How do migration policies impact migration flows? Income and substitution effects in a RUM model with budget constraint

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Abstract

How does the migration policy of one potential destination country affect migration flows to that country, and to other destination countries? When a country tightens its immigration policy regime, the cost to migrate to that destination becomes more expensive. Thus, some individuals who would have migrated to that country, either remain in their origin country or choose another destination. Potential migrants are subject to the classic income and substitution effects: emigration towards the country tightening its migration policy should decrease, whereas emigration towards other destinations (including the origin country) should increase. To the best of our knowledge, available theoretical models do not consider the effect of the budget constraint on migration decisions. This paper intends to fill this gap. We develop a RUM model of migration, in which we introduce the role of the budget constraint in the migration decision. We find that the migration rate between two countries depends on the attributes of both origin and destination countries, the bilateral migration cost, and a budget constraint effect. The latter effect depends on other alternative countries. Thus, multilateral resistance to migration arises. We propose a simulation of our model based on 12 European countries on the year 2006. Using a descent gradient learning algorithm, we are able to confirm the existence of a budget constraint effect on migration decisions.

Key words – Migration, Budget constraint, Public policy, RUM
JEL classification – C63, F22, J61, O15

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1 Introduction

The United Nations Population Division (UNPD) estimates, from national population censuses, that the international stock of foreign-born individuals represented about 3.23% of the world population in 2013. Based on the latter United Nations (UN) data, Lackzo and Appave (2014) estimate that in 2010, about 35% of international migration took place along the South-North axis, 34% along the South-South axis, 25% along the North-North axis, and 6% along the North-South axis. One may wonder why the wealthiest economies do not attract a larger share of immigrants from developing countries.

This may be explained by the fact that, as many studies have shown, there is a high discrepancy between migration intentions and migration decisions, due to financial constraints: many people would like to migrate but cannot afford the migration cost. These costs arise from various sources: official fees for documents and clearances, payments to intermediaries, travel expenses, payments of bribes, etc. (UNDP, 2009). In their extensive study on the determinants of world migration, Hatton and Williamson (2002) have shown that potential migrants may be constrained by their poverty. Similarly, in a theoretical and empirical contribution based on Gallup World Poll data, Dustmann and Okatenko (2014) show that when the credit constraint is binding (which is the case in Sub-Saharan Africa and in Asia), migration decisions increase with income; in the opposite case (in Latin America for instance), migration decisions are not much affected by wealth. Several empirical analysis focusing on different countries confirm the fact that budget constraints are binding in terms of international migration flows from developing countries; it seems to be the case in Bangladesh (Mendola, 2008), Mexico (McKenzie and Rapoport, 2007, 2010; Angelucci, 2013), and El Salvador (Halliday, 2006) but not in Norway (Abramitzky et al., 2013).

Thus, migration decisions are determined not only by the preferences of the individual and by the characteristics of origin and destination countries *e.g.* in terms of income and wealth differentials, but also by the capacity of individuals to afford their migration. The individual budget constraint is determined by the income of the potential migrant on the one hand, and by the bilateral migration cost on the other hand. The migration cost depends on geographical variables (the distance between the origin and the destination countries, the existence of a common border...), cultural variables (the existence of a common language or a common religion, colonial ties...), the size of the diaspora, and institutional variables such as general and bilateral migration policies.

The budget constraint may be relaxed either when the financing capacity of the individual increases – the individual can get richer, save or borrow money through the banking system of his origin country or through familial relationships and migrant networks – or when the migration cost decreases – when a country loosens its immigration policy or when the diaspora gets larger for instance.

In this study, we address the following question: how does the migration policy of one potential destination country affect migration flows to that country, and to other destination countries? A change in the migration policy of a potential destination implies either a contraction or a relaxation of the budget constraint of would-be migrants. For instance, if this potential destination tightens its immigration policy regime, that destination may become too expensive for some individuals who would either remain in their origin country or choose another destination. These changes in the migration decision can be related to income and substitution effects. Indeed, when a country tightens its immigration policy, it increases the *price* of migrating to that country. Potential migrants are thus subject to the classic income and substitution effects: for a *sufficient* price increase, emigration towards the country tightening its migration policy should decrease, whereas emigration towards other destinations (including the origin country) should increase.

Recent contributions make use of the Random Utility Maximisation (RUM) framework to model the individual migration decision[1]. In this framework, an individual selects his destination country in order to maximise his utility across all potential destinations, including his home country. His utility is made of a deterministic component that the researcher can estimate and an error term. The deterministic component includes variables which are identical across individuals such as the expected wage or the bilateral migration cost. The error term consists in a random variable which accounts for unobserved heterogeneity among individuals, such as preferences over destination countries. The number of potential destinations is the same across individuals and includes any country open to immigration.

In this paper, we develop a RUM model of migration, in which we explicitly introduce the role of the budget constraint in the migration decision. Our model consists in a multi-country framework with individuals who are heterogeneous in terms of wages and preferences over destination countries. Bilateral migration costs depend on the migration policy of the destination country. As in standard RUM models, individuals choose their migration destination in order to maximise their utility across all possible destinations, including their home country. However, only individuals who can afford the migration cost to a potential destination country are able to migrate to that country. Once we analytically solve the model, we find that the migration rate between two countries depends on the attributes of both origin and destination countries, the bilateral migration cost, and a budget constraint effect. Interestingly, the latter effect depends on attributes of alternative destination countries. Thus, *multilateral resistance to migration* arises when introducing the budget constraint in the standard RUM model.

We propose a numerical experiment in order to derive some insights from our RUM model. We simulate the bilateral migration rates between 12 European countries on the year 2006. We obtain 144 simulated bilateral migration rates. Using a descent gradient learning algorithm, we parametrize our model in order to minimise the squared distance between the *simulated* rates and the *observed* rates we obtained from the UN population division. We then look at the changes induced by a loosening of the immigration policy of one country, on migration flows toward that country and toward other destinations. Our numerical experiment confirms the importance of multilateral resistance to migration, in line with the studies of Bertoli and Fernández-Huertas Moraga (2013) and Bertoli et al. (2013).

The rest of the paper is organised as follows. In section 3 we present a RUM model of migration in which we introduce a budget constraint. In section 4 we present the numerical experiment and the results. Section 5 concludes.

[1]RUM models find their origin in the income maximisation framework of Roy (1951), and discrete choice models in particular logit type models developed by McFadden (1974, 1984). They have been introduced in the economics of migration by Borjas (1987, 1999) to study the determinants of migration flows. His work forms the basis for a recent body of theoretical and empirical studies of migration, among others see Grogger and Hanson (2011); Beine et al. (2015).

2 State of the art

In their papers, Beine et al. (2015) review the theoretical foundation of the gravity model of international migration (the RUM model) and the main challenges arising when bringing the RUM model to the data. In particular, they mention that multilateral resistance to migration may arise either from the assumption made by the econometrician on the error term defined in the utility function (Bertoli and Fernández-Huertas Moraga, 2013), or from explicitly accounting for the sequential nature of migration decisions in the RUM model (Bertoli et al., 2013).

In their study, Bertoli and Fernández-Huertas Moraga (2013) use a nested logit model, which allows them to relax the independence from irrelevant alternatives (IIA) assumption imposed by a logit model usually used in standard RUM models. Their framework allows them to show that the bilateral migration rate between two countries does not only depend on their relative attractiveness, but also on the one of alternative destinations. Using the CCEMG[2] estimator with high-frequency data on Spanish immigration over the period 1997-2009, they find that neglecting such multilateral resistance to migration biases downward the estimated effect of GDP at origin and upward the estimated effect of visa policies upon migration flows to Spain.

Bertoli et al. (2013) propose a sequential RUM model of migration. In their model, the bilateral migration rate between two countries depends on the present attractiveness of the two countries, the future attractiveness of alternative destinations, and the whole structure of time-invariant bilateral migration costs. The authors use migration data from the countries of the European Economic Association toward Germany over the period 2006-2012. They show that the European crisis diverted migration flows away from countries in difficulties toward Germany. Making use of the CCEMG estimator, they find that variations in the unemployment rate at origin positively influences bilateral migration toward Germany, and note that this effect is overestimated by standard specifications which do not control for the presence of multilateral resistance to migration.

To the best of our knowledge, these are the only two papers dealing with the multilateral resistance to migration. Our paper contributes to this emerging literature, by showing that multilateral resistance to migration also arises when considering the effect of the budget constraint on migration decisions.

An empirical literature asserts the role of credit constraints on migration decisions (by assuming that the bilateral migration cost is negatively correlated with the income of the origin country) (Beine et al., 2015), but no RUM model, to the best of our knowledge, proposes to explicitly take into account the role of the budget constraint on migration decisions. Our paper intends to fill this gap.

3 A RUM model of migration with budget constraint

In this section, we model the migration decision of an individual i considering P possible destinations, including his country of actual residence, country k. Following the literature on migration decisions, we start from a standard RUM model of migration, in which we introduce the budget constraint faced by potential migrants.

[2]Common Correlated Effects Mean Group

To decide whether or not he wants to migrate and where, individual i maximizes his utility at time $t+1$ subject to his budget constraint. An individual who decides to migrate at time $t+1$ must pay the migration cost at time t.

Following Beine et al. (2015), his utility of migrating from country k to country k' at time $t+1$ is:

$$U_{i,t+1}^{kk'} = W_{t+1}^{kk'} - C_t^{kk'} + \epsilon_{i,t+1}^{kk'} \tag{1}$$

where $W_{t+1}^{kk'}$ represents a deterministic component of utility in country k' at time $t+1$ (for instance including the average wage and amenities)[3], $C_t^{kk'}$ is the deterministic bilateral migration cost paid at time t (with $C_t^{kk} = 0$), and $\epsilon_{i,t}^{kk'}$ is an individual-specific stochastic term. The utility net of the bilateral migration cost, $C_t^{kk'}$, is given by: $V_{i,t+1}^{kk'} \equiv W_{t+1}^{kk'} + \epsilon_{i,t+1}^{kk'}$.

As standard in the migration literature, we assume that $\epsilon_{i,t}^{kk'}$ is independent and identically distributed (iid.) over individuals and destinations, and follows a univariate Extreme Value Type-1 distribution with a scale parameter τ. Assuming that the ϵ's are iid. imposes the IIA assumption. This assumption implies that the probability ratio of individuals choosing between two alternatives does not depend on the availability of other alternatives. In other words, it implies a proportional substitution across alternative destinations.

Individual i *intends* to migrate to country h if this destination maximises his utility:

$$\arg\max_{l=1\ldots P} U_{i,t+1}^{kl} = h$$

3.1 A standard RUM model without budget constraint

In standard RUM models, following the results of McFadden (1974, 1984), the unconditional probability that an individual relocates from country k at time t to destination k' at time $t+1$, is given by:

$$p_{t+1}^{kk'} = \Pr\left(U_{i,t+1}^{kk'} = \max_{l=1}^{P} U_{i,t+1}^{kl}\right) = \frac{e^{\left[W_{t+1}^{kk'} - C_t^{kk'}\right]/\tau}}{\sum_{q=1}^{P} e^{\left[W_{t+1}^{kq} - C_t^{kq}\right]/\tau}}$$

Calculations are presented in Appendix A.1.

Similarly, the unconditional probability that an individual remains in country k at time $t+1$, is given by:

$$p_{t+1}^{kk} = \Pr\left(U_{i,t+1}^{kk} = \max_{l=1}^{P} U_{i,t+1}^{kl}\right) = \frac{e^{\left[W_{t+1}^{kk}\right]/\tau}}{\sum_{q=1}^{P} e^{\left[W_{t+1}^{kq} - C_t^{kq}\right]/\tau}}$$

The bilateral migration rate is given by the ratio of these two probabilities:

$$M_{t+1}^{kk'} = \left(\frac{e^{\left[W_{t+1}^{kk'} - W_{t+1}^{kk}\right]}}{e^{\left[C_t^{kk'}\right]}}\right)^{1/\tau}$$

Assuming that the scale parameter of the error term distribution equals unity ($\tau = 1$), we can re-write the bilateral migration rate:

$$M_{t+1}^{kk'} = \frac{e^{\left[W_{t+1}^{kk'} - W_{t+1}^{kk}\right]}}{e^{\left[C_t^{kk'}\right]}} \tag{2}$$

[3] We assume a myopic individual making a repeated migration choice at each period of his life-time (Beine et al., 2015).

As underlined by Beine et al. (2015), this migration rate depends only on the characteristics of the origin and the destination countries, and the bilateral migration rate. This is representative of the independence from irrelevant alternatives property: any changes in the attractiveness or accessibility of other destinations will not affect the bilateral migration rate from k to k'.

3.2 A RUM model with budget constraint

However, there is a high discrepancy between migration intentions and migration decisions. This is partly explained by the fact that individuals are financially constrained. Let now assume that individual i faces a liquidity constraint: he will be able to reach his favourite destination only if he can afford the migration cost. Due to financial constraints (caused by an underdeveloped banking system for instance), we assume that individuals cannot borrow, thus they can only afford destinations for which the bilateral migration cost is lower than their income. In other words, individual i *decides* to migrate to country h if and only if: $w_{i,t}^k > C_t^{kh}$ where $w_{i,t}^k$ denotes the income of individual i in country k at time t.

