Goods and Factor Market Integration: A Quantitative Assessment of the EU Enlargement*

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Abstract

The economic effects from labor market integration are crucially affected by the extent to which countries are open to trade. In this paper we build a multi-country dynamic general equilibrium model with trade in goods and labor mobility across countries to study and quantify the economic effects of trade and labor market integration. In our model trade is costly and features households of different skills and nationalities facing costly forward-looking relocation decisions. We use the EU Labour Force Survey to construct migration flows by skill and nationality across 17 countries for the period 2002-2007. We then exploit the timing variation of the 2004 EU enlargement to estimate the elasticity of migration flows to labor mobility costs, and to identify the change in labor mobility costs associated to the actual change in policy. We apply our model and use these estimates, as well as the observed changes in tariffs, to quantify the effects from the EU enlargement. We find that new member state countries are the largest winners from the EU enlargement, and in particular unskilled labor. We find smaller welfare gains for EU-15 countries. However, in the absence of changes to trade policy, the EU-15 would have been worse off after the enlargement. We study even further the interaction effects between trade and migration policies and the role of different mechanisms in shaping our results. Our results highlight the importance of trade for the quantification of the welfare and migration effects from labor market integration.

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1 Introduction

The aggregate and distributional consequences of economic integration are a central theme of debate in many countries, especially regarding the effects of trade and labor market integration. In this context, economic research has made considerable advances on the quantification and understanding of the gains from economic integration, but most of the focus has been on the goods market. However, less attention has been devoted to quantifying the economic effects of labor market integration and, in particular, the effects of changes in migration policy and their interaction with trade in goods and with trade policy, despite the fact that the largest trade agreements signed in the world include specific commitments to labor markets integration.[1]

In this paper we build a quantitative multi-country dynamic general equilibrium model with costly trade in goods and labor mobility across countries subject to migration restrictions to study the effects of trade and labor market integration. We use the 2004 EU enlargement as a natural experiment and exploit the time variation in the integration process to identify the changes to migration costs associated to the change in policy. With the model and our estimates we quantify the general equilibrium effects from actual changes to migration and trade policies.

The model features households of different skills and nationality with forward-looking relocation decisions. In each period, households consume and supply labor in a given country and decide whether to relocate in the next period to a different country or not. The decision to migrate depends on the households location, nationality, skill, migration costs that are affected by policy, and an idiosyncratic shock à la Artuç, Chaudhuri, and McLaren (2010).[2] Taking into account the dynamic decision of households on where and when to migrate is particularly important in the context of the EU enlargement since countries reduced migration restrictions sequentially over time. Moreover, it turns out that the possibility to move in the future to another country whose real wages have increased adds to the welfare of a worker by raising her option value of being in a given location.[3]

The production side of the economy features producers of differentiated varieties in each country with heterogeneous technology as in Eaton and Kortum (2002). In addition, we allow technology levels to be proportional to the size of the economy in order to capture the idea that there are benefits from firms and people locating next to each other.[4] Production requires skilled and un-

[1] Trade agreements usually include commitments to labor market integration in multiple forms: direct labor market provisions aimed at regulating and integrating the labor market of signatory countries, visa and asylum provisions, and provisions liberalizing the flows of workers delivering services across countries (GATS mode IV). Besides the EU enlargements, examples of trade agreements that include elements of labor market integration are NAFTA, MERCOSUR, US with Australia, Chile, Singapore, the EU and Japan with Mexico, among many (WTO 2013).

[2] Keeping track of each household's nationality is relevant in the context of changes to migration policies. For instance, if U.K. eliminates migration restrictions to Polish nationals, Polish households can freely move to the U.K. regardless of the location they are currently residing in. Likewise, unless EU countries drop migration restrictions to Polish nationals, Polish nationals can't migrate from the U.K. to another EU country as British nationals can.

[3] In fact, even if migrants and natives obtain the same real wage they value each location differently since they face different continuation values as a result of different migration costs.

[4] In this sense, we follow Krugman (1980), Jones (1995), Kortum (1997), Eaton and Kortum (2001), and Ramondo, Rodríguez-Clare, and Saborío-Rodríguez (2016).

skilled labor. Firms also demand local fixed factors (structures, land) and, as a result, increases in population size put upward pressure on factor prices that can mitigate the benefits from having a larger market. Goods are traded across countries subject to trade costs which depend on geographic barriers and trade policy (tariffs) as in Caliendo and Parro (2015). As a consequence, a change to trade policy impacts the terms of trade which in turn influences the effect of a change to migration restrictions. All these features shape the economic effects of trade and labor market integration. Understanding the overall contribution of these channels is a quantitative question that we answer in the context of an actual change in policy.

We apply our framework to quantify the welfare and migration effects of the 2004 EU enlargement. The 2004 EU enlargement is an agreement between member states of the European Union (EU) and New Member States (NMS) that includes both goods market integration, and factors market integration. On the integration in the goods market, tariffs were reduced to zero starting in 2004, and the NMS countries resigned to previous FTAs and joined EU's FTAs. On factors market integration, migration restrictions were eliminated although, as described in detail later on, the timing of these changes to migration policies varied across countries.

Evaluating the effects of the EU enlargement requires information on how trade and migration costs changed due to the policy. For the case of trade policy one can directly observe the change in tariffs; however, changes in migration restrictions are not directly observed. To identify the changes in migration costs due to the change in policy, we exploit the cross-country variation in the timing of the adoption of the new migration policy.[5] Our identification strategy has a difference-in-difference flavor, and relies on the assumption that the trend in migration costs between countries that change migration policy and those that do not would have been the same in the absence of the EU enlargement. We confirm our identifying assumption by running several placebo tests.

To estimate these changes in migration costs due to the EU enlargement and to compute our model we require data on bilateral gross migration flows by nationality and skill. We use raw data from European Labour Force Survey (EU-LFS) to construct these migration flows for a group of 17 EU countries for the period 2002-2007.[6] To evaluate the changes to trade policy, we collect tariff data over the period 2002-2007.

To compute the effects of the EU enlargement we also need estimates of the migration cost elasticity, the elasticity of substitution between low and high skilled workers, and the trade elasticity. We estimate the migration elasticity by adapting to our model and application the two-step PPML estimation approach developed by Artuç and McLaren (2015), and by using data on gross migration flows and wages across countries and over time. In order to estimate the elasticity of substitution between low and high skilled workers we follow standard approaches (e.g. Katz and Murphy (1992)) and use detailed matched employer-employee data for Portugal. We instrument the relative supply of high to low skilled labor by using information on displaced workers that are forced to change firm

[5] We estimate the whole set of changes in migration costs due to the EU enlargement over the period 2002-2007. That is, for NMS nationals that migrate from NMS countries to EU countries, for NMS nationals that migrate across NMS countries, and for EU nationals that migrate from EU countries to NMS countries.

[6] We collect data up to the year 2007 in an attempt to exclude the effects of the 2008 global financial crisis.

because of firm closure. Finally, we obtain the trade elasticity from Caliendo and Parro (2015).

Using our model, estimated changes in migration costs, observed changes in tariffs, and estimated migration, trade, and substitution elasticities we proceed to our empirical analysis. We compute our model using the dynamic hat algebra developed in Caliendo, Dvorkin, and Parro (2017a). The method consists on expressing the equilibrium conditions of a counterfactual economy relative to a baseline economy. By doing so, one can solve the model and perform counterfactual analyses without needing to estimate the set of exogenous state variables, (hereafter referred to as fundamentals). In our application, we solve for a counterfactual economy where we hold trade and migration policy unchanged relative to a baseline economy which contains the actual evolution of policies.

We first evaluate the migration effects of the EU enlargement. We find that the stock of NMS nationals in EU-15 countries increases very gradually over time. For instance, three years after the EU enlargement (that is, in 2007) the stock of NMS nationals in EU countries increases by 0.03%, while ten years after the implementation, the stock raises by 0.23%. We find that in steady state, the stock of NMS nationals in EU-15 countries increases by 0.63%. Across skill groups, we find that the EU enlargement primarily increases migration of unskilled NMS workers to EU-15 countries, and to a much lesser extent the migration of skilled workers. We also find that migration would have been larger in the absence of changes to trade policy. For instance, the stock of NMS unskilled workers would have been about 150 thousands people larger in the steady state, and the stock of skilled workers would have been about 140 thousands people larger.

Turning to the welfare effects, we find that the largest winners are the NMS countries, and in particular the unskilled workers. Welfare of NMS unskilled workers increases 1.46%, while welfare for skilled workers increases 0.97%. On the other hand, we find smaller welfare effects for workers in EU countries; welfare increases 0.23% for high skilled and 0.12% for low skilled workers. However, in the absence of changes to trade policy, the EU-15 would have been worse off.

There are heterogeneous welfare effects across countries. Overall, Poland and Hungary are the largest winners from the EU enlargement. We find that the only losers from the EU enlargement are low skilled workers in the United Kingdom. On aggregate all groups of countries gain. NMS countries welfare increases by 1.41%, EU-15 countries welfare increases 0.14%, while for Europe as a whole welfare increases 0.36%.

The timing of changes to migration policy matters. We find that opening to trade and delaying opening to migration would have benefited EU-15 low-skilled workers more compared to EU-15 high skilled workers. We also find that NMS countries would have been worst off compared with the actual gains; yet welfare gains are still positive.

We also study the interaction between trade and migration and find that the level of trade integration has a quantitative impact on the welfare effects of changes to migration policy. Countries that receive migrants gain more under costly trade than under free trade while the reverse happens to the countries that experience an outflow of workers. For instance, welfare gains from reductions in migration restrictions for NMS countries would have been 13% higher under free trade compared

to autarky.

We also extend our model to account for potential congestion effects from public goods. We find that in the presence of public goods migration effects from the EU enlargement are somewhat lower as immigration strains public goods and reduces incentives to migrate. Welfare gains are larger in NMS countries that experience a net outflow of workers that help decongest public goods, and smaller in EU-15 countries that experience a net inflow of workers. We also evaluate the quantitative importance of the mechanisms that operate in the model and find that abstracting from trade, congestion effects, and scale effects results in a significantly different welfare evaluation of trade and migration policies.

Our paper brings together two different but complementary elements in the analysis: on the one hand, we use a reduced-form analysis that exploits migration policy changes to identify change in migration costs associated to the EU enlargement; on the other hand, we use a rich dynamic general equilibrium model that includes all the mechanisms described above to quantify the migration and welfare effects of actual changes to trade and migration policies.

We now briefly discuss the connection of this study to the literature. Our research is complementary to studies that have employed static models of trade and migration to investigate different mechanisms in which trade and migration are interrelated. For instance, the effects of immigration in a Ricardian model with technology differences across countries studied in Davis and Weinstein (2002), the welfare effects of migration through remittances in di Giovanni, Levchenko, and Ortega (2015), and crowding out effects and labor market adjustments to immigration across tradable and non-tradable occupations in Burstein, Hanson, Tian, and Vogel (2017).

Our paper also complements studies that focus on the impact of immigration on wages and employment of native workers, a question that has been extensively studied in the literature (e.g. Hanson and Slaughter (2002), Hanson and Slaughter (2016); Ottaviano and Peri (2012); Ottaviano et al. (2013); Hong and Mclaren (2016); and many more).

We also build on quantitative trade literature for trade policy analysis, such as Costinot and Rodriguez-Clare (2014), Ossa (2014), and in particular on Caliendo and Parro (2015). We depart from these studies by adding labor market dynamics and policy dependent mobility frictions. In this sense, our paper relates to studies that evaluate the impact of trade shocks on labor markets, like Artuç et al. (2010); Dix-Carneiro (2014); Dix Carneiro and Kovak (2017); Cosar (2013); Coşar et al. (2016); Kondo (2013); Menezes-Filho and Muendler (2011), McLaren and Hakobyan (2015), and Galle, Rodriguez-Clare, and Yi (2017). For a recent review with the advances in this literature, see McLaren (2017).

This study relates to quantitative research where labor reallocation plays an important role in order to analyze the spatial distribution of economic activity, such as in Ahlfeldt, Redding, Sturm, and Wolf (2015), Redding and Sturm (2008), Redding (2016), Allen and Arkolakis (2014), Caliendo, Parro, Rossi-Hansberg, and Sarte (2017b), Fajgelbaum, Morales, Serrato, and Zidar (2015), Monte, Redding, and Rossi-Hansberg (2015), Tombe and Zhu (2015).[7]

[7] For a review of new developments in quantitative spatial models see Redding and Rossi-Hansberg (2016).

There is a fast-growing literature using spatial dynamic general equilibrium models that we also contribute to. Our framework with labor market dynamics builds on Artuç et al. (2010), and it is particularly close to the general equilibrium model of trade and labor market dynamics developed in Caliendo et al. (2017a) (hereafter CDP). CDP focus on studying the dynamic adjustments of labor markets to a trade shock, while in this paper we focus on quantifying how counterfactual dynamic responses to migration and trade policy change the distribution of economic activity. Also, different from CDP, we bring into the analysis households of different skills and nationalities, and policy-dependent migration costs. Other papers, notably Desmet and Rossi-Hansberg (2014), employ spatial dynamic models to understand how the distribution of economic activity shapes the dynamics of local innovation and growth by determining the market size of firms. Following this research, Desmet et al. (2016) study how migration shocks shape the dynamics of local innovation and growth.[8]

Our paper also connects with studies that have used the EU enlargement (as an ex-ante and ex-post evaluation) to study the economics implications of the integration (e.g. Baldwin (1995), Baldwin et al. (1997), Dustmann and Frattini (2011), and Kennan (2017)). Our approach departs in several ways, and in particular by employing new quantitative techniques to study the general equilibrium effects of the enlargement in a model of costly trade and migration.

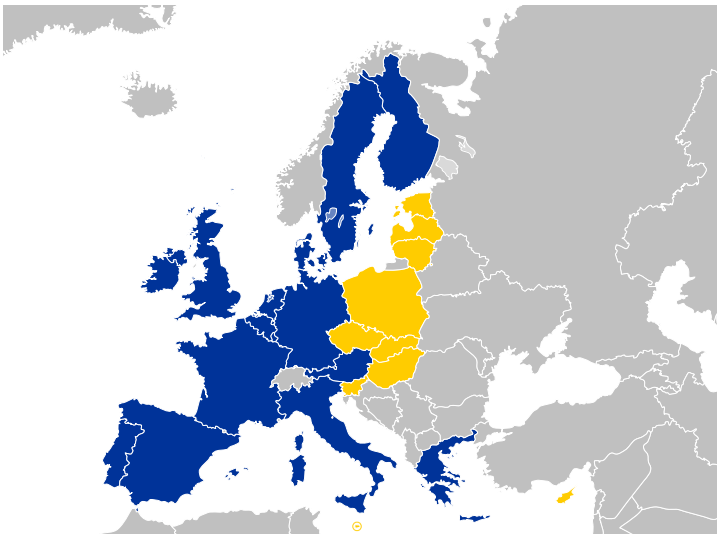
Finally, we mention other mechanisms in the literature that will not be part of our analysis. Some studies have focused on the substitution between migrants and natives in production, although the results on the value of the elasticity of substitution are contrasting, as documented by Borjas et al. (2012). As explained above, in our paper natives and migrants are perfect substitutes in production but they still value locations differently as a result of facing different migration restrictions. That is, when deciding to migrate and where to live, the option value for a migrant and a native vary and as a consequence migrants could in fact trade-off lower wages for a higher option value.

We will also abstract from selection effects in the migration decisions coming from unobserved heterogeneity in labor market skills. Selection effects could lead to an increase in productivity by better sorting migrants across location (e.g. Borjas (1987), Young (2013), Lagakos and Waugh (2013), Bryan and Morten (2017)). In our model, immigration increases productivity through a different force as explain later on. Diamond (2016) has also found a that skill internal migration increases amenities in U.S. skill cities over the period 1980-2000. We abstract from endogenous amenities in our model, but we believe that this mechanism is somehow less relevant in the context of the EU enlargement as we quantify the effects of international migration, and as we will document later on, most of the migration due to the enlargement was low skilled. Still, studying the impact of immigration on amenities at the country level is a promising avenue for future research.

The rest of the paper is structured as follows. Section 2 describes the main migration and trade policy changes as a consequence of the EU enlargement. In Section 3 we develop a dynamic

[8]See also Klein and Ventura (2009), who study the effects on output, welfare, and capital accumulation of removing labor mobility barriers in a neoclassical growth model.

Figure 1: 2004 Enlargement of the European Union



Note: EU-15 member states in blue, NMS countries in yellow.

model for trade and migration policy analysis. Section 4 describes the data construction and sources needed to compute the model, the estimation of changes to migration costs due to the EU enlargement, and the estimation of the relevant elasticities of the model. In Section 5 we compute the migration and welfare effects from the EU enlargement and discuss the results. Finally, section 6 concludes.

2 The 2004 Enlargement of the European Union

On May 1^{st} 2004 ten new countries with a combined population of almost 75 million officially joined the European Union (EU) bringing the total number of member states from 15 to 25 countries (Figure 1).[9] The New Member States (NMS), are: Czech Republic, Cyprus, Estonia, Latvia, Lithuania, Hungary, Malta, Poland, Slovenia, and Slovakia. In this section we highlight the features of the 2004 enlargement that directly affect the international migration of workers within Europe and international trade both between the enlarged set of EU members and between the EU and the rest of the world.[10]

2.1 Migration Policies

The freedom of movement of workers is considered as one of the four fundamental freedoms guaranteed by EU law (*acquis communautaire*), along with the free movement of goods.[11] EU law

[9]The existing EU-15 member states are Austria, Belgium, Denmark, Finland, Germany, Greece, Spain, France, Ireland, Italy, Luxembourg, Netherlands, Portugal, Sweden, and the United Kingdom.

[10]Appendix A describes the steps of the EU membership process, and reports additional information on the accessing countries.

[11]As effectively and concisely defined by Article 45 (ex Article 39 of the Treaty Establishing the European Community) of the Treaty on the Functioning of the European Union, the freedom of movement of workers entails "*the*

effectively establishes the right of EU nationals to freely move to another member state, to take up employment, and reside, as well as protects against any possible discrimination, on the basis of nationality, in employment-related matters.[12]

The Accession Treaty of 2003 allowed the "old" member states to temporarily restrict, for a maximum of 7 years, the access to their labor markets to citizens from the accessing countries, with the exception of Malta and Cyprus. These temporary restrictions were organized in three phases according to a 2+3+2 formula. The transitional arrangements were scheduled to end irrevocably seven years after accession, i.e. on April 30^{th}, 2011.

We now briefly summarize the phase-in period of the accession. Appendix A presents furthers details.

Before 2004. Workers could flow freely within the EU-15 member states but not between EU-15 and NMS as well as between NMS countries.

Phase 1. In 2004, the U.K., Ireland, and Sweden open their borders to NMS countries, which reciprocate by opening their borders to British, Irish and Swedish citizens. All the other EU-15 countries keep applying restrictions to NMS countries, except to Cyprus and Malta. All NMS countries decide to open their borders to EU-15 member states, except for Hungary, Poland, and Slovenia which apply reciprocal measures. NMS countries lift all restrictions among each others.

Phase 2. In 2006, Italy, Greece, Portugal, and Spain lift restrictions on workers from NMS countries. As a consequence, Hungary, Poland, and Slovenia drop their reciprocal measures towards these four member states. Slovenia and Poland dropped the reciprocal measures altogether in 2006 and 2007, respectively, while Hungary simplified them in 2008. During phase 2, The Netherlands and Luxembourg (in 2007), and France (in 2008) also lift restrictions on workers from NMS countries.

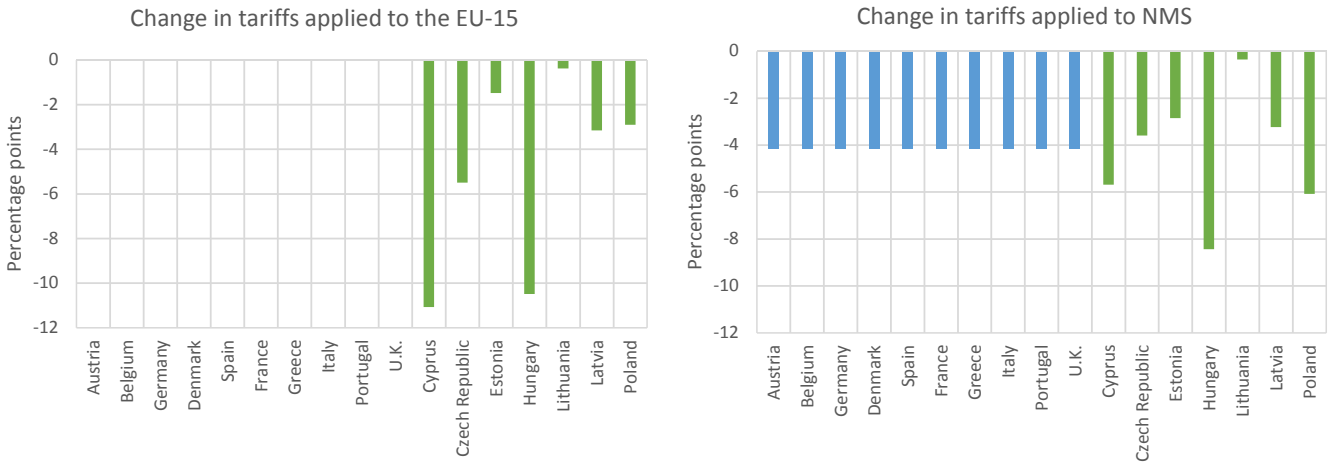
Phase 3. Belgium and Denmark opened their labor market to NMS countries in 2009, while Austria and Germany opened their labor markets at the end of the transitional period, in 2011.

As we can see, there is considerable variation in terms of which countries open to which over time across the phases. This variation is going to result useful for us in order to identify the changes in migration costs due to migration policy. Yet, phase 3 of the agreement was in the middle of the 2008 great financial crisis and this can interfere with our identification of the effects of the change in policy. As a result, in our quantitative analysis, we focus on the effects of the enlargement accounting for the first two phase-in periods. We now briefly describe the change in trade policy.

abolition of any discrimination based on nationality between workers of the member states as regards employment, remuneration and other conditions of work and employment".

[12]Once a worker has been admitted to the labor market of a particular member state, community law on equal treatment as regards remuneration, social security, other employment-related measures, and access to social and tax advantages is valid.

Figure 2: Tariffs changes due to the EU enlargement



Note: Tariffs changes from 2003 to 2004. Source WITS.

2.2 Trade Policies

As part of the enlargement process, NMS became part of the European Union Customs Union, and of the European common commercial policy. As a result, tariffs between NMS and EU-15 countries were reduced to zero starting in 2004. Figure 2 presents the change in tariffs applied to EU-15 countries and to NMS countries as a consequence of the EU-enlargement. The average tariff rate before the enlargement was about 4.3 percent between NMS countries, the average tariff applied by NMS to EU-15 countries was about 5 percent, and the average tariff applied by EU-15 to NMS countries was about 4.2 percent. After the accession, from 2004 on, tariffs between all EU-25 countries are zero. Also, as a consequence of the EU enlargement process, NMS automatically entered into the trade agreements to which the EU is a party, and forwent their own existing agreements. [13] This resulted in additional changes in trade policy for NMS. We use all these tariff changes in our quantitative assessment later on.

