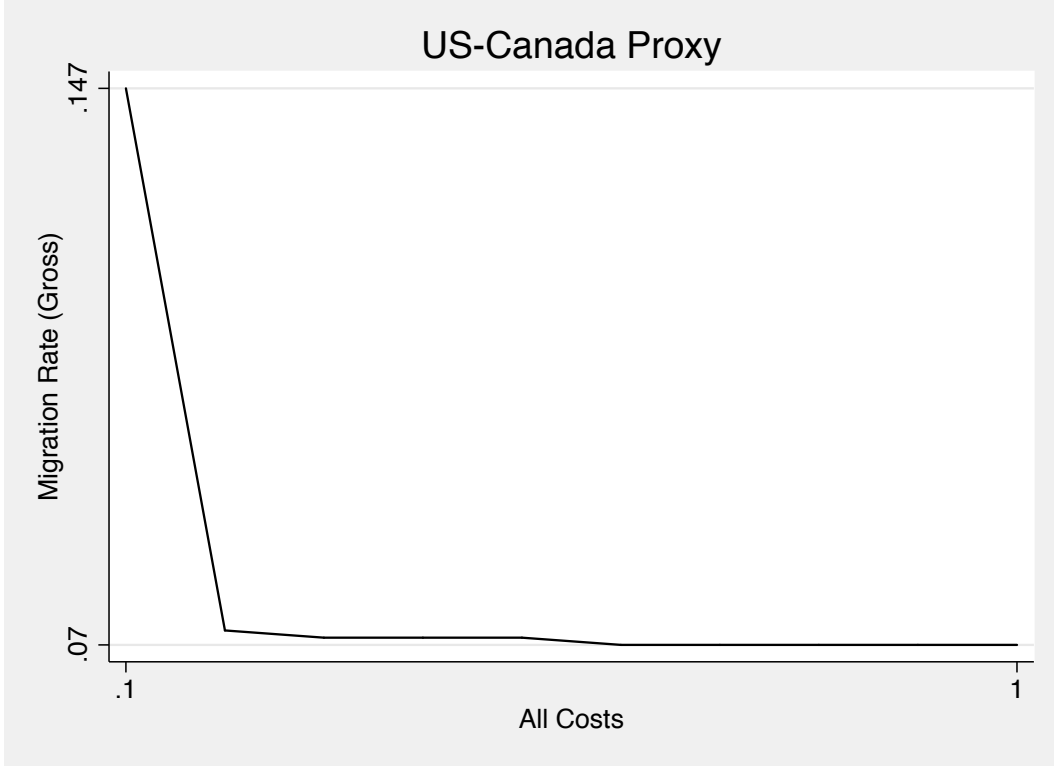
Flow Costs Only





All Costs





Wages:

$$w_{FF}^F = -((b_F(-1 + \beta_F)(\delta + r) + \beta_F(\delta + r + q_F\theta_F)(c_F - y_F))/(\delta + r + \beta_F q_F\theta_F))$$

$$w_{FF}^H = (((-1 + \beta_H)\delta q_H\theta_H(-b_H(\delta + r) + \beta_H c_H q_H\theta_H + \tau_{FH}(\delta + r + q_H\theta_H) - \beta_H q_H\theta_H y_H))/(\delta + r + \beta_H q_H\theta_H) + (\delta + r)(-(1 - \beta_H)r(-b_F + q_H\theta_H(\tau_{FH}/(\delta + r) + \phi_{FH})) + \beta_H(r + q_H\theta_H)(-c_H + y_H)))/(r(\delta + r) + q_H(\delta + \beta_H r)\theta_H)$$

$$w_{FH}^F = -(((-1 + \beta_F)b_H r(\delta + r)(\delta + r + \beta_F q_F\theta_F) + (\delta + r)(-b_F\delta q_F\theta_F + r(\delta + r)(\tau_{FH} + q_F\theta_F\phi_{FH})) - \beta_F^2 q_F r\theta_F(-c_F(\delta + r + q_F\theta_F) + (\delta + r)(\tau_{FH} + q_F\theta_F\phi_{FH}) + (\delta + r + q_F\theta_F)y_F) + \beta_F(b_F\delta q_F(\delta + r)\theta_F + c_F(\delta + r + q_F\theta_F)(r(\delta + r) + \delta q_F\theta_F) - r(\delta + r)(\delta + r - q_F\theta_F)(\tau_{FH} + q_F\theta_F\phi_{FH}) - (\delta + r + q_F\theta_F)(r(\delta + r) + \delta q_F\theta_F)y_F))/((\delta + r + \beta_F q_F\theta_F)(r(\delta + r) + q_F(\delta + \beta_F r)\theta_F)))$$

$$w_{FH}^H = (-b_H(-1 + \beta_H)(\delta + r) + (\delta + r + q_H\theta_H)(-\tau_{FH} + \beta_H(-c_H + \tau_{FH} + y_H)))/(\delta + r + \beta_H q_H\theta_H)$$

$$w_{HF}^F = (-b_F(-1 + \beta_F)(\delta + r) + (\delta + r + q_F\theta_F)(-\tau_{HF} + \beta_F(-c_F + \tau_{HF} + y_F)))/(\delta + r + \beta_F q_F\theta_F)$$

$$w_{HF}^H = (((-1 + \beta_H)\delta q_H\theta_H(-b_H(\delta + r) + \beta_H q_H\theta_H(c_H - y_H)))/(\delta + r + \beta_H q_H\theta_H) + (\delta + r)(-(-1 + \beta_H)r(b_F - \tau_{HF} - q_H\theta_H\phi_{HF}) + \beta_H(r + q_H\theta_H)(-c_H + y_H)))/(r(\delta + r) + q_H(\delta + \beta_H r)\theta_H)$$

$$w_{HH}^F = (((-1 + \beta_F)\delta q_F\theta_F(-b_F(\delta + r) + (\delta + r + q_F\theta_F)\tau_{HF} + \beta_F q_F\theta_F(c_F - y_F)))/(\delta + r +$$

$$\beta_F q_F \theta_F) - (\delta + r)(-(1 - \beta_F)r(b_H - (q_F \theta_F \tau_{HF})/(\delta + r)) + \beta_F(r + q_F \theta_F)(c_F - y_F)))/(r(\delta + r) + q_F(\delta + \beta_F r)\theta_F)$$

$$w_{HH}^H = -((b_H(-1 + \beta_H)(\delta + r) + \beta_H(\delta + r + q_H \theta_H)(c_H - y_H))/(\delta + r + \beta_H q_H \theta_H))$$