We assume that the income of individual i located in country k at time t $\left(w_{i,t}^k\right)$ follows a distribution φ with parameters μ_t^k and σ_t^k. The corresponding cumulative distribution function is denoted by Φ. Thereby:

$$\Phi\left(C_t^{kk'}\right) = \Pr\left(w_{i,t}^k < C_t^{kk'}\right)$$

The probability that the individual has the capacity to pay the cost to migrate from country k to destination k' is denoted by: $1 - \Phi\left(C_t^{kk'}\right) = \Pr\left(w_{i,t}^k \geq C_t^{kk'}\right)$. Note that the distribution of wages at time t is observed by the researcher.

Figure 1 represents the decision tree of an individual i. The sequence of decisions goes like this at each time period:

- At first, Nature attributes a wage to the individual i located in country k at time t: $w_{i,t}^k$.
- Individual i is able to rank the potential destinations (his current country of residence included) from the worst to the best utility-maximising destination. The individual chooses his destination in order to maximise his utility. h denotes the first-best of the individual, such that:

  $$\arg\max_{k'=1}^{P} U_{i,t+1}^{kk'} = h$$

  If $h = k$, he stays in his country because staying is the utility-maximising option. If $h \neq k$, the individual migrates to country h only if he can afford the bilateral migration cost: $w_{i,t}^k \geq C_t^{kh}$. In this last case, he pays the cost of his migration $\left(C_t^{kh}\right)$ and migrates to country h. If destination h is the utility-maximising option but is not affordable, the individual looks at his second-best destination, denoted h', such that:

  $$\arg\max_{\substack{k'=1 \\ k'\neq h}}^{P} U_{i,t+1}^{kk'} = h'$$

  The individual then checks if he can afford his second-best destination. If he can, he migrates to that destination. If not, he goes through the process all over again, until he finds the best affordable destination.

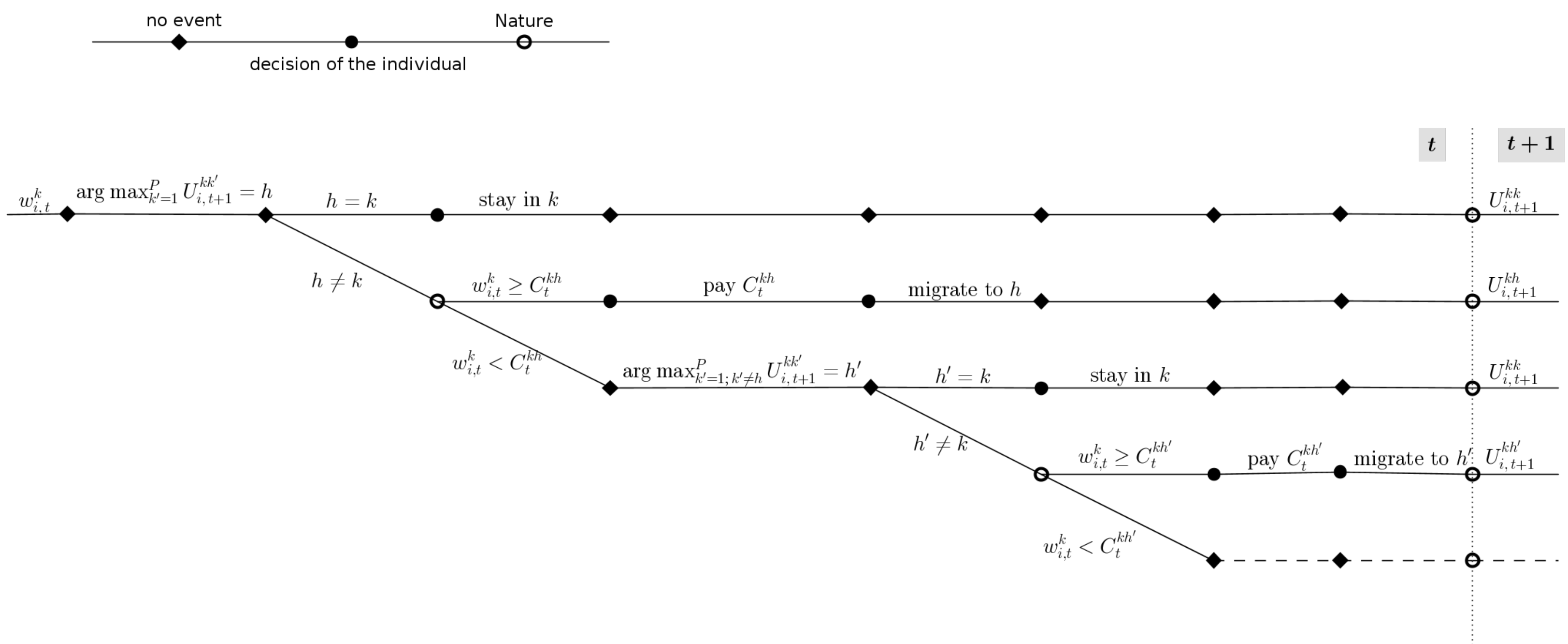

Figure 1: Decision tree of an individual i

- At the beginning of the next time period, individual i gets the utility corresponding to his country of residence. If he is located in country k, he gets: $U_{i,t+1}^{kk}$; if he is located in country h, he gets: $U_{i,t+1}^{kh}$, and so forth.

Taken into account the budget constraint has important consequences. Indeed, depending on their incomes, individuals do not face the same set of possible destinations. Simply said, very poor people cannot afford to migrate at all (although migrating to some destinations would probably enhance their utility), while rich people can probably afford almost all or all the destinations of the world. This variations in the set of affordable destinations is reflected in the expressions of the unconditional probability of migrating to any country. These probabilities and rates are denoted with the subscript BC when we take into account the Budget Constraint (BC).

Following the results of McFadden (1974, 1984), the unconditional probability that an individual relocates from country k at time t to destination k' at time $t+1$, taking into account the BC is given by:

$$p_{t+1,BC}^{kk'} = e^{\left[W_{t+1}^{kk'} - C_t^{kk'}\right]/\tau} \left[\sum_{l=k'}^{P} \frac{\Phi\left(C_t^{k(l+1)}\right) - \Phi\left(C_t^{kl}\right)}{\sum_{q=1}^{l} e^{\left[W_{t+1}^{kq} - C_t^{kq}\right]/\tau}}\right]$$

where $\Phi\left(C_t^{P+1}\right) = 1$. Calculations are presented in Appendix A.2.

Similarly, the unconditional probability of an individual i to stay in country k at time taking into account the BC, is given by:

$$p_{t+1,BC}^{kk} = e^{\left[W_{t+1}^{kk}\right]/\tau} \left[\sum_{l=k}^{P} \frac{\Phi\left(C_t^{k(l+1)}\right) - \Phi\left(C_t^{kl}\right)}{\sum_{q=1}^{l} e^{\left[W_{t+1}^{kq} - C_t^{kq}\right]/\tau}}\right]$$

Taking the ratio of the probability that individual i migrates to country k' over the probability that he does not migrate, we obtain the equilibrium bilateral migration rate between country k and country k' at time $t+1$:

$$\begin{aligned} M_{t+1,BC}^{kk'} &= \frac{\Pr\left(U_{i,t+1}^{kk'} = \max_{l=1}^{P} U_{i,t+1}^{kl}\right)}{\Pr\left(U_{i,t+1}^{kk} = \max_{l=1}^{P} U_{i,t+1}^{kl}\right)} \\ &= \frac{e^{\left[W_{t+1}^{kk'} - C_t^{kk'}\right]/\tau}}{e^{\left[W_{t+1}^{kk}\right]/\tau}} \frac{\left[\sum_{l=k'}^{P} \frac{\Phi\left(C_t^{k(l+1)}\right) - \Phi\left(C_t^{kl}\right)}{\sum_{q=1}^{l} e^{\left[W_{t+1}^{kq} - C_t^{kq}\right]/\tau}}\right]}{\left[\sum_{l=k}^{P} \frac{\Phi\left(C_t^{k(l+1)}\right) - \Phi\left(C_t^{kl}\right)}{\sum_{q=1}^{l} e^{\left[W_{t+1}^{kq} - C_t^{kq}\right]/\tau}}\right]} \end{aligned}$$

Assuming that the scale parameter of the error term distribution equals unity ($\tau = 1$), we can re-write the bilateral migration rate with BC:

$$\begin{aligned} M_{t+1,BC}^{kk'} &= \frac{e^{\left[W_{t+1}^{kk'} - W_{t+1}^{kk}\right]}}{e^{\left[C_t^{kk'}\right]}} \frac{\left[\sum_{l=k'}^{P} \frac{\Phi\left(C_t^{k(l+1)}\right) - \Phi\left(C_t^{kl}\right)}{\sum_{q=1}^{l} e^{\left[W_{t+1}^{kq} - C_t^{kq}\right]}}\right]}{\left[\sum_{l=k}^{P} \frac{\Phi\left(C_t^{k(l+1)}\right) - \Phi\left(C_t^{kl}\right)}{\sum_{q=1}^{l} e^{\left[W_{t+1}^{kq} - C_t^{kq}\right]}}\right]} \\ &= M_t^{kk'} f_t^{kk'} \end{aligned} \tag{3}$$

where $f_t^{kk'} = \frac{\left[\sum_{l=k'}^{P} \frac{\Phi\left(C_t^{k(l+1)}\right)-\Phi\left(C_t^{kl}\right)}{\sum_{q=1}^{l} e^{\left[W_{t+1}^{kq}-C_t^{kq}\right]}}\right]}{\left[\sum_{l=k}^{P} \frac{\Phi\left(C_t^{k(l+1)}\right)-\Phi\left(C_t^{kl}\right)}{\sum_{q=1}^{l} e^{\left[W_{t+1}^{kq}-C_t^{kq}\right]}}\right]}$ and denotes the budget constraint effect.

The migration rate with BC is equal to the migration rate without BC (equation 2) times a term summarizing the budget constraint effect, $f_t^{kk'}$. It depends on the income differential between the origin country and the destination country: $e^{\left[W_{t+1}^{kk'}-W_{t+1}^{kk}\right]}$, the influence exerted by the bilateral migration cost: $e^{\left[C_t^{kk'}\right]}$, and the budget constraint effect. In a standard RUM model without BC, the budget constraint term equals unity.

We can illustrate the difference between the two rates with a simple example. Imagine an individual i living in country k at time t and receiving the income $w_{i,t}^k$. He has the choice between staying in the same country or migrating to country h at time $t+1$. If he stays in country k, he gets utility $U_{i,t+1}^{kk} = V_{i,t+1}^{kk}$; if he migrates to country h, he gets utility $V_{i,t+1}^{kh}$ minus the bilateral migration cost C_t^{kh}. Assume that: $w_{i,t}^k < C_t^{kh} < V_{i,t+1}^{kh} - V_{i,t+1}^{kk}$. This implies that the individual intends to migrate to country h (since $V_{i,t+1}^{kk} < V_{i,t+1}^{kh} - C_t^{kk'}$) but cannot afford the migration cost (since $w_{i,t}^k < C_t^{kh}$). Thus, if the BC is not taken into account, this individual will be counted as a migrant; but if the BC is taken into account, he will not.

The term summarizing the budget constraint effect does not only depend on the attributes of country k and country k', but also on the attributes of other alternative destinations. Note that in a standard RUM model, the IIA assumption implies that the bilateral migration rate does not depend on other alternatives. Here, even if we assume that the individual-specific stochastic term $\epsilon_{i,t+1}^{kk'}$ follows an independent and identically distributed extreme value type 1 distribution, the bilateral migration rate depends on attributes of other alternative countries thanks to the introduction of the individual budget constraint in the modelling of the migration decision.

Thus, without relaxing the distributional assumptions on the stochastic component of utility and without explicitly accounting for the sequential nature of migration decisions as suggested by Beine et al. (2015), but simply by taking into account the BC, multilateral resistance to migration arises.

3.3 Comparative statics

The RUM model with BC allows us to determine the bilateral migration rate from one country to another. We have shown that this migration rate depends not only on the characteristics of the origin and destination countries and their relative accessibility, but also on the attractiveness and accessibility of other potential destinations. One question then arises: how does a change in the migration policy of one potential destination country affect migration flows to that country, and to other destination countries? In other words, what is the importance of the *multilateral resistance to migration* effect?

3.3.1 In a RUM model without budget constraint

The answer to that question is straightforward when the BC is not taken into account. If country k' tightens its immigration policy towards country k, the bilateral migration cost increases. Consequently, less individuals will find interesting to migrate toward country k' and the bilateral migrate rate from country k

to country k' will decrease. Indeed, from equation (2), we find that:

$$\frac{\partial M_{t+1}^{kk'}}{\partial C_t^{kk'}} = - M_{t+1}^{kk'} \leq 0$$

However, when country k' tightens its immigration policy towards country k, it will not affect the bilateral migration rate from country k to a third country j ($\neq k'$). From equation (2), we find that:

$$\frac{\partial M_{t+1}^{kj}}{\partial C_t^{kk'}} = 0 \ \forall j \neq k'$$

3.3.2 In a RUM model with budget constraint

However, the results are different when the BC is explicitly taken into account in the RUM model. If the bilateral migration rate from country k to country k' increases at the margin, then some people who would have migrated from country k to country k' before the increase may not intend to migrate any more to country k', some others may intend to migrate to country k' but not be able to afford this migration.

