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Estimating migration changes from the EU's free movement of people principle

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Abstract

We estimate the impact of the free movement of people (FMP) principle on bilateral intra-EU migration stocks using a gravity model. Employing a combination of the World Bank and the UN's global migration databases, with observations between 1960 and 2015, allows us to analyse the impact of the FMP for most EU member states. We find that implementing the FMP by an EU member state increased, on average, its stock of intra-EU migrants by 28%. The vast majority of intra-EU migration went to the old member states and we find that FMP had a substantial impact on migration originating from both old and new member states. The only exception is migration within new member states, which was negatively affected by FMP.

Keywords: International migration, immigration policies, intra-EU migration
JEL Classification: F22, J61, R23

1 Introduction

The free movement of people (FMP) is the right of EU citizens to work and reside within any country in the EU. The FMP between old member states (EU-15) has been legally evolving and gradually implemented between country pairs. For the founding EU members (Belgium, France, Germany, Italy, Luxembourg and the Netherlands), FMP was established in 1958. Subsequent members that joined prior to 2000 (Austria, Denmark, Finland, Greece, Ireland, Portugal, Spain, Sweden and the United Kingdom) also implemented FMP upon their official entry dates. The free movement of people principle, however, was not officially established until 1995,

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with the entry into force of the Schengen Agreement. In this context, new member states (EU-13) have been gradually allowed FMP after their accession, which occurred in 2004 for most new member states.[1]

Although the FMP has been widely regarded as one of the main reasons behind the increase in intra-EU migration in the last decades, concrete estimates of its effects are scarce. The contribution of this paper, therefore, is to estimate the impact of implementing the FMP on bilateral intra-EU migration stocks. These estimates will, in turn, provide valuable input for analysing EU migration policy changes, and ultimately estimate the economic impact of the FMP on intra-EU migration. In addition, we also estimate the impact of the membership of the no-border Schengen area, which is not equivalent to FMP nor does it include the same group of EU and non-EU members.

After analysing several available migration databases, we chose to employ a combination of the global bilateral migration stock databases from the World Bank (Özden et al., 2011) and the United Nations (United Nations, 2015b). Combined, both databases provide migration data between 1960 and 2015. The large time span of this database is an important feature for our analysis, since it allows us to cover the implementation period of the FMP between most EU members.[2]

We employ a structural gravity model approach based on the canonical random utility maximisation (RUM) model of migration. Thus, we follow the most recent literature that estimates bilateral migration determinants (cf. Beine et al., 2016a). In particular, we include country-time fixed effects, which can account for country-specific changes (e.g. economic growth, unemployment rates, internal policy changes) in both the country of origin and/or destination that can also affect migration flows. A key element of our analysis, moreover, is that we also employ country-pair fixed effects that account for the impact of bilateral time-invariant observed and unobserved migration determinants –such as geographical and cultural distance, language, institutional and legal settings, among others. This approach has the advantage that we can neatly isolate the effect of the bilateral *time-varying* FMP policy implementation from these other bilateral *time-invariant* migration determinants. Finally, this econometric setting also allows us to identify within-EU group specific and even country-specific impacts of the FMP implementation.

Our main finding is that the implementation of the FMP principle had, as expected, a positive and significant effect on bilateral intra-EU migrant stocks. In addition, we find that this effect has been substantial, with intra-EU bilateral migration stocks increasing on average around 28% after the implementation of the FMP. Since intra-EU migration between 1960 and 2015 doubled (103% increase),

[1] The EU-13 includes: Bulgaria, Croatia, Cyprus, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Romania, Slovakia and Slovenia.

[2] The use of these databases, on the other hand, has the disadvantage that it does not provide additional information on the characteristics of the migrants, such as age (or age group), working status, and educational (or skill) level. In particular, we cannot isolate the working age population from students and children that migrate for reasons other than finding a new job. However, comparing databases with additional migration details (for instance OECD, 2015), we find a high correlation between the total population and the working age population.

our results suggest that FMP explains around one-fourth of the total migration stock changes in this period. Hence, the implementation of the FMP is one of the main factors explaining the migration shifts within the EU during this period.[3]

This relatively large effect of the FMP contrasts with the results of previous studies, which found that the FMP or Schengen Agreement had little effect on the scale of migration (Grogger and Hanson, 2011; Ortega and Peri, 2013).[4] In comparison to previous studies, we clearly differentiate between the FMP principle that was implemented with EU accession and legally established by the Schengen agreement, versus membership to the border-free Schengen area. As we explain in Section 2, both concepts are related but they do not include the same group of EU countries and have different implementation dates. This distinction is relevant in our results. In particular, we find that being part of the Schengen no-border area does not have a significant impact on bilateral intra-EU migration.

Our methodology, moreover, allows us to provide precise estimates of this impact for the EU as a whole, for different country groupings and, in many cases, even for individual bilateral pairs. This feature is important, because we find large variations in the FMP impact by regions and specific countries. For most EU groupings estimates are close or above the average. For instance, the effect of the FMP when the destination is an old member state (EU-15) is a 40% increase in the migration stock. Migration from a new member state (EU-13) to an EU-15 country is increased by 48% when FMP is bilaterally implemented. The main exception is the negative impact of FMP on migration within the EU-13, which is around -54% and reduces the EU-average. Being a member of the no-border Schengen area, on the other hand, does not have a significant effect on the bilateral migration stock of the participating countries.

There is a large literature that analyses the determinants of international migration using the gravity model (for a survey, see Beine et al., 2016a). One of the main migration determinants that has been identified in this literature is the income and/or wage differential between countries (Mayda, 2010; Grogger and Hanson, 2011; Ortega and Peri, 2013; Bertoli et al., 2013). Other papers have also estimated the impact of other determinants, such as time-invariant factors –i.e. distance, language and cultural proximity– and country-specific time-varying factors, such as general migration policies, institutional factors and credit constrains, among others. Employing country-pair fixed effects in our analysis, however, comes at a cost, since we cannot identify the impact of these time-invariant bilateral indicators. Therefore, even though our methodology allows us to neatly isolate the FMP impact, it does not allow us to identify and measure the impact of country-pair time-invariant migration determinants. In particular, this creates a problem when using income differentials, such as the per-capita income gap between countries. We found that these bilateral income gaps have not changed relatively enough over time within the EU and they

[3] As we explain below, the literature has found other factors, in particular wage and income differentials, that have significant effects on migration.

[4] However, these studies used databases that did not cover the new member state accession, nor controlled for country-pair fixed effects.

are collinear with the country-pair fixed effects we employ. This impedes us to directly estimate the effect of income and/or wage differentials on intra-EU migration, and this income-gap effect is absorbed by the country-pair fixed effects.

Within this literature some studies have also tested the impact of bilateral migration policies, including the Schengen agreement that established the FMP and also created the Schengen area that abolished all internal border checks. Grogger and Hanson (2011) find that there are larger bilateral migration flows when both countries are part of the Schengen agreement, but the overall impact is relatively small. However, they use the Docquier et al. (2009) bilateral migration stock data for OECD countries for 1990 and 2000, and thus, only test for the FMP in old member states but not for the new member states that joined the EU later. Ortega and Peri (2013) estimate the effect of the participation in the Schengen border-free area and find that it reduced migration from non-EU countries to the EU, while generating only a small impact on intra-EU migration.[5]

Compared with most of these papers, we use a more recent database that includes bilateral migration stock data until 2015 and estimate the effects of FMP for intra-EU migration flows for all the current 28 member states. More importantly, we also use country-pair fixed effects to account for observable and unobservable country-pair time-invariant migration determinants. We can therefore better isolate the impact of time-varying migration policies, such as FMP and membership to the Schengen no-border area, from other migration determinants. In this respect, our paper is closest to the recent study by Beine et al. (2017) who analyse, as a by-product of their analysis, the effect of belonging to the no-border Schengen area. They also employ country-pair fixed effects and they also account for the impact to new member states, since they build an annual migration flow database for 30 countries for 1980 to 2010. They find positive effects of belonging to the Schengen area on migration flows.[6] The main difference with our paper is that we specifically test for the implementation of the FMP –which is not the same as a membership of the no-border Schengen area– and we analyse changes in migration stocks.[7]

Finally, some papers also use more detailed bilateral migration policies that go beyond membership to international agreements. For instance, the IMPALA database (Beine et al., 2016b) and the paper by (Ortega and Peri, 2013) compile databases with a richer set of migration policies and immigration policy barriers. However, these databases are restricted to sub-sets of OECD and/or EU countries and, thus cannot be used to provide broad intra-EU estimates.

The reminder of this paper is organised as follows. In Section 2 we define FMP and how it differs from membership to the no-border Schengen area. Section 3 de-

[5]They also use a database that does not include the accession of the new member states to the EU, and more importantly, they do not test for the FMP but for participation in the Schengen no-border area –i.e. leaving out Ireland and the UK.

[6]As part of our robustness tests we also employ migration flow data (instead of stock data) and find that belonging to the Schengen area does not have an impact on migration flows.

[7]Another difference is that we include destination-time fixed effects to account for inward multilateral resistance to migration, as explained in Section 4.2.

scribes the United Nations (2015b) database, our policy variables and stylised facts regarding intra-EU migration between 1990 and 2015. The theoretical foundations of our gravity model are explained in Section 4. Our econometric results and corresponding sensitivity analysis are then presented in Sections 5 and 6, respectively. We conclude and summarise our findings in Section 7.

2 The free movement of people principle within the EU and the Schengen agreement

The concept of the free movement of people has changed meaning since its inception. In the 1957 treaty establishing the European Economic Community it covered the free movement of workers and freedom of establishment. The Treaty of Maastricht introduced the notion of EU citizenship, which is enjoyed automatically by every national of an EU member state. In its current form it is the EU citizenship that underpins the right of persons to work, move and reside freely within the EU. The key legal event in officially establishing the EU internal market with free movement of people was the conclusion of the Schengen agreement. Although the agreement was signed in June 1985, it was not until June 1990 that the Convention implementing the Schengen Agreement was signed and it officially entered into force until March 1995.

Nevertheless, the FMP principle has been implemented by several old member states well before 1995. For most countries with accession dates prior to 2000, FMP was established when they officially became EU members. For countries that became members after 2000, however, the application of the FMP principle did not come instantly with EU membership. Under the Schengen agreement, each country must allow the FMP of the new member state within 7 years of EU membership. Therefore, the precise implementation date is a country-specific decision. In Table A.1 in the Appendix we provide the matrix of FMP implementation years by country of origin and destination. Some non-EU Schengen countries (Iceland, Liechtenstein, Norway and Switzerland) are also part of FMP and they also have specific bilateral implementation dates.[8]

It is important to note that the free movement of people (FMP) is not equivalent to membership of the no-border Schengen area. The two concepts are often confused because the FMP principle was legally established with the Schengen agreement. For instance, some EU countries have opted out of the non-border Schengen area: Bulgaria, Croatia, Ireland, Romania and the United Kingdom are non-Schengen EU members. Table 1 shows the year of EU membership and the year of implementation of the Schengen no-border area. Note that some non-EU countries are also part of the Schengen area –i.e. Iceland, Liechtenstein, Norway and Switzerland.