3 A Dynamic Model of Trade and Labor Markets Integration

In this section, we develop a dynamic general equilibrium model for trade and migration policy analysis. The model extends that in CDP by adding households of different nationalities and skills, and by taking into account the role of trade policy and migration policy.

The world is composed of N countries, indexed by i and j. Each country represents a competitive labor market where a continuum of firms produce goods with heterogeneous productivities. A fraction of goods are traded across countries, and the movement of goods is subject to trade costs. As we will see later on, a component of trade costs is tariffs, which are affected by trade policy in each country. As in Eaton and Kortum (2002) productivities have a Fréchet distribution with a

[13] In Appendix A.2 we provide more detail on the trade policy implemented after the EU enlargement.

dispersion parameter θ which, as we will see below, is also the trade cost elasticity. Production of goods in a given country requires skilled and unskilled labor, which are imperfect substitutes, and fixed factors that we call structures.

In the model, time is discrete and households have perfect foresight. Households make forward-looking labor relocation decisions subject to migration costs and idiosyncratic preferences. Each period they decide whether to stay in the same country or to move to a different country, a decision that depends on real wages and expected continuation values. Migration policy in each country has an impact on migration costs, and therefore on households' decisions.

We start by describing the problem of the households, we then set up the production structure in each country, and finally, we derive the market clearing conditions. After doing so, we define the equilibrium of the model.

3.1 Households

Households are forward-looking, observe the economic conditions in all countries and optimally decide where to work. Households face costs of moving across countries and are subject to idiosyncratic shocks that affect their moving decision. If they begin the period in a country, they work and earn the market wage. As described above, households in a given country are of different nationalities that we index by n, and with different skills that we index by s.

The value of a n national of skill s in country i at time t, $v^i_{n,s,t}$, is given by

$$v^i_{n,s,t} = log(C^i_{s,t}) + \underset{\{j\}_{j=1}^N}{max} \{\beta E[v^j_{n,s,t+1}] - m^{ij}_{n,s,t} + \nu\epsilon^j_{n,s,t}\},$$

where $C^i_{s,t}$ is the consumption aggregator that we describe below. The term $m^{ij}_{n,s,t}$ is the migration cost from country i to country j at time t for a household native from country n and skill level s.

The migration cost, $m^{ij}_{n,s,t}$ in our model is time varying, as it can be impacted by changes to migration policy. Specifically, we allow mobility costs to have a non-policy and a policy component, that is, $m^{ij}_{n,s,t} = \tilde{m}^{ij}_{n,s,t} + mpol^{ij}_{n,s,t}$, where $\tilde{m}^{ij}_{n,s,t}$ is the non-policy component of the cost of migrating from country i to country j for a household of nationality n and skill s, and $mpol^{ij}_{n,s,t}$ is the policy component that is impacted by migration restrictions. Moreover, we allow non-policy migration costs origin-specific components, destination-specific components, and bilateral components, that is $\tilde{m}^{ij}_{n,s,t} = \bar{m}^i_{n,s,t} + \bar{m}^j_{n,s,t} + \bar{m}^{ij}_{n,s,t}$

We assume that idiosyncratic preference shocks $\epsilon^j_{n,s,t}$ are stochastic i.i.d. of a Type-I extreme value distribution with zero mean, and dispersion parameter ν that later on we will refer to as the migration cost elasticity. Finally, β is the discount factor.

Using the properties of the Type-I extreme value distribution, we can solve for the expected (expectation over ϵ) lifetime utility of a worker of nationality n and skill s in country i, namely $V^i_{n,s,t} \equiv E[v^i_{n,s,t}]$,

$$V^i_{n,s,t} = log\left(C^i_{s,t}\right) + \nu log\left(\sum\nolimits_{j=1}^{N} exp(\beta V^j_{n,s,t+1} - m^{ij}_{n,s,t})^{1/\nu}\right). \quad (1)$$

The first term in equation (1) represents the current utility of that households in country i and the second term captures the expected value of staying in that country the next period and the option value of migrating to a different country. Note that the option value of migration varies by skill and nationality, and captures the fact that households of different nationalities living in the same country face different migration restrictions.

Households supply a unit of labor inelastically, and receive a competitive nominal wage $w^i_{s,t}$ that depends on the country of residency, and the skill level. Given this, the indirect utility of a household with skill s in country i is given by

$$C^i_{s,t} = \frac{w^i_{s,t}}{P^i_t}, \tag{2}$$

where P^i_t is the local price index.

Using the properties of the extreme value distribution, we also solve for the fraction of households of nationality n and skill s that migrates from country i to country j at time t, which we denote by $\mu^{ij}_{n,s,t}$

$$\mu^{ij}_{n,s,t} = \frac{exp(\beta V^j_{n,s,t+1} - m^{ij}_{n,s,t})^{1/\nu}}{\sum_{k=1}^{N} exp(\beta V^k_{n,s,t+1} - m^{ik}_{n,s,t})^{1/\nu}}. \tag{3}$$

This equation describes gross flows of migrants by nationality and skill across countries. Notice that $1/\nu$ captures the response of migration flows to migration costs, or in other words, the migration cost elasticity, which is a parameter that we need to estimate.

With the initial distribution of labor by nationality and skill across countries, and the migration flows at each period, we can solve for the evolution of labor by nationality and skill at each moment in time. Specifically,

$$L^i_{n,s,t+1} = \sum\nolimits_{j=1}^{N} \mu^{ji}_{n,s,t} L^j_{n,s,t}, \text{ for all } n, s. \tag{4}$$

Finally, the total labor supply in each country is then given by the sum of high-skill (h) and low-skill (l) workers of all nationalities,

$$L^i_t = \sum\nolimits_{n=1}^{N} \left(L^i_{n,h,t} + L^i_{n,l,t} \right).$$

We now turn to describe the production structure of each economy.

3.2 Production

A continuum of goods is produced in each country with technology as in Eaton and Kortum (2002). The technology to produce these goods requires both skilled and unskilled labor, and structures. Skilled and unskilled labor are imperfect substitutes, and structures is a fixed factor. Total factor productivity (TFP) is composed of two terms: an aggregate component (A^i_t), which is common to all varieties in a country, and a variety-specific component (z^i) that is a stochastic realization from

a Fréchet distribution. We allow technology levels to be endogenous and proportional to the size of the economy, that is $A_t^i = \phi_t^i L_t^i$, as in Ramondo et al. (2016).[14] Note that, although the elasticity of TFP with respect to population size is equal to one under this formulation, the elasticity of real income with respect to population is less than one because of the congestion effects in the presence of local fixed factors.[15]

Since each variety is identified by z^i, we use it to index a variety. Therefore, the production function of a given good in country i is given by

$$q_t^i(z^i) = z^i A_t^i \left(\left(\delta_h^i\right)^{\frac{1}{\rho}} \left(L_{h,t}^i\right)^{\frac{\rho-1}{\rho}} + \left(\delta_l^i\right)^{\frac{1}{\rho}} \left(L_{l,t}^i\right)^{\frac{\rho-1}{\rho}} \right)^{\frac{\rho(1-\gamma^i)}{\rho-1}} \left(H^i\right)^{\gamma^i},$$

where $L_{h,t}^i$ and $L_{l,t}^i$ are the amount of high and low skilled labor used to produce a given good in country i, ρ is the elasticity of substitution between high and low skilled labor, $(1-\gamma^i)$ is the share of labor payments in value added, δ_h^i is the weight of high-skilled labor in production, and δ_l^i is the weight of low-skilled labor, with $\delta_h^i + \delta_l^i = 1$. The stock of land and infrastructures is H^i, which, as mentioned before, is a fixed factor.

We refer to rentiers as the owners of the fixed factors H^i. As in Caliendo et al. (2017b) we assume that there is a mass one of rentiers in each economy and that rentiers consume local goods using (2), the same consumption aggregator as households. Rentiers obtain rents $r_t^i H^i$ from the fixed factors they own and rent to firms. We assume that these rents are sent to a global portfolio and that rentiers obtain a share ι^i of the global portfolio revenues $\chi_t = \sum_{i=1}^N r_t^i H^i$, where r_t^i is the rental price of structures in country i. Differences between remittances to the global portfolio and the income transfers from the global portfolio will generate imbalances in each country, and therefore, this assumption on the behavior of the rentiers will allow us, in our quantitative model, to match the observed trade imbalances across nations.

Goods can be traded across countries subject to trade costs. Specifically the cost of shipping goods from country j to country i is given by $\kappa_t^{ij} = (1+\tau_t^{ij}) d_t^{ij}$, where d_t^{ij} is an iceberg-type trade cost, and τ_t^{ij} is an ad-valorem tariff.

As in Eaton and Kortum (2002), using the properties of the Fréchet distribution we can solve for the bilateral trade shares π_t^{ij} and the price index P_t^i as a function of factor prices, productivities and trade costs. Specifically,

$$\pi_t^{ij} = \frac{A_t^j (\kappa_t^{ij} x_t^j)^{-\theta}}{\sum_{k=1}^N A_t^k (\kappa_t^{ik} x_t^k)^{-\theta}}, \tag{5}$$

$$P_t^i = \left(\sum_{j=1}^N A_t^j (\kappa_t^{ij} x_t^j)^{-\theta} \right)^{-\frac{1}{\theta}}, \tag{6}$$

[14] Note that an isomorphic relation arises from models with free entry of firms as in Melitz (2003).

[15] Given this, the production structure of our model can be mapped into existing static models with scale effects that show existence and uniqueness of the equilibrium (e.g. Kucheryavyy et al. (2016)).

where x_t^i is the unit price of an input bundle, namely

$$x_t^i \equiv \zeta^i \left(\delta_h^i (w_{h,t}^i)^{1-\rho} + \delta_l^i (w_{l,t}^i)^{1-\rho}\right)^{\frac{(1-\gamma^i)}{1-\rho}} (r_t^i)^{\gamma^i}, \tag{7}$$

where ζ^i is a constant. We now describe the market clearing conditions and the equilibrium of the model.

3.3 Market clearing

The total expenditure on goods by country i is given by labor income of workers of all skill levels and nationalities residing in country i, and by local rentiers. Namely, the goods market clearing is given by

$$X_t^i = \sum_{n=1}^N \sum_{s=h,l} w_{s,t}^i L_{n,s,t}^i + \iota^i \chi_t + T_t^i, \text{ for all } i, \tag{8}$$

where $\chi_t = \sum_{i=1}^N r_t^i H^i$ is the rent of the global portfolio, and where $T_t^i = \sum_{j=1}^N \tau_t^{ij} \frac{\pi_t^{ij}}{(1+\tau_t^{ij})} X_t^i$ are tariff revenues.

Finally, the labor markets clear, i.e

$$w_{s,t}^i L_{s,t}^i = \xi_{s,t}^i (1-\gamma^i) \sum_{j=1}^N \frac{\pi_t^{ji}}{(1+\tau_t^{ji})} X_t^j, \text{ for all } i, s, \tag{9}$$

where $\xi_{s,t}^i$ is the share of skill s in the labor payments, which is time varying given the CES production structure.

3.4 Equilibrium

We denote by $\Theta_t \equiv (\{d_t^{ij}\}, \{\tilde{m}_{n,h,t}^{ij}\}, \{\tilde{m}_{n,l,t}^{ij}\}, \{\phi_t^i\}, \{H^i\})_{i=1,j=1}^{N,N}$ the set of constant and time-varying fundamentals, that is, bilateral iceberg trade costs, mobility costs by nationality and skills, the exogenous component of productivity across countries, and the stock of fixed factors across countries. In addition, we denote by $\Upsilon_t \equiv (\{\tau_t^{ij}\}, \{mpol_{n,h,t}^{ij}\}, \{mpol_{n,l,t}^{ij}\})_{n=1,i=1,j=1}^{N,N,N}$ the different **e**conomic policies of a country: tariffs and migration policies that impact migration costs $m_{n,s,t}^{ij}$. The state of the economy is given by the distribution of labor across each market at a given moment in time $L_t = \left\{L_{n,h,t}^i, L_{n,l,t}^i\right\}_{n=1,i=1}^{N,N}$. We now seek to define the equilibrium of the model given fundamentals, trade policies, and migration policies. First, we formally define a *temporary equilibrium*, which is given by the set of factor prices that solve the static trade equilibrium.

Definition 1. *Given* $(L_t, \Theta_t, \Upsilon_t)$*, the* **temporary equilibrium** *is a set* $\{w_{h,t}^i, w_{l,t}^i, r_t^i\}_{i=1}^N$ *of factor prices that solves the static sub-problem given by the equilibrium conditions* (5), (6), (7), (8), and (9).

We denote by $\omega_{s,t}^i \equiv w_{s,t}^i / P_t^i$ real income and by $\omega_{s,t}^i(L_t, \Theta_t, \Upsilon_t)$ the solution of the temporary equilibrium given $(L_t, \Theta_t, \Upsilon_t)$. We now define the sequential competitive equilibrium of the model given a sequence of fundamentals and policies:

Definition 2. *Given an initial allocation of labor L_0, a sequence of fundamentals $\{\Theta_t\}_{t=0}^{\infty}$, and a sequence of policies $\{\Upsilon_t\}_{t=0}^{\infty}$, a* **sequential competitive equilibrium** *of the model is a sequence $\{L_{n,s,t}, \mu_{n,s,t}, V_{n,s,t}, \omega_{s,t}^{i}(L_t, \Theta_t, \Upsilon_t)\}_{n=1,t=0}^{N,\infty}$ for $s = \{h, l\}$, that solves the households' dynamic problem, equilibrium conditions* (1), (3), (4), *and the temporary equilibrium at each t.*

Definition 2 illustrates the equilibrium of the model given an initial condition on the state of the economy and for a given sequence of fundamentals and policies. Our goal now is to use the model to study the trade, migration and welfare effects of changes to trade and migration policies. We do so in the multi-country version of the model calibrated to the EU economies. Taking a large scale model to the data requires estimating a large set of unknown parameters—technologies, iceberg trade costs, the non-policy component of migration costs, and the endowments of fixed factors—that we refer to as fundamentals. We use the method proposed by CDP, dynamic hat algebra (henceforth DHA), to take the model to the data to study the effects of changes to trade and migration policies. The key advantage of DHA is that we can conduct our quantitative analysis without estimating the fundamentals of the economy. We now express the equilibrium conditions of the model in relative time differences and show how we can use the model and data to study the effects of the EU enlargement.

3.5 Solving for Policy Changes

Suppose we want to study the effects of changes in policy from $\{\Upsilon_t\}_{t=0}^{\infty} \to \{\Upsilon'_t\}_{t=0}^{\infty}$. Let $\dot{y}_{t+1} \equiv y_{t+1}/y_t$ denote the relative time change of a variable, and let $\hat{y}_{t+1} \equiv \dot{y}'_{t+1}/\dot{y}_{t+1}$ denote the relative time difference of the variable under a sequence of policies $\{\Upsilon'_t\}_{t=0}^{\infty}$ relative to the sequence of policies $\{\Upsilon_t\}_{t=0}^{\infty}$.

For instance, if y_{t+1} are prices, $\hat{y}_{t+1}$ is the relative change in prices as a consequence of the change in policy. Given this notation we can write the equilibrium conditions of the model for a given change in the sequence of policies. Importantly, what the next proposition shows is that, given data on the allocations of the economy, we can study the effects of a change in policy without information on the sequence of fundamentals. To simplify notation let $\hat{m}_{n,s,t}^{ij} \equiv \exp(m'^{ij}_{n,s,t+1} - m'^{ij}_{n,s,t}) / \exp(m^{ij}_{n,s,t+1} - m^{ij}_{n,s,t})$, and $\hat{u}^{i}_{n,s,t} \equiv \exp(V'^{i}_{n,s,t+1} - V'^{i}_{n,s,t}) / \exp(V^{i}_{n,s,t+1} - V^{i}_{n,s,t})$.

Proposition 1. *Given data $\{L_t, \mu_t, \pi_t, X_t\}_{t=0}^{\infty}$, elasticities $(\nu, \theta, \beta, \rho)$, and a sequence of counterfactual changes in policy $\{\hat{\Upsilon}_t\}_{t=0}^{\infty}$, solving the model does not require $\{\Theta_t\}_{t=0}^{\infty}$, and solves*

$$\hat{u}^{i}_{n,s,t} = \hat{C}^{i}_{s,t} \left(\sum_{j=1}^{N} \mu'^{ij}_{n,s,t-1} \dot{\mu}^{ij}_{n,s,t} \left(\hat{mpol}^{ij}_{n,s,t} \right)^{-1/\nu} \left(\hat{u}^{j}_{n,s,t+1} \right)^{\beta/\nu} \right)^{\nu},$$

$$\mu'^{ij}_{n,s,t} = \frac{\mu'^{ij}_{n,s,t-1} \dot{\mu}^{ij}_{n,s,t} \left(\hat{mpol}^{ij}_{n,s,t} \right)^{-1/\nu} \left(\hat{u}^{j}_{n,s,t+1} \right)^{\beta/\nu}}{\sum_{k=1}^{N} \mu'^{ik}_{n,s,t-1} \dot{\mu}^{ik}_{n,s,t} \left(\hat{mpol}^{ik}_{n,s,t} \right)^{-1/\nu} \left(\hat{u}^{k}_{n,s,t+1} \right)^{\beta/\nu}},$$

$$L'^{i}_{n,s,t+1} = \sum_{j=1}^{N} \mu'^{ji}_{n,s,t} L'^{j}_{n,s,t} \ ,$$

for all n*, and* s*, where* $\dot{\mu}^{ij}_{n,s,t}$ is the observed (data) change in migration flows over time, and $\hat{C}^{i}_{s,t} = \hat{\omega}^{i}_{s,t}(\widehat{L}_t, \widehat{\Upsilon}_t)$ *is obtained from solving the temporary equilibrium conditions.*[16]

The result in Proposition 1 follows directly from CDP, and shows how we can use data and estimated elasticities to study the effects of a change in policy without needing to estimate fundamentals.

We apply the result of Proposition 1 as follows. Consider a sequence of observed allocations (data) before and after the change in policy. This sequence of data contains information of the actual fundamentals and the policies in place at each time, including the policy changes due to the EU enlargement. To isolate the effect of the EU enlargement, we have to construct a counterfactual sequence of allocations that reflects the evolution of the economies in the absence of the EU enlargement. Proposition 1 shows how to compute this counterfactual economy under a new sequence of policies, $\hat{\Upsilon}_t$, relative to the data. For the case of the EU enlargement, the counterfactual sequence of policies is to leave tariffs and migration costs unchanged, that is, at the pre-enlargement level. Therefore, the solution to the equilibrium conditions in relative time differences showed in Proposition 1 answers the following question: "How would the economy look like if everything would have happened as in the data (changes in fundamentals, other policies, etc.) except for the EU enlargement?"

The methodology developed in CDP has two main attractive properties to quantify the effects of the EU enlargement. First, we only need to identify the change in policy and therefore, we do not need to identify the evolution of the whole set of unobservable parameters (fundamentals) during the period of analysis. Second, we solve for the counterfactual economy relative to an economy that is calibrated using time series, and therefore, when feeding into the model the actual changes in policy, it will match exactly the observed gross migration flows, trade flows, and all the rest of observed labor market allocations. We can apply the result in Proposition 1 to study any other counterfactual change in policy and/or to study changes in fundamentals. Of course, this requires the use of time series data on labor allocations, migration and trade flows, and expenditures, as well as estimates of the elasticities.[17] Implementing this methodology requires a measure of the changes in policies that we want to study. While the magnitude of changes in tariffs comes immediately from the data, measuring the change in migration costs associated with the EU enlargement is challenging.

In the next section, we describe how we construct the data to compute the model, we present

[16] Appendix F describes the equilibrium conditions of the temporary equilibrium in relative time differences.

[17] In practice, there is no infinite sequence of data. To overcome this, we follow CDP and use the maximum possible data available and then use the model to solve forward for the economy under a constant set of fundamentals and policies. In our application this would mean to use data from the years 2002 to 2007 and then solve forward with the level of fundamentals and policies implied by the data of the year 2007.

the estimation strategy used to measure the changes in migration costs, and we estimate all the relevant elasticities.

4 Estimation

To implement the DHA described in the previous section, we need data on bilateral migration shares by nationality and skill $\mu^{ij}_{n,s,t}$, bilateral trade shares π^{ij}_t, total expenditure by country X^i_t, and the distribution of labor by nationality and skill across countries $L^i_{n,s,t}$. In addition, we need to compute the share of labor payments in value added $(1-\gamma^i)$ and the share of labor by skill $\xi^i_{s,t}$. We also need estimates of the migration cost elasticity $1/\nu$, and an estimate of the elasticity of substitution between low and high skill workers, ρ. We also need to input a value for the trade cost elasticity θ, and for the discount factor β. In our quantitative analysis we use the value $\theta = 4.5$ from Caliendo and Parro (2015), whose methodology is consistent with the gravity-trade equation of our model. Finally, we impose a yearly discount factor $\beta = 0.97$. To evaluate the change in trade and migration policy we also need bilateral ad-valorem tariffs τ^{ij}_t, and the changes in migration costs associated to the policy for each country pair. In this section we describe the data construction, and estimation strategies to obtain the elasticities and changes in migration costs associated to the EU enlargement. Appendix B, C, and D present a more extensive description of the data and the estimation methodologies.

4.1 Gross Migration Flows by Skill and Nationality

A limitation to the understanding of the impact of migration flows on economic outcomes lies in the scarce availability of harmonized cross-country data on migration flows. In this section we describe the construction of bilateral gross migration flows across European countries.

We construct a comprehensive data set on bilateral gross migration flows for European countries from 2002 to 2007 using information contained in the European Labour Force Survey (EU-LFS), a large household survey providing confidential quarterly or annual results on labor participation of people aged 15 and over, as well as on persons outside the labor force from 1983 onward. The EU-LFS is currently conducted in the 28 member states of the European Union, two candidate countries and three countries of the European Free Trade Association (EFTA).[18] The main strength of the EU-LFS is to use the same concepts and definitions in every country, follow International Labour Organization guidelines using common classifications (NACE, ISCO, ISCED, NUTS), and record the same set of characteristics in each country. Because of these features, the EU-LFS is the basis for unemployment and education statistics in Europe.

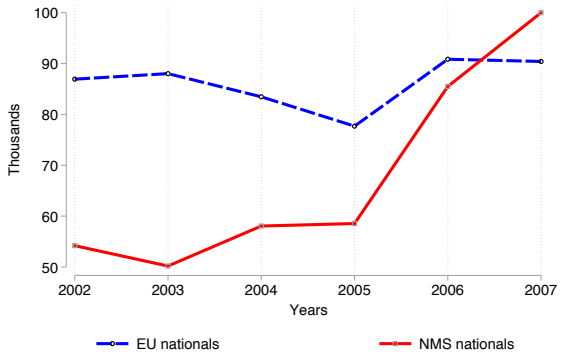
The survey contains information on a representative sample of the labor force in each country. Individuals are assigned a weight to represent the share of people with the same characteristics in

[18]The national statistical institute of each country in Europe conducts surveys that are centrally processed by Eurostat; each national institute is responsible for selecting the sample, preparing the questionnaires, conducting the direct interviews among households, and forwarding the results to Eurostat in accordance with the requirements of the regulation.

