Wage bargaining, relative prices and capital: the impact of immigration on wages and wage inequality*

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Abstract

This paper develops a model of immigration that encompasses different channels through which immigration impacts native wages. The framework incorporates a frictional labor market with different outside options for immigrants and natives, local demand conditions captured by relative prices, and capital-labor substitution. The model is calibrated on labor data for the four largest European Union economies, France, Germany, Italy and Spain. Three counterfactual scenarios are explored, where the adjustment speed of the capital stock and the sensitivity of domestic relative prices to immigration differ. Results shows that the impact of immigration on wages and wages inequality depends crucially on the latter factor, i.e. whether relative prices are determined by local vs. global conditions. In the former case, the migration pattern observed in the data has led to a non-negligible increase in native wage inequality. In the latter case, migration skewed towards the low-skilled has led to a (quantitatively small) decrease in native wage inequality, due to the lower wage bargaining power of immigrants who compete with native workers.

Keywords: immigration, search and matching, bargaining power, capital-labor ratio, relative prices

JEL codes: E24, J21, J31, J61, J64

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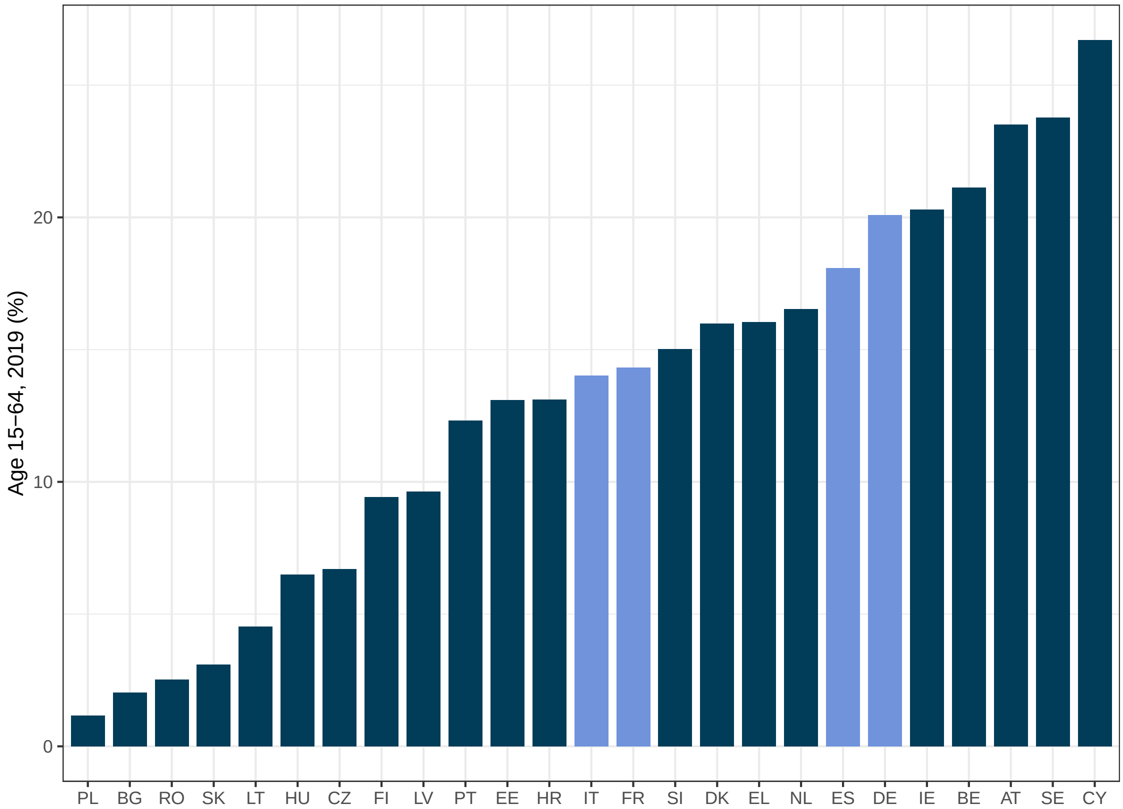
1 Introduction

Large-scale immigration has a potentially significant impact on the labor markets of host countries. Immigrant workers compete with some native employees, and complement others, creating heterogenous effects that may increase or decrease native wages and native wage inequality. Finding out the exact impact is an empirical question, and different available methodologies have different strengths and weaknesses.

Fig. 1.1: The share of immigrants in the working age population



European countries have been subject to significant immigration in the past decades, although to varying degrees. Figure 1.1 plots the share of immigrants in the working age (15-64) population across the European Union.[1] In the majority of the EU countries this share is above 10%, and in six countries it is above 20%. The four largest EU economies (France, Germany, Italy and Spain), on which the quantitative analysis of this paper will focus on, have immigrant shares in the 14%-20% range. This magnitude is large enough to ask whether immigration has had a sizable impact on European wages and on wage inequality. The main goal of this paper is to provide

[1] The figure omits Luxembourg, which is an outlier with an immigrant share of more than 50%.

a framework that can be used to analyze this question, using a tractable, quantitative general equilibrium approach.

There is a very large literature that analyses the impact of immigration on host country labor markets, focusing on many countries. Broadly speaking, there are two main strands in the literature to understand labor market changes caused by migration. Area studies utilize variation across geographical regions (cities, metropolitan areas, or larger units within countries) in their exposure to immigration. Examples of such papers are Card (1990) Altonji and Card (1991), Card (2001) in the United States; Dustmann et al. (2013) and Nickell and Saleheen (2015) in the UK; Pischke and Velling (1997) and D'Amuri et al. (2010) in Germany. The general consensus among these papers is that immigration has at most a very small negative impact on native wages.

There are various reasons why these conclusions need to be refined. First, native workers may respond to an immigration shock by moving to other parts of a country, diluting the regional differences on which local area studies are based (see for example Borjas, 1994). To mitigate this effect, a second strand of the literature focuses at large enough geographical units (typically countries) that can be considered having closed labor markets (apart from the immigration inflow). Given the lack of degrees of freedom for country level econometric estimation, such studies have utilized simple neoclassical production theory to quantify the impact of migration on wages ("the factor proportions approach"). Articles in this tradition include Borjas et al. (1997); Borjas (2003); Ben-Gad (2008) or Busch et al. (2020). Using an aggregate production function, on the other hand, necessarily ignores much of the fine-grained information available at the local level, and may lead to simplistic conclusions.

In more recent work, the fact that immigrant and native workers are heterogenous along many dimensions plays center stage. In particular, heterogeneity along skill levels is very important to understand the differential impact of immigration on native wages. A long tradition in the macroeconomic analysis of wages and inequality distinguishes skilled and unskilled workers, along with capital as factors of production (a seminal treatment is given in Hamermesh, 1993; another important study is Krusell et al., 2000). Other work has looked at a somewhat higher level of disaggregation, such as effects along the native wage distribution (Dustmann et al., 2013), or across occupation categories (Burstein et al., 2020; Nickell and Saleheen, 2015). Of course the different approaches are not mutually exclusive, and many papers – including the last two –

combine worker heterogeneity, a production function approach, and identification based on local labor market differences.

A different tradition in the study of labor markets focuses on search-and-matching frictions in employment and wage determination (Mortensen and Pissarides, 1994; Pissarides, 2000). This approach has recently made inroads into the migration literature (Ortega, 2000; Liu, 2010; Chassamboulli and Palivos, 2014; Chassamboulli and Peri, 2015; Moreno-Galbis and Tritah, 2016). An attractive feature of allowing for labor market frictions is that ex-ante identical workers become less than perfect substitutes ex-post. Once a job is filled, firms and workers share a surplus that makes job changes costly for both sides. If the relative bargaining position of immigrants and natives differ, an *immigrant wage gap* opens up between them. Taking this into account is potentially important to understand native wage changes due to immigration.

Based on these ideas, this paper builds a model of frictional labor markets with immigrants and natives. The labor markets are embedded in a macroeconomic environment where goods and services produced by different occupations are imperfect substitutes, and capital is a factor of production at the aggregate level. The model is calibrated to labor market data in the four largest EU economies, France, Germany, Italy and Spain, using observed employment numbers in occupation categories for immigrants and natives. Additional data on aggregate labor market tightness, job finding and job separation rates, along with data on average wages for each occupation, and estimates of the immigrant wage gap, allows for the quantification of the key labor market parameters.

