Economic incentives versus institutional frictions: dynamics of cross-country migration

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Abstract

In this paper we devise a theory of cross-country migration in the form of labor mobility based on regional and sectoral productivity shocks in a multi-country, multi-sector setting. Country-specific sociological and institutional factors induce a friction on such labor reallocation process driven by economic incentives. We use country level data to show how country to country migration can be determined by industrial composition in the countries, shocks in factor productivity in the regionally concentrated sectors and spatial dispersion of these shocks. The model explains both the nominal and relative flow of workers across U.S. well, which is taken as the frictionless benchmark case. On the other hand, when applied to Europe the model explains the relative flow network well, but predicts a higher nominal flow than is seen in the data. This missing mass of migrants is explained by socio-cultural-political barriers. We use dyad regression to analyze the effects of institutional and cultural 'distance' between countries to explain the frictions. Taken together, the economic mechanism along with institutional factors explain the 'European immobility puzzle'.

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1 Introduction

Across the world, workers constantly move from place to place in search for better economic opportunities. Especially in the current age of globalization, the world has seen an ever-increasing stock of people who live far away from their native countries. The rapid improvement of the communication and transportation technology along with the removal of legal and political barriers contributed to this increased flow of people between countries.

There are multiple reasons why people choose to migrate. Probably the most important motivation to migrate arises from pure economic factors e.g. higher wage or productivity in one country vis-a-vis another (Kennan and Walker [2011], Bertoli et al. [2013]). Several institutional factors also play an important role in shaping the same decision-making process. Differences in languages, cultures or customs may present an impediment in the process (Belot and Ederveen [2012]). Thus from a purely economic point of view, the phenomenon of migration can be thought of as an adjustment process or a reallocation process of labor resulting from asymmetric productivity shocks. However, various lingual-social or political for that matter, factors can induce frictions on this process reducing the extent of the reallocation process. Ultimately, how the actual dynamics shapes up is a complex interplay between such economic and sociological forces. Understanding of the mechanism underlying migration is of first-order importance as low levels of migration due to structural or institutional rigidities imply less flexible labor market. Thus the economy if hit by negative (spatial and/or sectoral) shocks, will take more time to adjust, prolonging the downturn. Batini et al. [2010] for example argues that low migration was a potential cause of the slow recovery after the 2007-08 crisis. What makes it more compelling is that U.S. is found to be much more flexible in terms of migration than Europe. Thus a similar downturn would be way more prolonged in Europe with a far more rigid labor market, which the European Union largely wanted to avoid by allowing free movement of labor. Thus a decomposition of the effects of sheer economic force and institutional factors is important as the conclusion would be very different if they are opposing rather than reinforcing each other.

Our primary target in this paper is to explain the relative contributions of different economic and institutional factors in determining the magnitude of migration across countries. These effects are most prominently seen in case of Europe vis-a-vis U.S. These two political unions being 'North' have far less variation in economic conditions among the constituent states than a 'North-South' relationship like U.S. and India. Thus one might imagine such an union to comprise smaller states sharing largely similar economic background (identical labor laws, integrated financial markets etc.), connected to each other by economic linkages though trade and migration. If the constituent states receive asymmetric productivity shocks, we would expect workers to flow from the low-productivity state to high productivity state, in a friction-less world. Thus the process of migration would manifest itself in two forms; first, the flow network of migrants across the states, capturing the relative weight of flow of workers and second, the total mass of migrants. In case of U.S., the average flow of migrants across states is about 2% in the last 20 years[1]. However, in case of Europe this rate is in the order of 1/100-th of the corresponding value for U.S. This phenomenon is referred to in the literature as the 'European immobility puzzle' (Braunerhjelm et al. [2000]). We explain it by constructing a model consistent with the U.S. data in terms of the labor network generated as well as the total mass of migrants. Then we show that the model captures the labor network across Europe well but overpredicts the total mass of migrants. The difference between the model and the data is explained by an array of various institutional factors.

In the following, we first present an N-country, two-sector model augmented with sector and country specific idiosyncratic productivity shocks. Labor being the only movable input, in face of different cross-sectional realization of shocks, it would move across states according to the relative attractiveness based on productivity. Thus from one set of labor allocation, we reach another set such that utilities are equalized across the states restoring equilibrium. The underlying logic is that migratory responses are ultimately utility enhancing[2] (Ashby [2007]). Therefore any friction not allowing free-movement of labor would reduce welfare. The analytical structure provided by Caliendo et al. [2014][3] helps us to explicitly pin down the effects on labor allocation. Assuming homogeneity of labor, we can easily construct a labor flow network by combining all pairs of countries. Thus after repeatedly shocking the economy, we generate a labor flow network resulting from the model as an equilibrium response to external perturbation. The driving mechanisms behind migration are two-folds. The first one is a pure general equilibrium channel which captures the labor flow as an outcome of sectoral reallocation process due to productivity differences across sectors. The second one is the trade channel through which we quantify the inter-country labor flow due to spill-over of productivity shocks due to the trade process. In general, the essential mechanism can be thought of as a planner's problem where the planner treats (perfectly divisible) labor as a movable productive input and allocates it across countries according to productivity shocks realized in different countries. Broadly, we borrow from the recently blooming literature in international trade theory (in the tradition of the celebrated Eaton and Kortum [2002] model) that combines a rich description of the production processes thus capturing the propagation of shocks across the network along with adjustable i.e. movable productive inputs. We show that a similarly specified model can serve as a benchmark case for a frictionless world. With repeated shocks

[1]This rate actually shows a secular decline over the same period as in 1990 the rate was about 3% and in 2011, the rate is about 1.5% of the whole population (Kaplan and Schulhofer-Wohl [2013])

[2]Tiebout [1956] makes an interesting observation that with low rigidities in labor market and no asymmetries in information or externalities induced by government, the consumers would reveal their preference through migration. This idea of 'voting with feet' is found to have significant empirical support Banzhaf and Walsh [2008]. However, in the current paper we do not differentiate between the consumption bundles. Only factor productivity drives migration.

[3]The labor flow generated in [Caliendo et al., 2014] is treated as a by-product of a single realization of shocks whereas we focus specifically on this aspect of labor reallocation with a sequence of shocks and study econometrically the effects of institutional factors.

(calibrates to real data) the model generates *weighted* and *directed* network of labor flow in the steady state that provides a micro-founded theory of multilateral *gravity equation* of migration.

However, there are various social-cultural-political-geographical factors working for and against this process which alters the allocation and hence induces a sub-optimal outcome. Thus such frictions are associated with an welfare loss. We augment the labor flow equations derived from the basic model with several types of frictions to analyze their relative deterrence effects. The contiguity of the countries is seen to induce a bigger flow in data compared to the model. On the other hand, distances in terms of language and culture seems to deter migration. This finding captures the basic proposition of Belot and Ederveen [2012]. With an enlarged database we also find other institutional factors like financial and legal conditions affects migration.

2 Literature review

This paper is related to several streams of literature. On the theoretical dimension, the paper adopts the view that a joint description of the global economy (in the very specific context of current problem i.e. Europe or the U.S.) is important to understand the mechanism underlying migration as evidently the mass of migrants between two countries is influenced by the other countries that are potential donors or receivers (as documented for example in Bertoli and Moraga [2013]). Thus the most general description of the process would be in terms of a network which is both weighted and directed signifying the differential mass of migrants migrating between different pairs of countries as well as capturing the direction of movement. Joint evolution of sectors and propagation of shocks in a interconnected economy and subsequent adjustments has been studied extensively in the recent years (see for example, Acemoglu [2012], Oberfield [2013], Foerster et al. [2011]). Fogli et al. [2012] shows that geographical dispersion of economic quantities imply indirect channels through which the aggregate business cycles is affected. They use county level data to show how unemployment has evolved spatially in the past 30 years including Great Recession.

However, our model depends heavily on the structure laid down by Caliendo et al. [2014] which shows that interregional trade propagates the disaggregated shocks to the rest of the economy. We borrow this idea of sector and region-specific TFP shocks and argue that the complex structure of regional composition of industries and asymmetric TFP shocks in these industries lead to migration. We create a network of regional and sectoral linkages which transmits the idiosyncratic shocks throughout the economy. The framework is broadly based on the international trade literature in the tradition of the Eaton-Kortum model and its subsequent modifications (Alvarez and Lucas [2007]) which incidentally lacks any stress on the process of labor allocation. We analyze the model in the steady state to pin down the labor flow network. Thus even though we borrow the methodology of trade theory and we explicitly calibrate the model to match the trade characteristics of the data, for our purpose it only works as a medium of propagation of shocks. More importantly, we recognize the role of various frictions in determining the actual level of migration. Albeit different in scope, Redding et al. [2012] provides a theory of structural change which can be interpreted as bilateral migration, based on a similar trade theoretic structure. An expanded framework was used by Redding [2014] to study the welfare gains from trade. As such the present contribution attempts to bridge the trade theoretic literature to the labor migration literature (Goston and Nelson [2013]).