To sum up, the FMP principle is applied in all EU members (and in four non-EU members), but participation in the Schengen no-border area applies only to a

[8]The FMP implementation dates for non-EU countries are not shown in Table A.1 due to space constraints, but are available upon request.

Table 1: EU and non-EU members: EU entry and Schengen dates

	Country	code	EU member since:	Schengen no-border area signed	Schengen no-border area implemented
1	Austria	AUT	1995	1995	1998
2	Belgium	BEL	1958	1985	1995
3	Bulgaria	BGR	2007		
4	Cyprus	CYP	2004		
5	Czech Rep.	CZE	2004	2003	2008
6	Denmark	DNK	1973	1996	2001
7	Estonia	EST	2004	2003	2008
8	Finland	FIN	1995	1996	2001
9	France	FRA	1958	1985	1995
10	Germany	DEU	1958	1985	1995
11	United Kingdom	GBR	1973		
12	Greece	GRC	1981	1992	2000
13	Hungary	HUN	2004	2003	2008
14	Croatia	HRV	2013		
15	Ireland	IRL	1973		
16	Italy	ITA	1958	1990	1998
17	Latvia	LVA	2004	2003	2008
18	Lithuania	LTU	2004	2003	2008
19	Luxembourg	LUX	1958	1985	1995
20	Malta	MLT	2004	2003	2008
21	Netherlands	NLD	1958	1985	1995
22	Poland	POL	2004	2003	2008
23	Portugal	PRT	1986	1991	1995
24	Romania	ROU	2007		
25	Slovakia	SVK	2004	2003	2008
26	Slovenia	SVN	2004	2003	2008
27	Spain	ESP	1986	1991	1995
28	Sweden	SWE	1995	1996	2001
	Iceland	ISL		1999	2001
	Liechtenstein	LIE		2008	2012
	Norway	NOR		1999	2001
	Switzerland	CHE		2004	2009

Source: European Parlament website.

subset of the countries with FMP. Furthermore, the implementation years of both are usually different.

3 Data and stylised facts

In this section we describe the two databases used in this study: the global bilateral migrations stock databases from the World Bank (Özden et al., 2011) and from United Nations (United Nations, 2015b). We explain how we construct our dependent variable and the main explanatory variables. We then present stylised facts regarding intra-EU migration stocks between 1960 and 2015.

3.1 Bilateral migration data

After analysing the different databases available, we chose to use two databases to obtain our migration stock panel data. The first database is the World Bank migration database (Özden et al., 2011), which has data for every decade between 1960 and 2000 (5 time periods) for 226 countries/territories.[9] This database is based on the population census and registers initially compiled by the United Nations (United Nations, 2008).[10].

This database consistently identifies and deals with three main sources of discrepancies when dealing with global bilateral migration matrices. First, migrants are identified using different definitions: country of birth, country of citizenship, duration of stay or type of visa. Since only the first two definitions are widely available for all countries, then it needs to be determined which definition is preferred. As explained in Özden et al. (2011) and in United Nations (2015b) identifying a migrant by place of birth is the best option when determining migration and physical movement. In particular, when using country of citizenship, this definition effectively equates international migrants with foreign citizens, which can be problematic.[11] Thus, to estimate the migrant stock, international migrants have been equated with the foreign-born population whenever this information is available, which is the case in most countries or areas (United Nations, 2015b). When information on place of birth is lacking in the country data, then the information on the country of citizenship was used to identify international migrants. Second, given that many political boundaries changed between 1960 and 2000 (i.e. many countries became independent and some countries fragmented, such as the Soviet Union), the study uses the most recent set of countries as their "master country list". Third and final, there are many omitted or missing census data. In principle, the UN recommends a population census every 10 years (i.e. one for each census cycle), but very few countries –outside of the OECD– conduct census or registers on every census cycle. This issue is dealt by using interpolation and extrapolation estimates based on existing data (see Özden et al., 2011, for details). This process results in a consistently constructed and complete matrix of bilateral migration stocks.[12]

The second database we use is the United Nations (2015b) dataset "Trends in International Migrant Stock: The 2015 Revision". This database also provides bilateral estimates of the stock (or total number) of international migrants by country of origin and destination for 232 countries and areas, for the following reference years:

[9]The World Bank also has migration data after 2000, from the Migration and Remittances database (Ratha et al., 2018; World Bank, 2018). However, as explained in Appendix A.2 these data have problematic issues and do not seem compatible with the previous World Bank (Özden et al., 2011) database.

[10]This was a collaborative effort between the United Nations Population Division, the United Nations Statistics Division, the World Bank, and the University of Sussex.

[11]For instance, it can wrongly identify migrants as native-borns when citizenship is based on *jus sanguinis* (nationality of parents) instead of *jus soli* (country born). In addition, foreign migrants that adopt the citizenship of the country of destination will not be identified as migrants.

[12]This database also splits the migration stocks by gender, but we do not use these additional data.

1990, 1995, 2000, 2005, 2010 and 2015.[13] This UN database has been constructed using a very similar methodology than the database by Özden et al. (2011). First, it is based on the raw data on population censuses and registers compiled by the UN's Population Division. Second, it also uses country of birth as the main definition to identify migrants. Finally, it also uses interpolation and extrapolation methods to fill-in missing census data.

The main differences between both databases are the following:

- The UN database also employs nationally representative surveys to complement the data from the population census and registers.
- The UN database also has data on refugees, but the coverage differs by country. When available, the data on refugees was included in the UN's total migration data. The World Bank database, on the other hand, did not include refugee data as migrants when they could be separately identified.
- The precise interpolation and extrapolation methods differ between both databases. For example, the UN database adjusted their estimates for specific country circumstances –e.g. conflicts, economics booms and busts, major shifts in migration policies (United Nations, 2015b). While Özden et al. (2011) use nine different methods to fill-in missing cells in their bilateral matrix.

However, given that both databases use the same primary raw data and very similar data processing methods, it is not surprising that they are highly correlated (0.93) on their overlapping years (1990 and 2000). Therefore, even though the differences in the database described above can generate different estimates for specific country-years (in particular when refugees are an important issue), overall we consider that both databases convey the same underlying data.[14] Therefore, we combine both database to take advantage of their different time periods and thus, have a comprehensive global database with more than 200 countries for the period 1960 to 2015.[15] Since we are concerned mainly with intra-EU migration, we also compare our combined database with the EuroStat 2011 population census, to analyse how close are both data sources to each other. We find a very strong correlation with both databases as shown in Appendix A.5.

The resulting panel data can be used directly in our structural gravity estimates. In particular, having migration data prior to 1995 and after 2005, allows us to estimate the impact of the implementation of the FMP for most EU countries,

[13]The UN database also has bilateral migration stocks by gender and the age distribution of migrants in the country of destination (but not combined with bilateral data). The database also provides the population data for each country.

[14]Moreover, the total number of observation is very similar in both databases for 1990 and 2000, at around fifty thousand observations in each database.

[15]To test the sensitivity of our results, we also run our gravity estimates using both databases separately. Our main results are robust to using these alternative data (see Section 6.2). Thus, our results are not dependant on combining both databases.

including the EU enlargement after 2004.[16] To sum up, combining the World Bank and UN databases, we have the migration stock variable M_{odt} by country of origin o, country of destination d and for seven time periods t.[17] Using decadal data also allows us have a better mapping of the data to the population census cycles. This minimises the probability of using interpolations instead of the basic data taken from population census.

Alternatively, we can also proxy migration flows (m_{odt}) as the difference between migration stocks ($M_{odt} - M_{odt-1}$). However, migration flows estimated in this way are problematic because they do not directly reflect actual flow data. In addition, it is common to have "negative" flow data as a result of using the difference in stocks. For instance, of the total number of flow observations we calculate, 14% have negative values. This feature of the data is problematic and in Section 4.4 we explain how we deal with this issue.

Finally, it is important to note that our resulting migration stock data does not include temporary migrants (i.e. "posted workers"), which can be an important labour supply source for some specific countries or sectors. However, temporary workers represent less than 1% of total EU employment and thus, just a fraction of permanent migrant workers (European Parliament, 2016).

3.2 Explanatory variables

To analyse intra-EU migration policies we construct two dummy variables to capture the effects of the FMP principle and membership to the Schengen no-border area. The first dummy has a value of one for the year and years after the FMP principle has been implemented between a particular EU origin and destination country pair. Similarly, the second dummy has a value of one when the country becomes a member of the Schengen no-border area. As discussed later on, these dummy variables will be used as our main policy variables in our econometric analysis.

To account for the FMP principle between EU member states we use the matrix in Table A.1 to create a bilateral year-country dummy variable (F_{odt}). This variable is equal to one if FMP is in force between country of origin o and country of destination d in year t. This variable is asymmetric, in the sense that the year of implementation between countries does not have to be same (e.g. Dutch citizens could already work in Poland in 2004, but Polish citizens could only work in the Netherlands from 2007).

Note that FMP is closely related to membership of the Schengen no-border area, but are not equivalent (i.e. Ireland and the UK have FMP but are not part of the Schengen area). The main difference is that Schengen allows EU citizens to move freely between countries (no borders), but does not (necessarily) allow them to work

[16] In Appendix A we describe other migration databases that do not have data for the whole period (Artuç et al., 2015), for all EU countries (OECD, 2015) or have other limitations (United Nations, 2015a; Ratha et al., 2018).

[17] We have data for 1960, 1970, 1980, 1990, 2000, 2010 and 2015. Although the last observation has a 5-year difference instead of the 10-year difference, we include it to have the latest available data. When we exclude this last observation, our main results are very similar.

in that country. On the other hand, the FMP principle allows both (even when there can be border checks to enter some non-Schengen countries). Thus, we also create a bilateral country dummy to account for membership in the Schengen area (S_{odt}). However, this will be a symmetric variable, in the sense that it only has value of one when both countries become members of the Schengen area. The correlation between the FMP and the Schengen dummy variables is 0.5, which reflects that most EU countries are part of both sets, but not all of them are and there might also be differences in the time of implementation of both policies.

Finally, we use the CEPII database to obtain additional bilateral time-invariant indicators, which are used in the standard gravity specification in our sensitivity analyses. This database provides dyadic data on geographical distance, common language, common border and colonial ties.