Given the observed and calibrated *migration equilibrium*, I calculate counterfactual scenarios without any immigrants in the labor force. Broadly speaking, there are two extreme assumptions about the macroeconomic environment in which wage determination takes place. In highly open economies, relative prices of goods and services associated with different occupations are determined in global markets, and do not respond to labor supply changes. Similarly, the capital-output ratio adjusts quickly to an immigration shock. Under these circumstances, the main effect of immigration on wages is via the bargaining process, which leads to an *increase* in native wages and a *decline* in native wage inequality, at least for the pattern of migration observed in Europe.

In the second case, when the economy in question is closed, both relative prices and the capital-output ratio change, at least in the short-run. If, as in the data, the occupation composition of immigrants is different from natives, relative price movements lead to changes in relative wages. Given migration patterns, this leads to a significant decline in low-skilled wages, and to an increase in wage inequality. A lower capital-output ratio further decreases native real wages, since the real rental rate of capital rises. One of the main conclusions of this paper, therefore, is that the extent of openness is the key determinant of how native wages and wage inequality are impacted by large-scale immigration.

My approach combines key ingredients from three closely related papers. Chassamboulli and Palivos (2014) work in a very similar framework, embedding frictional labor markets into a macroeconomic environment with capital. They rely on the same key mechanisms: bargaining power, relative prices, and capital-labor substitution. In contrast to the present paper, however, they work with only two labor types, skilled and unskilled workers, whereas I include 8 occupation categories in the analysis. This allows me to use occupation-level wage data in the calibration, also estimating productivity differentials across occupations.[2]

Chassamboulli and Palivos (2014) calibrate their model to the United States, assuming a closed economy, whereas I allow for the possibility that relative prices are determined globally. Not necessarily consistent with the closed economy setup, they assume that the capital stock is always in steady state, while in my case the capital-labor ratio may change with the immigration shock. This allows me to explore a key determinant of how immigrants impact native wages, i.e. the extent of openness in goods and capital markets.

An advantage of the setup in Chassamboulli and Palivos (2014) from a theoretical perspective is that they allow for different substitution elasticities between capital on the one hand, and skilled and unskilled labor on the other hand. With 8 occupation categories picking the right elasticities would be very difficult, so I focus on the Cobb-Douglas case. The upside of my choice is that the calibration and the calculation of the various counterfactuals in particularly simple.

The second closely related paper is Moreno-Galbis and Tritah (2016). They use the same framework on the labor market, with a slight difference in the wage bargaining assumption.[3] The key common assumption in their paper and the current one is the lower outside option of immigrants, which leads to different wages even for workers that have the same productivity. Moreno-Galbis

[2] Chassamboulli and Palivos, 2014 generate a skilled-unskilled wage gap by assuming differential search costs, a much less realistic assumption than differences in productivity (human capital).

[3] These differences are not important for the main results.

and Tritah (2016) use the matching model to motivate a reduced-form econometric exercise, testing the qualitative implications of the wage setting process. In the current paper, however, the labor market is embedded in a macroeconomic environment, and the full model is calibrated to labor market data. This allows me to run counterfactual exercises about the impact of immigration on wages and wage inequality.

Finally, Burstein et al. (2020) emphasizes the different levels of tradability for occupations, at least across regions in the United States. As I also show, the extent of tradability is crucial to understand how immigration affects wages. There are two important differences in the modeling approach of Burstein et al. (2020) and the current paper. First, they do not consider capital as a factor of production, thus omitting the effect of the capital-labor ratio on real wages. Second, they work in a neoclassical setting, and do not consider matching frictions. They allow native and immigrant workers to differ exogenously within the same occupation, while here ex-post heterogeneity arises endogenously due to the different outside options.

Overall, to the best of my knowledge, this is the first paper to incorporate matching frictions in a broader macroeconomic framework in the European context. The combination of detailed occupations, relative price effects, and the role of the capital-labor ratio is a unique feature of the model. Also, I provide a detailed analysis of both (real and nominal) wages by occupation, and wage inequality overall. The focus on wage inequality is important from a policy perspective, since it drives much of the discussion about the desirability of future immigration. While I look at only at the four largest EU economies, but the approach can be applied to any country that reports the necessary data for the calibration.[4]

The rest of the paper is organized as follows. Section 2 describes the search-and-matching framework of the labor market, while Section 3 details how this is embedded into a macroeconomic environment. Section 4 presents a detailed description of the data and the calibration process. Section 5 contains the results on nominal and real wages, and on wage inequality. Finally, Section 6 concludes.

[4] I report numbers for the four countries mostly for expositional purposes. Similar results are available for most EU economies from the author upon request.

2 A model of segmented search

This section describes the search model, which forms the basis in the quantification of the impact of immigration on wage inequality. The model is an extended version of Moreno-Galbis and Tritah (2016), who introduced differential outside options into evaluating the effect of immigration on native wages. The main assumptions are as follows.

Jobs are created by competitive, single-employee firms, as in the standard approach (Pissarides, 2000). The labor market is segmented by occupations, and workers can only search in one chosen occupation. In case of immigrants, and in line with the empirical evidence, this may involve occupational downgrading once in the host country. To keep the model simple, separation rates are exogenous and constant (Merz, 1995; Andolfatto, 1996).

In each occupation, immigrants and natives are searching together. In terms of productivity, they are perfect substitutes for firms once hired. They differ, however, in their outside option. This is both because of immigrants' more limited eligibility for unemployment benefits, and also because of their weaker support networks in the host country. This difference introduces an important channel through which immigration impacts wage setting and wage inequality.

2.1 Unemployment and matching

The model is set in discrete time, with a quarterly frequency. Potential workers (the unemployed) search for jobs and meet vacancies opened by firms randomly. This process is captured by the aggregate matching function for each occupation:

$$m_{j,t} = \mu v_{j,t}^{1-\sigma} u_{j,t}^{\sigma},$$

where m denotes new matches (job interviews), v is open vacancies, and u is the number of unemployed looking for jobs in occupation j. The unemployed are composed by natives and immigrants:

$$u_{j,t} = u_{j,t}^{n} + u_{j,t}^{m},$$

where m, n denote immigrants and natives, respectively. For future reference, we can define the share of immigrants among the unemployed as

$$\upsilon_{j,t} = \frac{u^m_{j,t}}{u_{j,t}}.$$

Employment n_t evolves through separations and new matches. As in much of the literature (Merz, 1995; Andolfatto, 1996), I assume that a new match becomes productive in the following period. In equilibrium, all matches are successful, so the flow equation of employment is given by

$$n_t = (1 - s)\, n_{t-1} + m_{t-1}, \tag{2.1}$$

where s is the exogenous separation rate.

I assume that the labor force is fixed at the occupation level, and regular movements into and out of the labor force are not important to understand the impact of immigration on labor market equilibrium. The labor force is composed of the employed and the unemployed:

$$n_{j,t} + u_{j,t} = l_{j,t}, \tag{2.2}$$

where $l_{j,t}$ is exogenously given (but not necessarily constant). The labor force is composed of immigrants ($l^m_{j,t}$) and natives ($l^n_{j,t}$), whose numbers are also fixed.

Using the matching function, we can define the job finding (f_t) and job filling (q_t) rates as follows:

$$f_{j,t} = \frac{m_{j,t}}{u_{j,t}} = \mu \left(\frac{v_{j,t}}{u_{j,t}} \right)^{1-\sigma} \tag{2.3}$$

$$q_{j,t} = \frac{m_{j,t}}{v_{j,t}} = \mu \left(\frac{v_{j,t}}{u_{j,t}} \right)^{-\sigma}. \tag{2.4}$$

Given the assumption of constant returns to scale in matching, f_t and q_t are only functions of labor market tightness, $\theta_{j,t} = v_{j,t}/u_{j,t}$. Note that since immigrant and native job searchers are not distinguishable ex ante by firms, the job finding rate is the same for the two sub-groups within an occupation.

2.2 Job creation

Firms create jobs via posting vacancies. Opening and maintaining a vacancy is subject to a period cost of κ. The value of a filled job depends on the (occupation specific) productivity $\zeta_{j,t}$ and on the wage rate $w_{j,t}$. More specifically, the value functions for a filled position and an open vacancy are as follows:

$$
\begin{aligned}
J^i_{j,t} &= p_{j,t}a_{j,t} - w^i_{j,t} - r_t k_{j,t} + \beta \mathbb{E}_t \left[(1-s)\, J^i_{j,t+1} + sV_{j,t+1} \right] \\
V_{j,t} &= -\kappa + \beta \mathbb{E}_t \left[q_{j,t} \bar{J}_{j,t+1} + (1-q_{j,t})\, V_{j,t+1} \right].
\end{aligned}
$$

Note that once a job interview is in place, firms learn the identity of the applicant. Given the different outside options of natives and immigrants, their negotiated wages in general will also differ. This means that the value of a filled position has to be conditioned on the worker type i. Since the type is not known when a vacancy is posted, advertising firms calculate with the average job value, $\bar{J}_{j,t} = \upsilon_{j,t} J^m_{j,t} + (1-\upsilon_{j,t})\, J^n_{j,t}$.