There is a huge empirical literature on migration and various factors that magnifies or lessens it. Treyz et al. [1993] was as early attempt that considered a behavioral model of migration and using time-series data showed that migration is affected, among others, by relative employment opportunities, relative wages, industry composition and local amenities. In our theoretical model, the first three effects have been explicitly taken care of and we consider a data set richer in scope to pin down more disaggregated effects of various institutional factors. Klein and Ventura [2009] constructs a growth model to study the welfare gains from removing barriers to migration as there exists substantial productivity differences between the countries (see also Klein and Ventura [2007] for the theretical aspect). However, they focus on the historical evolution of the migration pattern and study aggregated data. The effects of various types of frictions have been studied in details. For example, Kaplan and Schulhofer-Wohl [2013] studies the reason behind the secular decline in U.S. interstate migration over the last two decades and finds reduced geographic specificity and higher information about the states to be important factors. Even then, U.S. interstate migration is far more prominent than Intra-Europe migration. Empirically, Palmer and Pytlikova [2013] finds lax labor laws to be an attractive factor for migration, whereas Belot and Ederveen [2012] finds cultural differences to present an obstacle. See Molloy et al. [2011] and Coen-Pirani [2010] for a detailed overview of the interstate migration in U.S.

3 A model of migration

We consider a model with $T < \infty$ periods. There are N islands (N countries belonging to the European Union or N states of U.S.). In the following, we will refer to both countries and states as 'islands' to avoid confusion, unless explicitly mentioned. Each island is populated by a continuum of homogenous households. There are tradables and non-tradable final goods produced by firms in each island for the consumption of the households. For fixing the notion, we assume manufacturing industry constitutes the tradables and the service industry produces the non-tradables. Each of the final goods producing industries also produces a continuum of intermediate goods using local labor and a local fixed capital stock. This stock might be interpreted as the structures and land which does not grow over time or at least, grows at a much slower pace than labor movement. The islands trade on intermediate inputs. The final goods are only for consumption. The household supplies its labor to both sectors in the home country. Capital is endowed (exogenously) to the islands. The islands have their own TFP shocks. Since labor is the only mobile factor, sector and island-specific productivity shocks will lead to multi-lateral flow of labor across sectors and islands. This feature is obtained from the model proposed by Caliendo et al. [2014]. The flow of workers from one island to another is interpreted as migration.

3.1 Households' problem

In each island a continuum of households constitutes the demand side. They are the sole suppliers of labor which is used in the local production processes. There are two final goods, tradables (M) and non-tradables(S). As has been described above, we lump manufacturing industries to constitutes the tradable sector and the service producing industries to constitute the non-tradable sector. The instantaneous utility function of households in the n-th island at a generic time-point t is given as

$$U_{nt} = (C^M_{nt})^{\alpha}(C^S_{nt})^{(1-\alpha)}. \tag{1}$$

The budget constraint is given as

$$P^M_{nt}C^M_{nt} + P^S_{nt}C^S_{nt} \leq I_{nt}, \tag{2}$$

where

$$I_{nt} = r_{nt}\frac{K_{nt}}{L_{nt}} + w_{nt}. \tag{3}$$

The last equation says that per capita income is the sum of rental income earned from capital stock (or structures and land) and wage. The expected lifetime utility of an agent who over time migrates to a sequence of islands $\{k\}_{1,\ldots,T}$, should be written as

$$U^T = \mathbb{E}\left(\sum_{t=1}^{T} U_{kt}\right) \qquad \text{where } U_{kt} \text{ is given by Eqn. 1.} \tag{4}$$

In order to solve the model, we will assume that there is no uncertainty in the economy in the sense that at every period, the agents first see the realized values of the factor productivity and then decide where to move. However, given diminishing productivity of labor, the utility is equalized across all islands to restore equilibrium ensuring an interior solution. This allows us to solve each period separately as there is no dynamic trade-off. Therefore, we will drop the time index in the later calculations with the implicit understanding that the solution holds true for every period. Clearly the consumption choice is given by

$$C^M_{nt} = \alpha\frac{I_{nt}}{P^M_{nt}} \text{ and } C^S_{nt} = (1-\alpha)\frac{I_{nt}}{P^S_{nt}}. \tag{5}$$

Therefore, the utility of households in one island is

$$\begin{aligned} U_{nt} &= (\frac{\alpha}{P^M_{nt}})^{\alpha}(\frac{1-\alpha}{P^S_{nt}})^{1-\alpha}I_{nt}, \\ &= \frac{I_{nt}}{P_{nt}}, \end{aligned} \tag{6}$$

where P_{nt} is the standard ideal price index defined as

$$P_{nt} = \big(\frac{P^M_{nt}}{\alpha}\big)^{\alpha}\big(\frac{P^S_{nt}}{1-\alpha}\big)^{1-\alpha}. \tag{7}$$

Since the agents are free to move across the islands, in equilibrium we would have

$$U_{nt} = \bar{U}_t, \quad \text{i.e. utility is equalized across the islands.} \tag{8}$$

Note that utility has to be equalizes across islands at every point of time, but not necessarily across time. In other words, in general $\bar{U}_t = \bar{U}_{t'}$ for any $t, t' \leq T$. Thus the lifetime utility of an agent is

$$U^T = \sum_{t=1}^{T} \bar{U}_t \tag{9}$$

whatever be the sequence of islands she migrated to in her lifetime.

3.2 Supply side

The final goods (both manufactured goods and the service products) are used for consumption. However, in each sector these goods (M and S) are produced by a bundling technology which uses a continuum of intermediate goods. These intermediates are in turn produced by combining local labor and capital stock. Note that as in Caliendo et al. [2014], we keep the trade channel open as the final goods producing firms can buy intermediate goods from any island. Thus we can identify the source of fluctuation in labor allocation through this channel. As a simple example of the production process that we consider, one might imagine a restaurant that buys a sequence of exotic ingredients along with domestic ingredients, labor and capital to produce a meal that is consumed domestically. This particular structure (along with its predecessors and variants) has been thoroughly analyzed in a number influential papers (see for example, Eaton and Kortum [2002], Redding [2014], Alvarez and Lucas [2007]). In particular, Caliendo and Parro [2014] and Caliendo et al. [2014] developed an elegant block recursive algorithm to solve the static model that we will utilize. Note that many papers trace the fluctuation in the production structure to the input-output channel for a domestic economy (e.g. Acemoglu [2012], Foerster et al. [2011], Caliendo et al. [2014] which we do not consider to be appropriate for explaining country-country migration.

3.2.1 Intermediates

Firms of both sectors in each island i, produces a continuum of varieties of intermediate goods following an i.i.d. shock process, $\xi^{M,S}_n$ and a deterministic productivity level $Z^{M,S}_n$. As in Caliendo et al. [2014], this shock process follows a Frechet distribution with shape parameter $\theta^{M,S}$. The production functions for both sectors ($j = M, S$) are defined as

$$q^j_n = \xi^j_n Z^j_n (k^j_n)^{\beta_n} (l^j_n)^{1-\beta_n}, \tag{10}$$

where lowercase letters l and k denote the demand for labor and capital respectively by a representative firm. The shock process Z is assumed to follow a random walk in logarithm that is, we assume that

$$Z^i(t+1) = \psi_{it} Z^i(t) \quad \text{where } \psi_i \sim \ N(1, \sigma_i) \text{ and } i \in \{M, S\}. \tag{11}$$

The unit cost of production in each sector in island n, can be found by minimizing

$$w_n^j l_n^j + r_n^j k_n^j, \tag{12}$$

subject to

$$\xi_n^j Z_n^j (k_n^j)^{\beta_n} (l_n^j)^{1-\beta_n} = 1. \tag{13}$$

It is straightforward to show that the unit cost,

$$c_n^j = \frac{1}{\xi_n^j Z_n^j} [\beta_n^{-\beta_n} (1-\beta_n)^{(1-\beta_n)}] r_n^{\beta_n} w_n^{(1-\beta_n)}. \tag{14}$$