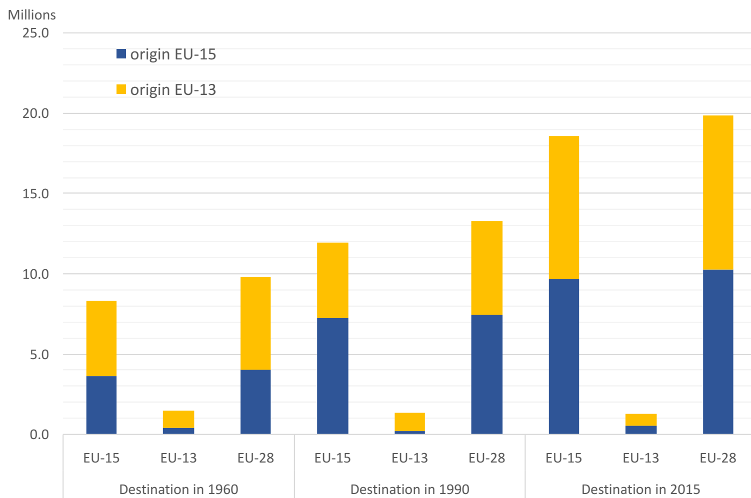
3.3 Stylised facts on intra-EU migration

In this section, we detail some intra-EU migration stylised facts obtained from the combination of the World Bank (Özden et al., 2011) and the United Nations (2015b) bilateral migration stock databases. In Figure 1 we observe that intra-EU migration stocks more than doubled in the period between 1960 to 2015, from around 10 million migrants to 20 million. These absolute changes in migration stocks are also reflected in relative terms, where the share of intra-EU migrants increased from less than 3% of the population, to 4.5%. Moreover, Figure 1 also shows that the vast majority of intra-EU migrants chose the EU-15 as their destination. Thus, almost all the changes in migration are generated by people from all over the EU migrating to the EU-15. It is important to note that already in 1960 there was a large stock of EU-13 migrants in the EU-15 (almost 5 million). On the other hand, the region of origin of the intra-EU migrants is more balanced. In 2015, for instance, migrants coming from old and new member states had almost an equal share of the total intra-EU migration, with around 10 million migrants coming from each region.

However, intra-EU migration reflects different migration patterns during the full period. In Table 2 we observe that between 1960 and 1990, most of the intra-EU migration was driven by migration between old member states (EU-15 to EU-15). There was almost no migration originating from the EU-13, and the number of EU migrants coming into EU-13 countries even decreased, due to the 43% reduction of migrants from EU-15 to EU-13. It is important to recall that this period coincides with the implementation of FMP between EU-15 countries.

This migration pattern changed dramatically in the 1990-2015 period. There was a sharp increase of migrants from the new member states to the EU-15 (89%) and a substantial decrease of EU-13 to EU-13 migrants (-35%). In part, this reflects the implementation of FMP between EU-13 and EU-15 countries when the new members began to join the EU after 2004. This made migrating to the EU-15 more attractive and the EU-13 less so. In addition, during this period migrants from the EU-15 still kept migrating to other EU-15 countries (34%). There was a very large relative increase of EU-15 to EU-13 migration (140%), but since the initial stock

Figure 1: Intra-EU migration stocks for 1960, 1990 and 2015, by region of origin and destination



Source: Combined World Bank and UN bilateral migration stock databases.

of EU-15 migrants in the EU-13 was very low (just around 200 thousand) then the absolute effect was limited.

Table 2: Intra-EU percentage changes in migration stocks between 1960, 1990 and 2015, between different EU regions

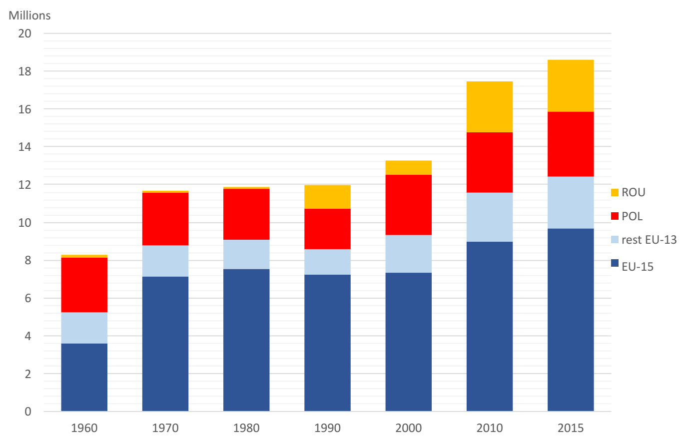
% change between :	**1960 and 1990 Destination:**			**1990 and 2015 Destination:**			**1960 and 2015 Destination:**		
	EU-15	EU-13	EU-28	EU-15	EU-13	EU-28	EU-15	EU-13	EU-28
Origin:									
EU-15	99.7	-43.4	84.7	33.7	140.3	37.2	167.1	36.1	153.4
EU-13	1.3	0.9	1.2	88.8	-34.8	65.6	91.3	-34.3	67.6
EU-28	44.2	-11.6	35.7	55.5	-3.4	49.6	124.3	-14.5	103.0

Source: Combined World Bank and UN bilateral migration stock databases.

Looking at the change in intra-EU migration stocks for the full period (between 1960 and 2015), we find that migrants from the EU-15 represent the largest share of intra-EU migrants, moving mainly to other EU-15 countries, but also to EU-13 countries. Migration from EU-13 countries was much less pronounced than for EU-15 countries, with migration between EU-13 to EU-15 almost doubling (91%), but with a sharp decrease in EU-13 to EU-13 migration (-34%).

We also find that migration from EU-13 countries is dominated by two countries: Poland and Romania. In Figure 2 we observe that in 2015 around two-thirds of EU-13 migrants in the EU-15 came from either country. Poland migrants in the EU-15 where already substantial in 1960, while Romanians began migrating to the EU-15 in the 1980s and in the 2000s there was another substantial increase, which is probably linked to FMP.

Figure 2: Migration stocks in the EU-15 by EU region of origin, separating Poland and Romania



Source: Combined World Bank and UN bilateral migration stock databases.

4 Theoretical background: The micro-founded migration gravity model

In this section we present the theoretical micro-foundations of the migration version of the gravity model, the most recent developments in the literature and the econometric specification that we use in our estimates.

4.1 The canonical random utility maximisation model

According to the recent survey by Beine et al. (2016a), the majority of migration studies that employ the gravity model are based on the canonical random utility maximisation (RUM) model of migration. This model describes the utility that individual i, living in country of origin o at time t, derives from migrating to country of destination d, which is given by:

$$U_{iodt} = w_{odt} - c_{odt} + \epsilon_{odt} \tag{1}$$

where w_{odt} represents the utility gains from migrating, while c_{odt} represents the time-specific cost of migrating and ϵ_{odt} is an individual-specific stochastic term. In this setting, the distributional assumptions regarding this stochastic term (ϵ) are key to determine the expected probability that choosing to migrate to country d maximises the utility U of individual i. In particular, the literature has followed the assumption by McFadden (1974) of an independent and identically distributed extreme value type 1 distribution (iid EVT-1), which applied to Equation 1 results in:

$$E(m_{odt}) = \frac{e^{w_{odt} - c_{odt}}}{\sum_{l \in D} e^{w_{olt} - c_{olt}}} s_{ot} \tag{2}$$

where m is the gross migration flow from country o to d in year t, D is the set of country choices (in principle all countries, indexed by l in the sample) and s is the population of country o at time t. In the canonical RUM model it is assumed that the deterministic component of utility does not vary with the country of origin o, and this allows Equation 2 to be re-written as:

$$E(m_{odt}) = \phi_{odt} \frac{y_{dt}}{\Omega_{ot}} s_{ot} \quad (3)$$

where $y_{dt} = e^{w_{dt}}$, $\phi_{odt} = e^{-c_{odt}}$ and $\Omega_{ot} = \sum_{l \in D} \phi_{olt} y_{lt}$. This last equation is already very similar to the gravity model (cf. Yotov et al., 2016), and it states that the expected migration flow from o to d is determined by the net utility $(w - c)$ of migrating to d. In terms of Equation 3, net utility is given by the difference between the attractiveness of migrating to d (given by y_{dt}) minus the accessibility of country d from o (given by $\phi_{odt} \leq 1$). This net utility, in turn, is inversely proportional to the exponentiated value of the expected utility of prospectively migrating to other countries or staying in the home country, which is given by Ω_{ot} (Beine et al., 2016a). Finally, the migration flows are proportional to the population s in the home country, which represents the capacity it has to send out migrants.

Note that Equation 3 can be easily linked with the gravity model for trade flows, where migrant accessibility (ϕ) can be associated with trade frictions (e.g. distance, language, colonial ties), population (s) is equivalent to the concept of export capacity (e.g. home GDP), attractiveness (y) is associated with the size of the import market (destination GDP), and the Ω term (when defined slightly differently, as explained below) can be associated with the concept of multilateral resistance terms introduced by Anderson and van Wincoop (2003).

The canonical formulation of the RUM model from Equation 3 implicitly includes the property of independence from irrelevant alternatives that follows from the iid-EVT-1 assumption from McFadden (1974). This property, however, ignores the possibility of prospective individual migrants analysing several potential destinations simultaneously and/or evaluating them differently (Beine et al., 2016a). This is a problematic feature of the canonical RUM model. If there are unobserved individual heterogeneity –e.g. talents, risk-aversion and psychological costs of migrating– considering these alternatives can be relevant if potential destination countries have different costs and payoffs. For example, when individual migrants have different psychological costs of migrating, then it is possible that individuals with lower psychological costs may migrate to countries that are more difficult to adapt to, but that can provide higher payoffs. Another problem with the canonical RUM specification is that it cannot account for different time dimensions regarding different and/or sequential location decisions (Artuç et al., 2010; Arcidiacono and Miller, 2011; Kennan and Walker, 2011).

4.2 The RUM model with multilateral resistance to migration

To deal with the impact of alternative destinations in the decision to migrate from o to d and potential sequential decisions, Bertoli and Fernández-Huertas (2013) propose to modify Equation 3 by accounting for the multilateral resistance (MR) to migrate. In that case the Ω term has to be modified to account for destination d (Ω_{odt}). This last term is equivalent to the multilateral resistance terms commonly used in trade gravity models (Olivero and Yotov, 2012), to account for the general equilibrium effects associated with changes in trade conditions in third-countries.[18] In addition, ignoring these MR terms results in biased estimated coefficients of other migration determinants (Bertoli and Fernández-Huertas, 2013). In particular, the estimated coefficient of the origin term (w_{ot}) is overestimated when alternative country destination are not considered. This bias is even larger when coordinated migration policies (such as the FMP) are analysed, since they affect multiple destinations simultaneously (Bertoli and Fernández-Huertas, 2013; Bertoli et al., 2013).

In the context of migration, the inward MR terms are associated with changes in the prospective destination country set (D) that can affect the expected utility to migrate to country d. These changes in migration attractiveness and costs, includes changes in general conditions (economical, social and political) in the destination countries, as well as general migration policy changes that make migrating to that particular country more or less costly for potential migrants from all countries. The outward multilateral resistance terms are associated with the heterogeneity in the preference to migrate, which does not vary across destinations but only at the country of origin.

There are different empirical strategies to account for the multilateral resistance term. We follow Ortega and Peri (2013) and use origin-time fixed effects (α_{ot}) to account for outward multilateral resistance. We also use the specification by Beine and Parsons (2015) and employ destination-time fixed effects (α_{dt}) to proxy for inward multilateral resistance. These sets of fixed effects will account for multilateral effects that can affect bilateral migration flows (e.g. the effect of US migration policies on EU migration flows). They will also absorb the country population variables (s_{ot} and s_{dt}), in addition to all other observable and unobservable time-varying country-specific characteristics, including different national policies and GDP changes (Yotov et al., 2016). Note that these fixed effects do not include bilateral migration policy changes, such as the FMP, which is the focus of our study but which can be individually identified, as we explain below.