Let's go back to the previous example where an individual i had the choice between staying in country k or migrating to country h at time t. We assume that $C_t^{kh} < w_{i,t}^k < V_{i,t+1}^{kh} - V_{i,t+1}^{kk}$. Because migrating is the utility maximizing option and because the budget constraint is not binding, individual i intends and decides to migrate from country k to country h.

Assume now that the bilateral migration cost from country k to country h increases at the margin. In that case, there are three possibilities.

- First, if it increases such that the previous inequality remains unchanged ($C_t^{kh(1)} < w_{i,t}^k < V_{i,t+1}^{kh} - V_{i,t+1}^{kk}$), then this individual will still migrate from country k to country h. The marginal variation of the bilateral migration rate from country k to country h is the same when we consider a BC and when we consider no BC, $\frac{\partial M_{t+1,BC}^{kk'}}{\partial C_t^{kk'}} = \frac{\partial M_{t+1}^{kk'}}{\partial C_t^{kk'}}$.

- Second, if the bilateral migration cost increases such that $w_{i,t}^k < C_t^{kh(2)} < V_{i,t+1}^{kh} - V_{i,t+1}^{kk}$, then individual i intends to migrate from country k to country h (since $V_{i,t+1}^{kk} < V_{i,t+1}^{kh} - C_t^{kh(2)}$) but cannot afford this migration (since $w_{i,t}^k < C_t^{kh(2)}$); thus he will not migrate. In that case, the marginal variation of the bilateral migration rate from country k to country h is different when we consider a BC and when we consider no BC, $\frac{\partial M_{t+1,BC}^{kk'}}{\partial C_t^{kk'}} \neq \frac{\partial M_{t+1}^{kk'}}{\partial C_t^{kk'}}$.

- Third, if the bilateral migration cost increases so much that $w_{i,t}^k < V_{i,t+1}^{kh} - V_{i,t+1}^{kk} < C_t^{kh(3)}$, then individual i does not intend to migrate to country h any more as migrating is not the utility maximising option any more. The marginal variation of the bilateral migration rate from country k to country h is the same when we consider a BC and when we consider no BC, $\frac{\partial M_{t+1,BC}^{kk'}}{\partial C_t^{kk'}} = \frac{\partial M_{t+1}^{kk'}}{\partial C_t^{kk'}}$.

In the second and third cases, individual i changes his migration decision because of the increase in the bilateral migration cost from country k to country h. In the second case, h is still the most attractive destination but he cannot afford to reach that destination any more; in the third case, h is not an attractive destination any more.

Indeed, from equation (3), we get:

$$\frac{\partial M_{t+1,BC}^{kk'}}{\partial C_t^{kk'}} = -\, M_{t+1,BC}^{kk'} \left(1 - \frac{1}{f_t^{kk'}} \frac{\partial f_t^{kk'}}{\partial C_t^{kk'}}\right)$$

Calculations of the derivative of $\mathrm{M}_{t+1,BC}^{kk'}$ with respect to the bilateral migration cost are presented in Appendix section A.3. Intuitively, we expect that $\frac{\partial M_{t+1,BC}^{kk'}}{\partial C_t^{kk'}} \leq \frac{\partial M_{t+1}^{kk'}}{\partial C_t^{kk'}} \leq 0$. Without considering the budget constraint, a marginal change in the bilateral migration cost from country k to country k' reduces the corresponding bilateral migration rate because destination k' becomes unattractive for some individuals. But when we account for the budget constraint, the bilateral migration rate from country k to country k' should reduce even more because destination k' becomes unattractive for some individuals, and unaffordable for some others (for whom migrating to country k' is still the utility maximising option).

In the second and third cases, the question remains as to where this individual would go instead. In our example, he had only the choice between two countries. But if he had the choice between several countries, it may well be the case that instead of going to h, he decides to go to a third destination j that is affordable ($C_t^{kj} < w_{i,t}^k$), either because country j becomes more attractive than country h ($V_{t+1}^{kj} - C_t^{kj} > V_{i,t+1}^{kh} - C_t^{kh}$), or because country h has become unaffordable ($V_{t+1}^{kj} - C_t^{kj} < V_{i,t+1}^{kh} - C_t^{kh}$ and $C_t^{kj} < w_{i,t}^k < C_t^{kh}$).

Indeed, from equation (3), we get:

$$\frac{\partial M_{t+1,BC}^{kj}}{\partial C_t^{kk'}} = M_{t+1,BC}^{kj} \left(\frac{1}{f_t^{kj}} \frac{\partial f_t^{kj}}{\partial C_t^{kk'}}\right) \ \forall j \neq k'$$

Calculations of the derivative of $\mathrm{M}_{t+1,BC}^{kj}$ with respect to the bilateral migration cost are presented in Appendix section A.3. Intuitively, we expect that $\frac{\partial M_{t+1,BC}^{kj}}{\partial C_t^{kk'}} \geq 0 \, \forall j \neq k'$.

These changes in the migration decision can be related to income and substitution effects. Indeed, when a country tightens its immigration policy, it increases the *price* of migrating to that country. Potential migrants are thus subject to the classic income and substitution effects: for a *sufficient* price increase, emigration towards the country tightening its migration policy should decrease, whereas emigration towards other destinations (including the origin country) should increase.

Going back to our example, as long as the bilateral migration cost only slightly increases (case 1), the income effect is negligible and there is no substitution effect; individual i still migrates to country h. On the other hand, when the migration cost increases sufficiently (such that $w_{i,t}^k < C_t^{kh}$, case 2 and 3), the income effect is such that the individual substitutes migration to country j to migration to country h; here the income effect is very small and the substitution effect is large.

We see here that the IIA assumption does not hold any more: if country k' tightens its migration policy towards country k, this will affect the bilateral migration rate from country k to country j ($\neq k'$).

4 Numerical experiment

The analytic expression of the bilateral migration rate between any two countries (equation 3) cannot be estimated by a standard econometric approach, the effect of the budget constraint on migration decisions being unobserved. This unobserved factor is much likely to be correlated with some observable regressors, to be serially correlated, and to be spatially correlated across origin-destination dyads. In presence of such unobserved factor, one may use a multi-factor error structure and in particular the CCEMG estimator of Pesaran (2006), as Bertoli and Fernández-Huertas Moraga (2013) and Bertoli et al. (2013) suggest in their papers on the *static* and *dynamic* multilateral resistance to migration[4]. The latter estimator allows the unobserved term to be heteroskedastic, serially and spatially correlated, and correlated with other regressors.

In their papers, Bertoli and Fernández-Huertas Moraga (2013) and Bertoli et al. (2013) show that the results obtained with the CCEMG estimator differ from those obtained with standard econometric techniques which do not allow to control for the presence of unobserved factors (the multilateral resistance to migration for instance).

The CCEMG estimator requires balanced panel data on bilateral migration flows towards at least one destination country, from at least 30 origin countries and for at least 20 time periods. Yet, those high-frequency panel data on bilateral migration flows are poorly available. The quality of annual (or decennial) flow data is not sufficient enough to execute this estimator. Unfortunately, we have been unable to obtain a biannual or quarterly dataset which has not been exploited yet, to bring our RUM model with budget constraint to the data. There is not point, indeed, in using the same data than Bertoli and Fernández-Huertas Moraga (2013) or Bertoli et al. (2013), as we would find the same empirical results but propose another interpretation of it.

Thus, we propose a numerical experiment in order to derive some insights from our theoretical model. We use equation (3) to simulate the bilateral migration rate between several countries. We then look at the changes induced by a change in the migration policy of one country, on the immigration rate toward that country and toward other destination countries.

4.1 Specification

Let us re-write the utility of an individual i to migrate from country k to country k' at time $t+1$ (equation 1) as follows:

$$U_{i,t+1}^{kk'} = W_{t+1}^{kk'} \left(1 - \frac{C_t^{kk'}}{W_{t+1}^{kk'}}\right) + \epsilon_{i,t+1}^{kk'}$$

The bilateral migration cost is now a function of $W_{t+1}^{kk'}$ which represents a deterministic component of the utility in country k' at time $t+1$. Let consider that $W_{t+1}^{kk'}$ is akin to the average wage of individuals coming from country k in country k' at time $t+1$. Assume that this average wage is the same for all individuals, regardless of their origin country, such that $W_{t+1}^{kk'} \equiv W_{t+1}^{k'} \forall k$. Using data from the World Development Indicators of the World Bank, we approximate $W_{t+1}^{k'}$ by the GDP per capita[5] in country k' in 2006.

Thereby, we can specify the bilateral migration cost between country k and country k' at time t as follows:

$$C_t^{kk'} = W_{t+1}^{k'} \left[\theta_1 \, \text{dist}^{kk'} + \theta_2 \left(1 - \text{lang}^{kk'}\right) + \theta_3 \, \text{pol}_t^{k'}\right]$$

[4]See Beine et al. (2015) for a review of alternative econometric techniques, with their advantages and limitations.
[5]in purchasing power parity in constant 2011 international $

where $\text{dist}^{kk'}$ denotes the distance in kilometres (normalised between 0 and 1) between the most populated cities of country k and country k'. This dyadic variable comes from the CEPII GeoDist database (Mayer and Zignago, 2011). $\text{lang}^{kk'}$ denotes the probability that an individual from country k and an individual from country k' understand one another in some language. This variable comes from the CEPII Language database (Melitz and Toubal, 2012). Then, $\text{pol}_t^{k'}$ denotes the strictness of the migration policy implemented by the destination country at time t. This variable ranges from 0 to 1, the highest score representing the strictest regulation. This index comes from the Inventory of migration policies (1990-2005) of the fondazione Rodolfo Debenedetti (fRDB). This index is only available for 12 western European countries[6] and up to 2005, which is why we parametrize our model on these countries on the year 2006. Finally, θ_1, θ_2 and θ_3 are parameters to be determined.

To further specify the individual budget constraint ($w_{i,t}^k \geq C_t^{kk'}$), we need to determine the distribution of wages. Thus, we assume the wage of an individual i living in country k at time t follows a Log-Normal distribution such that:

$$w_{i,t}^k \rightsquigarrow \ln \mathcal{N}\left[\mu_t^k, \left(\sigma_t^k\right)^2\right] \;\; \forall\, i;\; \forall\, t$$

where μ_t^k denotes a country-specific scale such that the mean of the distribution is equal to the GDP per capita in 2005 in country k (W_t^k)[7], and where σ_t^k denotes a country-specific shape and approximates the level of inequalities in country k at time t. For the latter variable, we use the GINI coefficient of equivalised disposable income from Eurostat for the year 2005[8].

Using the Log-Normal cumulative distribution function of wages in country k, we can easily calculate the probability that an individual located in country k can afford the migration cost toward a destination k': $1 - \Phi\left(C_t^{kk'}\right) = \Pr\left(w_{i,t}^k \geq C_t^{kk'}\right)$.

We provide some descriptive statistics of the data presented here-before in Table 1. Note that the CEPII Language dataset presents only 132 observations because the probability that an individual from country k and an individual from country k' understand one another in some language when $k' = k$ is not considered in the original database. Yet, it does not impact our simulation as $C_t^{kk} \equiv 0$.

Variable	**Obs.**	**Mean**	**Std. Dev.**	**Min**	**Max**
W_t^k	144	36454.1	5443.917	25580.92	46080.85
W_{t+1}^k ($W_{t+1}^{k'}$)	144	37505.07	5643.579	25904.65	47318.41
$\text{dist}^{kk'}$	144	1348.764	771.8182	76.95715	3362.978
$\text{lang}^{kk'}$	132	.4470647	.2327627	.1366178	.993461
$\text{pol}_t^{k'}$	144	2.819167	.4431759	1.5	3.21
σ_t^k	144	.29975	.0420092	.239	.381

Table 1: Descriptive statistics

[6] Austria, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Netherlands, Portugal, Spain, and the United Kingdom.

[7] The scale parameter is calculated as such: $\mu_t^k = \ln\left(W_t^k\right) - \frac{1}{2}\left(\sigma_t^k\right)^2$

[8] Statistics on Income and Living Conditions, 16.02.2015 Revision.

4.2 A gradient descent learning algorithm

Our objective is to parametrize our model in order (i) to reproduced as well as possible real data, and (ii) to predict as well as possible data that are unobserved or missing because of statistical issues. To this end, we use a batch gradient descent Least Mean Squares learning algorithm. The latter algorithm allows us to preform a linear regression *i.e.* to iteratively minimise the squared distance between *observed* bilateral migration rates and *simulated* rates obtained from our RUM model with BC.

Let denote the observed bilateral migration rate between country k and country k' at time $t+1$ by $M_{t+1,obs}^{kk'}$. We approximate $M_{t+1,obs}^{kk'}$ by taking the ratio of the immigration flow from country k to country k' in 2006, over the population of country k in 2006 (which is a proxy for the number of individuals who decide to stay in country k). Population data come from the World Population Prospects (2012 Revision) of the UNPD. Immigration flows of foreign individuals by country of citizenship and destination country are not available for all studied country-pairs. When possible, we use data from the International Migration Flows to and from Selected Countries (2010 Revision) of the UNPD[9]. For Ireland and the United Kingdom, we use data from the International Migration Database of the OECD[10]. No immigration data is available on the year 2006 for Greece, even when searching for another criterion to define the migrant's origin country. Table 2 summarises bilateral immigration data. Over the 114 country-pairs studied, we can only calculate 67 observed bilateral migration rates.