Thus the firms would produce the variety as long as the price more than c_n^j. Assuming perfect competition, price exactly equals to the unit cost. For notational convenience, we define

$$B_n^j = \beta_n^{-\beta_n} (1-\beta_n)^{(1-\beta_n)} \quad \text{and} \quad \omega_n^j = B_n^j r_n^{\beta_n} w_n^{(1-\beta_n)}. \tag{15}$$

Let $p_n^{M,S}$ denote the equilibrium price of two sectors in location n. For a firm producing intermediates, profit is given by

$$\pi^j_{intermediates} = p_n^j q_n^j - w_n l_n^j - r_n k_n^j. \tag{16}$$

Thus at optimal,

$$w_n l_n^j = (1-\beta_n) p_n^j q_n^j, \tag{17}$$

$$r_n k_n^j = \beta_n p_n^j q_n^j. \tag{18}$$

3.2.2 Final goods

As has been described above, the final goods production in both sectors ($j = M, S$) is carried out competitively using a bundling technology,

$$Q_n^j = [\int (\tilde{q}_n^j(\xi^j))^{\gamma_n^j} \phi^j(\xi^j) d\xi^j]^{1/\gamma_n^j}, \tag{19}$$

where

$$\phi^M(\xi^M) = exp\big(- \sum_{n=1}^{N} (\xi_n^M)^{-\theta^M} \big), \tag{20}$$

$$\phi^S(\xi^S) = exp\big(- (\xi_n^S)^{-\theta^S} \big). \tag{21}$$

Note that the pattern of trade is incorporated in the above production functions in terms of intermediates.

Therefore, the profit of the final goods producers in both sectors ($j = M, S$) are defined as

$$\pi^j_{final} = P^j_n Q^j_n - \int p^j_n \tilde{q}^j_n \phi^j_n d\xi^j. \quad (22)$$

The solution is given as

$$\tilde{q}^j_n = (\frac{p^j_n}{P^j_n})^{-\frac{1}{1-\gamma^j_n}} Q^j_n, \quad (23)$$

which on substitution in the production function, generates

$$P^j_n = [\int (p^j_n)^{\frac{\gamma}{\gamma-1}} \phi^j dz^j]^{\frac{\gamma-1}{\gamma}} \quad (24)$$

3.2.3 Closing the model

Final goods are non-tradable in all sectors. Only the intermediates in the manufacturing sector M are tradables. The cost of transportation from location n to i (in units of good produced in location n) is given as

$$\begin{aligned} \tau^M_{ni} &\geq 1, \\ \tau^S_{ni} &= \infty. \end{aligned} \quad (25)$$

For obvious reasons, we define $\tau^M_{nn} = 1$. Such a structure imposes a ice-berg cost on transportation. Therefore, the pricing equation is given as

$$p^M_n = \min_i (\frac{\kappa^M_{in} \omega^M_i}{\xi^M_i Z^M_i}). \quad (26)$$

Following Eaton and Kortum [2002], such a specification gives us

$$P^M_n = \Gamma(f_n)^{\gamma^M_n/(\gamma^M_n-1)} [\sum_{i=1}^{N} [\omega^M_i \kappa^M_{in}]^{-\theta^M} (Z^M_i)^{\theta^M}]^{-1/\theta^M}, \quad (27)$$

where $f_n = 1 + (\gamma^M_n)/(\theta^M(\gamma^M_n - 1))$. On the other hand, the price index of the non-tradables is given as

$$P^S_n = \Gamma(f_n)^{\gamma^M_n/(\gamma^M_n-1)} \omega^S_n (Z^S_n)^{-1}. \quad (28)$$

The labor and capital market clearing equations are

$$L^M_n + L^S_n = L_n \text{ and } K^M_n + K^S_n = K_n, \quad \forall n \leq N. \quad (29)$$

and at the aggregate level

$$\sum_n L_n = 1. \quad (30)$$

The most important equation of labor allocation is

$$L^N_n = [\frac{\omega_n}{P_n \bar{U}}]^{1/\beta_n} K_n, \quad (31)$$

where ω_n is described in Eqn. 15.

3.2.4 Regional market clearing

Since final goods are only consumed (no investment opportunity),

$$L_n C_n^M = Q_n^M \quad \text{and} \quad L_n C_n^S = Q_n^S. \tag{32}$$

In terms of expenditure on the final goods in location n, we find

$$X_n^M = \alpha I_n L_n \quad \text{and} \quad X_n^S = (1-\alpha) I_n L_n. \tag{33}$$

We define the share of the expenditure on intermediates in the total revenue,

$$\pi_{ni}^M = \frac{X_{ni}^M}{X_n^M} = \big(\Gamma(f_n)^{\gamma/(1-\gamma)} \frac{\kappa_{ni}^M \omega_i^M}{P_n^M Z_n^M}\big)^{-\theta^M}. \tag{34}$$

For the non-tradables,

$$\pi_{nn}^S = 1. \tag{35}$$

Now we can define a competitive equilibrium. Given total labor endowment L (we normalize it so that $L = 1$) and the capital endowment $\{K_n\}_n^N$, a competitive equilibrium is an utility level $\bar{U}$, factor prices $\{r_n, w_n\}_n^N$, labor allocation $\{L_n\}_n^N$, final goods expenditure $\{X_n^M, X_n^S\}_n^N$, consumption vector $\{c_n^M, c_n^S\}_n^N$, prices of final goods $\{P_n^M, P_n^S\}_n^N$ and pairwise regional intermediate expenditure share in every sector $\{\pi_n^M, \pi_n^S\}_n^N$ such that all markets clear.

3.3 The effects of temporal shock

The above system of equations can be solved at every time point t after realization of the sequence of sector and island specific shocks $\hat{T}_n^j$. Given a set of parameters $\{\theta^j, \alpha, \beta_n\}_{n,j=\{S,M\}}^N$ and data for $\{I_n, L_n, \pi_{ni}^j, \hat{T}_n^j\}_{n,i,j=\{S,M\}}^{N,N}$ the system yields solution for $\{\hat{w}_n, \hat{L}_n, \hat{X}_n^j, \hat{P}_n^j, X{\prime}_n^j, \pi{\prime}_{ni}^j\}_{n,i,j=\{M,S\}}^{N,N}$ with the hat notation denoting the ratio of the new value of a variable to that of the old value. From these we can find out $\{\hat{r}_n, \hat{\pi}_{nn}^j, \hat{A}_n^j, G\hat{D}P_n^j, \hat{\bar{U}}\}_{n,j=\{M,S\}}^N$.

3.4 The network of migration

Given the labor dynamics across countries, we are in a position to construct the labor mobility network. Note that due to any TFP shock, all of the countries will face a fluctuation in the efficient level of employment. Some countries will lose workers whereas others will gain.

Since workers are assumed to be homogenous both in terms of consumption pattern and labor supply, they would show no particular preference for any country under the no-friction regime that is when there is no friction opposing labor mobility. Recall that for the n-th country, the total change is $\hat{L}_n$. Therefore, total change for the n-th

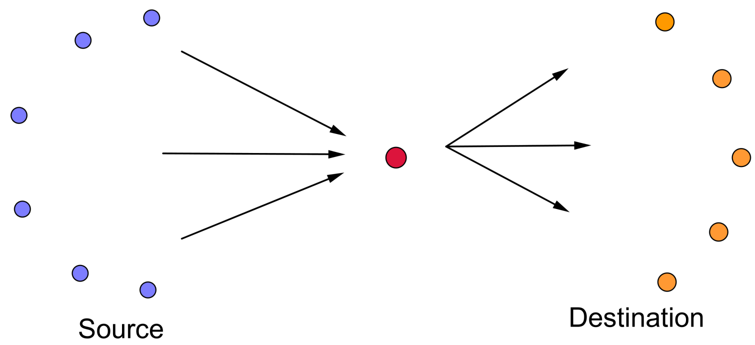


Figure 1: An illustration of flow of workers after realization of productivity shocks. Some countries are donor and others are receivers.

country is $(\hat{L}_n - 1)L_n$. Thus one can write the labor flow from the j-th country to the i-th country at time t as

$$F^t_{ji} = \left(\frac{(\hat{L}_j - 1)L_j}{\sum_{n \in \mathcal{N}^{out}} (\hat{L}_n - 1)L_n} \right) (\hat{L}_i - 1)L_i, \tag{36}$$

where $\mathcal{N}^{out}$ is the set of countries from which labor migrates to other countries and $j \in \mathcal{N}^{out}$. The above flow equation uses the fact that the labor is homogenous in that the inflow from a country j to country i will be proportional to the contribution of country j relative to the total mass of displaced workers. Note that one could alternatively write it as

$$F^t_{ji} = -\left(\frac{(\hat{L}_i - 1)L_i}{\sum_{n \in \mathcal{N}^{in}} (\hat{L}_n - 1)L_n} \right) (\hat{L}_j - 1)L_j, \tag{37}$$

where $\mathcal{N}^{in}$ is the set of countries to which labor migrates from other countries. Evidently in absence of links to the rest of the world,

$$\sum_{i \in \mathcal{N}^{in}} (\hat{L}_i - 1)L_i = -\sum_{j \in \mathcal{N}^{out}} (\hat{L}_j - 1)L_j, \tag{38}$$

that is total inflow must be equal to total outflow.