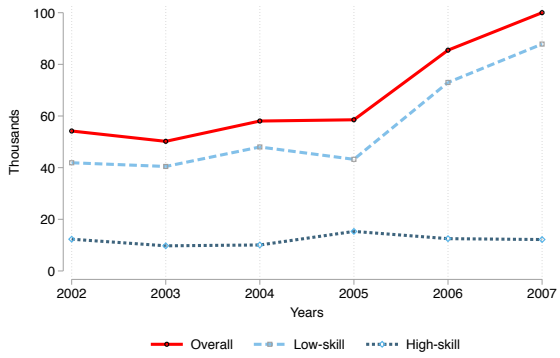
the country. For each individual in a specific year, we have information on age, nationality, skills and, crucially for our purpose, country of residence 12 months before. We use the information on country of residence in the previous year to construct bilateral gross migration flows by year, country of origin, nationality and skill for a group of 17 EU countries.[19]

Figure 3: Migration flows and stocks of NMS nationals in the EU-15, 2002-2007

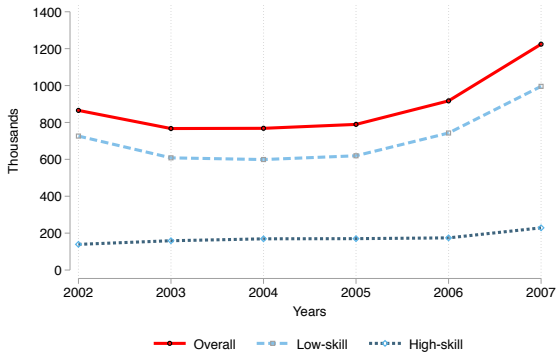
(a) Migration of EU-15 and NMS nationals to EU



(b) Migration of NMS nationals to EU, by skill



(c) Stock of NMS nationals in EU-15, by skill



Note: Own elaboration using the data set on gross migration flows described in Section 4 and Appendix B.2. Migration flows includes 10 EU-15 countries and 7 NMS countries. EU-15 and NMS nationalities are defined in Section 4 and Appendix B.2.2 and cover all the EU-25 members. High-skill includes all individuals with at least tertiary education, while low skills include the residual workers with education up to post secondary non-tertiary education (see Appendix B.2.3).

We group migrants in three broad nationality categories that follow immediately from the 2004 European enlargement: EU-15 nationals, NMS nationals, and Other nationals (rest of the world). Moreover, we follow the international standard classification of education (ISCED 1997) and define high skill labor as college educated and low skill labor as individuals with high school degree or less. We constraint our sample to include only individuals of working age—between 15 and 65 years old—and only countries with consistent information on nationality, skills and country of origin over

[19] As an example, looking at the U.K. survey in 2004, we know if a Polish high-skilled worker moved to the U.K. from Poland in the previous 12 months. Migration shares, $\mu^{ij}_{n,s,t}$ are computed as the share of migrants that moved to a specific destination country over a population defined by country of origin, nationality and skills.

the period 2002-2007. We end up with a total of 17 countries, ten former EU members, Austria, Belgium, Germany, Denmark, Spain, France, Greece, Italy, Portugal, and the United Kingdom, and seven NMS, Cyprus, Czech Republic, Estonia, Hungary, Lithuania, Latvia, and Poland. Our group of countries covers 91 percent of the 2004 EU-25 population.[20]

As an illustration, Figure 3 plots the gross flows and stocks of NMS migrants in EU15 countries that arise from our constructed gross migration flows data.[21] As we can see from the panels, the largest fraction of migrants was unskilled.

4.2 Trade, Employment, Production, Consumption

We construct the bilateral trade shares π_t^{ij} for the 17 countries in our sample, and a constructed rest of the world, using trade flows from the World Input-Output Database (WIOD), and we also compute total expenditure by country X_t^i from WIOD. Employment $L_{n,s,t}$ is computed using the stocks of workers by country, nationality, skills and year from the EU-LFS. The share of labor payments in value added $(1-\gamma^i)$ is computed with information on labor compensation retrieved from the socio economic accounts of the WIOD. The share of labor by skill $\xi_{s,t}^i$ in total labor payment is obtained using labor compensation data by skill from the socio economic account of the WIOD data set.

4.3 Identifying Changes in Migration and Trade Costs due to the EU Enlargement

In this section we present our strategy to measure the changes in migration costs due to the EU enlargement for each pair of countries in our sample. As we described in Section 2.1, the elimination of migration restrictions was implemented at different points in time for different pairs of countries. The main changes in migration policy over the period 2002-2007 were the United Kingdom opening to NMS countries in 2004, followed by Greece, Italy, Spain, and Portugal in 2006, and NMS countries opening their respective labor markets to each other in 2004. Therefore this is the set of changes in migration costs that we are going to estimate in what follows.

Our strategy employs a difference-in-difference approach based on the migration shares equilibrium equation (3). Define $y_{n,s,t}^{ij} \equiv \log \mu_{n,s,t}^{ij}$, then the log odds of the probability of migrating from country i to country j with respect to the probability of staying in country i for workers of nationality n and skill s is given by

$$y_{n,s,t}^{ij} - y_{n,s,t}^{ii} = -\frac{1}{\nu}\left(m_{n,s,t}^{ij} - m_{n,s,t}^{ii}\right) + \frac{\beta}{\nu}V_{n,s,t+1}^{j} - \frac{\beta}{\nu}V_{n,s,t+1}^{i}. \tag{10}$$

[20] Country surveys for Ireland, Malta, Netherlands, Sweden, Slovenia, Bulgaria, Slovakia, Luxembourg, Romania and Finland do not contain sufficient information to compute migration flows consistently between 2002 and 2007, so we assign these countries to the rest of the world (RoW). More information on each case is contained in Appendix B.1.

[21] Appendix B.2 describes in greater detail how we construct the gross migration flows, and provides a set of external validation statistics.

Intuitively, the log odds are decreasing in the cost of migrating from i to j relative to the cost of staying in i, and increasing in the value of living in j compared to the value of living in country i. Equation (10) provides therefore a natural starting point to measure the change in relative migration costs from country i to j between two time periods; a decrease in migration costs, controlling for the change in the relative value of living in j, would result in an increase in the ratio of migrants to stayers.

Our goal is to estimate the change in migration costs due to the EU enlargement ($mpol^{ij}_{n,post-enlarg.}$ -$mpol^{ij}_{n,pre-enlarg}$). In order to separate changes in policy from changes in the non-policy components of migration costs, we estimate (10) in a difference in difference fashion and impose our identification restriction that the change (before and after the enlargement) in the trend in migration costs between countries that changed migration policy and those that do not is only due to the EU enlargement. We control for destination-nationality-skill-time and origin-nationality-skill-time factors such as the value terms and changes in the non-policy origin and destination specific migration costs with origin-nationality-skill-time and destination-nationality-skill-time fixed effects.[22]

Therefore, our identification of changes in migration costs due to the change in policy is internally consistent with both the model developed in Section 3 and our migration cost structure discussed in the subsection 3.1. We next describe in more detail how we proceed to identify the changes in migration costs due to the enlargement for each of the policy changes in our period of analysis.

Example: Change in the Migration Costs from NMS to the U.K.

To explain in more detail our identification strategy, we start by describing the estimation of the change in the cost of migrating from NMS to the U.K. We then follow with the rest of changes to migration policy. In the case of the U.K. we consider three sets of gross migration flows: from NMS countries to the U.K., our treated group in the difference-in-difference jargon; from NMS countries to Austria, Belgium, Denmark, France, and Germany (EU-5), our first control group, that corresponds to a set of EU countries that did not open their labor market to NMS countries before 2008; and from EU-5 to the U.K., the second control group. Starting from equation (10) and using our migration cost structure discussed in the subsection (3.1), we can express equation (10) as a function of origin-specific factors, destination-specific factors, non-policy bilateral mobility costs and the cost associated to migration policy:

[22]The decision to open could, in fact, be affected by the current stock or the recent inflows of immigrants in the country, or by the political orientation of the government. We control for these, and other, possibilities through the destination-skill-time fixed effects. Similarly, the economic situation in the NMS countries, as well as other *push* migration factors, are accounted for by the origin-skill-time fixed effects.

$$y^{ij}_{n,s,t} - y^{ii}_{n,s,t} = \underbrace{-\frac{1}{\nu} mpol^{ij}_{n,s,t}}_{\textbf{migration policy}} \quad \underbrace{-\frac{1}{\nu}\left(\bar{m}^{i}_{n,s,t} - \frac{1}{\nu} m^{ii}_{n,s,t}\right) - \frac{\beta}{\nu} V^{i}_{n,s,t+1}}_{\textbf{origin-specific factors}}$$
$$\underbrace{-\frac{1}{\nu}\bar{m}^{j}_{n,s,t} + \frac{\beta}{\nu} V^{j}_{n,s,t+1}}_{\textbf{destination-specific factors}} \quad \underbrace{-\frac{1}{\nu}\bar{m}^{ij}_{n,s,t}}_{\textbf{bilateral non-policy component}} \tag{11}$$

In our empirical model, we capture the origin specific factors with origin-skill-time fixed effects, and the destination specific factors with destination-skill-time fixed effects. Notice that our first control group identifies the origin fixed effects, and the second control group identifies the destination fixed effects. The bilateral non-policy component will be captured with a bilateral dummy, whose coefficient will capture migration costs pre-enlargement from NMS countries to the U.K. relative to the migration costs from NMS countries to the EU-5 group and the migration costs from the EU-5 group to the U.K. Finally, the change in costs due to the policy can be captured with another bilateral and time-varying dummy, whose coefficient will capture the change in these relative migration costs before and after the enlargement, our object of interest. We pool the flows of low and high skilled workers for the bilateral dummies to capture the fact that changes in migration policy were non-discriminatory across skills and nationalities. Therefore, our empirical model resulting from our structural model is given by:

$$\underbrace{y^{ij}_{n,s,t} - y^{ii}_{n,s,t}}_{\text{Flows to U.K. and control groups minus stayers}} = \underbrace{\delta^{U.K.}_{n,s,t} I_{n,s,t}\left(j = U.K.\right)}_{\text{U.K. destination-skill FE}} + \underbrace{\sum_{o \in NMS} \alpha^{o}_{n,s,t} I_{n,s,t}\left(i = o\right)}_{\text{Set of origin-skill FE}} +$$
$$\underbrace{+ \beta^{U.K.}_{n} \sum_{o \in NMS} I_{n,s,t}\left(j = U.K., i = o\right)}_{\text{Set of U.K.-origin-skill FE}} + \tag{12}$$
$$\underbrace{+ \beta^{U.K.}_{n,post} \sum_{o \in NMS} I_{n,s,t}\left(j = U.K., i = o, t \in post\right)}_{\text{Set of U.K.-origin-skill FE * post2003}} + \varepsilon^{ij}_{n,s,t},$$

where $I\left(.\right)$ is an indicator function, $\delta^{U.K.}_{n,s,t}$ represents the coefficients of a set of year-skill dummies for when the destination is the U.K., $\alpha^{o}_{n,s,t}$ represents the coefficients of a set of year-skill dummies for each source NMS country, $\beta^{U.K.}_{n}$ is the coefficient of a dummy for when the origin is an NMS country and the destination is the U.K., and $\beta^{U.K.}_{n,post}$ is the coefficient of a dummy for when the origin is an NMS country, the destination is the U.K., and t belongs to the post 2003 period.[23] Finally, $\varepsilon^{ij}_{n,s,t}$ is a random disturbance of relative migration costs and it is assumed to be orthogonal to changes in migration policy.

[23]Note that the origin-nationality-skill-time fixed effects $\alpha^{o}_{n,s,t}$ also control for changes in the cost of staying in country o for a s-skilled n national.

The coefficient $\beta^{U.K.}_{n,post}$ is then our main coefficient of interest, representing the change in migration costs between the pre- and post-enlargement periods, normalized by the opposite of the migration elasticity $(-1/\nu)$, i.e.

$$\beta^{U.K.}_{n,post} \equiv -\frac{1}{\nu}\left(mpol^{NMS,UK}_{NMS,post-enlarg.} - mpol^{NMS,UK}_{NMS,pre-enlarg.}\right). \tag{13}$$

In other words, given an estimate of the migration elasticity, $\beta^{U.K.}_{n,post}$ provides an estimate of the average change in the cost of migrating from NMS countries to the U.K. due to the enlargement process, after controlling for any destination-skill-nationality-time and origin-skill-nationality-time confounding factors.[24]

Note the importance of using three sets of gross flows, from NMS to the U.K., from NMS to EU-5 countries, and from EU-5 countries to the U.K., in order to identify destination-nationality-skill-time and origin-nationality-skill-time fixed effects.[25] The coefficient $\beta^{U.K.}_{n,post}$ is then the sum of three components: the average change in the cost of migrating from NMS countries to the U.K., our target, minus both the change in the cost of migrating from NMS countries to EU-5 countries and the change in the cost of migrating from EU-5 countries to the U.K. for NMS nationals. We exploit the fact that (i) EU-5 countries did not open their labor markets to NMS countries in the sample period (which justifies choosing EU-5 as the control group), and (ii) those NMS nationals residing in EU-5 before the EU enlargement did not experience changes in migration costs associated to the EU enlargement.[26] Appendix C.1 and C.2 provide support for the common trend assumption underlying the difference-in-difference strategy.

Change in the Migration Costs from NMS to U.K., Greece, Italy, Spain, and Portugal

The top panel of table 1 presents our estimates of the changes in migration costs for the case of NMS nationals moving from NMS countries to the U.K, Greece, Italy, Spain, and Portugal. As we can see, all estimates are positive and significant (except for Spain), pointing to a reduction in the cost of migrating from NMS to Europe for NMS nationals both in 2004 and 2006.[27] These coefficients are hard to interpret since they reflect the change in the migration cost scaled by the migration elasticity and measured in units of utility. To understand the magnitude, in terms of consumption, real wages, etc., of these changes we need to use these estimates as inputs in our quantitative model.

[24]Note that one could have estimated a coefficient across NMS origin countries and skills. Instead, we constrained the point estimate to be equal across skill groups. This does not mean that the migration costs are the same for different skill groups, it only means that the change in policy was proportionally equal across different skill groups.

[25]Given that we are aggregating data at the origin-destination-year level for a given nationality we account for possible random effects common to all individuals migrating from the same origin country to the same destination country in the same year.

[26]One reason why this is the case is that NMS nationals already legally working in one of the old member states at the date of accession for an uninterrupted period of at least 12 months continue to have access to the labor market of that member state. NMS nationals who had in 2004 legally worked in e.g. Germany for at least 12 months could keep working there even if the German labor market was not generally open to NMS nationals.

[27]Recall, from equation (13), that a positive estimate implies a reduction in migration costs.

Table 1: Estimates of Changes in Migration Costs, NMS nationals and EU nationals

NMS nationals					
Destination $j \rightarrow$	***U.K. (2004)***	***GR (2006)***	***IT (2006)***	***ES (2006)***	***PT (2006)***
$\beta^j_{n,post}$	3.52^{***}	2.29^{**}	1.01^{*}	0.18	1.01^{***}
	(1.11)	(0.83)	(0.55)	(0.54)	(0.49)
R^2	0.96	0.97	0.98	0.97	0.98
Obs.	564	564	564	564	564

Placebo: EU nationals					
Destination $j \rightarrow$	***U.K. (2004)***	***GR (2006)***	***IT (2006)***	***ES (2006)***	***PT (2006)***
$\beta^j_{n,post}$	0.74	-0.08	-0.02	0.46	-1.22
	(1.40)	(1.52)	(1.35)	(1.34)	(1.45)
R^2	0.88	0.90	0.89	0.90	0.90
Obs.	564	564	564	564	564

Notes: The table reports difference-in-difference estimates, from separate regressions, of the change in migration cost from NMS countries to either the United Kingdom (U.K.), Greece (GR), Italy (IT), Spain (ES), or Portugal (PT) for NMS nationals (top panel) or EU-15 nationals (bottom panel). Recall, from equation (13), that a positive estimate implies a reduction in migration costs. The bottom panel represents a placebo exercise since no migration policy changes occurred for EU-15 nationals. The treatment period (post) is 2004-2007 for the U.K., and 2006-2007 for the other destinations. Parentheses includes robust standard errors, *** p<0.01, ** p<0.05, * p<0.10. Similar significance is obtained if instead we use two-way clustering at the origin-destination-country level.

Placebo Experiments

To support our identification strategy we also run placebo experiments. The intuition is that we expect the costs of migrating from NMS countries to the U.K., Greece, Italy, Spain, and Portugal not to have changed for EU-15 nationals as a consequence of the EU enlargement. The bottom panel of table 1 reports these estimates, and reassuringly shows no change in the migration costs due to the enlargement from NMS to Europe for those that already were European citizens.

Change in the Migration Costs from NMS to NMS

We now consider the other main changes in migration policy: NMS countries opening their respective labor markets to each other. In these cases we cannot apply anymore the difference-in-difference methodology since, because of data limitations, there is no control group we can exploit.[28] Therefore, to estimate this set of migration costs we proceed in an alternative way. Taking the product between the ratio of migrants to stayers in one direction and in the opposite direction, we can differentiate the value functions, and the resulting ratio will only contain information on migration

[28] Bulgaria and Romania, which could have potentially been an alternative control group, have limited information on nationality.

Table 2: Changes in Migration Costs, NMS to NMS

	NMS nationals
β_{post}	1.71^{***}
	(0.49)
R^2	0.99
Obs.	252

Notes: $^{***}p < 0.01$, robust standard errors

frictions.[29] Taking logs, we get

$$\left(y^{ij}_{n,s,t} - y^{ii}_{n,s,t}\right) + \left(y^{ji}_{n,s,t} - y^{jj}_{n,s,t}\right) = -\frac{1}{\nu}\left(\left(m^{ij}_{n,s,t} - m^{ii}_{n,s,t}\right) + \left(m^{ji}_{n,s,t} - m^{jj}_{n,s,t}\right)\right).$$

With this measure we can only estimate a combination of migration costs in one direction and in the opposite direction, and therefore we need to impose more structure to separate them. In particular, we assume the change in migration costs to be symmetric, and to be the same for each pair of NMS countries. Following the same logic as in equation (11), but noticing that all origin-specific and destination-specific factors cancel out, we regress the measure of migration frictions on a constant and a dummy variable for the post-enlargement period,

$$\left(y^{ij}_{n,s,t} - y^{ii}_{n,s,t}\right) + \left(y^{ji}_{n,s,t} - y^{jj}_{n,s,t}\right) = \alpha + \beta_{post} I^{ij}_{n,s,t}\left(t \in post\right) + \varepsilon^{ij}_{n,s,t},$$

where $I\left(.\right)$ is an indicator function and *post* represents the post 2003 period, and the constant captures the non-policy bilateral migration costs. Then, β_{post} captures the average change, between the pre- and post-enlargement period, of the migration frictions.[30]

Table 2 reports the results, and shows a reduction in the cost of migrating from NMS to NMS countries, for NMS nationals, in 2004.

Change in Trade Policy

Finally, we employ bilateral tariffs τ^{ij}_t between each pair of countries, using information from the World Integrated Trade Solution (WITS) data set, to capture changes in trade costs due to the EU enlargement. We use effectively applied rates and we combine information from two different data sets, the TRAINS data set and the WTO data set, to have complete and consistent information on tariffs over time.[31]

Armed with this set of estimates of the changes in trade and migration costs associated with the EU enlargement , we now proceed to estimate the necessary elasticities for our quantitative

[29] In the international trade literature this ratio is known as the Head and Ries index, and it is used to identify trade frictions.

[30] We also used the same strategy in order to identify the changes in costs of migrating to NMS for EU nationals. For this case we used the flows of EU nationals from the EU to NMS before and after the change in policy. Given that there where not many flows over our sample period and no significant variation in the flows we ended up obtaining not economically significant estimates for this case.

[31] In Appendix B.3.1 we explain in detail how we construct the bilateral tariff data for each country pair.

analysis.

4.4 International Migration Elasticity

The migration elasticity is a key parameter to evaluate the welfare effects associated to changes in the barriers to migrate: welfare effects depend on the magnitude of the change in barriers, and on how sensitive the decision to migrate is to the barriers themselves. Artuç et al. (2010) and CDP, provide estimates of the elasticities for internal migration flows, while here we deal with international migration. We therefore adapt the methodology of Artuç and McLaren (2015) to the structure of our model, and apply it to the flows of EU nationals within the EU, to provide a value for the international migration elasticity.[32]

The first stage of the methodology is a fixed-effect estimation that uses the migration share equation (3) and bilateral gross migration flows data to estimate value differences and the migration cost function normalized by ν. The second stage of the methodology relies on the Bellman equation. We insert the estimated value differences from the first stage into the Bellman equation, and construct a linear regression to retrieve the international migration elasticity by exploiting the variation in real wages. We estimate the second stage model as an IV regression, using two-period lagged values of real wages as instruments, and clustering standard errors at the country level.[33]

In our preferred specification with $\beta = 0.97$ we obtain an elasticity of 0.44—significant at 1 percent—which implies a value of ν of 2.3. This is the value that we use when performing our quantitative analysis.

4.5 Elasticity of Substitution Between Low and High Skilled Workers

In this section, we provide an estimate of the elasticity of substitution between low and high skilled workers. Following the literature, low-skilled workers include workers with a high-school degree or less, and high-skilled workers are workers with some college education and college graduates. We estimate the elasticity of substitution using detailed information on workers' wages and hours, as well as firms' location and industry, from the Portuguese matched employer-employee data (*Quadros de Pessoal*) for the period 1991-2008.[34] Our estimation strategy builds on standard approaches (e.g.

[32] We describe in detail the implementation of the methodology and report the results, both for the baseline case and for the extension with public good described later, in Appendix D.

[33] We emphasize three merits of the Artuç and McLaren (2015) methodology: First, the estimation strategy does not require taking logarithm of probabilities. Given that most of the migration shares are very small this is an important feature that avoids causing large errors and imprecise estimates, and allows us to work with 17 countries. Second, we can be agnostic about exactly what information workers have when they form their expectations of future wages, and only assume that forecast errors are mean zero conditional on contemporaneous information. Third, we impose only a mild assumption on bilateral migration costs: we assume that migration costs for EU nationals flowing across EU-15 member states did not vary over time and skills. Note, however, that we can still let the cost of migrating out of country i, and into country j, be skill-dependent.