We randomly divide our dataset of 67 observed rates in two sub-samples. The first one is the *training* set (90% of the observations) and is used to parametrize our model (to train our learning algorithm). The second one is a *testing* set and is used to verify whether our model, once parametrized, is a good predictor of real data (to evaluate the performance of our model)[11].

4.2.1 Training phase

The LMS algorithm allows us to find values for θ_1, θ_2 and θ_3 that minimise the following error function:

$$J(\theta) = \frac{1}{2}\sum_{n=1}^{N}\left(M_{t+1,BC}^{(n)} - M_{t+1,obs}^{(n)}\right)^2$$

where N is the number of training examples in our training set[12].

The batch gradient descent algorithm we use stars with random values of θ_1, θ_2 and θ_3 and iteratively updates the set of parameters toward values that minimize the function $J(\theta)$. This algorithm can be written as follows:

repeat until convergence{
$\theta_x \coloneqq \theta_x - \alpha\frac{\partial J(\theta)}{\partial \theta_x}\ \forall x = 1;2;3$
}

[9]http://esa.un.org/unmigration/MigrationFlows.aspx

[10]http://stats.oecd.org/Index.aspx?DataSetCode=MIG

[11]As a robustness test we intend to perform a cross validation. It consists in randomly partitioning our dataset into a training set and a testing set several times, in order to calculate the average cross-validation error as a performance indicator.

[12]A training example, indexed by n, is made of all variables needed to calculate $M_{t+1,BC}^{(n)}$ (described in sub-section 4.1) and a target value. For instance, the training example kk' if given by $\left(W_t^k; W_{t+1}^k; W_{t+1}^{k'}; \mathrm{dist}^{kk'}; \mathrm{lang}^{kk'}; \mathrm{pol}_t^{k'}; \sigma_t^k\ ;\ M_{t+1,obs}^{kk'}\right)$.

Destination country	Data source	Residency criterion	Available origin countries	Note
Austria	United Nations Population Division	more than 3 months	Germany, Denmark, Spain, Finland, the Netherlands	A zero indicates that the value is zero, not available or not applicable. Therefore, we replace zeros by missing values.
Denmark	United Nations Population Division	more than 6 months	Austria, Germany, Spain, Finland, the Netherlands	A zero indicates that the value is zero, not available or not applicable. Therefore, we replace zeros by missing values.
Finland	United Nations Population Division	more than 1 year	Austria, Germany, Denmark, Spain, the Netherlands	A zero indicates that the value is zero, not available or not applicable. Therefore, we replace zeros by missing values.
France	United Nations Population Division	more than 1 year	Austria, Germany, Denmark, Spain, Finland, Italy, the Netherlands, Portugal	
Germany	United Nations Population Division	no minimum duration	Austria, Denmark, Spain, Finland, Italy, the Netherlands, Portugal, the United Kingdom	
Greece	no data available			
Italy	United Nations Population Division	more than 1 year	Austria, Germany, Denmark, Spain, Finland, the Netherlands	
Ireland	OECD	no minimum duration	Austria, Germany, Denmark, Spain, Finland, the Netherlands	
The Netherlands	United Nations Population Division	other criterion	Austria, Germany, Denmark, Spain, Finland	
Portugal	United Nations Population Division	permanent	Austria, Germany, Denmark, Spain, Finland, the Netherlands	
Spain	United Nations Population Division	no minimum duration	Austria, Germany, Denmark, Finland, the Netherlands, Portugal	
The United Kingdom	OECD	more than 1 year	Austria, Germany, Denmark, Ireland, Spain, Finland, the Netherlands	

Table 2: Immigration flows of foreign individuals by country of citizenship and destination country, data availability for 2006

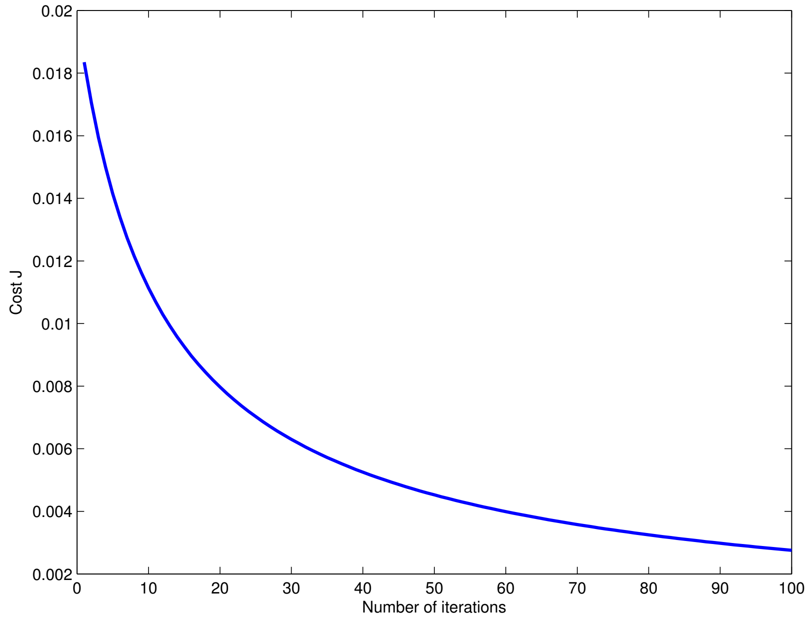

Figure 2: Squared error

where α denotes the learning rate, and where the sign $:=$ means that we *replace* θ_x by $\theta_x - \alpha\frac{\partial J(\theta)}{\partial \theta_x}$. Notice that the parameters update is done simultaneously at each iteration.

After training our algorithm on a set of 60 examples with a learning rate of $\alpha = 0.1$, we find the following values for our parameters: $\theta_1 = 1.192226$, $\theta_2 = 0.393312$ and $\theta_3 = 0.842484$. Figure 2 presents the evolution the squared error for each of the iteration performed. The error term gets closer to zero as the algorithm moves toward the minimum[13].

We present our simulated data in Appendix A.4 and some descriptive statistics on simulated and observed bilateral migration rates in Table 3.

Variable	0bs.	Mean	Std. Dev.	Min	Max
Population, 2006	144	30875.04	27706.23	4226.104	83740.3
Bilateral migration, 2006	67	3263.91	5423.465	33	20658
Bilateral migration rate, 2006	67	.00015	.0002971	1.67e-06	.0019606
Simulated bilatreal migration rate	144	.0901028	.2767702	6.86e-09	1
Simulated bilateral migration cost	144	5.313113	2.256762	0	10.24286

Table 3: Descriptive statistics - observed and simulated data

[13]A batch gradient descent algorithm might only find a local minima. To ensure we found the global minima, we train our algorithm with random values for our parameters. For any initial values, we find the same result. However, as a robustness test, we intend to use a stochastic gradient descent algorithm which updates parameters one training example at a time, and might find more easily the global minima of the error function.

4.2.2 Testing phase

We then check whether the simulated bilateral migration rates obtained for the testing set is relatively close to the observed rates. Part to be completed.

4.3 Preliminary results

4.3.1 Changes induced by a loosening of the German immigration policy, on immigration toward Germany

In this part, we look at what happens when Germany loosens its immigration policy regime, focusing on the consequences for Germany. Results are presented in Table 4. In the latter table, we present two simulations. The first one presents the results when we use the fRDB index to define the strictness of migration policies in the destination country. For this simulation, the first row of the table can be read as follows: the simulated cost to migrate from Austria to Germany is about 3.54; Germany is the third less expensive destination for Austrians; and the simulated bilateral migration rate from Austria to Germany is about 0.0134%. The second simulation presents the results when Germany restricts its immigration policy. In that case, Germany becomes the less or the second less expensive destination country for any origin country. Consequently, the bilateral migration rates between any origin country and Germany increase substantially.

		fRDB index $\text{pol}_t^{DEU} = 2.57$			**loosen immigration policy** $\text{pol}_t^{DEU} - 10 = 7.43$		
Origin	**Destination**	**mig. cost**	**ranking**	**mig. rate**	**mig. cost**	**ranking**	**mig. rate**
AUT	DEU	3.539781	3	.0133888	1.52406	1	.1623128
DEU	DEU	0	1	1	0	1	1
DNK	DEU	3.429941	3	.0142499	1.41422	1	.1367829
ESP	DEU	5.474955	5	.0002474	3.459234	2	.0157349
FIN	DEU	4.807381	3	.0009956	2.79166	2	.0479066
FRA	DEU	4.452931	3	.0023816	1.873816	1	.1871742
GBR	DEU	3.542687	3	.0149685	1.526966	1	.2672324
GRC	DEU	6.176995	5	.000032	4.161274	2	.0033527
IRL	DEU	4.095406	4	.0038887	2.079684	1	.0503956
ITA	DEU	6.082731	6	.0000987	3.503615	2	.0155342
NLD	DEU	2.597063	3	.0469813	.5813415	1	.3766829
PRT	DEU	5.728948	5	.000101	3.713227	2	.0083824

Table 4: Loosening of the German immigration policy regime, impact on Germany

4.3.2 Changes induced by a loosening of the German immigration policy, on immigration toward other countries

We now look at the consequences for other countries, when Germany loosens its immigration policy regime. Results are presented in Table 5. As expected, we find that changing the migration cost toward Germany modifies the immigration rates toward other countries. While the migration rates toward Germany increases substantially (results presented in Table 4), the migration rates toward other countries also change.

Table 5: Loosening of the German immigration policy regime, impact on other countries (simulated data)

		fRDB index $\text{pol}_t^{DEU} = 2.57$			**loosen immigration policy** $\text{pol}_t^{DEU} - 10 = 7.43$		
Origin	**Destination**	**mig. cost**	**ranking**	**mig. rate**	**mig. cost**	**ranking**	**mig. rate**
AUT	AUT	0	1	1	0	1	1
DEU	AUT	4.909494	5	.0010439	5.473252	5	.0002737
DNK	AUT	5.066432	7	.0009403	5.63019	7	.0002684
ESP	AUT	7.293209	9	5.43e-06	7.856966	9	1.53e-06
FIN	AUT	5.95193	7	.0000825	6.515687	8	.0000199
FRA	AUT	6.474696	8	.0000262	7.038454	8	6.57e-06
GBR	AUT	6.161838	9	.0001258	6.725595	8	.000041
GRC	AUT	6.271644	6	.0000343	6.835402	6	9.22e-06
IRL	AUT	6.541973	11	.0000803	7.105731	11	.0000284
ITA	AUT	5.880439	5	.0002024	6.444196	5	.0000623
NLD	AUT	5.362336	6	.0005252	5.926094	6	.0001538
PRT	AUT	7.613827	10	2.19e-06	8.177585	9	6.70e-07
AUT	DNK	6.040252	9	.0001347	6.733133	10	.0000263
DEU	DNK	5.641896	6	.0002357	6.334777	7	.0000419
DNK	DNK	0	1	1	0	1	1
ESP	DNK	8.619544	11	3.60e-07	9.312426	12	7.71e-08
FIN	DNK	5.751452	6	.0001806	6.444333	7	.0000316
FRA	DNK	7.262302	11	4.89e-06	7.955183	11	8.78e-07
GBR	DNK	6.042778	8	.0002119	6.735659	9	.0000532
GRC	DNK	8.580329	11	2.11e-07	9.273211	11	4.39e-08
IRL	DNK	6.238379	9	.000185	6.931261	10	.0000521
ITA	DNK	8.581736	10	8.91e-07	9.274617	11	2.08e-07
NLD	DNK	5.458926	7	.0005647	6.151807	7	.0001227
PRT	DNK	8.761249	12	2.53e-07	9.45413	12	6.08e-08
AUT	ESP	6.962096	11	5.17e-06	7.487015	11	1.45e-06
DEU	ESP	6.784204	10	4.48e-06	7.309123	10	1.17e-06
DNK	ESP	7.06382	12	3.73e-06	7.588739	12	9.85e-07
ESP	ESP	0	1	1	0	1	1
FIN	ESP	7.353193	11	1.03e-06	7.878112	11	2.63e-07
FRA	ESP	5.695253	6	.0000807	6.220172	6	.0000228
GBR	ESP	5.758922	7	.0001293	6.283841	7	.0000458
GRC	ESP	7.224331	8	1.68e-06	7.749251	8	4.99e-07
IRL	ESP	5.735996	7	.0001567	6.260916	7	.0000613
ITA	ESP	6.376275	7	.0000326	6.901194	7	.0000108
NLD	ESP	6.432659	11	.0000222	6.957579	11	6.67e-06
PRT	ESP	4.442742	3	.001094	4.967662	3	.0003442
AUT	FIN	6.096569	10	.0000681	6.553767	9	.0000233
DEU	FIN	7.013592	12	4.14e-06	7.540349	11	1.07e-06
DNK	FIN	5.037219	6	.0007643	5.563976	6	.0002385
ESP	FIN	8.625936	12	2.04e-07	9.152692	11	6.35e-08
FIN	FIN	0	1	1	0	1	1
FRA	FIN	8.109196	12	3.38e-07	8.635952	12	9.19e-08
GBR	FIN	6.871928	12	.0000228	7.398685	12	7.97e-06
GRC	FIN	7.440464	9	1.70e-06	7.897663	9	5.92e-07
IRL	FIN	6.272437	10	.0001002	6.729635	9	.0000435
ITA	FIN	8.612216	11	4.81e-07	9.138972	10	1.60e-07
NLD	FIN	6.229322	10	.0000591	6.686521	10	.0000209
PRT	FIN	8.223245	11	4.54e-07	8.680443	11	1.76e-07