With a single realization of a set of shocks across the sectors and the islands, there will be donors and receivers. Those island that experienced relatively better shocks will be ranked higher in relative attractiveness. Thus workers will migrate to the receivers. Therefore, at every point of time such a set of shocks would generate a directed and weighted network of migrants. But this network would be unidirectional in the sense that labor flow is always one-way between any pair. However, with repeated shocks in the steady state, an island that was a net donor in one period, may turn out to be a net receiver the next period. Thus in general over sufficient number of time points (with large enough T), we will generate bilateral flow for each and every possible pairs of islands. Evidently the net flow (inflow-outflow) would be much smaller than the gross flow (inflow+outflow). This is another characteristic of model that matches the data well, for example in case of U.S. the gross flow is about 10 times larger than the net flow as has been documented in Kaplan and Schulhofer-Wohl [2013].

4 Results

We calibrate (see Table 1 for the parameter values) the parameters of the theoretical model for two sets of data. The first one is for 15 of the countries in the European Union and Norway. The second one is for the states of U.S. In both cases, as mentioned earlier we will not be seeing any 'South' to 'North' kind of migration. The islands in both the cases have inherent homogeneity. However, institutional frictions should be much clear in the EU countries. In the following, we discuss the 2 datasets (U.S. andEuropean countries) briefly and then compare the results from the theoretical model with the real data. The shape parameters (of the shock distribution z) θ describe competitiveness in production process. Its value is taken to be the average value of θ computed in Eaton and Kortum [2002] which shows that it varies over a huge range from 3.60 to 12.86. We have rounded the average value to the nearest digit to keep it simple. For the same value describing the service sector, we chose a smaller value for it to indicate a higher range of heterogeneity in the service sector. However, it does not really matter because in the current formulation, service goods are not traded. Another important point is that while generating the shocks to the productivity Z, we divided each shock by the length of the time horizon T to keep the system in the steady state. Thus, for any $i-$th sector

$$\psi_{it} = \frac{\tilde{\psi}_{it}}{T} \quad \text{where } \tilde{\psi} \sim N(1, \sigma), \tag{39}$$

so that

$$\sum_{t}^{T} \psi_{it} = \sum_{t}^{T} \frac{\tilde{\psi}_{it}}{T} \to 1 \quad \text{for } T \to \infty. \tag{40}$$

The values given are for U.S. For Europe only the standard deviation of the shocks differ as the time-series of shocks are different in the European countries. However this does not change anything qualitatively.

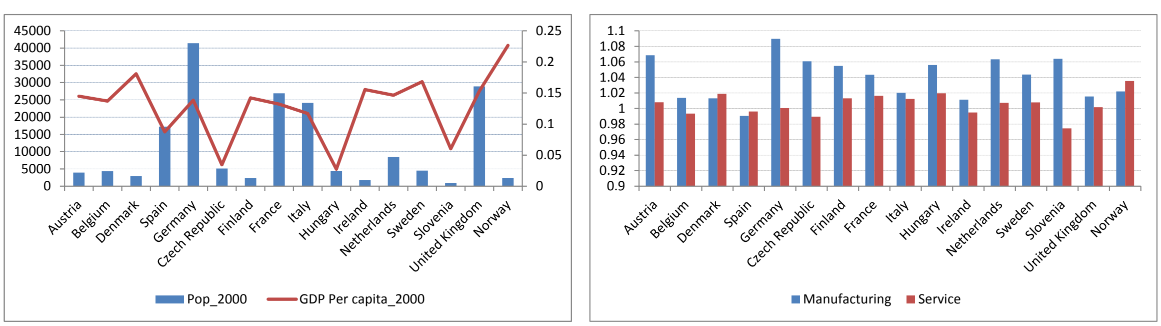
Table 1: Parameter values calibrated for simulation purpose (U.S.)

Description	parameter	value
Service goods' share in cost	1-α	0.6
Capital share in cost	β	0.3
Dispersion of shocks: Manufacturing	θ_m	8
Dispersion of shocks: Service	θ_s	2
Std. dev. of shocks: Manufacturing	σ_M	0.0380
Std. dev. of shocks: Service	σ_S	0.0057
Length of simulation	T	200
# simulations averaged	-	O(10)

4.1 The migration network of Europe

We look into bilateral migration data from 2000 to 2007 for 16 countries. Our objective is to build the complete 16 ×16 matrix from the theoretical model and compare each element with the data. However, there is incompleteness in the available data depicting the bilateral flow of labor as a few countries do not report the migration statistics at all, some countries stop reporting after a period of time and some start only after a time point. So we extract the maximum amount of data available and compare it with the results that the theoretical model provides.

To simulate the bilateral migration - driven by productivity shocks, from the theoretical model we use a block recursive algorithm (see Sec. 8.2). We use the parameter values described in 1, and provide the population data for the countries (L_i; we normalize it so that $\sum_i L_i = 1$), the per-capita GDP, the sectoral TFP shocks and the bilateral trade relationship between countries (π_m and π_s) as inputs of the model (see Sec. 8.3). Fig. 2 provides snapshot of the data for a single year, 2000. From the right panel in Fig. 6 we can see that sectoral shocks are highly asymmetric across countries. To capture this pattern, we estimate the degree of variation of the shocks across sectors



(a) GDP per capita and normalized population

(b) TFP distribution

Figure 2: Data description for EU countries for the year 2000

We compare the theoretical results (referred to henceforth as TFP driven migration) with the actual data of migration. In order to compare meaningfully, we consider the dyads for which actual migration data is available (both m_{ij} and m_{ji}) and sum it up ($m_{ij} + m_{ji}$) to get rid of the direction of migration and regress this on the TFP driven migration (theoretical m_{ij} and m_{ji}).

From the theoretical model we get that due to TFP differences net migration in the 16 countries should be around 1% to 2%. In the next table we regress the dyad specific bilateral migrations from actual data on the TFP driven migration results (from theoretical model). Table 2 contains results of regressing data on model-predicted migration. To do that we construct the *l.h.s.* variable as

$$y_k = \frac{m_{ij}^{data} + m_{ji}^{data}}{\sum_n L_n^{data}}. \tag{41}$$

We normalize the migration flow by the total population so that we can talk about total flow of migration in percentage terms. Similarly, we construct the regressor as

$$x_k = \frac{m_{ij}^{model} + m_{ji}^{model}}{\sum_n L_n^{model}}. \tag{42}$$

Note that we already normalized the labor allocation in the model so that the denominator is 1. In the regression we control for contiguity which is a dummy variable showing whether two countries in a dyad shares a border or not.

Table 2: Regression results for EU - Nominal

	TFP driven migration	Contiguity	Intercept	Adjusted R^2
2000	0.05836***	0.00001***	0.00000	0.77380
2001	0.05870***	0.00002***	0.00000	0.76270
2002	0.06118***	0.00001***	0.00000	0.77240
2003	0.05456***	0.00001***	0.00000	0.63560
2004	0.05709***	0.00001**	0.00000	0.58090
2005	0.06132***	0.00001**	0.00000	0.66860
2006	0.06376***	0.00001***	0.00000	0.68340
2007	0.06030***	0.00001***	0.00000	0.73690

Note: *p<.1, **p<.05, ***p<0.01.

