Who gains and who loses from migration? Theory and an application to Italy

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Abstract

We study the impact of a shock in the supply of low-skill immigrants on the welfare of workers in the receiving country within a novel general equilibrium search and matching model. We break the complementarity between skills imposed by the CES production function and we use an alternative mechanism which allows for the adjustment of the prices of the goods produced and consumed by all agents in the economy. The model is also characterized by workers heterogeneity, firing costs, search frictions, wage bargaining and the presence of a central authority which collects revenues by taxing wages and profits and redistributes the income through the provision of a public good, unemployment benefits and tax subsides. We find that as a consequence of the shock the aggregate output and the provision of public good increase. In addition, the wage level of low-skill workers decreases and unemployment is higher, while the wage level of high-skill workers increases due to the lower average price level. The overall effect on welfare is positive for native workers (on average a gain of about 10%) thanks to the increased provision of public good which more than compensates the decline in the wage of low-skill workers. The overall effect on the welfare of immigrant workers is instead negative, with an average loss of about 2.5%.

1 Introduction

The recent rise in immigration is a hotly debated and politically charged topic. At the heart of this discussion is the widespread belief by the general public and policy-makers that immigration

has adverse effects on the labour market. The fear of crowded out job opportunities and depressed wages is one of the main reasons for natives to oppose more liberal migration policies. However, the empirical evidence does not point to any significantly large effect of immigration on the labour market (Dustmann et al., 2001, 2013; Manacorda et al., 2012; Peri, 2014). Nevertheless, the adjustment mechanisms which operate within the receiving economy which prevent to observe significant movements in labour market outcomes are still unclear.

The aim of this paper is to fill this gap by studying the short-term impact of a migratory shock defined as the significant increase in the supply of labour of a specific skill level on the economy of the receiving country. To reach this objective we develop a general equilibrium search and matching model characterized by the presence of firing costs where two goods are produced using high-skill and low-skill labour, respectively, and both goods are consumed by all individuals, who are either native or foreign-born, i.e. immigrants. A central authority collects revenues by taxing wages and profits and redistributes the income through the provision of a public good, unemployment benefits and tax subsides. We break the complementarity channel between workers of different skills used so far in the literature (Battisti et al., 2018; Chassamboulli and Palivos, 2014; Ortega, 2000) by refraining from using a CES production function, which according to Borjas (2014), "greatly limit the structure of immigration wage effects". By allowing for multiple goods and competitive prices, then migration on top of changing the skill structure of the economy, may affect not only wages, but also the price level and the output mix. This type of mechanism, which we believe to be more realistic, has not been explored in the literature, as far as we are aware of, and this is precisely the scope of this paper.

We calibrate the model using data from Italy for each year in the period 2009-2015. We analyse the effect of an increase in the supply of low-skill labour not only on the wage level and unemployment rate of both high-skill and low-skill workers, but also on total production, the provision of public good, and the overall welfare of both categories of workers. We find that while the wage level of low-skill workers decrease as a consequence of the increased supply of low-skill workers, the wage of high-skill workers is higher due to the lower average price level. On the other hand, unemployment is higher among low-skill workers due to the excess labour supply. The overall effect on welfare is positive for high-skill workers and negative for low-skill workers. At the same time, welfare is higher among natives and lower among immigrants. We study how the magnitude of these effects differs in economy with rigid versus flexible labour markets. We find that countries characterized by higher firing costs, such as some of the southern European economies, respond with less flexibility to immigration, resulting in smaller wage effects and negative employment effects for native workers. We also analyse issues of congestion in the provision of the public good,

due to the enlarged size of the population. Finally, we focus on policy measures that could be implemented to redistribute wealth across workers, such as unemployment benefits, taxes and tax subsidies.

In the literature, studies of the effect of immigration on native labour market outcomes are abundant.[1] Several papers have chosen a model with a production technology that distinguishes between high-skill and low-skill labour, and assume that immigrants are perfect substitutes with their corresponding native skill category. In these papers, whenever immigrants with a specific skill level arrive in the economy, they induce a change in the overall skill composition, which leads to a disequilibrium between supply and cost minimising demand for different labour types at existing wages and output levels. Due to the excess supply of a specific type of workers at the ongoing wage rate, the absorption of immigrants into the economy involves short-run changes in wages and employment levels of different skill types. In particular, those workers that are most similar to immigrants in their skill composition may lose, but workers with different skills may gain due to complementarity (Dustmann et al., 2001, 2013). In case immigrants and natives are only imperfect substitutes within the same (observable) skill group, an increase in labour supply due to immigration will primarily affect other immigrants already living in the host country (Manacorda et al., 2012; Ottaviano and Peri, 2012). Within this framework, few papers use a general equilibrium search and matching framework to quantify the impact of immigration on native wages and employment. Chassamboulli and Palivos (2014) use a nested CES production function with capital, high-skill and low-skill labour for the production of a single good to study the impact of a high-skill biased immigration in the USA in the period 2000-2009 on the wages of natives. Our model on top of refraining from using a CES function, extends this framework by including two goods, a central Government, several parameters for policies and by evaluating the impact on a number of economic variables, including welfare. Battisti et al. (2018) calibrate a search and matching model to 20 different OECD countries and find that immigration in the period 2000-2011 has increased the welfare of native workers in the majority of these countries. Compared to our framework, they only have one good and introduce asymmetries between natives and immigrants with the same level of skills. Moreover, in their economy prices are competitively set equal to the marginal productivity. Ortega (2000) considers a two-country model and shows that two equilibria with and without immigration between the two countries can exist, but the former Pareto dominates the latter. However, they do not differentiate between high-skill and low-skill workers. Liu (2010) develops a dynamic general equilibrium model with imperfect substitution between domestic and illegal immigrants to quantify the welfare effects of illegal immigration. The

[1] Please see Blau and Kahn (2012); Longhi et al. (2010) for recent surveys of the literature on the topic.

paper that most closely resembles this study is the one by Iftikhar and Zaharieva (2016). They use a general equilibrium search and matching model to study the impact of immigration on the German labour market. Our paper adds to their framework as in our model we consider two final goods in a closed economy, so both prices are determined endogenously. In their framework the use of a small open economy leads the prices to be set either internationally or to be normalized in the calibration exercise. In addition, they do not include firing costs and taxes are set only on wages and not on profits.[2]

The contribution of this paper to the existing literature is therefore multi-fold. First, while much of the existing research has looked at wage effects of immigration taking into account only the complementarity channel, this paper makes a novel contribution to the literature by exploring the price channel through the inclusion of two consumption goods and equilibrium prices to be determined in equilibrium. This novel approach allows us to study the overall impact on immigration not only on wages, but also on prices, on the output mix and on total welfare. Second, we use a general equilibrium search and matching model which allows us to study the role and the impact of labour market frictions. Third, by including employment protection legislation (firing costs), we investigate how the magnitude of the effects on wages, unemployment and welfare changes in more rigid economies, such as Southern European countries, versus more flexible economies, such as the UK and the US. Fourth, we consider the congestion effect that a severe immigration shock may generate in the provision of a public good, such as health and education, with important policy implications. Finally, we analyse several Pareto-efficient interventions that could reallocate the wealth across workers. Specifically, we consider changes in the taxation rate, in tax subsidies provided to low-skill workers, as well as in unemployment benefits. As immigrants may affect the unemployment rate in the economy, to study the effect of unemployment benefits and income taxes it is of particular interest.

This paper is organized as follows. In Section 2 we provide empirical evidence regarding the Italian labour market for the period 2005-2015, that is before and after the immigration shock. In Section 3 we describe the search and matching model, which we calibrate in Section 4. Section 5 describes the results, Section 6 concludes the paper with policy recommendations.

[2]Other papers which use a search and matching model to study the impact of immigration on the labour market but not in a general equilibrium setting are Nanos and Schluter (2014) and Moreno-Galbis and Tritah (2016).

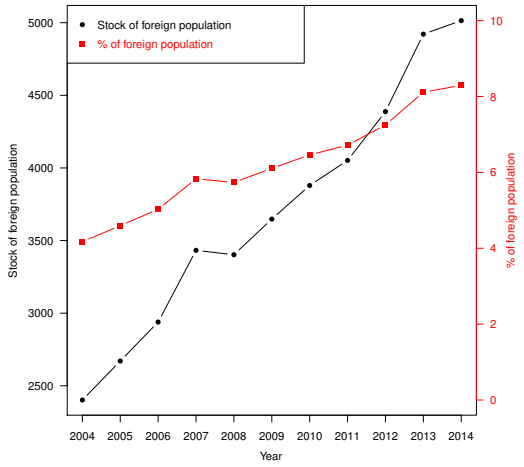
2 Empirical Evidence

In this section we present some figures on the Italian labour market, to support and motivate the assumptions on which our theoretical model is based.