Origin	Destination	mig. cost	ranking	mig. rate	mig. cost	ranking	mig. rate
AUT	FRA	2.85989	2	.0303261	2.85989	2	.0303606
DEU	FRA	1.825957	2	.1313227	1.825957	2	.1313289
DNK	FRA	2.606941	2	.0331099	2.606941	2	.033119
ESP	FRA	2.513681	2	.0779368	2.513681	2	.0780307
FIN	FRA	3.506731	2	.0125748	3.506731	2	.0125863
FRA	FRA	0	1	1	0	1	1
GBR	FRA	1.310341	2	.2710189	1.310341	2	.2710325
GRC	FRA	4.250069	2	.0023402	4.250069	2	.0023428
IRL	FRA	1.908865	2	.0487979	1.908865	2	.0487998
ITA	FRA	3.183344	2	.0230157	3.183344	2	.0230259
NLD	FRA	1.49147	2	.124337	1.49147	2	.1243375
PRT	FRA	2.813226	2	.0499362	2.813226	2	.0500317
AUT	GBR	5.368201	5	.0002869	5.837896	5	.0000994
DEU	GBR	4.387263	4	.0020796	4.903657	4	.0006504
DNK	GBR	4.37508	4	.0023404	4.844775	4	.0009187
ESP	GBR	5.28554	4	.0003072	5.755235	4	.0001081
FIN	GBR	5.376209	4	.0002087	5.845904	4	.000066
FRA	GBR	4.156096	2	.0036979	4.67249	2	.0012035
GBR	GBR	0	1	1	0	1	1
GRC	GBR	6.853774	7	5.30e-06	7.323469	7	1.78e-06
IRL	GBR	3.247498	3	.010481	3.717193	3	.0055249
ITA	GBR	6.530987	8	.0000312	7.047381	8	.0000105
NLD	GBR	3.401311	4	.0128203	3.871007	4	.0059523
PRT	GBR	5.450098	4	.000153	5.919793	4	.0000548
AUT	GRC	4.639559	4	.0007928	4.980546	4	.0003879
DEU	GRC	6.609939	9	5.34e-06	7.016769	8	1.90e-06
DNK	GRC	5.980741	9	.0000408	6.387571	9	.0000154
ESP	GRC	6.131107	6	.0000263	6.537938	6	.0000106
FIN	GRC	5.672274	5	.0000576	6.079104	5	.000021
FRA	GRC	6.728636	10	4.84e-06	7.135466	9	1.79e-06
GBR	GRC	6.436912	10	.000025	6.843742	10	.0000112
GRC	GRC	0	1	1	0	1	1
IRL	GRC	6.093607	8	.000063	6.434595	8	.000034
ITA	GRC	4.894281	3	.0005349	5.301112	3	.0002347
NLD	GRC	6.11095	9	.0000351	6.451937	9	.0000163
PRT	GRC	5.913752	6	.0000312	6.254739	6	.000015
AUT	IRL	8.189833	12	1.04e-06	8.813128	12	2.25e-07
DEU	IRL	7.002722	11	.0000103	7.683046	12	1.78e-06
DNK	IRL	6.735522	11	.0000345	7.415847	11	6.22e-06
ESP	IRL	7.702748	10	3.96e-06	8.383072	10	8.62e-07
FIN	IRL	7.74018	12	1.51e-06	8.420506	12	2.57e-07
FRA	IRL	6.684319	9	.0000288	7.364643	10	5.38e-06
GBR	IRL	4.775748	5	.0036767	5.456072	6	.0009807
GRC	IRL	10.24286	12	6.86e-09	10.92318	12	1.53e-09
IRL	IRL	0	1	1	0	1	1
ITA	IRL	9.74833	12	1.07e-07	10.42865	12	2.61e-08
NLD	IRL	5.55201	8	.0006438	6.175305	8	.0001624
PRT	IRL	7.599458	9	4.17e-06	8.279782	10	9.96e-07

Origin	Destination	mig. cost	ranking	mig. rate	mig. cost	ranking	mig. rate
AUT	ITA	5.41571	7	.000265	5.966117	6	.0000758
DEU	ITA	6.52367	8	.000012	7.074077	9	2.93e-06
DNK	ITA	6.646444	10	.0000145	7.196851	10	3.66e-06
ESP	ITA	6.16188	7	.000044	6.712287	7	.0000127
FIN	ITA	6.933182	10	4.18e-06	7.483589	10	1.01e-06
FRA	ITA	6.310542	7	.0000245	6.871927	7	6.20e-06
GBR	ITA	6.514151	11	.0000383	7.064558	11	.0000128
GRC	ITA	5.708257	3	.0000806	6.258664	3	.0000222
IRL	ITA	6.798175	12	.0000312	7.348582	12	.0000112
ITA	ITA	0	1	1	0	1	1
NLD	ITA	6.528112	12	.0000244	7.078519	12	6.87e-06
PRT	ITA	6.588835	7	.0000126	7.139243	7	3.88e-06
AUT	NLD	5.393297	6	.0004953	5.976199	7	.0001316
DEU	NLD	3.99799	3	.0087387	4.619026	3	.0022923
DNK	NLD	4.818425	5	.0017602	5.439461	5	.000459
ESP	NLD	6.989774	8	.000012	7.610809	8	2.95e-06
FIN	NLD	6.221292	9	.0000462	6.842329	9	9.48e-06
FRA	NLD	5.087553	5	.0008303	5.708588	5	.0001926
GBR	NLD	4.27771	4	.0057534	4.898746	4	.0017716
GRC	NLD	8.013926	10	6.50e-07	8.634961	10	1.57e-07
IRL	NLD	4.872687	6	.0016746	5.493723	6	.000583
ITA	NLD	7.416633	9	8.76e-06	8.037668	9	2.36e-06
NLD	NLD	0	1	1	0	1	1
PRT	NLD	7.189842	8	6.06e-06	7.810877	8	1.62e-06
AUT	PRT	5.873469	8	.0000326	6.248101	8	.0000137
DEU	PRT	5.800836	7	.000026	6.191078	6	9.89e-06
DNK	PRT	5.876618	8	.0000327	6.26686	8	.0000129
ESP	PRT	3.422329	3	.0056314	3.812571	3	.0026156
FIN	PRT	5.977325	8	.0000168	6.367568	6	6.31e-06
FRA	PRT	4.901024	4	.0002517	5.291266	4	.0001027
GBR	PRT	4.779442	6	.0004289	5.169684	5	.0002039
GRC	PRT	6.016451	4	.0000136	6.406694	4	5.48e-06
IRL	PRT	4.43985	5	.000664	4.814482	5	.0003629
ITA	PRT	5.579949	4	.0000822	5.970191	4	.0000367
NLD	PRT	5.327775	5	.0001228	5.702407	5	.0000548
PRT	PRT	0	1	1	0	1	1

5 Conclusion

To be completed.

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A Appendix

A.1 Probability to migrate to country k'

We calculate the probability to migrate to country k', using a conditional logit model. Note that in this Appendix, we do not consider the probability to migrate to country k' conditional on $\left(w_{i,\,t}^{k} \geq C_{t}^{kk'}\right)$. Hereafter, we follow Train (2009) who details the results of McFadden (1974, 1984).

The probability to migrate to country k' is given by:

$$
\begin{aligned}
\Pr\left(k'\right) &= \Pr\left(U_{i,\,t+1}^{kk'} = \max_{l=1}^{P} U_{i,\,t+1}^{kl}\right) \\
&= \Pr\left(U_{i,\,t+1}^{kk'} > U_{i,\,t+1}^{kl} \forall l \neq k'\right)
\end{aligned}
$$

We can re-write the utility of an individual i located in country k at time t relocating in country k' at time $t+1$:

$$
\begin{aligned}
U_{i,\,t+1}^{kk'} &= W_{i,t+1}^{kk'} - C_{t}^{kk'} + \epsilon_{i,t}^{kk'} \\
&= V_{i,\,t+1}^{kk'} + \epsilon_{i,t}^{kk'}
\end{aligned}
$$

where $V_{i,\,t+1}^{kk'} = W_{i,t+1}^{kk'} - C_{t}^{kk'}$ denotes the representative utility of the individual – known by the research – and $\epsilon_{i,t}^{kk'}$ is the stochastic part of the utility – unknown by the researcher.

Thus:

$$
\begin{aligned}
\Pr\left(k'\right) &= \Pr\left(V_{i,\,t+1}^{kk'} + \epsilon_{i,t}^{kk'} > V_{i,\,t+1}^{kl} + \epsilon_{i,t}^{kl}\,\forall l \neq k'\right) \\
&= \Pr\left(\epsilon_{i,t}^{kl} < V_{i,\,t+1}^{kk'} - V_{i,\,t+1}^{kl} + \epsilon_{i,t}^{kk'}\,\forall l \neq k'\right) \qquad (4)
\end{aligned}
$$

To solve equation (4), we must assume that $\epsilon_{i,t}^{kl}$ follows a given distribution. As standard in the migration literature, we assume that $\epsilon_{i,t}^{kl}$ follows a Gumbel distribution or equivalently an independent and identically distributed Extreme Value Type-1 distribution. The corresponding cumulative distribution function of each observed component is given by $F\left(\epsilon_{i,t}^{kl}\right) = e^{-e^{-\left(V_{i,\,t+1}^{kk'} - V_{i,\,t+1}^{kl} + \epsilon_{i,t}^{kk'}\right)}}$. As the ϵ's are independent and identically distributed, the cumulative distribution function over all alternative countries ($l \neq k'$) is given by the product of each observed component. Thereby, we can re-write the probability to migrate to country k' conditional on $\epsilon_{i,t}^{kk'}$:

$$
\Pr\left(k'\right)|\epsilon_{i,t}^{kk'} = \prod_{l \neq k'} e^{-e^{-\left(V_{i,\,t+1}^{kk'} - V_{i,\,t+1}^{kl} + \epsilon_{i,t}^{kk'}\right)}}
$$

However $\epsilon_{i,t}^{kk'}$ is unknown, so the unconditional probability to choose country k' is given by the integral of $\Pr\left(k'\right)$ over all values of $\epsilon_{i,t}^{kk'}$ weighted by the probability density function $f\left(\epsilon_{i,t}^{kk'}\right) = \left(e^{-\epsilon_{i}^{kk'}} e^{-e^{-\epsilon_{i,t}^{kk'}}}\right)$:

$$
\Pr\left(k'\right) = \int_{\epsilon_{i,t}^{kk'}=-\infty}^{\infty} \left[\prod_{l \neq k';\, l=1}^{P} e^{-e^{-\left(V_{i,\,t+1}^{kk'} - V_{i,\,t+1}^{kl} + \epsilon_{i,t}^{kk'}\right)}}\right] e^{-\epsilon_{i}^{kk'}} e^{-e^{-\epsilon_{i,t}^{kk'}}} \,\mathrm{d}\epsilon_{i,t}^{kk'}
$$

which is equivalent to:

$$\Pr\left(k'\right) = \int_{u=\infty}^{0} \left[\prod_{l\neq k';l=1}^{P} e^{-e^{\left(V_{i,\,t+1}^{kl}-V_{i,\,t+1}^{kk'}\right)}u}\right] e^{-u}\left(-\mathrm{d}u\right)$$

where:

$$\begin{aligned}
u &= e^{-\epsilon_{i,t}^{kk'}} \\
e^{-\left(V_{i,\,t+1}^{kk'}-V_{i,\,t+1}^{kl}+\epsilon_{i,t}^{kk'}\right)} &= e^{\left(V_{i,\,t+1}^{kl}-V_{i,\,t+1}^{kk'}-k'\right)} \\
&= e^{\left(V_{i,\,t+1}^{kl}-V_{i,\,t+1}^{kk'}\right)} e^{\left(-\epsilon_{i,t}^{kk'}\right)} \\
&= e^{\left(V_{i,\,t+1}^{kl}-V_{i,\,t+1}^{kk'}\right)} u \\
\mathrm{d}u &= -e^{-\epsilon_{i,t}^{kk'}}\,\mathrm{d}\epsilon_{i,t}^{kk'}
\end{aligned}$$

with:

$$\begin{aligned}
u &\in \left]-\infty;\infty\right[\\
-u &\in \left]-\infty;\infty\right[\\
e^{-u} &\in \left]0;\infty\right[
\end{aligned}$$