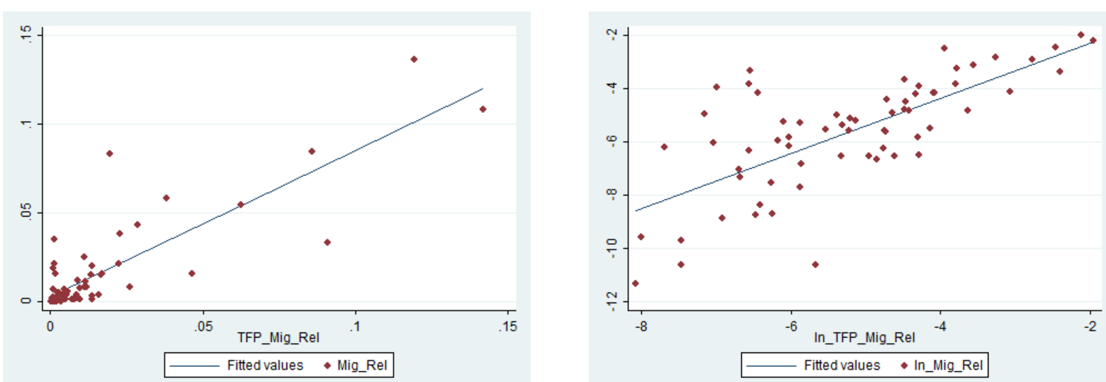
We find from Table 2 that though the coefficient of TFP driven migration is much lower than 1 which should have been the case if the model match the data perfectly, but it is significant and in each year the model has sufficiently high R^2. This is an interesting finding as it basically suggests that the total mass of migrants predicted by the model is much higher than what is seen in the data. A legitimate question at this point would be how do know that the model predicted mass of migrants have any real meaning at all? In the next section we answer that question by showing that it describes the U.S. migration process with reasonably high accuracy. The gross flow of migrants in the model matches U.S. data pretty well. To account for the discrepancies in the total flow, we divide the relevant variables on both sides of the regression by the sum of the all values of weights that is the new *l.h.s.* variable is $\tilde{y}_k = y_k / \sum_k y_k$ and the regressor is $\tilde{x}_k = x_k / \sum_k x_k$. The control variable remain as is.

Table 3: Regression results for EU - Relative

	TFP driven migration	Contiguity	Intercept	Adjusted R^2
2000	0.84328***	0.01700***	-0.00046	0.77380
2001	0.83180***	0.01779***	-0.00042	0.76270
2002	0.85237***	0.01418***	-0.00013	0.77240
2003	0.79403***	0.01494***	0.00063	0.63560
2004	0.77543***	0.01344**	0.00116	0.58090
2005	0.81675***	0.01351**	0.00052	0.66860
2006	0.75724***	0.01441***	0.00122	0.68340
2007	0.71356***	0.01980***	0.00104	0.73690

Note: *p<.1, **p<.05, ***p<0.01.

The results are presented in Table 3. Evidently, the estimated coefficient is now about 0.8 which is much closer to 1. Note that $\tilde{y}$, $\tilde{x} \in [0, 1]$ making them comparable in order. So in relative sense the theoretical model does quite well in explaining the migration in Europe. However, the it does not match the total migration; in fact predicts a much higher value.



(a) Relative - normalized values

(b) Log relative - log of normalized values

Figure 3: Scatter plots showing the normalized actual dyad migration data on TFP simulated results for the European countries for year 2000.

In the Fig. 3 on the left panel we plot the normalized bilateral migration data on the y-axis and the predicted values of the same on the x- axis. In the right panel we take the natural log of both variables to reduce the effects of the outliers. Each point on the scatter plot denotes the real data and the prediction for a dyad.

4.2 The migration network for USA

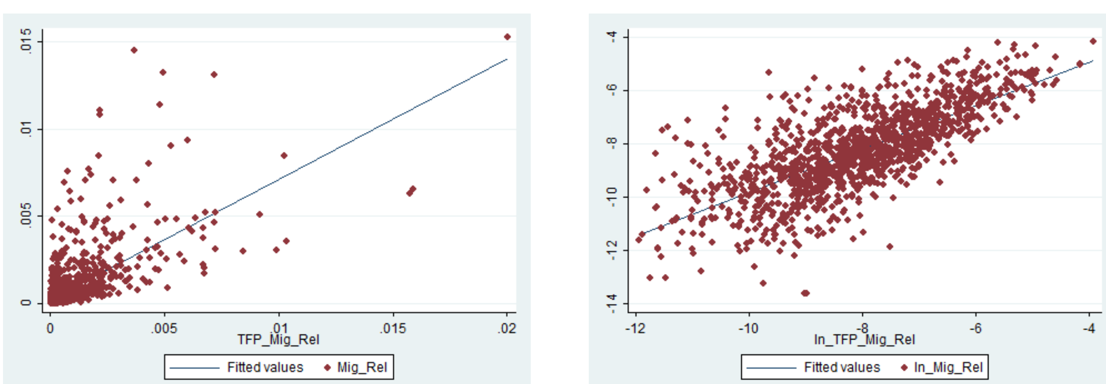
To check robustness of the mechanism and to test the model on a frictionless benchmark case, we redo the above exercise on USA. We plug in data of population, per capita GDP, bilateral trade and TFP distribution for 51 states in the model to generate a migration network. The American Community Survey (ACS) provides data of interstate migration for 2007. Other years are not available.

Table 4 shows the results of regressing actual data (at level values - nominal and normalized - relative) on theoretical model results. Even at the nominal level the table shows that TFP changes can explain most of the migration seen in real data. These regressions are also on dyad observations and do not consider the direction of flow of migration. The interesting result is that the predicted total mass of migrants match pretty well with the data. Calibrating the model we see that the total flow should be around 2%. From previously mentioned ACS data we do get the overall migration to be around 2%. Thus the orders of the variables are perfectly comparable.

Table 4: Regression results for US

	TFP driven migration	Contiguity	Intercept	Adjusted R^2
Nominal	0.82695***	0.00006***	0.00000	0.62990
Relative	0.68521***	0.00243***	0.00004	

Note: *p<.1, **p<.05, ***p<0.01.



(a) Relative - normalized values

(b) Log relative - log of normalized values

Figure 4: Scatter plots showing the normalized interstate migration data on the simulation results for US year 2007, in level and in log.

Fig. 4 plots the normalized actual interstate migration on the normalized values of migration predicted. In the right panel we take natural log - showing a very clear clustering around the fitted line. Evidently, the bulk of the labor flow is captured by the theoretical model which emphasizes the productivity-driven migration in line of Klein and Ventura [2009] and Kennan and Walker [2011]. That is, in case of U.S. which was taken as the closest approximation to a frictionless place (in terms of social and political dimensions), is actually described well by a model emphasizing only economic incentives behind migration.

4.3 Working of the model: multilateral gravity equations

From the tables presented above, the model explains about 63% of the fluctuations in edge weight of the migration network in case of U.S. (see Table 4)) controlling for contiguity. Similarly, in case of Europe the model explains about 70% on an average (see Table 3). In both cases the coefficient assigned to the TFP-driven migration is sufficiently high (about 0.8 on an average). The reason the model fits well with the data is that it effectively creates a network that describes a multilateral gravity equation between all pairs of islands. The basic descriptive equation of gross flow of labor between any pair of islands (dyads) is

$$\mathbb{F}_{i,j} = C\left(\frac{L_i.L_j}{d_{i,j}^{\eta}}\right), \tag{43}$$

where the *l.h.s.* is the weight of the edge of the network between the $i-$th and the $j-$th island (representing trade flow or migration) and the *r.h.s.* shows that it is proportional to the product of the two islands' population and inversely proportional to some power of the distance between these two islands. The emergence of such a pattern have been subject to a huge number of empirical studies in the trade theoretic literature (see Chaney [2014]). Fig. 5 describes the relationship between the weights of the dyads in terms of labor flow and the products of populations of the corresponding countries.