2.1 The size of immigration

The stock of immigrants in Italy increased from less than 2 millions in 2004 to approximately 5 millions in 2014, corresponding to a share in the labour force of approximately 6% in 2004 and 16% in 2015 (Figure 1). While it is perceived that the number of incoming immigrants in Italy is increasing over time, it is often hard to quantify the exact number, because of the potentially high share of immigrants entering illegally in the country. OECD reports data on the inflows of immigrants to Italy from countries all over the world. The National Institute of Statistics (ISTAT) provides data on the number of non-EU immigrant entries from 2004 to 2015.

Figure 1. Stock and share of immigrants.



Source: LFS.x

Table 1 shows that there were approximately 280.000 new entries in 2005, but this number almost doubled in 2007, when the pick of the inflow was reached. Since 2008, the total number of entries slowed down, went back to approximately 280.000 units in 2013 and settled to 250.000 units in 2015.

It is interesting to report also the total number of inflows, which shows a pick in 2007, is entirely due to the entry of Romania and Bulgaria in the EU in 2007. Specifically, the number of Romanians jumped from approximately 39.000 in 2006 to more than 271.000 in 2007, while the

number of Bulgarians jumped from approximately 2.000 in 2006 to more than 13.000 in 2007. The total number of outflows (both EU and non-EU nationals) also increased over time, with a pick of 17% in 2008.

When looking at the labour market status of Italian residents both natives and immigrants, we find interesting numbers (Table 2). First of all, the activity rate and the employment rate are much higher for immigrants than for natives. Among immigrants, 1.3 millions were in the labour force in 2004 and almost 1.2 millions were employed. In 2014 2.7 millions were in the labour force and 2.3 millions were employed. Due to the 2008-2009 economic crisis, the employment rate of immigrant workers went from 66.9% in 2004 to 58.9% in 2015, while the activity rate went down by 3 percentage points. When looking at the same figures for Italian workers, we observe that the number of people in the labour force has not change significantly during the decade considered, while the number of employed people has significantly declined from more than 21 millions to approximately 20 millions. The employment rate of Italian workers went from 57.2% in 2004 to 56.0% in 2014, while the activity rate remained constant at 62% and passed the 63% threshold after 2014. In terms of unemployment, as expected, the unemployment rate is higher among immigrants than among natives. The gap was of approximately 2 percentage points in the period 2004-2008; after the economic crisis in 2008-2009, the unemployment rate of immigrants increased much more compared to the one of natives, and the gap went up to 6 percentage points in 2013.

2.2 The classification of workers by skill level

To classify workers according to their skill level is a hard task. This is because it is not clear what is a good proxy to be used to capture the skills of an individual. Possible alternatives which have been used in the literature include educational attainment (Altonji and Card, 1991; Dustmann et al., 2001), occupation (Card, 2001), or experience and education (Borjas, 2003). All of those have pros and cons. The benefit of using the education level is that it is in general available for all workers, however it is a rather imprecise measure of the individual skills. One of the main problems

Table 1. Immigration dynamics (in thousands).

	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Inflow - Total	394.8	282.8	254.6	515.2	496.5	406.7	424.5	354.3	321.3	279.0	248.4	250.5
Inflow - Romania	66.1	45.3	39.7	271.4	174.6	105.6	92.1	90.1	81.7	58.2	50.7	46.4
Inflow - Bulgaria	4.1	2.4	2.1	13.4	8.4	6.2	5.9	5.1	4.8	3.7	2.9	2.8
Outflow - Total	14.0	16.0	17.0	20.3	27.0	32.3	32.8	32.4	38.2	43.6	48.0	44.7
Outflow (% unemployed)	13.3	12.0	13.8	15.5	17.2	14.3	13.1	11.7	11.0	9.6	10.2	9.8

Source: OECD.

Table 2. Labour force (in thousands).

	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Immigrants												
Labour force	1070.3	1291.2	1421.9	1578.3	1846.8	2016.5	2162.4	2308.4	2455.7	2637.7	2759.8	2815.2
Employed	965.0	1158.2	1299.1	1447.4	1690.1	1790.2	1912.1	2030.3	2109.8	2182.8	2294.1	2359.0
Activity rate	74.2	73.4	73.6	73.2	73.2	72.5	71.3	70.9	70.5	70.5	70.4	70.3
Empl. rate	66.9	65.8	67.2	67.1	67.0	64.3	63.1	62.3	60.6	58.3	58.5	58.9
Unempl. rate	9.8	10.3	8.6	8.3	8.5	11.2	11.6	12.0	14.1	17.2	16.8	16.2
Italians												
Labour force	23236.6	22993.1	22990.0	22797.0	22907.9	22588.8	22420.2	22351.1	22801.3	22621.5	22755.1	22682.8
Employed	21398.0	21248.8	21458.5	21447.0	21400.3	20908.5	20614.8	20567.9	20456.2	20007.7	19984.8	20106.0
Activity rate	62.2	61.8	62.1	61.8	62.2	61.5	61.2	61.3	62.8	62.6	63.2	63.3
Empl. rate	57.2	57.1	57.9	58.1	58.1	56.8	56.2	56.3	56.3	55.2	55.4	56.0
Unempl. rate	7.9	7.6	6.7	5.9	6.6	7.4	8.1	8.0	10.3	11.6	12.2	11.4

Source: Istat.

is the issue of mismatch, particularly overeducation, as often workers are hired to perform a job which requires skills asssociated with an education level, which is lower compared to the one of the individual. This phenomenon is specifically relevant for immigrants, as investigated by Dustmann et al. (2013) and Eckstein and Weiss (2004), who show that immigrants downgrade considerably upon arrival and therefore the allocation of immigrants according to their measured skills, such as education, would place them at different locations across the native wage distribution than where we actually find them. Alternatively, we could use as a proxy the individual's occupation, which is still an imperfect measure of the skill level, but is probably more accurate than education. In the literature there is a clear mapping between occupations and education levels, as well as between occupations and skill levels (ILO, 2012).[3] In this context, skill is defined as the ability to carry out the tasks and duties of a given job, while the skill level is defined as a function of the complexity and range of tasks and duties to be performed in an occupation. However, occupation is only available for employed individuals, while it is missing for unemployed and inactive individuals. In what follow, we classify individuals in two categories, high-skill and low-skill. To do so, we follow the ILO classification, and we refer to high-skill workers (with skill levels 3 or 4) as those individuals with a tertiary level of education who work as managers or professionals. Moreover, we will refer to low-skill employees (with skill levels 1 or 2) as those individuals with a primary or secondary level of education who work as clerks, sales workers, craft workers, plant and machine operators and in elementary occupations.

For those for whom, we do not observe the occupation as they are currently unemployed, we use

[3]Please refer to the Appendix for details of the mappings.

Table 3. Employed employees by country of origin, occupation and education levels.

		Education level			
		Immigrants		Natives	
		Low	High	Low	High
Occupation	High	0.175	0.665	0.315	0.8873
Level	Low	0.825	0.335	0.685	0.1127

the occupation in their last job. For those for whom no information is available, either because they are stepping for the first time in the labour market or because they have not worked before in Italy or because they did not report the information, we use the education level. We observe that the majority of unemployed workers without infomation on previous occupation are young and their average age is below 40, both among natives and immigrants. In order to correct for the issue of mismatch, we look at the probability for high educated workers (with a tertiary level of education) and low educated workers (primary or secondary levels) under the age of 40 to work in a high skill occupation (with skill levels 3 or 4, as classified by ILO) versus a low skill occupation (with skill levels 1 or 2, as classified by ILO) for both natives and immigrants. We then randomly adjust the distribution of unemployed workers by low-skill and high-skill according to their education level, by the probability described in Table 3.

2.3 Workers' occupation by country of origin and skill level

Table 4 provides data on the distribution of immigrant (Panel A) and native (Panel B) employees by occupation in Italy from 2004 to 2015. We observe that more than 90% of immigrants are hired either as clerks and sales workers, craft workers and machine operators or in elementary occupations, which are occupations which require lower skill levels (1 or 2 according to the ILO classification). Hence, according to our classification, more than 90% of immigrants are low-skill. Looking at the trend, we observe that the share of immigrants hired in elementary occupations and managerial positions is roughly stable over time. However, we also find that a larger share of immigrants (approximately 10%) in 2015 works as clerks and sales workers rather than as craft workers and machine operators.

