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ABSTRACT

Immigration, Search, and Redistribution: A Quantitative Assessment of Native Welfare*

We study the effects of immigration on native welfare in a general equilibrium model featuring two skill types, search frictions, wage bargaining, and a redistributive welfare state. Our quantitative analysis suggests that, in all 20 countries studied, immigration attenuates the effects of search frictions. These gains tend to outweigh the welfare costs of redistribution. Immigration has increased native welfare in almost all countries. Both high-skilled and low-skilled natives benefit in two thirds of countries, contrary to what models without search frictions predict. Average total gains from immigration are 1.25% and 1.00% for high and low skilled natives, respectively.

JEL Classification: F22, J61, J64

Keywords: immigration, search, labor market frictions, fiscal redistribution, cross-country comparisons

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1 Introduction

Many OECD countries have experienced high immigration rates during the last two decades and foreign-born workers now make up a significant share of their total labor force. The overall economic effects of immigration on the native population are very much debated. Based on simple models of factor complementarity, economists have long been optimistic about the existence of a net immigration surplus for natives (Borjas, 1995). They have also been aware of the redistributive effects of immigration caused by factor price adjustments (Borjas, 2003). However, once we take into account labor market frictions and redistributive fiscal policies, the net effect of immigration on native welfare is harder to calculate. To our knowledge, no previous paper on the effects of immigration has taken into account both imperfect competition in the labor market and redistribution. This paper begins to fill this gap.

We analyze the effects of immigration in the presence of skill heterogeneity, search frictions, wage bargaining, and a redistributive welfare state. Our setup is rich enough to replicate the large observed differences in labor market outcomes between natives and immigrants across countries. Matching a number of salient moments, we calibrate and simulate our model to provide quantitative predictions for 20 OECD countries for three different scenarios. While it is impossible to obtain closed-form solutions for our full general equilibrium model, analytical results are available for simplified versions.

The effect of immigration on labor market outcomes and welfare is likely to depend on four important empirical facts. We start our analysis by a discussion of these facts. First, the skill composition of the immigrant labor force differs from that of natives.[1] This discrepancy is a key aspect in the traditional complementarity-competition channel. In particular, the share of tertiary-educated immigrants relative to the share of tertiary-educated natives determines which group of native workers would be more exposed to potential competition and which would benefit from complementarity. In about a third of the surveyed countries, on average, immigrants are better educated than natives. In some of the major European host economies, however (e.g. France and Germany), they are substantially less educated.

The second key fact relates to the relative wage levels of immigrants and natives. In all countries surveyed, and in each skill group, natives command a wage premium over immigrants. These premia vary significantly across countries, however; they are highest in Italy and Greece, and lowest in Australia, the United States and Switzerland. The wage gap may reflect differences in (effective) labor productivity. But it may also relate to differences in the outside option of natives relative to migrants. These two determinants of wage effects

[1] We use 'skill' and 'educational attainment' interchangeably.

have different implications on the labor market effects of immigrants.

The third fact relates to unemployment risk. In most countries, both low and high skilled immigrants are much more likely to be jobless than natives. All countries in our sample provide some unemployment insurance, albeit at very different levels of generosity. Heterogeneity in unemployment risk leads to net redistribution from the group with lower exposure to the group with higher unemployment rates.

Finally, the size of government (measured by the share of taxes or public expenditures in GDP) is a crucial statistic to assess the net fiscal effect of immigrants. There is strong cross-country heterogeneity and the presence of generous redistribution programs has important implications for native welfare if immigrants and natives differ with respect to their income and unemployment probabilities.

These features describe four different margins through which immigrants affect native welfare. In our quantitative analysis, we aim at capturing all of them. To this end, we must go beyond the complementarity and labor market competition channel of the canonical model. We need a setup in which wages and unemployment rates can differ for workers with similar educational attainments, and where the public sector redistributes income to the unemployed and to low wage earners. Our model combines a production function featuring skill complementarity with a labor market characterized by search-and-matching. Competitive firms create vacancies for high skilled or low skilled workers. But they cannot distinguish *ex ante* between natives and immigrants, who are, within skill groups, perfect substitutes to each other. For given education, our model allows immigrants to differ from natives with respect to their outside options and their exogenous job break-up rate. This helps explaining the empirical fact that foreign-born workers face higher unemployment risk than natives and have higher unemployment rates and lower wages.[2] The idea is that immigrants, whose social networks are to a greater extent through work than those of natives, suffer more from joblessness than natives.

In equilibrium, immigration affects native welfare through four channels. Two of them work through the labor market: the traditional complementarity effect on wages and a novel effect on job-creation. The latter arises from the fact that the ex post value of a match for a firm depends on whether the worker is a native or an immigrant. An immigrant worker has a lower outside option, but faces a higher exogenous split rate. Together, these two effects result in higher or lower incentives for job creation when the share of immigrants in the labor force goes up. Redistribution also works through two channels: one through unemployment benefits and another through proportional taxes and lump-sum transfers. How these channels affect native welfare depends on the relative skill composition of immigrants, as well as on

[2] See, e.g., Arai and Vilhelmsson (2004).

labor market institutions.

We calibrate the parameters of our model such that it matches 11 salient empirical moments that we have collected for 20 OECD countries. We use the quantitative model to study the effects of the three scenarios on native welfare, separately for all countries in our sample: (i) a 1% increase in the labor force share of immigrants beyond the levels for 2011, keeping the skill composition fixed, (ii) the transition from a hypothetical autarky situation to the *status quo*, and (iii) the inflows realized between 2000 and 2011. While around two thirds of countries would benefit from a small increase in the immigrant share, we find effects to be highly heterogeneous across countries and skill groups. In 19 out of 20 countries, welfare effects of total migration for natives are positive. For 14 of these 19 countries both low skilled and high skilled natives are found to benefit from migration, while in the remaining five countries migration may have created a redistributive conflict between natives of different skills. Positive effects on labor market efficiency tend to outweigh costs coming from the welfare state.

Finally, we perform a quantitative comparative statics exercise to better understand the relative importance of the different mechanisms present in our framework. For this purpose, based on observed data, we draw a vector of moments for 10,000 artificial economies, calibrate our model to each of them, and run regressions to obtain conditional correlations between these moments and our variable of interest: native welfare. Wage and unemployment gaps between immigrants and natives, and the size of government are found to be important determinants of the welfare effect of immigrants, stressing the differences between our model and a simpler model with competitive labor markets which could not deliver those results.

The remainder of this paper is structured as follows. Section 2 frames this paper relative to the existing literature. Section 3 presents cross country variation of measures related to immigrants, their performance and redistribution in 20 OECD countries. Section 4 presents our model. Section 5 discusses our calibration strategy and provides our quantitative results. Section 6 concludes.

2 Relation to the Literature

Hanson (2009) points out that the literature on the effects of immigration is characterized by a "near obsession" with wages.[3] This strand of research uses increasingly sophisticated approaches, based on dividing the labor market into cells to estimate own and cross elasticities of substitution, and to employ the obtained parameter estimates to simulate the

[3] Longhi, Nijkamp, and Poot (2008) provide a discussion and meta analysis of this literature.

complementarity-substitution channel of immigration.[4] Some recent papers have moved a step forward and applied the structural empirical framework of the cell-approach to a situation where wages are set non-competitively. For instance D'Amuri, Ottaviano and Peri (2010), Felbermayr et al. (2010), Brücker, Jahn and Upward (2011, 2013) postulate, in reduced form, that wages are decreasing functions of unemployment rates. While these models do allow for unemployment, the labor market imperfections are not micro-founded and the role of labor market institutions is not explicitly modeled. Moreover these studies do not have any role for the government. With the exception of Felbermayr et al. (2010), they do not calculate effects on aggregate native welfare.

In the presence of non-Walrasian features of the labor market, immigration can improve the efficiency of labor markets and mitigate the effects of existing distortions. Schmidt, Stilz and Zimmermann (1994) suggest that immigrants generate efficiency gains by weakening the bargaining power of labor unions. Borjas (2001) argues that immigrant workers react more flexibly to differences in job opportunities than native workers because they are not tied to any specific location. Thereby they smooth out labor market frictions. Angrist and Kugler (2003) conclude that low labor market flexibility increases the negative effects of immigration in Europe. More recently, Chassamboulli and Palivos (2014) study immigration in a search-and-matching model in which immigrants have inferior outside options than natives. Hence, bargaining results in lower wages for immigrants ex post, which encourages firms to create more vacancies for all types of workers ex ante. We generalize this idea by allowing matches with immigrants to have different expected duration than those with natives and by introducing a welfare state. Different to Chassamboulli and Palivos (2014), our objective is to conduct a quantitative analysis for a large sample of countries.

There is also a separate literature on the fiscal effects of immigration. Calibrating dynamic equilibrium models featuring demographics and fiscal policy for the US and Sweden, Storesletten (2000, 2003) finds that immigration can strongly benefit natives if it occurs in the 'right' age bracket (middle-aged workers) and if immigrants have a sufficiently high employment probability. Realized migration, however, often falls short from the ideal composition, so that immigration may turn out a burden rather than a blessing for the native taxpayer.[5] Dustmann and Frattini (2013) provide a comprehensive analysis of the net fiscal contribution of immigrants in the UK and find an overall positive impact. However, virtually all papers in this literature abstract from a micro-founded modeling of labor market imperfections. They use an "accounting approach" based on observed taxes and transfers

[4] E.g. Borjas (2003) and Ottaviano and Peri (2012) and the references therein.

[5] In many countries there is has been a fierce debate about the net fiscal contribution of immigrants. For Germany, see Sinn et al. (2001) and Bonin (2002).

without considering the equilibrium responses of the economy. Therefore, these analyses do not include complementarity-based welfare gains.

Finally, there are a few papers that evaluate the global welfare gains from immigration, often accruing in large part to the immigrants themselves. Benhabib and Jovanovic (2012) use a model with human capital externalities as in Lucas (1990) to estimate the level of migration that would maximize world welfare. They find that, from a global perspective, migration ought to be much larger than it is today. Di Giovanni, Levchenko and Ortega (2014) quantify the welfare effects of international migration in a model that carefully incorporates total factor productivity and skill differences, within a Melitz (2003) framework of international trade with a home market effect. Docquier, Ozden, and Peri (2014) evaluate wage and employment gains from immigration and emigration in all OECD countries. They assume a classical perfect competition model of labor demand and supply for two skills, capturing therefore only the complementarity effects, plus a possible externality effect from human capital intensity. None of the mentioned papers include a public sector. Moreover, while a global perspective is interesting, it is the impact of immigrants on natives in receiving countries that is most likely to drive immigration policies.

3 Cross-country Summary Statistics

In this section we provide some summary statistics on immigrants and on their relative labor market performance. We also survey some relevant institutional features of 20 OECD countries. These facts motivate our modeling approach, and play a central part in our quantitative exercise.[6]

3.1 Immigrants in the work force

Table 1 provides summary statistics on eight important measures that characterize the structure of immigration, immigrants' labor market performance and the generosity of welfare states across the 20 countries in our sample. The data are taken from Censuses or similar sources and are relative to year 2011 or the closest available year.[7] Row [1] of table 1 shows that immigrants make up a substantial share of the labor force in all countries considered, with the cross-country average standing at about 17%. They make up almost 10% even in the country with the smallest share (Portugal).[8] Row [2] refers to the skill structure of

[6] We have been able to compile a set of comparative and reliable moments for 16 EU member states, plus Switzerland, the United States, Canada and Australia. See Appendix B for details.

[7] Table 1 shows summary statistics. Table B.1 in our Appendix provides additional detail on each country.

[8] The countries in our sample are, on average, more open to migration than the average OECD country, where the labor force share of immigrants amounts to 10%. Also note that labor force shares lie substantially above

the migrant labor force relative to the native one. On average across our 20 countries, the share of tertiary educated immigrants relative to the share of tertiary educated natives is almost unity. However, there is a substantial amount of heterogeneity across countries. For example, in Canada, the share of university graduates in the labor force is 1.63 times bigger among immigrants than among natives. This strong heterogeneity in relative skill patterns forebodes heterogeneous distributional effects of immigration. Immigrants can be expected to compete with natives in the same skill category, so that one could expect low-skilled natives to be more likely to benefit from immigration in Canada, and high–skilled natives in Slovenia.

Table 1: Summary Statistics of moments of interest

	Variable	Average	Top 10%	Bottom 10%	Top value (Country)	Bottom Value (Country)
[1]	Share of immigrants in the labor force	17.1%	21.8%	12.0%	39.1% (Luxembourg)	9.9% (Portugal)
[2]	Share of tertiary-educated, immigrants rel. to natives	0.99	1.45	0.64	1.63 (Canada)	0.40 (Slovenia)
[3]	Low-skilled average wage, immigrants rel. to natives	0.86	0.96	0.75	0.99 (Canada)	0.72 (Greece)
[4]	High-skilled average wage, immigrants rel. to natives	0.86	1.00	0.74	1.01 (Switzerland)	0.64 (Italy)
[5]	Low-skilled unemployment, immigrants rel. to natives	1.62	2.36	1.13	2.43 (Switzerland)	0.91 (United States)
[6]	High-skilled unemployment, immigrants rel. to natives	2.19	3.45	1.38	3.50 (Austria)	1.14 (Portugal)
[7]	Replacement Ratio (benefits/wages)	38.9%	54.7%	24.0%	62.9% (Belgium)	21.9% (Greece)
[8]	Public spending as share of GDP	45.3%	51.9%	39.1%	54.8% (Denmark)	33.4% (Switzerland)

We are using several data sources; see Appendix B for details.