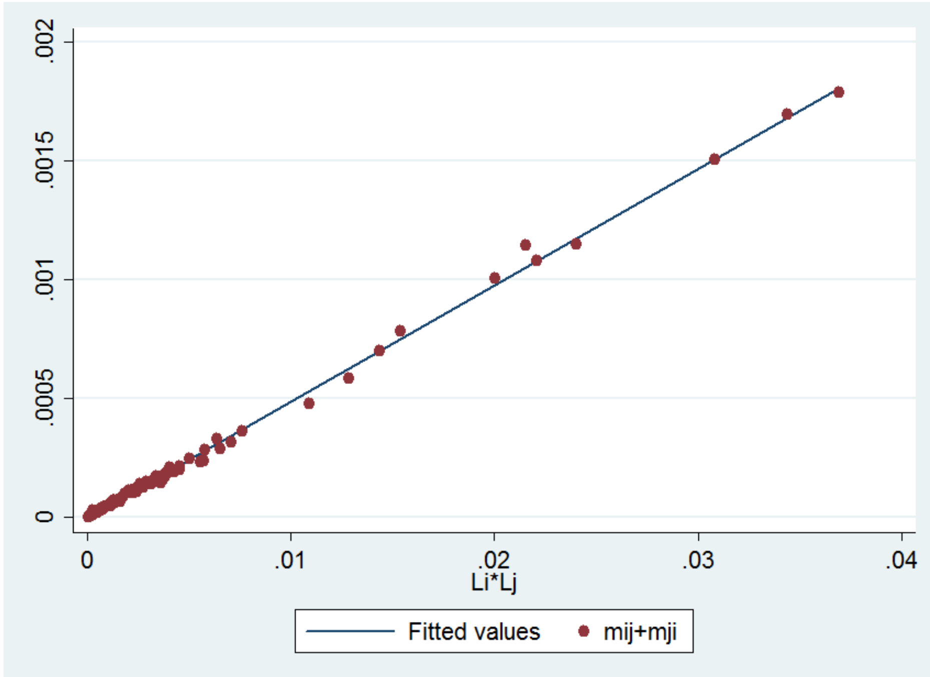


Figure 5: The model captures the multilateral gravity relation between donor and receiver countries. We have plotted the weight of dyads $(m_{ij} + m_{ji})$ as a function of the product of populations $(L_i.L_j)$ for all dyads $i, j \in N$

Since the distances between the islands do not have particularly large variations, the weights of the dyads depend almost linearly on the product of population. Thus the model provides a macro description of the migration network very easily.

5 European immobility puzzle

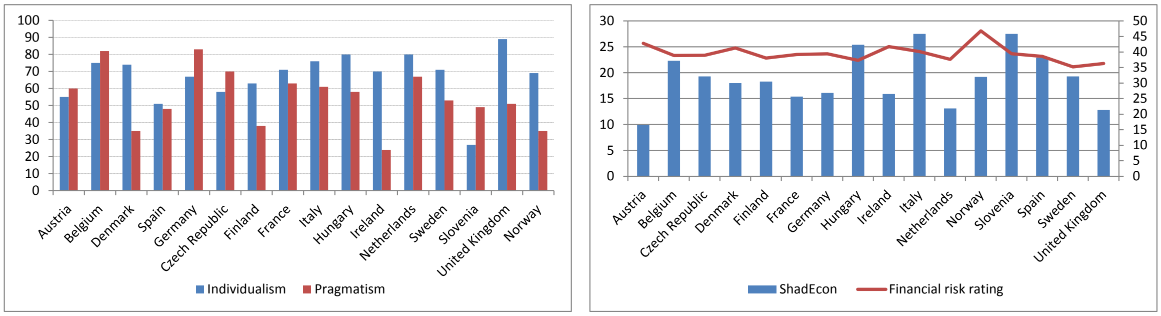
As is well known, one of the basic principles behind the formation of the European union was to ensure freedom of movement of productive inputs. In particular, it was supposed to reduce the barriers in the labor flow making the market more flexible. Multilateral gravity equation helps us to pin down the relative strengths of the edges of the migration network. However, as is clear from the above results, the model shows that under reasonable parameterization the predicted mass of migrants are in the order of 100 times more than what is seen in Europe for the period we considered (2000-07). This refers to the puzzle that even after the legal and political barriers have been systematically removed thus potentially reducing economic frictions on the labor allocation process, people did not respond immediately to the existing incentives. This problem has attracted attentions both from theoretical and policy-making point of view. In particular, Belot and Ederveen [2012] ascribes this role to the negative effects of cultural differences indicating that such distances can induce an extremely low migratory response if properly addressed. In this paper, we complement this analysis using many other types of frictions ranging from social to political along with the obvious factor, lingual differences. Generally, in this section we look into a list of fine-grained measures of institutional differences between the 16 European countries and argue that these substitute some of the TFP driven migration instead of complementing and thus, provide "frictions" opposing the incentives.

5.1 Distances in institution and culture

We look at a broad list of variables which could ideally be considered as frictions. We start with historical links between countries. We used the CEPII data to determine colonial links between countries or whether the two countries in the dyad were the same country historically.

One of the hypothesis could be that language barrier is one of the reasons which stops people from migrating easily. To control for this we looked into several language indices. From the CEPII, bilateral data on whether two countries speak same official language, native language, language proximity index and common language index was obtained. In Table 6, LangIndex is the common language index. This index gives an approximate distance between two countries due to language. If the index is higher that means the two countries have less language barriers. We also looked into Ethnologue language statistics - country specific data on total number of languages used as first language, immigrant languages in the country and probability that two people selected at random will have different mother tongues (Greenberg's diversity index).

Differences in culture could be another barrier to migration - to control for this we use the Hofstede's cultural indices. This is a rich set of index encompassing cultural aspects such as individualism versus collectivism in the economy, uncertainty avoidance, power distance (strength of social hierarchy), masculinity-femininity (task orientation versus person-orientation), long-term orientation and indulgence versus self-restraint. In Table 6 'Indiv' refers to Individualism and 'Pragm' refers to Pragmatism and they are two of the Hofstede cultural index. These indices are country specific. For dyad level regression we considered the numerical differences between these indices for the two countries as a proxy of their 'distance' in the corresponding category. So a higher value in distance for 'individualism' would mean that one country in the dyad believes in individualistic society as a way of life and the other country believes in a relatively less individualistic society which is another way of saying that the country believes in a more collective/ family-oriented way of life.



(a) Hofstede index: individualism & pragmatism

(b) Shadow economy and financial risk rating in 2001

Figure 6: Cultural and Financial Indices for European countries

Next we considered several stability indices broadly related to the polity. The main sources of this data was Political Risk Services, International Country Risk Guide, Freedom House and World Bank reports. We looked into government stability, democracy index, ethnic tensions, religious conflicts, military in politics and external conflicts to understand the political stability in the economy. For each of these risk rating available on country level we considered the 'distance' between the ratings between two countries for dyad regressions. For socio-economic stability we looked into corruption index, freedom of press, socio-economic conditions and voice and accountability. Distance between financial stability indices like financial risk rating, investment profile and existence of shadow economy are also included as controls. Distance in shadow economy index would mean in the dyad one of the countries has a huge underground economy and the other one does not.

We also looked into some of the Europe specific dummies - such as using euro or not and entry into European union. In the next section we look into the regression results on all the mentioned distance variables.

5.2 Explaining the missing flow: effects of institutional factors

For the 16 countries in Europe (same as Sec. 4.1) we computed all the institutional distance measures. As a response variable we consider the ratio of actual bilateral migration data to TFP driven migration. We regress this on the various institutional measures. The results are tabulated in Table 6. The reason we took the ratio of the data to the model (y_k/x_k as defined in Eqn. 41 and 42 resp.) as the variable to be explained is that this way we get rid of the gravity-effects which is driven solely by economic causes. Thus the left over variations would be driven by other non-economic factors. Two methodological points are to be noted. One, some variation in the data could be due to misreporting which we cannot rectify and two, we are considering the model to capture the economic incentives completely and in the gravity equation set up, the proportionality term captures all institutional effects, magnifying or lesseing the flow. Consider any pair $\{i, j\}$ of dyad k. Given this interpretation, note that

$y_k = C_{ij}^{data}.L_i.L_j/d_{ij}^{\eta}$ and $x_k = C_{ij}^{model}.L_i.L_j/d_{ij}^{\eta}$ and from Fig. 5, we see that C^{model} is roughly a constant, independent of the specific dyad considered. Thus the idea is that a low value of the variable (y_k/x_k) indicates that less migration occurred between a pair of countries consisting the dyad k in reality, than in the model. Therefore, a negative value of the coefficient of a suitably defined distance metric would indicate presence of a friction. Alternatively, in presence of similarities in any dimension for example, lingual, we would expect a higher flow.

Table 5: Correlation matrix for political stability indices

	Voiceacc	Polstab	Govteffec	Reg quality	Ruleoflaw	Corrupt	Transparency
Voiceacc	1.00						
Polstab	0.83	1.00					
Govteffec	0.83	0.72	1.00				
Regulation quality	0.56	0.53	0.72	1.00			
Ruleoflaw	0.91	0.84	0.94	0.63	1.00		
Corruptcont	0.93	0.84	0.91	0.66	0.96	1.00	
TransparencyCPI	0.91	0.76	0.85	0.56	0.91	0.91	1.00

We use stepwise regression methodology to pin down the predictors. Most of the considered 'friction' variables under an umbrella term broadly defining similar characteristics, are correlated. For example, Table 5 shows the correlation matrix a number of variables that belong to a broad class of political stability indicators. Given this level of correlation in the data, we do not consider all variables simultaneously as that will not increase the predictive power.