When we look at the distribution of native employees by occupation, we observe that approximately 63% of workers are hired in occupations which require lower skill levels (levels 1 or 2 of the ILO classifcation), while 37% of workers are hired as managers and professionals, which are occupations which require higher skill levels (levels 3 or 4 of ILO classifcation). Hence, approximately 63% of native workers are classified as low-skill, according to our definition. Over time, the

Table 4. Shares of employees by occupation.

Panel A: Immigrants

	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Managers[1]	10.9	9.2	9.4	10.1	8.5	7.3	7.2	6.7	5.9	6.0	7.0	6.8
Clerks and sales workers[2]	16.4	17.0	18.4	18.8	18.3	17.3	16.4	23.6	25.6	26.7	26.9	27.2
Craft workers and machine operators[3]	39.8	40.4	42.7	42.8	41.2	39.3	38.2	36.4	33.8	0.318	30.3	30.1
Elementary occupations	33.0	33.3	29.5	28.3	31.9	36.1	38.1	33.2	34.7	35.4	35.6	35.9

Panel B: Natives

	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Managers[1]	35.5	35.5	37.8	38.8	38.5	37.5	36.9	36.4	36.5	37.4	37.4	37.6
Clerks and sales workers[2]	27.5	27.7	26.8	26.7	27.5	28.4	29.3	30.0	30.5	30.5	30.6	30.7
Craft workers and machine operators[3]	27.6	27.5	26.5	26.0	25.7	25.5	25.0	24.7	23.7	22.9	22.7	22.4
Elementary occupations	8.3	8.2	7.8	7.4	7.2	7.3	7.5	7.7	7.9	8.1	8.1	8.1
Military service	1.2	1.2	1.2	1.2	1.1	1.2	1.3	1.2	1.3	1.2	1.2	1.2

Source: Istat and OECD.

[1] It includes also professionals, technicians and associate professionals.
[2] It includes also service workers.
[3] It includes also skilled agricultural and fishery workers, plant and machine operators and assemblers.

patterns are similar to those observed for immigrants: fewer employees work as craft workers or machine operators and more as clerks and sales workers in 2015, but the percentage point change is smaller (approximately 5%).

To have a better understanding of the distribution of immigrants across occupations, in Table 5 we report the number of immigrants as a share of the total number of employees by occupation. In 2005, approximately 4% of all employees were immigrant. Specifically, among workers employed in elementary occupations, approximately 15% were immigrants, among craft workers approximately 6% were immigrants and among clerks or sale workers less than 3% were immigrants. Among managers the percentage of immigrants was just 1.4%. Ten years after, in 2015, the number of immigrants as a share of the whole pool of employees is up to 10%: in elementary occupations, the share of immigrants is up to 34%; among all craft workers 14% are immigrants and among clerks and sales workers 10% are immigrants. The share of immigrants in managerial positions is still rather low (approximately 2%).

2.4 Labour force composition by country of origin and skill level

According to our classification, the great majority of immigrants is represented by low-skill workers, whose share has increased by approximately 15 percentage points in the period 2004-2015. The share of high-skill workers is instead in the period considered higher by 2 percentage points only (Figure 2a).

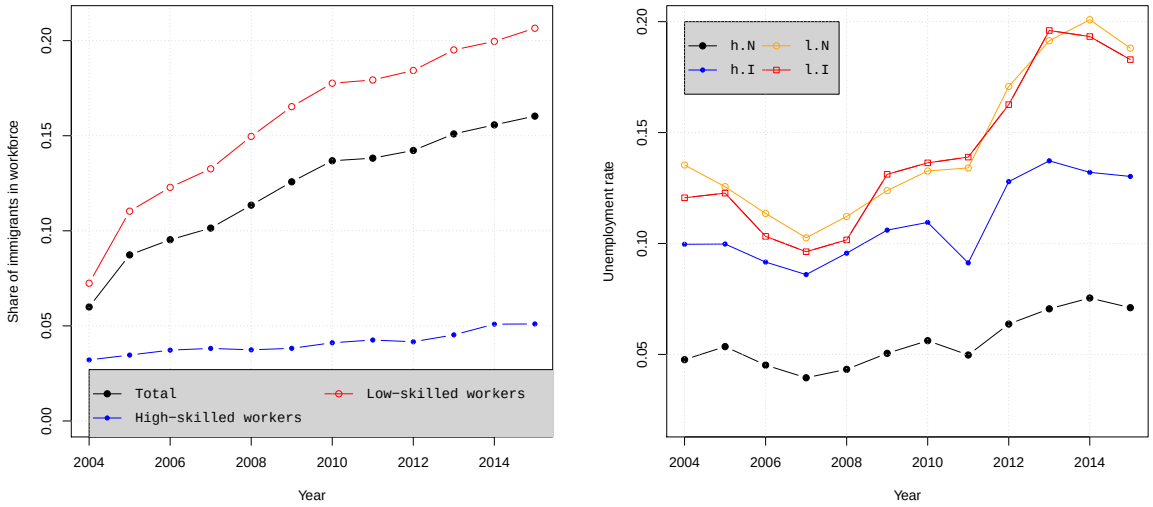
Table 5. Share of immigrants by occupation.

	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Managers	1.4	1.4	1.5	1.7	1.7	1.6	1.8	1.8	1.6	1.7	2.1	2.1
Clerks and sales workers	2.6	3.2	4.0	4.5	5.0	5.0	4.9	7.2	8.0	8.7	9.2	9.4
Craft workers and machine operators	6.1	7.4	8.9	10.0	11.3	0.116	12.4	12.7	12.8	13.2	13.3	0.137
Elementary occupations	15.2	18.2	18.7	20.5	25.9	29.7	31.9	29.9	31.0	32.6	33.6	34.2
Total	4.3	5.2	5.7	6.3	7.3	7.9	8.5	9.0	9.3	9.8	10.3	10.5

Source: Istat.

[1] It includes also professionals, technicians and associate professionals.
[2] It includes also service workers.
[3] It includes also skilled agricultural and fishery workers, plant and machine operators and assemblers.

Figure 2. Share of immigrants and unemployment rates by skill level. Source: LFS.



(a) Share of immigrants in the labour force by skill level.

(b) Unemployment rate by country of origin and skill level.

Unemployment rates for natives and immigrants are also reported in Table 2. The unemployment rate of immigrants is higher compared to the unemployment rate of natives, and the gap increases over time. When we break the unemployment rates by skill-level (Figure 2b), we find out that both among natives and immigrants, the unemployment rate of low-skill workers is higher compared to the unemployment rate of high-skill workers. Among low-skill workers, the unemployment rate is similar between natives and immigrants, while among high-skill workers the unemployment rate of immigrants is much higher compared to the unemployment rate of natives. The patterns are similar over time, however among low-skill workers the unemployment rate of natives was higher than the unemployment rate for migrants until 2008, and afterwards this relationship flips and the rates look similar between the two groups.

2.5 (Nominal) wages by country of origin and skill level

We use data from the Labour Force Survey as provided by the National Institute of Statistics (ISTAT) to compute the average wage of employees by skill level and country of origin (natives and immigrants) for the years 2009-2015.[4] As in the previous section, we refer to high-skill workers as workers employeed as managers or professionals with a tertiary level of education. Few caveats need to be mentioned here in relation to the data used. First, the information on the individual wage is not released by ISTAT before 2009. Second, we observe wages in the range between 250 euro and 3000 euro, while we have no detailed information for wages below 250 euro and above 3000 euro. Hence, the observed distribution of wages is left and right truncated. In order to correct the observed wage distribution with the aim of reconstructing the true wage distribution, we fit a beta distribution (left panel of Table 6). In the right panel of Table 6 we report the relative wages of high-skill natives, high-skill immigrants and low-skill immigrants with respect to the wages of low-skill natives.

Table 6. Monthly (nominal) wages of workers by country of origin and skill level.

	Absolute wages				Relative wages			
	w.h.N	w.l.N	w.h.I	w.l.I	w.h.N	w.l.N	w.h.I	w.l.I
2009.Q2	1569.00	1119.00	1523.00	946.00	1.40	1.00	1.36	0.85
2010.Q1	1617.00	1138.00	1692.00	938.00	1.42	1.00	1.49	0.82
2011.Q1	1645.00	1159.00	1655.00	972.00	1.42	1.00	1.43	0.84
2012.Q1	1668.00	1165.00	1587.00	970.00	1.43	1.00	1.36	0.83
2013.Q1	1656.00	1153.00	1627.00	947.00	1.44	1.00	1.41	0.82
2014.Q1	1696.00	1171.00	1584.00	935.00	1.45	1.00	1.35	0.80
2015.Q1	1716.00	1197.00	1594.00	971.00	1.43	1.00	1.33	0.81

Note: w.h.N= average wage of high-skill natives (in euro); w.h.I= average wage of high-skill immigrants (in euro); w.l.N= average wage of low-skill natives (in euro); w.l.I= average wage of low-skill immigrants (in euro). Values are corrected for censorship.
Source: Rilevazione Continua delle Forze di Lavoro (RCFL), ISTAT.