Introducing the notation $\zeta_{j,t} = p_{j,t}a_{j,t}$, the value of a filled job can be written as

$$
J^i_{j,t} = \zeta_{j,t} + \beta \mathbb{E}_t \left[(1-s)\, J^i_{j,t+1} + sV_{j,t+1} \right].
$$

As standard in the literature, we assume free entry into vacancy creation. The free entry condition implies that the value of vacancies is identically zero, $V_{j,t} \equiv 0$. Substituting this into the three value functions ($V_{j,t}$, $J^n_{j,t}$ and $J^m_{j,t}$) and rearranging yields the well-know job creation condition:

$$
\frac{\kappa}{q_{j,t}} = \beta \mathbb{E}_t \left[\zeta_{j,t+1} - \bar{w}_{j,t} + \frac{(1-s)\,\kappa}{q_{j,t+1}} \right], \tag{2.5}
$$

where $\bar{w}_{j,t} = \upsilon_{j,t} w^m_{j,t} + (1-\upsilon_{j,t})\, w^n_{j,t}$. This is the standard formula, where the cost of creating and maintaining a vacancy equals to the expected flow profit of a filled job and the option value of not having to post a vacancy again in the future.

2.3 Wage setting

To describe wage setting, we first define the value functions of workers and the unemployed for natives and immigrants in occupation j:

$$W_{j,t}^{i} = w_{j,t}^{i} + \beta \mathbb{E}_t \left[(1-s) W_{j,t+1}^{i} + s U_{j,t+1}^{i} \right]$$
$$U_{j,t}^{i} = b_{j,t}^{i} + \beta \mathbb{E}_t \left[f_{j,t} W_{j,t+1}^{i} + (1-f_{j,t}) U_{j,t+1}^{i} \right],$$

where b_t^i is the outside option for a worker when unemployed. Notice that b is different for natives and immigrants, and possibly also depends on the occupation type. The latter is allowed because typically unemployment replacement rates are lower at higher wage levels (see the calibration section below). We can define the net value of a job as the difference between the two value functions:

$$W_{j,t}^{i} - U_{j,t}^{i} = w_{j,t}^{i} - b_{j,t}^{i} + \beta \mathbb{E}_t \left[(1-s-f_{j,t}) \left(W_{j,t}^{i} - U_{j,t}^{i} \right) \right].$$

Wage setting follows the Nash-barganing solution (Mortensen and Pissarides, 1994), which implies a constant sharing rule each period:

$$W_{j,t}^{i} - U_{j,t}^{i} = \eta \left(J_{j,t}^{i} + W_{j,t}^{i} - U_{j,t}^{i} \right),$$

where η measures the exogenous bargaining power of workers, assumed to be the same for each agent. Using the value function definitions in this equation, one can derive the wage equation. Since the derivation is well-known, I omit the details here:

$$w_{j,t}^{i} = \eta \left(\zeta_{j,t} + \kappa \theta_{j,t} \right) + (1-\eta) b_{j,t}^{i}. \tag{2.6}$$

The equation clearly shows that due to the different outside option assumption, immigrants and native will generally receive different wages in the same occupation type.

2.4 Labor market steady state

Since I am interested in the systematic impact of immigration, I will concentrate on the steady state. This is not the same concept as a long-run equilibrium, as changes in various model parameters will also change the steady state. Focusing on the steady state simply means that I abstract away from the dynamic adjustment unrelated to the systematic impact of immigration.

The steady state can be summarized by the following conditions, using equations (2.1), (2.2), (2.3), (2.4), (2.5) and (2.6):

$$
\begin{aligned}
u_j^i &= \frac{s l_j^i}{s + f_j} \\
q_j &= \mu \theta_j^{-\sigma} \\
f_j &= \mu \theta_j^{1-\sigma} \\
\frac{\kappa}{q_j} &= \frac{\zeta_j - \upsilon_j w_j^m - (1-\upsilon_j) w_j^n}{1 - \beta(1-s)} \\
w_j^i &= \eta(\zeta_j + \kappa\theta_j) + (1-\eta) b_j^i.
\end{aligned}
$$

Notice that the unemployment rate u_j^i / l_j^i is the same for natives and immigrants, as it only depends on the inflow and outflow rates determined by aggregate tightness.

3 The macroeconomic environment

Having described the labor market, we now embed it into a general macroeconomic environment, which allows us to add two short-run factors to quantify the effect of migration on wages and wage inequality. First, we allow for demand-side effects that lead to relative price – and hence wage – changes across occupations (Cortes, 2008; Burstein et al., 2020). This effect captures the impact of increased competition within occupation categories due to the uneven immigration patterns presented earlier. Second, the capital stock may not adjust immediately as the labor force increases with immigration, leading to a general decline in the price of labor relative to the price of capital (Borjas et al., 1996; Borjas et al., 1997). While this does not necessarily influence *wage* inequality, it does contribute to overall inequality once capital income is taken into account.

3.1 Final goods

To keep the model tractable, I use a simple specification to embed the labor market into the broader environment. I assume that consumption and investment require a homogenous final good, which is assembled from individual varieties produced at the different labor market segments described in the previous section, and physical capital. The aggregate production function is given as

$$Y = K^{\alpha} Z^{1-\alpha},$$
$$Z = \prod_j z_{j,t}^{\chi_j}$$

where K is the economy-wide capital stock, z_j is total production in occupation j, and $\sum_j \chi_j = 1$ (constant returns to scale). Recall that $z_j = a_j n_j$, where a_j is labor productivity and n_j is the number of workers engaged in occupation j. The Cobb-Douglas specification is somewhat restrictive, but leads to a particularly tractable framework.[5] Moreover, it would be difficult to calibrate a more general production function, where the elasticity of substitution between occupations is different from unity. Finally, the unit elasticity leads to a particularly simple and tractable model, which is very easy to calibrate from labor market data.

The final good is produced by competitive firms. The representative firm solves the following problem:

$$\max \Pi = PK^{\alpha} \left(\prod_j z_{j,t}^{\chi_j} \right)^{1-\alpha} - rPK - \sum_j p_j z_j,$$

where p_j is the price of an individual variety (as introduced earlier), P is the price of the final good, and r is the real rental rate of capital.

The derivation of the first-order conditions is standard, and leads to the following equations:

$$r = \alpha K^{\alpha-1} Z^{1-\alpha} \tag{3.1}$$
$$z_j = \frac{\chi_j (1-\alpha) PY}{p_j}. \tag{3.2}$$

[5] The same assumption about the substitutability of occupations was made in the context of economic growth by Dvorkin and Monge-Naranjo, 2019

The aggregate price index follows from the first-order conditions, and it is defined as

$$P = \underbrace{\alpha^{-\alpha} (1-\alpha)^{-(1-\alpha)}}_{\vartheta} r^{\alpha} P_z^{1-\alpha} \tag{3.3}$$

$$P_z = \prod_j \left(\frac{p_j}{\chi_j} \right)^{\chi_j}. \tag{3.4}$$

3.2 Aggregate equilibrium

The macroeconomic equilibrium is defined by a set of prices, $\{p_j\}$ and r, and the associated quantities $\{z_j\}$ and K. The determination of these prices depends on whether the economy is closed, or integrated in the international economic environment (small open economy). Alternatively, even for open economies, one can think about the closed economy setup as a short-run step along the adjustment path when a migration shock hits. In the following I define the two alternative sets of assumptions and state the respective conditions for price determination.

Open economy Prices and the rental rate of capital are determined on international markets. In this case, migration has no impact on the prices of individual varieties. The rental rate of capital is also given by the international capital market, which I assume is in steady state. I omit the formal derivation of the determination of the real interest rate, assuming that it is the same as in standard neoclassical growth models. The steady state real rental rate of capital is given by

$$r^* = \frac{1}{\beta} - 1 + \delta, \tag{3.5}$$

where β is the subjective discount factor and δ is the depreciation rate of the capital. With open capital markets the capital stock always adjusts so that the rental rates are equalized across countries at the steady state level.