Table 6 shows the regression results for the European country dyads. For each year, from 2000 to 2007, we regress ratio of actual bilateral migration data to TFP driven migration on euro currency dummy and distance between -language index, Hofstede index of individualism (vs. collectivism) and pragmatism, financial risk rating and shadow economy, controlling for contiguity.

Table 6: Regression results for EU - frictions

	Contiguity	LangIndex	Indivi	Pragm	Euro	FinRiskRat	ShadowEco	Intercept	AdjR^2
2000	0.23***	0.38**	-0.11***	-0.11***	-0.05	0.02	-0.01**	0.63***	0.45
2001	0.26***	0.36**	-0.11**	-0.11***	-0.06	0.02*	-0.01*	0.63***	0.47
2002	0.21**	0.39**	-0.12***	-0.12***	-0.07	0.02	-0.01*	0.70***	0.43
2003	0.22***	0.48***	-0.11**	-0.11***	-0.06	0.03*	-0.01	0.61***	0.45
2004	0.18**	0.52***	-0.11***	-0.13***	-0.06	0.02*	-0.01	0.67***	0.43
2005	0.18**	0.45***	-0.10**	-0.10***	-0.06	0.02	-0.01*	0.58***	0.41
2006	0.18**	0.54***	-0.07*	-0.08**	-0.09	0.01	-0.01*	0.52**	0.33
2007	0.16*	0.56***	-0.09**	-0.10**	-0.19***	0.02	-0.02**	0.64***	0.40

Note: *p<.1, **p<.05, ***p<0.01.

The signs of the coefficients have meaningful interpretation - for example having similar language helps in migration (positive signs of the LangIndex) and different cultures act as an impediment to migration (negative signs for distance between cultural index). This exercise shows that there are factors which encourage or discourage migration, over and above mere economic incentives.

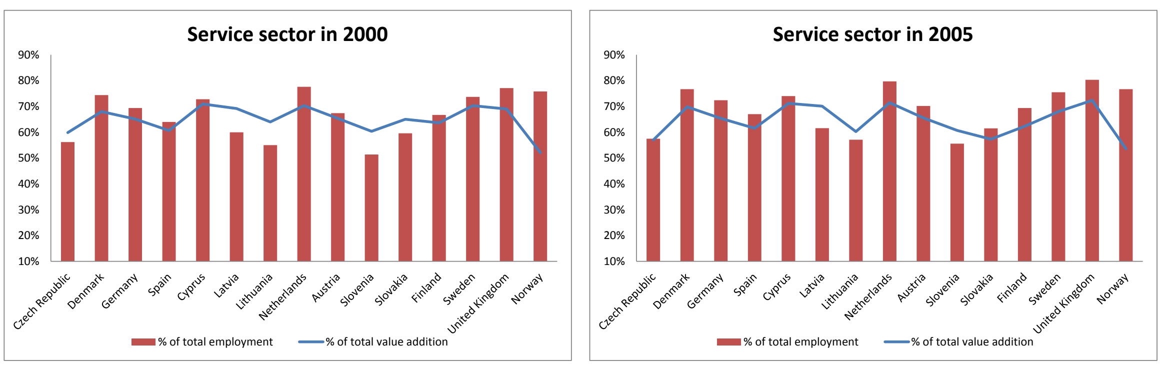
6 Counterfactuals

The model that we have presented above captures the economy in a very short horizon of time. But it is well known that over a considerable amount of time several economic variables do change substantially. The empirical observation of structural shift is probably the most prominent example of it which states that over time the service sector tends to dominate the manufacturing sector (Acemoglu [2007]). Another interseting observation is that the level of migration itself shows time-varying properties, for example even in the U.S. there exists a secular decline in the aggregate level of interstate migration. It has shown about 50% fall over the period of last two decades (Kaplan and Schulhofer-Wohl [2013]). Similarly in a growing economy, any particular sector taken in isolation, shows a secular increase in per-capita capital stock. In the context of the present model, we can use parametric variations to understand the changes in the behavior of economic incentive-driven migration process in face of these long-run changes in the 'deep' parameters of the economy.

A common observation in the following exercises is that the multilateral gravity-type interpretation of the flow network generated is valid in all cases. What really shows the effects of the parametric variations is the total mass of labor migrating when subjected to shocks.

6.1 Structural change

The shift of employment from agriculture to manufacturing and then eventually to service sector is referred to as structural change (Acemoglu [2007]). Of course, in the modern age agriculture has mostly become obsolete in most of the developed countries and the speed at which this change takes place differ from country to country. However, the gradual shift of employment from manufacturing to service are present beneath the facade of growth process of modern economies almost without any exception. There is a large literature making connections between economic growth and structural change (see Acemoglu [2007] for a detailed analysis). In the present context, the effects of structural change on economic growth is not important per se. But since this refers to an ever-increasing share of service goods in the consumption basket (assuming a demand-driven structural change), we see an increase in size of the non-tradable sector. This will have important consequences for labor migration pattern at the aggregate level. Redding et al. [2012] builds a model of structural change on a framework similar to ours and explains the movement of labor away from agriculture resulting in urbanization over a century. Instead we take the phenomena of structural change as given and by parametric variation of preference, we seek to determine the effects on migratory responses.



(a) 2000

(b) 2005

Figure 7: Sectoral decomposition of different countries five years apart. The production process across all countries show an unidirectional change in favor of service indicating a structural shift. Due to this movement away from tradables to non-tradables, it would affect the level of migration.

There are broadly two ways to capture the structural change. One interpretation is that it is demand-driven that is over time people demand more service goods than manufactured goods (see for example Echevarria [1997] for a preference-driven mechanism). The simplest way to address this issue in the current context is to do comparative static between to economies with different preference for manufactured goods. For comparison we assume a symmetric economy consisting of $N = 10$ islands where all islands have equal share in initial population and then trade matrix is perfectly symmetric in the sense that all elements are $1/N$ indicating equal weights attached to all islands by all islands and per-capita GDP is normalized at 1 for every island. With $\alpha = 0.7$ and $\beta = 0.3$, the total mass of people migrating is about 1.5% whereas if we reduce α to 0.4, the corresponding value is about 1.6% indicating a marginal increase. The interpretation is that with higher weight attached to service goods, that sector becomes more important which is non-tradable. The productivity shocks in the non-tradable sector cannot be mitigated through trade by definition. Thus it shows a higher level of adjustment in terms of the only movable input, labor.

6.2 Increasing asymmetries in the trade network

The trade network (interstate or intra-Europe) is extremely skewed as has been documented in several studies. See for example, Chaney [2014] for regional, and Foerster et al. [2011] and Acemoglu [2012]for sectoral asymmetries in trade. Such asymmetries in trade network also affects the migration process as that network is the medium of transmission of idiosyncratic sectoral and spatial shocks to other sectors and islands. Thus different degree of asymmetry in the trade network would imply different levels of spill-over effects of such shocks[4] and would eventually result in different levels of migratory responses.

The benchmark case is $\alpha = 0.4$, $\beta = 0.3$ and a completely symmetric trade matrix with all elements $1/N$. From that we make the trade matrix completely asymmetric in the sense that it is set to be equal to an identity matrix, effectively making it manufacturing non-tradable good. The mass of people migrating under this set of parameter values, is about 1.8%. This indicates that again a similar mechanism at work. More emphasis on non-tradables increase the extent of adjustment process.

6.3 Capital deepening

The economic growth process is almost synonymous with accumulation of capital of different varieties. Thus over time the production process uses more and more capital intensive technology. In the context of non-balanced economic growth this phenomena has been studied by Acemoglu and Guierrieri [2008] among others. In the present model, such dependence of capital intensive technology will evidently affect the migratory responses of workers. The benchmark case is the same as in the above case (Sec. 6.2). By increasing the capital intensity in the production process (β) to 0.7, we find that the total mass of migrants become almost half of the benchmark scenario. This is intuitive because the less labor required in the production process, the less would be the extent of adjustment. However, a potential limitation of this exercise is that in the model capital is fixed. Thus labor movement becomes much more pronounced as that is the only factor that can be adjusted.

[4]In fact, this is shown very elegantly by Caliendo et al. [2014] although they include an input-output channel as well which we have totally neglected when modeling multi-country trading process.