We observe that while the wages of high-skill workers are rather similar between natives and immigrants, low-skill immigrants enjoy lower wages compared to low-skill natives. Specifically, employees with a low skill level who are immigrant earn 20% less than natives with a low skill level. High-skilled workers either natives or immigrants enjoy a wage which is more than 30% higher than the wage of low-skill native workers. From 2009 to 2015 the wage level of all categories of employees has increased in absolute terms: the wage of native workers is 9 percentage points higher if high-skill and 7 percentage points higher if low-skill. The wage of immigrant workers is

[4]Unfortunately ISTAT data on wages are not realised before 2009 and there is no alternative representative and reliable source of information on wages for Italy before 2009.

5 percentage points higher if high-skill and less than 3 percentage points higher if low-skill. In relative terms, native workers are better off, while immigrants are worse off; specifically, low-skill immigrants earn a relative wage with respect to the wage of low-skill natives which is 4 percentage points lower.

It is noteworthy to mention that the wage of high-skill immigrants may not be accurate due to their limited numerosity in the sample.

2.6 Job creation and job destruction by country of origin and skill level

In order to compute the probability for a worker to find a job as well as the probability for a worker to lose his job, we follow Shimer (2012). Specifically, to measure the job finding probability for unemployed workers $Q_t \in [0,1]$ and the exit probability for employed workers $\Delta_t \in [0,1]$ in Italy in the period 2004-2014 we use publicly available data from the Italian Labour Force Survey (LFS). We do not consider transitions in and out of the labour force, but we focus on the workers' transitions between employment and unemployment. We also assume that all unemployed workers find a job with probability Q_t and all employed workers lose a job with probability Δ_t during period t, ignoring any heterogeneity or duration dependence that makes some unemployed workers more likely to find and some employed workers less likely to lose a job within the period.

For $t \in \{0,1,2,...\}$, we refer to the interval $[t, t+1]$ as period t. We assume that during period t, all unemployed workers find a job according to a Poisson process with arrival rate $q_t \equiv -log(1-Q_t) > 0$ and all employed workers lose their job according to a Poisson process with arrival rate $\delta_t \equiv -log(1-\Delta_t) > 0$. Hence, q_t and δ_t represent the job finding and employment exit rates and Q_t and Δ_t are the corresponding probabilities. By fixing $t \in \{0,1,2,...\}$ and letting $\tau \in [0,1]$ be the time elapsed since the last measurement date, we can define $e_{t+\tau}$ as the number of employed workers at time $[t+\tau]$, $u_{t+\tau}$ as the number of unemployed workers at time $[t+\tau]$, and $u_t^s(\tau)$ denote "short term unemployment", that is workers who are unemployed at time $[t+\tau]$, but were employed at some time $t' \in [t, t+\tau]$. Note that $u_t^s(0) = 0$ for all t. Therefore, the law of motion for unemployment at time $[t+\tau]$ reads:

$$\dot{u}_{t+\tau} = e_{t+\tau}\delta_t - u_{t+\tau}q_t, \tag{1}$$

The number of unemployed workers at date $[t+1]$ is then equal to the number of unemployed workers at date t who do not find a job (a fraction $1 - Q_t = e^{-qt}$) plus the u_{t+1}^s short-term unemployed workers, i.e., those who are unemployed at date $[t+1]$ but held a job at some point

during period t:

$$u_{t+1} = (1 - Q_t)u_t + u^s_{t+1}. \tag{2}$$

By inverting Equation 2, we find an expression for the job finding probability as a function of unemployment and short term unemployment:

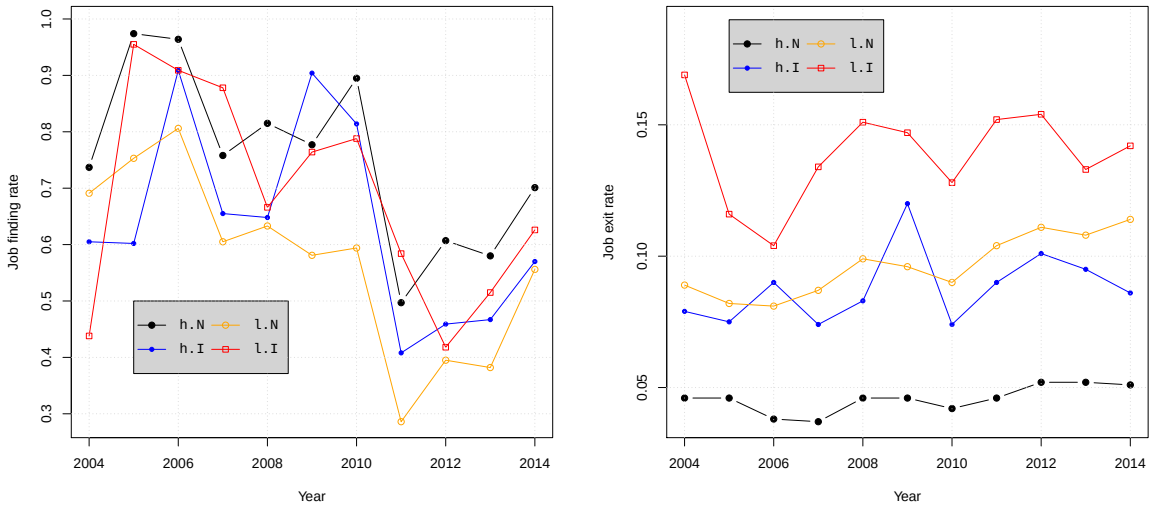
$$Q_t = 1 - \frac{u_{t+1} - u^s_{t+1}}{u_t}. \tag{3}$$

An implicit equation for the employment exit rate can be obtained by solving Equation 1:

$$u_{t+1} = \frac{[1 - \exp(-q_t - \delta_t)]\,\delta_t l_t}{q_t + \delta_t} + \exp(-q_t - \delta_t)u_t, \tag{4}$$

where $l_t \equiv u_t + e_t$ is the size of the labour force during period t, which we assume to be constant since entries or exits from the labour force are not allowed.

Figure 3. Annual job finding and job exit rates 2004-2014. Source: our calculations on LFS



(a) Job finding rate 2004-2014.

(b) Job exit rate 2004-2014.

The results of our calculations are reported in Figure 3. We can notice that both rates are rather different for high-skill and low-skill workers and for natives and immigrants. Immigrants tend to have higher exit rates. Heterogeneity among workers of different country of origin may be due to the difference in the job tenure, as obviously immigrants on average have shorter tenure as they have been in the country for a shorter period of time. As in Dustmann et al. (2010), we show that the job finding rate of high-skill workers is higher than the job finding rate of low-skill

workers, both at aggregate level and among natives only. This relationship is instead ambiguous among immigrants. It is also important to notice that the parameters of immigrants are much more volatile compared to the parameters of natives, probably due to measurement errors.

In short, we have found that: 1) high-skill workers haves a higher job finding rates and a lower job exit rate; 2) high skill native and immigrants have a similar job finding rate; 3) low-skill immigrants have a higher job finding rate than natives; and, finally, 4) low-skill immigrants have a higher job exit rate than natives. In the literature, the segregation of immigrants in the secondary labour market seems to be the main reason of their penalization, that is, immigrants are mainly hired in temporary jobs, seasonal activities, small firms and low-skill occupations. The literature on the dualism between capital and labour intensive labour markets points out the fact that in the former workers are high-skill and are hired on permanent jobs, while in the latter workers are low-skill and are hired on temporary jobs and may be laid off at little or no cost to employers (Piore, 1979). The concentration of immigrants in the secondary labour market is the most important factor explaining their disadvantage in terms of risk of losing a job. In most countries the probability of being hired on a temporary job is significantly higher for immigrants than for natives and the more utilized is temporary work, the greater would be the gap between immigrants and natives (OECD, 2007). In Italy, however, the share of immigrants hired on temporary contracts is only slightly higher than the share of natives , as shown in Table 7. However, many immigrants who are hired on a permanent job are not safer from the risk of losing their job, as they are working mostly in small firms. Indeed, in Italy the risk of losing a job in small firms is much higher than in large firms not only because the mortality rate of small firms is very high, but also because according to the Italian legislation it is easier for firms with fewer than 15 employees to fire workers, whereas there are more constraints on dismissals in larger firms (Fullin, 2011).