[34] We resort to *Quadros de Pessoal* for a number of reasons. First, *Quadros de Pessoal's* provides an exhaustive coverage of firms and their workers over a long time-span. Second, we can estimate an elasticity of substitution between low and high-skill workers that is consistent with the skills definitions from the EU-LFS. Third, we can estimate an elasticity of substitution using data from an European country, and we can compare our findings to other estimates available in the literature for other countries. Last but not least, we can exploit the richness of the data

Katz and Murphy (1992)), but we instrument the endogeneity of the relative supply of high to low skilled workers. We estimate the following econometric model based on the equilibrium conditions of the theory laid out in Section 3,

$$\ln \frac{w_{h,t}^{vr}}{w_{l,t}^{vr}} = -\frac{1}{\rho} \ln \frac{L_{h,t}^{vr}}{L_{l,t}^{vr}} + \alpha^{vr} + \varepsilon_t^{vr}, \tag{14}$$

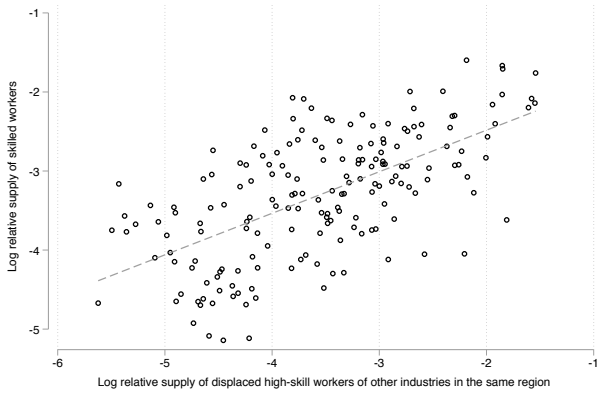
where $\left(w_{h,t}^{vr}/w_{l,t}^{vr}\right)$ is the ratio of high- and low-skilled workers' wages in industry v and region r (in Portugal), $\left(L_{h,t}^{vr}/L_{l,t}^{vr}\right)$ is the corresponding relative supply, and ρ is the elasticity of substitution between low and high skilled workers. Finally, we have written the relative weight of high- and low-skilled workers $(1/\rho)\ln\left(\delta_h^{vr}/\delta_l^{vr}\right)$ as the sum of an industry-region fixed effect and a residual industry-region-time effect $\alpha^{vr} + \varepsilon_t^{vr}$.

The main difficulty faced by researchers in this area is that the relative number of more educated workers and their relative wages are determined simultaneously by demand and supply. Because of that, the relative supply term $\left(L_{h,t}^{vr}/L_{l,t}^{vr}\right)$ in equation (14) could be correlated with industry-region demand shocks (ε_t^{vr}), making it difficult to identify the elasticity of substitution via OLS. We tackle this issue using instrumental variable estimation. Our instrument for $\left(L_{h,t}^{vr}/L_{l,t}^{vr}\right)$ is constructed using information on the local availability of low- and high-skilled workers that change firm because of displacement, and in particular because of firm closure.[35] A firm closure can be considered as an exogenous shock to a worker's career, since it results in a separation of all plant's workers and it is not related to the worker's own job performance (Dustmann and Meghir (2005)). Moreover, when instrumenting the relative labor supply of a given industry, we consider only closures of firms that belong to other industries, so that their closure is hardly related to the market of the industry under consideration. Finally, as workers tend to search and accept more easily new jobs in the same local labor market of the past job, we consider closures of firms that belong to the same region of the industry under consideration. Overall, the local availability of displaced workers can then be considered as an exogenous labor supply shock for local firms. Figure 4 shows the correlation between the instrumented variable and the instrument.

to implement an instrumental variable strategy, described below, that facilitates the identification of the elasticity of substitution.

[35] Displacement is usually defined as the permanent and involuntary separation of workers from their jobs without cause (i.e. for economic reasons). Displacement occurs when a firm shuts down or substantially downsizes.

Figure 4: Relative supply of high-skilled workers and displaced high-skilled workers, by industry and region, 1992-2005



Note: Own elaboration using the matched employer-employee data set *Quadros de Pessoal* described in Section B.5 and Appendix E. Low-skill includes all workers with a high-school degree or less, and high-skilled are workers with some college education and college graduates. Each circle in the plot corresponds to an industry-region-year, where regions are approximately NUTS II (5 regions), and industries are NACE 1-digit. The dashed line corresponds to the predicted values of a linear OLS model, with slope of 0.53 (with standard error 0.050) and R^2 equal to 0.39.

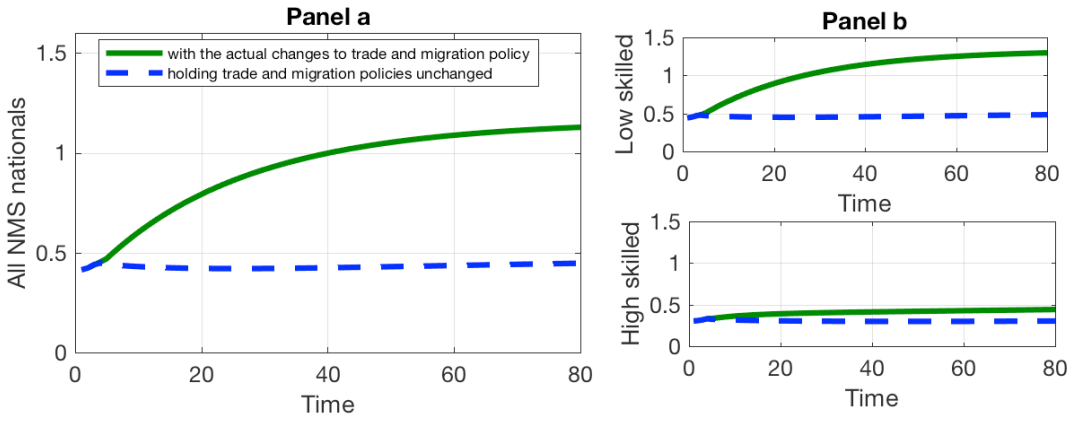
Employing the methodology and data outlined above (and described more in detail in Appendix E), we obtain an elasticity of 4, which is the number we use in our quantitative analysis. The estimate of the elasticity of substitution is pretty robust to alternative different specifications, methodologies, and levels of data aggregation (Appendix E). Our estimate is slightly above those commonly found for the U.S. (Katz and Murphy (1992); Johnson (1997); Krusell et al. (2000); Ottaviano and Peri (2012); Ciccone and Peri (2005)) which range between 1.5 and 2.5, but below the elasticity of substitution of 5 between low- and medium-skilled workers found for Germany (Dustmann et al. (2009)). Since the set of European countries we consider in the quantitative analysis is pretty diverse in terms of labor market institutions and workforce characteristics we consider our benchmark estimate of 4 as a good compromise.[36]

5 Economic Effects of the 2004 EU Enlargement

In this section, we use the estimated changes in migration costs, and the observed changes in tariffs, to quantify the migration and welfare effects of the EU enlargement. We first compute the migration effects from the actual changes to migration and trade policies over the period 2002-2007, and we then quantify the welfare effects. We also use our model to study the interaction between

[36]Many papers estimating the elasticity of substitution between low- and high-skilled workers do not consider endogeneity issues. Two important exceptions are Angrist (1995) and Ciccone and Peri (2005). Angrist (1995) estimate the relationship between the return to schooling and the supply of more educated workers among Palestinians in the West Bank and the Gaza Strip during the 1980s, exploiting the fact that the increase in the supply of more educated workers was mainly driven by the creation of new local institutions of higher education. Ciccone and Peri (2005) estimate the long-run elasticity of substitution between low- and high-skilled workers at the U.S. state level using data from five 1950-1990 decennial censuses. They exploit time- and state-specific child labor and compulsory school attendance laws as instruments.

Figure 5: Evolution of the stock of NMS migrants in EU15 countries (percent)



Notes: This figure presents the stock of NMS migrants in EU-15 countries. The green lines show the evolution of this stock with actual changes to trade and migration policies. The dashed lines show the evolution holding trade and migration policies unchanged. The panel, (left column) presents the results for all workers, and panel b (right column) presents the results for high and low skilled workers.

trade openness and migration policy, and to decompose the role of the different mechanisms of the model in shaping the welfare effects.

5.1 Migration Effects

We start by quantifying the migration effects from the EU enlargement. In particular, with our structural model we want to answer questions such as: How did the stock of new member states (NMS) migrants in EU-15 countries respond to the EU enlargement? Was NMS migration gradual or a once for all process? What was the change in the stock of NMS migrants in EU-15 countries across skill groups, and in the short and long run? What would have been the migration effects in the absence of changes to trade policy?

To compute the migration effects, we feed into our structural model the estimated changes in migration costs and the observed changes in tariffs over 2002-2007, and compute the change migration effects compared with an economy where migration and trade policies stayed unchanged. Figure 5 displays the evolution of the stock of NMS nationals in EU-15 countries (for all workers and by skill). The darker line shows the evolution of the stock in the baseline economy with the actual changes to migration and trade policy between 2002-2007. The dashed line shows the evolution of the stock of NMS nationals in the counterfactual economy, where we hold migration costs and tariffs constant at the levels before the EU enlargement. Therefore, the difference between the two lines is the migration effects from the EU enlargement. From the figure, panel a, we can see a very gradual increase in the stock of NMS migrants in EU-15 countries. For instance, three years after the EU enlargement (that is, in 2007) the stock of NMS nationals in EU-15 countries increases by 0.03%, while ten years after the implementation, the stock raises by 0.23%. We find that in steady state, the stock of NMS nationals in EU-15 countries increases by 0.63% . Across individual

Table 3: Migration effects by skill group: Change in the stock of NMS nationals in EU-15

	High skill (%)		*High skill (thous.)*	
	Δ EU enlargement	w/o trade policy	Δ EU enlargement	w/o trade policy
2002	0	0	0	0
2007	0.014	0.019	51.9	69.3
2015	0.058	0.066	215.8	246.2
Steady state	0.130	0.168	485.2	625.9
	Low skill (%)		*Low skill (thous.)*	
	Δ EU enlargement	w/o trade policy	Δ EU enlargement	w/o trade policy
2002	0	0	0	0
2007	0.066	0.070	246.1	262.6
2015	0.301	0.312	1,124	1,162
Steady state	0.753	0.793	2,809	2,959

Notes: This table shows the percentage and absolute change in the stock of low skill and high skill NMS nationals in EU-15 countries due to the 2004 EU enlargement. Columns 2 and 4 report the counterfactual change in the absence of trade policy changes.

countries, we find that the United Kingdom is the country that experienced the largest increase in the stock of NMS nationals.

We now turn to compute the change in the stock of migrants across different skills, and after doing so, we discuss the interaction between migration and trade policies. Figure 5, panel b, presents the evolution of the stock of low and high skill NMS migrants in EU15 countries. In Table 3, columns (1) and (3), we decompose the stock of NMS nationals in EU-15 countries by skill. We find that the EU enlargement primarily increases the migration of low skilled NMS workers to EU-15 countries, and to a much lesser extent the migration of high skilled workers. For instance, as we can see from the table, the stock of NMS high skilled workers in EU-15 countries increases by 0.014 percentage point, or 51.9 thousands by 2007, by 0.06 percentage point or 215.8 thousands by 2015, and by 0.13 percentage point or by about 485.2 thousands in the long run. We find that the change in the stock of NMS unskilled workers is much larger. Specifically, for the case of low skilled workers, the stock of NMS nationals in EU-15 countries increases by 0.066 percentage point or 246.1 thousands by 2007, by 0.3 percentage point or 1.1 million by 2015, and by 0.75 percentage point or by about 2.8 million in the steady state.

We can also use the model to compute what the migration effects would have been in the absence of changes to trade policy. In columns (2) and (4) of Table 3, we compute the change in the stock of NMS nationals in EU-15 countries holding trade policy constant. We find that migration would have been larger in the absence of changes to trade policy. For instance, the stock of low skilled workers would have been about 150 thousands larger in the long run, and the stock of high skilled workers would have been about 140 thousands larger.

5.2 Welfare Effects

We now turn to the welfare analysis. We start by describing the welfare effects of the EU enlargement in our model developed in Section 3. We then study the interaction between trade and changes to migration policy. Finally, we quantify the welfare effects of the different mechanisms that operate in our structural model.

Table 4, column (1) presents the welfare effect of the EU enlargement. Similar to the previous section, to compute these welfare effects, we feed into our structural model the estimated changes in migration costs and the observed changes in tariffs over 2002-2007, and compute the change in welfare, measured in terms of consumption equivalent, compared with an economy where migration and trade policies stayed unchanged. We do so across skills, and nationalities (NMS nationals and EU nationals), and to facilitate the analysis we aggregate individual countries into NMS and EU-15 countries using employment as weights. Before turning to the results, it is important to clarify the interpretation of the welfare numbers from the table. In particular, the welfare effect for a given country and skill group, say NMS low skilled workers, corresponds to the change in welfare, measured in consumption equivalent, of a representative low skilled worker living in NMS countries previous to the EU enlargement. In other words, this welfare number takes into account both migrants and stayers.

Turning to the results in the table, we can see that the largest winners are the NMS countries, and in particular the low skilled workers. Welfare of NMS low skilled workers increases 1.46%, while welfare for skilled workers increases 0.97%. The larger welfare effect for low skilled workers is explained by a higher option value of migration for low skilled workers than for high skilled workers due to the fact that, for instance, low skilled workers are relatively more scarce in EU-15 countries. As a result, as we explained above, more low skilled workers than high skilled workers migrate to EU-15 countries after the EU enlargement. On the other hand, we find relatively smaller welfare effects for workers in EU-15 countries. Welfare increases 0.23% for high skilled workers and 0.12% for low skilled workers. High skilled workers in EU-15 countries benefit from the increase in the relative supply of low skilled labor after the reduction in migration restrictions, and the resulting expansion in total output. We find that aggregate NMS welfare increases 1.41%, using employment to aggregate across skills. Welfare in EU-15 countries increases 0.14%, and aggregate welfare for Europe increases 0.36%.

In column (2) of Table 4, we present the welfare effects of only changes to trade policy. Specifically, we feed into our structural model the changes to tariffs over 2002-2007, but we hold migration costs constant at the initial level. We find positive welfare effects across all countries and skill groups. Welfare gains are larger for NMS countries than for EU countries as they experience a larger decline in tariffs. For the case of EU-15 countries, welfare gains for high skilled and low skilled workers, are about 0.18%, and for the EU-15 as a whole as well. In NMS countries, welfare gains for high and low skilled workers are 0.83% and 81%, respectively, and 0.81% for the aggregate NMS.

The third column in Table 4 presents the welfare effects of only changes to migration policy. To

Table 4: Welfare effects of trade and migration policies, percent

		EU enlargement	Only changes to trade policy	Only changes to migration policy
EU-15	*High skill*	0.231	0.178	0.049
	Low skill	0.123	0.183	-0.059
	Aggregate	0.144	0.182	-0.037
NMS	*High skill*	0.965	0.833	0.132
	Low skill	1.464	0.812	0.629
	Aggregate	1.405	0.815	0.570
	Europe	0.359	0.290	0.066

Notes: This table shows the percentage change in welfare, measured as consumption equivalent, from changes to migration and trade policy. Column 2 presents the welfare effects due to changes in migration and trade policies, Column 3 presents the welfare effects from only changes to trade policy, and Column 4 shows the welfare effects due to only changes to migration policy.

do so, we feed into the model the estimated changes in migration costs, but hold tariffs constant at the initial level. We find that welfare for both EU-15 and NMS countries, and across both skill groups, are lower in the absence of changes to trade policy. In particular, we find that in the absence of changes to trade policy, the EU-15 countries as a whole would have lost from the EU enlargement. For the case of NMS countries, welfare would have increased 0.13% for skilled workers, and 0.63% for unskilled workers. Welfare for NMS as whole increases by 0.57% with only changes to migration policy, and welfare for Europe would have been 0.07%.

In Table 5 we study further the interaction between trade and migration policies. In particular, we study the welfare effects of the changes to migration policy under three different levels of goods market integration. Column (1) replicates the third column in the previous table, and therefore it shows the welfare effects of the actual changes to migration policy under the actual level of trade integration at the time of the EU-enlargement. In Column (2) we compute the welfare effects of the actual changes to migration policy if Europe would have been under trade autarky at the time of the enlargement. To do so, we first compute the equilibrium allocations when trade costs are set to infinite, and we then feed into the model the changes to migration policies. In Column (3), we study the welfare effects of the actual changes to migration policy if Europe would have been a free trade area at the time of the enlargement. To do so, we first compute the equilibrium allocations when tariffs are eliminated, and we then feed into the model the changes to migration and trade policies.

We can see from the table how the level of trade openness impacts the welfare effects of migration policy. In particular, for the case of NMS countries, welfare effects would have been about 13% lower under trade autarky compared to free trade. The intuition is that NMS countries that experience a net outflow of workers that put upward pressures on labor costs would have experienced a loss in their terms of trade with trade restrictions compared with a situation of free trade. The opposite

Table 5: Trade openness and welfare effects of migration policy (percent)

		Only changes to migration policy	Changes to migration policy under trade autarky	Changes to migration policy under free trade
EU-15	*High skill*	0.049	0.061	0.048
	Low skill	-0.059	-0.052	-0.060
	Aggregate	-0.037	-0.030	-0.039
NMS	*High skill*	0.132	0.078	0.141
	Low skill	0.629	0.572	0.638
	Aggregate	0.570	0.514	0.580
	Europe	0.066	0.063	0.067

Notes: This table shows the percentage change in welfare, measured as consumption equivalent, due to the actual changes to migration policy. Column 2 presents the welfare effects under the actual level of trade openness, Column 3 shows the welfare effects under trade autarky, and Column 4 shows the welfare effects under free trade.

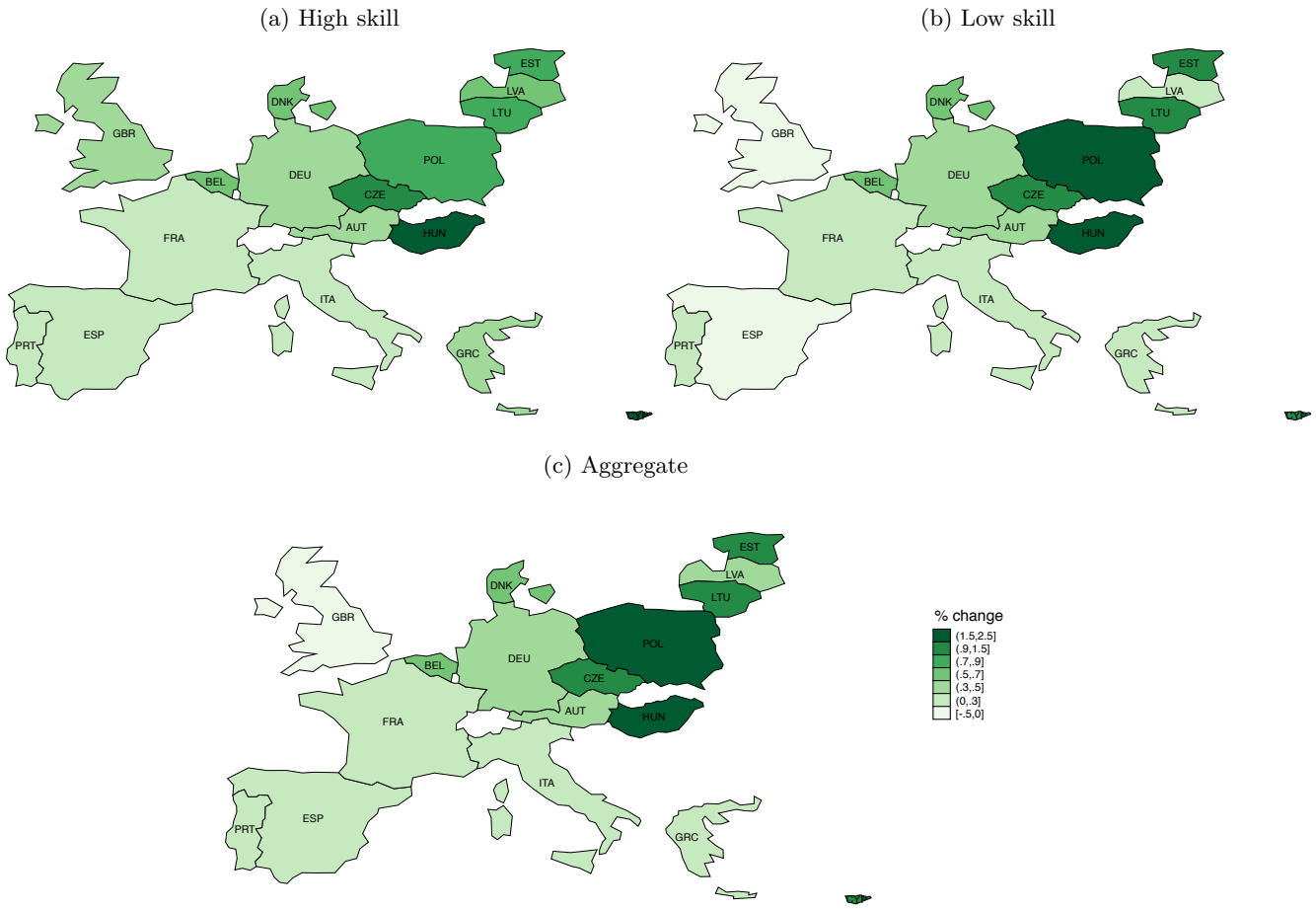
happens in EU-15 countries that experience a net inflow of workers. We can see from the table that EU-15 countries would have had smaller welfare losses from the changes to migration policy under trade autarky, although this effect is very small. The important take away of these exercises is that trade has a quantitative impact on the welfare evaluation of migration policy.

Finally, Figure 6 presents the welfare effects of the EU enlargement across different countries. We can see from the figure that although NMS countries are the largest winners, there is heterogeneity in the welfare effects across countries. Overall, we find that Poland, and Hungary are the largest winners from the EU enlargement. We find that the only country that experience welfare losses is the United Kingdom, and specifically unskilled workers whose welfare declines 0.17% as a consequences of the enlargement.

5.2.1 Timing of Migration Policy

What would have been the welfare effects if countries would change migration restrictions with a different timing? In this subsection we study the importance of the timing of changes to migration policy. To do so, Figure 7 panel a, shows the welfare effects for EU-15 and NMS countries, relative to the actual effects, assuming that instead of changing policy as they did over 2002-2007, countries would have changed policy in different years. That is, we study the effects from a bilateral reduction in migration restrictions between the United Kingdom, Greece, Italy, Spain, Portugal, and NMS happening in the year 2004, or 2005, and so on. The figure shows that delaying the opening in migration, NMS countries would have lower welfare gains compared to the actual gains, and the same is true for the case of EU-15 high-skilled workers. For instance, if countries, would have changed migration policy all in 2012, welfare gains for NMS low-skilled workers would have been about 12% lower than the actual gains. On the other hand, we find that low-skilled workers in EU-15 countries would have been better of by delaying changes to migration policy. The result

Figure 6: Welfare effects, percent



Notes: These figures present the welfare effects of the EU enlargement across different countries and skill groups.