Adopting the MR terms to Equation 3 yields the gravity-migration specification:

$$ln(m_{odt}) = \phi_{odt} + \alpha_{ot} + \beta_{dt} \tag{4}$$

where the multilateral resistance to migration is captured by the origin-time (α_{ot}) and the destination-time (β_{dt}) fixed effects. In this regard, α_{ot} will pick up the

[18] See Bertoli et al. (2013) and Beine et al. (2016a) on how MR to migration can also be linked to sequential migration decision processes or to more general distributional assumptions on the stochastic term ϵ in Equation 1.

country of origin time-variant migration determinants –i.e. the population size in the country of origin (s_{ot}), changes in local economic conditions (wages, GDP, unemployment, political and social developments) and any additional origin-time unobservable determinants. On the other hand, β_{dt} will account for observable and unobservable country of destination time-variant determinants, such as wages and general migration policies. Finally, the ease to migrate from country o to d is given by ϕ, which encompasses the bilateral determinants to migrate. This group of migration determinants ϕ, includes both the benefits and costs to migrate and can be further divided between dyadic time-invariant and time-variant components. We denote the time-invariant vector of migration determinants as $\mathbf{D}_{od}$, which is associated with a broad concept of distance, that can be geographical, linguistic, cultural or historical (e.g. colonial ties) or political –based for example, on government institutional quality indicators (Ariu et al., 2016). We denote the time-varying vector of migration determinants as $\mathbf{P}_{odt}$, which includes bilateral migration policies that can change over time (such as visa requirements and the free movement of people within the EU), or economical bilateral relations that change over time (i.e. the wage or income gap between countries).[19] Separating the bilateral component ϕ in this way yields the econometric specification:

$$ln(m_{odt}) = \gamma P_{odt} + \mathbf{D}_{od} + \alpha_{ot} + \beta_{dt} + \theta_{odt} \tag{5}$$

where θ_{odt} is the error term and γ is the estimated coefficient for P, while the vector of coefficients for the three groups of fixed effects (country-pair, origin-time and destination-time) are omitted in Equation 5.

4.3 Country-pair fixed effects

Since our main variable of interest (FMP) is a bilateral time-varying determinant, we can also employ a more traditional trade-based gravity specification using country-pair fixed effects (δ_{od}) to account for any observable and unobservable time-invariant migration cost components in vector $\mathbf{D}$. In the trade literature (Agnosteva et al., 2014; Egger and Nigai, 2015), these country-pair fixed effects has been proven to be a better measure of the bilateral trade frictions than the standard set of gravity variables (i.e. distance, common language and borders, and colonial ties). More importantly, they also account for potential bilateral time-invariant omitted variables (Yotov et al., 2016). In addition, using these country-pair fixed effects can also account for the potential endogeneity of bilateral migration policies –in our case the FMP and the Schengen area– to the migration flows, since these policies are more likely to occur if pre-existing migration flows are higher.[20]

[19] The wage or income gaps between countries, however, are persistent and do not change significantly over time. Thus, most of the wage gap effect is accounted for by the country-pair fixed effects. In other words, there is not enough variation of the wage gap over time to make it distinctively different from the country-pair fixed effects.

[20] See Yotov et al. (2016) for the equivalent explanation in the case of trade flows, on how country-pair fixed effects accounts for the endogeneity of bilateral trade policies to bilateral trade flows.

Including these country-pair fixed effects (μ) yields the following econometric specification:

$$ln(m_{odt}) = \gamma P_{odt} + \mu_{od} + \alpha_{ot} + \beta_{dt} + \theta_{odt}. \quad (6)$$

Note that the inclusion of the time index (t) in Equation 6 requires time series data on bilateral migration flows. Hence, a branch of the literature that works with cross-section data requires a different econometric specification that can deal with the multilateral resistance effects, omitted variables and endogeneity issues (see for example Ariu et al., 2016). In this respect, using the country-pair fixed effects is a much simpler and parsimonious way to deal with observable and unobservable bilateral time-invariant migration determinants that can also effectively deal with potential estimation bias from omitted variables and endogeneity problems. Of all the studies analysed in the recent survey by Beine et al. (2016a), only Beine et al. (2017) use country-pair fixed effects. Thus, the use of μ in Equation 6 is a relatively novel approach in the migration gravity literature, even when it is a standard feature in the trade literature.

Since many bilateral migration flows are zero, these cannot be included in the econometric specification in 6. Therefore, we use the standard gravity Pseudo-Poisson maximum likelihood (PPML) approach, which yields consistent estimates in the presence of heteroskedasticity and when there are zero migration flows for many country pairs (Santos Silva and Tenreyro, 2006). Then we estimate the following specification:

$$m_{odt} = e^{[\gamma P_{odt} + \mu_{od} + \alpha_{ot} + \beta_{dt}]} + \theta_{odt}. \quad (7)$$

4.4 Using migration gross flows or stocks as the dependant variable

The migration flows from our theoretically-based gravity specification are non-negative by definition. Nevertheless, when these gross flows (m) are proxied as the difference between migration stocks ($M_t - M_{t-1}$) this creates the problem that some gross flows can be negative.[21] Given that the exponential function never yields negative values, then we cannot use Equation 7, without first dealing with negative gross flows.

Some papers have used different approaches to deal with this problem. For instance, by taking only non-negative values, set the negative values to zero or add the negative values as an increase in the inverse flows (cf. Beine et al., 2016a). In this paper, even when we also use the constructed flow data in our estimates, we prefer to work with the original bilateral migration stocks (M_{odt}) data as our main specification.[22] The reason is twofold. First, using stocks instead of gross flows, avoids the problem of negative gross flows. Second, it also avoids the accounting and statistical issue that gross migration flows are not equivalent to simple migration stock changes. As explained in Beine et al. (2016a), differences can arise from migration to third countries and return migration, deaths, naturalisations (when the

[21] In our combined database 14% of the calculated flow value are negative.

[22] This is a common strategy in the literature. For example, Grogger and Hanson (2011), Belot and Hatton (2012) and Llull (2016) also use bilateral migration stocks instead of constructed flows.

immigrant status is defined by citizenship) and births (if the country of destination applies the principle of *jus sanguinis*).

Nonetheless, micro-founded gravity models based on the random utility maximisation (RUM) approach are based on migration *flows*, not on *stocks*. To adjust Equation 6 to handle stocks instead of flows, we define the bilateral migration stock in year t as the gross flow plus the initial stock in $t-1$, such that:

$$M_{od(t)} = m_{od(t)} + M_{od(t-1)}. \tag{8}$$

Substituting Equation 8 into 4 we obtain:

$$M_{odt} = e^{[\gamma \mathbf{P}_{odt} + \theta ln(\rho_{odt}) + \mu_{od} + \alpha_{ot} + \beta_{dt}]} + \theta_{odt} \tag{9}$$

where $\rho_{odt} = \left(1 + \frac{M_{od(t-1)}}{m_{odt}}\right)$ is a term that allows us to use migration stocks as the dependant variable while retaining the theoretical micro-foundations of the gravity model.[23]

Equation 9 will be our main econometric specification and we have a balanced-panel dataset with 234 countries for seven 10-year periods (1960 to 2015), for a total of 368,430 observations. This translates into 3276 country-year fixed effects (1638 fixed effects for country of origin-year and 1638 for country of destination-year) and 54,756 country-pair fixed effects. However, giving the large number of zeros in the data (245184 observations, or 67% of the total), many of these observations are dropped during the PPML regressions when country-pairs have all zero values.

Our main variable of interest will be the γ coefficient for variable P, which is the bilateral policy variable: either FMP or being part of the Schengen area. Given that the indicator variables for FMP and Schengen are somehow correlated (0.5) our main specification estimate one indicator at a time, but we also present results when both are present. When we use only FMP (or the Schengen area indicator) then the estimated coefficient of this policy variable (γ) from Equation 9, will provide the quantitative effect of FMP (or Schengen) on intra-EU bilateral migration stocks. For instance, the percentage change of implementing the FMP (or Schengen) on migration stocks ($\hat{\gamma}$) is given by:

$$\hat{\gamma} = (e^{\gamma} - 1) * 100. \tag{10}$$

As a robustness test for our main migration stock estimates, we run the PPML estimates using gross migration flows –i.e. using Equation 7– by applying the three common adjustments from the literature to deal with negative flows: deleting these negative flow values (Beine et al., 2011), setting them to zero (Bertoli and Fernández-Huertas, 2015) or, as in Beine and Parsons (2015), adding them as a positive flow in the inverse country order (from d to o) instead of the original order (from o to d).

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[23]See Appendix C for the derivation of Equation 9. Note that the correlation between the ρ term and the lagged value of the dependent value $M_{od(t-1)}$ is extremely low: 0.05. Thus, there are no auto-correlation issues by using the lagged of the dependent variable to compute ρ. Since $ln(\rho)$ become indeterminate when $m_{odt} = 0$, we set its value to zero in these cases.

It is important to recall that the migration literature has found that wage and/or income differentials are one of the main determinants to explain migration. In our specification, however, using country-pair fixed effects does not allow us to separately estimate the impact of any bilateral country differences (including income differentials, which do not have enough variation in our data). Thus, the income differentials will be absorbed and accounted for by the country pair fixed effects.

Finally, endogeneity issues have been identified as an important topic in the empirical migration literature. For example, there can be reverse-causality issues between income gaps and national institutions, with migration. However, employing country-pair fixed effects in our econometric specification greatly limits these concerns. Our specification, however, will be weakened if there were other bilateral and time-varying variables that where omitted in the analysis. On such variable could be diasporas, where the initial stock of migrants in a country can influence both the future migration flows and the likelihood of implementing FMP. However, by using migration stocks (instead of flows) as our main dependent variable, we are implicitly controlling for initial migration stocks (i.e. diasporas) in our results.

5 Econometric results

In this section we present the main results following the econometric specification from Equation 9 and additional results that are derived from this specification. To estimate the PPML regressions we use the STATA ado files from Larch et al. (2017), which provide a much faster PPML estimation than the normal STATA command. It is tailor-made for gravity estimates and it allows for the use of a large number of country-pair fixed effects.[24]

5.1 Main specification

The results from our main specification are presented in Table 3. We find that the implementation of the FMP principle had a positive and significant effect on the bilateral migrant stock.[25] In particular, using Equation 10 we find that when the destination country implements the FMP principle to a country of origin, that bilateral migration stock increases by 28% (from Column 2 in Table 3, where $\gamma = 0.248$ and using Equation 10). Participation in the no-border Schengen area, on the contrary, does not have a significant effect on bilateral stocks. This can be explained that the migration incentives provided by the FMP are much stronger than those granted by Schengen membership and thus, should have a much larger expected effect on the migration stocks.

[24]For instance, we have 54,756 country-pair fixed effects, which cannot be handled by the standard PPML STATA command.

[25]Note that as shown by Fally (2015), using PPML in conjunction with country-time and country-pair fixed effects generates a perfect fit of the data ($R^2 = 1$). Thus, this statistic is non-informative for our PPML estimates and we do not report it.