Table 7. Share of workers in temporary contracts by country of origin. Source: LFS.

	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Immigrants	0.145	0.147	0.153	0.147	0.156	0.143	0.151	0.158	0.163	0.152	0.158	0.164
Natives	0.118	0.121	0.129	0.130	0.131	0.123	0.124	0.130	0.135	0.129	0.133	0.140

In addition, immigrant workers tend to be concentrated in industries which are more vulnerable to economic slowdowns and in low-skill occupations. In Italy, for instance, male immigrants are mainly employed in construction and manufacturing sectors, which are either seasonal or very sensitive to business cycle fluctuations, whereas females are mainly employed as housekeepers and elderly caregivers, which are less sensitive to business cycles, as shown by the impact of the current

economic crisis (Fullin and Reyneri, 2011). Both male and female immigrants, on the other hand, are much more concentrated in manual and low-skill occupations compared to natives. As the costs of turnover for low-skill jobs are lower than for high-skill jobs (training is less important, substituting workers is easier and less time consuming, recruiting and selection costs are lower), the risks of being hired with short-term contracts and/or being fired are higher for people working in low-skill occupations than for those working in highly skilled ones.

The concentration of immigrants in the secondary sector also affects the risk of remaining unemployed, although in an opposite way. A large secondary labour market provides a great deal of poorly qualified jobs that are more suitable for immigrants than for natives, who are not willing to accept them. Immigrants have lower reservation in comparison with natives since they take the wages in their home country as a reference, and they also assume that good job opportunities are scarce and they need to make money as soon as possible (Dustmann, 2000; Kalter and Kogan, 2002; Kogan, 2007). For the same reasons, immigrants may be more prone to accepting fixed-term labour contracts, making their job search easier and quicker. Moreover, social capital based on personal relations is everywhere the best method that allows the unemployed to find a job. Immigrants turn to personal relations even more than natives, but their performance depends on which social networks they can rely on (Kalter and Kogan, 2002). If the social networks of immigrants are restricted to their fellow countrymen and women, as is very likely, immigrants may manage finding a job even faster than natives, but those networks are only able to provide them with poorly qualified jobs. Segregation in low skilled employment seems to be the price that immigrants are willing to pay in order to reduce job search duration (Fullin and Reyneri, 2011a). The availability of financial support may also make a job search different for immigrants and natives, as poor support pushes the unemployed into finding a job as soon as possible. In Italy all immigrants, whatever their citizenship, are formally entitled to get unemployment benefits just as natives, but in practice they have less access to benefits, because their work history includes more spells of temporary and non-registered jobs, and in any case the generosity of unemployment benefits is quite poor (Employment Committee, 2009). In welfare systems, such as the South European ones, where public benefits are scarce, job seekers have to rely on the support of their family, but most immigrants are single or heads of household, so they cannot rely on family support (Uhlendorff and Zimmermann, 2014).

In the empirical literature, there is evidence that low educated workers have the highest gross mobility (turnover) compared to middle and high educated workers (Landesmann et al., 2015). For the case of Italy, Fullin (2011) finds that immigrant workers lose their jobs more often than natives but, once being unemployed they have more probabilities of finding a job than natives.

3 The Model

Consider the following continuous time infinite-horizon economy. There is a continuum of mass σ of employees. All employees supply labour inelastically, are risk neutral and discount the future at constant rate r. Employees differ according to their skill level and their country of origin. We distinguish between natives N, who are born in the home country and immigrants I, who are born in a foreign country. Each individual is either high-skill, h, or low-skill, l. Hence, the total measure of employees σ is the sum of the four different categories of employees, i.e. $\sigma = \sigma_{l,N} + \sigma_{l,I} + \sigma_{h,N} + \sigma_{h,I}$. Employees can be either employed or unemployed, hence $\sigma_{i,N} = e_{i,N} + u_{i,N}$ and $\sigma_{i,I} = e_{i,I} + u_{i,I}$, where $i \in \{l, h\}$.

The economy is also populated by a measure χ of employers. Employers are ex-ante homogeneous and post skill-specific vacancies, which are open to both natives and immigrants. Employers and employees are brought together through a random and costly search process, as in the standard Diamond, Mortensen and Pissarides (DMP) model. From the match between employers and employees two goods, y_h and y_l are produced, using labour as sole input. Each employer specializes in the production of one of the two goods. Good y_h is produced using only high-skill workers h, whose productivity is x_h, while good y_l is produced using only low-skill workers l, with productivity x_l, where $x_h > x_l$. Goods are sold at price p_h and p_l, respectively.

Firms and workers come together via a matching function $m(v_i, u_i)$, where u_i is the measure of unemployment (natives and immigrants, $u_i = u_{i,N} + u_{i,I}$) and v_i is the measure of vacancies, and $\theta_i \equiv v_i/u_i$ is defined as the labour market tightness. The function $m(v_i, u_i)$ is twice differentiable, increasing in its arguments, and exhibits constant returns to scale. Each vacancy is skill-specific, but open to both native and immigrant workers. Hence, there are two labour markets, one for high-skill employees and one for low-skill employees. Within each market, the probability that an employer with an open vacancy meets either a native or an immigrant employee may be defined as $q(\theta_i) \equiv m(u_i, v_i)/v_i$. The probability that an unemployed worker, either native or immigrant, meets an employer may be defined as $\theta_i q(\theta_i) = m(u_i, v_i)/u_i$. It is assumed that $q(\theta_i) \to 1$ and $\theta_i q(\theta_i) \to 0$ as $\theta_i \to 0$, and $q(\theta_i) \to 0$ and $\theta_i q(\theta_i) \to 1$ as $\theta_i \to \infty$.

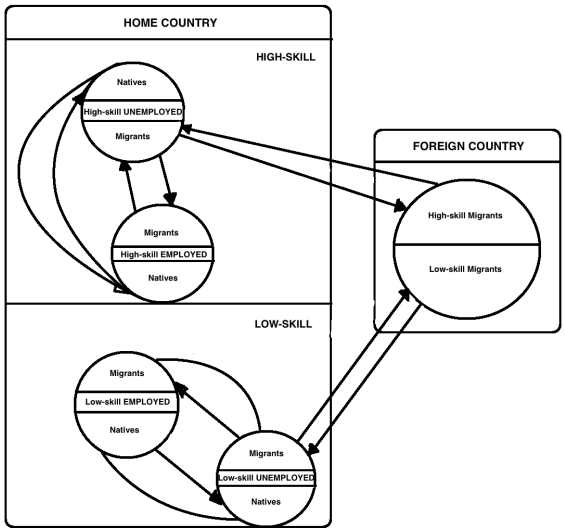
The probability that a vacancy is filled with a worker is equal to the product of the probability that an employer meets an employee and the probability that the job offer is signed, that is: $\kappa_{i,j} q(\theta_i)$. Similarly, the probability that an unemployed worker finds a job is equal to the product of the probability that an employee meets an employer and the probability that the job offer is signed, that is: $\kappa_{i,j} \theta_i q(\theta_i)$. While the probability for an employee to meet an employer $q(\theta_i)$ and the probability for an employer to fill a vacancy $\theta_i q(\theta_i)$ are identical for all employers and employees

searching in a given labour market (high-skill or low-skill), the probabilities to sign a job offer $\kappa_{i,j}$ differ both according to the country of origin and the skill level of the employee, i.e, the labour market employers and employees are operating in. This heterogeneity is found in the data (see Section 2.6) and can be explained by the fact that the "compatibility" between employer and employee is different between natives and immigrants as unobservable characteristics may favour the match formation of natives compared to immigrants once a contact happens. It is important to remark that this heterogeneity among employees is ex-ante and does not imply an ex-post heterogeneity in the new matches, as "non-compatible" matches are not formed (Rogerson et al., 2005). The match between an employer and an employee can be exogenously destroyed at Poisson rate $\delta_{i,j}$: in this case, the employee becomes unemployed and the employer is left with an open vacancy. When this happens, the employer is required to pay firing costs F, which include two components, as in Garibaldi and Violante (2005). A share ϕ of this cost will then be transferred to the employee as a severance payment, while the share $1-\phi$ is a deadweight loss (red-tape cost).

Immigrants coming from abroad join the home labour market as unemployed at exogenous rate η. Immigrants also leave the home labour market and go back abroad at exogenous rate λ. Both λ and η are the same among workers with different skills as they are influenced by socio-political phenomena, which affect all the workers in the same way.

Figure 4 provides a schematic representation of labour flows within the model. Per each flow, we report the probability for the workers to move from one status (origin) to the other (destination). The possibility for unemployed immigrants to leave the home country creates an asymmetry between natives and immigrants, which is crucial for the model.