Closed economy In this case the individual prices are determined by demand conditions, as captured by eq. [3.2]. Using this condition for two different varieties, relative prices are given by

$$\frac{p_j a_j n_j}{p_1 a_1 n_1} = \frac{\chi_j}{\chi_1}. \tag{3.6}$$

Without loss of generality, I use good 1 as the numeraire, i.e. $p_1 = 1$. The rental rate of capital is determined by the supply and demand of capital, linked by eq. [3.1]. For a given capital stock, the condition determines the real rental rate endogenously.

The model is solved by selecting the appropriate equilibrium concept and by calibrating the necessary parameter values. I describe the calibration and data in the next section, and present results afterwards.

4 Calibration and data

4.1 Data

The main goal of the paper is to evaluate counterfactual scenarios about the extent and consequences of immigration into European countries. I calibrate the steady state equilibrium to recent labor market data when available. In principle, most European Union countries could be included in the analysis, but for presentation purposes I restrict the country sample to the four biggest EU countries: France, Germany, Italy and Spain. In addition to being the largest economies in the EU, they also had significant immigrant shares in employment (see Table 1 below).

Since search is occupation specific, ideally calibration should also be done at this level. Unfortunately even when data exists in principle, there are often too many missing observations. In these cases I use aggregate statistics, and indicate when data constraints are present. The main data source is Eurostat, but I also use auxiliary data from the OECD and from an ILO article (Amo-Agyei, 2020). Detailed data sources are listed in Appendix A.

First, I fix some parameters that are either not very important for the results, or have standard values in the literature. For the discount factor, I use $\beta = 0.99$, which is usual for quarterly frequency. I set the elasticity of the matching function to $\sigma = 0.5$ and the exogenous bargaining power of workers to $\eta = 0.5$. The first value is in the range of admissible values as estimated by Petrongolo and Pissarides (2001). The assumption that $\eta = \sigma$ is equivalent to the Hosios condition (Hosios, 1990), and it is commonly assumed in the literature. Note that overall bargaining power is determined not only by this parameter, but also by the outside option of workers, a parameter we calibrate separately.

The three key labor market indicators I use are the separation rate s, the job finding rate f and labor market tightness θ. Tightness can be directly calculated from observations on vacancies and unemployment. These data in principle exist at the occupation level, but for most EU countries vacancy observations are missing. I therefore rely on aggregate tightness and assume it is the same - at the chosen time period of 2019 - across the occupations.

To calculate the job finding and separation rates, I use an extended version of Shimer's method (Shimer, 2005). The original approach assumes two relevant labor market states - employment and unemployment - and uses data on the duration of unemployment to identify the unemployment outflow rate (interpreted as the job finding rate). The two-state assumption, along with the flow equation of employment (eq. [2.1]), defines the job separation rate. Shimer (2005) shows that in the context of the United States this approach yields a very good approximation of the underlying flow rates, and is much less data intensive than a direct flow-based method.

Tab. 1: Descriptive statistics, aggregate

Country	Sep. rate	Job find. rate	Tightness	Wage gap	Immig. share
Germany	0.03	0.52	1.17	0.20	0.20
Spain	0.06	0.32	0.04	0.28	0.18
France	0.04	0.34	0.15	0.09	0.14
Italy	0.03	0.24	0.14	0.30	0.14

Source: Eurostat, own calculations

An alternative to using unemployment duration is to utilize data on job tenure. Job tenure information can be used to directly calculate the job separation rate. Maintaining the two-state assumption, eq. [2.1] can than be used to calculate the job finding rate. In general, the two procedures yield different results when (i) movements into and out of inactivity, and (ii) job-to-job transitions are present. Therefore I take simple averages of the rates based on unemployment duration and job tenure. A final issue is the time aggregation bias discussed in Shimer (2005), which I correct for by relying on an underlying continuous time process. Appendix B contains the details.

I rely on Amo-Agyei (2020) for the immigrant wage gap in each country. In addition to the aggregate numbers, the paper also (graphically) reports wage differences by occupation categories, but not for all countries in the sample. I therefore use the country level averages and assume it to be the same for each occupation.

Tab. 2: Descriptive statistics, occupations

	OC1	OC2	OC3	OC4	OC5	OC7	OC8	OC9
Immigrant share								
Germany	0.14	0.15	0.14	0.13	0.23	0.24	0.35	0.49
Spain	0.14	0.09	0.12	0.12	0.24	0.23	0.19	0.41
France	0.11	0.12	0.09	0.10	0.17	0.17	0.15	0.24
Italy	0.08	0.05	0.06	0.06	0.20	0.20	0.20	0.35
Relative wage								
Germany	2.33	1.40	1.06	0.84	0.64	0.82	0.77	0.57
Spain	1.99	1.37	1.15	0.88	0.70	0.85	0.89	0.67
France	1.88	1.29	0.96	0.72	0.68	0.73	0.77	0.60
Italy	3.37	1.18	1.14	0.93	0.76	0.81	0.84	0.68
Replacement rate								
Germany	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.59
Spain	0.56	0.56	0.56	0.54	0.54	0.54	0.54	0.54
France	0.68	0.68	0.67	0.67	0.67	0.67	0.67	0.67
Italy	0.53	0.53	0.53	0.62	0.62	0.62	0.62	0.62

Source: Eurostat, own calculations

Table 1 shows the country-specific values used for the calibration. The job separation rates vary between 0.03-0.06, while job finding rates vary between 0.24-0.57. Labor market tightness, the ratio of vacancies to unemployment, is also highly different across countries, with a range of 0.04-1.17. The immigrant wage gap is universally positive, with the highest difference of 0.3 in Italy, and the lowest difference of 0.09 in France. The country with the highest immigrant share Germany (0.20), while France and Italy have somewhat lower values (0.14).

The last part of the calibration uses occupation specific indicators. I collect data on employment by occupation and country of birth, which is used to calculate the share of immigrants among workers in an occupation. To calibrate the outside option parameters for native and immigrant workers, I use the following procedure. First, data on wages by occupation is available from Eurostat. I work under the natural assumption that these are averages based on the actual observed native-immigrant composition in employment. Due to the lack of reliable data, I work with 8 out of the 9 main occupation categories, omitting category 6 ("Skilled Agricultural, Forestry and Fishery Workers"). Since there are only a few worker in this occupation, the quantitative conclusions are not sensitive to the inclusion or omission of this category.

Third, I use OECD data on unemployment benefit replacement rates for various worker categories. I take values for singles, at the level of the average wage and at the level of 67% of the average wage. Using data on unemployment duration, I calculate average durations for each country, and match the benefit replacement rate schedule to that average duration. Finally, for occupations where the wage is above the average, I use the average wage replacement rate. For occupations whose wage is below average, I use the 67% value for the replacement rate. This makes the replacement rate occupation specific, although only distinguishing two broad categories of occupations.

Table 4.1 presents the occupation-specific indicators that are used in the calibration. The share of immigrant workers varies by occupation, but it is typically higher in less skilled jobs. The relative wage - defined as the ratio relative to the economy-wide relative wage - also declines by skill requirements. As discussed above, the unemployment replacement rate is distinguished between occupation that have above and below average wages.

4.2 Calibration

Note that we observe a migration equilibrium, but we do not know if it is a closed, or open economy one, as defined earlier. Luckily, the structure of the model allows me to base the calibration of the parameter values on labor market data, and postpone the question of the equilibrium type to the derivation of counterfactuals.

First, without loss of generality I can choose units such that in the observed migration equilibrium $\forall j : p_j = 1$. This choice implies that $\zeta_j = a_j$, i.e. I can calibrate the productivity parameters directly from the labor market equilibrium conditions below. To conserve notation, I will omit the time and occupation indices when no confusion arises. I work with quarterly data, which is appropriate for labor market parameterization in the European context (monthly data is mostly unavailable).

Using data on the job finding rate and tightness, the matching efficiency parameter can be calculated as

$$\mu = \frac{f}{\theta^{1-\sigma}}.$$

This, substituted into eq. [2.4] yields the job filling rate q.

Next, let $\bar{b}_u = \bar{b}/\bar{w}$ be the observed replacement rate. Substituting this into the wage equation [2.6] and rearranging leads to

$$\bar{w} = \frac{\eta\,(a + \kappa\theta)}{1 - (1 - \eta)\,\bar{b}_u}.$$

Plugging this into the job creation condition [2.5] and rearranging yields the calibrated value of the vacancy cost:

$$\kappa = \frac{q(1-\eta)\left(1-\bar{b}_u\right)\bar{w}}{\eta\left[1-\beta(1-s)+f\right]}.$$

Putting κ back into the wage equation, one can rearrange for the occupation specific productivity parameter a.