When we regress both FMP and Schengen together we find that the FMP coefficient is higher, but Schengen remains not significant. However, given the correlation of 0.5 between the FMP dummy and the Schengen dummy variables, to avoid multicorrelation issues, our preferred specification will be from Column (2).[26] In Table 3 we show the results when standard errors are clustered by country of origin, country of destination and year, but the FMP coefficient is also significant when using robust standard errors and clustered standard errors by country pairs.

Table 3: PPML gravity estimates on bilateral migration stocks using FMP and Schengen dummies

	(1)	(2)	(3)	(4)	(5)	(6)
FMP	0.292***	0.248***			0.342***	0.324***
	(0.087)	(0.085)			(0.111)	(0.105)
Schengen			0.091	0.026	-0.089	-0.136
			(0.085)	(0.078)	(0.119)	(0.109)
ln (ρ)		0.031**		0.033***		0.033***
		(0.012)		(0.012)		(0.0127)
Observations	193,014	163,933	193,014	163,933	193,014	163,933

Notes: Origin-time, destination-time and origin-destination fixed effects coefficients not shown. Multiway clustering (by origin, destination and year) of standard errors in parentheses, with significance levels: *** p<0.01, ** p<0.05, * p<0.1. Source: Own estimates using the combined World Bank and UN bilateral migration database.

The value of the FMP coefficient is slightly higher at 0.292 (with $\hat{\gamma} = 34\%$), if we do not include the $ln(\rho)$ term (see column 1). A possible reason for this difference is that the number of observations is significantly reduced in the second column, since the data for the year 1960 is lost (to estimate the ρ term that includes the initial migration stocks). When use the same sample, the FMP coefficient is 0.262 ($\hat{\gamma} = 30\%$) without using the $ln(\rho)$ adjustment. So the difference between using or not this adjustment is significant, but with a moderate effect. Therefore, it is important to include the $ln(\rho)$ term to make our gravity equations compatible with the theoretical micro-foundations from the RUM model.

5.2 FMP effects by EU groupings and country-specific results

The coefficient of FMP shown in Table 3 is an average of all countries that have implemented FMP. In other words, it provides the average effect of FMP on migration stocks, irrespective of the destination or origin countries involved. To analyse within EU differences, we re-run our PPML estimates using several sub-sets of the FMP dummy variable. In Table 4 we present the estimated FMP coefficient (γ) and

[26] The simple correlation matrix with our main variables is presented in Table A.2 in the Appendix.

its percentage change impact on migration stocks ($\hat{\gamma}$). Note that our preferred FMP effect is the one we estimate using the $ln(\rho)$ adjustment term, where our estimates are compatible with the micro-foundations of the RUM model. Nevertheless, we also include the FMP effects without this adjustment to expose the differences that the $ln(\rho)$ term makes. It is important to remark that the estimated coefficients in Table 4 come from Equation 9 and use the same sample, so they all have the same number of observations –unless the equation is estimated without $ln(\rho)$.

Table 4: PPML gravity estimated FMP coefficients for different EU groupings

EU group	**with ln(ρ) adjustment**	**significance level**	$\hat{\gamma}$	**without adjustment**	**significance level**	$\hat{\gamma}$
ALL	0.248	***	28.1%	0.292	***	33.9%
EU15 as destination	0.338	***	40.2%	0.398	***	48.9%
EU13 as destination	-0.246			-0.330		
EU15 as origin	0.301	***	35.1%	0.379	***	46.1%
EU13 as origin	0.132			0.085		
EU13 to EU15	0.394	**	48.3%	0.375	*	45.5%
EU15 to EU13	0.962	***	161.7%	0.920	***	150.9%
EU13 to EU13	-0.776	***	-54.0%	-0.873	***	-58.2%
EU15 to EU15	0.250	***	28.4%	0.336	***	39.9%
with non-EU	0.384	**	46.8%	0.471	***	60.2%
Observations		163,933			193,014	

Notes: EU15 are the old member states and EU13 are the new member states. "With non-EU" implies a bilateral flow between an EU country and at least one of the following countries: Switzerland, Liechtenstein, Norway or Iceland. Multiway clustered standard errors, with significance levels: *** $p<0.01$, ** $p<0.05$, * $p<0.1$. Source: Own estimates using the combined World Bank and UN bilateral migration databases.

As expected, we find that the impact of FMP is higher when the EU-15 is the destination and there is no significant FMP effect when the destination is the EU-13. The effect of FMP on EU-13 to EU-15 migration (48%) is also larger than the average for all EU countries (28%). Surprisingly, however, the FMP coefficient is not statistically significant when a EU-13 country is the origin. This is a consequence of citizens from EU-13 countries migrating away from other EU-13 countries, which is reflected in a relatively large and negative FMP coefficient for EU-13 to EU-13 migration (-54%). Therefore, the positive EU-13 to EU-15 effect is counterbalanced by a negative EU-13 to EU-13, making the average EU-13 as origin effect positive, but not statistically significant. On the other hand, EU-15 as origin has a positive and significant effect, since FMP is estimated to make citizens from the EU-15 migrate to all sub-regions. In particular, the largest FMP effect comes when migration is from EU-15 to EU-13 (162%), while the EU-15 to EU-15 effect is close to the average (28%). Nonetheless, the very large EU-15 to EU-13 effect is not very noticeable, since the there is a relatively small initial EU-15 migrant stock in the EU-13 (see Figure 1). Finally, migration between and within non-EU countries that have implemented FMP (Iceland, Liechtenstein, Norway and Switzerland) is positive and significant, with an impact that is above the average for all EU countries (47%).

It is important to remark that the intra-EU grouping used above is arbitrary. We can employ different groupings, and more importantly, our econometric specification allows us, whenever there is enough variation over time in the FMP variable, to have much more detailed groups or to look at individual EU countries. For example, we can estimate the FMP coefficient for individual countries as origin or destination –i.e. how does FMP affect a specific country by being the origin or destination of migration. Moreover, we can even construct country-pair specific FMP dummies that estimate the effect on particular bilateral migration flows. As an example, in Table A.3 in the Appendix we present results for The Netherlands, when it is the country of origin or the country of destination, as well as country-pair FMP effects. As shown there, not all country-pairs can be estimated, since we require that the FMP dummy for the country-pair changes during our time sample (1960-2015).[27] Similar results are estimated for other EU countries, but are not presented here because of space constraints.[28] In the particular case of the Netherlands, we observe that the impact of FMP was much larger than the average EU effect, with a five times larger effect when it is the country of origin, and ten times more when it is the destination country. Here we also observe the same pattern found in Table 4, where the FMP impact is largest for EU-15 as origin (Netherlands in this case) and a the EU-13 as destination, followed by the inverse flow (EU-13 citizens migrating to the Netherlands) and with lower impacts on intra-EU-15 migration.

5.3 Using migration flows instead of stocks

We also run the estimates using gross flows instead of stocks. As explained in Section 3, we need to deal with the negative flow values problem.[29] To overcome this limitation we employ the three adjustments in the literature to deal with this problem (Beine et al., 2016a): set negative flows to zero, delete negative flows or count negative flows as positive reverse flows –i.e. if the flow from country k to j is negative, then we add it as a positive flow from country j to k.

The results using migration flows are shown in Table 5. We find that the FMP dummy is positive and significant in the first two treatments of negative flow values, and not significant when using the third treatment. These results use three-way (multiway) clustering of standard errors by country of origin, destination and time. When we use a two-way country-pair clustering (see Table A.4 in the Appendix), all three treatments have significant FMP coefficients. Hence, our results using migration flows are less robust than when using migration stocks (where different standard error clustering did not change the significance of the coefficients). How-

[27]For instance, we cannot estimate the FMP on the original EU member countries, for which FMP started in 1958, before our initial observation in our sample.

[28]Country-specific results are available upon request.

[29]Recall that proxying migration flows as the difference between migration stocks can sometimes result in negative values.

ever, the results using flows are in line with our main result from using stocks: FMP has a positive effect on migration, while belonging to the Schengen no-border are does not.

Table 5: PPML gravity estimates on bilateral migration flows using FMP and three different adjustments to negative migration, three-way clustering of standard errors flows

	negatives set to zero			negatives deleted			negatives as reverse flow		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
FMP	0.585**		0.601**	0.392**		0.479**	0.368		0.392
	(0.237)		(0.297)	(0.180)		(0.239)	(0.274)		(0.280)
Schengen		0.249	-0.0327		0.0486	-0.181		0.163	-0.0449
		(0.243)	(0.310)		(0.129)	(0.213)		(0.177)	(0.150)
Observations	155,094	155,094	155,094	114,562	114,562	114,562	200,232	200,232	200,232

Notes: In columns 1-3 negative bilateral migration flows are deleted, in columns 4-6 they are set to zero and in columns 7-9 they are assigned as a positive reverse flow. Includes country-time and country-pair fixed effects. Multiway (by origin, destination and year) clustering of standard errors in parentheses, with significance levels: *** p<0.01, ** p<0.05, * p<0.1.

Source: Own estimates using the combined World Bank and UN bilateral migration databases.

6 Sensitivity analysis

In this section we run a series of robustness tests to check under which circumstances our main results hold.

6.1 Different country samples

First, we find that our main results are robust to changing the country sample to include only OECD and EU countries, and combinations of both (i.e. only OECD and only EU).[30] The estimated FMP coefficients using these sub-samples are shown in Table 6 and have values that remain close to those of the full sample. We also observe that the Schengen coefficient remains not statistically significant. Thus, although these sub-sample estimates considerably reduce the number of observations, our results are robust.

We also exclude Poland and Romania from our sample (see the last column in Table 6) to check if the results are mainly driven by the large migration outflows from these countries (see Section 3.3). Here we find, however, that the estimated FMP coefficient is still positive and significant, and even slightly larger than in the

[30]Note that five EU countries are not part of the OECD: Bulgaria, Croatia, Cyprus, Malta and Romania. Lithuania became an OECD member only until 2018 and thus, is not considered as part of the OECD sample in our estimates.

Table 6: PPML gravity estimates on bilateral migration stocks using FMP and different country samples

	full sample	OECD and EU	only OECD	only EU	excl. POL and ROU
	(1)	(2)	(3)	(4)	(5)
FMP	0.324***	0.292***	0.301***	0.271***	0.386***
	(0.105)	(0.057)	(0.053)	(0.082)	(0.096)
Schengen	-0.136	-0.097	-0.055	-0.137	-0.033
	(0.109)	(0.115)	(0.099)	(0.143)	(0.090)
$\ln(\rho)$	0.033***	0.044***	0.045***	0.055***	0.035***
	(0.013)	(0.004)	(0.006)	(0.012)	(0.013)
Observations	163,933	9,960	7,314	4,662	161,740

Notes: Includes country-time and country-pair fixed effects. Multiway (by origin, destination and year) clustering of standard errors in parentheses, with significance levels: *** p<0.01, ** p<0.05, * p<0.1.

Source: Own estimates using the combined World Bank and UN bilateral migration databases.

full sample.[31] Thus, our results are not driven by the migration experiences of these two EU countries.