3.2 Labor market outcomes for natives and immigrants

Native and immigrant workers differ strongly regarding their labor market performances. Rows [3] and [4] in Table 1 show that, across the countries in our sample, the average wage received by immigrants is typically lower than the one received by natives, even within the same skill class. Using EU-SILC and Census data, both for high and low skilled workers, the average yearly wage paid to immigrants amounts to only 86% of that paid to natives, with large cross-country heterogeneity. For example, there is no wage gap in Canada for

population shares. The work force includes only migrants with work permits.

low-skilled workers and in Switzerland for high-skilled workers. The wage gap is highest in Greece for low-skilled workers and in Italy for high-skilled workers.

The inferior labor market performance of immigrants relative to similarly skilled natives could have different explanations. First, the wage gaps could be due to lower bargaining power of migrants, as explained above. Second, even within the same skill class, migrants may suffer a productivity disadvantage relative to natives because of inadequate language skills or imperfect portability of human capital; see Poutvaara (2008). Hence, the value to the firm of filling a vacancy with a migrant may be higher or lower than filling it with a native. In the absence of directed search, this means that the expected value of vacancy creation depends on the share of migrants in the labor force.[9]

Rows [5] and [6] report the evidence on relative unemployment rates within the groups of low and high skilled workers. Discrepancies are large, in particular for the high skilled. Cross-country heterogeneity is large, too. On average, the likelihood of unemployment for an immigrant is 1.6 times and 2.2 times the corresponding likelihood for a native in the low and high skilled labor market segments, respectively. Unemployment gaps are largest in Switzerland for the low-skilled and in Austria for the high-skilled, and lowest in the United States for the low-skilled and in Portugal for the high-skilled. We model these discrepancies by assuming that matches with immigrants are more likely to break up. The shorter expected longevity of a match with an immigrant reduces incentives for vacancy creation much like lower migrant productivity.

3.3 Welfare state characteristics

Differential labor market performance has important implications for our analysis: first, it opens the door for immigration to affect job creation incentives (which may harm or benefit natives); second, if immigrants have higher unemployment rates, then natives lose from the redistribution through unemployment benefits. The magnitude of the latter channel depends on the generosity of benefits. Following the literature, we measure this by the replacement ratio: the percentage of after-tax wage income replaced by unemployment benefits. This measure is a gross simplification of complex policies of each country, and responds to the need of creating a comparable measure across countries. Row [7] of Table 1 shows that this rate varies from 63% in Belgium to 22% in Greece, with the average across countries at about 39%. The generosity of unemployment benefits affects the effective bargaining power of workers, their wages, and the degree of labor market tightness.

[9] An alternative option, which we rule out in this paper, is that the additional surplus from employing an immigrant may compensate the firm for the "distaste" of employing immigrants. This would be a classical employer discrimination motivation.

Quantitatively even more relevant, however, is the scale of the overall redistribution. Many European countries engage in substantial redistribution. Government spending as a share of GDP is a simple measure of the redistributive role of the government.[10] Row [8] of Table 1 reports the summary statistics for our sample. The government spending share averages 45%, with Switzerland occupying the lowest level (33%) and Denmark the highest (54%). Transfers and public goods provision may imply redistribution towards migrants, but they also affect the distributional effect of immigration within the group of natives.

4 Model

We model each country as an economy open to international capital flows, but small enough to have no effect on world interest rates.[11] There is no international trade in goods, and the stock of international migrants of different skills is taken as exogenous. Our focus is on understanding the economic effects of a given inflow of immigrants, not in explaining its causes. For simplicity, in the description, we omit time and country indexes.

There is a single final output good whose aggregate quantity is given by Y and whose price is normalized to unity. The government redistributes income in two ways: through unemployment benefits and through a lump-sum transfer, which can be interpreted to also include publicly provided private goods. Taxes are a constant fraction of wage income. Utility is linear in consumption.

4.1 Production

The final output good is produced using capital K and a composite input good Z. In turn, good Z is produced using two intermediate inputs, Y_L and Y_H, which are linear functions of employment of low skilled and high skilled workers, respectively, as in Acemoglu (2001). More precisely, the supply side is characterized by the following set of expressions:[12]

$$\begin{aligned} Y &= AK^{\alpha}Z^{1-\alpha}, \alpha \in (0,1)\,; \\ Z &= \left[xY_L^{\rho} + (1-x)\,Y_H^{\rho}\right]^{\frac{1}{\rho}}, \rho \in (0,1)\,; \\ Y_i &= \sum_{j \in \{N,I\}} (1-u_{ij})\,\pi_{ij} Q_{ij}, i \in \{L,H\}\,, \end{aligned} \tag{1}$$

[10] We find this a better measure than the GDP share of income transfers as many publicly provided goods, like health care and old-age care, provide benefits that are not dependent on the recipient's income.

[11] The assumption of a small open economy is stronger than needed. What is enough is that capital movements in response to migration flows are small enough not to affect world interest rates.

[12] Chassamboulli and Palivos (2014) and Ottaviano and Peri (2012) use a similar structure.

where α is the output elasticity of capital, A denotes the total factor productivity, ρ governs the elasticity of substitution between the low skill intensive good Y_L and the high skill intensive good Y_H, $x \in (0,1)$ is a productivity parameter, Q_{ij} is the supply of different types of labor, with $i \in \{L, H\}$ indexing skills (high and low education) and $j \in \{N, I\}$ distinguishing native (N) and immigrant (I) workers. Finally, u_{ij} is the unemployment rate and π_{ij} labor productivity for group $i \times j$. We assume that natives and migrants are perfect substitutes in production but we allow for different effectiveness (productivity) between immigrants and natives in a skill group.[13]

We assume that capital is freely mobile internationally so that the return to capital is determined on world markets. The stock of capital owned by natives is given by $\bar{K}$. The optimal use of capital in production can differ from $\bar{K}$ and it is determined by the usual first order condition $r + \delta = \alpha A K^{\alpha-1} Z^{1-\alpha}$ where $r + \delta$ is the user cost of capital, given by the sum of the interest rate on a risk-free asset and capital depreciation rate. Hence, gross capital income R generated in the economy is given by:

$$R \equiv (r + \delta)K = \alpha A K^{\alpha} Z^{1-\alpha} = \alpha Y. \tag{2}$$

Intermediate goods are produced under perfect competition. So, their price equals their marginal contribution to the production of the final good Y, namely:

$$p_L = AK^{\alpha}(1-\alpha)xY_L^{\rho-1}\left[xY_L^{\rho} + (1-x)Y_H^{\rho}\right]^{\frac{1-\alpha-\rho}{\rho}}, \tag{3}$$

$$p_H = AK^{\alpha}(1-\alpha)(1-x)Y_H^{\rho-1}\left[xY_L^{\rho} + (1-x)Y_H^{\rho}\right]^{\frac{1-\alpha-\rho}{\rho}}. \tag{4}$$

The production function of the intermediate goods is very simple: once a worker of group $i \times j$ ($i \in \{L, H\}$, $j \in \{N, I\}$) has been hired he/she produces π_{ij} units of the intermediate good Y_i. The labor market, however, is not competitive, and therefore equilibrium prices of the intermediate goods are not equal to wages.

4.2 Labor Markets

There is a separate labor market for each type of worker (H and L) and supplies are given. Firms post vacancies specific to a skill. Depending on the vacancies and unemployed in each market, matches are formed in each period. Labor supply is taken as exogenous and natives and immigrants of the same skill type compete for the same jobs. The total supply of workers in labor market i is therefore given by $Q_i = \sum_{j \in \{N,I\}} Q_{ij}, i \in \{H, L\}$. Immigration represents an exogenous change in the number of foreign-born workers Q_{iI}.

[13] See the debate in Ottaviano and Peri (2012).

Matching process. Firms cannot distinguish between natives and immigrants when posting vacancies. In other words, they cannot direct their search activities. So, while there are four types of workers, there are only two labor markets (for high and low skilled workers). At each instant of time, a mass V_i of open vacancies and a mass of $U_i = \sum_{j\in\{N,I\}} U_{ij}$ of unemployed workers exist in each labor market i. We denote the mass of successful matches by M. For each market, we use a standard constant returns to scale matching function that is increasing in both its arguments, concave and homogeneous of degree one:[14]

$$M(U_i, V_i) = \xi U_i^{\varepsilon} V_i^{1-\varepsilon}, \quad i = H, L, \tag{5}$$

where $\varepsilon \in (0,1)$ is the matching elasticity and ξ is a scale parameter. Labor market tightness, defined as $\theta_i \equiv V_i/U_i$, is measured as the number of vacancies per unemployed person. The rate at which the firms fill vacancies is $M_i/V_i = q(\theta_i) = \xi\theta^{-\varepsilon}$. The rate at which the unemployed find jobs is $M_i/U_i = m(\theta_i) = \xi\theta^{1-\varepsilon}$. Market tightness makes it easier for an unemployed to find a job and conversely harder for a firm to fill a vacancy. Existing matches are broken at the exogenous rate s_{ij}, which may differ between natives and migrants as well as across skill types. Heterogeneity in s_{ij} is one important determinant of the heterogeneity in wage rates and unemployment rates across groups.

Bellman Equations. With these assumptions the Bellman (asset) equations determining the value to a firm producing good i of an open vacancy J_i^V and of a filled job J_{ij}^F are as follows:

$$rJ_i^V = -c_i + q(\theta_i)\left[(1-\phi_i)J_{iN}^F + \phi_i J_{iI}^F - J_i^V\right], \tag{6}$$

$$rJ_{ij}^F = \pi_{ij}p_i - w_{ij} - s_{ij}\left[J_{ij}^F - J_i^V\right], \tag{7}$$

where c_i is the flow cost of an open vacancy (denoted in terms of the numéraire good). The variable $\phi_i \equiv U_{iI}/\left(U_{iI} + U_{iN}\right)$ denotes the share of immigrants among those searching for a job. The flow value of an open vacancy, rJ_i^V, has no index j, since firms cannot direct their search. Instead, the term in brackets includes both the case that the job is filled by a native and the case that the job is filled by an immigrant. An open vacancy is turned into a filled job with the rate $q\left(\theta_i\right)$. This generates a capital gain equal to the expected value of the filled job minus value of the open vacancy. Similarly, the flow value of a filled job is equal to the flow return of a filled job $(\pi_{ij}p_i - w_{ij})$ minus the expected capital loss occurring if the match breaks (at rate s_{ij}).

[14] Ljungqvist and Sargent (2005) also analyze the case in which there are separate matching functions by level of unemployment benefits, or for both skills and benefits.

For workers, the Bellman equations determining the value of employment, J_{ij}^E, and unemployment, J_{ij}^U, are as follows:

$$rJ_{ij}^U = g + b_{ij} + h_{ij} + m(\theta_i)\left[J_{ij}^E - J_{ij}^U\right], \quad (8)$$

$$rJ_{ij}^E = g + w_{ij}(1-t) - s_{ij}\left[J_{ij}^E - J_{ij}^U\right], \quad (9)$$

where t is a proportional tax rate on labor, g is a lump-sum transfer, $b_{ij} < \pi_{ij}p_i$ the unemployment benefit, and h_{ij} the non-monetary effect on utility of losing one's job.[15] Without loss of generality, we normalize h_{ij} to zero for natives ($h_{HN} = h_{LN} = 0$). The value of h_{iI} will be negative for immigrants if they experience larger disutility from unemployment due to not being in their home country. The flow value of unemployment is given by $(b_{ij} + h_{ij})$ plus the capital gain arising from a successful match, which occurs at rate $m(\theta_i)$. Similarly, the flow value of employment is the net wage minus a capital loss arising from job destruction. Assuming $h_{iI} < 0$ follows Chassamboulli and Palivos (2014).