Figure 4. The labor flows in the model in the labour markets of skilled and low-skill workers.



3.1 Employees

All employees consume both goods and benefit from the provision of a public good. We assume that employees consume everything and do no save. The employees' utility function reads as follows:

$$Y_i = y_{hi}^{\gamma} y_{li}^{(1-\gamma)} + \nu, \tag{5}$$

where y_{hi} is the quantity demanded and consumed of product h and y_{li} is the quantity demanded and consumed of product l, while ν is the utility coming from the public good provided by the Government. Employees maximize their utility function, subject to the following budget constraint:

$$p_h y_{hi} + p_l y_{li} = \begin{cases} (1-t)(w_i + \tau \mathbb{1}_i) & \text{if the worker is employed,} \\ b(1-t)(w_i + \tau \mathbb{1}_i) & \text{if the worker is unemployed,} \end{cases} \tag{6}$$

where

$$\mathbb{1}_i = \begin{cases} 0 & \text{if } i = h \\ 1 & \text{if } i = l. \end{cases} \tag{7}$$

Employed workers earn a wage w_i, which is taxed at proportional rate t. Moreover, in order to introduce the possibility of progressive taxation, we assume that workers receive a tax subsidy τ, only if they are low-skill. Unemployed workers instead receive unemployment benefits, which are a proportion b of their net wage (Pissarides, 2000, p. 206).

From the maximization of the utility function, we can solve for the quantities of goods h and l, which are demanded by each individual, depending on her skill-level and employment status. Specifically, if the worker is employed she will demand the following quantities of good h and good l:

$$\begin{aligned} y_{hi}^{e} &= \frac{\gamma(1-t)(w_i + \tau \mathbb{1}_i)}{p_h}, \\ y_{li}^{e} &= \frac{(1-\gamma)(1-t)(w_i + \tau \mathbb{1}_i)}{p_l}, \end{aligned} \tag{8}$$

while if the worker is unemployed, she will demand respectively:

$$\begin{aligned} y_{hi}^{u} &= \frac{b\gamma(1-t)(w_i + \tau \mathbb{1}_i)}{p_h}, \\ y_{li}^{u} &= \frac{b(1-\gamma)(1-t)(w_i + \tau \mathbb{1}_i)}{p_l}. \end{aligned} \tag{9}$$

We can also compute the indirect utility of employed workers, which can be written as

$$Y^e_{i,j} = \psi(1-t)(\tilde{w}_{i,j} + \tilde{\tau}\mathbb{1}_i) + \nu \text{ and} \tag{10}$$

$$Y^u_{i,j} = b\psi(1-t)(\tilde{w}_{i,j} + \tilde{\tau}\mathbb{1}_i) + \nu, \tag{11}$$

where $\tilde{\tau} \equiv \tau/p$ is the real level of tax subsidy and $\tilde{w}_{i,j} \equiv w_{i,j}/p$ is the real wage, computed using $p \equiv p_h^{\gamma} p_l^{1-\gamma}$ as the appropriate price index. Finally, $\psi \equiv \gamma^{\gamma}(1-\gamma)^{1-\gamma}$ is a parameter depending on preferences. Let $W^e_{i,N}$ be the present discounted value of the utility of an employee with skill level i and country of origin j currently working. Following Pissarides (2000), we can write the Bellman's equation for an employee currently working as:

$$rW^e_{i,N} = Y^e_{i,N} + \delta_{i,N}\left(W^u_{i,N} + \phi\tilde{p}_i x_i F - W^e_{i,N}\right), \tag{12}$$

$$rW^e_{i,I} = Y^e_{i,I} + \delta_{i,I}\left(W^u_{i,I} + \phi\tilde{p}_i x_i F - W^e_{i,I}\right). \tag{13}$$

Employed workers, both natives and immigrants, enjoy the indirect utility of being employed $Y^e_{i,j}$ until the match is exogenously destroyed at rate $\delta_{i,j}$, when they lose their job and become unemployed. When the match is destroyed, employees receive a transfer from the employers which is a share of the total firing costs F. The firing costs are proportional to the productivity of the employee, $\phi\tilde{p}_i x_i F$. The corresponding Bellman's equations for unemployed workers read:

$$rW^u_{i,N} = Y^u_{i,N} + \kappa_{i,N}\theta_i q(\theta_i)\left(W^e_{i,N} - W^u_{i,N}\right), \tag{14}$$

$$rW^u_{i,I} = Y^u_{i,I} + \lambda\left(W_{i,FC} - W^u_{i,I}\right) + \kappa_{i,I}\theta_i q(\theta_i)\left(W^e_{i,I} - W^u_{i,I}\right). \tag{15}$$

While both natives and immigrants find a job with probability $\kappa_{i,j}\theta_i q(\theta_i)$, immigrants can also leave the home country at rate λ, and enjoy utility $W_{i,FC}$ elsewhere. We can interpret λ both as the individual decision to go back home or as a government policy, which forces immigrants without a job to be expelled.

3.2 Employers

Employers who operate in the labour market i consume both goods and receive the provision of the public good ν, which enters the employers' utility function as follows:

$$Y_i = y_{hi}^{\gamma} y_{li}^{(1-\gamma)} + \nu. \tag{16}$$

For simplicity, as per the employees, we also assume that employers do no save. Thus they maximize their utility subject to the following budget constraint:

$$p_h y_{hi} + p_l y_{li} = \begin{cases} (1-t)\left(p_h x_h - w_h\right) & \text{if the employer is operating in good market } h, \\ (1-t)\left(p_l x_l - w_l\right) & \text{if the employer is operating in good market } l. \end{cases} \tag{17}$$

The employer's profit, which is computed as the employer productivity minus the wage paid to the employee (in real terms), is taxed at the flat tax rate t. By solving the maximization of the utility function, we can compute the optimal quantity of goods h and l demanded by employers, according to the market they are operating in:

$$\begin{aligned} y_{hi}^h &= \frac{\gamma\left(1-t\right)\left(\tilde{p}_h x_h - \tilde{w}_h\right)}{\tilde{p}_h}, \\ y_{li}^h &= \frac{\left(1-\gamma\right)\left(1-t\right)\left(\tilde{p}_h x_h - \tilde{w}_h\right)}{\tilde{p}_l}, \end{aligned} \tag{18}$$

if the employer is operating in good market h or

$$\begin{aligned} y_{hi}^l &= \frac{\gamma\left(1-t\right)\left(\tilde{p}_l x_l - \tilde{w}_l\right)}{\tilde{p}_h}, \\ y_{li}^l &= \frac{\left(1-\gamma\right)\left(1-t\right)\left(\tilde{p}_l x_l - \tilde{w}_l\right)}{\tilde{p}_l}, \end{aligned} \tag{19}$$

if the employer is operating in good market l. Let $J_{i,j}$ be the present discounted value of the utility of an employer hiring an employee with skill level i and of country of origin j. The employer's Bellman's equations for a filled position read:[5]

$$rJ_{i,N} = (1-t)(\tilde{p}_i x_i - \tilde{w}_{i,N}) + \delta_{i,N}\left(V_i - J_{i,N} - \tilde{p}_i x_i F\right), \tag{20}$$

$$rJ_{i,I} = (1-t)(\tilde{p}_i x_i - \tilde{w}_{i,I}) + \delta_{i,I}\left(V_i - J_{i,I} - \tilde{p}_i x_i F\right), \tag{21}$$

where $i \in \{l, h\}$. The employer value functions in Equations (20) and (21) take into account the presence of firing costs. In particular, every time an exogenous shock $\delta_{i,j}$ destroys a match, the employer is required to pay firing costs F, which are proportional to the productivity of the employee, as in Pissarides (2000). This cost includes both a severance payment which is a transfer to the worker and a red-tape cost, which is a deadweight loss, i.e $\tilde{p}_i x_i F = \phi\tilde{p}_i x_i F + (1-\phi)\tilde{p}_i x_i F$. The firm's Bellman's equation for hiring an employee with skill level i, i.e. the value of a skill-specific

[5] See in particular Equation (9.9) in Pissarides (2000).

vacancy for an employer, is given by:

$$rV_i = -c\tilde{p}_i x_i + \pi_{i,N}\kappa_{i,N} q\left(\theta_i\right)\left(J_{i,N} - V_i\right) + \left(1 - \pi_{i,N}\right)\kappa_{i,I} q\left(\theta_i\right)\left(J_{i,I} - V_i\right), \tag{22}$$

where $c\tilde{p}_i x_i$ is the vacancy cost which is proportional to the productivity of the employee, $\kappa_{i,j} q\left(\theta_i\right)$ is the rate at which a vacancy is filled, and $\pi_{i,N} \equiv u_{i,N} / \left(u_{i,N} + u_{i,I}\right)$ is the probability for an employer operating in good market i to meet a native versus an immigrant employee. This probability is computed as the share of unemployed natives on the total number of unemployed workers.