To calibrate the separate outside options for immigrants and natives, we first express the native wage as a function of the average wage:

$$w^n = \frac{\bar{w}}{1-\omega+\omega\lambda},$$

where $\lambda = w^m/w^n$ is the immigrant wage gap and ω is the share of immigrants among the employed (in a particular occupation).[6] Given the value of λ, this equation also defines the immigrant wage w^m. Using these wages in the wage equation [2.6], we can solve for the unknown parameters b^m and b^n. Finally, for future usage we can also calculate the differential replacement rates as $b_u^i = b^i/w^i$.

Turning to parameters outside the labor market, I use standard values from the literature to set $\beta = 0.99$ (the discount factor), $\delta = 0.015$ (depreciation rate) and $\alpha = 0.33$ (capital share in GDP). This yields the steady state real rental rate of capital r^* as defined by eq. [3.5]. To select the variety share parameters χ_j, I utilize eq. [3.2] and the choice of unitary prices in the benchmark equilibrium. Rearranging the relative demand condition for varieties, the shares are given as

$$\frac{\chi_j}{\chi_1} = \frac{a_j n_j}{a_1 n_1} \quad j > 1,$$

where n_j are simply the observed employment levels in each occupation and a_j was already calibrated from the labor market. We need an extra condition to pin down the value of χ_1: this is given by the assumption of constant returns-to-scale, i.e. that $\sum_j \chi_j = 1$.

Since the calibrated parameters are either difficult to interpret (μ, κ) or fairly closely related to data observations (a, b_u^i) I do not present them here to conserve space. All values are reasonable given the observed data moments. Details are available from the authors upon request.

[6] Note that in the steady state equilibrium, the unemployment rate is the same for immigrants and native. This implies that the share of immigrants among the employed is the same as the share of immigrants among the unemployed.

5 The impact of migration

The calibrated migration equilibrium serves as the benchmark against we can evaluate counterfactuals. The most important questions concern the impact of immigration on aggregate and occupation-level wages, and on wage inequality. Unfortunately, it is not possible to give an unequivocal answer to this question given the available data. The reason is that we do not observe whether the migration shock led to changes in relative prices and the capital-output ratio. In other words, we do not know whether, and to what extent, the observed economy is in an open or closed equilibrium, as defined in section 2.

To circumvent this problem, I examine one intermediate and two extreme scenarios. In one extreme, I calculate the non-migration equilibrium under the assumption that neither relative prices nor the rental rate of capital changes, i.e. the capital stock adjusts to the increased population (the open economy setting). In the other extreme, I assume a closed economy in the short-run. In this case, relative prices are determined by the relative demand conditions [3.2]. These are different in a closed economy without migrants, since their occupational distribution differs from natives (see Table [4.1]). I also assume that the capital stock is in steady state before migration occurs, but there is no additional capital accumulation once immigrants arrive. Note the inverted logic in this exercise: since we observe the equilibrium with immigration, we essentially "reverse engineer" the no-migration past by making assumptions about the nature of the unobserved adjustment process.

As an intermediate step, I also calculate a counterfactual case without immigrants when prices do not change (free trade), but capital takes longer to adjust. This way I can separate the impact of price changes (the demand side) from the impact of factor prices. It is important to emphasize that the second effect will have no impact on wage inequality, since capital has a symmetric effect on all occupations. If, as often discussed in the literature (Borjas, 1995; Ben-Gad, 2008; Krusell et al., 2000), skilled and unskilled labor have different elasticities of substitution with capital, there would also be distributional effects when the capital-labor ratio changes. Introducing this channel, however, would substantially complicate the model, and I leave it for further research.

To summarize, I study three possible scenarios to quantify the impact of immigration on wages, working backwards from the migration equilibrium.

1. **Scenario 1** ("Open"): migration does not change relative prices or the capital-labor ratio.
2. **Scenario 2** ("Capital"): migration does not change relative prices, but the capital stock remains constant at its pre-migration level.
3. **Scenario 3** ("Closed"): migration leads to changes in relative prices, and the capital stock remains constant at its pre-migration level.

5.1 Nominal and real wages

I start the analysis with presenting nominal and real wages under the three alternative scenarios. Recall that the capital stock does not have a direct impact on nominal wages, because it only enters the aggregate production function. It does, however, influence real wages through the rental rate of capital and the overall price index (equations [3.1] and [3.3]). Changes in relative prices impact both nominal wages (through the marginal value product of labor, $\zeta = pa$) and real wages (through the price index P). Ultimately it is real wages that are linked to welfare, but looking at nominal wages separately helps identify the role of prices in real wage changes.

Table 3 present results for the three scenarios, as discussed in the previous section. The table cells contain changes (in percentages) between the hypothetical no-migration equilibrium and the observed migration equilibrium. As discussed earlier, I calculate wages for 8 out of 9 occupation categories. Wage changes vary by occupation because the composition of immigrants is different from natives. Note that the table contains *native* wages, which are the appropriate indicators to understand the changes relative to the no-migration equilibrium.

The impact of immigration on real wages is highly heterogenous both across occupations and across countries. As shown in Table 4.1, the share of immigrants is much higher in low-skilled occupations, as much as 49% in Germany in unskilled jobs (OCC9). If local demand constrains output increases, an increased labor supply leads to lower relative prices for goods and services intensive in low-skilled workers. One the other hand, high-skilled workers benefit (except in France), since relative prices in their sectors rise. These results are in line with findings of Borjas (2003), who also estimates a large short-run negative impact of immigration among the low-skilled.

Also note that real wage changes are lower (or more negative) than nominal wage changes. This

Tab. 3: Nominal and real wage changes

		Nominal wage change			Real wage change		
Country	Occupation	Closed	Capital	Open	Closed	Capital	Open
France	OC1	0.91	0.91	0.91	-1.97	-3.61	0.91
France	OC2	0.35	0.95	0.95	-2.53	-3.56	0.95
France	OC3	3.81	0.69	0.69	0.93	-3.83	0.69
France	OC4	2.48	0.79	0.79	-0.41	-3.73	0.79
France	OC5	-4.90	1.34	1.34	-7.79	-3.18	1.34
France	OC7	-5.10	1.35	1.35	-7.99	-3.17	1.35
France	OC8	-2.73	1.18	1.18	-5.62	-3.34	1.18
France	OC9	-13.94	1.95	1.95	-16.83	-2.57	1.95
Germany	OC1	2.79	2.79	2.79	1.50	-4.25	2.79
Germany	OC2	1.84	2.98	2.98	0.55	-4.06	2.98
Germany	OC3	2.91	2.77	2.77	1.62	-4.27	2.77
Germany	OC4	3.71	2.61	2.61	2.42	-4.43	2.61
Germany	OC5	-6.11	4.48	4.48	-7.40	-2.56	4.48
Germany	OC7	-7.32	4.69	4.69	-8.61	-2.35	4.69
Germany	OC8	-20.99	6.94	6.94	-22.28	-0.10	6.94
Germany	OC9	-42.42	9.84	9.84	-43.71	2.80	9.84
Italy	OC1	2.19	2.19	2.19	2.99	-2.37	2.19
Italy	OC2	4.82	1.32	1.32	5.62	-3.24	1.32
Italy	OC3	4.34	1.48	1.48	5.14	-3.08	1.48
Italy	OC4	4.21	1.54	1.54	5.01	-3.03	1.54
Italy	OC5	-8.85	5.61	5.61	-8.05	1.05	5.61
Italy	OC7	-8.96	5.65	5.65	-8.16	1.08	5.65
Italy	OC8	-8.80	5.60	5.60	-8.00	1.03	5.60
Italy	OC9	-25.50	9.98	9.98	-24.70	5.42	9.98
Spain	OC1	3.37	3.37	3.37	1.76	-3.02	3.37
Spain	OC2	7.33	2.28	2.28	5.72	-4.11	2.28
Spain	OC3	5.18	2.88	2.88	3.57	-3.51	2.88
Spain	OC4	5.11	2.89	2.89	3.50	-3.50	2.89
Spain	OC5	-7.46	6.11	6.11	-9.07	-0.28	6.11
Spain	OC7	-5.99	5.76	5.76	-7.59	-0.63	5.76
Spain	OC8	-2.11	4.80	4.80	-3.72	-1.59	4.80
Spain	OC9	-28.13	10.53	10.53	-29.74	4.14	10.53

is because with the capital stock fixed, the capital-labor ratio falls, and rental rate of capital rises. This leads to an increase in the overall price index P, which hurts real wages uniformly. Since migration shocks in the four countries are large (14%-20% of employment), a constant capital stock leads to a significant increase in the real rental rate of capital. In France, for example, the higher price level adds almost 3% to the nominal wage decline of 14% in unskilled occupations.