Wage bargaining. Firms post vacancies until the value of posting a vacancy drops to zero. The free entry condition $J_i^V = 0$ applies to vacancies in both skill classes. As it is customary in the literature, we assume that wages are bargained once a match has been formed (and the identity of the worker – native or immigrant – has been revealed). Let the bargaining power of the worker be $\beta \in (0,1)$; then, the worker receives the share β of the total surplus of the match $\left(J_{ij}^E + J_{ij}^F - J_{ij}^U - J_i^V\right)$. Incorporating the free entry condition, this implies

$$(1-\beta)\left(J_{ij}^E - J_{ij}^U\right) = \beta J_{ij}^F. \quad (10)$$

As usual in this type of models, we focus on the steady state, i.e. the situation where the flows into and out of unemployment must be equal for each type of workers: $s_{ij}(Q_{ij} - U_{ij}) = m(\theta_i)U_{ij}$ for $i = H, L$ and $j = N, I$. Thus, we obtain:

$$U_{ij} = \frac{s_{ij}}{s_{ij} + m(\theta_i)}Q_{ij}, \text{ and } E_{ij} = \frac{m(\theta_i)}{s_{ij} + m(\theta_i)}Q_{ij}; \text{ for } i = H, L \text{ and } j = N, I, \quad (11)$$

where E_{ij} is total employment in labor market cell $i \times j$. As usual, tighter market leads to lower equilibrium unemployment, and higher separation rates to more equilibrium unem-

[15] One might argue that h_{ij} should be positive, as those losing a job have more time available for leisure. However, social psychologist Jahoda (1981) highlights that employment provides several important non-monetary payoffs, including social contacts beyond the family. Blanchflower and Oswald (2004) provide evidence on significant utility costs of unemployment in the United States and in the United Kingdom, and Winkelmann and Winkelmann (1995) and Schöb (2012) in Germany. These studies suggest a negative value of h_{ij}. If natives have wider social networks than immigrants, non-monetary costs of unemployment would be bigger for immigrants.

ployment.

4.3 Public sector

We consider a very simple budget constraint. The government collects income by proportional taxation on labor. Capital is not taxed. The government uses its revenues to finance the payment of unemployment benefits and the lump-sum transfer g.[16] With these assumptions, the government budget constraint is

$$\sum_i \sum_j b_{ij} U_{ij} + g \sum_i \sum_j Q_{ij} = t \sum_i \sum_j w_{ij} E_{ij}. \tag{12}$$

The left-hand side of equation (12) corresponds to government expenditures, given by the sum of total unemployment benefits and the lump-sum transfers. The right-hand side corresponds to government revenues. We will treat b_{ij} and g as exogenous[17] and let t adjust to satisfy (12).

4.4 Equilibrium

Job-creation conditions. Combining the Bellman Equations (6), (7), and the free entry condition $J_i^V = 0$, we derive, for each labor market i, a relationship between labor market tightness θ_i and the expected present discounted value of the job surplus to the firm:

$$\frac{c_i}{q(\theta_i)} = \sum_{j \in \{N,I\}} \phi_{ij} \frac{\pi_{ij} p_i - w_{ij}}{r + s_{ij}}. \tag{13}$$

This can be seen as a job-creation condition. It states that the expected cost of creating a vacancy (the left-hand-side) must be equal to the expected per period operating profit from a job filled with either a native or a migrant, $\pi_{ij} p_i - w_{ij}$, discounted at the specific effective discount rate $r + s_{ij}$ (the right-hand-side). The job surplus to the firm can be high because the worker has high productivity π_{ij}, because she is paid a low wage w_{ij}, or because she has a low separation rate s_{ij}. This points at a key channel through which immigrants

[16] It would be easy to introduce publicly provided private goods into our model. Assuming that the government provides also a pure public good would increase the gains of immigration mechanically as the fixed costs would be divided more widely. Therefore, our formulation provides conservative estimates on potential benefits of immigration. In our data, regressing the log of public expenditures on the log of population size produces a coefficient of 1.03 (t statistic: 18.66; R squared: 0.95). This is consistent with our hypothesis that government expenditures can be expressed in terms of per capita transfers, the role for pure public goods being limited.

[17] We take replacement rates from the data and calculate unemployment benefits using replacement rates and wages.

affect labor markets for natives. If they are paid a lower wage than natives for the same productivity, an increase in their share ϕ_{ij} increases the surplus of the firm (right hand side) and in equilibrium it must increase job creation and labor market tightness θ_i. This, in turn, decreases native unemployment and increases native wages.

Wage equations. Substituting the value functions (8) and (9) into (10), and recognizing that the free entry condition implies $J_{ij}^F = (\pi_{ij}p_i - w_{ij}) / (r + s_{ij})$ from (7), one can express the wage rate as a convex combination of the value product of a match, $\pi_{ij}p_i$, and the outside option $b_{ij} + h_{ij}$:

$$\begin{aligned} w_{ij} = \beta \frac{r + s_{ij} + m(\theta_i)}{(r + s_{ij})[1 - t(1 - \beta)] + \beta m(\theta_i)} \pi_{ij} p_i \\ + (1 - \beta) \frac{r + s_{ij}}{(r + s_{ij})[1 - t(1 - \beta)] + \beta m(\theta_i)} (b_{ij} + h_{ij}). \end{aligned} \tag{14}$$

The lower is the bargaining power of the worker (β) the closer is the wage to the outside option. If $\beta = 0$, $w_{ij} = (b_{ij} + h_{ij}) / (1 - t)$ which is exactly the outside option. As β approaches unity, the worker's income approaches the product of her labor $\pi_{ij}p_i$ and the outside option becomes irrelevant. Moreover, the tighter is the market (as $m(\theta_i)' > 0$) the larger is the weight on $\pi_{ij}p_i$ as workers have a stronger effective bargaining position.[18] It is also straightforward to show that (for a given equilibrium value of labor market tightness) higher separation rates are associated with lower wages. This means that if we adjust the separation rates of two groups in such a way that market tightness is unaffected, the group with higher separation rates is also going to have lower equilibrium wages.

From (13) and (14), it is easy to see that heterogeneity between native and immigrant workers in their productivity π_{ij} and in their separation rates s_{ij} have qualitatively similar effects. Lower productivity of migrants and higher separation rates represent a downward shift of the job-creation curve in wage-tightness space. Differences in the outside option h_{ij} shift the wage curves (14) in similar qualitative fashion.

Definition of equilibrium. The equations above define a set of ten equilibrium conditions: one first-order condition governing the optimal capital stock (2), two profit maximizing conditions on goods markets (3) and (4), the government budget constraint (12), two job-creation conditions (13) for each skill category, and four wage equations (14). We use them to solve for ten equilibrium values: $\{K; p_L, p_H; t; \theta_L, \theta_H; w_{LN}, w_{LI}, w_{HN}, w_{HI}\}$. Knowing θ_i, one can immediately obtain U_{ij}, Y_{ij} and ϕ_i from (11). Note that choosing the price of the

[18] Note that utility obtained from public goods consumption drops out from (14).

final output good as the numéraire implies a restriction on goods prices p_L, p_H which makes either (3) or (4) redundant (Walras' Law).[19]

4.5 Analytical results without public sector

The model we have outlined above captures several mechanisms through which natives' outcomes are affected by the characteristics and size of the immigrant population. Because of the complexity of the model, it has to be analyzed numerically. Before proceeding to numerical analysis, this subsection presents some analytical results for a simplified model without a public sector.

Remark 1. *Let us abstract from a public sector so that* $g = b_{ij} = 0$*, and assume that natives and immigrants are identical except for the outside options so that* $s_{ij} = s_i$*,* $\pi_{ij} = 1$*, and* $h_{iI} < 0$*. Then, the model implies that*

(i) *an inflow of immigrants with the same skilled-unskilled composition as natives increases wages and decreases unemployment rates of natives, and therefore increases native welfare;*

(ii) *an inflow of immigrants of skill* i *will unambiguously benefit natives of skill* $i' \neq i$*. It may benefit natives of skill* i *as well, but that depends on the parameters;*

(iii) *a worsening of the outside option of immigrants increases wages, decreases unemployment rates and increases welfare for natives.*

Proof. See the Appendix.

The result in (i) is intuitive. In a model where immigrants have worse outside option than natives (as in Chassamboulli and Palivos, 2014) immigrants affect natives through skill complementarity and through their effect on vacancy creation. The skill complementarity channel is inactive if we assume that immigrants have the same skill distribution as natives. The job creation channel is driven by the fact that immigrants' lower outside option translates into a larger surplus for the firm when a vacancy is filled by an immigrant. A higher share of immigrants encourages firms to create more vacancies. The resulting tighter labor markets benefit natives by lowering their unemployment rate and increasing their wages.

The intuition for (ii) is also straightforward: without a government, an inflow of immigrants of skill i will affect natives of skill $i' \neq i$ only through the factor complementarity

[19] That restriction arises from setting the price index dual to the production function system (1) equal to unity. I.e., $P = A^{-1}(r+\delta)^{\alpha}\Pi^{1-\alpha}(\alpha^{-\alpha}(1-\alpha)^{\alpha-1})$ with $\Pi = (p_L^{\rho/(\rho-1)}x^{1/(1-\rho)} + p_H^{\rho/(\rho-1)}(1-x)^{1/(1-\rho)})^{\rho/(1-\rho)}$.

channel, which is unambiguously positive. On the other hand, our model cannot deliver sharp predictions concerning the effect on natives of the same skill as immigrants. The reason is that there are two counteracting effects at work: a factor competition effect (which is negative for natives) and a vacancy creation effect (positive for natives). The latter will tend to dominate when natives have high unemployment rates and when wage gaps between immigrants and natives are large.

The result in (iii) is driven by the same mechanism as (i): The surplus from the match that the firm gets is a negative function of the outside option of the worker. And because vacancies cannot be directed to immigrants or natives, the additional vacancies that firms post benefit natives as well.

Remark 2. *Let us abstract from a public sector so that* $g = b_{ij} = 0$. *and assume that natives and immigrants are identical except for separation rates so that* $h_{iI} = 0$, $\pi_{ij} = 1$, *and* $s_{iI} > s_{iN}$. *Then, the model implies that*

(i) *an inflow of immigrants with the same skilled-unskilled composition as natives decreases wages and increases unemployment rates of all natives, and therefore decreases native welfare;*

(ii) *an inflow of immigrants of skill* i *will unambiguously reduce the welfare of natives of skill* i, *and may have either positive or negative effect on natives of skill* $i' \neq i$;

(iii) *an increase in the separation rates for immigrants affects negatively welfare of all natives, through both wages and unemployment rates.*

Proof. In the text; also see the Appendix for further discussion.

The intuition for the result in (i) above is the same (in the opposite direction) as the intuition for result (i) of Remark 1. The only effect of a balanced immigrant inflow is through the vacancy creation effect, which is negative in this case: more immigrants mean that the firm's expected surplus from a match is lower. This reduces the number of posted vacancies, and market tightness adjusts, putting downward pressure on wages and upward pressure on unemployment of natives. The first part of the result in (ii) is a joint effect of negative factor competition effect and negative vacancy creation effect. The effect on natives of the other skill type is indeterminate and depends on whether the inflow of immigrants of the other type results in an increase or in a decrease in the number of filled jobs of that type. Result (iii) follows the same intuition: if immigrants have higher separation rates, expected surplus will be lower and welfare will be lower for workers of the same skill class. Through production complementarity, there will also be a spillover effect for natives of a different skill.

The two remarks above illustrate the mechanisms at work in the labor markets of our model and emphasize the importance of immigrants' outside option and separation rates in determining their impact on natives. We will next simulate welfare effects for the countries in our sample using the full-fledged model and employing country-level moments for calibration.

5 Quantitative Analysis

We parameterize the described model for each of the 20 countries in our data set. Our main object of interest is per capita group-specific welfare $\mathcal{W}_{ij}$. It equals the sum of average earned after-tax income, multiplied by the probability of being employed, the sum of the unemployment benefit and the non-monetary effect on utility of losing one's job, h_{ij}, multiplied be the probability of being unemployed, income accruing to the average capital stock k_{ij} owned by members of the group ij, as well as lump-sum transfer g (or, equivalently for our purposes, a publicly provided private good):

$$\mathcal{W}_{ij} = (1 - U_{ij})(1 - t)w_{ij} + U_{ij}(b_{ij} + h_{ij}) + rk_{ij} + g. \tag{15}$$

We are also interested in utilitarian overall native or immigrant (per capita) welfare, which we obtain averaging across skill categories as follows: $\mathcal{W}_j = \sum_i \frac{Q_{ij}}{\sum_i Q_{ij}} \mathcal{W}_{ij}$.

5.1 Calibration

External parameters. To prepare the calibration we tie model parameters to observable data. First, we set unemployment benefits b_{ij} equal to the net wage $w_{ij}(1-t)$ times the observable country-specific replacement rate ϱ, i.e. $b_{ij} = \varrho w_{ij}(1-t)$. Second, we assume that all capital used in the status quo equilibrium is native owned, so that $\bar{K} = K$, and we pin down that value by using information on the user cost, and the observable capital share α in GDP. GDP is denoted by Y so that, $\bar{K} = \alpha Y/(r+\delta)$. Third, we normalize c_L to a constant.[20] This leaves us with a total of 26 exogenous parameters which we need to determine using data $\{Q_{ij}, s_{ij}, \pi_{ij}, h_{iI}, \varrho, c_H, \xi, A, x, G, \beta, \varepsilon, \rho, r, \delta, \alpha\}$, with $i \in \{H, L\}$ and $j \in \{N, I\}$.