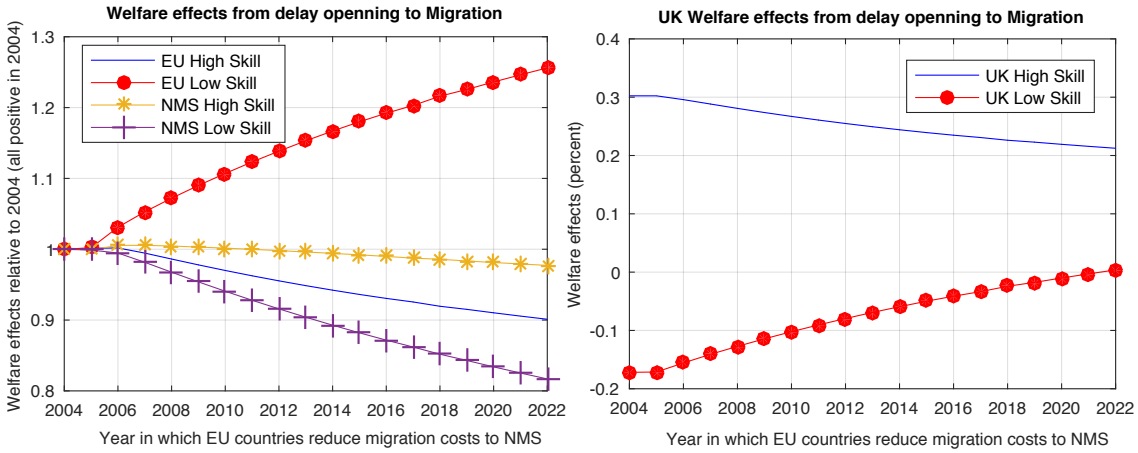
is explained by the fact that EU-15 low skills gained from changes to trade policy but lost from changes to migration policy, and therefore, delaying the changes to migration policy increases the relative impact of trade policy in their welfare.

In part, the previous result is driven by the United Kingdom that is the only country that experiences welfare losses for low-skill workers. Given that, on panel b we investigate the welfare effects on the United Kingdom of delaying the change in migration policy. The figure plots the welfare effects under different opening years, and we find that welfare losses of low-skilled workers would have been increased and welfare gains of high-skilled workers would have been declined by delaying opening to migration.

5.2.2 Extensions: Accounting for the Provision of Public Goods

In this section we extend our model to account for additional congestion effects coming from the provision of public goods. In particular, this extension is motivated by evidence on the fact that migrants are net beneficiaries of the welfare system across countries, and therefore are more likely

Figure 7: Welfare effect of changes in the timing of migration policy



to use social benefits and consume public goods than natives.[37] To capture the congestion of public goods due to immigration, we assume that households derive some utility from the per capita provision of public goods in the economy. Specifically, the indirect utility of a household with skill s in country i is given by

$$C_{s,t}^{i} = \left(\frac{G^{i}}{L_{t}^{i}}\right)^{\alpha_i} \left((1-\tau_{L}^{i})\frac{w_{s,t}^{i}}{P_{t}^{i}}\right)^{1-\alpha_i}, \tag{15}$$

where P_t^{i} is the local price index, and α_i is the fraction of public goods in total consumption.[38] The supply of public goods, G^i, is fixed over time. In order to supply G^i the government purchases final goods and finances its spending from three sources: tariff revenues, labor taxes (τ_L^i), and lump sum transfers from the owners of fixed factors in each country. As a result, the government budget constraint is given by

$$P_{t}^{i}G^{i} = T_{t}^{i} + \sum_{n=1}^{N}\sum_{s=h,l}\tau_{L}^{i}w_{s,t}^{i}L_{n,s,t}^{i} + R_{t}^{i} \text{ for all } i, \tag{16}$$

where the double summation term on the right-hand side represents labor tax revenues, and R_t^i are lump-sum taxes.

The total expenditure on goods by country i is now given by government purchases, by net labor income of workers of all skill levels and nationalities residing in country i, and by local rentiers. Namely, the goods market clearing is given by

$$X_{t}^{i} = P_{t}^{i}G^{i} + \sum_{n=1}^{N}\sum_{s=h,l}(1-\tau_{L}^{i})w_{s,t}^{i}L_{n,s,t}^{i} + \iota^{i}\chi_{t} - R_{t}^{i}, \text{ for all } i, \tag{17}$$

[37] See Kerr and Kerr (2011) for a survey.

[38] Similar specifications for preferences of public goods have been used recently in other quantitative studies, see Fajgelbaum et al. (2015).

with $\chi_t = \sum_{i=1}^{N} r_t^i H^i$. As we can see, the net income of rentiers is given by the share of the global portfolio minus lump-sum taxes, $(\iota^i \chi_t - R_t^i)$.

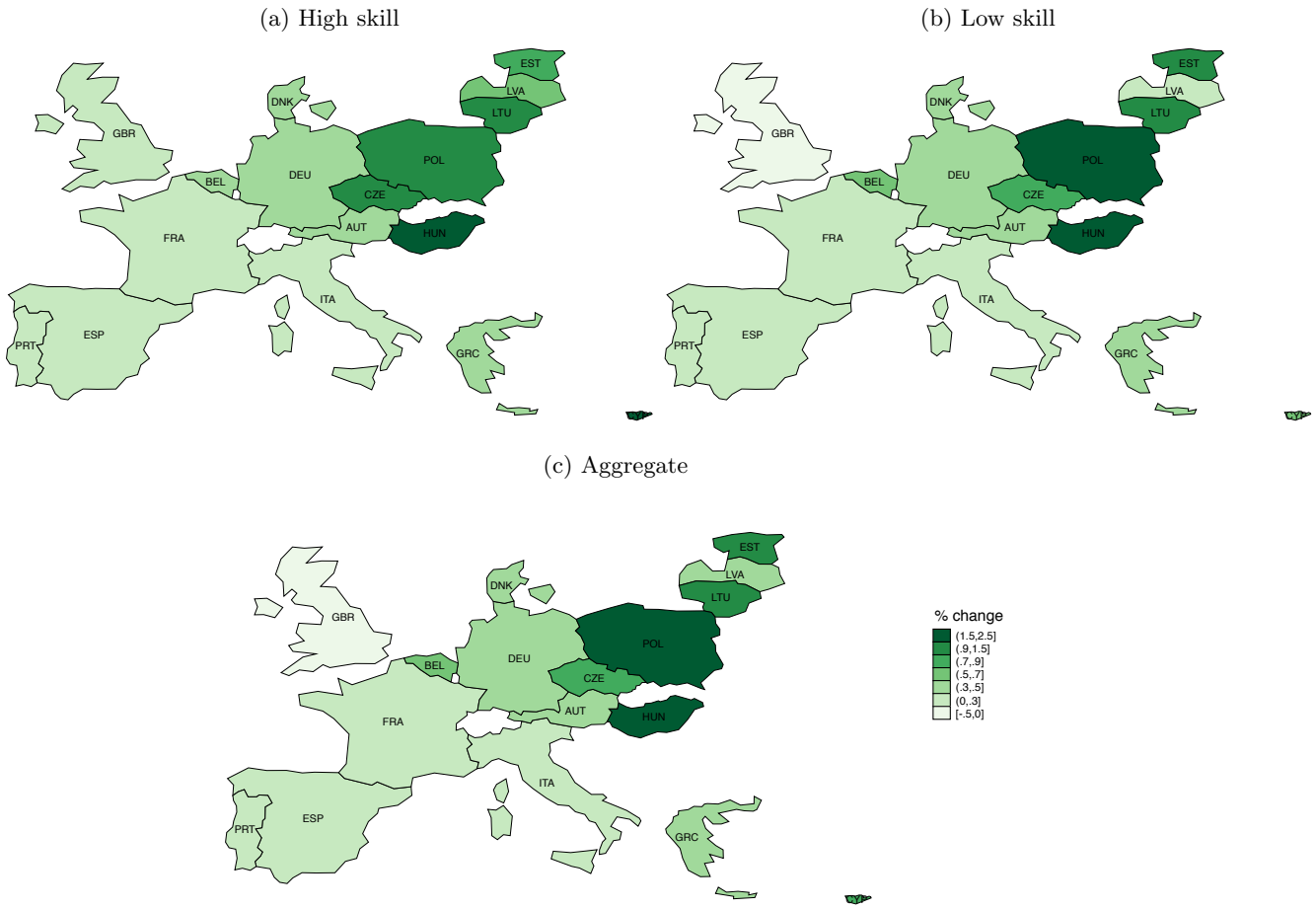
The equilibrium of this economy is the same as that described in Section 3.4, but with the indirect utility given by (15), and the market clearing conditions given by (16) and (17). Given this, the CDP solution method described in Section (3.5) also applies in this economy with public goods. To compute the the model, we need to re-estimate the migration cost elasticity $1/\nu$ consistent with the utility function (15). In Appendix (D.1) we show how to adapt the estimation methodology to the model with public goods. We estimate a value of $\nu = 1.89$ that we feed into the model to quantify the migration and welfare effects of the EU enlargement. We also need to compute the fraction of public goods in total consumption α^i, which we construct as final government consumption over total final consumption by country using consumption data from the WIOD.[39] Finally, we resort to data on labor income taxes from the OECD Tax Database.

We now turn to quantify the migration and welfare effects of the EU enlargement in the model with public goods. Starting with the migration effects, we still find a very gradual increase in the stock of NMS nationals in EU-15 country as a consequence of the enlargement. In terms of the magnitudes, we find somewhat lower migration effects in the model with public goods. Specifically, three years after the EU enlargement (that is, in 2007) the stock of NMS nationals in EU countries increases by 0.02%, while ten years after the implementation, the stock raises by 0.22%. In steady state, the stock of NMS nationals in EU-15 countries increases by 0.52% as a result of the EU enlargement. In the presence of public goods, immigration strains public goods which introduces an additional source of congestion. As a consequence, the households' utility and incentives to migrate reduce compared to the economy without public goods. Across skills, we find that most of the migration, as a consequence of the enlargement, is unskilled, similarly to our finding in Section 5.1. In the long run, the stock of NMS skilled workers in EU-15 countries increases by 0.10 percentage point or by about 361.8 thousands, while the stock of NMS unskilled workers increases by 0.63 percentage point or by about 2.3 million. In terms of the interaction between migration and trade policies, we still find that migration would have been larger, by about half million workers in steady state, in the absence of changes to trade policy.

We now turn to the analysis of the welfare effects of the EU enlargement in the presence of public goods. Overall, in the presence of public goods we find larger welfare gains for NMS countries, and smaller welfare gains for EU-15 countries, compared with the results in Section 5.1. This result is explained by the fact that EU-15 countries experience a net inflow of workers, which congests public goods and has a negative impact on welfare compared with a model without public goods. On the other hand, the net outflow of workers in NMS countries contributes to decongesting public goods, which has a positive effect on welfare. We still find that the largest winners are the NMS countries, and in particular the unskilled workers. Welfare of NMS unskilled workers increases 1.52%, while welfare for skilled workers increases 1.07%. On the other hand, we find smaller welfare effects for workers in EU countries. Welfare increases 0.09% for skilled workers and 0.03% for unskilled

[39] The values of α^i across countries range from 0.16 to 0.31, with a mean value of 0.21.

Figure 8: Welfare effects with public goods, percent



Notes: These figures present the welfare effects of the EU enlargement across different countries and skill groups with the presence of public goods.

workers. Skilled workers in EU-15 countries benefit from the increase in the relative supply of unskilled labor after the reduction in migration restrictions, and the resulting expansion in total output. We find that aggregate NMS welfare increases 1.47%, while EU-15 welfare increases 0.05%. Aggregate welfare for Europe increases 0.29% as a result of the EU enlargement in the model with public goods.

Finally, Figure 8 presents the welfare effects from the EU enlargement in the presence of public goods. Poland and Hungary are the largest winners in this case, and the United Kingdom experiences welfare losses. Welfare losses for low-skilled workers in the U.K. are 0.43%, and high-skilled workers are now slightly worse off.

5.2.3 Welfare Effects: Additional Results

We now proceed to further study the role of trade, fixed factors and scale effect in shaping the welfare effects from the EU enlargement. In the previous section, we already studied the role of

Table 6: Welfare effects under different model assumptions

		EU enlargement	No scale effects	Autarky, no congestion and scale effects
EU-15	*High skill*	0.231	0.141	0.083
	Low skill	0.123	0.065	-0.041
	Aggregate	0.144	0.080	-0.017
NMS	*High skill*	0.965	1.274	-0.010
	Low skill	1.464	1.782	0.453
	Aggregate	1.405	1.723	0.399
	Europe	0.359	0.360	0.054

Notes: This table shows the percentage change in welfare, measured as consumption equivalent, under different model assumptions. Column 1 presents the welfare effects due to the actual changes in migration and trade policies, Column 2 presents the welfare effects in a model without scale effects, and Column 3 shows the welfare effects in a model with trade autarky, without scale effects, and without congestion effects.

public goods, their welfare effects, and how they reduce the incentive to migration by straining the stock of public goods and reducing households' utility as a result. In this section, we study the role of other mechanisms in shaping the welfare effects of the EU enlargement, namely, scale effects, fixed factors, and trade openness. Table 6 shows the results. Column (1) of the table reproduces the benchmark results, that is, the welfare effects from changes to migration and trade policies described in Section 5.1 and 5.2. In column (2), we shut down the scale effects (that is, we set the agglomeration elasticity equal to zero) in the benchmark model, but we let the other mechanisms operate. In this case, we still find that EU-15 and NMS countries gain from the enlargement, but welfare gains are a bit lower in EU-15 countries and larger in NMS countries compared with the model in which all mechanisms operate. In particular, the absence of scale effects subtracts 0.06 percentage points of welfare in EU-15 countries and adds 0.3 percentage points of welfare in NMS countries. The reason is that the net inflow of migrants in EU-15 results in an increase in productivity in the presence of scale effects, and the NMS that have a net outflow of workers experience a productivity decline in the presence of scale effects.

Finally, in column (3) we compute the welfare effects under autarky, and where we also shut down all congestion effects (infrastructure and public goods) as well as scale effects. To do so, we first compute the equilibrium allocations when trade costs are set to infinite, and we then feed into the model the changes to migration and trade policies. Welfare effects in EU-15 and NMS countries, at the aggregate and across skills, are substantially smaller than those in Column (1). For instance, EU-15 countries are now worse off, NMS welfare is reduced by more than half.

With this final counterfactual exercise we want to emphasize again the importance of accounting for trade, and other ingredients of the model such as local fixed factors and scale effects when evaluating the welfare impact of migration and trade policies.

6 Conclusion

Migration and trade are two themes that, historically and nowadays, are central in Europe as well as in other regions of the world. The freedom of movement of workers and of goods are considered as two of the four fundamental freedoms guaranteed by EU law. At the same time, immigration into Europe during the enlargement process, as well as the influx of refugees from war-torn countries, are recent major shocks whose economic effects are hard to evaluate, since they interact with heterogeneous production structures, free intra-Community trade, and the European Union Customs Union. In this context, the international economics literature has made considerable advances on the quantification and understanding of the gains from economic integration, but most of the focus has been on the goods market, and less attention has been devoted to the factors market and to migration policy. In this paper we aim at making progress in this area.

We quantify the general equilibrium effects of trade and labor market integration. We show that in order to evaluate the economic effects of labor market integration it is crucial to take in to account the process of integration in the goods market. We find that the EU enlargement primarily fostered the migration of low skilled workers and that trade policy helped to moderate migration flows and mitigate congestion effects. The largest winners were the new member states, and in particular their low skilled workers, although we find positive welfare effects for high skilled workers as well. Importantly, we find that in the absence of changes to trade policy, the EU-15 would have been worse off after the enlargement. This result is robust to the inclusion of other mechanisms in the model, like the presence of public goods financed with labor taxes.

Our paper incorporates different but complementary elements in the analysis. We use reduced-form analysis that exploits migration policy changes to identify changes in migration costs and key elasticities. We build a rich dynamic general equilibrium model that includes important mechanisms considered in the literature to quantify the migration and welfare effects of actual changes to trade and migration policies. Among other things, we show quantitatively how the effects of labor market integration are affected by the extent to which countries are open to trade. Future work might aim at studying the distributional effects across sectors of the economy. Sectoral linkages are important for trade policy quantitative analysis and they might well be also for migration policy evaluation.

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A EU Accession and the Freedom of Movement of Workers

In this Appendix we describe in detail the process that resulted in the entry of ten new countries into the European Union in 2004, i.e. the EU membership process.

The process of joining the EU broadly consists of 4 stages. It is in essence based on the prospective member's ability of satisfying the accession criteria—also called the "Copenhagen criteria" after the European Council in Copenhagen in 1993 which defined them. The accession criteria have a political (stability of institutions guaranteeing democracy, the rule of law, human rights, and respect for and protection of minorities), economic (a functioning market economy and the capacity to cope with competition and market forces) and administrative/institutional (capacity to effectively implement EU law, and ability to take on the obligations of membership) component. The four stages that characterize the membership process are the following.

1. *Official candidate for membership.* A country wishing to join the EU submits a membership application to the Council of the European Union, which asks the European Commission to assess the applicant's ability to meet the Copenhagen criteria. If the Commission's opinion is positive, membership negotiations cannot start until all EU governments agree, in the form of a unanimous decision by the EU Council. Negotiations take place between ministers and ambassadors of the EU governments and the candidate country in what is called an intergovernmental conference.

2. *Negotiations.* The negotiation process includes three stages: screening, definition of counterparties' negotiation positions, and closing of the negotiations. In the screening phase, the European Commission, together with the candidate country, prepares a detailed report of how well the candidate country is prepared in each of the 36 Chapters of the EU Law, spanning all major economic, social, and institutional aspects (e.g the free movement of goods, justice, and defense policy). If the results of the screening are satisfactory the Commission makes a recommendation to open negotiations. The candidate country then has to submit its position on every chapter of EU Law, and the EU must adopt a common position. Negotiations then continue until the candidate's progress is considered satisfactory in any field.

3. *Accession Treaty.* Once negotiations are successfully concluded, the Accession Treaty (containing the detailed terms and conditions of membership, all transitional arrangements and deadlines, as well as details of financial arrangements and any safeguard clauses) is prepared.

4. *Support and Ratification.* The Accession Treaty becomes binding once (i) it wins the support of the EU Council, the Commission, and the European Parliament; (ii) it is signed by the candidate country and representatives of all existing EU countries; and (iii) it is ratified by the candidate country and every individual EU country, according to their constitutional rules.

Table A.1 shows the date of application, the accession date, as well as population for each NMS country.

Table A.1: NMS Countries Characteristics

	Date of Application	Accession Date	2004 Population
Cyprus	July 3rd, 1990	May 1st, 2004	1.01
Estonia	November 24th, 1995	May 1st, 2004	1.36
Hungary	March 31st, 1994	May 1st, 2004	10.11
Latvia	October 13th, 1995	May 1st, 2004	2.26
Lithuania	December 8th, 1995	May 1st, 2004	3.34
Malta	July 3rd, 1990	May 1st, 2004	0.40
Poland	April 5th, 1994	May 1st, 2004	38.18
Czech Republic	January 17th, 1996	May 1st, 2004	10.20
Slovakia	June 27th, 1995	May 1st, 2004	5.37
Slovenia	June 10th, 1996	May 1st, 2004	2.00

Notes: 2004 population (in millions) from the World Bank World Development Indicators. Total population is based on the de facto definition of population, which counts all residents regardless of legal status or citizenship.

A.1 Migration Policies

The new members states had to comply with the fundamental principles of the European Union. Article 6 of the Treaty on the European Union states that "The Union is founded on the principles of liberty, democracy, respect for human rights and fundamental freedoms, and the rule of law, principles which are common to the member states." The freedom of movement of workers is considered as one of the four fundamental freedoms guaranteed by EU law (*acquis communautaire*), along with the free movement of goods, services, and capital.[40] EU law effectively establishes the right of EU nationals to freely move to another member state, to take up employment, and reside there with their family members, as well as protects against any possible discrimination, on the basis of nationality, in employment-related matters.

The Accession Treaty of 2003 (European Union (2003)) allowed the "old" member states to temporarily restrict—for a maximum of 7 years—the access to their labor markets to citizens from the accessing countries, with the exception of Malta and Cyprus.[41] These temporary restrictions were organized in three phases according to a 2+3associated to the +2 formula: During an initial period of 2 years (May 1st, 2004 to April 30th, 2006), member states, through national laws, could regulate the access of workers from all new member states, except Malta and Cyprus; member states could then extend their national measures for an additional 3 years (until April 30th, 2009), upon notification to the European Commission; an additional extension for other 2 years was possible

[40] As effectively and concisely defined by Article 45 (ex Article 39 of the Treaty Establishing the European Community) of the Treaty on the Functioning of the European Union, the freedom of movement of workers entails "the abolition of any discrimination based on nationality between workers of the member states as regards employment, remuneration and other conditions of work and employment", Council of the European Union (2012).

[41] These restrictions could only be applied to workers but not to the self-employed. They only applied to obtaining access to the labor market in a particular member state, not to the freedom of movement across member states. Once a worker has been admitted to the labor market of a particular member state, Community law on equal treatment as regards remuneration, social security, other employment-related measures, and access to social and tax advantages is valid.

in case the member state notified the European Commission of a serious disturbance in its labor market or threat thereof.[42] The transitional arrangements were scheduled to end irrevocably seven years after accession—i.e. on April 30th, 2011.

Figure A.1 shows the set of bilateral arrangements before the 2004 enlargement (Panel a), and during each of the three phases (Panels b, c, and d). A blue cell means that there are no restrictions in place in flowing from the origin to the destination country, i.e. EU law on free movement of workers apply. A yellow (mixed blue-yellow) cell means that some restrictions are in place during (part of) the phase.

Before 2004. Panel (a) shows that, before the 2004 enlargement, workers could flow freely within the EU-15 member states but not between EU-15 and NMS as well as between NMS countries.

Phase 1. On May 1st, 2004, the U.K. (together with Ireland and Sweden) opens its borders to NMS countries, which reciprocate by opening their borders to British citizens. All the other EU-15 countries keep applying restrictions to NMS countries, except to Cyprus and Malta. All NMS countries decide to open their border to EU-15 member states, except for Hungary, Poland, and Slovenia which apply reciprocal measures. Finally, NMS countries lift all restrictions among each others.

Phase 2. On May 1st, 2006, Greece, Portugal, and Spain, followed by Italy on July 27th, lift restrictions on workers from EU-8 countries. As a consequence, Hungary and Poland drop their reciprocal measures towards these four member states. Slovenia lifts its reciprocal measures on May 25th, 2006, Poland on January 17th, 2007, while Hungary simplifies its reciprocal measures on January 1st, 2008. During phase 2, The Netherlands (on May 1st, 2007), Luxembourg (on November 1st, 2007), and France (on July 1st, 2008) also lift restrictions on workers from EU-8 countries.

Phase 3. Belgium, Denmark, Germany and Austria keep restricting access to their labor markets under national law. Hungary applies (simplified) reciprocal measures, limiting access to its labor market for workers from EU-15 member states that restrict the access of Hungarian workers.

