Migration Gravity Revisited

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Abstract

Recent contributions to the literature of international migration propose varieties of gravity estimations to analyse international migration matrices and to estimate parameters of highest political interest. Probable third country effects and multilateral resistance of migration are often accounted for at the estimation stage. A comprehensive treatment of these effects in a counterfactual analysis - as Anderson and van Wincoop (2003) are prominently credited for in the international trade literature - seems to be missing. This paper derives and estimates a structural version of a gravity equation for migration flows building on the model of Anderson (2011). The identified structural parameters and the closed form structure of the model make ex-ante counterfactual analysis possible. Thus, this paper provides a (extendible) framework for the analysis of dyadic migration data. I provide quantified effects on migration flows for a hypothetical reduction of language barriers within the European Union. Existing migration gravity derivations which build on different versions of a Random Utility Model (RUM) are reviewed with respect to multilateral resistance in addition.

JEL-Codes: F22, O15, O24.
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1 Introduction

The seminal contribution of Anderson and van Wincoop (2003) terminated the period of the gravity equation to be a theoretical orphan. They propose a strikingly successful attempt to build a theoretical foundation for the gravity equation of international trade. Today one can say that this contribution belongs to the most cited papers in the international trade literature. For several years the paper was mostly cited for the joint contribution with Feenstra (2004) for the simple estimation of the gravity equation including fixed effects to account for the general equilibrium nature of the model, namely the Multilateral Resistance Terms (MRT henceforth). Recent developments of the new quantitative trade literature aiming to quantify welfare effects from variations in the underlying trade system of the world and the risen popularity to structurally estimate trade models shed light on the actual contribution of Anderson and van Wincoop (2003). The theoretical basis they propose allows to conduct exante counterfactual analysis' which can capture the general equilibrium effects even for these hypothetical settings. Hence, Anderson and van Wincoop (2003) explicitly model the general equilibrium outcome and overcome standard assumptions – like the Stable Unit Treatment Value Assumption (SUTVA) – to identify effects of interest. Many excellent contributions since Anderson and van Wincoop (2003) refine their method to far less restrictive assumptions on the theoretical side. Head and Mayer (2014) acknowledge in their review of the progress of gravity literature for international trade: "In recent years, estimation has become just a first step before a deeper analysis of the implications of the results, notably in terms of welfare." The structural gravity model now build the basis for policy analysis of trade liberalizations (**?**, **?** for TTIP, and Anderson and Yotov (2010)) This is somehow the really short story of the evolution of the gravity equation of *trade* over the last decade. The very early re-formulation of the Newton law of gravity in economics has been an attempt to explain migration patterns by Ravenstein (1885). But only recently the gravity equation of *international migration* regained the interest of economists. Although it's empirical performance is as persuasive as for trade patterns, a theoretical foundation has not yet been established as Anderson and van Wincoop (2003) did for the trade gravity. Grogger and Hanson (2011), Beine, Docquier, and Özden (2011), **?**, and Ortega and Peri (2013), Anderson (2011) changed this fact with their excellent contributions and made a starting point to put the gravity equation of migration into a light (yet not completely) as the gravity equation of trade. Especially Anderson (2011) focused on the (general) equilibrium outcome when transferring the gravity idea to migration.

In this paper I want to highlight the advantages and importance of the equilibrium nature of the theoretical model of international migration Anderson (2011), based on a Random Utility Model (RUM), to derive and structurally estimate a new gravity equation of migration which explicitly accounts for multilateral resistance at the estimation stage and for a counterfactual analysis. To the best of my knowledge, I propose the first counterfactual analysis based on a structural gravity model of migration.

The next section recaps the structural migration gravity model of **?** which I will use for the empirical analysis. Section 3 presents the esimation stage before section 4 provides the data description. Section 5 gives the results of the estimation stage and depicts the counterfactual analysis.