6.2 Employing the migration databases separately

As explained in Section 3, we combined the World Bank (Özden et al., 2011) and the United Nations (2015b) migration databases to obtain a longer time-series that allowed us to analyse the full effect of FMP on intra-EU migration. Nevertheless, using both databases separately we obtain very similar results as with the combined database. In Table A.5 in the Appendix we present the results using the World Bank database, which has decadal observations from 1960 to 2000. In this case, we also find that the FMP coefficient is positive and statistically significant, although with lower values than when using the combined database. In particular, the FMP effect on migration stocks is reduced from 28% to around 18%. This decrease can be explained by the absence of the FMP from the new members states in the sample period, since it only started after 2000.

In Table A.6 in the Appendix we present the results using the UN databases, which has 5-year observations from 1990 to 2015. Using these data we find that the FMP coefficient is again positive and statistically significant. In this case, however, the magnitude of the coefficient is higher, with an expected 53% effect of FMP on migration stocks. This higher coefficient can be explained by the stronger migration

[31] A possible explanation for this result is that migration from these countries is affected relatively more by country-pair effects, such as income differentials.

from new member states (EU-13) after 2000 that is picked-up in the sample period of this database.[32]

6.3 Lead and lagged effects of FMP implementation

We next analyse if the FMP effect on migration can be experienced before and/or after the full bilateral implementation of FMP. This will create a lead and/or lagged effect of FMP on migration changes. We test this possibility in Table 7. Here we find that only the lagged FMP dummy variable has a positive and significant effect. This effect is smaller than the FMP coefficient value, but the combination of both effects (FMP and the lag of FMP) yield a 30% increase on migration stocks. This combined value is very similar to the 28% effect we found in our main specification, which suggests that the FMP effect may take a longer period to be fully experienced. On the other hand, the FMP lead dummy does not have a significant effect, which implies that there are no anticipatory effects of the FMP implementation. In other words, only after the FMP has been effectively implemented, does intra-EU migration stocks begin to change.

Table 7: PPML gravity estimates on bilateral migration stocks using lagged and lead FMP dummies

	(1)	(2)	(3)	(4)
FMP	0.248***	0.194**	0.247**	0.185***
	(0.085)	(0.078)	(0.098)	(0.069)
FMP_lag		0.115*		0.118*
		(0.061)		(0.061)
FMP_lead			0.009	0.018
			(0.091)	(0.089)
ln (ρ)	0.031**	0.031**	0.032**	0.031**
	(0.012)	(0.012)	(0.013)	(0.013)
Observations	163,933	163,933	163,933	163,933

Notes: Includes country-time and country-pair fixed effects. Multiway (by origin, destination and year) clustering of standard errors in parentheses, with significance levels: *** p<0.01, ** p<0.05, * p<0.1. Source: Own estimates using the combined World Bank and UN bilateral migration databases.

6.4 Standard gravity equation

We also estimate the standard gravity specification by substituting the country-pair fixed effects (μ_{od}) in Equation 9 by the vector $\mathbf{D}$ with bilateral country-pair migration determinants. This vector includes the following variables: distance, common

[32] In addition, here we also observe that the Schengen coefficient is positive and significant. This results can be a consequence of the Schengen dummy acting as a substitute for the FMP dummy variable of the old member states (EU-15), which does not vary in the sample period of this database.

language, common border and colonial ties. Using this setting has the advantage that we can explicitly account for some migration determinants.[33]

However, the results using this standard specification are extremely problematic (see Table A.7 in the Appendix). First, the estimated FMP coefficient of 3.3 is over ten times larger than the estimated coefficient using our main specification with country-pair fixed effects. This clearly suggests that our main specification is effectively accounting for non-observable time-invariant bilateral variables and/or variables not included in the standard gravity equation. Thus, the standard gravity specification is grossly over-estimating the impact of FMP. Second, we find that the coefficients for distance and being a colony before 1945 have the correct sign and are significant, but the other standard gravity determinants –common language, common border and having a common colonial past– have the opposite sign to what was expected.

These results indicate that the standard gravity approach suffers from serious problems with omitted variables and/or model mis-specification. This confirms the importance of using the country-pair fixed-effect approach to estimate the FMP effects on bilateral migration.

Finally, Jochmans (2017) argues that PPML gravity models with country-time fixed effects can generate biased fixed effects estimators. To correct for this bias, he propose the use of generalised method-of-moment (GMM) estimators. However, as explained in Appendix D it is not feasible to use this alternative estimator for our data.

7 Summary and conclusions

Employing the combined World Bank (Özden et al., 2011) and United Nations (2015b) databases we estimate the effect of the EU's free movement of people (FMP) principle on intra-EU bilateral migration stocks using a structural gravity model. This model belongs to the most recent crop of RUM migration models, which include multilateral resistance terms. In addition, we are one of the first papers to use country-pair fixed effects, which accounts for all time-invariant country-pair observable and non-observable bilateral migration determinants. This specification allows us to neatly isolate the effect of FMP –which is a bilateral time-varying variable– on bilateral migration stocks.

Our main econometric result is that the implementation of the FMP principle has a positive, significant and substantial impact on the intra-EU migrant stock. In particular, we find that the intra-EU migration stocks increase, on average, by 28% after an EU country allows the free movement of citizens from another EU member state.

[33] In this setting, one can also estimate the impact of some additional dyadic variables, in particular, the wage and/or income differential between countries. However, including income differential indicators can also create an endogeneity problem on this specification, which requires alternative estimation techniques (cf. Beine et al., 2016a).

Moreover, our econometric specification allows to estimate the FMP impact on different EU groupings and even specific country pairs (if the FMP changed for this country pair during our sample period). We find relatively large variations in the impact of FMP by region and country. For instance, the migrant stock from new member states (EU-13) to old member states (EU-15) changes by 48% when FMP is implemented. This is almost double the average impact of FMP on intra-EU migration. We also find that the impact of FMP is above average when the country of destination is an old member state (40%), and for non-EU countries that are part of the FMP (47%). In particular, the estimated average effects are driven down by a negative impact of FMP on migration between new member states (-54%).

We find that being a member of the border-free Schengen area does not have an effect on the intra-EU bilateral migration stock. These results can be explained by two main differences between the FMP and the Schengen area indicators. First, by allowing EU citizens to reside and work in other EU countries, the expected migration impact of the FMP principle is larger than just being part of the no-border Schengen area. Second, the Schengen area comprises a sub-group of EU countries that are part of the wider FMP group. For instance, important destination countries such as Ireland and the UK are not part of the Schengen area.

When we proxy migration flows as the difference between migration stocks in a period, we also find that FMP has a positive and statistically significant impact on intra-EU migration. Using different corrections for negative flows, we find that FMP increases intra-EU migration flows between 40% and 80%. However, these estimations have to be treated carefully, since the migration flow data are constructed and do not directly measure actual migration flows.

These results are robust to different specifications and other sensitivity tests. The FMP impact on intra-EU migration stocks remain statistically significant when we only include OECD and/or EU countries in the sample. These results hold even when we do not include Poland and Romania, which account for a large share of EU migrants. Our results are also robust to using the World Bank (Özden et al., 2011) and United Nations (2015b) databases separately. When we use lagged FMP indicators, we find that the full FMP effect is fully realised more than ten years after implementation, but the total average effect remains very similar if we include or not lags. We also estimate the standard gravity specification without country-pair fixed effects and explicitly employ bilateral country-pair data (such as distance, common language, common border and colonial ties). However, in this specification our results become problematic, with some migration determinants becoming insignificant and/or having the wrong expected sign. The estimated FMP coefficient, furthermore, is much larger using this standard gravity specification and this signals potential mis-specification problems of the model and/or the omission of relevant migration determinants. These results highlight the importance of using country-pair fixed-effects to account for unobservable country-pair time-invariant migration determinants, which can create significant biases in the estimated FMP coefficient.

In general, the overall 28% impact of FMP on intra-EU migration stocks, explains around one-fourth of the total change in stocks between 1960 and 2015. When we look at particular migration flows, however, we find that the impact of FMP has been larger. For instance, we find that FMP increased migration from the EU-13 to EU-15 countries by 48%, which represents around half of the total change of EU-13 migrants in the EU-15 (91%). Therefore, the implementation of the FMP principle between EU countries has been one of the main determinants of intra-EU migration.

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Appendix

A Other bilateral migration databases

A.1 United Nations flow database

The UN has an additional database with migration flows for a selected group of 45 countries: "The International Migration Flows to and from Selected Countries: The 2015 Revision" (United Nations, 2015a). The database contains all 28 EU countries, four OECD non-EU countries (Australia, New Zealand, Canada the United States) and the remaining 13 countries are non-EU European and/or ex-Soviet Union countries. However, for our study, the main problem with this database is that it cannot be used as a panel data. This database uses different definitions to identify migrants (e.g. foreign-born or foreign citizen), use different concepts to determine migrant's origin and destination, and does not use a consistent country aggregation (some countries have data by country of origin, but others by region or only total migration flows). Finally, although the database has observations between 1980 and 2013, the majority of the data are for the 2000s, with almost no coverage for the 1980s and limited coverage for the 1990s and 2010s.

Therefore, unlike the UN bilateral migration stock database (United Nations, 2015b), this particular UN database does not consistently construct a complete set of bilateral flows.

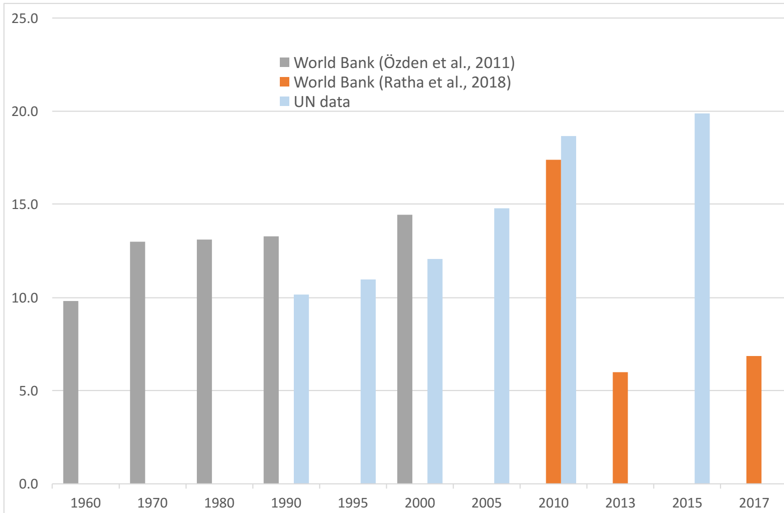
A.2 World Bank Migration and Remittances data

The World Bank's Migration and Remittances data (Ratha et al., 2018) has also global bilateral migration stock data for the years 2010, 2013 and 2017 (World Bank, 2018). However, we found some problematic issues with the latest observations in the database. In particular, we identified serious problems with the data for intra-EU migration stocks after 2010. When we compute the intra-EU stocks of migrants (EU citizens living in another EU country) we found a complete collapse in the intra-EU migration stocks after 2010 (see Figure A.1), which is not consistent with the EU migration experience after the 2008 crisis shown by the UN database.