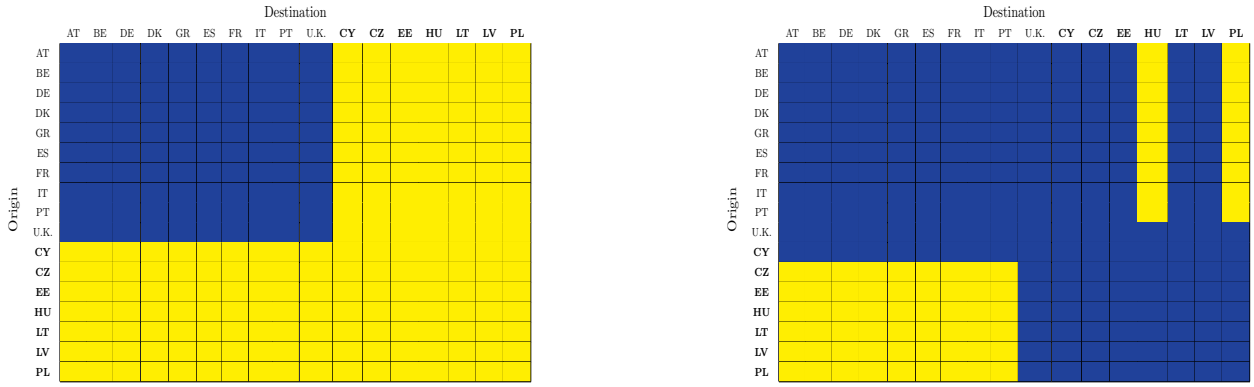
Belgium and Denmark opened their labor market to NMS countries on May 2009, while Austria and Germany opened their labor markets at the end of the transitional period, on May 2011.

[42] The EU-25 member states that decide to lift restrictions can, throughout the remainder of the transitional period, be able to reintroduce them, using the safe-guard procedure set out in the 2003 Accession Treaty, should they undergo or foresee disturbances on their labor markets. Notwithstanding the restrictions, a member state must always give preference to EU-2 (Malta and Cyprus) and EU-8 workers over those who are nationals of a non-EU country with regard to access to the labor market.

Figure A.1: Migration restrictions: transitional arrangements between EU-15 and NMS

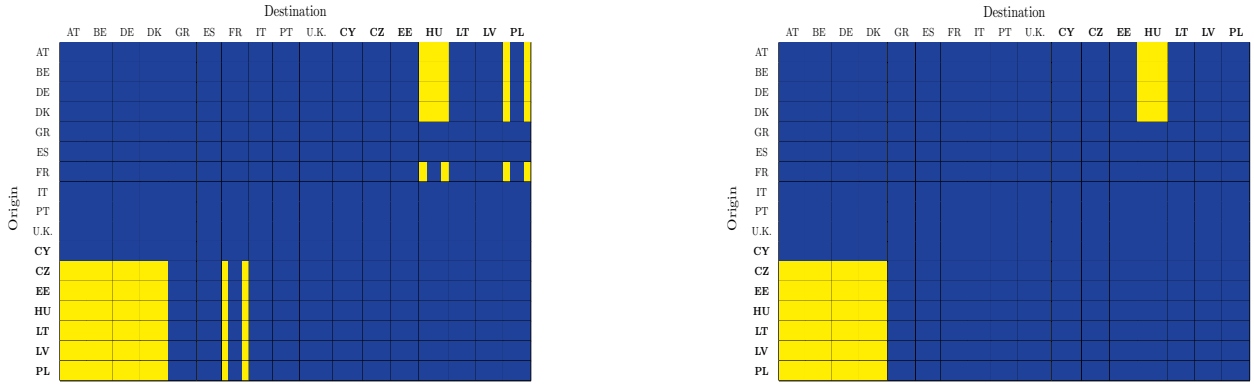
(a) Before the 2004 Enlargement

(b) Phase 1 - May 1st, 2004 to April 30th, 2006



(c) Phase 2 - May 1st, 2006 to April 30th, 2009

(d) Phase 3 - May 1st, 2009 to April 30th, 2011



Note: Origin countries on the rows, destination countries on the columns. EU-15 member states (AT, BE, DE, DK, GR, FR, IT, PT, U.K.) followed by NMS countries (CY, CZ, EE, HU, LT, LV, PL)) in bold. A blue cell means that there are no migration restrictions in place in flowing from the origin to the destination country, i.e. EU law on free movement of workers apply. A yellow (mixed blue-yellow) cell means that some migration restrictions are in place during (part of) the phase.

A.2 Trade Policies

New member states became part of the European Union Customs Union, and of the European common commercial policy.[43] The customs union implies that members apply the same tariffs to goods imported from the rest of the world, and apply no tariffs internally among members.[44] The common commercial policy covers trade in goods and services, intellectual property rights,

[43]The customs union initiated with the Treaty of Rome in 1957, kick-started on July 1st 1968, and it is regulated by the Treaty on the Functioning of the European Union. The common commercial policy is also set down in the Treaty on the Functioning of the European Union.

[44]Once the goods have cleared customs, they can circulate freely or be sold anywhere within the EU customs territory. Import duties collected by customs remain an important source of income for the EU. In 2013, they represented nearly 11 percent of the EU budget, which amounts to €15.3 billion. Besides common tariffs, an important aspect of the customs union is the implementation of common and streamlined procedures across the union regardless of where in the EU the goods are declared. Reduced time, homogeneity of rules, and lower uncertainty can be significant factors in boosting trade relationships (Hummels et al. (2007); Hummels and Schaur (2013); Martincus et al. (2015); Handley and Limao (2015)).

and foreign direct investment. As a consequence of the EU enlargement process, the new member states automatically entered into international trade agreements to which the EU is a party, and forwent their own existing agreements.[45]

B Data

B.1 List of Countries

The sample includes 17 European countries and a constructed rest of the world (RoW). Of our 17 countries, 10 are pre-2004 EU members and 7 countries joined the EU in 2004. The list of pre-2004 EU members includes Austria, Belgium, Germany, Denmark, Spain, France, Greece, Italy, Portugal, and the United Kingdom while the new members are Cyprus, Czech Republic, Estonia, Hungary, Lithuania, Latvia and Poland. Overall, these 17 countries cover about 91 percent of the population of the 25 members of the European Union in 2004.

We assign Ireland, The Netherlands, Malta, Sweden and Slovenia to the RoW aggregate because their EU-LFS country surveys do not contain sufficient information regarding the country of residence 12 months before the worker was interviewed. Specifically, Ireland does not provide information on the country of origin for any year in the survey, making it impossible to construct migration flows from any country in the sample to Ireland. The country surveys for the Netherlands and Malta are available from 2006 and 2009 onward respectively, hence after the enlargement of the European Union. The case of Sweden presents two different problems: first, data before 2005 contain information on the country of residence 12 months before only if this is Sweden itself. Moreover, in 2005 and 2006 there is no information on the country of origin in the Swedish survey. Finally, in the Slovenian survey information on the country of origin is available from 2008 on only.

We also assign Bulgaria, Slovakia, Luxembourg, Romania and Finland to the RoW due to missing information on the nationality of the workers. More specifically, Romania has information on nationality only from 2004 onward, Bulgaria has no information on nationality before 2008, Slovakia has no information before 2003 while Finland does not distinguish the nationality of the countries involved in the 2004 enlargement from the nationality of Bulgaria and Romania, which entered the European Union in 2007.

B.2 Construction of the Data-set on Gross Migration Flows

Data on gross migration flows by country of origin, destination, nationality, skill, and year are constructed from the micro data of the European Labour Force Survey (EU-LFS). For each individual surveyed, the questionnaire reports the country in which the individual resided 12 months before—besides reporting the current country of residence, the year and week in which the individual

[45] The entry of the new member states into the EU common commercial policy also had an impact in terms of bargaining power. While all the ten new EU member states were already part of the WTO before 2004, from 2004 on they participate to the WTO's activities through the European Commission. EU trade policy is in fact carried on by the European Commission, on behalf of the European Union, working closely with the member states and keeping informed the European Parliament.

was interviewed, and a sampling weight that makes the survey representative at the national level. We refer to the country in which the survey was carried out as "destination", and to the country in which the interviewed individual was living 12 months before as "origin". The questionnaire also reports information regarding the age, education, and nationality of the worker. We focus on individuals between 15 and 65 years old, and use the information reported to infer if the individual is a migrant—in case the country where she resides today is different from the one she was residing one year before—as well as the origin country, and the year of migration.

B.2.1 Frequency, Completeness, and Date of Migration

From 1983 to 1997, the European Labour Force Survey was conducted only in spring (quarter 1 or 2 depending on the country). Since 1998, the transition to a quarterly continuous survey (with reference weeks spread uniformly throughout the year) has been gradually conducted by member states. Some countries first introduced a continuous annual survey (meaning the reference weeks were uniformly distributed throughout the spring quarter) and then switched to a quarterly collection, whereas others moved directly to a quarterly continuous survey. For simplicity, we make every survey continuous quarterly. We emphasize that the reason for doing this is just practical. The procedure outlined below does not affect our results in any way since our analysis is carried on at the destination-origin-nationality-skill-year level and the procedure operates instead at the intra-annual level.

1. For each survey we count the number of weeks in which interviews were carried on.
2. We multiply the sampling weight associated to each interview by the number of weeks covered in the survey and divide by 52.
3. We compute a representative week by averaging out the sampling weight associated to each interview, by destination, origin, and year.
4. We assign the representative week to any week not originally covered by the survey, thereby ending up with 52 weeks for each country of destination and year.

We make three further corrections to the EU-LFS survey. First, in a minority of instances in some surveys—about 1.8 percent of the individuals, once accounting for sampling weights—interviewed individuals could, instead of indicating the specific country of origin, refer to a broad group.[46] When the broad group is "European Union (EU-15)" we re-assign individuals to each individual EU-15 country proportionally, by destination and year, on the basis of all the other observations in which information on the specific country of origin is available. When the broad group is either "Other European Economic Area", "Other Central and Eastern Europe", or "Other Europe" we re-assign individuals to each individual NMS country proportionally, by destination and year, on the basis of all the other observations in which information on the specific country of origin is

[46] This can also happen because of confidentiality concerns, which may differ on a country-by-country basis due to national legislation, especially before the country joins the European Union.

Table A.2: Nationality mapping - before 2004

Before 2004

Code	Label	EU-15 survey	NMS8 survey
0	Nationals	EU-15	NMS8
111	EU-15	EU-15	EU-15
911	Non EU-15	NMS8 or other **	NMS8 or other **
800	Non-National/Non-Native *	EU-15, NMS8 or other **	EU-15, NMS8 or other **

After 2004

0	Nationals	EU-15	NMS8
1	EU-15	EU-15	EU-15
2	NMS10	NMS8	NMS8
Multiple codes	Other categories	Other	Other

Notes: * Non-National/Non-Native in case the distinction EU/Non-EU is not possible

** NMS8 using levels of "other" flows based on 2004-8 data, residual belongs to "other"

available. When the broad group is "Other or stateless" we re-assign, by destination and year, individuals to the RoW. When the country of origin is missing we re-assign individuals to all other countries proportionally, by destination and year, on the basis of all the other observations in which information on the specific country of origin is available.

Second, for a few destination-origin-year-months the information is not complete. In those cases, we use a standard interpolation procedure when the missing information is between two years in which we have data, or backward projection if the missing year is at the beginning of the series.[47] Since the analysis carried on in the paper refers to the 2002-2007 period and some of the destination-origin-year-months with incomplete observations refer to countries that we drop from the analysis, the potential impact of the interpolations and projections on the results is even smaller.

Third, the survey does not report the exact date of migration but only the country in which the interviewed individual was living 12 months before. In other words, an individual that is interviewed in April of 2006 in the United Kingdom and declares that 12 months before she was living in Poland could have migrated out of Poland any time in the previous 12 months. Therefore, we spread the sampling weight associated to this individual to the previous 12 months.

B.2.2 Nationality

The EU-LFS contains information on the nationality of the interviewed individuals. However, mainly because of country-specific privacy regulations, the variable "nationality" has different cat-

[47] Interpolation is performed for the U.K. in 2008, and France in 2003, 2004 and 2005. Backward projection is used for Latvia in 2001, 2002 and 2003, Czech Republic in 2001, Italy in 2001, 2002, 2003, and 2004, Slovakia in 2001 and 2002.

egories before and after 2004. Specifically, before 2004 the variable "nationality" takes only four values: "Nationals" (code 0), "EU-15" (code 111), "Non EU-15" (code 911), and "Non-National/Non-Native" (code 800) in case the distinction EU-15/Non-EU-15 is not available. After 2004, the category "Non EU-15" has been expanded to distinguish between "New member states NMS10" (code 2) and other countries or groups of countries we will refer to as "other categories". Our goal is to create the following three nationality categories: "EU-15", "NMS10" and "Other". In order to do so we have to redistribute individuals from the "Non EU-15" category before 2004 into "NMS10" and "Other", as well as redistribute individuals from the "Non-National/Non-Native" category before 2004 into "EU-15", "NMS10" and "Other". We now describe the procedure to construct the nationality dimension of our migration data.[48]

In order to construct the nationality we need to deal with the *number* of people with nationality "Other" (different from EU-15 and NMS nationals). We assume that the accession of NMS countries does not affect the flow of "other" nationals within the EU28. For every destination and origin country pair, and for every year, we compute the number of "other" nationals for the period 2004 onward. We then take the simple average—at the destination-origin level— over the period 2004-2008 and we subtract it to the codes 800 and 911 before 2004.[49] In practice, we do the following:

1. For the 800 group, we do a preliminary step: we split the 800 group in EU-15 and non EU-15 nationals using the average 2004-2008 shares of nonEU-15 within non-natives. In practice, we do the following: consider an 800 observation—for a given destination-origin-year-week—with weight x: the number of successes, n, from a Binomial with probability equal to the average share described above and number of experiments equal to x is the number of "nonEU-15" associated to the observation. Then, $x - n$ is the number of EU-15 associated to the observation. In other words, we assume that each person summarized by the observation has an equal and independent probability of being "nonEU-15". Note that it is important to apply a Binomial to each observation because we want to preserve the information regarding the reference week. We will use this information later on when we compute the emigration shares.

2. Then, for every 911 and 800-turned-nonEU-15 observation, we apply a similar procedure to split between NMS8 and "other" nationals. In practice, we do the following:

   (a) We compute the average number of "Other" post 2004 *divided by the sum of the weights of the 911 and 800-turned-nonEU-15 observations.*

   (b) We consider one of the 911 or 800-turned-nonEU-15 observations—for a given destination-origin-year-week—with weight x: the number of successes, n, from a Binomial with probability equal to the average share described in (a) and number of experiments equal

[48] After 2004, the surveys for Latvia report the category NMS13 instead of distinguishing between NMS10 and NMS3. When creating nationalities described below, we use NMS13 in place of NMS10 for Latvia.

[49] For destination-origin pairs that appear before 2004 but not after, we assign, for each destination, the average share across all origins. Note that in more than 99 percent of the cases this happens when country of origin is missing.

to x is the number of "other" associated to the observation. Then, $x - n$ is the number of NMS8 nationals associated to the observation. In other words, we assume that each person summarized by the observation has an equal and independent probability of being "other". Note that, here as well, it is important to apply a Binomial to each observation because we want to preserve the information regarding the reference week. We will use this information later on when we compute the emigration shares.

We define 3 nationalities, "EU-15", "NMS10" and "Other" based on table A.2.

The Case of Poland The variable nationality for Poland is available only since 2004 and it only includes three codes: 0 "National / Native of own Country", 5 "EU28", and 8 "Europe outside EU28". In order to separate EU-15 from NMS10 nationals, we construct an alternative nationality variable for Poland applying the origin-year-specific shares of EU-15, NMS10, and Other nationals computed for Hungary to the survey for Poland. We choose Hungary as a reference because, just like Poland and unlike other NMS countries, it applies reciprocal measures to EU-15 nationals. Poland lifted the reciprocal measures on January 1st, 2007, while Hungary simplified the reciprocal measures on January 1st, 2008.

B.2.3 Education

The EU-LFS contains information on the education level of the interviewed individuals. Each individual is assigned an education level according to the International Standard Classification of Education (ISCED 1997). We use the ISCED classification to split individuals into two education levels, defining as high skilled all the individuals with at least tertiary education. We assign to the low skilled group the residual workers with education up to post secondary non-tertiary education. When information on education is missing, we proceed as follows: if in a destination-origin-year-week we only observe individuals with either high skill (low skill) or missing education, we assume all the individuals with missing education to be low (high) skilled. If in a destination-origin-year-week we observe individuals with high skill, low skill and missing education, we proportionally split the missings to high and low skill. Finally, if for a destination-origin-year-week we do not have any information on education, we proportionally assign education using the average annual shares of high and low skill migrants for that same destination-origin-year or destination-origin.

B.2.4 Stocks and Flows

Our goal is to construct a data set of migration flows that is internally consistent. Let's consider a given nationality-skill pair. For each country-sector-year pair (i, v, t) we potentially have two separate measures of the stock of individuals: the first measure comes directly from the EU-LFS (i, t) survey; the second measure can be constructed from the set of EU-LFS $\{(i, t+1)\}_i$ surveys for the following year. For example, the Polish survey of 2006 provides a measure of the number of low-skill NMS nationals working in sector v in Poland in 2006. However, another measure can be

constructed using the surveys for all countries in 2007—including the survey for Poland—reporting immigrants that were working in sector v in Poland the year before. Let's define the first measure as $S_{06}^{PL,v}$ and the second measure as $\tilde{S}_{06}^{PL,v}$. If $S_{06}^{PL,v} > \tilde{S}_{06}^{PL,v}$ we can conjecture that the difference $\left(S_{06}^{PL,v} - \tilde{S}_{06}^{PL,v}\right)$ captures migrants from Poland to the RoW. To the contrary, if $S_{06}^{PL,v} < \tilde{S}_{06}^{PL,v}$ we can replace $S_{06}^{PL,v}$ with $\tilde{S}_{06}^{PL,v}$, and adjust the migration flows between $t-1$ and t accordingly. The following algorithm captures this idea.

1. Consider a given nationality, skill level, time interval $t \in [0, ..., T]$, and set of countries $i \in \{EU, NMS, ROW\}$ where EU is the set of our 10 EU countries, NMS is the set of our 7 NMS countries, and ROW is a residual set of countries (that must be commonly defined in each survey).

2. Let $S_t^{i,v}$ be the stock of people in country i-sector v-year t according to country i survey in year t. Let $F_{t-1,t}^{ijuv}$ be the flow of migrants from sector u in country i to sector v in country j between $t-1$ and t according to country j survey in year t.

3. Consider $t = T$.

   (a) For each country and sector iu in $t = T-1$, it must be the case that either

      i. $S_{T-1}^{iu} > \sum_j \sum_v F_{T-1,T}^{ijuv}$ (the stock is higher than the sum of the outflows) or

      ii. $S_{T-1}^{iu} < \sum_j \sum_v F_{T-1,T}^{ijuv}$ (the stock is lower than the sum of the outflows).

   (b) In the first case, we assume that the difference between the stock and the flows represents migration from i to ROW. In order to determine the sector of destination we use the average matrix for all other destinations, i.e.

$$\tilde{F}_{T-1,T}^{iROWuv} = \left(S_{T-1}^{iu} - \sum_j \sum_v F_{T-1,T}^{ijuv}\right) \sum_{j \neq ROW} \left[\left(F_{T-1,T}^{ijuv} / \sum_v F_{T-1,T}^{ijuv}\right)\right] / 17$$

   for all v. Housekeeping: We also set $\tilde{F}_{T-1,T}^{ijuv} = F_{T-1,T}^{ijuv}$ for all $j \neq ROW$, and $\tilde{S}_{T-1}^{iu} = S_{T-1}^{iu}$.

   (c) In the second case:

      i. We trust the flows and update the stock in $T-1$, i.e. we set $\tilde{S}_{T-1}^{iu} = S_{T-1}^{iu} + \left[\left(\sum_j \sum_v F_{T-1,T}^{ijuv}\right) - S_{T-1}^{iu}\right]$;

      ii. We also update the inflows, between $T-2$ and $T-1$ to be consistent with the new stock $\tilde{S}_{T-1}^{jv}$. We do so by assigning the difference between $\tilde{S}_{T-1}^{jv}$ and S_{T-1}^{jv} to inflows from ROW. In order to determine the sector of origin we use the average matrix for all other countries of origin, i.e.

$$\tilde{F}_{T-1,T}^{ROWjuv} = \left(\tilde{S}_{T-1}^{jv} - S_{T-1}^{iv}\right) \sum_{i \neq ROW} \left[\left(F_{T-1,T}^{ijuv} / \sum_u F_{T-1,T}^{ijuv}\right)\right] / 17$$

for all u. Housekeeping: We also set $\tilde{F}^{ijuv}_{T-1,T} = F^{ijuv}_{T-1,T}$ for all $j \neq ROW$, and $\tilde{F}^{iROWuv}_{T-1,T} = 0$ for all uv.

(d) Housekeeping: we set $\tilde{S}^{iv}_{T} = S^{iv}_{T}$ for all $i \neq ROW$.

4. Consider now $t = T - 1$ and loop back to point 3.

After having performed the algorithm described above, we have the flows of migrants for each pair of countries-sectors as well as the stock of people in each country, sector, and year, but we do not have information on the stock of people in the RoW, as well as their distribution across sectors. We use information on population levels and on the share of population between 15 and 64 years old from the World Bank World Development Indicators database to construct the stock of people in the rest of world in 2002.[50] We further use the average year-nationality-skill-sector share from our 17 countries (EU members plus NMS countries) and apply them to the RoW population to split people in the relevant groups for our analysis.

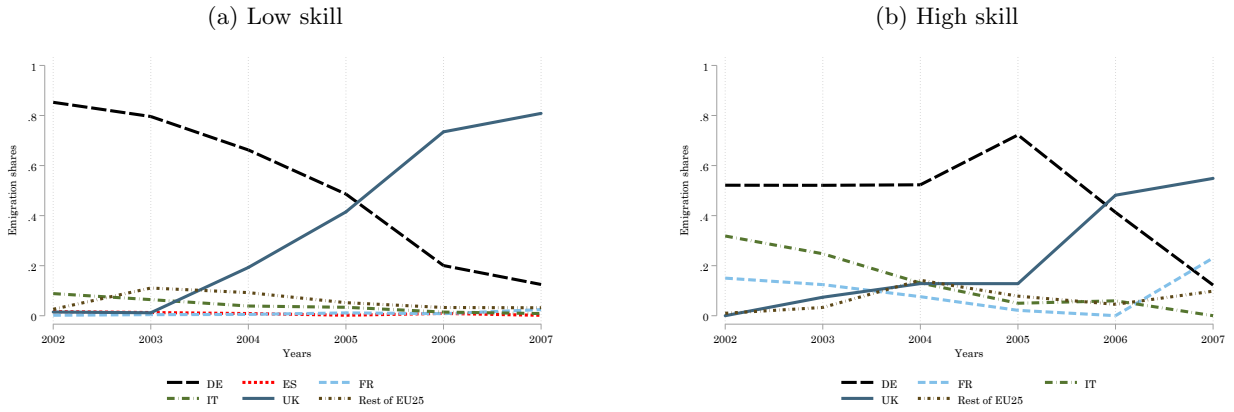
Some destination-origin-nationality-skill-year sequences of migration flows consists in sequences of zeros followed by positive values. While sequences of tiny values followed by larger flows do not represent an issue, sequences of zeros followed by positive values cannot be handled by the model. We perform the following procedure to, essentially, replace zeros with small positive values. We start from the stock of individuals in 2002, which includes three zeros: high skill EU nationals in Estonia and Latvia, and low skill EU nationals in Lithuania. We compute the average ratio of low to high skill EU nationals across NMS countries and apply the (inverse) ratio to the stock of high (low) skill to turn the zeros into positive values. Then we consider the migration shares and set them to be equal to the average migration share by year, nationality and skill group across countries if the migration share is equal to zero. In case the average migration share is missing, we compute the average across years. At the end of this procedure, we use the new migration shares and the new stock for 2002 to recompute the stocks and flows by skill, nationality, origin, destination and year. At the end of the procedure described above, we have a set of flows of workers by country of origin, destination, nationality and skill in each year and a consistent set of stocks. We perform a number of checks that confirm that the share of population by destination, as well as the change in the share of population between 2002 and 2007, again by destination, is not significantly affected.