Then:

$$\begin{aligned}
\Pr\left(k'\right) &= \int_{u=o}^{\infty} \left[\prod_{l\neq k';l=1}^{P} e^{-e^{\left(V_{i,\,t+1}^{kl}-V_{i,\,t+1}^{kk'}\right)}u}\right] e^{-u}\mathrm{d}u \\
&= \int_{u=o}^{\infty} e^{-\left[\sum_{l\neq k';l=1}^{P} e^{\left(V_{i,\,t+1}^{kl}-V_{i,\,t+1}^{kk'}\right)}\right]u} e^{-u}\mathrm{d}u \\
&= \int_{u=o}^{\infty} e^{-\left[\sum_{l\neq k';l=1}^{P} e^{\left(V_{i,\,t+1}^{kl}-V_{i,\,t+1}^{kk'}\right)}\right]u-u} \mathrm{d}u \\
&= \int_{u=o}^{\infty} e^{-u\left[\sum_{l\neq k';l=1}^{P} e^{\left(V_{i,\,t+1}^{kl}-V_{i,\,t+1}^{kk'}\right)}+1\right]} \mathrm{d}u \\
&= \left[-\frac{e^{-u\left[\sum_{l\neq k';l=1}^{P} e^{\left(V_{i,\,t+1}^{kl}-V_{i,\,t+1}^{kk'}\right)}+1\right]}}{1+\sum_{l\neq k';l=1}^{P} e^{\left(V_{i,\,t+1}^{kl}-V_{i,\,t+1}^{kk'}\right)}}\right]_{0}^{\infty} \\
&= \lim_{u\to\infty}\left[-\frac{e^{-u\left[\sum_{l\neq k';l=1}^{P} e^{\left(V_{i,\,t+1}^{kl}-V_{i,\,t+1}^{kk'}\right)}+1\right]}}{1+\sum_{l\neq k';l=1}^{P} e^{\left(V_{i,\,t+1}^{kl}-V_{i,\,t+1}^{kk'}\right)}}\right] - \lim_{u\to 0}\left[-\frac{e^{-u\left[\sum_{l\neq k';l=1}^{P} e^{\left(V_{i,\,t+1}^{kl}-V_{i,\,t+1}^{kk'}\right)}+1\right]}}{1+\sum_{l\neq k';l=1}^{P} e^{\left(V_{i,\,t+1}^{kl}-V_{i,\,t+1}^{kk'}\right)}}\right] \\
&= \frac{1}{1+\sum_{l\neq k';l=1}^{P} e^{\left(V_{i,\,t+1}^{kl}-V_{i,\,t+1}^{kk'}\right)}} \\
&= \frac{1}{\sum_{l=1}^{P} e^{\left(V_{i,\,t+1}^{kl}-V_{i,\,t+1}^{kk'}\right)}}
\end{aligned}$$

where $V_{i,\,t+1}^{kk'} - V_{i,\,t+1}^{kk'} = 0$. Then,

$$\begin{aligned}\Pr\left(k'\right) &= \frac{1}{e^{\left(-V_{i,\,t+1}^{kk'}\right)}\sum_{l=1}^{P} e^{\left(V_{i,\,t+1}^{kl}\right)}} \\ &= \frac{e^{\left(V_{i,\,t+1}^{kk'}\right)}}{\sum_{l=1}^{P} e^{\left(V_{i,\,t+1}^{kl}\right)}}\end{aligned}$$

which is equivalent to:

$$\Pr\left(k'\right) = \Pr\left(U_{i,\,t+1}^{kk'} = \max_{l=1}^{P} U_{i,\,t+1}^{kl}\right) = \frac{e^{\left[W_{t+1}^{kk'} - C_t^{kk'}\right]}}{\sum_{l=1}^{P} e^{\left[W_{t+1}^{kl} - C_t^{kl}\right]}}$$

A.2 Probability to migrate to country k', conditional on the capacity to pay for the migration cost

The migration cost being different over destinations, an individual i is able to rank the potential destinations (his current country of residence, country k, included) from the less to the most costly destination:

$$C_t^{k1} < ... < C_t^{k(P-1)} < C_t^{kP}$$

where P denotes the number of countries considered in the model. Here, destination P is the most expensive destination. Their is no cost for an individual to stay in his current country of residence: $C_t^{kk} = 0$, thus destination 1 is the residence country of the individual: $C_t^{k1} = C_t^{kk}$.

We first calculate the probability to migrate to the most expensive country in terms of migration costs, here country P. The capacity of an individual i to pay for the cost of migration toward destination P is denoted by: $1 - \Phi\left(C_t^{kP}\right) = \Pr\left(w_{i,\,t}^{k} \geq C_t^{kP}\right)$. Following the results of McFadden (1974, 1984)[14], the probability to migrate to country P conditional on $w_{i,\,t}^{k} \geq C_t^{kP}$ is given by:

$$\Pr\left(U_{i,\,t+1}^{kP} = \max_{l=1}^{P} U_{i,\,t+1}^{kl} | w_{i,\,t}^{k} \geq C_t^{kP}\right) = \frac{e^{\left[W_{t+1}^{kP} - C_t^{kP}\right]}}{\sum_{l=1}^{P} e^{\left[W_{t+1}^{kl} - C_t^{kl}\right]}}$$

where $\sum_{l=1}^{P} e^{\left[W_{t+1}^{kl} - C_t^{kl}\right]}$ is the set of alternative countries. Note that an individual who can migrate to country P can migrate to any other destinations.

The probability to migrate to country P when $w_{i,\,t}^{k} < C_t^{kP}$ is:

$$\Pr\left(U_{i,\,t+1}^{kP} = \max_{l=1}^{P} U_{i,\,t+1}^{kl} | w_{i,\,t}^{k} < C_t^{kP}\right) = 0$$

Here note that $w_{i,t}^{k}$ varies over individuals but the distribution of this variable is known by the researcher, this is why we can write the probability conditional on: $w_{i,\,t}^{k} > C_t^{kP}$ (Train, 2009). Thus, the unconditional probability to migrate to country P is the ratio of the utility to go in country P over the set of possible

[14]cf. Appendix A.1.

alternatives:

$$\Pr\left(U_{i,\,t+1}^{kP}=\max_{l=1}^{P}U_{i,\,t+1}^{kl}\right)=\left[1-\Phi\left(C_t^{kP}\right)\right]\frac{e^{\left[W_{t+1}^{kP}-C_t^{kP}\right]}}{\sum_{l=1}^{P}e^{\left[W_{t+1}^{kl}-C_t^{kl}\right]}}$$

We now write the probability to migrate to country $(P-1)$ when $w_{i,\,t}^{k}\geq C_t^{kP}$:

$$\Pr\left(U_{i,\,t+1}^{k(P-1)}=\max_{l=1}^{P}U_{i,\,t+1}^{kl}|w_{i,\,t}^{k}\geq C_t^{kP}\right)=\frac{e^{\left[W_{t+1}^{k(P-1)}-C_t^{k(P-1)}\right]}}{\sum_{l=1}^{P}e^{\left[W_{t+1}^{kl}-C_t^{kl}\right]}}$$

and the probability to migrate to country $(P-1)$ when $C_t^{k(P-1)}\leq w_{i,\,t}^{k}<C_t^{kP}$:

$$\Pr\left(U_{i,\,t+1}^{k(P-1)}=\max_{l=1}^{P}U_{i,\,t+1}^{kl}|C_t^{k(P-1)}\leq w_{i,\,t}^{k}<C_t^{kP}\right)=\frac{e^{\left[W_{t+1}^{k(P-1)}-C_t^{k(P-1)}\right]}}{\sum_{l=1}^{P-1}e^{\left[W_{t+1}^{kl}-C_t^{kl}\right]}}$$

The set of possible alternatives now excludes destination P as the individual is not able to afford it. We also write the probability to migrate to country $(P-1)$ when $w_{i,\,t}^{k}<C_t^{k(P-1)}$:

$$\Pr\left(U_{i,\,t+1}^{k(P-1)}=\max_{l=1}^{P}U_{i,\,t+1}^{kl}|w_{i,\,t}^{k}<C_t^{k(P-1)}\right)=0$$

Thus, the unconditional probability that an individual i migrates to country $(P-1)$ is:

$$\begin{aligned}\Pr\left(U_{i,\,t+1}^{k(P-1)}=\max_{l=1}^{P}U_{i,\,t+1}^{kl}\right)&=\left[1-\Phi\left(C_t^{kP}\right)\right]\frac{e^{\left[W_{t+1}^{k(P-1)}-C_t^{k(P-1)}\right]}}{\sum_{l=1}^{P}e^{\left[W_{t+1}^{kl}-C_t^{kl}\right]}}\\&\quad+\left[\Phi\left(C_t^{kP}\right)-\Phi\left(C_t^{k(P-1)}\right)\right]\frac{e^{\left[W_{t+1}^{k(P-1)}-C_t^{k(P-1)}\right]}}{\sum_{l=1}^{P-1}e^{\left[W_{t+1}^{kl}-C_t^{kl}\right]}}\\&=e^{\left[W_{t+1}^{k(P-1)}-C_t^{k(P-1)}\right]}\left[\frac{\left[1-\Phi\left(C_t^{kP}\right)\right]}{\sum_{l=1}^{P}e^{\left[W_{t+1}^{kl}-C_t^{kl}\right]}}+\frac{\left[\Phi\left(C_t^{kP}\right)-\Phi\left(C_t^{k(P-1)}\right)\right]}{\sum_{l=1}^{P-1}e^{\left[W_{t+1}^{kl}-C_t^{kl}\right]}}\right]\end{aligned}$$

Generalising, we get the unconditional probability that an individual i migrates to destination k' $(\neq k)$:

$$\Pr\left(U_{i,\,t+1}^{kk'}=\max_{l=1}^{P}U_{i,\,t+1}^{kl}\right)=e^{\left[W_{t+1}^{kk'}-C_t^{kk'}\right]}\left[\sum_{l=k'}^{P}\frac{\Phi\left(C_t^{k(l+1)}\right)-\Phi\left(C_t^{kl}\right)}{\sum_{q=1}^{l}e^{\left[W_{t+1}^{kq}-C_t^{kq}\right]}}\right]$$

where $\Phi\left(C_t^{P+1}\right)=1$.

Similarly, the unconditional probability that an individual i stays in country k is given by:

$$\Pr\left(U_{i,\,t+1}^{kk}=\max_{l=1}^{P}U_{i,\,t+1}^{kl}\right)=e^{\left[W_{t+1}^{kk}\right]}\left[\sum_{l=k}^{P}\frac{\Phi\left(C_t^{k(l+1)}\right)-\Phi\left(C_t^{kl}\right)}{\sum_{q=1}^{l}e^{\left[W_{t+1}^{kq}-C_t^{kq}\right]}}\right]$$

A.3 Derivative of the bilateral migration rate with respect to C_t^{kj}

The bilateral migration rate is given by:

$$\mathrm{M}_t^{kk'} = \frac{e^{\left[W_{t+1}^{kk'} - W_{t+1}^{kk}\right]}}{e^{\left[C_t^{kk'}\right]}} f^{k'}$$

where:

$$f^{k'} = \frac{A^{k'}}{B^{k'}}$$

and where:

$$A^{k'} = \sum_{l=k'}^{P} \frac{\Phi\left(C_t^{k(l+1)}\right) - \Phi\left(C_t^{kl}\right)}{\sum_{q=1}^{l} e^{\left(W_{t+1}^{kq} - C_t^{kq}\right)}}$$

$$B^{k'} = \sum_{l=1}^{P} \frac{\Phi\left(C_t^{k(l+1)}\right) - \Phi\left(C_t^{kl}\right)}{\sum_{q=1}^{l} e^{\left(W_{t+1}^{kq} - C_t^{kq}\right)}}$$

First, let us find the derivative of $A^{k'}$. Three cases may occur: $j > k'$, $j = k'$ and $j < k'$. Let us decompose the term $A^{k'}$ when $j > k'$:

$$\begin{aligned}
A^{k'} =& \sum_{l=k'}^{P} \frac{\Phi\left(C_t^{k(l+1)}\right) - \Phi\left(C_t^{kl}\right)}{\sum_{q=1}^{l} e^{\left(W_{t+1}^{kq} - C_t^{kq}\right)}} \\
=& \underbrace{\sum_{l=k'}^{j-2} \frac{\Phi\left(C_t^{k(l+1)}\right) - \Phi\left(C_t^{kl}\right)}{\sum_{q=1}^{l} e^{\left(W_{t+1}^{kq} - C_t^{kq}\right)}}}_{k' \to (j-2)} + \underbrace{\frac{\Phi\left(C_t^{kj}\right) - \Phi\left(C_t^{k(j-1)}\right)}{\sum_{q=1}^{j-1} e^{\left(W_{t+1}^{kq} - C_t^{kq}\right)}}}_{(j-1)} + \underbrace{\frac{\Phi\left(C_t^{k(j+1)}\right) - \Phi\left(C_t^{kj}\right)}{\sum_{q=1}^{j} e^{\left(W_{t+1}^{kq} - C_t^{kq}\right)}}}_{j} \\
& + \underbrace{\sum_{l=j+1}^{P} \frac{\Phi\left(C_t^{k(l+1)}\right) - \Phi\left(C_t^{kl}\right)}{\sum_{q=1}^{l} e^{\left(W_{t+1}^{kq} - C_t^{kq}\right)}}}_{(j+1) \to P}
\end{aligned}$$