There are two types of parameters in the model. Some of them can be directly equated to their empirically observable counterparts or can be taken from the literature. Other parameters are obtained by matching a set of moments. Moreover, while most model parameters vary across countries, some are assumed to be fixed.

[20] We checked that it is just a normalization by changing the value of c_L and verified that results are unaffected.

Table 2: Parameters taken from available data or the literature

Parameter	Description	Mean	s.d.	Source
Parameters without country variation				
β	worker bargaining power	0.5	n.a.	Petrongolo and Pissarides (2001)
ε	matching elasticity	0.5	n.a.	Petrongolo and Pissarides (2001)
ρ	substitution elasticity	0.5	n.a.	Ottaviano and Peri (2012)
r	interest rate (monthly)	0.004	n.a.	Chassamboulli and Palivos (2014)
δ	depreciation rate (monthly)	0.0061	n.a.	Chassamboulli and Palivos (2014)
Parameters varying across countries				
ϱ	replacement rate	0.39	0.13	OECD Benefits and Wages
α	capital share	0.35	0.05	OECD Labor Cost Indicators
Q_{LN}	low skilled natives	0.72	0.07	Eurostat, Census, HILDA
Q_{HN}	high skilled natives	0.28	0.07	Eurostat, Census, HILDA
Q_{LI}	low skilled immigrants	0.15	0.08	Eurostat, Census, HILDA
Q_{HI}	high skilled immigrants	0.06	0.05	Eurostat, Census, HILDA

Population shares Q_{ij} are normalized so that $Q_{LN} + Q_{HN} = 1$.
See Appendix B for details on data sources.

Table 2 below lists model parameters that we take from the empirical literature or can observe directly in standard data bases. We follow Petrongolo and Pissarides (2001) and most of the related literature in setting the bargaining power of workers β equal to the elasticity of the matching function, ε, ensuring that the Hosios condition is met. The parameter ρ determining the elasticity of substitution between the high skill intensive and the low skill intensive good, is set, in line with Ottaviano and Peri (2012), at $\rho = 0.5$, which corresponds to an elasticity of 2. The user cost of capital $(r + \delta)$ is about 12% per year, or about 1% per month following Chassamboulli and Palivos (2014) and similar to other papers in the literature. The above mentioned parameters do not vary across the 20 countries considered, due to data limitations.

Table 2 also presents exogenous parameters that we take from the data and which vary across countries. We have country-specific information on average replacement rates ϱ from the OECD Benefits and Wages data base. We also allow the capital shares α, to vary across countries and we take those from OECD data. Finally, we use observed data on immigrant stocks Q_{ij} as we have information on immigrants as percentage of labor force in each skill group. Without loss of generality, we normalized the native labor force of a country to 1 such that $\sum_i Q_{iN} = 1$.[21]

Calibration of unobserved model parameters. We pin down the remaining parameters of the model such that the baseline equilibrium of our model reproduces a number of moments that we observe for our 20 OECD economies. Table 3 shows the 11 empirical moments available for our analysis. Since there are 15 parameters left to determine

[21] We construct the four population shares from the immigrant share, the skill composition of natives and of immigrants, and this normalization.

Table 3: Matched Moments

Moment	Source	Mean	S.d.
Moments without country variation			
Avg. job duration, low skilled (quarters)	Chassamboulli and Palivos (2014)	29.4	n.a.
Avg. job duration, high skilled (quarters)	Chassamboulli and Palivos (2014)	52.6	n.a.
Moments varying across countries			
Native wage premium, low skilled	EU-SILC, Censuses, HILDA	1.18	0.11
Native wage premium, high skilled	EU-SILC, Censuses, HILDA	1.18	0.15
Skilled-Unskilled wage ratio, native workers	EU-SILC, Censuses, HILDA	1.54	0.23
Unempl. rate low skilled natives	EU LSF, CPS, Can. LFS, HILDA	0.08	0.04
Unempl. rate low skilled immigrants	EU LSF, CPS, Can. LFS, HILDA	0.12	0.05
Unempl. rate high skilled natives	EU LSF, CPS, Can. LFS, HILDA	0.04	0.02
Unempl. rate high skilled immigrants	EU LSF, CPS, Can. LFS, HILDA	0.08	0.03
Government Expenditures as % of GDP	IMF	0.45	0.06
Real per-capita GDP, US=1 (PPP)	World Bank WDI	0.82	0.29

All shares refer to working age population, aged 15-64.
All the moments above are constructed for each of our 20 countries.

$(\{s_{ij}, \pi_{ij}, h_{iI}, c_H, \xi, A, x, G\})$ we face an identification problem.

We solve the issue by setting $\pi_{ij} = 1$. The rationale for this specific choice is twofold. First, given the structure of the moments that we want to match, we want to maintain a basic trade-off in the model, namely that the presence of immigrant can encourage or discourage job creation. The first case occurs with $h_{iI} < 0$ (as in Chassamboulli and Palivos, 2014); the second happens if $s_{iI} > s_{iN}$ or if $\pi_{iI} < \pi_{iN}$. So, we want to maintain flexibility on h_{iI}. Moreover, while s_{ij} and π_{ij} affect the value of a filled vacancy in a similar way, allowing variation in s_{ij} has the advantage that it affects both wages and unemployment rates. Second, empirical results by LaLonde and Topel (1991), Borjas and Friedberg (2009), and Kerr and Kerr (2011) show that immigrants are paid less than natives after controlling for observable productivity drivers such as education and language.[22]

With this restriction, we calibrate the remaining 11 parameters of the model so that our model exactly reproduces the set of moments, country by country, as summarized by Table 4. The moments mostly have country variation and have been discussed in Section 2 above. Note that the standard deviations reported in the table refer to variation across countries.

Driven by unemployment rate differences, we calibrate separation rates to be larger for immigrants than for natives. The gap is particularly large for the low skilled (2 percentage points on average) reflecting the significantly higher unemployment rate of low skilled immigrants. For the high skilled the difference is only 1%. The parameters h_{LI} and h_{HI} are mostly negative capturing the worse options (lower utility arising from a loss of social networks) of immigrants when unemployed. This is revealed by the lower equilibrium wage of immigrants. Three exceptions are high skilled immigrants in Australia, Switzerland and

[22] Note that, even with $\pi_{ij} = 1$, different skills command different productivities due to the parameter x included in equation (1). In Section 5.2.3, we conduct a sensitivity analysis that identifies those countries for which failure of our identifying assumption is most problematic.

Table 4: Calibrated Parameter Values

Parameter	Description	Mean	S.d.
ξ	Match Efficiency Parameter	0.42	0.18
A	Total Factor Productivity	0.57	0.11
x	Low Skill Share in Production of Intermediates	0.51	0.05
c_H	Cost of high skill vacancy	0.72	0.55
G	Public expenditures	0.36	0.12
s_{LN}	Job-separation rate, low skilled natives	0.03	0.00
s_{LI}	Job-separation rate, low skilled immigrants	0.05	0.01
s_{HN}	Job-separation rate, high skilled natives	0.02	0.00
s_{HI}	Job-separation rate, high skilled immigrants	0.03	0.01
h_{LI}	Unemployment penalty for low skilled Immigrants	-0.97	1.09
h_{HI}	Unemployment penalty for high skilled Immigrants	-1.60	1.25

Calibrated from moments of the data of our 20 countries, full model.

the US, for which the values of h_{HI} are positive. Using the calibrated parameters of table 4, in the next sections we will perform some exercises of comparative static analysis using, as reference, the current situation and identifying marginal changes in the share of immigrants. Then we will move to simulate the welfare effects of more substantial changes in immigration comparing the current situation with counter-factual scenarios, in each of our 20 countries.

5.2 Results

In our simulations we mostly focus on the welfare effects of immigrants on native workers who make up the relevant political constituency for migration policy. We report results for the 20 countries in our sample on three simulation scenarios that either take an ex ante perspective (effects of a marginal increase of immigration, starting from the current situation) or an ex post perspective (effects of recent or total migration).

5.2.1 Welfare Effects of a Marginal Increase in Immigration

We start by simulating the welfare effects of increasing the immigrant stock so that its share of the labor force increases by one percentage point, leaving its relative skill composition unchanged. We use this scenario to provide insights on the different mechanisms present in our model. In particular, in five steps, we gradually add all features of our framework. This incremental procedure illustrates the relative role of each model "ingredient" in shaping the effects on native welfare.[23] To save space, Table 5 provides results for two countries only, the US and Germany, in each of the increasingly rich models. We report welfare effects on natives and immigrants in all countries for the complete model in Table 6.[24]

Table 5 starts with Model 1, in which all effects derive exclusively from classical complementarity channel between immigrants and natives. By setting $h_{ij} = 0$; $s_{iI} = s_{iN}$; $b_{ij} = 0$;

[23] We assume that capital stocks adjust endogenously in all models.

[24] Table B.2 at the end of our Appendix provides full country coverage on the stripped-down model variants.

Table 5: Welfare effects (%) for natives

	US			Germany		
	$\mathcal{W}_N$	$\mathcal{W}_{LN}$	$\mathcal{W}_{HN}$	$\mathcal{W}_N$	$\mathcal{W}_{LN}$	$\mathcal{W}_{HN}$
Model 1: only complementary effects	0.00	0.01	-0.02	0.00	-0.05	0.11
Model 2: adding wage heterogeneity	0.04	0.08	0.00	0.07	0.03	0.17
Model 3: adding unemployment heterogeneity	0.04	0.08	0.00	0.02	-0.03	0.12
Model 4: adding redistribution through b_{ij}	0.05	0.08	0.01	0.02	-0.02	0.12
Model 5: adding redistribution through g	0.05	0.06	0.03	-0.01	-0.03	0.04

$g = 0$, we eliminate the effects of any labor market heterogeneity and of the public sector. This setup relates to more traditional models such as Borjas (2003), Ottaviano and Peri (2012), or Docquier et al. (2014), in which only the different skill composition of immigrants, and elasticity of substitution, affect wages.[25] We find that overall welfare effects on natives $\mathcal{W}_N$ are positive but very close to zero both in Germany and the US. However, effects on specific skill groups are more pronounced. High-skilled natives in Germany see a 0.11% increase in their welfare, while low skilled lose 0.05%. In the US, high skilled individuals lose 0.02%, while low-skilled individuals gain 0.01%. This pattern reflects the fact that, in the US, immigration drives up the relative supply of skilled workers, reducing their wages (and, thus, welfare), while, in Germany, the opposite happens.

Model 2 accounts for observed immigrant-native wage differences by allowing for differences in the outside option of immigrants and natives (i.e., $h_{iI} \neq 0$). This model is similar to Chassamboulli and Palivos (2014), and adds the job creation effect of immigrants described in Remark 1 above. In both the US and Germany, this channel adds incentives to create jobs and lowers unemployment. Average native welfare goes up by 0.07% in Germany and by 0.04% in the US. Moreover, in both countries, both skill groups gain from immigration. In the complete country sample (Table B.2 in the Appendix), 14 out of 20 countries experience gains for both skill groups when accounting for this channel. In the remaining six cases a distributive conflict remains. In these countries, the skill composition of migrants is heavily biased towards high skilled for which the job creation channel is relatively unimportant.

Model 3 matches heterogeneity in native-immigrants unemployment rates by allowing different separation rates (i.e., $s_{iI} \neq s_{iN}$). Matches with migrants have a shorter expected duration, which weakens the vacancy creation effect and the strength of the complementarity channel. This generalization has a very small effect in the US, while it cuts the total immigration surplus to less than a third in Germany. The reason lies in the high unemployment rates amongst German immigrants relative to natives, while native-immigrants unemployment rates are almost identical in the US.

Finally, Model 4 adds tax-financed unemployment benefits ($b_{ij} > 0$) and Model 5, the

[25] These models do not feature search frictions on the labor market; Model 1 does.

most comprehensive variant, also includes general redistribution ($g > 0$). Both in Germany and in the US, unemployment benefits generate relatively little redistribution and do not alter welfare implications by much.[26] Introducing other public expenditures matters much more, especially in Germany, where it turns the overall native welfare effect to slightly negative by especially reducing college educated surplus. In the US, public transfers are comparably less relevant and their introduction has no major effect on native welfare gains.