2 Migration Gravity

In a multi-country setting emigration is a discrete choice from a set of countries in the world from the perspective of a single worker. Following Anderson (2011), a worker h migrates from country j to i if her utility of choosing i is bigger than for all other possible choices.[1] The utility in country j is given

[1] Also Grogger and Hanson (2011), Beine, Docquier, and Özden (2011) and Ortega and Peri (2013) use similar versions of a Random Utility Model (RUM) to derive a migration flow equation. See Beine, Bertoli, and Fernández-Huertas Moraga (2014) for an overview on RUMs used for migration modeling.

by her indirect wage, w_j plus an idiosyncratic part of utility from staying in country j, ϵ_{jjh}. Migration to country i involves country-pair specific costs of migration, $\delta_{ji} > 1 \ \forall \ i \neq j$ and $\delta_{jj} = 1$, which reduce utility in country i in an iceberg type way, w_i/δ_{ji}. Migration also involves a worker and country-pair specific factor of utility ϵ_{jih}. So a worker decides to migrate from country j to i if $(w_i/\delta_{ji})\epsilon_{jih} \geq w_j\epsilon_{jjh}$. We separate the utility of a representative migrant into two parts. One part which is observable and determined by characteristics at the country-pair level, $V_{ji} = \ln(w_i) - \ln(w_j) - \ln(\delta_{ji})$. The second part of the utility which is worker and country pair specific, $\varepsilon_{jih} = \ln \epsilon_{jih}$, is not observable for the researcher.

The probability of the decision of worker h to migrate from j to i, P_{jih}, is given by

$$\begin{aligned} P_{jih} &= \text{Prob}(V_{ji} + \varepsilon_{jih} > V_{jk} + \varepsilon_{jkh} \ \forall \, k \neq i) \\ P_{jih} &= \text{Prob}(\varepsilon_{jkh} < \varepsilon_{jih} + V_{ji} - V_{jk} \ \forall \, k \neq i), \end{aligned} \tag{1}$$

where V_{ji} gives the observed part of the utility from immigration to country i for all workers from j, V_{jk} gives the observed part of the utility from immigrating to any other country k from j for all workers from j and ε_{jih} and ε_{jkh} are the worker and country-pair specific utility components correspondingly. V's are known to the researcher and ε's are private information to the workers and assumed independently, identically distributed extreme value with unobserved density

$$f(\varepsilon_{jih}) = e^{-\varepsilon_{jih}} e^{-e^{-\varepsilon_{jih}}} \tag{2}$$

and cumulative distribution

$$F(\varepsilon_{jih}) = e^{-e^{-\varepsilon_{jih}}}. \tag{3}$$

Conditional on ε_{jih} equation (1) is the cumulative distribution for each ε_{jkh}

evaluated at $\varepsilon_{jih}+V_{ji}-V_{jk}$ given by equation (3)). For independent ε's we can write the cumulative distribution over all other alternatives as the product of the individual cumulative distributions. As usual we reach the unconditional P_{jih} by integrating $P_{jih} \mid \varepsilon_{jih}$ over all possible values of ε_{jih} for the given density 2:

$$P_{jih} = \int \left(\prod_{k \neq i} e^{-e^{-(\varepsilon_{jih}+V_{ji}-V_{jk})}} \right) e^{-\varepsilon_{jih}} e^{-e^{-\varepsilon_{jih}}} d\varepsilon_{jih}.$$

Starting from this expression we can derive the standard multinomial-logit choice probability expression.

$$\begin{aligned} P_{jih} &= \int_{\varepsilon_{jih}=-\infty}^{\infty} \left(\prod_{k} e^{-e^{-(\varepsilon_{jih}+V_{ji}-V_{jk})}} \right) e^{-\varepsilon_{jih}} d\varepsilon_{jih} \\ &= \int_{\varepsilon_{jih}=-\infty}^{\infty} \exp\left(-\sum_{k} -e^{-(\varepsilon_{jih}+V_{ji}-V_{jk})} \right) e^{-\varepsilon_{jih}} d\varepsilon_{jih} \\ &= \int_{\varepsilon_{jih}=-\infty}^{\infty} \exp\left(-e^{-\varepsilon_{jih}} \sum_{k} -e^{-(V_{ji}-V_{jk})} \right) e^{-\varepsilon_{jih}} d\varepsilon_{jih} \end{aligned} \tag{4}$$