B.2.5 Migration Data Checks

In this appendix, we provide some external validation for our constructed gross migration data. First, we compare the final migration data set with the raw data in terms of (i) the share of each country population relative to the aggregate population, and (ii) the ratio between low and high skill workers. In terms of the share of each country population relative to the aggregate population we find that the correlation between the raw and final data is 0.998 in 2002, the first year in the sample. The correlation between the 2002-2007 changes of the same shares is 0.542. In terms of

[50] Total population is based on the de facto definition of population, which counts all residents regardless of legal status or citizenship. The values used are midyear estimates.

Figure A.2: Top migration destinations from Poland, share of NMS nationals by skill, 2002-2007



Note: These figures show the migration share out of Poland for low-skill and high skill NMS nationals for the top 3 migration destinations in 2002 or 2007, plus the aggregate share for all other EU countries.

the ratio of low to high skill workers, the cross-country correlation between the raw and final data is 0.996, while the correlation between the 2002-2007 changes is 0.865. Overall, we conclude that the data comparison in terms of population shares and skill ratio is quite satisfactory.

Second, we compare the migration data set with migration information coming from alternative data sources: Statistics Denmark and the UK Office for National Statistics. As mentioned above, it is not easy to find accessible and comparable migration data. The UK is of particular interest given the role it played in the 2004 EU enlargement, while Denmark is particularly well known for collecting precise statistical information. We find that the correlation between the immigration shares into Denmark, by year and country of origin, based on Statistics Denmark information and based on our data is 0.79 for the 2003-2007 period. The correlation between the UK Office for National Statistics aggregate inflow of migrants from NMS and the inflow based on our data is 0.93 for the 2003-2007 period.[51]

Finally, we use our migration data set to investigate a number of specific migration patterns that have either been documented in the literature, or that have been prominently featured in the press and are part of the public awareness. We focus on three migration routes: (i) from Poland to Germany/UK, (ii) Portugal to France, and (iii) Italy to Germany/France/UK. The 2011 German Census reports that about 2.7 million people whose country of birth is Poland live in

[51]Denmark: Statistics Denmark series on immigration by sex, age, citizenship, country of last residence and time are published in the StatBank, INDVAN time series. These data include persons who took up residence in Denmark and who had resided abroad before. The data come from the CPR, the central population register. We select people between 15 and 64 years, aggregate the data by year and country of origin, and build immigration shares by dividing by the corresponding Denmark population from the World Bank World Development Indicators database. UK: We use the UK Office for National Statistics "Revised Net Long-Term International Migration" time series. These data include long-term migrants, i.e. those that change their usual country of residence. The primary data source is the International Passanger Survey (IPS), a continuous voluntary survey conducted at all principal air and sea routes and the channel tunnel. Slovenia and Slovakia are included in the UK Office for National Statistics sample but not in our data, while Cyprus is included in our data but not in the UK Office for National Statistics sample.

Germany.[52] While Germany has been, for several reasons throughout history, the main European destination for Polish emigrants, Dustmann et al. (2015) notes that "Whereas Germany was the main destination in 1997, absorbing about 27 percent of the Polish emigrant population, the largest destination country in 2007 was the UK (with 31 percent of all emigrants)."[53] Figure A.2, using our data on migration flows, clearly shows the leapfrogging of Germany by the UK in terms of main European destination for emigration, both for low-skilled and high-skilled NMS nationals. Just like for Poland, a large fraction of the Portuguese population lives abroad, and France has traditionally been the main European destination for Portuguese migrants.[54] The 2011 French Census reports that about 6 percent of the Portuguese population lives in France. After France, the other top four countries in terms of Portuguese-born people in 2011 are Spain, Luxembourg, Germany, and Belgium. Our data set on gross flows of migrants for the 2002-2007 period confirms this ranking. The third case we consider features another country which has experienced throughout history large outflows of population: Italy. According to the 2011 Italian Census, the top four countries in terms of stock of Italian-born population are France, Germany, Switzerland, and the United Kingdom. Once again, with the exclusion of Switzerland our data is entirely consistent with the information coming from the census.

B.3 Bilateral Trade

The bilateral trade flows between each state in the sample are computed using information from the WIOD database (Timmer et al. (2015a)). We keep the set of countries consistent with the migration data and we pool all the remaining countries in the rest of the world. Values are in US dollars at current prices.

Table A.3 shows the share of NMS, EU-15, and Rest of the World, into either NMS or EU-15 imports or exports. The table points to three patterns. First, the larger trade integration among NMS countries, whose average weight into imports or exports increases by 60 and 50 percent, respectively within 5 years. Second, the larger weight of NMS in EU-15's trade, which increases by about 30 percent, within 5 years. Third, both EU-15 and NMS countries tend to trade more with the Rest of the World, and less with EU-15 countries themselves. All patterns are consistent with the reductions in tariffs, between EU-15 and NMS, among NMS countries, and between EU and the Rest of the World discussed in Section 2.2.

[52]The 2011 Population and Housing Census marks a milestone in census exercises in Europe. For the first time, European legislation defined in detail a set of harmonized high-quality data from the population and housing censuses conducted in the EU Member States.

[53]The figures mentioned in Dustmann et al. (2015)'s quote come from the Polish Labour Force Survey, a rotating quarterly panel conducted in Poland by the Polish Central Statistical Office. The survey registers the country of present residence for individuals who are part of the household but who have been residing abroad for more than 3 months.

[54]The New York Times article "Pictures Tell the Story of Portuguese in France" captures the importance of the Portuguese presence in France in the 1960s.

Table A.3: Imports and exports shares, EU-15 and NMS, 2002 and 2007

Imports shares

	NMS importing from:			*EU-15 importing from:*		
	Other NMS	EU-15	RoW	NMS	Other EU-15	RoW
2002	5.7	52.6	41.7	3.9	46.9	49.2
2007	9.1	48.0	43.0	5.2	42.3	52.5
Change	+3.4	-4.6	+1.3	+1.3	-4.6	+3.3

Exports shares

	NMS exporting to:			*EU-15 exporting to:*		
	Other NMS	EU-15	RoW	NMS	Other EU-15	RoW
2002	6.2	54.6	39.2	3.8	43.8	52.4
2007	9.3	50.1	40.6	4.9	40.8	54.3
Change	+3.1	-4.5	+1.4	+1.1	-3.0	+1.9

Notes: This table shows the weighted average imports and exports shares for NMS and EU-15 countries. Averages have been constructed using the WTO and TRAINS tariff data, as described in Section 4 and Appendix B.3.1, using the same set of ten EU-15 countries and seven NMS countries as in our data set on gross migration flows. The remaining countries are aggregated into the Rest of the World (RoW).

B.3.1 Tariffs

The bilateral tariff data are constructed using the information in the WITS database. We use effectively applied rates and we combine information from two different datasets, the TRAINS data set and the WTO data set; the two datasets are compatible because TRAINS combines information from different sources, among which WTO data. We start from the TRAINS data set, which is the most complete of the two and we proceed as follows to make the series complete:

1. Use average EU-25 tariff applied to NMS8 to replace missing tariff when the destination country of the exported good is a EU-15 country and the origin belongs to the NMS8 group.

2. Use average EU27 tariff applied to NMS2 to replace missing tariff when the destination country of the exported good is a EU-15 country and the origin country belongs to the NMS2 group.

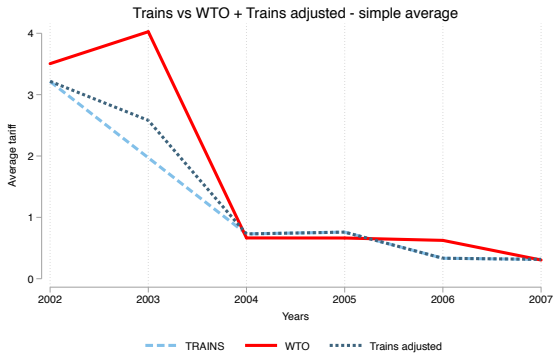
3. If the two criteria above do not fill the missing cells:

   (a) Use WTO values to impute Trains values if WTO is not missing

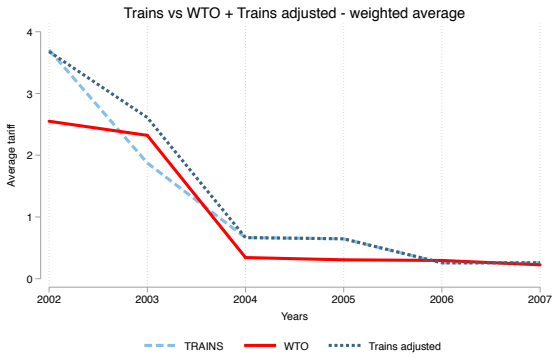
   (b) Missing values for 2003 are replaced with values from 2002. This could happen because some NMS lowered their tariff before the formal access to the European Union. We do not replace the missing values with zeros, but we impute the non-zero value of the previous year.

Figure A.3: Tariffs data

(a) Simple average



(b) Weighted average



(c) If we have missings in one year, we interpolate using the values of the year before. This is the case for Lithuania in 2000.

(d) If all the values for a country are missing, we construct an average tariff of similar countries and impute that value. This is the case for Latvia for which we do not observe tariffs when exporters goods abroad; we thus use the average tariffs applied to the exports of Lithuania and Estonia.

We follow the same procedure using simple tariffs and weighted tariffs—where weights are given by the amount of exports—and we obtain two complete sets of tariffs for each country in our sample over time.

Figure A.3 reports the comparison among the simple and weighted average TRAIN tariff, the WTO tariff, and the tariff we construct using the methodology described above.

B.4 Real Wages Share of Labor Compensation in Value Added

We compute the share of labor compensation in value added at the national level using information from the socio economic accounts in the WIOD database. To construct the series of real wages we use the information on the price levels of the countries in our sample from the Penn World Tables. We use the variable "Price level of CCON, equal to the PPP (ratio of nominal CON to CCON) divided by the nominal exchange rate (National currency per USD)" which in other words is just the ratio of expenditure at local prices to that at reference prices measured in the currency of the base country—in our case the US.

Because the PPP is in units of the currency of country j per unit of the currency of the base country, it is common to divide it by the nominal exchange rate to obtain what is called the "price level" of country j (see Feenstra et al. (2015)). Moreover, we the WIOD database provides also information on the employment level of each country over time, which constitutes the denominator of the formula for real wages.

B.5 Portuguese Matched Employer-Employee Data

Employer-employee data come from *Quadros de Pessoal*, a longitudinal data set matching virtually all firms and workers based in Portugal.[55] Reported data cover the firm itself, as well as each of its workers. Each firm and each worker entering the database are assigned a unique, time-invariant identifying number which can be used to follow firms and workers over time.

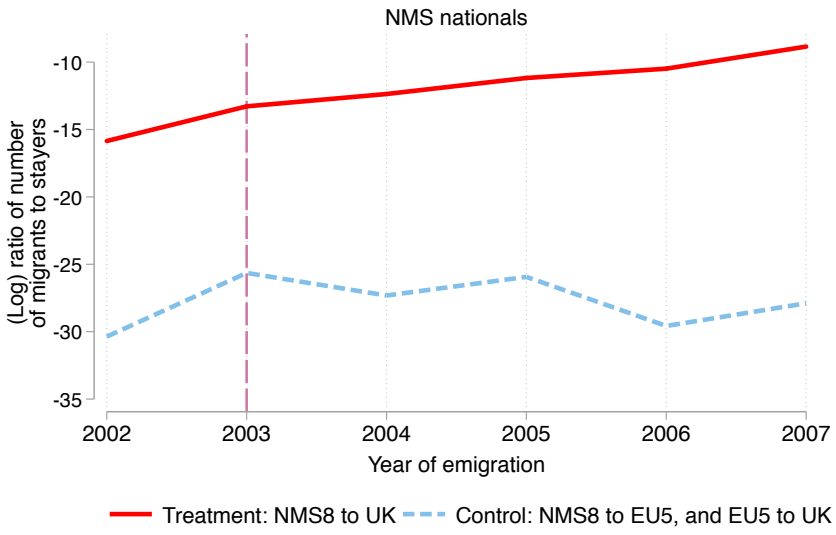
Currently, the data set collects data on about 350,000 firms and 3 million employees. Each year, every firm with wage earners is legally obliged to fill in a standardized questionnaire. Reported data cover the firm itself, each of its plants, and each of its workers. The worker-level data cover information on all personnel working for the reporting firms in a reference week. They include information on gender, age, occupation, schooling, hiring date, earnings, hours worked (normal and overtime), etc. The information on earnings includes the base wage (gross pay for normal hours of work), seniority-indexed components of pay, other regularly paid components, overtime work, and irregularly paid components.[56] It does not include employer's contributions to social security.

The administrative nature of the data and their public availability at the workplace—as required by the law—imply a high degree of coverage and reliability. The public availability requirement facilitates the work of the services of the Ministry of Employment that monitor the compliance of firms with the law (e.g., illegal work).

C Change in Migration Costs: Placebo Plots and Residual Cases

In Section 4.3, we described the methodology used to identify changes in migration costs for the main events in our sample period: the United Kingdom opening to NMS countries in 2004, followed by Greece, Italy, Spain, and Portugal in 2006, and NMS countries opening their respective labor markets to each other and (mostly) to EU-15 countries in 2004. We also ran a number of placebo experiments to support our identification strategy. In this appendix we provide additional support for the identification strategy by showing, in sub-appendix C.1, a series of plots that allow to evaluate the common trend assumption. Sub-appendix C.2 reports similar plots for the placebo experiments.

Figure C.1: Log odds of migrating to the U.K. vs. staying in a NMS country for NMS nationals, treatment and control flows, 2002-2007



Note: Treatment flows in solid red, control flows in dashed blue. The pink vertical dashed line marks the beginning of the treatment period.

C.1 Common Trend Assumption

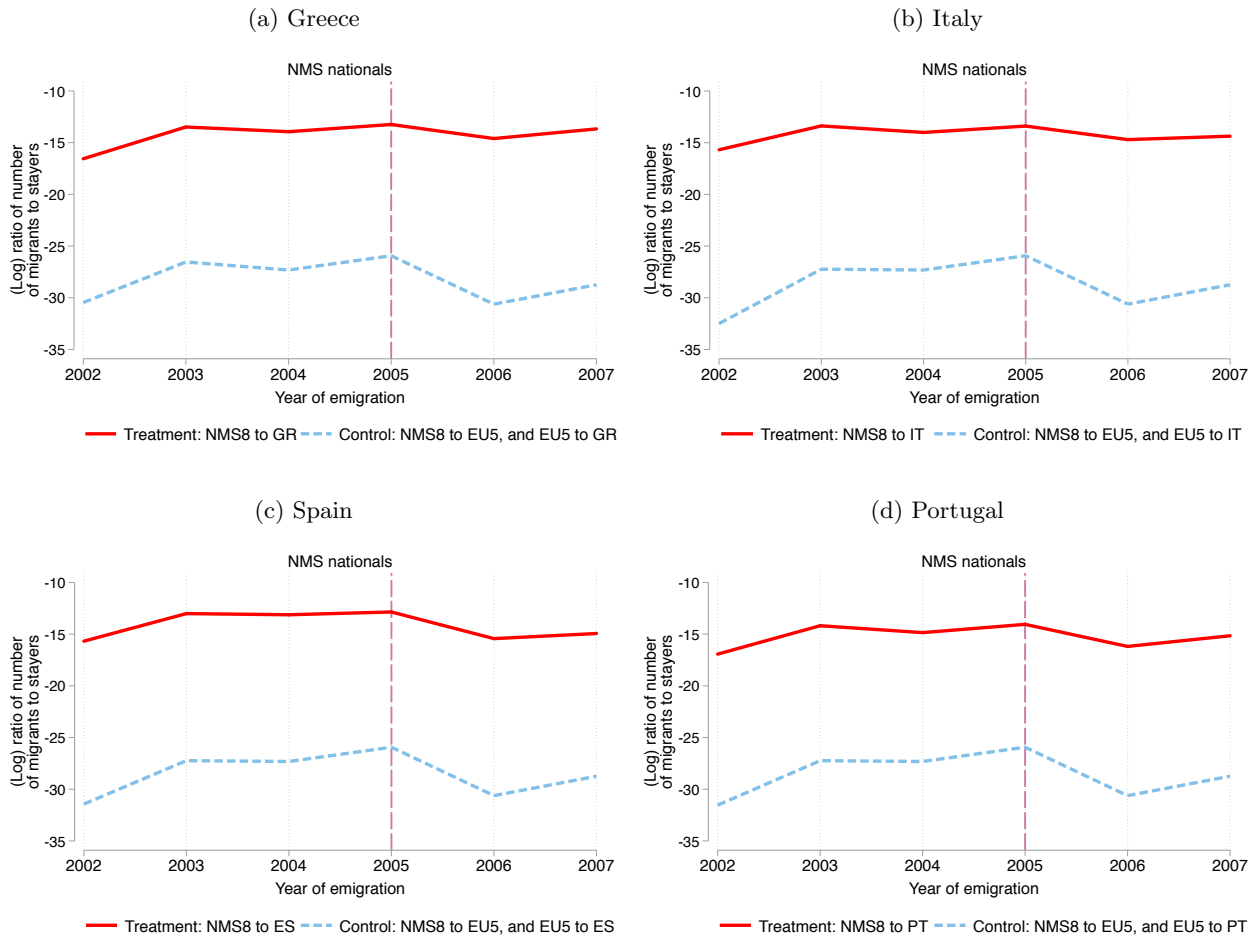
Figure C.1 shows the evolution over time of the (log) odds of migrating vs. staying (equation 10) for the treated and control groups of NMS nationals. The treated group is represented by the NMS to U.K. flow of NMS nationals, with the treatment period being after 2003. The control group is represented by the NMS to EU-5 and EU-5 to U.K. flows of NMS nationals. The figure clearly conveys two messages: First the odds for both the treated and control groups were increasing before the 2004 enlargement; second, when comparing the pre-treatment and treatment periods, the change in the odds of migrating is clearly positive for the treated group and close to zero for the control group. These patterns are consistent with a substantial reduction in migration costs from NMS to the United Kingdom.

Turning to the southern European destinations, Figure C.2 reports the evolution of the (log) odds for Greece, Italy, Spain, and Portugal—with the treatment period being after 2005. Overall, the comparison between the log odds of the treatment and the control groups before the policy

[55]Public administration and non-market services are excluded. *Quadros de Pessoal* has been used by, among others, \cite{Cabral03} to study the evolution of the firm size distribution; by \cite{Blanchard01} to compare the U.S. and Portuguese labor markets in terms of unemployment duration and worker flows; by \cite{Cardoso05} to study the determinants of both the contractual wage and the wage cushion (difference between contractual and actual wages); by \cite{Carneiro12} who, in a related study, analyze how wages of newly hired workers and of existing employees react differently to the business cycle; by \cite{Martins09c} to study the effect of employment protection on worker flows and firm performance. See these papers also for a description of the peculiar features of the Portuguese labor market.

[56]It is well known that employer-reported wage information is subject to less measurement error than worker-reported data. Furthermore, the Quadros de Pessoal registry is routinely used by the inspectors of the Ministry of Employment to monitor whether the firm wage policy complies with the law.

Figure C.2: Log odds of migrating to Greece/Italy/Spain/Portugal vs. staying in a NMS country for NMS nationals, treatment and control flows, 2002-2007



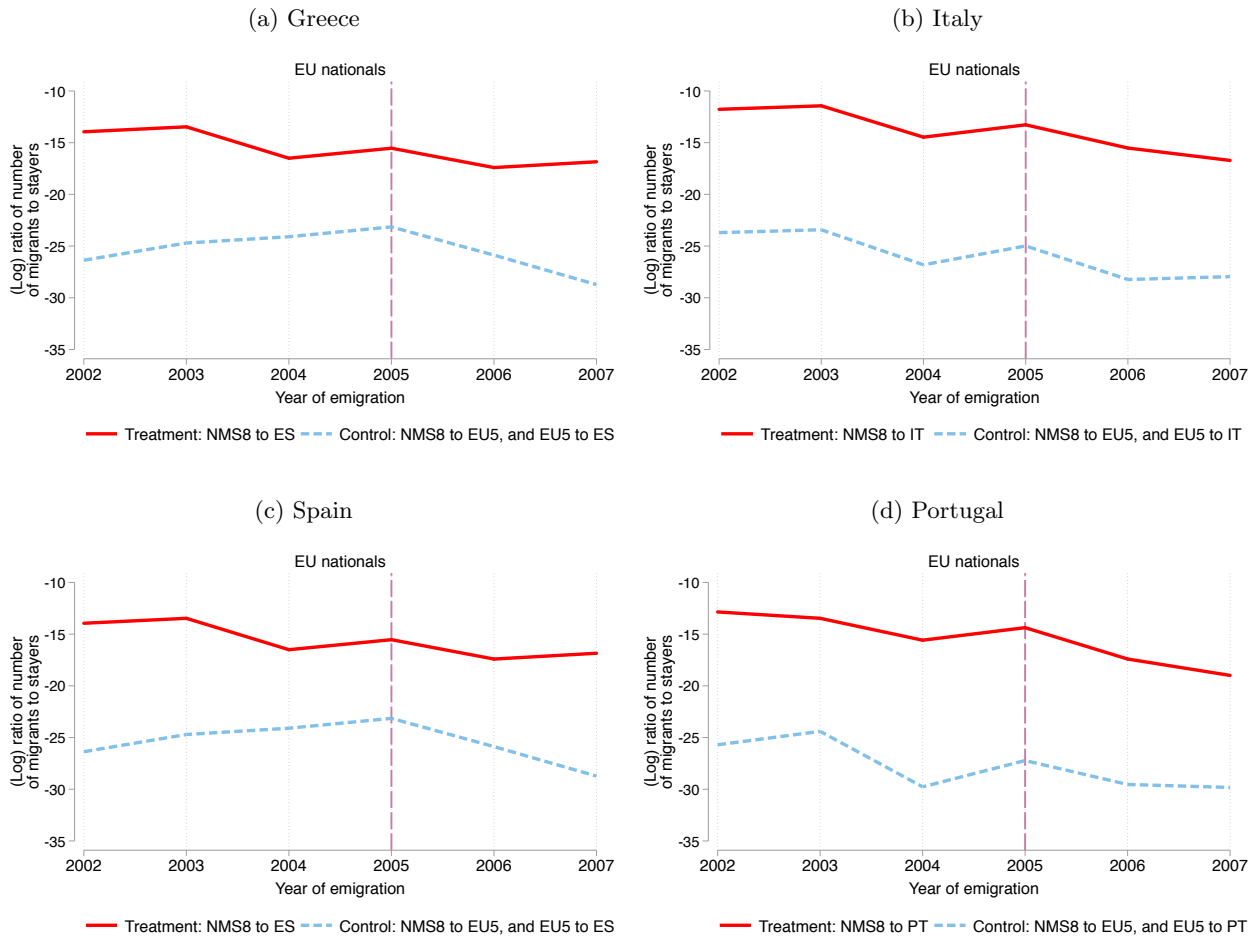
Note: Treatment flows in solid red, control flows in dashed blue. The pink vertical dashed line marks the beginning of the treatment period.

changes confirms that the control groups represent a good measure of counterfactual log odds in the absence of a policy change. Except for the case of Greece, the odds of migrating vs. staying decreases, from the pre-treatment to the treatment period, both for the control and the treated groups *but significantly less for the latter*, pointing to a positive contribution associated to a reduction in migration costs.