By doing so, we find the derivative of $A^{k'}$ with respect to C^{kj} when $j > k'$:

$$\begin{aligned}
\frac{\partial A^{k'}}{\partial C^{kj}} =& \frac{\Phi'\left(C_t^{kj}\right)}{\sum_{q=1}^{j-1} e^{\left(W_{t+1}^{kq} - C_t^{kq}\right)}} - \frac{\Phi'\left(C_t^{kj}\right)}{\sum_{q=1}^{j} e^{\left(W_{t+1}^{kq} - C_t^{kq}\right)}} + \frac{\left[\Phi\left(C_t^{k(j+1)}\right) - \Phi\left(C_t^{kj}\right)\right]}{\left[\sum_{q=1}^{j} e^{\left(W_{t+1}^{kq} - C_t^{kq}\right)}\right]^2} e^{\left(W_{t+1}^{kj} - C_t^{kj}\right)} \\
& + \sum_{l=j+1}^{P} \frac{\Phi\left(C_t^{k(l+1)}\right) - \Phi\left(C_t^{kl}\right)}{\left[\sum_{q=1}^{l} e^{\left(W_{t+1}^{kq} - C_t^{kq}\right)}\right]^2} e^{\left(W_{t+1}^{kj} - C_t^{kj}\right)} \\
=& \frac{\Phi'\left(C_t^{kj}\right) e^{\left(W_{t+1}^{kj} - C_t^{kj}\right)}}{\sum_{q=1}^{j-1} e^{\left(W_{t+1}^{kq} - C_t^{kq}\right)} \sum_{q=1}^{j} e^{\left(W_{t+1}^{kq} - C_t^{kq}\right)}} + \left\{ \sum_{l=j}^{P} \frac{\Phi\left(C_t^{k(l+1)}\right) - \Phi\left(C_t^{kl}\right)}{\left[\sum_{q=1}^{l} e^{\left(W_{t+1}^{kq} - C_t^{kq}\right)}\right]^2} \right\} e^{\left(W_{t+1}^{kj} - C_t^{kj}\right)} > 0
\end{aligned}$$

Similarly, let us decompose the term $A^{k'}$ when $j > k'$:

$$
\begin{aligned}
A^{k'} =& \sum_{l=k'}^{P} \frac{\Phi\left(C_t^{k(l+1)}\right) - \Phi\left(C_t^{kl}\right)}{\sum_{q=1}^{l} e^{\left(W_{t+1}^{kq} - C_t^{kq}\right)}} \\
=& \underbrace{\frac{\Phi\left(C_t^{k(j+1)}\right) - \Phi\left(C_t^{kj}\right)}{\sum_{q=1}^{j} e^{\left(W_{t+1}^{kq} - C_t^{kq}\right)}}}_{k'(=j)} + \underbrace{\sum_{l=k'+1}^{P} \frac{\Phi\left(C_t^{k(l+1)}\right) - \Phi\left(C_t^{kl}\right)}{\sum_{q=1}^{l} e^{\left(W_{t+1}^{kq} - C_t^{kq}\right)}}}_{(k'+1)\to P}
\end{aligned}
$$

Thereby, we find the derivative of $A^{k'}$ with respect to C^{kj} when $j = k'$:

$$
\begin{aligned}
\frac{\partial A^{k'}}{\partial C^{kk'}} =& \frac{-\Phi'\left(C_t^{kk'}\right)}{\sum_{q=1}^{k'} e^{\left(W_{t+1}^{kq} - C_t^{kq}\right)}} + \frac{\left[\Phi\left(C_t^{k(k'+1)}\right) - \Phi\left(C_t^{kk'}\right)\right]}{\left[\sum_{q=1}^{k'} e^{\left(W_{t+1}^{kq} - C_t^{kq}\right)}\right]^2} e^{\left(W_{t+1}^{kk'} - C_t^{kk'}\right)} + \sum_{l=k'+1}^{P} \frac{\Phi\left(C_t^{k(l+1)}\right) - \Phi\left(C_t^{kl}\right)}{\left[\sum_{q=1}^{l} e^{\left(W_{t+1}^{kq} - C_t^{kq}\right)}\right]^2} e^{\left(W_{t+1}^{kk'} - C_t^{kk'}\right)} \\
=& \frac{-\Phi'\left(C_t^{kk'}\right)}{\sum_{q=1}^{k'} e^{\left(W_{t+1}^{kq} - C_t^{kq}\right)}} + \left\{\sum_{l=k'}^{P} \frac{\left[\Phi\left(C_t^{k(l+1)}\right) - \Phi\left(C_t^{kl}\right)\right]}{\left[\sum_{q=1}^{l} e^{\left(W_{t+1}^{kq} - C_t^{kq}\right)}\right]^2}\right\} e^{\left(W_{t+1}^{kk'} - C_t^{kk'}\right)}
\end{aligned}
$$

Finally, we find the derivative of $A^{k'}$ with respect to C^{kj} when $j < k'$:

$$
\frac{\partial A^{k'}}{\partial C^{kj}} = \left\{\sum_{l=k'}^{P} \frac{\left[\Phi\left(C_t^{k(l+1)}\right) - \Phi\left(C_t^{kl}\right)\right]}{\left[\sum_{q=1}^{l} e^{\left(W_{t+1}^{kq} - C_t^{kq}\right)}\right]^2}\right\} e^{\left(W_{t+1}^{kj} - C_t^{kj}\right)} > 0
$$

Second, let us find the derivative of $B^{k'}$. Let us decompose the term $B^{k'}$:

$$
\begin{aligned}
B^{k'} =& \sum_{l=1}^{P} \frac{\Phi\left(C_t^{k(l+1)}\right) - \Phi\left(C_t^{kl}\right)}{\sum_{q=1}^{l} e^{\left(W_{t+1}^{kq} - C_t^{kq}\right)}} \\
=& \underbrace{\sum_{l=1}^{j-2} \frac{\Phi\left(C_t^{k(l+1)}\right) - \Phi\left(C_t^{kl}\right)}{\sum_{q=1}^{l} e^{\left(W_{t+1}^{kq} - C_t^{kq}\right)}}}_{1\to(j-2)} + \underbrace{\frac{\Phi\left(C_t^{kj}\right) - \Phi\left(C_t^{k(j-1)}\right)}{\sum_{q=1}^{j-1} e^{\left(W_{t+1}^{kq} - C_t^{kq}\right)}}}_{j-1} + \underbrace{\frac{\left(C_t^{k(j+1)}\right) - \Phi\left(C_t^{kj}\right)}{\sum_{q=1}^{j} e^{\left(W_{t+1}^{kq} - C_t^{kq}\right)}}}_{j} + \underbrace{\sum_{l=j+1}^{P} \frac{\Phi\left(C_t^{k(l+1)}\right) - \Phi\left(C_t^{kl}\right)}{\sum_{q=1}^{l} e^{\left(W_{t+1}^{kq} - C_t^{kq}\right)}}}_{(j+1)\to P}
\end{aligned}
$$

By doing so, we find the derivative of $B^{k'}$ with respect to C^{kj}:

$$
\begin{aligned}
\frac{\partial B^{k'}}{\partial C^{kj}} =& \frac{\Phi'\left(C_t^{kj}\right)}{\sum_{q=1}^{j-1} e^{\left(W_{t+1}^{kq} - C_t^{kq}\right)}} - \frac{\Phi'\left(C_t^{kj}\right)}{\sum_{q=1}^{j} e^{\left(W_{t+1}^{kq} - C_t^{kq}\right)}} + \frac{\left[\Phi\left(C_t^{k(j+1)}\right) - \Phi\left(C_t^{kj}\right)\right]}{\left[\sum_{q=1}^{j} e^{\left(W_{t+1}^{kq} - C_t^{kq}\right)}\right]^2} e^{\left(W_{t+1}^{kj} - C_t^{kj}\right)} \\
&+ \sum_{l=j+1}^{P} \frac{\Phi\left(C_t^{k(l+1)}\right) - \Phi\left(C_t^{kl}\right)}{\left[\sum_{q=1}^{l} e^{\left(W_{t+1}^{kq} - C_t^{kq}\right)}\right]^2} e^{\left(W_{t+1}^{kj} - C_t^{kj}\right)} \\
=& \frac{\Phi'\left(C_t^{kj}\right) e^{\left(W_{t+1}^{kj} - C_t^{kj}\right)}}{\sum_{q=1}^{j-1} e^{\left(W_{t+1}^{kq} - C_t^{kq}\right)} \sum_{q=1}^{j} e^{\left(W_{t+1}^{kq} - C_t^{kq}\right)}} + \left\{\sum_{l=j}^{P} \frac{\left[\Phi\left(C_t^{k(l+1)}\right) - \Phi\left(C_t^{kl}\right)\right]}{\left[\sum_{q=1}^{l} e^{\left(W_{t+1}^{kq} - C_t^{kq}\right)}\right]^2}\right\} e^{\left(W_{t+1}^{kj} - C_t^{kj}\right)}
\end{aligned}
$$

We can know find the derivative of $f^{k'}$ with respect to C^{kj}:

$$\begin{aligned}\frac{\partial f^{k'}}{\partial C^{kj}} =& \frac{1}{[B^{k'}]^2}\left[\frac{\partial A^{k'}}{\partial C^{kj}} * B^{k'} - \frac{\partial B^{k'}}{\partial C^{kj}} * A^{k'}\right]\\ \left[B^{k'}\right]^2 \frac{\partial f^{k'}}{\partial C^{kj}} =& \frac{\partial A^{k'}}{\partial C^{kj}} * B^{k'} - \frac{\partial B^{k'}}{\partial C^{kj}} * A^{k'}\end{aligned}$$

Noting that $\forall j\ B^{k'} = \sum_{l=1}^{k'-1} \frac{\Phi\left(C_t^{k(l+1)}\right) - \Phi\left(C_t^{kl}\right)}{\sum_{q=1}^{l} e^{\left(W_{t+1}^{kq} - C_t^{kq}\right)}} + A^{k'}$, we can re-write the derivative $\frac{\partial B^{k'}}{\partial C^{kj}}$ as a function of $A^{k'}$. In case $j > k'$:

$$\frac{\partial B^{k'}}{\partial C^{kj}} = \frac{\partial A^{k'}}{\partial C^{kj}}$$

in case $j = k'$:

$$\frac{\partial B^{k'}}{\partial C^{kj}} = \frac{\Phi'\left(C_t^{kj}\right)}{\sum_{q=1}^{j-1} e^{\left(W_{t+1}^{kq} - C_t^{kq}\right)}} + \frac{\partial A^{k'}}{\partial C^{kj}}$$

and finally when $j < k'$:

$$\frac{\partial B^{k'}}{\partial C^{kj}} = \frac{\Phi'\left(C_t^{kj}\right) e^{\left(W_{t+1}^{kj} - C_t^{kj}\right)}}{\sum_{q=1}^{j-1} e^{\left(W_{t+1}^{kq} - C_t^{kq}\right)} \sum_{q=1}^{j} e^{\left(W_{t+1}^{kq} - C_t^{kq}\right)}} + \sum_{l=j}^{k'-1} \frac{\left[\Phi\left(C_t^{k(l+1)}\right) - \Phi\left(C_t^{kl}\right)\right]}{\left[\sum_{q=1}^{l} e^{\left(W_{t+1}^{kq} - C_t^{kq}\right)}\right]^2} e^{\left(W_{t+1}^{kj} - C_t^{kj}\right)} + \frac{\partial A^{k'}}{\partial C^{kj}}$$