The third main effect – specific to the frictional nature of the labor market – is a differential increase in the nominal wages of all native workers. Lower outside options of immigrants lead to a worse wage bargaining position for them, which increases firm profits. Higher profits increase the expected surplus of job creation, leading both to more jobs and higher wage offers to natives, whose outside options are better. The impact is not uniform across occupations: lower skilled workers benefit more, since a higher share of immigrant workers allows firms to increase native wages more than in occupations with lower immigrant shares. In most cases, this effect is not strong enough to overcome the other two, especially for low-skilled occupations.

In the second scenario ("Capital"), when relative prices do not change but the capital stock has not adjusted yet, nominal wages changes are driven by the increased relative bargaining position of native workers only. This means that nominal wages rise across all occupations, but the increase is highest among the low-skilled (as the share of immigrants is highest among them). Real wages, however, still fall in most cases, since the increased real rental rate of capital drives up the price index. Although not a subject of the quantitative exercise, capital owners benefit and labor is worse off via this channel. Overall, as Table 3 demonstrates, the majority of native workers are hurt by immigration. But in Italy, for example, the impact on the real wages on low-skilled natives is positive, as the bargaining effect on nominal wages is higher than the price level increase due to the lower capital-labor ratio.

Immigration has a uniformly positive impact on native real wages in the "Open" case. Neither the demand, nor the capital effect is in operation, and wage changes driven solely by the bargaining channel. This is the point made by Moreno-Galbis and Tritah (2016), and relies crucially on the lower outside option of immigrant workers. This is supported empirically by the existence of an immigrant wage gap. As Table 3 shows, the effect is sizable, especially for low-skilled workers (up to 10% in Germany, Italy and Spain). The effect of immigration, therefore, is not uniformly negative for low wage workers. The net impact depends on the strength of the relative price (demand) channel, the capital channel, and the bargaining channel.

Tab. 4: Over-qualification rates

	Immigrants	Natives
Germany	31.2	15.6
Spain	53.5	34.3
France	30.4	20.6
Italy	51.4	17.1

Source: Eurostat

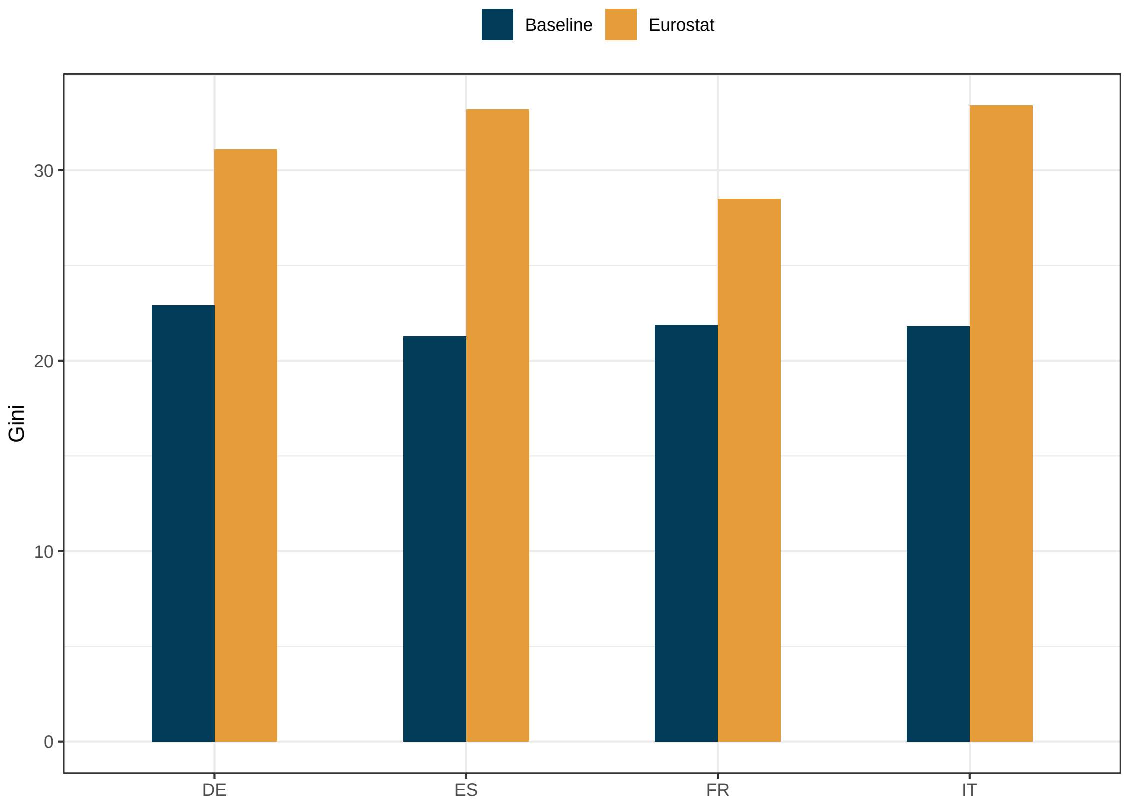
The three channels discussed so far operate in the short- and medium-run. There are two additional changes in the long-run that accompany immigrants' assimilation into the host country labor market. First, the bargaining disadvantage of immigrants eventually disappears, both because they acquire the same entitlements and natives, and also because they establish local networks and connections. Second, some (or all) of the occupational downgrading observed when arriving in the host country is reversed. Table 4 lists over-qualification rates for immigrants in the four countries, which are uniformly higher for immigrants. Without additional information on the home-country occupational distribution of immigrants, it is not possible to predict the precise effects of the gradual reversal of occupational downgrading. We do expect, however, that as immigrants are becoming more similar to natives (both in bargaining positions and in occupational structure), the short- and medium-run wage effects eventually disappear.

5.2 Wage inequality

The previous section discussed the effect of immigration on nominal and real wages in different scenarios. Now we turn to a more systematic analysis of wage inequality by looking at standard measure of inequality, the Lorenz curve and the summary statistics derived from it, the Gini coefficient. As before, we focus on native wages, since the policy debate is mostly about the impact of immigration on the native wage distribution. The calculations are based on wages by occupation category, using the native distribution of workers across occupations as weights.

Given the aggregate nature of the data used, and the macroeconomic model based on occupations, the calculations by definition miss wage inequality within occupations. Figure 5.1 shows the actual Ginis from Eurostat for the four analyzed countries, compared to the occupation-based Ginis calculated in the baseline migration equilibrium. As expected, the empirical measures are