C.2 Placebo Experiment

As shown in Section 2.1, a placebo experiment confirms the prior that EU nationals did not experience any significant change in the cost of migrating back to Europe from NMS countries. Figure C.3 reports the evolution of the (log) odds for the treated and control groups.

Figure C.3: Log odds of migrating vs. staying for EU nationals (Placebo), from NMS countries to Greece/Italy/Spain/Portugal, treatment and control, 2002-2007



Note: Treatment flows in solid red, control flows in dashed blue. The pink vertical dashed line marks the beginning of the treatment period.

D International Migration Elasticity

In this appendix we describe in detail the estimation method used to find the international migration elasticity in Section 4.4. We estimate the international migration elasticity, $1/\nu$, by adapting the method presented in Artuç and McLaren (2015) to our theory and data. The method has two stages: first the Poisson regression stage where we estimate value differences and the migration cost function, normalized by ν, for every time period. Second, the Bellman equation stage, where we insert the estimated value differences into a Bellman equation and construct a linear regression to retrieve the international migration elasticity, $1/\nu$.[57]

The estimation method relies on the following two equilibrium conditions from the model: the

[57]Since we estimate the elasticity using only flows of EU nationals within EU-15 we drop the n subscript.

migration share equation

$$\mu_{t,s}^{ij} = \frac{\left[\exp\left(\beta V_{t+1,s}^{j} - m_{t,s}^{ij}\right)\right]^{1/\nu}}{\sum_{k=1}^{N}\left[\exp\left(\beta V_{t+1,s}^{k} - m_{t,s}^{ik}\right)\right]^{1/\nu}}, \tag{18}$$

and the Bellman equation

$$\begin{aligned} V_{t,s}^{i} &= \log\left(C_{t,s}^{i}\right) + \nu \log\left[\sum_{k=1}^{N}\left[\exp\left(\beta V_{t+1,s}^{k} - m_{t,s}^{ik}\right)\right]^{1/\nu}\right] = \\ &= \log\left(w_{t,s}^{i}/P_{t}^{i}\right) + \beta E_{t} V_{t+1,s}^{i} + \Omega_{t,s}^{i}, \end{aligned} \tag{19}$$

where

$$C_{t,s}^{i} = \frac{w_{t,s}^{i}}{P_{t}^{i}}$$

is the consumption aggregator, and

$$\Omega_{t,s}^{i} = \nu \log \sum\nolimits_{k=1}^{N}\left[\exp\left(\beta\left(V_{t+1,s}^{k} - V_{t+1,s}^{i}\right) - m_{t,s}^{ik}\right)\right]^{1/\nu}$$

is the option value of migration.

First stage: Poisson regression The first stage is a fixed-effect estimation—based on the migration share equation and bilateral gross migration flows data—to estimate value differences and the migration cost function normalized by ν.

The estimating equation can be derived as follows. In the migration share equation (18), multiply both numerator and denominator on the right hand side by $\left[\exp\left(-\beta V_{t+1,s}^{i}\right)\right]^{1/\nu}$,

$$\mu_{t,s}^{ij} = \frac{\left[\exp\left(\beta\left(V_{t+1,s}^{j} - V_{t+1,s}^{i}\right) - m_{t,s}^{ij}\right)\right]^{1/\nu}}{\sum_{k=1}^{N}\left[\exp\left(\beta\left(V_{t+1,s}^{k} - V_{t+1,s}^{i}\right) - m_{t,s}^{ik}\right)\right]^{1/\nu}}.$$

Then multiply both sides by the mass of agents $L_{t,s}^{i}$,

$$L_{t,s}^{i}\mu_{t,s}^{ij} = \frac{\left[\exp\left(\beta\left(V_{t+1,s}^{j} - V_{t+1,s}^{i}\right) - m_{t,s}^{ij}\right)\right]^{1/\nu}}{\sum_{k=1}^{N}\left[\exp\left(\beta\left(V_{t+1,s}^{k} - V_{t+1,s}^{i}\right) - m_{t,s}^{ik}\right)\right]^{1/\nu}} L_{t,s}^{i},$$

and rewrite as

$$L_{t,s}^{i}\mu_{t,s}^{ij} = \exp\left(\frac{\beta}{\nu}V_{t+1,s}^{j} - \frac{\beta}{\nu}V_{t+1,s}^{i} - \frac{1}{\nu}m_{t,s}^{ij} + \log L_{t,s}^{i} - \frac{1}{\nu}\Omega_{t,s}^{i}\right). \tag{20}$$

We interpret the equation above as Poisson pseudo-maximum likelihood. The first stage regression is then

$$Z_{t,s}^{ij} = \exp\left(\lambda_{t,s}^{j} + \alpha_{t,s}^{i} - \frac{1}{\nu}m_{t,s}^{ij}\right) + \varepsilon_{t,s}^{ij}, \tag{21}$$

where $Z_{t,s}^{ij} = L_{t,s}^{i}\mu_{t,s}^{ij}$ asymptotically is the mass of agents with skill s moving from i to j in t, $\lambda_{t,s}^{j}$ is a destination-skill-time fixed effect, $\alpha_{t,s}^{i}$ is an origin-skill-time fixed effect.

The estimation of (21) can be done pooling the observations associated to all years and skills in the data. Since we estimate the migration elasticity using only flows of EU nationals within EU-15 we assume that bilateral migration costs do not vary over time and skills, that is $m_{t,s}^{ij} = m^{ij}$ for all $\{t, s\}$ pairs. Note, however, that the cost of migrating out of country i, and into country j, is still potentially skill-dependent because of $\alpha_{t,s}^{i}$, and $\lambda_{t,s}^{j}$, respectively. Finally, $\varepsilon_{t,s}^{ij}$ is a random disturbance of relative migration costs.

The $\lambda_{t,s}^{j}$ and $\alpha_{t,s}^{i}$ terms are not separately identified, so without loss of generality we set $\lambda_{t,s}^{1} = 0$ (or equivalently choose cell $\lambda_{t,s}^{1}$ as the omitted category for the fixed effects). Similarly, not all m^{ij} are separately identified, so without loss of generality we set all $m^{i,1}$ and m^{1j} to zero. Overall, this is equivalent to defining the destination-skill-time fixed effects as

$$\lambda_{t,s}^{j} = \frac{\beta}{\nu}\left(E_t V_{t+1,s}^{j} - E_t V_{t+1,s}^{1}\right) - \frac{1}{\nu}m^{1j}, \tag{22}$$

and the origin-skill-time fixed effects as

$$\alpha_{t,s}^{i} = -\frac{\beta}{\nu}\left(E_t V_{t+1,s}^{i} - E_t V_{t+1,s}^{1}\right) + \log L_{t,s}^{i} - \frac{1}{\nu}\Omega_{t,s}^{i} - \frac{1}{\nu}m^{i,1}.$$

Note that the migration option value for an agent with skill s living in country i in year t can be written as

$$\frac{1}{\nu}\Omega_{t,s}^{i} = -\lambda_{t,s}^{i} - \alpha_{t,s}^{i} + \log L_{t,s}^{i} - \frac{1}{\nu}\left(m^{i,1} - m^{1j}\right). \tag{23}$$

Analogously to Silva and Tenreyro (2006), we use Poisson Pseudo Maximum Likelihood (PPML) to estimate equation (21). This implies that, if we write the estimating equation (21) in the form $W_{t,s}^{ij} = \exp\left(x_{t,s}^{ij}\gamma_{t,s}\right) + \varepsilon_{t,s}^{ij}$, where $x_{t,s}^{ij}$ is a vector of dummy variables and $\gamma_{t,s}$ is the vector of parameters to be estimated, then we choose the parameters to solve the first-order condition

$$\sum_{t}\sum_{ij}\left[W_{t,s}^{ij} - \exp\left(x_{t,s}^{ij}\gamma_{t,s}\right)\right]x_{t,s}^{ij} = 0.$$

Second stage: Bellman equation In stage 1 we have estimated the destination-skill-time and origin-skill-time fixed effects $\lambda_{t,s}^{j}$ and $\alpha_{t,s}^{i}$. The second stage rewrites the Bellman equation (19) as an estimating equation using the estimated values from the first stage.

Using (19), we can write

$$\frac{\beta}{\nu}E_t V_{t+1,s}^{i} = \frac{\beta}{\nu}\left[\log\left(\frac{w_{t+1,s}^{i}}{P_{t+1}^{i}}\right) + \beta E_t V_{t+2,s}^{i} + \Omega_{t+1,s}^{i}\right].$$

Using (23) to substitute out the continuation value $\Omega_{t+1,s}^{i}$, and using the expression for the

Table D.1: International Migration Elasticity, Second Stage Estimates

	Baseline	With public good
$1/\nu$	0.44^{***}	0.53^{***}
	(0.13)	(0.14)
Obs.	100	100

Notes: Standard errors clustered at the country-level in parentheses. *** p<0.01

destination-skill-time fixed effects (22), we get

$$\begin{aligned} \lambda^i_{t,s} + \tfrac{\beta}{\nu} E_t V^1_{t+1,s} + \tfrac{1}{\nu} m^{1,i} = \tfrac{\beta}{\nu} \log\left(\tfrac{w^i_{t+1,s}}{P^i_{t+1}}\right) \\ + \tfrac{\beta^2}{\nu} E_t V^1_{t+2,s} - \beta \alpha^i_{t+1,s} + \beta \log L^i_{t+1,s} - \tfrac{\beta}{\nu}\left(m^{i,1} - m^{1,i}\right). \end{aligned} \tag{24}$$

Define

$$\phi^i_{t,s} = \lambda^i_{t,s} + \beta \alpha^i_{t+1,s} - \beta \log L^i_{t+1,s}, \tag{25}$$

and

$$\xi_{t,s} = \frac{\beta^2}{\nu} E_t V^1_{t+2,s} - \frac{\beta}{\nu} E_t V^1_{t+1,s},$$

and rewrite (24) as

$$\phi^i_{t,s} = \xi_{t,s} + \kappa^i + \frac{\beta}{\nu} \log\left(\frac{w^i_{t+1,s}}{P^i_{t+1}}\right) + \epsilon^i_{t,s}, \tag{26}$$

where $\phi^i_{t,s}$ is the dependent variable constructed from Stage 1 estimates using (25), $\xi_{t,s}$ is a time-skill dummy, $\kappa^i = -(\beta/\nu)\left(m^{i,1} - m^{1,i}\right)$ is a country fixed effect, and $\epsilon^i_{t,s}$ is the regression residual. The remaining right hand-side variables are all taken from the data: $\log\left(w^i_{t+1,s}/P^i_{t+1}\right)$ is the (log) real wage; $\log\left(L^i_{t+1}\right)$ is the lead of the (log) population in country i. We estimate (26) as an IV regression, using two-period lagged values of real wages as instruments similar to Artuç et al. (2010), and clustering standard errors at the country level.

We build wages, for each country i and year $t \in [2002 - 2009]$, as the ratio of the economy-wide "Labour compensation" (in millions of national currency) and "Number of persons engaged" (in thousands) from the WIOD Socio-Economic Accounts (SEA) data set (Timmer et al. (2015b)). Then, we use the purchasing-power-parity adjusted real exchange rate from version 9.0 of the Penn World Tables to compare wages across countries and time (Feenstra et al. (2015)). To compute wages by skill level we resort once again to the WIOD Socio-Economic Accounts: The high-skilled wage is computed by applying the high-skilled share of labor compensation and the high-skilled share of total hours; we convert hours into persons by assuming that the number of hours per person does not vary with skills.

Table (D.1) reports the second stage IV estimates for $1/\nu$ for $\beta = 0.97$ for the baseline case and for the extension with public good described below. The estimates for alternative values of $\beta = \{0.90, 0.95\}$ are the same up to the second decimal digit.

D.1 Estimation with Public Goods

In section 5.2.2 of the main text we extended our model to account for additional congestion effects coming from the provision of public goods. It turns out that this extension only slightly modifies the methodology for the estimation of the international migration elasticity outlined above. The first stage, based on the migration share equation, is unchanged. The second stage relies on a modified Bellman equation that includes the per capita provision of public goods $\left(G^i/L^i_{t+1}\right)$, weighted by the fraction of public goods in total consumption (α_i), as well as wages net of labor income taxes,

$$\frac{\beta}{\nu}E_tV^i_{t+1,s} = \frac{\beta}{\nu}\left\{ \begin{array}{c} \alpha_i \log\left(G^i/L^i_{t+1}\right) + (1-\alpha_i)\log\left[\left(1-\tau^i_{t+1}\right)\frac{w^i_{t+1,s}}{P^i_{t+1}}\right] \\ +\beta E_tV^i_{t+2,s} + \Omega^i_{t+1,s} \end{array} \right\}.$$

Following the same steps outlined above for the case without public good, it is easy to obtain the estimating equation

$$\phi^i_{t,s} = \xi_{t,s} + \kappa^i + \frac{\beta}{\nu}\left\{-\alpha_i \log L^i_{t+1} + (1-\alpha_i)\log\left[\left(1-\tau^i_{t+1}\right)\frac{w^i_{t+1,s}}{P^i_{t+1}}\right]\right\} + \epsilon^i_{t,s}, \tag{27}$$

where the country fixed effect is now defined as $\kappa^i = (\beta/\nu)\,\alpha_i \log G^i - (\beta/\nu)\left(m^{i,1} - m^{1,i}\right)$. In terms of data, we need to compute the fraction of public goods in total consumption α_i, which we construct using the WIOD World Input-Output Database, and we need information on labor income taxes. In order to compute net real wages we resort to the OECD Tax Database, which provides data on combined central and sub-central government income tax plus employee social security contribution, as a percentage of gross wage earnings, for people whose income is 100 percent of the average wage (OECD (2016)). In the OECD Tax Database the average wage is defined as the average annual gross wage earnings of adult, full-time, manual and non-manual workers. Data are available for each year for 14 countries in our sample, all except Lithuania, Latvia and Cyprus. For these three countries we compute the tax rate as the average of the tax rate for all the other NMS countries, by year.

E Elasticity of Substitution Between Low and High Skilled Workers

In Section 4.5 we provided an estimate of the elasticity of substitution between low and high skilled workers. To construct the data, we consider all industries in the economy except for agriculture and fishing, international organizations, and government and justice. We consider all single-job workers between 18 and 65 years old, working no more than 480 hours per month, earning at least the minimum wage, excluding apprentices and workers for which no information on education is available. We trim the top and bottom 1 percent of workers according to the distribution of hourly wages in each year. We end up with 25.7 millions observations that we aggregate into skill-year

groups to construct hours. To construct the average wage in each cell we use a more selective sample that includes only employees with a permanent contract, working at least 35 hours per week. The average weekly wage in a skill-year cell is constructed by using only the base wage, and then taking the weighted average over workers where the weights are the regular hours worked by the individual. Wages are deflated to 2005 using Statistics Portugal monthly consumer price index by special aggregates that we convert to annual. In order to classify workers as "displaced" we partly follow Carneiro and Portugal (2006) and define a firm as shutting down after year t when the firm is observed in the *Quadros de Pessoal* data in year t but is not observed in the dataset in any of the three subsequent years. If a firm is last active in t we record the total regular hours worked by its low- and high-skilled workers in t and use these hours to construct the instrument for $t+1$.[58]

Table E.1 reports the estimates, which are all significant at 1 percent. Employing the IV methodology and data outlined above, we obtain an elasticity of 4, which is the number we use in our quantitative analysis. Our estimate is slightly above those commonly found for the U.S. (Katz and Murphy (1992); Johnson (1997); Krusell et al. (2000); Ottaviano and Peri (2012); Ciccone and Peri (2005)) which range between 1.5 and 2.5, but below the elasticity of substitution of 5 between low- and medium-skilled workers found for Germany (Dustmann et al. (2009)). Since the set of European countries we consider in the quantitative analysis is pretty diverse in terms of labor market institutions and workforce characteristics we consider our benchmark estimate of 4 as a good compromise.

The estimate of the elasticity of substitution turns out to be pretty robust to alternative different specifications, methodologies, and levels of data aggregation. Table E.1 reports an alternative set of estimates using OLS with linear or spline (with break in 1993) trends, at the industry-region and country-level. It also reports a set of estimates based on an alternative way to construct the data series for hours and wages based on Autor et al. (2008). In this case we construct a fix-weighted ratio of high-skill to low-skill wages for a composition-constant set of sex-education-experience groups. To do that, we regress monthly deflated wages, for each sex and year, on five education categories (3 years or less, between 4 and 6 years, between 7 and 9 years, between 10 and 12 years, and 13 years and above), a quartic in experience (defined as age minus 6 minus the number of education years), and all the interactions between the education dummies and the quartic in experience. The predicted wages for each sex-education-experience-year group are then aggregated at the skill-year level with a constant set of weights based on the aggregate hours shares of each group. The series for hours is constructed by aggregating at the skill-year level the series for total regular hours worked by sex, five education groups and experience. The aggregation employs a series of weights to turn hours into efficiency units. Weights are constructed by normalizing the predicted wages described above by the top wage across cells. Estimates for the elasticity of substitution, using different types of trends turn out to be slightly smaller, but overall pretty similar to all the others.

[58] We construct the lead because the information reported in *Quadros de Pessoal* is collected in October of every year from 1994 on (before that it was collected in March).

Table E.1: Elasticity of substitution between low- and high-skill workers, Portuguese matched employer-employee data

	Industry-region-level			Country-level			Country-level (composition-adjusted)		
	Elasticity	R^2	Obs.	Elasticity	R^2	Obs.	Elasticity	R^2	Obs.
IV	4.0	0.84	180						
Linear trend	5.2	0.94	210	4.2	0.97	14	3.6	0.97	14
Spline	3.7	0.92	210	3.1	0.98	14	3.0	0.99	14

Note: All estimates are significant at 1 percent. All industry-region-level estimates include industry-region fixed effects. Industry-region-level OLS estimates include industry-region-specific trends.

F Equilibrium Conditions of the Temporary Equilibrium in Changes

In this appendix, we describe the equilibrium conditions of the production structure in relative time differences. As in the main text, let $\dot{y}_{t+1} \equiv y_{t+1}/y_t$ denote the relative time change of a variable and by $\hat{y}_{t+1} \equiv \dot{y}'_{t+1}/\dot{y}_{t+1}$ the relative time difference of the variable under a sequence of policies $\{\Upsilon'_t\}_{t=0}^{\infty}$ relative to the sequence of policies $\{\Upsilon_t\}_{t=0}^{\infty}$. Also, let's define $\omega_{s,t} = w_{s,t}\left(r_t\right)^{\gamma^i/\left(1-\gamma^i\right)}$.

The cost of the bundle of inputs and the price index in relative time differences are

$$\hat{x}_t^i = \left(\frac{\xi_{h,t-1}^{\prime i}\left(\dot{\omega}_{h,t}^{\prime i}\right)^{1-\rho} + \xi_{l,t-1}^{\prime i}\left(\dot{\omega}_{l,t}^{\prime i}\right)^{1-\rho}}{\xi_{h,t-1}^{i}\left(\dot{\omega}_{h,t}^{i}\right)^{1-\rho} + \xi_{l,t-1}^{i}\left(\dot{\omega}_{l,t}^{i}\right)^{1-\rho}} \right)^{\frac{(1-\gamma^i)}{1-\rho}},$$

$$\hat{P}_t^i = \left(\sum\nolimits_{j=1}^{N} \pi_{t-1}^{\prime ij} \dot{\pi}_t^{ij} \hat{A}_t^j (\hat{\kappa}_t^{ij} \hat{x}_t^j)^{-\theta} \right)^{-\frac{1}{\theta}},$$

while the bilateral expenditure shares in relative time differences are

$$\hat{\pi}_t^{ij} = \left(\frac{\hat{\kappa}_t^{ij} \hat{x}_t^j}{\hat{P}_t^i} \right)^{-\theta} \hat{A}_t^j.$$

The share of skilled labor in the counterfactual equilibrium is given by

$$\xi_{s,t}^{i'} = \xi_{s,t-1}^{i} \frac{\left(\dot{\omega}_{s,t}^{\prime i}\right)^{1-\rho}}{\left(\dot{x}_t^{\prime i}\right)^{\frac{1-\rho}{1-\gamma^i}}}.$$

Total expenditure in the counterfactual equilibrium is given by

$$X_t^{\prime i} = \Xi \left(\dot{\omega}_{h,t}^{\prime}\right)^{1-\gamma^i} \left(\dot{\xi}_{h,t}^{\prime i}\right)^{\gamma^i} \left(\dot{L}_{h,t}^{\prime i}\right)^{1-\gamma^i} w_{h,t-1}^{\prime i} L_{h,t-1}^{\prime i} + \left(\dot{\omega}_{l,t}^{\prime}\right)^{1-\gamma^i} \left(\dot{\xi}_{l,t}^{\prime i}\right)^{\gamma^i} \left(\dot{L}_{l,t}^{\prime i}\right)^{1-\gamma^i} w_{l,t-1}^{\prime i} L_{l,t-1}^{\prime i} + \iota^i \chi_t^{\prime},$$

with $\Xi = \frac{1}{\sum_{j=1}^{N} \frac{\pi_t^{'ij}}{(1+\tau_t^{'ij})}}$ and $\chi_t' = \sum_{i=1}^{N} \left(\dot{\omega}_{h,t}^{'i}\right) \left(\frac{\dot{L}_{h,t}^{'i}}{\dot{\xi}_{h,t}^{'i}}\right)^{1-\gamma} r_{t-1}^{i} H^{i}$.

Finally, the labor market condition of skilled labor market

$$\dot{\omega}_{s,t}^{'i} = \left(\frac{1}{\left(\dot{\xi}_{s,t}^{'i}\right)^{\gamma^i} \left(\dot{L}_{s,t}^{'i}\right)^{1-\gamma^i}} \left(\frac{(1-\gamma^i)\xi_{s,t}^{'i}}{w_{s,t-1}^{'i} L_{s,t-1}^{'i}} \sum\nolimits_{j=1}^{N} \frac{\pi_t^{'ji} X_t^{'j}}{\tau_t^{'ji}} \right) \right)^{\frac{1}{1-\gamma^i}}.$$