If we define $t = e^{(-\varepsilon_{jih})}$ such that $-e^{(-\varepsilon_{jih})} d\varepsilon_{jih} = dt$ and noting that t approaches 0 as ε_{jih} goes to infinity and t is infinite if ε_{jih} approaches negative infinity, we get

$$\begin{aligned} P_{jih} &= \int_{\infty}^{0} \exp\left(-t \sum_{k} e^{-(V_{ji}-V_{jk})} \right) (-dt) \\ &= \int_{0}^{\infty} \exp\left(-t \sum_{k} e^{-(V_{ji}-V_{jk})} \right) dt \\ &= \left. \frac{\exp\left(-t \sum_{k} e^{-(V_{ji}-V_{jk})} \right)}{-\sum_{k} e^{-(V_{ji}-V_{jk})}} \right|_{0}^{\infty} \\ &= \frac{1}{\sum_{k} e^{-(V_{ji}-V_{jk})}} = \frac{e^{V_{ji}}}{\sum_{k} e^{V_{jk}}} \end{aligned} \tag{5}$$

Adopted to the multi-country discrete choice of a representative worker, we closely followed the standard logit setting à la McFadden (1974) and Train (2003) to derive these logit probabilities. The multi-country migration flow equation at the aggregate is then given by

$$M_{ji} = G(V_{ji})N_j \qquad \forall j \tag{6}$$

where N_j is the number of natives in j and $G(V_{ji})$ gives the proportion of migrants from j to i, which is given by equation (5)

$$G(V_{ji}) = \frac{e^{V_{ji}}}{\sum_k e^{V_{jk}}}. \tag{7}$$

Now, plugging in the V's, we can write the mulitlateral migration flow equation as

$$M_{ji} \;=\; \frac{\frac{w_i}{\delta_{ji}}}{\sum_k (\frac{w_k}{\delta_{jk}})} N_j. \tag{8}$$

The migration flow from country j to i is positively associated with the real wage in the destination country i, bilateral migration barriers to all other potential countries than i, δ_{jk} and the number of natives of the source country j; Beine, Bertoli, and Fernández-Huertas Moraga (2014) call the latter the potential for sending migrants of a country. Migration is negatively associated with bilateral migration barriers captured by δ_{ji} and the real wage in all other countries than i. Importantly note that the idiosyncratic or worker specific part of the utility is captured implicitly by the functional form of equation (5). So the logit probabilities already capture the unobserved part of the migrants utility, ε_{jih}.

Remember also that $\sum_i M_{ji} = N_j$, i.e., all natives from country j are split up over all N countries, including the home country. $\sum_j M_{ji} = L_i$ is the number of all migrants coming to i, including natives that stay in i, M_{ii}. This is then the labor force available in country i.

3 Migration Gravity Estimation

Following Anderson (2011) we define $W_j \equiv \sum_k \omega_k/\delta_{jk}$ and note that the labor force supplied to i from all origins

$$L_i = \sum_j M_{ji}. \tag{9}$$

With the world labor supply $N^w \equiv \sum_j N_j = \sum_i L_i$, the labor market clearance equation is given by

$$L_i = \omega_i \sum_j ((1/\delta_{ji})/W_j)N_j. \tag{10}$$

It follows that

$$\omega_i = \frac{L_i}{\Omega_i N^w}, \quad \text{with} \tag{11}$$

$$\Omega_i = \sum_j \frac{1/\delta_{ji}}{W_j}\frac{N_j}{N^w}. \tag{12}$$

Using the one before the last equation, we can write W_j as

$$W_j = \sum_k \frac{\omega_k}{\delta_{jk}} = \sum_k \frac{L_k}{\Omega_k \delta_{jk} N^w}. \tag{13}$$

Substituting the same equation into M_j we can write

$$M_{ji} = \frac{\omega_i/\delta_{ji}}{\sum_k \omega_k/\delta_{jk}} N_j = \frac{L_i N_j 1/\delta_{ji}}{N^w \Omega_i W_j}. \tag{14}$$

Replace $1/\delta_{ji}$ by $\delta_{ji}^{1-\theta}$ to end up with the following system:

$$M_{ji} = \frac{L_i N_j}{N}\left(\frac{\delta_{ji}}{\Omega_i W_j}\right)^{1-\theta}, \quad \text{with} \tag{15}$$

$$\Omega_i = \left[\sum_j \left(\frac{\delta_{ji}}{W_j} \right)^{1-\theta} \frac{N_j}{N} \right]^{\frac{1}{1-\theta}}, \quad W_j = \left[\sum_i \left(\frac{\delta_{ji}}{\Omega_i} \right)^{1-\theta} \frac{L_i}{N} \right]^{\frac{1}{1-\theta}}. \tag{16}$$

This structure equals the standard gravity system from Anderson and van Wincoop (2003). Ω_i and W_j indicate analogously the multilateral resistance terms for the migration gravity.