Table 6: Welfare effects (%) of a one percentage point increase in immigration

Countries	Natives			Immigrants		
	$\mathcal{W}_N$	$\mathcal{W}_{LN}$	$\mathcal{W}_{HN}$	$\mathcal{W}_I$	$\mathcal{W}_{LI}$	$\mathcal{W}_{HI}$
Australia	0.01	0.06	-0.08	-0.01	0.09	-0.11
Austria	-0.03	-0.03	-0.03	0.19	0.20	0.11
Belgium	-0.02	-0.03	-0.01	0.12	0.12	0.12
Canada	0.04	0.08	-0.08	0.08	0.11	0.03
Denmark	0.06	0.11	-0.05	0.18	0.27	0.10
Estonia	0.05	0.07	0.02	0.24	0.16	0.37
France	0.02	0.00	0.05	0.09	0.09	0.08
Germany	-0.01	-0.03	0.04	0.06	0.02	0.20
Greece	0.07	0.02	0.18	0.26	0.22	0.48
Ireland	0.05	0.10	-0.03	0.18	0.16	0.21
Italy	0.07	0.05	0.14	0.37	0.30	0.81
Luxembourg	-0.02	-0.03	-0.01	0.04	0.05	0.02
Netherlands	-0.01	-0.03	0.02	0.10	0.07	0.19
Portugal	0.08	0.09	0.07	0.21	0.15	0.37
Slovenia	0.02	-0.04	0.17	0.04	0.01	0.22
Spain	0.04	-0.01	0.12	0.18	0.10	0.42
Sweden	-0.02	-0.01	-0.04	0.08	0.10	0.04
Switzerland	-0.04	-0.03	-0.04	0.00	0.03	-0.06
United Kingdom	0.00	-0.03	0.05	0.06	-0.03	0.21
United States	0.05	0.06	0.03	0.09	0.14	0.03
Average	0.02	0.02	0.03	0.13	0.12	0.19
Median	0.02	0.00	0.02	0.10	0.10	0.16

All columns refer to our full model, i.e. model 5 as of Table 5.

Table 6 shows welfare effects for all countries for the full model (Model 5). Natives in most countries benefit from a one-percentage-point increase in immigrant share of the level force at current (2011) skill composition. However, in Austria, Belgium, Germany, Luxembourg, the Netherlands, Sweden and Switzerland native welfare falls. In these cases, welfare gains turn negative due to general redistribution, which plays a larger role than unemployment benefits. Countries with initially high unemployment rates (Italy, Greece, Portugal) are among those benefiting most from the job-creation channel. In all countries, welfare effects – whether positive or negative – are relatively small, ranging between -0.04% (Switzerland) to +0.08% (Portugal), and averaging 0.02%.

Table 6 also shows that, across most countries, previous immigrants benefit from additional immigration. This is mostly because they benefit strongly from the vacancy creation effect but do not suffer from increased redistribution as their incomes are lower than natives'.

[26] In the larger country sample, this is a robust finding (see Table B.2 in the Appendix).

The vacancy creation effect in a non-Walrasian market can therefore turn the conventional wisdom upside down: existing immigrants, even if potentially competing with new immigrants may actually gain from immigration rather than being the group losing the most. Note that positive welfare gains accruing to previous immigrants make the welfare gains available to natives smaller; see Felbermayr and Kohler (2007).

5.2.2 Gains from Realized Immigration

In this section, we report the welfare effects of realized immigration as of 2011 (i) relative to a hypothetical 'closed border' situation, in which countries are assumed to have no foreign-born workers at all, and (ii) relative to the situation as in year 2000. Table 7 presents the results.

Table 7: Native Welfare Effects, observed migration flows

	Autarky vs. Status Quo			**2000 vs. 2011**				
	Welfare effects			**Migrant shares**		**Welfare effects (%)**		
Countries	$\mathcal{W}_N$	$\mathcal{W}_{LN}$	$\mathcal{W}_{HN}$	2000	2011	$\mathcal{W}_N$	$\mathcal{W}_{LN}$	$\mathcal{W}_{HN}$
Australia	0.24%	1.26%	-1.72%	11.8%	21.0%	0.30%	1.37%	-1.77%
Austria	1.77%	1.74%	1.94%	12.7%	18.3%	0.01%	0.20%	-0.82%
Belgium	1.70%	1.37%	2.30%	12.5%	17.8%	0.03%	0.05%	-0.01%
Canada	1.19%	1.79%	-0.57%	10.7%	19.9%	0.07%	0.04%	0.16%
Denmark	1.90%	2.39%	0.86%	10.3%	12.0%	0.52%	1.28%	-1.10%
Estonia	1.47%	1.47%	1.46%	13.8%	14.7%	0.15%	0.41%	-0.31%
France	0.77%	0.52%	1.27%	10.4%	13.0%	0.09%	0.11%	0.05%
Germany	0.31%	-0.07%	1.23%	13.6%	15.3%	-0.08%	-0.26%	0.36%
Greece	2.02%	1.40%	3.51%	12.3%	14.0%	0.01%	-0.18%	0.45%
Ireland	1.77%	2.30%	0.95%	10.2%	15.3%	0.46%	0.91%	-0.25%
Italy	1.87%	1.64%	2.97%	5.2%	11.8%	0.69%	0.57%	1.29%
Luxembourg	0.72%	0.45%	1.15%	23.2%	39.1%	-0.03%	0.50%	-0.85%
Netherlands	0.48%	0.23%	0.98%	9.4%	14.0%	0.10%	0.21%	-0.13%
Portugal	1.27%	1.23%	1.41%	4.6%	9.9%	0.54%	0.54%	0.55%
Slovenia	0.52%	-0.20%	2.30%	1.8%	13.1%	0.41%	-0.23%	2.00%
Spain	1.90%	0.96%	3.43%	6.6%	17.7%	0.85%	0.27%	1.79%
Sweden	0.63%	0.77%	0.34%	11.5%	17.8%	0.05%	0.36%	-0.57%
Switzerland	-0.14%	0.04%	-0.46%	19.1%	29.2%	-0.20%	0.39%	-1.20%
United Kingdom	0.35%	-0.22%	1.10%	9.6%	14.2%	-0.07%	-0.43%	0.42%
United States	0.80%	0.97%	0.53%	9.2%	13.5%	0.30%	0.53%	-0.05%
Average	1.08%	1.00%	1.25%	10.9%	17.1%	0.21%	0.33%	0.00%
Median	0.99%	1.10%	1.19%	10.6%	15.0%	0.09%	0.31%	-0.03%

We construct immigrant shares and skill composition from OECD data. See Appendix B for details.

Countries featuring positive marginal effects in Table 6, such as Italy, Portugal, Greece and Ireland, are also among those that gain the most from total immigration. A high unemployment rate of natives (especially among the low skilled) and large immigrant wage gaps lead to strong beneficial job-creation effects. Moreover, the job creation effect takes a non-linear form: we find a positive overall effects for 19 out of our 20 countries while only 13 countries had positive *marginal* effects. The magnitudes of the welfare effects of total immigration vary strongly across countries; in our sample, both the median and the average

welfare gains are close to 1%.

As to the distributional effects of immigration, we find that, in 14 out of 20 countries, there is no distributive conflict amongst natives. This highlights the importance of the job-creation effect, which can be positive for both groups, over the simple complementarity effect, which is always positive for one and negative for the other group. Australia, Canada and Switzerland, whose immigrant composition is most skewed in favor of highly skilled, are the only countries showing negative effects on the welfare of high skilled natives. Germany, Slovenia and the United Kingdom exhibit negative (but very small) effect on welfare of the low skilled.

The comparison of the status quo with a 'closed border' situation reveals the total welfare gains from international mobility. More informative for the current policy debate are the gains from immigration inflows from recent migration flows (from 2000 to 2011). All of the considered countries have seen the immigrant share in the work force increase quite substantially in that period. Not shown in the table, countries differ strongly as to the skill composition of recent immigration. Most countries experienced an increase in the share of high skilled among immigrants. However the opposite is true for a few countries, including Germany, Greece and the United Kingdom.

Our simulations find that 16 countries out of 20 experienced positive effects for the aggregate native welfare, and in five of these countries both low skilled and high skilled natives benefited. Because migration has been relatively skilled in the considered countries and because of fiscal transfers, low skilled have benefited in 16 out of 20 cases. On average they experienced a welfare increase of 0.33 percent, while high skilled natives have not benefited. The positive effects for the low skilled, the very low effects for the high skilled, and the small positive effects on welfare are consistent with the findings of Docquier et al. (2014).[27] The simulations of the welfare effects of immigration during the last 10 years show on average a positive effect on per capita income (after-tax earned income and transfers) for natives. In all countries, a substantial part of these gains derived from lower unemployment amongst low skilled natives. The model attributes to immigration an average unemployment rate decrease by 0.47 percentage points. High skilled unemployment also fell in 15 out of 20 countries because of immigration (on average by 0.38 percentage points).

[27] Those authors simulate the labor market effects of immigrants in a model featuring competitive labor markets. They focus on net immigration between 1990-2000 into OECD countries. Their study neither features the job creation nor the income redistribution effects, but it allows for potentially positive externalities from the high to the low skilled.

5.2.3 Immigrant-Native Productivity Gaps within Skill Groups

In the preceding analysis, we have solved the identification issue by assuming no productivity differences between immigrants and natives of the same skill level, i.e. by setting $\pi_{ij} = 1$. In this robustness check, we introduce a parameter $\eta \in (0, 1)$ which makes the immigrant-native productivity gap proportional to the observed wage gap between immigrants and natives.[28] Setting $\pi_{iN} = 1$, this implies that $\pi_{iI} = [\eta\,(w_{iN}/w_{iI} - 1) + 1]^{-1} \leq 1$. In the absence of a wage gap (i.e., $w_{iN} = w_{iI}$) or with $\eta = 0$, one has $\pi_{iI} = 1$ (as assumed in our default specification). At the other extreme, with $\eta = 1$, the entire wage gap is explained by a productivity gap.

Research by LaLonde and Topel (1991), Borjas and Friedberg (2009), and Kerr and Kerr (2011) suggests that a substantial immigrant-native wage gap persists even after controlling for the portability of human capital. Hence, it is plausible to assume that η lies closer to 0 than to 1.

Figure 1 plots that level of η, for which the overall native welfare gain due to immigrants, as shown in the second column of Table 7 for the case $\eta = 0$, changes sign. For example, in Canada, immigration would be beneficial for natives even if almost all of the wage gap is due to productivity differences (within skill groups) between natives and migrants. In contrast, in Germany or Sweden, the gain would already turn negative with an η larger than 0.13 or 0.20, respectively. We may conclude that our assumption $\pi_{ij} = 1$ may be problematic for countries at the lower end of Figure 1, while it is less of an issue for countries in the upper regions. Clearly, the figure illustrates the need for further empirical research on the origin of immigrant-native wage differentials.

5.3 A linear decomposition of Welfare effects

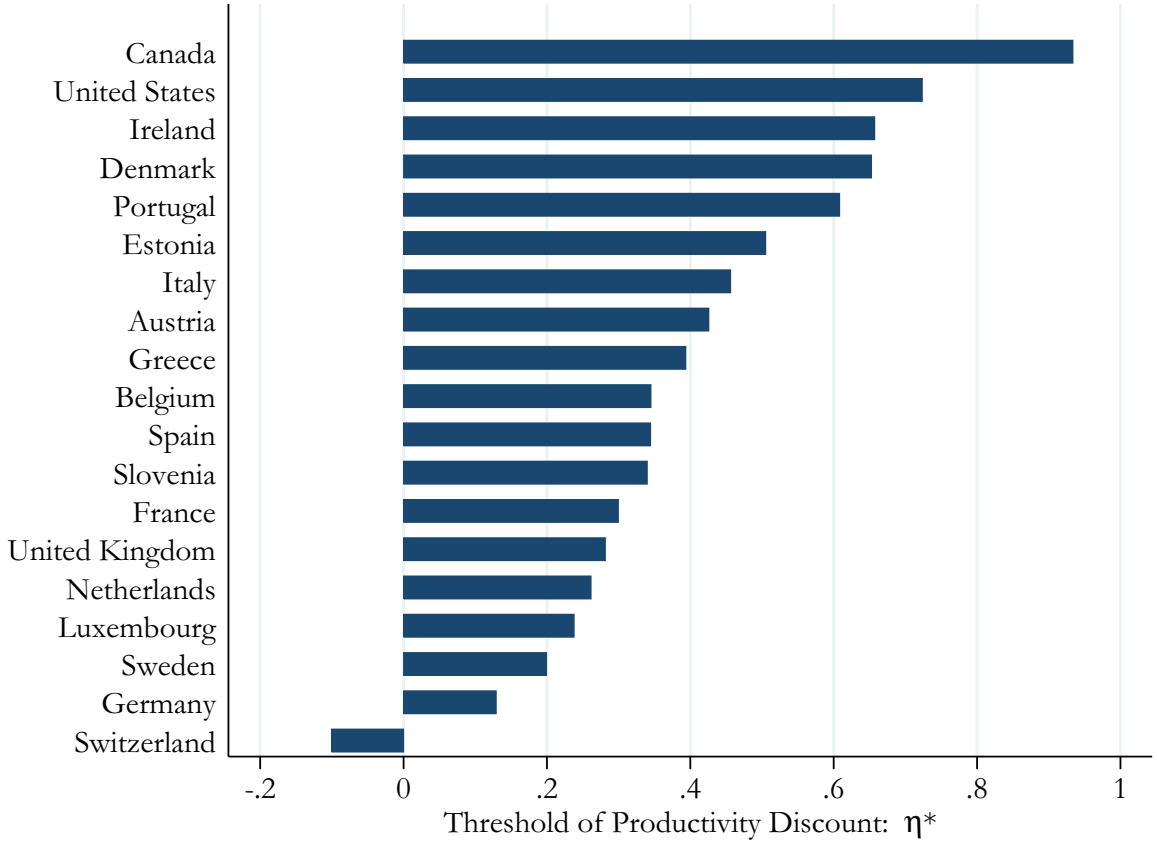
Our simulations show that the effects of immigration on native welfare depend in complicated ways on the labor markets characteristics, the composition of the immigrant inflow and on redistributive institutions in the host countries. We use a parsimonious regression analysis based on Monte Carlo type simulations to investigate how native welfare gains depend on measurable initial moments of country-specific variables.