7 Summary and conclusion

We have presented a model of migration based on a richly specified structure originally developed in the trade theoretic literature following the Eaton-Kortum model (Eaton and Kortum [2002]). We employ a technique originally developed by Caliendo et al. [2014] to pin down the migratory responses in a static multi-country, multi-sector economy. Essentially, we treated the model as representing a general equilibrium set-up. In steady state, the system is subjected to consecutive shocks under realistic parameterization and from that we generate an *undirected* and *weighted* network of migration. We calibrate the model to U.S. and a set of European countries (it is the lack of data on the latter that forced us to focus on a subset rather than the all countries). The model performs well in explaining the total network of labor flow across U.S. and it matches the gross flow of labor with the real data. Interestingly, the model matches the relative flow network for the European countries pretty well but predicts a much higher value of gross flow of labor than is seen in the data.

The predictive power of the model lies in the fact that it essentially generates a multilateral gravity equation in labor flow thus capturing the relative weights pretty well. But the gross flow depends not only on economic factors but also on an array of institutional factors that comprises various social, political and lingual dimensions. The good match of the data with the model in case of U.S. indicates the (institutional) frictionless character of interstate migration. However, when we study the differences between model and data in case of the European countries, several factors emerge as dominant frictions reducing migratory responses even in face of economic incentives. Common language turns out to be an important factor, so are several other social characteristics (individualism and pragmatism). The presence of informality in the form of shadow economy also affects the migration decision to a great extent along with financial stability.

A simplifying assumption made throughout the exercise that makes the model tractable, is that people migrate for economic incentives only. While there are other reasons (for example, family-related or retirement-related), this is broadly consistent with the data (Kennan and Walker [2011]). An important issue was raised by Molloy et al. [2011] regarding the effects of the housing sector on migration. While it is true that there are several instances of sudden increase in country-specific migration due to housing sector boom, in general that does not play an important role. The present model could be easily augmented with a housing sector. But Kaplan and Schulhofer-Wohl [2013] argues that the housing sector shows much more volatility than the process of migration which is highly inertial. Molloy et al. [2011] considered this particular channel and showed that there exists a very weak connections if any, in case of U.S. There are two other simplications that allows us to solve the model based on the framework provided by Caliendo et al. [2014]. The first is regarding the technical issue that labor is the only mobile factor. Secondly, we have assumed that labor is homogenous. This assumption implies that labor is perfectly substitutable across countries (islands) and sectors. Thus we do not have to keep track of different types of labor migrating all over the world (the set of islands considered). While this assumption restricts us from discussing other issues like skill-specific migration, we retain it because of the tractability it provides to the model.

Given the static nature of the model an important question crops up that can we make long-run predictions from this model? We have discussed three important scenarios that provides us corresponding results which are obtained by appropriate changes in the deep parameters describing the economy. However, since by nature the model is not dynamic, we do not expect it to pick up the effects of economic fundamentals like a growing capital stock which might aggravate or reduce the degree of migratory responses generated from the model. But the results would broadly mimic the present as the current model takes the most basic incentive to migrate into account.

Finally, we can ask a seemingly obvious question : why did we take social distances as a friction? Would it be possible to imagine a scenario where a higher social distance actually complements migratory responses rather than substituting it. The answer is, it is possible. In south-to-north migration this may in fact provide an incentive to migrate. For example, people would migrate from low income countries to comparatively prosperous but only selectively. Along with economic incentives, migrants also weigh their chances on the socio-political conditions of the receiving countries. Thus a higher distance between a donor country and a receiver country may compel individuals to migrate. However, when the countries are more-or-less similar in these respects, this might hinder the labor reallocation process as is found in case of the European countries.

8 Appendix

8.1 Equilibrium conditions

The basic references for solving this types of models are Caliendo and Parro [2014] and Caliendo et al. [2014]. Below, we list the equilibrium conditions. We normalize the population so that $L = 1$ in the following.

- Labor mobility conditions (N equations):

$$\hat{L}_n = \frac{(\frac{\hat{\omega}_n}{\hat{P}_n})^{1/\beta_n}}{\sum_n L_n(\frac{\hat{\omega}_n}{\hat{P}_n})^{1/\beta_n}} L, \tag{44}$$

  where

$$\hat{P}_n = (\hat{P}_n^M)^{\alpha}(\hat{P}_n^S)^{1-\alpha}. \tag{45}$$

- Regional market clearing conditions ($2N$ equations):

$$X_n^{j'} = \alpha^j(\hat{\omega}_n(\hat{L}_n)^{1-\beta_n} I_n L_n), \tag{46}$$

  where the index j refers to sectors M and S.

- Price index ($2N$ equations):

$$\hat{P}_n^j = (\sum_{i=1}^{N} \pi_{ni}^j (\hat{x}_i^j)^{-\theta^j} (\hat{Z}_i^j)^{\theta_j})^{-1/\theta^j}, \quad (47)$$

where the index j refers to sectors M and S.

- Trade shares ($2N^2$ equations):

$$\pi_{ni}^{j'} = \pi_{ni}^j (\frac{\hat{x}_i^j}{\hat{P}_n^j})^{-\theta^j} (\hat{Z}_i^j)^{\theta^j}, \quad (48)$$

where the index j refers to sectors M and S.

- Labor market clearing (N equations):

$$\hat{\omega}_n (\hat{L}_n)^{(1-\beta_n)} I_n L_n = \sum_j \sum_i \pi_{in}^{j'} X_i^{j'}, \quad (49)$$

where the index j refers to sectors M and S.

8.2 Solution algorithm

The system can be solved block recursively. We are follow the algorithm presented in Caliendo et al. [2014] for solving the labor allocation problem resulting from asymmetric productivity shocks and then ammend it and modify it to suit our purpose. Below we present the steps to be followed for solving the model. Consider exogenous changes in productivity $\hat{Z}_n^M$, $\hat{Z}_n^S$ for all n. Define an weight $f \in (0,1)$ to be used to update the guess. In practice, $f = 0.99$ works well.

- Guess relative change in regional factor prices $\hat{\omega}$.
- Set $\hat{x}_n^j = \hat{\omega}_n$ and

$$\hat{P}_n^j = (\sum_{i=1}^{N} \pi_{ni}^j (\hat{x}_i^j)^{-\theta^j} (\hat{Z}_i^j)^{\theta_j})^{-1/\theta^j}. \quad (50)$$

- Find

$$\pi_{ni}^{j'} = \pi_{ni}^j (\frac{\hat{x}_i^j}{\hat{P}_n^j} \hat{\kappa}_{ni}^j)^{-\theta^j} (\hat{Z}_i^j)^{\theta^j}. \quad (51)$$

- Find

$$\hat{L}_n = \frac{(\frac{\hat{\omega}_n}{\hat{P}_n})^{1/\beta_n}}{\sum_n L_n (\frac{\hat{\omega}_n}{\hat{P}_n})^{1/\beta_n}} L, \quad (52)$$

where

$$\hat{P}_n = (\hat{P}_n^M)^{\alpha} (\hat{P}_n^S)^{1-\alpha}. \quad (53)$$

- Find
$$X_n^{j'} = \alpha^j(\hat{\omega}_n(\hat{L}_n)^{1-\beta_n} I_n L_n). \tag{54}$$

- Find
$$\hat{\omega}^{new} = \frac{\sum_i \pi_{in}^{j'} X_i^{j'}}{\hat{L}_n^{(1-\beta_n)}(I_n L_n)} \tag{55}$$

- Update the guess by
$$\hat{\omega}^* = f.\hat{\omega} + (1-f).\hat{\omega}^{new} \tag{56}$$

- Stop if $||\hat{\omega} - \hat{\omega}^*|| \leq \epsilon$

- Find net labor inflow,
$$F_n = (\hat{L}_n - 1)L_n. \tag{57}$$

- Construct the network of labor flow,
$$F_{ij} = -\left(\frac{(\hat{L}_j - 1)L_j}{\sum_{n\in\mathcal{N}^{out}}(\hat{L}_n - 1)L_n}\right)(\hat{L}_i - 1)L_i, \tag{58}$$

  where $\mathcal{N}^{out}$ is the set of countries from which labor migrates to other countries and $j \in \mathcal{N}^{out}$. This process generates an directed labor flow network.

- Define a new matrix, $F = triu(abs(F + F'))$ where the operator $triu(.)$ gives the upper triangular part and $abs(.)$ denotes absolute value of their respective arguments.

Thus one would generate the undirected, weighted network between N islands. With repeated shocks for T periods, one would have T networks each for each period. Summing over them one can generate the final network. We have averaged the final network thus produced over $O(10)$ realizations to arrive at a stable network free of fluctuations in the edge weights.

8.3 Data description and calibration

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