3.3 Wage Bargaining

The wage of native and immigrant employees is chosen as to maximize the surplus of the match between employer and employee, specific for each of the two categories of employees:

$$\left(W^e_{i,N} - \phi\tilde{p}_i x_i F - W^u_{i,N}\right)^{\beta}\left(J_{i,N} + \tilde{p}_i x_i F - V_i\right)^{1-\beta}, \tag{23}$$

$$\left(W^e_{i,I} - \phi\tilde{p}_i x_i F - W^u_{i,I}\right)^{\beta}\left(J_{i,I} + \tilde{p}_i x_i F - V_i\right)^{1-\beta}, \tag{24}$$

where β is the bargaining power of the employees and $1-\beta$ is the bargaining power of the employers. It is worth mentioning that the maximization with respect to wages amounts to maximize the Nash product with respect to $\tilde{w}_i$, being the price index p taken as given in competitive markets. Employers and employees also take V_i, $W^u_{i,N}$ and $W^u_{i,I}$ as given in the bargaining process. Firing costs F enter into the maximization as employers internalize the cost they will have to pay in case of match destruction. The share of the firing costs which is transferred to the employees enters into the maximization as it is part of the outside options for the employees. This implies that the first order condition for the maximization of the Nash product for employees in Equation (25) reads:

$$(1-\beta)(W^e_{i,j} - \phi\tilde{p}_i x_i F - W^u_{i,j}) = \beta\psi\left(J_{i,j} + \tilde{p}_i x_i F - V_i\right). \tag{25}$$

3.4 The Equilibrium

3.4.1 The Equilibrium in the Labour Markets

In this economy there are two separate labour markets, one for high-skill employees and one for low-skill employees, and each market is characterised by the specific market tightness $\theta_i \equiv \left(u_{i,N} + u_{i,I}\right)/v_i$. We assume that the measure of high-skill natives in the labour force is equal to $\sigma_{h,N}$ and the measure of low -skilled natives in the labour force is equal to $\sigma_{l,N}$. Hence, employment

and unemployment for native employees can be computed as:

$$e_{i,N} = \sigma_{i,N}\left[\frac{\kappa_{i,N}\theta_i q\left(\theta_i\right)}{\delta_{i,N}+\kappa_{i,N}\theta_i q\left(\theta_i\right)}\right], \tag{26}$$

$$u_{i,N} = \sigma_{i,N}\left[\frac{\delta_{i,N}}{\delta_{i,N}+\kappa_{i,N}\theta_i q\left(\theta_i\right)}\right]. \tag{27}$$

Assuming that the measure of high-skill and low-skill immigrants is equal to $\sigma_{h,I}$ and $\sigma_{l,I}$, respectively, the measures of employed and unemployed immigrants are given by:

$$e_{i,I} = \sigma_{i,I}\left\{\frac{\eta\kappa_{i,I}\theta_i q\left(\theta_i\right)}{\lambda\delta_{i,I}+\eta\left[\kappa_{i,I}\theta_i q\left(\theta_i\right)+\delta_{i,I}\right]}\right\}, \tag{28}$$

$$u_{i,I} = \sigma_{i,I}\left\{\frac{\eta\delta_{i,I}}{\lambda\delta_{i,I}+\eta\left[\kappa_{i,I}\theta_i q\left(\theta_i\right)+\delta_{i,I}\right]}\right\}. \tag{29}$$

Finally, the measure of immigrants in the foreign country is:

$$FC_{i,I} = \sigma_{i,I}\left\{\frac{\lambda\delta_{i,I}}{\lambda\delta_{i,I}+\eta\left[\kappa_{i,I}\theta_i q_{i,I}\left(\theta_i\right)+\delta_{i,I}\right]}\right\} \tag{30}$$

3.4.2 The Equilibrium in the Good Markets

We assume that the Government runs a balanced budget in each period. This implies that fiscal policy is neutral with respect to the aggregate demand of both goods. By applying the Walras' Law in an economy with two goods, we can prove that the equilibrium in one market is enough to guarantee the equilibrium in the other market. Since the real prices $\tilde{p}_h$ and $\tilde{p}_l$ are defined as:

$$\tilde{p}_h \equiv \frac{p_h}{p_h^{\gamma}p_l^{1-\gamma}} = \left(\frac{p_h}{p_l}\right)^{1-\gamma}, \tag{31}$$

$$\tilde{p}_l \equiv \frac{p_l}{p_h^{\gamma}p_l^{1-\gamma}} = \left(\frac{p_h}{p_l}\right)^{-\gamma}, \tag{32}$$

we can solve the two-equation system above and derive an expression for the two prices as a function of the productivities of the employees, the employment of both high-skill and low-skill employees and the parameter γ:

$$\tilde{p}_h = \left(\frac{\gamma}{1-\gamma}\right)^{1-\gamma}\left[\frac{x_l\left(e_{l,N}+e_{l,I}\right)}{x_h\left(e_{h,N}+e_{h,I}\right)}\right]^{1-\gamma}, \tag{33}$$

$$\tilde{p}_l = \left(\frac{1-\gamma}{\gamma}\right)^{\gamma}\left[\frac{x_h\left(e_{h,N}+e_{h,I}\right)}{x_l\left(e_{l,N}+e_{l,I}\right)}\right]^{\gamma} \tag{34}$$

Eqs. 33 and 34 show how an increase in the measure of low-skill immigrant workers $e_{l,I}$ has a positive effect on the real price of good h, while a negative effect on the real price of good l.

3.4.3 The Free Entry Condition in the Labour Market

The free-entry condition in the labour market implies that the value of a vacancy in each of the two markets is equal to zero, that is $V_i = 0$. Hence, in equilibrium employers are indifferent whether to open a high-skill or a low-skill vacancy.

Substituting Eqs. 20 and 21 in Equation 22 and applying the free-entry condition, we are able to derive the job-creation curve, which is market-specific and reads as:

$$\begin{aligned} & \pi_{i,N}\kappa_{i,N}q(\theta_i)\frac{(1-t)\left(\tilde{p}_i x_i - \tilde{w}_{i,N}\right) - \delta_{i,N}\tilde{p}_i x_i F}{r+\delta_{i,N}} + \\ + \quad & (1-\pi_{i,N})\kappa_{i,I}q(\theta_i)\frac{(1-t)\left(\tilde{p}_i x_i - \tilde{w}_{i,I}\right) - \delta_{i,I}\tilde{p}_i x_i F}{r+\delta_{i,I}} = c\tilde{p}_i x_i \end{aligned} \tag{35}$$

This equation states that the expected profit for an employer with a job filled with either a native or an immigrant employee, discounted at the specific discount rate $(r+\delta_{ij})$ must be equal to the cost of creating a vacancy (the right hand side of Equation 35). The profit of the employer is a positive function of the employee's productivity $\tilde{p}_i x_i$ and a negative function of the wage $w_{i,j}$ and of the job destruction rate δ_{ij}.

3.4.4 Equilibrium wage bargaining

Using Equations 12-13, Equations 20-21 and the wage bargaining equations (Equations 24 and 25), we are able to derive the wage-setting condition for native and immigrant employees in market i:

$$\tilde{w}_{i,j} = \frac{\tilde{p}_i x_i\left[\beta\psi(1-t) + (\beta\psi + (1-\beta)\phi)rF\right] + (1-\beta)\,rW^u_{i,j} - (1-\beta)\left[\psi(1-t)\tilde{\tau}_i\mathbb{1}_i + \nu\right]}{\psi(1-t)}. \tag{36}$$

As expected, the firing costs enter positively into the wage setting condition, as employers are bound to pay the cost at separation. It is easy to see that the heterogeneity between native and

immigrant employees enters only through the outside option of being unemployed $W^u_{i,j}$.