We first create a sample of 10,000 artificial economies, each described by a 15-dimensional vector of characteristics (initial labor force shares of natives and migrants, wage gaps, unemployment rates, GDPs, government shares, etc.).[29] We draw these 'moments' from a jointly distributed normal distribution $\mathcal{N}(\mu, \mathbf{\Sigma})$, where μ is a (15-dimensional) vector of means and

[28] I.e., we posit $\pi_{iN}/\pi_{iI} - 1 = \eta\,(w_{iN}/w_{iI} - 1)$.

[29] The country moments are those listed in the lower half of Table 2 and the nine moments that vary across countries in Table 3 (job duration has no country variation). This gives us a total of 15 moments.

Figure 1: Critical value of η at which immigration gain changes sign



Note: The Figure shows that value of η (the share of the within-group wage difference explained by productivity differences) at which the overall native welfare gain resulting from the total observed stock of immigrants changes sign. The reference scenario is displayed in the second column of Table 7.

$\mathbf{\Sigma}$ is the corresponding variance-covariance matrix, both generated from our sample of 20 OECD countries.[30]

In the next step, we calibrate the model parameters of the artificial economies such that they match the drawn characteristics, following the same procedure as in the sections above. We then simulate the effects of a one percentage point increase in the labor force share of immigrants for our artificial countries. This exercise creates observations on 10,000 economies which feature the same joint distribution of the average moments of the 15 relevant variables as the 20 real OECD economies that we do observe.

With these data we run a simple OLS regression (for all natives, and then separately by skill) where welfare gains for natives as a dependent variable are regressed on country characteristics of our simulated data (these are simple transformations of the 15 random

[30] We truncate the distribution at $\mu_k \pm 2\sigma_k$ to avoid meaningless realizations.

Table 8: Native Welfare Gains by Skill, Semi-Log Moment Regression

Dependent variable: Welfare Gains of Natives from one 1% point increase in immigrant stock			
	(1)	(2)	(3)
	All Natives	Low Skilled	High Skilled
Native/Immigrant Wage gap, Skilled	0.086***	0.065***	0.124***
	[6.38]	[4.88]	[10.15]
Native/Immigrant Wage gap, Unskilled	0.102***	0.066***	0.152***
	[6.75]	[4.44]	[11.11]
Immigrant/Native Unemployment Gap, Skilled	-0.016	-0.015	-0.017
	[-1.22]	[-1.18]	[-1.42]
Immigrant/Native Unemployment Gap, Unskilled	-0.096***	-0.081***	-0.114***
	[-5.64]	[-4.84]	[-7.41]
Share of Immigrants in the Labor Force	-0.145***	-0.111***	-0.195***
	[-10.57]	[-8.17]	[-15.65]
Share of Tertiary Educated: Immigrant/Native ratio	0.058***	0.176***	-0.347***
	[4.57]	[13.89]	[-29.96]
Share of Tertiary Educated among Natives	0.007	0.001	0.019*
	[0.62]	[0.08]	[1.83]
Replacement Rate	0.051***	0.058***	0.039***
	[3.06]	[3.49]	[2.61]
Government Expenditures as share of GDP	-0.062***	-0.052***	-0.074***
	[-4.36]	[-3.69]	[-5.70]
Observations	10000	10000	10000
R^2	0.042	0.057	0.213

Standardized beta coefficients; t statistics in brackets. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$
All regressors are in logs. Artificial economies obtained with sampling from joint normal.

variables). More precisely, we run a semi-log 'moment regression':

$$\Delta \ln \mathcal{W}_{iN} = \sum_{k=1,\ldots,K} \beta_k \ln X_{ik} + u_i \tag{16}$$

where $\Delta \ln \mathcal{W}_{iN}$ denotes the proportional welfare gain for natives in economy i, X_{ik} is an $i \times K$ matrix of country characteristics and u_i is an error term that captures specification error.[31] To facilitate the quantitative comparison of effects, Table 8 presents standardized beta coefficients from regression (16),[32] and the associated t-statistics (in square brackets). The estimates should be interpreted as a way of summarizing the conditional correlation of a certain country characteristic with the native welfare effect of immigration in a linear coefficient. Thus, regression (16) is a way of obtaining quantitative comparative statics results and by no means a test of the model.

Column (1) of table 8 shows that the native/immigrant wage gaps turn out to be the most important positive determinants of the overall native welfare gains from immigration. Increasing the high skilled and the low skilled wage gaps by one standard deviation leads to an increase in the welfare gains by 0.09 and 0.1 standard deviations, respectively. This result shows the strength of the job-creation effect discussed above. The second most important

[31] The theoretical model is highly non-linear; the investigation device (16), however, is approximately log-linear.
[32] Standardized beta coefficients measure the impact of an independent variable on the dependent variable in units of standard deviations, i.e., $\hat{\beta}_k \sigma (\ln X_k) / \sigma (\Delta \ln \mathcal{W}_N)$.

positive driver is the skill ratio between natives and immigrants: relatively highly educated immigrants are associated with larger gains.[33] The replacement rate ranks third: a higher replacement rate increases the gains as immigrants' job-creating effects are stronger if labor market frictions are initially more pronounced. This effect dwarfs the negative redistributive role of replacement rates.

The pre-existing share of immigrants in the labor force turns out to be the most important negative determinant of the welfare gains (standardized beta of -0.15). This suggests that there may be a level of the share of immigrants at which the (usually) positive welfare effects of immigrants estimated in the previous section may turn negative. The logic for this result relates to infra-marginal effects: if additional immigration raises the wages of incumbent migrants, firms' incentives to create jobs fall and the value of immigration for immigrants is diminished; see Felbermayr and Kohler (2007). Immigrant/native unemployment gaps also reduce the welfare gains of immigration, as expected. The role of general redistribution ranks only as the third most important negative determinant (standardized beta of -0.06).

Looking at the welfare gains of low skilled (column (2)) or high skilled natives (column (3)), a similar picture emerges. However, the relative skill composition of immigrants is the dominant determinant of welfare gains: the larger the share of immigrants with tertiary education, the higher the welfare gains for the low skilled and the smaller the gains for the high skilled. The associated standardized betas are quite substantial: 0.18 and -0.35, respectively. This shows that the classical complementarity/substitution channel is still important for quantifying the distributive consequences of migration, but matters much less for overall native welfare gains. Native wage gaps with immigrants still augment the welfare gains, and the strength of labor market imperfections (as measured by the replacement rate) matters more for low skilled than for high skilled natives.

6 Conclusions

The impact of immigration on wages, employment and welfare of natives depends on the characteristics of immigrants and on the institutions of the host country. The research on the economic effects of immigration, however, has often implicitly assumed market clearing in perfectly competitive labor markets, and no government in charge of redistribution or unemployment insurance. In this paper, we propose a model that addresses these two issues. We start by showing that, in most countries, immigrants earn lower wages than natives and face higher unemployment risk, holding observable skills constant. However, there is substantial

[33] On the other hand, the share of tertiary educated among natives is unimportant once educational attainments of immigrants relative to natives are taken into account.

heterogeneity across countries, both with regard to immigrants' relative labor market performance, and with regard to institutional features or the size and skill composition of the immigrant stock.

We develop a model that is sufficiently flexible to capture these facts. We use a standard search-and-matching model where firms cannot discriminate between immigrants and natives ex ante. However, when a match is formed, wage bargaining accounts for immigrants' lower outside options and lower expected match duration. These two ingredients imply the share of immigrants affects vacancy creation by firms, with obvious consequences for wages and tightness in the labor markets for both low and high skilled workers. We also add a redistributive government to the model. As stressed in the public finance literature, migration may increase redistribution that can hurt natives who typically hold better paying jobs and are less likely to be unemployed. Our model accounts for that. Indeed, time and again, surveys show that unemployment and fiscal transfers are the most important determinants of overall attitudes towards migration by natives (Boeri, 2010).[34]

Introducing random-search frictions into a model featuring skill complementarity has quantitatively important implications on the effects of immigration on the welfare of natives. First, when foreign workers have worse outside option than natives, immigration boosts firms' incentives to create vacancies; this benefits all workers (natives and incumbent immigrants) and increases the immigration surplus. Part of this advantage is eroded by the fact that matches with immigrants typically have shorter duration. However, our quantitative exercise suggests that the net effect from both channels is positive in virtually all countries of our sample, and sometimes substantial. Interestingly, this job-creation effect seem more important in countries where domestic labor market institutions are more conducive to native unemployment. In total, the benefits from immigration deriving from labor market imperfections are quantitatively more important than the classical complementarity/substitution channel or even than redistribution.

Third, in the presence of search frictions and wage bargaining, it is likely that, due to the forces described above, immigration does not create a distribution conflict between high and low skilled natives as in the classical model. Nonetheless, the composition of the immigrant work force relative to natives is still the main predictor of skill-specific native welfare effects.

Fourth, the presence of a redistributive welfare state makes immigration less attractive to natives. It turns a positive aggregate gain into a negative one in 7 out of 20 countries. However, in most of these countries, the conditional quantitative relevance of high immigrant unemployment is more important than redistribution.

[34] In contrast, the same data from the European Social Survey indicate that the wage effects of immigration are relatively unimportant, despite their prominent role in the economic literature.

Finally, accounting for all channels through which immigration affects natives, the latter are better off with the current migration stocks than in a hypothetical situation of "closed borders" in 19 out of 20 countries. Averaging across all countries in our sample, the gains of high skilled natives from open borders amounts to 1.25% while that of low skilled natives is 1.00%.

Our "macro" approach based on the structural calibration of a model on data from several countries complements previous reduced-form one-country analyses of the effects of immigration. Still, there are many ways in which our analysis can be extended. For example, by accounting for population dynamics, labor force participation and life-cycle aspects. We hope further research will continue to combine micro and macro approaches to answer the policy relevant questions about the economic impact of immigrants.

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Appendix - For Online Publication

A Analytics of Simplified Models

A.1 Remark 1

Before we can discuss this specific result, we need to derive a few equations, which are simplifications of the model we presented above. Assuming that separation rates are the same for immigrants and natives, the ratio of natives and immigrants among employed and unemployed is the same as their ratio in the labor force: immigrants and natives have the same chance of getting matched with a firm and have the same probability of making a transition from employment to unemployment (because they have the same split rates). Hence ϕ_i, introduced in equation (6) is equal to $Q_{iI}/(Q_{iI}+Q_{iN})$ in this case, i.e. the share of immigrants in the labor force. The ratio Y_H/Y_L that determines the marginal productivity of each type of workers can then be written as:

$$\frac{Y_H}{Y_L} = \frac{m(\theta_H)\left[s_L + m(\theta_L)\right]}{m(\theta_L)\left[s_H + m(\theta_H)\right]} * \frac{Q_{HN}+Q_{HI}}{Q_{LN}+Q_{LI}} \tag{17}$$

In equilibrium the vacancy/employment ratio is $s_i/q(\theta_i)$. Substituting (17) into (3) and (4), we can write the two equilibrium conditions for equilibrium market tightness θ_H and θ_L explicitly:

$$\begin{aligned} p_L^{BE} &= xA\left[x + (1-x)\left(\Lambda(\theta_H,\theta_L)\Omega\right)^{\rho}\right]^{\frac{1-\rho}{\rho}} \\ &= \frac{\phi_L h_{LI}}{1-t} + c_L \frac{(r+s_L)\left(1-t\left(1-\beta\right)\right)+\beta\xi\theta_L^{1-\varepsilon}}{\xi\theta_L^{-\varepsilon}\left(1-\beta\right)\left(1-t\right)} \end{aligned} \tag{18}$$

$$\begin{aligned} p_H^{BE} &= (1-x)\,A\left[x\left(\Lambda(\theta_H,\theta_L)\Omega\right)^{-\rho} + (1-x)\right]^{\frac{1-\rho}{\rho}} \\ &= \frac{\phi_H h_{HI}}{1-t} + c_H \frac{(r+s_H)\left(1-t\left(1-\beta\right)\right)+\beta\xi\theta_H^{1-\varepsilon}}{\xi\theta_H^{-\varepsilon}\left(1-\beta\right)\left(1-t\right)} \end{aligned} \tag{19}$$

where the term

$$\Lambda(\theta_H,\theta_L) = \frac{\xi\theta_H^{1-\varepsilon}\left[s_L + \xi\theta_L^{1-\varepsilon}\right]}{\xi\theta_L^{1-\varepsilon}\left[s_H + \xi\theta_H^{1-\varepsilon}\right]}$$

depends positively on the tightness of market H and negatively on the tightness of market L. The term $\Omega = \frac{Q_{HN}+Q_{HI}}{Q_{LN}+Q_{LI}}$ is the supply of highly educated relatively to less educated. This term may also be affected by immigration if the skill mix among immigrants differs from that of natives.