I estimate the following migration gravity model:

$$k_{ij} \equiv \frac{m_{ij}}{l_i n_j} = \exp\left(k - (1-\theta)\ln\delta_{ij} - \ln\Omega_i^{1-\theta} - \ln W_j^{1-\theta}\right) + \varepsilon_{ij}, \tag{17}$$

and control for Ω_i and W_j using importer and exporter fixed-effects as we control for the multilateral resistance terms in the trade gravity. Migration costs are specified as

$$\delta_{ij}^{1-\theta} = \exp(\gamma_1 \ln DIST_{ij} + \gamma_3 LANG_{ij} + \gamma_4 CONTIG_{ij} + \gamma_4 COMLEG_{ij}), \tag{18}$$

, where $\ln DIST_{ij}$ is the log of distance between country i and j. $\gamma_3 LANG_{ij}$, $\gamma_4 CONTIG_{ij}$, and $\gamma_4 COMLEG_{ij}$ are common gravity dummy variables indicating whether i and j share a common official language, are contiguous, and share a common legal system. Following Santos Silva and Tenreyro (2006) I estimate this equation consistently via Poisson Pseudo Maximum Likelihood to account for potential zeros in the migration matrix. I also provide OLS results in comparison in section 5

4 Data

As a measure for M_{ij} I use the yearly inflow of foreign citizens who intend to be residents in the receiving countries from the International Migration Database (IMD) collected by the OECD. The IMD collects data which are collected at the national level by statistical offices and official registers who try to maintain consistent definitions of immigrants over time. The IMD also seems to offer the most extensive coverage in terms of origin and destination countries' combinations of dyadic migration flow data. The migration flow variable thus the entry of legal migrants. Additional information to estimate stem from the GeoDist data set provided by CEPII [2]. I use cross sectional data of 2006 before.

5 Estimation Results and Counterfactual Analysis

Table [1] provides estimation results of equation 17. My preferred specification is given in column (1) where I estimate the migration gravity equation in levels via PPML as proposed by Santos Silva and Tenreyro (2006). This specification includes importer and exporter fixed effects to capture the multilateral resistance terms (Fally (2015)). As expected I estimate a negative and highly significant effect of bilateral distance on migration flows. Countries which share a common language and a common legal system observe highly significant more migration flows. For this specification, sharing the same border does not have a significant influence on migration flows. Column (2) provides for the same specification the OLS results for log migration flows. The last two columns repeat the first two but excluding the fixed effects. The differences to the first two columns highlight the importance of the theory consistent estimation of the gravity equation. All estimates are in line with our expectations. In the counterfactual analysis I will use the results of the preferred specification of Column (1). The importance of a common language as a migration barrier is already indicated by its estimated coefficient from Table [1].

[2] http://www.cepii.fr/CEPII/en/bdd_modele/presentation.asp?id=6

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	(1)	(2)	(3)	(4)
VARIABLES	PPML	OLS	PPML gold medal	OLS gold medal
ldist	-1.064***	-1.131***	-0.371***	-0.643***
	(0.101)	(0.0696)	(0.111)	(0.0476)
comlang_off	1.140***	0.967***	0.630**	1.361***
	(0.161)	(0.146)	(0.304)	(0.141)
contig	0.407	-0.393*	0.224	-0.679**
	(0.251)	(0.207)	(0.651)	(0.282)
comleg	0.387***	0.508***	0.266	0.421***
	(0.123)	(0.0895)	(0.209)	(0.109)
Observations	2,213	2,006	1,960	1,811
R-squared	0.828	0.812	0.157	0.623
Exporter FE	Yes	Yes	No	No
Importer FE	Yes	Yes	No	No

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

[The results of the counterfactual analysis have to be conducted]

6 Conclusion

For now I conclude that transferring a structural gravity model as Anderson and van Wincoop (2003) to the literature on international migration (Anderson (2011)) seems to be as valuable as for the trade literature. Controlling for theoretically motivated multilateral resistance enable us to incorporate GE effects and/or third country effects. To see potential third country effects the counterfactual analysis has yet to be provided. Using fitted values from the estimation stage without recalculating MRTs to evaluate potential political scenarios of interest might lead to biased quantification of migration flows.

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