Thereby, we can deduct that when $j > k'$:

$$\begin{aligned}\left(B^{k'}\right)^2 \frac{\partial f^{k'}}{\partial C^{kj}} =& \frac{\partial A^{k'}}{\partial C^{kj}}\left[\sum_{l=1}^{k'-1} \frac{\Phi\left(C_t^{k(l+1)}\right) - \Phi\left(C_t^{kl}\right)}{\sum_{q=1}^{l} e^{\left(W_{t+1}^{kq} - C_t^{kq}\right)}} + A^{k'}\right] - A^{k'}\left[\frac{\partial A^{k'}}{\partial C^{kj}}\right]\\ =& \frac{\partial A^{k'}}{\partial C^{kj}} \sum_{l=1}^{k'-1} \frac{\Phi\left(C_t^{k(l+1)}\right) - \Phi\left(C_t^{kl}\right)}{\sum_{q=1}^{l} e^{\left(W_{t+1}^{kq} - C_t^{kq}\right)}} > 0\end{aligned}$$

when $j = k'$:

$$\begin{aligned}\left(B^{k'}\right)^2 \frac{\partial f^{k'}}{\partial C^{kj}} =& \frac{\partial A^{k'}}{\partial C^{kj}}\left[\sum_{l=1}^{k'-1} \frac{\Phi\left(C_t^{k(l+1)}\right) - \Phi\left(C_t^{kl}\right)}{\sum_{q=1}^{l} e^{\left(W_{t+1}^{kq} - C_t^{kq}\right)}} + A^{k'}\right] - A^{k'}\left[\frac{\Phi'\left(C_t^{kj}\right)}{\sum_{q=1}^{j-1} e^{\left(W_{t+1}^{kq} - C_t^{kq}\right)}} + \frac{\partial A^{k'}}{\partial C^{kj}}\right]\\ =& \frac{\partial A^{k'}}{\partial C^{kj}} \sum_{l=1}^{k'-1} \frac{\Phi\left(C_t^{k(l+1)}\right) - \Phi\left(C_t^{kl}\right)}{\sum_{q=1}^{l} e^{\left(W_{t+1}^{kq} - C_t^{kq}\right)}} - \frac{\Phi'\left(C_t^{kj}\right)}{\sum_{q=1}^{j-1} e^{\left(W_{t+1}^{kq} - C_t^{kq}\right)}} A^{k'}\end{aligned}$$

and when $j < k'$:

$$\begin{aligned}
\left(B^{k'}\right)^2 \frac{\partial f^{k'}}{\partial C^{kj}} =& \frac{\partial A^{k'}}{\partial C^{kj}} \left[\sum_{l=1}^{k'-1} \frac{\Phi\left(C_t^{k(l+1)}\right) - \Phi\left(C_t^{kl}\right)}{\sum_{q=1}^{l} e^{\left(W_{t+1}^{kq} - C_t^{kq}\right)}} + A^{k'}\right] \\
& - A^{k'} \left[\frac{\Phi'\left(C_t^{kj}\right) e^{\left(W_{t+1}^{kj} - C_t^{kj}\right)}}{\sum_{q=1}^{j-1} e^{\left(W_{t+1}^{kq} - C_t^{kq}\right)} \sum_{q=1}^{j} e^{\left(W_{t+1}^{kq} - C_t^{kq}\right)}} + \sum_{l=j}^{k'-1} \frac{\left[\Phi\left(C_t^{k(l+1)}\right) - \Phi\left(C_t^{kl}\right)\right]}{\left[\sum_{q=1}^{l} e^{\left(W_{t+1}^{kq} - C_t^{kq}\right)}\right]^2} e^{\left(W_{t+1}^{kj} - C_t^{kj}\right)} + \frac{\partial A^{k'}}{\partial C^{kj}}\right] \\
=& \frac{\partial A^{k'}}{\partial C^{kj}} \sum_{l=1}^{k'-1} \frac{\Phi\left(C_t^{k(l+1)}\right) - \Phi\left(C_t^{kl}\right)}{\sum_{q=1}^{l} e^{\left(W_{t+1}^{kq} - C_t^{kq}\right)}} \\
& - A^{k'} \left[\frac{\Phi'\left(C_t^{kj}\right) e^{\left(W_{t+1}^{kj} - C_t^{kj}\right)}}{\sum_{q=1}^{j-1} e^{\left(W_{t+1}^{kq} - C_t^{kq}\right)} \sum_{q=1}^{j} e^{\left(W_{t+1}^{kq} - C_t^{kq}\right)}} + \sum_{l=j}^{k'-1} \frac{\left[\Phi\left(C_t^{k(l+1)}\right) - \Phi\left(C_t^{kl}\right)\right]}{\left[\sum_{q=1}^{l} e^{\left(W_{t+1}^{kq} - C_t^{kq}\right)}\right]^2} e^{\left(W_{t+1}^{kj} - C_t^{kj}\right)}\right]
\end{aligned}$$

To conclude:

- when $j > k'$:

$$\begin{aligned}
\frac{\partial \mathrm{M}_t^{kk'}}{\partial C_t^{kj}} &= \frac{e^{\left[W_{t+1}^{kk'} - W_{t+1}^{kk}\right]}}{e^{\left[C_t^{kk'}\right]}} \frac{\partial f^{k'}}{\partial C_t^{kj}} \\
&= \mathrm{M}_t^{kk'} \left[\frac{1}{f^{k'}} \frac{\partial f^{k'}}{\partial C_t^{kj'}}\right]
\end{aligned}$$

With no budget constraint $f_t^{k'} = 1$, thus $\frac{\partial \mathrm{M}_t^{kk'}}{\partial C_t^{kj}} = M_t^{kk'} = 0$. With a budget constraint effect $f_t^{k'} > 1$, $\frac{\partial f^{k'}}{\partial C_t^{kj}} > 0$, thus $\frac{\partial \mathrm{M}_t^{kk'}}{\partial C_t^{kj}} > 0$.

- when case $j = k'$:

$$\begin{aligned}
\frac{\partial \mathrm{M}_t^{kk'}}{\partial C_t^{kk'}} &= -\frac{e^{\left[W_{t+1}^{kk'} - W_{t+1}^{kk}\right]}}{e^{\left[C_t^{kk'}\right]}} f^{k'} + \frac{e^{\left[W_{t+1}^{kk'} - W_{t+1}^{kk}\right]}}{e^{\left[C_t^{kk'}\right]}} \frac{\partial f^{k'}}{\partial C_t^{kk'}} \\
&= -\mathrm{M}_t^{kk'} \left[1 + \frac{1}{f^{k'}} \frac{\partial f^{k'}}{\partial C_t^{kk'}}\right]
\end{aligned}$$

With no budget constraint $f_t^{k'} = 1$, thus $\frac{\partial M_t^{kk'}}{\partial C_t^{kk'}} = -M_t^{kk'} < 0$. With a budget constraint effect => ?

- when $j < k'$:

$$\begin{aligned}
\frac{\partial \mathrm{M}_t^{kk'}}{\partial C_t^{kj}} &= \frac{e^{\left[W_{t+1}^{kk'} - W_{t+1}^{kk}\right]}}{e^{\left[C_t^{kk'}\right]}} \frac{\partial f^{k'}}{\partial C_t^{kj}} \\
&= \mathrm{M}_t^{kk'} \left[\frac{1}{f^{k'}} \frac{\partial f^{k'}}{\partial C_t^{kk'}}\right]
\end{aligned}$$

With no budget constraint $f_t^{k'} = 1$, thus $\frac{\partial \mathrm{M}_t^{kk'}}{\partial C_t^{kj}} = M_t^{kk'} = 0$. With a budget constraint effect => ?

A.4 Simulated data

Table 6: Simulated and observed migration rates

Origin	Destination	Simulated mig.cost	Simulated ranking	Simulated mig. rate
AUT	AUT	0	1	1
AUT	DEU	3.539781	3	.0133888
AUT	DNK	6.040252	9	.0001347
AUT	ESP	6.962096	11	5.17e-06
AUT	FIN	6.096569	10	.0000681
AUT	FRA	2.85989	2	.0303261
AUT	GBR	5.368201	5	.0002869
AUT	GRC	4.639559	4	.0007928
AUT	IRL	8.189833	12	1.04e-06
AUT	ITA	5.41571	7	.000265
AUT	NLD	5.393297	6	.0004953
AUT	PRT	5.873469	8	.0000326
DEU	AUT	4.909494	5	.0010439
DEU	DEU	0	1	1
DEU	DNK	5.641896	6	.0002357
DEU	ESP	6.784204	10	4.48e-06
DEU	FIN	7.013592	12	4.14e-06
DEU	FRA	1.825957	2	.1313227
DEU	GBR	4.387263	4	.0020796
DEU	GRC	6.609939	9	5.34e-06
DEU	IRL	7.002722	11	.0000103
DEU	ITA	6.52367	8	.000012
DEU	NLD	3.99799	3	.0087387
DEU	PRT	5.800836	7	.000026
DNK	AUT	5.066432	7	.0009403
DNK	DEU	3.429941	3	.0142499
DNK	DNK	0	1	1
DNK	ESP	7.06382	12	3.73e-06
DNK	FIN	5.037219	6	.0007643
DNK	FRA	2.606941	2	.0331099
DNK	GBR	4.37508	4	.0023404
DNK	GRC	5.980741	9	.0000408
DNK	IRL	6.735522	11	.0000345
DNK	ITA	6.646444	10	.0000145
DNK	NLD	4.818425	5	.0017602
DNK	PRT	5.876618	8	.0000327
ESP	AUT	7.293209	9	5.43e-06
ESP	DEU	5.474955	5	.0002474
ESP	DNK	8.619544	11	3.60e-07
ESP	ESP	0	1	1
ESP	FIN	8.625936	12	2.04e-07
ESP	FRA	2.513681	2	.0779368
ESP	GBR	5.28554	4	.0003072
ESP	GRC	6.131107	6	.0000263
ESP	IRL	7.702748	10	3.96e-06
ESP	ITA	6.16188	7	.000044
ESP	NLD	6.989774	8	.000012
ESP	PRT	3.422329	3	.0056314

Origin	Destination	Simulated mig.cost	Simulated ranking	Simulated mig. rate
FIN	AUT	5.95193	7	.0000825
FIN	DEU	4.807381	3	.0009956
FIN	DNK	5.751452	6	.0001806
FIN	ESP	7.353193	11	1.03e-06
FIN	FIN	0	1	1
FIN	FRA	3.506731	2	.0125748
FIN	GBR	5.376209	4	.0002087
FIN	GRC	5.672274	5	.0000576
FIN	IRL	7.74018	12	1.51e-06
FIN	ITA	6.933182	10	4.18e-06
FIN	NLD	6.221292	9	.0000462
FIN	PRT	5.977325	8	.0000168
FRA	AUT	6.474696	8	.0000262
FRA	DEU	4.452931	3	.0023816
FRA	DNK	7.262302	11	4.89e-06
FRA	ESP	5.695253	6	.0000807
FRA	FIN	8.109196	12	3.38e-07
FRA	FRA	0	1	1
FRA	GBR	4.156096	2	.0036979
FRA	GRC	6.728636	10	4.84e-06
FRA	IRL	6.684319	9	.0000288
FRA	ITA	6.310542	7	.0000245
FRA	NLD	5.087553	5	.0008303
FRA	PRT	4.901024	4	.0002517
GBR	AUT	6.161838	9	.0001258
GBR	DEU	3.542687	3	.0149685
GBR	DNK	6.042778	8	.0002119
GBR	ESP	5.758922	7	.0001293
GBR	FIN	6.871928	12	.0000228
GBR	FRA	1.310341	2	.2710189
GBR	GBR	0	1	1
GBR	GRC	6.436912	10	.000025
GBR	IRL	4.775748	5	.0036767
GBR	ITA	6.514151	11	.0000383
GBR	NLD	4.27771	4	.0057534
GBR	PRT	4.779442	6	.0004289
GRC	AUT	6.271644	6	.0000343
GRC	DEU	6.176995	5	.000032
GRC	DNK	8.580329	11	2.11e-07
GRC	ESP	7.224331	8	1.68e-06
GRC	FIN	7.440464	9	1.70e-06
GRC	FRA	4.250069	2	.0023402
GRC	GBR	6.853774	7	5.30e-06
GRC	GRC	0	1	1
GRC	IRL	10.24286	12	6.86e-09
GRC	ITA	5.708257	3	.0000806
GRC	NLD	8.013926	10	6.50e-07
GRC	PRT	6.016451	4	.0000136

Origin	Destination	Simulated mig.cost	Simulated ranking	Simulated mig. rate
IRL	AUT	6.541973	11	.0000803
IRL	DEU	4.095406	4	.0038887
IRL	DNK	6.238379	9	.000185
IRL	ESP	5.735996	7	.0001567
IRL	FIN	6.272437	10	.0001002
IRL	FRA	1.908865	2	.0487979
IRL	GBR	3.247498	3	.010481
IRL	GRC	6.093607	8	.000063
IRL	IRL	0	1	1
IRL	ITA	6.798175	12	.0000312
IRL	NLD	4.872687	6	.0016746
IRL	PRT	4.43985	5	.000664
ITA	AUT	5.880439	5	.0002024
ITA	DEU	6.082731	6	.0000987
ITA	DNK	8.581736	10	8.91e-07
ITA	ESP	6.376275	7	.0000326
ITA	FIN	8.612216	11	4.81e-07
ITA	FRA	3.183344	2	.0230157
ITA	GBR	6.530987	8	.0000312
ITA	GRC	4.894281	3	.0005349
ITA	IRL	9.74833	12	1.07e-07
ITA	ITA	0	1	1
ITA	NLD	7.416633	9	8.76e-06
ITA	PRT	5.579949	4	.0000822
NLD	AUT	5.362336	6	.0005252
NLD	DEU	2.597063	3	.0469813
NLD	DNK	5.458926	7	.0005647
NLD	ESP	6.432659	11	.0000222
NLD	FIN	6.229322	10	.0000591
NLD	FRA	1.49147	2	.124337
NLD	GBR	3.401311	4	.0128203
NLD	GRC	6.11095	9	.0000351
NLD	IRL	5.55201	8	.0006438
NLD	ITA	6.528112	12	.0000244
NLD	NLD	0	1	1
NLD	PRT	5.327775	5	.0001228
PRT	AUT	7.613827	10	2.19e-06
PRT	DEU	5.728948	5	.000101
PRT	DNK	8.761249	12	2.53e-07
PRT	ESP	4.442742	3	.001094
PRT	FIN	8.223245	11	4.54e-07
PRT	FRA	2.813226	2	.0499362
PRT	GBR	5.450098	4	.000153
PRT	GRC	5.913752	6	.0000312
PRT	IRL	7.599458	9	4.17e-06
PRT	ITA	6.588835	7	.0000126
PRT	NLD	7.189842	8	6.06e-06
PRT	PRT	0	1	1

We can read the second line of the table as follows: The simulated cost for an Austrian to migrate toward Germany is about 3.54. Germany is the third less expensive destination country for Austrians (the most expensive destination is Ireland, and the less expensive is Austria). The simulated bilateral migration rate from Austria to Germany is about 0.0134%.