In addition, when looking at net migration flows, we also found some serious issues wit three EU countries: net positive migration for Poland and Czech Republic (more EU citizens coming into these countries than leaving) and a net negative migration for Germany. These are very counter-intuitive result, which are not present with the UN data, for example. This problem, however, is only found for the 2010-2017 update of the database, but not with the initial database compiled by Özden et al. (2011) for 1960 to 2000.Therefore, we decided not to use this updated World Bank database for our analysis.[34]

[34] After communicating with the World Bank team that ran the updated version of the database, we have not received a response on the counter-intuitive results for intra-EU migration stock nor for the net migration flows of Poland, the Czech Republic and Germany.

Figure A.1: Intra-EU migration stocks from the World Bank and UN databases, in millions



Sources: UN bilateral migration stock database and World Bank Migration databases.

There World Bank also has another migration database available: the Panel Data on International Migration 1975-2000 [35]. However, it only has data for the six largest migrant receiving countries: Australia, Canada, France, Germany, the UK and the US.

A.3 OECD DIOC databases

The OECD DIOC database (OECD, 2015) is comprised of two related databases. The first is the DIOC-2010 (Database on Immigrants in OECD Countries), which is available only for OECD countries for bilateral migration stocks as measured in 2001 and 2005. The second is the global bilateral migration database DIOC-E-2010, which is an extension of the DIOC-2010 database and has information for OECD countries, but also for more than 50 non-OECD countries.

The advantage of this database, is that it records the educational attainment of immigrants and the migrants' labour force status.[36] Having information on the working population can isolate non-working migrants, such as students who emigrate temporarily to complete their education or children who migrate with their families but who are not in the labour market.

The disadvantage of this database is that the information for 2005 is very incomplete (many country-pair data points are missing) and this leaves only two years with

[35] http://microdata.worldbank.org/index.php/catalog/390/overview

[36] The educational characteristics refer to the highest level of education completed using the ISCED (International Standard Classification of Education) from UNESCO. The labour force status indicates the individual's position in the labour market at the time of the census.

complete information: 2000 and 2010. More importantly, the lack of an extended time span does not allow us to estimate our econometric specification, which needs variation over time to isolate the bilateral time-invariant migration determinants from our time-varying policy variables (see Section 4).

On the other hand, comparing the bilateral OECD data using only working migrant population with the UN data for 2010 (total migration population) for European countries, we find a very high correlation of 0.93 between the two databases. Even though there are some countries that exhibit lower correlations with the UN data (Belgium, Italy and Bulgaria have correlations of around 0.75) these remain relatively high. This limits the concern that we are underestimated the working population when using the UN database.

A.4 Migration database by Artuç et al. (2015)

This database compiles and estimates the worldwide bilateral migration stocks for 195 countries, for migrants identified by country of birth. It includes only people aged 25 and over to proxy for working-age population and it also has information for two skill levels (based on educational achievement: college graduate and less educated). Finally, the database has information for two years: 1990 and 2000.

The methodology described in Artuç et al. (2015) has three steps. First, they use as starting point the database from Docquier et al. (2009) who compiled a dataset on bilateral migration stocks to OECD host countries. This is based on census and register immigration data by educational attainment and country of birth for 30 OECD countries. Second, they collect similar data for 46 non-OECD destinations in 2000, and 30 countries in 1990. In the third and last step, the data collected in the previous steps are used to predict the size and composition of the migration flows for those country dyads where there is no data: 119 non-OECD host countries in 2000 and 135 countries in 1990.

Although this database has also information on education achievement and working age population, we are faced with the same limitation as with the OECD (2015) database: we do not have enough time variation in the data to isolate the effect of changing FMP status within the EU, with respect to other country-pair migration determinants.

A.5 Data comparisons with EuroStat 2011 population census

To assess the veracity of our combined World Bank UN database, we compare it with other migration data sources. First, we use the EuroStat population census from 2011 to obtain the number of person that have a different citizenship as that of the reporting country. We use this definition to obtain migration stocks by country of destination in 2011. These data also distinguish between migrants from EU and from non-EU countries. When we compare the total migration stocks obtained from EuroStat in 2011 with those from the UN database in 2010, we find a strong correlation of 0.97 for total migration into the EU, and of 0.90 for EU migrants into other EU countries.

Next, we take the EuroStat data on immigration and emigration flows to EU countries: total number of long-term immigrants (emigrants) arriving (leaving) from the reporting country during the reference year. There is data for the period 2005 to 2015, so we can construct the total net migration flows (immigrants minus emigrants) for 5-year periods (2006 to 2010 and 2011 to 2015). These data can be compared with the UN flows estimated as the difference between the 2010 and 2005 and the 2015 and 2010 stocks, respectively. For the flows up to 2010 we find a very high correlation between both datasources (0.87), but a lower correlation for the period between 2011 and 2015 (0.58). However, the UN database is not directly measuring flows, so this might create some of the discrepancies in the later years. Note also that EuroStat does not present bilateral migration flows, but just totals by country.

B Additional tables

Table A.1: Free movement of people: year of implementation by EU country of origin and destination

Origin \ Destination:	AUT	BEL	DEU	DNK	ESP	FIN	FRA	GBR	GRC	IRL	ITA	LUX	NLD	PRT	SWE	BGR	CYP	CZE	EST	HRV	HUN	LTU	LVA	MLT	POL	ROU	SVK
AUT		1994	1994	1994	1994	1994	1994	1994	1994	1994	1994	1994	1994	1994	1994	2014	2004	2011	2011	2018	2011	2011	2011	2004	2011	2014	2011
BEL	1994		1958	1973	1986	1994	1958	1973	1981	1973	1958	1958	1958	1986	1994	2014	2004	2009	2009	2015	2009	2009	2009	2004	2009	2014	2009
DEU	1994	1958		1973	1986	1994	1958	1973	1981	1973	1958	1958	1958	1986	1994	2014	2004	2011	2011	2015	2011	2011	2011	2004	2011	2014	2011
DNK	1994	1973	1973		1986	1954	1973	1973	1981	1973	1973	1973	1973	1986	1954	2009	2004	2009	2009	2013	2009	2009	2009	2004	2009	2009	2009
ESP	1994	1986	1986	1986		1994	1986	1986	1986	1986	1986	1986	1986	1986	1994	2009	2004	2006	2006	2015	2006	2006	2006	2004	2006	2014	2006
FIN	1994	1994	1994	1954	1994		1994	1994	1994	1994	1994	1994	1994	1994	1954	2007	2004	2006	2006	2013	2006	2006	2006	2004	2006	2007	2006
FRA	1994	1958	1958	1973	1986	1994		1973	1981	1973	1958	1958	1958	1986	1994	2014	2004	2008	2008	2015	2008	2008	2008	2004	2008	2014	2008
GBR	1994	1973	1973	1973	1986	1994	1973		1981	1973	1973	1973	1973	1986	1994	2014	2004	2004	2004	2018	2004	2004	2004	2004	2004	2014	2004
GRC	1994	1981	1981	1981	1986	1994	1981	1981		1981	1981	1981	1981	1986	1994	2009	2004	2006	2006	2015	2006	2006	2006	2004	2006	2009	2006
IRL	1994	1973	1973	1973	1986	1994	1973	1973	1981		1973	1973	1973	1986	1994	2012	2004	2004	2004	2013	2004	2004	2004	2004	2004	2012	2004
ITA	1994	1958	1958	1973	1986	1994	1958	1973	1981	1973		1958	1958	1986	1994	2012	2004	2006	2006	2015	2006	2006	2006	2004	2006	2012	2006
LUX	1994	1958	1958	1973	1986	1994	1958	1973	1981	1973	1958		1958	1986	1994	2014	2004	2007	2007	2015	2007	2007	2007	2004	2007	2014	2007
NLD	1994	1958	1958	1973	1986	1994	1958	1973	1981	1973	1958	1958		1986	1994	2014	2004	2007	2007	2018	2007	2007	2007	2004	2007	2014	2007
PRT	1994	1986	1986	1986	1986	1994	1986	1986	1986	1986	1986	1986	1986		1994	2009	2004	2006	2006	2013	2006	2006	2006	2004	2006	2009	2006
SWE	1994	1994	1994	1954	1994	1954	1994	1994	1994	1994	1994	1994	1994	1994		2007	2004	2004	2004	2013	2004	2004	2004	2004	2004	2007	2004
BGR	2007	2007	2007	2007	2007	2007	2007	2007	2007	2007	2007	2007	2007	2007	2007		2007	2007	2007	2013	2007	2007	2007	2007	2007	2007	2007
CYP	2004	2004	2004	2004	2004	2004	2004	2004	2004	2004	2004	2004	2004	2004	2004	2007		2004	2004	2015	2004	2004	2004	2004	2004	2007	2004
CZE	2004	2004	2004	2004	2004	2004	2004	2004	2004	2004	2004	2004	2004	2004	2004	2007	2004		2004	2013	2004	2004	2004	2004	2004	2007	2004
EST	2004	2004	2004	2004	2004	2004	2004	2004	2004	2004	2004	2004	2004	2004	2004	2007	2004	2004		2013	2004	2004	2004	2004	2004	2007	2004
HRV	2018	2015	2015	2013	2015	2013	2015	2018	2015	2013	2015	2015	2018	2013	2013	2013	2015	2013	2013		2013	2013	2013	2018	2013	2013	2013
HUN	2009	2009	2009	2009	2006	2006	2008	2004	2006	2004	2006	2007	2007	2006	2004	2009	2004	2004	2004	2013		2004	2004	2004	2004	2009	2004
LTU	2004	2004	2004	2004	2004	2004	2004	2004	2004	2004	2004	2004	2004	2004	2004	2007	2004	2004	2004	2013	2004		2004	2004	2004	2007	2004
LVA	2004	2004	2004	2004	2004	2004	2004	2004	2004	2004	2004	2004	2004	2004	2004	2007	2004	2004	2004	2013	2004	2004		2004	2004	2007	2004
MLT	2004	2004	2004	2004	2004	2004	2004	2004	2004	2004	2004	2004	2004	2004	2004	2014	2004	2004	2004	2018	2004	2004	2004		2004	2014	2004
POL	2007	2007	2007	2007	2006	2006	2007	2004	2006	2004	2006	2007	2007	2006	2004	2007	2004	2004	2004	2013	2004	2004	2004	2004		2007	2004
ROU	2007	2007	2007	2007	2007	2007	2007	2007	2007	2007	2007	2007	2007	2007	2007	2007	2007	2007	2007	2013	2007	2007	2007	2007	2007		2007
SVK	2004	2004	2004	2004	2004	2004	2004	2004	2004	2004	2004	2004	2004	2004	2004	2007	2004	2004	2004	2013	2004	2004	2004	2004	2004	2007	
SVN	2007	2007	2007	2007	2006	2006	2007	2004	2006	2004	2006	2007	2007	2006	2004	2007	2004	2004	2004	2018	2004	2004	2004	2004	2004	2007	2004

Source: European Parlament website.