Fig. 5.1: Empirical and calculated Gini coefficients in the observed equilibrium

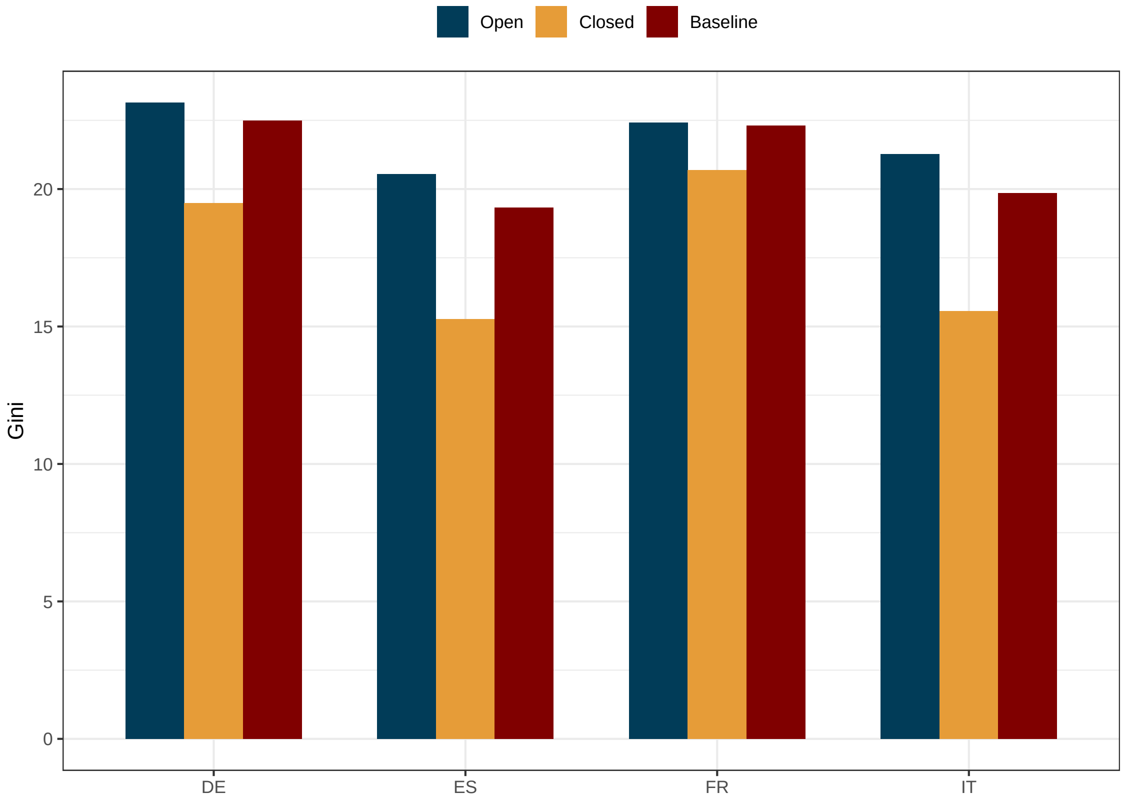


higher, since they include more information about the actual wage distributions. That said, occupational differences are highly important to understand wage inequality, and the model-based Ginis capture about two-thirds of overall wage differences. As long as *within-occupation* wage distributions are not highly systematically different between immigrants and natives, focusing on inequality *across occupations* gives us an accurate picture of the impact of migration on *changes* in inequality.

Figure 5.2 shows Gini coefficients from the baseline and two of the three scenarios discussed before. I omit the "Capital" scenario because in terms of wage distributions it is equivalent to the baseline, since the impact of the capital stock (through the price level P) is uniform across occupations. Wage inequality changes due to immigration operate via the other two main channels, the demand and bargaining channels.

As can be seen on the Figure, the bargaining channel alone (the change from the "Open" to the "Baseline" scenario) leads to reduction in wage inequality as measured by the Gini coefficient. The reason is that immigrants are overrepresented among low-skilled occupations. Recall that

Fig. 5.2: Gini coefficients in the three migration scenarios



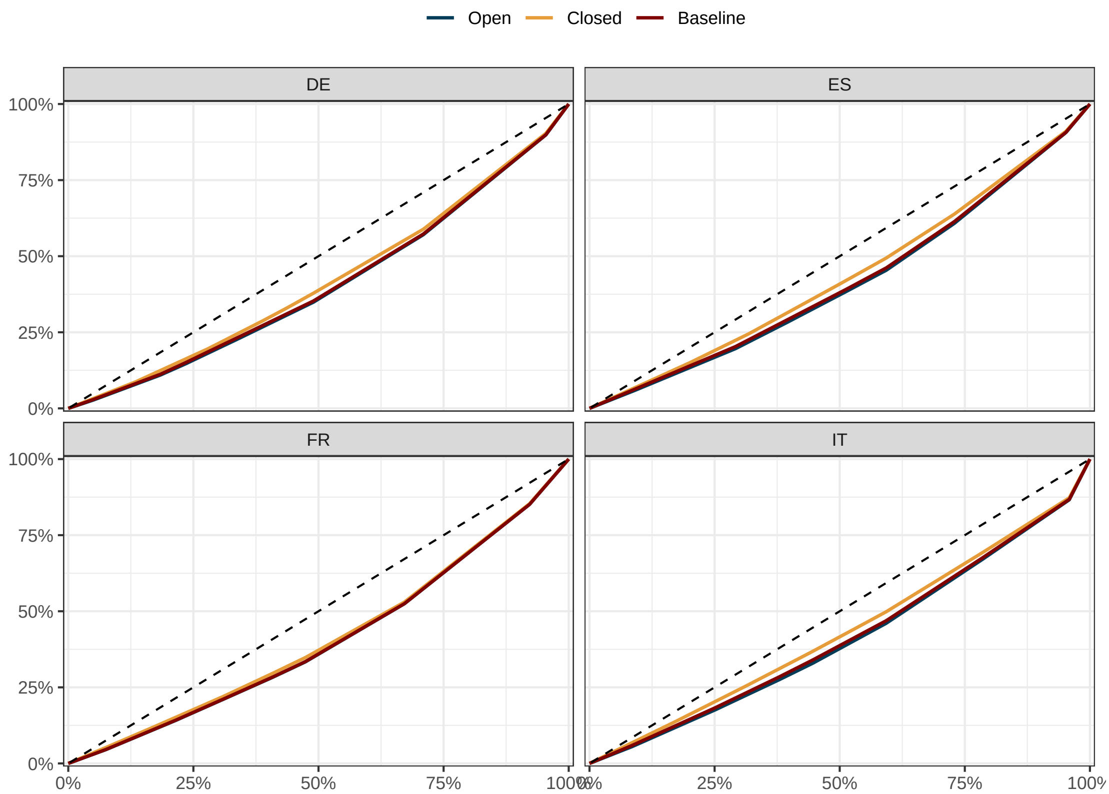
the lower bargaining position of immigrants allows firms to pay higher wages to natives, and this effect is bigger for the low-skilled. It can be shown that - due to the labor market setup - average wages are the same between the two scenarios. Natives simply benefit at the expense of lower paid immigrant workers.

When we compare the baseline migration equilibrium with the “Closed” no-migration scenario (the change from the “Closed” to the “Baseline” scenario), the result is very different. Due to the strong demand effects, the immigration shock, which is skewed towards the low-skilled, depresses the relative price of goods produced in the low-skill intensive sectors. In our calibrated model, this effect is stronger than the bargaining channel. With significant demand effects, native wage inequality increases.

Gini coefficients are useful because they condense information about income distribution into a single number. This also means, however, that much information about the underlying distribution is lost. For completeness, I also present Lorenz curves that show the cumulative wage distributions in the various scenarios. In particular, for the reasons outlined above, I retain the

“Closed”, “Open”, and “Baseline” scenarios. The results are shown on Figure 5.3.

Fig. 5.3: Lorenz curves

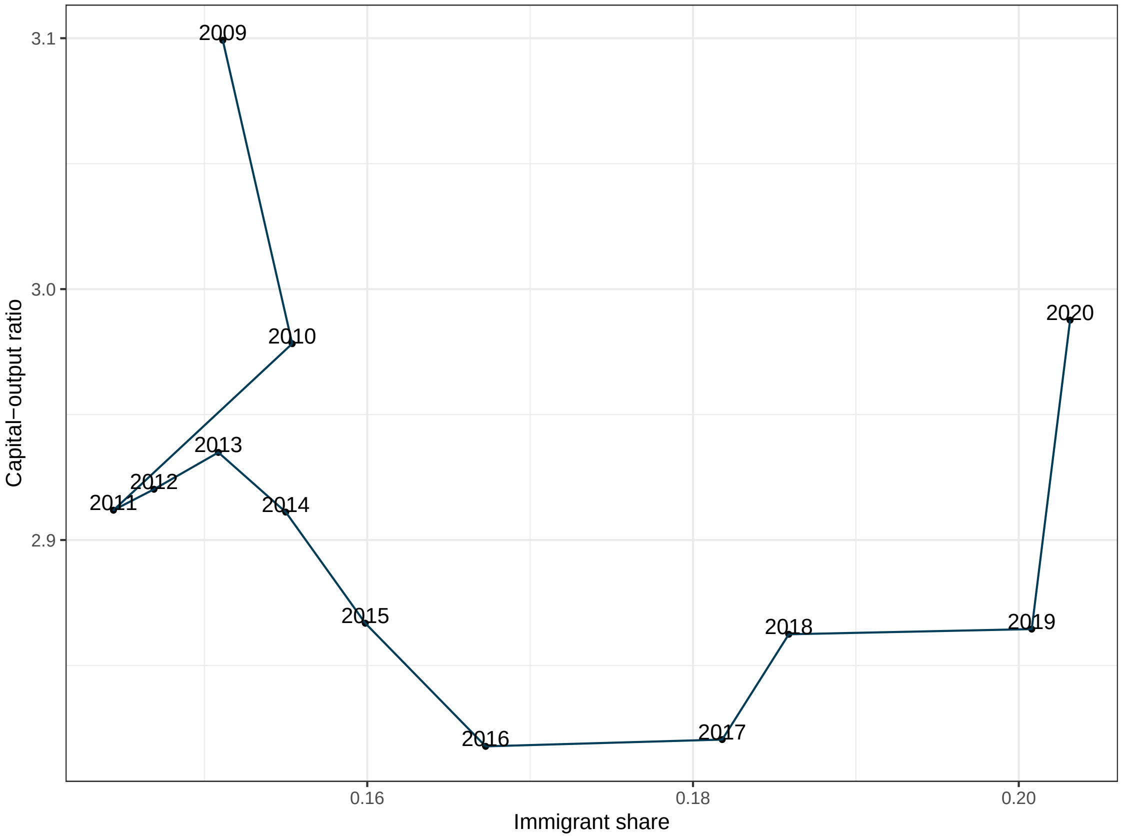


Overall, the figures support the conclusions drawn from the Gini comparisons. The impact of immigration on inequality crucially depends on the strength of the demand channel. When relative prices respond strongly, leading to an equally strong realignment of relative wages, native wage inequality rises significantly. On the other hand, the bargaining channel decreases native wage inequality, but the quantitative impact is moderate. Looking at the different countries, immigration has had a potentially bigger impact in Spain and Italy, compared to Germany and (specially) France.