(i) When the inflow of immigrants is balanced (the ratio to low to high skilled is the same as in the original native population) it is not going to affect Ω and since immigrants of each type are as productive as natives, there is also no effect through $\Lambda(\theta_H, \theta_L)$. The left hand side of equation (18) remains the same. The right hand side of the same equation will need to adjust to the increase in ϕ_L. Since this change has no first order impact on the left-hand side of equation (18) we can write the partial derivative of θ_L with respect to ϕ_L for the right-hand side of equation (18)

$$\begin{aligned}\frac{\partial \theta_L}{\partial \phi_L} &= -\frac{d/d\phi_L}{d/d\theta_L} \\ &= \frac{\frac{h_{LI}}{1-t}}{c_L \frac{(1-\epsilon)\beta\xi\theta_L^{-\epsilon}(\xi\theta_L^{-\epsilon}(1-\beta)(1-t))-[(r+s_L)(1-t(1-\beta))+\beta\xi\theta_L^{1-\epsilon}][(1-\beta)(1-t)\xi(-\epsilon)\theta_L^{-\epsilon-1}]}{[\xi\theta_L^{-\epsilon}(1-\beta)(1-t)]^2}}\end{aligned} \tag{20}$$

The sign of this derivative will be driven by the sign of the term

$$\begin{aligned}&(1-\epsilon)\beta\xi\theta_L^{-\epsilon}(\xi\theta_L^{-\epsilon}(1-\beta)(1-t)) - [(r+s_L)(1-t(1-\beta)) \\ &+ \beta\xi\theta_L^{1-\epsilon}][(1-\beta)(1-t)\xi(-\epsilon)\theta_L^{-\epsilon-1}]\end{aligned} \tag{21}$$

which simplifies to

$$\begin{aligned}&[\beta(1-\beta)(1-\epsilon)\xi^2 + \beta\xi\epsilon(1-\beta)(1-t)]\theta_L^{-2\epsilon} \\ &+ \xi\epsilon(r+s_L)(1-t(1-\beta))(1-\beta)(1-t)\theta_L^{-\epsilon-1} > 0\end{aligned} \tag{22}$$

Equivalently, using equation (19), we find

$$\frac{\partial \theta_H}{\partial \phi_H} = -\frac{d/d\phi_H}{d/d\theta_H} > 0 \tag{23}$$

This confirms the intuition that as the number of immigrants increases without changing the ratio between high skilled and low skilled workers, the value of a vacancy goes up, due to the fact that immigrants leave a higher surplus to the firm. Since we have a free entry condition that ensures that the equilibrium value of a vacancy remains zero, more vacancies will be created compared to the total number of workers, thereby increasing market tightness in both markets. As market tightness decreases in both markets, unemployment rates for natives will also decrease, since

$$U_{iN} = \frac{s_i}{s_i + m(\theta_i)} Q_{iN} \quad \text{for } i = H, L \tag{24}$$

In this equation, the arrival of new immigrants will only affect the unemployment rate through θ_i. As θ_i increases, $m(\theta_i)$ also increases (the probability to find a job is higher the higher market tightness is), which reduces the unemployment rate of natives. Evaluating the effects on equilibrium wages is only slightly more complicated. We use our wage bargaining equation, observing that the match surplus will be a positive function of market tightness, i.e. $\frac{\partial p_i}{\partial \theta_i} > 0$. We are interested in the effect of a change in market tightness on wages of natives:

$$\frac{\partial w_{iN}}{\partial \theta_i} = \beta p_i \frac{m'(\theta_i)[(r+s_i)(1-t(1-\beta)) + \beta m(\theta_i)] - [r+s_i+m(\theta_i)\beta m'(\theta_i)]}{[(r+s_i)\,(1-t\,(1-\beta)) + \beta m\,(\theta_i)]^2} \tag{25}$$

After a few simple steps, this simplifies to

$$\frac{\partial w_{iN}}{\partial \theta_i} = \beta m'(\theta_i)[(1-\beta)(r+s_i)p_i(1-t)] \tag{26}$$

Therefore

$$\frac{\partial w_{iN}}{\partial \theta_i} > 0 \text{ if and only if } p_i(1-t) > 0 \tag{27}$$

which is a condition of non-negative surplus that has to be assumed from the start.

(ii) A change in the outside option of immigrants affects labor market tightness through the same channel discussed above, namely vacancy creation effects. If the outside option for immigrants worsens, unemployment of natives falls and wages of natives increase.

In particular, consider a decrease in h_{iI} (i.e. an increase in its absolute value). Note that h_{iI} only enters equations (18) and (19) when it is multiplied by ϕ_i. Therefore the effect of a change in h_{iI} is analytically equivalent to a change in ϕ_i: having more immigrants or changing the outside option of current immigrant has the same qualitative effects. Therefore, the effects of labor market tightness on unemployment rates and wages of natives are equivalent to the analysis above. Just for clarity in the exposition, let us consider an inflow of less skilled immigrants, focusing on the effects on high skilled natives. An increase in Q_{LI} will affect Ω in equation (19). By reducing the relative size of the high skilled population, it will increase market tightness in the high skilled market. From equation (19) we can then look at the effect of an increase in θ_H on p_H:

$$\frac{\partial p_H}{\partial \theta_H} = c_H \frac{\frac{(1-\epsilon)\beta\xi^2(1-\beta)(1-t)}{\theta_H^{2\epsilon}} + \epsilon[(r+s_H)(1-t(1-\beta)) + \frac{\beta\xi}{\theta_H^{\epsilon-1}}]\frac{\xi(1-\beta)(1-t)}{\theta_H^{\epsilon+1}}}{[\xi\theta_H^{-\epsilon}(1-\beta)(1-t)]^2} \geq 0 \tag{28}$$

so that higher labor market tightness is associated with a larger equilibrium surplus from the match, lower unemployment rates and higher wages for high skilled natives.

(iii) The effect on natives of skill $i' \neq i$ is entirely driven by complementarity channel, which is positive from the concavity of the production function, as in Borjas (1995).

A.2 Remark 2

Results (i) and (ii) operate through identical mechanisms as in the case of Remark 1, with the fundamental difference that the effect of larger migration stocks is now negative, rather then positive, for the expected surplus from a match. Given this equivalence, we focus here on (iii).

For simplicity, consider a situation where immigrants and natives have identical separation rates initially. We then increase split rates of immigrants of one type and look at the effects for natives (of either type). Naturally, the direct stronger effects will be on the immigrants themselves. However, our focus here is primarily on natives, which means that we are focusing on the indirect effect of separation rates, which operates through the job creation margin.

In this paragraph we discuss effects on natives of the same skill level, while on the next paragraph we discuss effects on natives of a different skill level. If immigrants have higher separation rates than natives, this means that the surplus from being matched with an immigrant is lower, because the match lasts shorter on average. Note that we are ruling out that the firm can target natives or immigrants when it creates a vacancy. Therefore, from the free entry condition

$$rJ_i^V = -c_i + q(\theta_i)\left[(1-\phi_i)J_{iN}^F + \phi_i J_{iI}^F - J_i^V\right] = 0 \tag{29}$$

we see that as the value of a filled vacancy falls, equilibrium market tightness will have to fall in order for the equality to hold. Intuitively, in order for firms to break even in an environment where they get a lower surplus from the match, the market will have to adjust so that the probability of filling a vacancy will be larger for firms. In other words, at higher levels of separation rates for immigrants, less vacancies get created so that equilibrium market tightness is lower.

The rest of the discussion in this paragraph follows from the results on labor market tightness, which is the channel through which separation rates of immigrants affect labor markets of natives.[35] Below, we discuss the effects on wages and unemployment rates. These are generated by difference in separation rates, but since they operate though labor market

[35] We are abstracting from the fiscal channel here, which adds a further mechanism: if immigrants have larger separation rates, they will have larger equilibrium unemployment rates, which imply larger transfers from natives even in the absence of wage gaps.

tightness, they have been previously looked at in the context of search models. Higher separation rates for immigrants, which bring about lower equilibrium labor market tightness, generate larger unemployment rates for natives. Unemployment rates for natives of skill i are

$$u_{iN} = \frac{s_{iN}}{s_{iN} + m(\theta_i)} \tag{30}$$

since $m(\theta_i)$ is increasing in θ_i (in our model we use the functional form $m(\theta_i) = \xi\theta^{1-\varepsilon}$), the unemployment rate of natives will be higher the lower is equilibrium market tightness, even though separation rates of natives are unchanged.

We next discuss the effect of separation rates of immigrants on wages of natives, operating once again through market tightness. Let us write gross wages of natives as a function only of market tightness and exogenous parameters again:

$$w_{iN} = \beta \frac{r + s_{iN} + \xi\theta^{1-\varepsilon}}{(r + s_{iN})(1 - t(1 - \beta)) + \beta\xi\theta^{1-\varepsilon}} p_i \tag{31}$$

We want to investigate the sign of $\frac{\partial w_{iN}}{\partial \theta_i}$. It is straightforward to see that the term on the right-hand side of equation (31) is increasing in θ_i. The price $p_i = p_i(\theta_i)$ is a positive function of labor market tightness, and it is easy to show that the expression $\beta \frac{r+s_{iN}+\xi\theta^{1-\varepsilon}}{(r+s_{iN})(1-t(1-\beta))+\beta\xi\theta^{1-\varepsilon}}$ is also a positive function of θ_i. Therefore, an increase in the separation rates of immigrants, reducing labor market tightness, also lowers wages for natives.

Within a wage bargaining framework, wages are a convex combination of the surplus from the match and the outside option of the worker. Lower labor market tightness lowers also the value of the outside option to the worker (because it is harder to find a job when unemployed), the price of the intermediate good is lower, and its weight is also lower (because the expected value of a match following the current match is lower).

Summarizing, through its negative effects on labor market tightness, higher separation rates for immigrants result in higher unemployment rates and lower wages, for immigrants but also for natives of the same skill class. These dynamics will also have second-order spillover effects of the same sign on native workers of a different skill class, operating through equations 3 and 4, governing prices of the intermediate goods. A lower employment for one skill level corresponds to a lower price in the other sector, due to complementarities. The mechanism feeds on itself and moves the system along a saddle path to a new steady state. Therefore, our model predicts that larger separation rates for immigrants in one sector will lower wages and increase unemployment of natives of the same skill level and also of natives of a different skill level.

B Data Sources

Our quantitative analysis uses data of population shares (skill shares of the labor force in each country, percentage of foreign-born individuals in each country, skill shares among immigrants), wages (skill premia and immigrant wage gaps by skill level), unemployment rates, generosity of the unemployment insurance scheme, GDP per capita and size of the public sector. For each of these, we list our data sources below. Following Chassamboulli and Palivos (2014) and Krusell, Ohanian, Rios-Rull, and Violante (2000), we define skilled workers as those workers who hold a Bachelor degree (or equivalent) or above.

Population shares For all of the EU countries in our analysis, we have used information on population shares from the 2012 Eurostat Yearbook (data for 2011), restricting our sample to individuals between 15 and 64 years of age with skill information derived from the ISCED education classification system. From the Eurostat Yearbook we use data on the share of low skilled among natives, the share of low skilled among immigrants and the share of foreign born in the population.

For the US, equivalent population shares are constructed using the Public Use Micro File dataset from the 2005 US Census. Similarly, for Canada we construct population shares using the Micro File version of the 2006 Canadian Census. For Australia, we use the 2009 wave of the panel dataset Household, Income and Labour Dynamics in Australia (HILDA) representative survey.[36]

Unemployment Rates In the descriptive section of our paper we present figures for unemployment rates by skill class and by immigration status. Although this is a basic statistics we were not able to find this summary information for a large number of countries and using high-quality data, so we had to use a few data sources to generate these statistics. For all EU countries and Switzerland we have used descriptive data from the EU Labour Force Survey. For Germany, there no information on country of birth in the European Labour Force Survey so we had to use nationality instead, for years 2005-2011. For the United States, we used the Current Population Survey for years 2005-2012. For Canada, since the Labour Force Survey (LFS) does not include migration information, we constructed unemployment rates by skill level for 2005-2012, and then used the 2006 Census Microfiles to construct unemployment rates for immigrants and natives. We then constructed trends using the census data and the LFS data together. For Australia, we use data from the Household, Income and Labour Dynamics in Australia (HILDA) Survey from 2005 to 2011

[36] More information on the survey is available in Wooden and Watson (2007) and Salehin and Breunig (2012).