Table A.2: Pair-wise correlations

	FMP	Schengen	Stocks (comb)	Stocks (UN)	Stocks (WB)	ln(ρ) (comb)	ln(ρ) (UN)	ln(ρ) (WB)	Flows (comb)	Flows (UN)	Flows (WB)
FMP	1										
Schengen	0.503	1									
Stocks (comb)	0.014	0.164	1								
Stocks (UN)	0.013	0.168	0.973	1							
Stocks (WB)	0.026	0.214	1.000	0.927	1						
ln(ρ) comb	0.141	0.191	0.046	0.051	0.046	1					
ln(ρ) UN	0.185	0.242	0.055	0.056	0.093	0.687	1				
ln(ρ) WB	0.118	0.224	0.046	0.073	0.056	1.000	0.316	1			
Flows (comb)	0.003	0.158	0.874	0.874	0.956	0.038	0.047	0.040	1		
Flows (UN)	0.002	0.155	0.808	0.810	0.874	0.043	0.042	0.073	0.957	1	
Flows (WB)	0.006	0.206	0.956	0.921	0.921	0.040	0.077	0.046	1.000	0.970	1

Source: Own estimates using World Bank (WB), United Nations (UN) and their combined (comb) bilateral migration databases.

Table A.3: PPML gravity estimated coefficients for the Netherlands as origin and destination country

Grouping	γ	**sign. Level**	$\hat{\gamma}$	**Grouping**	γ	**sign. Level**	$\hat{\gamma}$
NLD as origin	0.872	***	139.2%	**NLD as destination**	1.287	***	262.2%
From Netherlands to:				**To Netherlands from:**			
Austria	0.177		19.4%	Austria	0.428	*	53.4%
Belgium	n.a.			Belgium	n.a.		
Germany	n.a.			Germany	n.a.		
Denmark	0.929	***	153.2%	Denmark	1.496	***	346.4%
Spain	0.496		64.2%	Spain	1.475	***	337.1%
Finland	1.482	***	340.2%	Finland	1.151	***	216.1%
France	n.a.			France	n.a.		
United Kingdom	1.315	***	272.5%	United Kingdom	1.018	***	176.8%
Greece	0.968	***	163.3%	Greece	1.798	***	503.8%
Ireland	1.085	***	195.9%	Ireland	0.512	***	66.9%
Italy	n.a.			Italy	n.a.		
Luxembourg	n.a.			Luxembourg	n.a.		
Portugal	2.147	***	755.9%	Portugal	0.838	***	131.2%
Sweden	0.623	***	86.5%	Sweden	1.079	***	194.2%
Bulgaria	3.768	***	4229.3%	Bulgaria	1.478	***	338.4%
Cyprus	1.419	***	313.3%	Cyprus	1.182	***	226.1%
Czech Republic	2.638	***	1298.5%	Czech Republic	-1.810	***	-83.6%
Estonia	n.a.			Estonia	n.a.		
Croatia	n.a.			Croatia	n.a.		
Hungary	1.569	***	176.6%	Hungary	0.853	***	86.3%
Lithuania	3.396	***	2884.4%	Lithuania	2.104	***	719.9%
Latvia	3.617	***	3622.6%	Latvia	2.047	***	674.5%
Malta	4.705	***	10949.8%	Malta	1.441	***	322.5%
Poland	1.703	***	449.0%	Poland	1.967	***	614.9%
Romania	1.639	***	415.0%	Romania	0.571	***	77.0%
Slovakia	3.088	***	2093.3%	Slovakia	0.584	***	79.3%
Slovenia	0.525		69.0%	Slovenia	1.556	***	374.0%
Observatios		163,933		Observatios		163,933	

Notes: All regressions include the $ln(\rho)$ term and all fixed effect coefficients. Multiway clustered standard errors, with significance levels: *** p<0.01, ** p<0.05, * p<0.1. Source: Own estimates using the combined World Bank and UN bilateral migration databases.

Table A.4: PPML gravity estimates on bilateral migration flows using FMP and three different adjustments to negative migration flows, country-pair clustering of standard errors

	negatives set to zero			negatives deleted			negatives as reverse flow		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
FMP	0.585***		0.601***	0.392***		0.479***	0.368**		0.392**
	(0.159)		(0.186)	(0.145)		(0.159)	(0.156)		(0.177)
Schengen		0.249*	-0.0327		0.0486	-0.181		0.163	-0.0449
		(0.148)	(0.170)		(0.135)	(0.156)		(0.166)	(0.188)
Observations	155,094	155,094	155,094	114,562	114,562	114,562	200,232	200,232	200,232

Notes: In columns 1-3 negative bilateral migration flows are deleted, in columns 4-6 they are set to zero and in columns 7-9 they are assigned as a positive reverse flow. Includes country-time and country-pair fixed effects. Country pair (by origin and destination) clustering of standard errors in parentheses, with significance levels: *** p<0.01, ** p<0.05, * p<0.1.

Source: Own estimates using the combined World Bank and UN bilateral migration database.

Table A.5: PPML gravity estimates on bilateral migration stocks using only the World Bank (Özden et al., 2011) database

	(1)	(2)	(3)	(4)	(5)	(6)
FMP	0.253**	0.162*			0.283**	0.203**
	(0.129)	(0.097)			(0.119)	(0.102)
Schengen			0.008	-0.067	-0.095	-0.163
			(0.118)	(0.105)	(0.092)	(0.107)
ln (ρ)		0.023*		0.036**		0.023*
		(0.014)		(0.017)		(0.013)
Observations	135,271	107,189	135,271	107,189	135,271	107,189

Notes: Includes country-time and country-pair fixed effects. Multiway (by origin, destination and year) clustering of standard errors in parentheses, with significance levels: *** p<0.01, ** p<0.05, * p<0.1. Source: Own estimates using the World Bank bilateral migration database.

Table A.6: PPML gravity estimates on bilateral migration stocks using only the United Nations (2015b) database

	(1)	(2)	(3)	(4)	(5)	(6)
FMP	0.443***	0.426***			0.366***	0.360***
	(0.098)	(0.096)			(0.122)	(0.122)
Schengen			0.265***	0.249***	0.135**	0.117*
			(0.049)	(0.045)	(0.058)	(0.060)
ln (ρ)		0.013**		0.013**		0.012**
		(0.006)		(0.006)		(0.006)
Observations	68,658	68,426	68,658	68,426	68,658	68,426

Notes: Includes country-time and country-pair fixed effects. Multiway (by origin, destination and year) clustering of standard errors in parentheses, with significance levels: *** p<0.01, ** p<0.05, * p<0.1. Source: Own estimates using the UN bilateral migration database.

Table A.7: PPML gravity estimates on bilateral migration stocks *without* country-pair fixed effects

	(1)	(2)
FMP	3.774***	3.289***
	(0.111)	(0.153)
Distance	-0.0039***	-0.0034***
	(0.0001)	(0.0002)
Contiguous	-2.433***	-2.318***
	(0.061)	(0.068)
Common Language	-0.924***	-0.896***
	(0.065)	(0.077)
Common Colony	-0.640***	-0.749***
	(0.105)	(0.122)
Colony before 1945	0.678***	0.701***
	(0.188)	(0.210)
ln(ρ)		0.617***
		(0.136)
Observations	323,574	278,855

Notes: Includes Origin-time and destination-time fixed effects. Multiway (by origin, destination and year) clustering of standard errors in parentheses, with significance levels: *** p<0.01, ** p<0.05, * p<0.1. Sources: Own estimates using the combined World Bank and UN bilateral migration databases and, the CEPII database.

C Adjusting the RUM model from migration flows to stocks

Here we explain the derivation of Equation 9. We start with the original RUM model from Equation 4:

$$ln(m_{odt}) = \phi_{odt} + \alpha_{ot} + \beta_{dt}$$

Including country-pair fixed effects we get:

$$\begin{aligned}
m_{odt} &= e^{(\mathbf{P}_{odt}+\mu_{od}+\alpha_{ot}+\beta_{dt})} \\
M_{odt} &= \frac{M_{odt}}{m_{odt}} \quad e^{(\mathbf{P}_{odt}+\mu_{od}+\alpha_{ot}+\beta_{dt})} \\
\text{Equation 8 is:} & \\
m_{odt} &= M_{odt} - M_{od(t-1)} \\
M_{odt} &= m_{odt} + M_{od(t-1)} \\
\text{Substituting Eq. 8 into 4:} & \\
M_{odt} &= \frac{m_{odt} + M_{od(t-1)}}{m_{odt}} \quad e^{(\gamma\mathbf{P}_{odt}+\mu_{od}+\alpha_{ot}+\beta_{dt})} \\
ln(M_{odt}) &= ln\left(1 + \frac{M_{od(t-1)}}{m_{odt}}\right) + (\mathbf{P}_{odt} + \mu_{od} + \alpha_{ot} + \beta_{dt}) \\
\text{Using} \quad \rho_{odt} &= 1 + \frac{M_{od(t-1)}}{m_{odt}} \quad \text{we get:} \\
ln(M_{odt}) &= \mathbf{P}_{odt} + ln(\rho_{odt}) + \mu_{od} + \alpha_{ot} + \beta_{dt}
\end{aligned}$$

We then obtain the econometric PPML specification in Equation 9:

$$M_{odt} = e^{[\gamma\mathbf{P}_{odt}+\theta ln(\rho_{odt})+\mu_{od}+\alpha_{ot}+\beta_{dt}]} + \epsilon_{odt}$$

D Using GLM estimators

To check the robustness of our results, we attempted to estimate our main specification using the alternative estimator proposed by Jochmans (2017). Nonetheless, there are two practical limitations to run these tests.

First, we are forced to use a smaller sample of countries to estimate this alternative estimator. The problem arises from the computation of the very large number of country-pair fixed-effects combinations. With the combined World Bank and UN database we have 234 countries, which translates into 54,756 country-pair fixed effects. In our main specification using PPML, we solve this issue by employing the tailor-made Stata command (ppml_panel_sg) created by Larch et al. (2017), which does not need to create these additional 54,756 variables. Using the standard Stata commands, however, this computation becomes unfeasible once the number of countries is too large and the number of variables exceeds 32,000. Therefore, we restrict the sample to include only countries that are members of the OECD and/or the EU, which leaves us with 41 countries and 1681 country-pairs.

Second, using the generalised linear model (GLM) with the gamma distribution, as proposed by Jochmans (2017), takes a long time to estimate and this slow process does not allow for many iterations. This is a well known problem when using the GLM estimator, where the limited number of iterations generally does not allow the estimates to convergence towards the optimal values (cf. Beine et al., 2016a). By contrast, even when using the full country-sample, the tailor-made program by Larch et al. (2017) provides much faster convergence speeds, while the GLM estimator is so slow that it did not converge in our estimates. Running the GLM estimates for more than 40 hours did not allow for more than one thousand iterations and no convergence was reached. On the other hand, the (ppml_panel_sg) Stata program takes less than an hour to obtain between 10,000 and 30,000 iterations, when convergence is usually reached. Therefore, we cannot evaluate the validity of the estimated coefficients using the GLM model proposed by Jochmans (2017).

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