5.3 Discussion

To summarize, the quantitative results for the four countries analyzed paint an ambiguous picture about the effects of immigration on wages and on wage inequality. The conclusions strongly depend on the strength of the demand channel, i.e. how much local demand conditions influence the relative wages of different occupations. When this channel is weak, immigration may even

Fig. 5.4: Capital-output ratios and immigration in Germany



mitigate wage inequality among natives. Alternatively, with strong demand effects, native wage inequality rises significantly.

The capital channel has a sizable impact on wages, but not on the wage distribution, at least in our framework where the elasticity of substitution between capital and labor is uniform across occupations. In any case, the capital-labor (or capital-output) ratio can be expected to adjust to the increased supply of labor, driven by the temporarily higher rental rate of capital. This may happen very quickly under open capital markets, which is the more likely case in the European Union. But even in a closed economy, the capital-output ratio is expected to return its steady state value over time.

Unfortunately, it is extremely hard to empirically distinguish between the various scenarios. In case of capital, Figure 5.4 illustrates this point by showing the evolution of the capital-output ratio and the share of immigrant workers between 2009-2019 (data for the latter starts in 2009). We see that the share of immigrants rose since 2011, by a total of 5 percentage points by 2009. The capital-output ratio fluctuated, but overall fell between 2011 and 2019. This seems to support the existence of a capital channel in the short-run. However, the period coincides with the global financial crisis and its aftermath. We know that investment activity was depressed for many years, caused by the crisis and leading to an overhang until the mid 2010s. It is impossible to disentangle the effect of migration from the effect of the financial crisis. Looking at the other countries (not shown) is even muddier.

It would be equally difficult to isolate the demand cannel.[7] One potential avenue of investigation would be to distinguish goods and services in terms of their tradability, and quantify their occupation content to see how much particular occupations are subject to local demand conditions. This is possibly feasible, with data on the occupational composition of production sectors. Note, however, that there are two practical issues the limit the usefulness of such an exercise. First, employment data in industry-occupation cells are likely to be incomplete (a casual check on Eurostat confirms this). Second and more importantly, putting one digit sectors (at which level such data is available) into tradable and non-tradable categories is highly imprecise and in the end subjective. That said, extending the current framework would be an interesting and perhaps an informative exercise.

6 Conclusion

This paper investigated the impact of immigration on wages and wage inequality using a macroeconomic framework. The model incorporates three main channels via which immigration impacts native wages: bargaining power in wage negotiations, local demand conditions for goods and services produced by workers in different occupations, and possible changes in the capital-labor ratio. I calibrated the model to European labor market data for the for largest economies in the European Union: France, Germany, Italy and Spain. Depending on the operation of the various channels, I calculated three counterfactuals and compared them with the observed migration equilibrium.

The main results are as follows. First, the given that immigrants tend to cluster in low-skilled occupations, the bargaining channel increases native wages and reduces native wage inequality. This channel is empirically supported by the immigrant wage gap. Due to the lower bargaining

[7] A similar exercise was done in a local labor market context in the United States by Burstein et al. (2020).

power of immigrants, firm profitability rises and they are able to pay higher wages to natives. This is strongest among the low-skilled, pushing up native wages there the most.

Second, the capital channel lowers the real wage of natives because it increases the rental rate on capital. In the current specification, however, it does not affect wage inequality, since the price level impact different occupations uniformly. Third, the extent to which occupations are affected by local demand conditions - as opposed to global demand - is crucial to understand how native wages change due to immigration. Strong demand effects increase native wage inequality, because (negative) wage changes are the strongest among the low-skilled.

The missing step in the current exercise is to pin down the relative importance of the three channels. In the long-run, when immigrants becomes more-and-more similar to natives, and the capital stock adjusts, the wage distribution is expected to return to its pre-migration pattern (absent other shocks). In the short-run, not only the strength, but the timing of the identified effects determine the overall evolution of native wage inequality. Disentangling these should be the goal of potentially very fruitful, but highly difficult future research.

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A Data sources

Eurostat

- Employment by sex, age, migration status, occupation and educational attainment level: LFSA_EGAISEDM (2021, 2022)
- Over-qualification rates by country of birth: LFSA_EOQGAC
- Employment by sex, age, occupation and educational attainment level: LFSA_EGISED
- Employed foreign-born by change in skill level from last job before migrating to current job, sex, age, country of birth and educational attainment level: LFSO_21EDUC05
- Foreign-born population by main obstacle to get a suitable job, sex, age, country of birth and educational attainment level: LFSO_21OBST01
- Mean annual earnings by sex, economic activity and occupation: EARN_SES18_49
- Job vacancy statistics by NACE Rev. 2 activity, occupation and NUTS 2 regions - quarterly data: JVS_Q_ISCO_R2
- Previous occupations of the unemployed, by sex (1 000): LFSQ_UGPIS
- Employment by sex, age, time since job started and economic activity (from 2008 onwards, NACE Rev. 2) - 1 000: LFSQ_EGDN2

OECD

- Net replacement rate in unemployment: NRR
- Unemployment by duration: DUR_D

International Labor Organization

- Migrant pay gaps using hourly wages, latest years: Amo-Agyei (2020), Figure 17

B Job finding and job separation rates

- Continuous time

$$
\begin{aligned}
\dot{n}_\tau &= f_t\left(1-n_\tau\right) - s_t n_\tau \\
\dot{n}_\tau + \left(f_t+s_t\right) n_\tau &= f_t \\
e^{(f_t+s_t)\tau} n_\tau &= f_t \int_0^\tau e^{(f_t+s_t)\nu} d\nu + c \\
e^{(f_t+s_t)\tau} n_\tau &= f_t \left[\frac{e^{(f_t+s_t)\nu}}{f_t+s_t}\right]_0^\tau + c \\
e^{(f_t+s_t)\tau} n_\tau &= \frac{f_t}{f_t+s_t}\left[e^{(f_t+s_t)\tau} - 1\right] + c \\
n_\tau &= \frac{f_t}{f_t+s_t}\left[1-e^{-(f_t+s_t)\tau}\right] + e^{-(f_t+s_t)\tau} n_t \\
n_{t+1} &= \frac{f_t}{f_t+s_t}\left[1-e^{-f_t-s_t}\right] + e^{-f_t-s_t} n_t \\
S_t &= \frac{n_{t+1}-n^s_{t+1}}{n_t} \\
s_t &= -\log(1-S_t) \\
F_t &= 1-e^{-f_t}
\end{aligned}
$$

- Unemployment duration and job finding rate

$$
\begin{aligned}
f_t &= 1-\frac{u_t-u^s_t}{u_{t-1}} \\
1-u_t &= \left(1-s_t\right)\left(1-u_{t-1}\right) + f_t u_{t-1} \\
u_t &= u_{t-1} + s_t\left(1-u_{t-1}\right) - f_t u_{t-1} \\
s_t &= \frac{u_t-\left(1-f_t\right)u_{t-1}}{1-u_{t-1}} \\
u_{t+1} &= \frac{s_t}{f_t+s_t}\left[1-e^{-(f_t+s_t)}\right] + u_t \\
1-e^{f_t} &= \frac{u_{t+1}-u^s_{t+1}}{u_t}
\end{aligned}
$$

– Continuous time

$$u_{t+1} = \frac{s_t}{f_t + s_t}\left[1 - e^{-f_t - s_t}\right] + e^{-f_t - s_t} u_t$$
$$1 - e^{f_t} = \frac{u_{t+1} - e^s_{t+1}}{e_t}$$