(Waves 5-11). For wage gaps and unemployment rates, we average data over this period to maximize comparability across countries and minimize the role of business cycle and short term fluctuations, given that the focus of our study is on steady state comparisons.

Wages For EU countries, we constructed a measure of the wage gap between low skilled and high skilled native workers (i.e. the skill premium), and of the gaps between immigrant and native workers (for low skilled and high skilled workers) using the European Union Statistics on Income and Living Conditions (EU-SILC) for years 2005-2011 (2010 for Ireland).[37] For the US, Canada and Australia we construct wage gaps based on the three datasets we just described.

Government Expenditures Our data source for government expenditures is the variable "General government total expenditure" as percentage of GDP from the World Economic Outlook Database of the International Monetary Fund. For each country, we take an average for 2005-2012 to make sure that heterogeneity across countries is not driven by asymmetries in the respective business cycles.

Replacement Rates In order to parameterize the level of unemployment benefits differently for each country we utilize data on the average net replacement rates, i.e. the ratio between unemployment benefits and average net wages. We use data from the OECD Wages and Statistics Dataset, averaging net replacement rates for the period 2005-2011 to smooth out business cycle fluctuations. Replacement rates are constructed for the average worker across the same sectors in all countries, to maximize comparability.

Gross Domestic Product We use data on 2011 GDP PPP in international dollars from the World Bank World Development Indicators.

Capital Shares We calculate capital shares using labor share data from the OECD. We average labor income shares for the period 2005-2012 and calculate the capital share α as the complement to one of the labor share.

Stocks and skill compositions, 2000-2011 In section 5.2.2 above, we analyze the welfare effect for natives of the actual 2000-2011 migration flows across countries. Unfortunately, we are aware of no perfect data for this exercise. This is due to the fact that using stock data is undesirable, because differences in stocks are driven by population dynamics unrelated to

[37] We thank Eurostat for providing us with summary statistics based on the EU-SILC dataset.

migration. Therefore, one would want to use data on net flows in this period. Regrettably, we are aware of no skill-specific flow data for these countries.

Therefore, we use OECD data on inflows and outflows to construct net flows in the period 2000-2011, which we use to construct the size of the treatment. Since we are unable to have information of the skill composition of that specific flow, we will use stock data for 2000 from the dataset constructed by Frédéric Docquier, Çaglar Özden, Christopher Parsons and Ehran Artuc, aggregated at the level of the destination country.

Table B.1: Summary statistics for country-specific moments

	(1) $\frac{Q_{LN}}{Q_N}$	(2) Q_I	(3) $\frac{Q_{LI}}{Q_I}$	(4) $\frac{w_{HN}}{w_{LN}}$	(5) $\frac{w_{LN}}{w_{LI}}$	(6) $\frac{w_{HN}}{w_{HI}}$	(7) u_{LN}	(8) u_{LI}	(9) u_{HN}	(10) u_{HI}	(11) $\frac{\bar{b}}{W(1-t)}$	(12) GDP	(13) $\frac{G+B}{GDP}$
Countries													
Australia	0.70	0.21	0.57	1.40	1.01	1.00	0.04	0.05	0.01	0.03	0.43	39.7	0.36
Austria	0.83	0.18	0.83	1.35	1.34	1.18	0.04	0.10	0.02	0.06	0.52	42.2	0.50
Belgium	0.68	0.18	0.72	1.44	1.29	1.14	0.08	0.20	0.03	0.10	0.63	38.8	0.52
Canada	0.80	0.20	0.68	1.81	1.01	1.19	0.09	0.09	0.04	0.07	0.26	40.4	0.41
Denmark	0.71	0.12	0.53	1.37	1.18	1.16	0.06	0.12	0.03	0.08	0.57	40.9	0.55
Estonia	0.69	0.15	0.64	1.52	1.16	1.35	0.12	0.14	0.05	0.09	0.24	22.0	0.41
France	0.71	0.13	0.77	1.45	1.17	1.04	0.10	0.16	0.05	0.10	0.49	35.2	0.55
Germany	0.74	0.15	0.81	1.40	1.13	1.16	0.09	0.16	0.03	0.11	0.44	39.5	0.46
Greece	0.75	0.14	0.87	1.68	1.39	1.38	0.13	0.15	0.09	0.15	0.22	25.8	0.49
Ireland	0.66	0.15	0.52	1.61	1.07	1.24	0.11	0.16	0.04	0.08	0.54	41.7	0.44
Italy	0.86	0.12	0.89	1.56	1.34	1.57	0.08	0.11	0.05	0.08	0.23	32.6	0.49
Luxembourg	0.64	0.39	0.68	1.42	1.29	1.08	0.04	0.07	0.02	0.04	0.30	89.0	0.41
Netherlands	0.70	0.14	0.75	1.39	1.13	1.15	0.04	0.09	0.02	0.06	0.39	42.8	0.48
Portugal	0.83	0.10	0.81	2.08	1.09	1.22	0.10	0.14	0.08	0.09	0.52	25.4	0.47
Slovenia	0.76	0.13	0.90	1.49	1.12	1.06	0.07	0.08	0.04	0.05	0.26	27.0	0.44
Spain	0.67	0.18	0.79	1.55	1.30	1.34	0.17	0.23	0.08	0.16	0.42	32.0	0.43
Sweden	0.69	0.18	0.67	1.24	1.21	1.13	0.08	0.16	0.03	0.11	0.42	41.5	0.51
Switzerland	0.68	0.29	0.69	1.44	1.17	0.99	0.03	0.08	0.02	0.05	0.34	51.3	0.33
UK	0.62	0.14	0.69	1.52	1.04	1.15	0.08	0.10	0.03	0.06	0.29	35.7	0.43
USA	0.70	0.14	0.68	2.11	1.15	1.00	0.10	0.09	0.03	0.04	0.27	48.1	0.40
Statistics													
Mean	0.72	0.17	0.72	1.54	1.18	1.18	0.08	0.12	0.04	0.08	0.39	39.6	0.45
Median	0.70	0.15	0.71	1.47	1.16	1.15	0.08	0.11	0.03	0.08	0.40	39.6	0.45
S.d.	0.07	0.07	0.11	0.23	0.11	0.15	0.04	0.05	0.02	0.03	0.13	13.9	0.06
Min	0.62	0.10	0.52	1.24	1.01	0.99	0.03	0.05	0.01	0.03	0.22	22.0	0.33
Max	0.86	0.39	0.90	2.11	1.39	1.57	0.17	0.23	0.09	0.16	0.63	89.0	0.55
S.d./mean	0.09	0.39	0.15	0.15	0.09	0.12	0.43	0.37	0.55	0.33	0.40	0.40	0.13

Q_{LN}/Q_N Share of low skilled among natives. $Q_I = Q_{LI} + Q_{HI}$ Share of immigrants in the labor force.
Q_{LI}/Q_I Share of low skilled among immigrants. $\frac{w_{HN}}{w_{LN}}$ Skill premium among natives.
$\frac{w_{LN}}{w_{LI}}$ Native/immigrant wage ratio for low skilled. $\frac{w_{HN}}{w_{HI}}$ Native/immigrant wage ratio for high skilled.
u_{ij} are unemployment rates for each skill level for immigrants and natives.
$\frac{\bar{b}}{W(1-t)}$ denotes the average Replacement Rate: ratio between benefits and average wages (OECD data).
GDP is per capita GDP PPP for year 2011 in current international dollars (in 1000s).
In column 11, we use OECD data for net replacement rates.
In column 13, G denotes a public good, and B denotes total expenditures on unemployment benefits.
For the USA, data from IPUMS 2005 Census. For Canada, data from the 2006 Census and 2005-2012 LFS.
For EU countries: Eurostat data for population shares, EU-SILC and EU-LFS for wage gaps.

Table B.2: Native Welfare Gains increase in Migration of one percentage point

Countries	Model 1			Model 2			Model 3			Model 4			Model 5		
	$\mathcal{W}_N$	$\mathcal{W}_{LN}$	$\mathcal{W}_{HN}$	$\mathcal{W}_N$	$\mathcal{W}_{LN}$	$\mathcal{W}_{HN}$	$\mathcal{W}_N$	$\mathcal{W}_{LN}$	$\mathcal{W}_{HN}$	$\mathcal{W}_N$	$\mathcal{W}_{LN}$	$\mathcal{W}_{HN}$	$\mathcal{W}_N$	$\mathcal{W}_{LN}$	$\mathcal{W}_{HN}$
Australia	0.01%	0.08%	-0.13%	0.01%	0.09%	-0.12%	0.00%	0.08%	-0.13%	0.00%	0.08%	-0.13%	0.01%	0.06%	-0.08%
Austria	0.00%	0.00%	0.01%	0.08%	0.09%	0.07%	0.05%	0.05%	0.04%	0.04%	0.04%	0.04%	-0.03%	-0.03%	-0.03%
Belgium	0.00%	-0.04%	0.06%	0.09%	0.07%	0.12%	0.03%	0.01%	0.06%	0.03%	0.01%	0.07%	-0.02%	-0.03%	-0.01%
Canada	0.01%	0.09%	-0.20%	0.04%	0.11%	-0.13%	0.03%	0.10%	-0.14%	0.03%	0.10%	-0.14%	0.04%	0.08%	-0.08%
Denmark	0.01%	0.14%	-0.22%	0.09%	0.21%	-0.13%	0.05%	0.17%	-0.17%	0.07%	0.19%	-0.16%	0.06%	0.11%	-0.05%
Estonia	0.00%	0.04%	-0.06%	0.09%	0.12%	0.05%	0.07%	0.10%	0.03%	0.08%	0.11%	0.03%	0.05%	0.07%	0.02%
France	0.00%	-0.05%	0.09%	0.07%	0.04%	0.12%	0.03%	-0.01%	0.08%	0.04%	0.00%	0.10%	0.02%	0.00%	0.05%
Germany	0.00%	-0.05%	0.11%	0.07%	0.03%	0.17%	0.02%	-0.03%	0.12%	0.02%	-0.02%	0.12%	-0.01%	-0.03%	0.04%
Greece	0.01%	-0.09%	0.19%	0.15%	0.07%	0.31%	0.13%	0.05%	0.29%	0.15%	0.06%	0.31%	0.07%	0.02%	0.18%
Ireland	0.01%	0.11%	-0.13%	0.07%	0.15%	-0.04%	0.04%	0.13%	-0.07%	0.05%	0.15%	-0.08%	0.05%	0.10%	-0.03%
Italy	0.00%	-0.02%	0.10%	0.14%	0.12%	0.25%	0.13%	0.10%	0.23%	0.13%	0.11%	0.24%	0.07%	0.05%	0.14%
Luxembourg	0.00%	-0.02%	0.04%	0.03%	0.02%	0.06%	0.02%	0.00%	0.05%	0.02%	0.00%	0.05%	-0.02%	-0.03%	-0.01%
Netherlands	0.00%	-0.04%	0.06%	0.06%	0.03%	0.12%	0.03%	0.00%	0.09%	0.03%	0.00%	0.09%	-0.01%	-0.03%	0.02%
Portugal	0.00%	0.02%	-0.06%	0.08%	0.08%	0.06%	0.05%	0.06%	0.04%	0.08%	0.09%	0.04%	0.08%	0.09%	0.07%
Slovenia	0.01%	-0.11%	0.27%	0.07%	-0.04%	0.30%	0.06%	-0.05%	0.29%	0.06%	-0.05%	0.30%	0.02%	-0.04%	0.17%
Spain	0.01%	-0.09%	0.13%	0.13%	0.04%	0.25%	0.08%	-0.01%	0.19%	0.09%	0.01%	0.21%	0.04%	-0.01%	0.12%
Sweden	0.00%	0.01%	-0.02%	0.08%	0.10%	0.04%	0.02%	0.04%	-0.01%	0.02%	0.04%	-0.01%	-0.02%	-0.01%	-0.04%
Switzerland	0.00%	-0.01%	0.02%	0.02%	0.03%	0.02%	0.00%	0.01%	0.00%	-0.01%	-0.01%	-0.01%	-0.04%	-0.03%	-0.04%
UK	0.00%	-0.06%	0.07%	0.05%	-0.02%	0.12%	0.03%	-0.04%	0.11%	0.03%	-0.03%	0.11%	0.00%	-0.03%	0.05%
USA	0.00%	0.01%	-0.02%	0.04%	0.08%	0.00%	0.04%	0.08%	0.00%	0.05%	0.08%	0.01%	0.05%	0.06%	0.03%
Average	0.00%	0.00%	0.01%	0.07%	0.07%	0.08%	0.05%	0.04%	0.05%	0.05%	0.05%	0.06%	0.02%	0.02%	0.03%
Median	0.00%	-0.02%	0.03%	0.07%	0.08%	0.06%	0.04%	0.05%	0.04%	0.04%	0.04%	0.04%	0.02%	0.00%	0.02%