By solving a system of two equations in two unknown using Equations 12 and 14, we get an expression for the value function of native unemployed employees $W^u_{i,N}$, which reads as:

$$\begin{aligned} W^u_{i,N} &= \frac{Y^u_{i,N}}{r} + \frac{\beta\psi}{r(1-\beta)(r+\delta_{i,I})\pi_{i,N}} \{(r+\delta_{i,I})c\tilde{p}_i x_i \theta_i - \kappa_{i,I}\theta_i q(\theta_i)(1-\pi_{i,N}) [(1-t)(\tilde{p}_i x_i - \tilde{w}_{i,I}) \\ &- \delta_{i,I}\tilde{p}_i x_i F] \} + \frac{(r+\delta_{i,I})(\beta\psi + (1-\beta)\phi)\pi_{i,N}\kappa_{i,N}\theta_i q(\theta_i)\tilde{p}_i x_i F}{r(1-\beta)(r+\delta_{i,I})\pi_{i,N}}, \end{aligned} \tag{37}$$

Similarly for immigrants, using Equations 13 and 15, we get an expression for the value function of immigrant unemployed employees $W^u_{i,I}$:

$$\begin{aligned} W^u_{i,I} &= \frac{Y^u_{i,I} + \lambda W_{i,FC}}{r+\lambda} + \frac{\beta\psi}{(r+\lambda)(1-\beta)(r+\delta_{i,N})(1-\pi_{i,N})} \{(r+\delta_{i,N})c\tilde{p}_i x_i \theta_i + \\ &- \kappa_{i,N}\theta_i q(\theta_i)\pi_{i,N} [(1-t)(p_i\tilde{x}_i - \tilde{w}_{i,N}) - \delta_{i,N}p_i\tilde{x}_i F] \} \\ &+ \frac{(r+\delta_{i,N})(\beta\psi + (1-\beta)\phi)(1-\pi_{i,N})\kappa_{i,I}\theta_i q(\theta_i)\tilde{p}_i x_i F}{(r+\lambda)(1-\beta)(r+\delta_{i,N})(1-\pi_{i,N})}. \end{aligned} \tag{38}$$

Finally, substituting Equation 35 into Equation 36, we get the wages of high-skill and low-skill native and immigrant employees, as a function of the parameters of the model:

$$\begin{aligned} \tilde{w}_{i,N} &= \frac{\{(r+\delta_{i,I}) [(1-t)\pi_{i,N} + c\theta_i]\} \beta\psi\tilde{p}_i x_i - (r+\delta_{i,I})\pi_{i,N}(1-\beta)(1-b)\psi(1-t)\tilde{\tau}\mathbb{1}_i}{(1-t)\psi(r+\delta_{i,I})\pi_{i,N}[1-(1-\beta)b]} + \\ &+ \frac{\{(r+\delta_{i,I})\pi_{i,N}[r+\kappa_{i,N}\theta_i q(\theta_i)][\beta\psi + (1-\beta)\phi]\}\tilde{p}_i x_i F}{(1-t)\psi(r+\delta_{i,I})\pi_{i,N}[1-(1-\beta)b]} + \\ &- \frac{\beta\psi\kappa_{i,I}\theta_i q(\theta_i)(1-\pi_{i,N}) [(1-t)(\tilde{p}_i x_i - \tilde{w}_{i,I}) - \delta_{i,I}\tilde{p}_i x_i F]}{(1-t)\psi(r+\delta_{i,I})\pi_{i,N}[1-(1-\beta)b]}. \end{aligned} \tag{39}$$

$$
\begin{aligned}
\tilde{w}_{i,I} &= \frac{\{(r+\delta_{i,N})\left[(1+\lambda/r)(1-t)(1-\pi_{i,N})+c\theta_i\right]\}\beta\psi\tilde{p}_i x_i}{(1-t)\psi(r+\delta_{i,N})(1-\pi_{i,N})\left[1+\lambda/r-(1-\beta)b\right]} + \\
&- \frac{(r+\delta_{i,N})(1-\pi_{i,N})(1-\beta)\left[(1+\lambda/r-b)\psi(1-t)\tilde{\tau}\mathbb{1}_i+\lambda/rW_{FC}\right]}{(1-t)\psi(r+\delta_{i,N})(1-\pi_{i,N})\left[1+\lambda/r-(1-\beta)b\right]} + \\
&- \frac{(r+\delta_{i,N})(1-\pi_{i,N})(1-\beta)\lambda/r\nu}{(1-t)\psi(r+\delta_{i,N})(1-\pi_{i,N})\left[1+\lambda/r-(1-\beta)b\right]} + \\
&+ \frac{\{(r+\delta_{i,N})(1-\pi_{i,N})\left[r+\lambda+\kappa_{i,I}\theta_i q(\theta_i)\right]\left[\beta\psi+(1-\beta)\phi\right]\}\tilde{p}_i x_i F}{(1-t)\psi(r+\delta_{i,N})(1-\pi_{i,N})\left[1+\lambda/r-(1-\beta)b\right]} + \\
&- \frac{\beta\psi\kappa_{i,N}\theta_i q(\theta_i)\pi_{i,N}(1-t)\left[(\tilde{p}_i x_i-\tilde{w}_{i,N})-\delta_{i,N}\tilde{p}_i x_i F\right]}{(1-t)\psi(r+\delta_{i,N})(1-\pi_{i,N})\left[1+\lambda/r-(1-\beta)b\right]}. \qquad (40)
\end{aligned}
$$

We can notice from the wage equations above that they are both a positive function of the employee's productivity and a negative function of the subsidy provided by the Government to low-skill employees $\tilde{\tau}$. For immigrant employees, the wage is also a negative function of the public good ν, as immigrant employees will not be able to enjoy the good when they leave the country at rate λ. Interestingly, the wage of native employees is a negative function of the profit the employer will get if she hires an immigrant employee and vice-versa the wage of immigrant employees is a negative function of the profit the employer gets when hiring a native employee.

3.5 The Government

To conclude the presentation of the model, we assume that the Government runs a balanced budget in each period. Hence, the Government's revenues coming from the taxation of the employers' profits and the taxation of the employees' income are used to finance tax subsidies, unemployment benefits, and the furniture of public goods, that is:

$$
\begin{aligned}
t\left[\tilde{p}_h x_h\left(e_{h,N}+e_{h,I}\right)+\tilde{p}_l x_l\left(e_{l,N}+e_{l,I}\right)\right] &+ t\tilde{\tau}\left(e_{l,N}+e_{l,I}\right)=\tilde{\tau}\left(e_{l,N}+e_{l,I}\right)+ \\
&+ (1-t)\,b\left[\tilde{w}_{h,N}u_{h,N}+\tilde{w}_{h,I}u_{h,I}+\tilde{w}_{l,N}u_{l,N}+\tilde{w}_{l,I}u_{l,I}\right]+ \\
&+ \nu\left(\sigma_{h,N}+\sigma_{l,N}+e_{h,I}+e_{l,I}+u_{h,I}+u_{l,I}+\chi\right)^{\rho}, \qquad (41)
\end{aligned}
$$

where ρ measures the degree of congestion in the provision of public goods ($\rho=0$ is the case of a pure public good).

4 Calibration

In this section we calibrate the model using data from Italy for each year in the period 2009-2014.[6] Table 8 reports the list of parameters, which we calibrate and describes their role in the model. To select the parameters' values, we draw from the existing literature, we estimate a number of variables and we use statistics from the Italian Institute of statistics (Istat) as well as from OECD. Table 9 reports the values of the parameters used in our calibration in 2009 and describes the source.

Table 8. Description of calibrated parameters.

Parameter	Description	Parameter	Description
α	Elasticity wrt unemployment	$\kappa_{h,N}$	Hiring chances
β	Employees' bargaining power	$\kappa_{l,N}$	Hiring chances
r	Discount rate	$\kappa_{h,I}$	Hiring chances
t	Tax rate	$\kappa_{l,I}$	Hiring chances
c	Vacancy cost	ρ	Degree of congestion
$\sigma_{h,N}$	Mass of native HS workers	F	Firing cost
$\sigma_{l,N}$	Mass of native LS workers	γ	Elasticity of substitution
$\sigma_{h,I}$	Mass of immigrant HS workers	b	Unemployment benefit
$\sigma_{l,I}$	Mass of immigrant LS workers	x_h	Productivity of HS workers
χ	Mass of employers	x_l	Productivity of LS workers
λ	Rate of immigrants returning back	$W_{h,FC}$	Utility of HS workers abroad
η	Rate of immigrants entering the country	$W_{l,FC}$	Utility of LS workers abroad
$\delta_{h,N}$	Job destruction rate	$\delta_{l,N}$	Job destruction rate
$\delta_{h,I}$	Job destruction rate	$\delta_{l,I}$	Job destruction rate
τ	Degree of progressivity	ϕ	% firing cost transferred to employees

As standard in the literature (Pissarides, 2000), we assume that the matching function is shaped as a Cobb-Douglas, $m(v_i, u_i) = u_i^{\alpha} v_i^{1-\alpha}$, with α being the elasticity with respect to unemployment. The parameter α is set to a conservative value of 0.5, which is standard in the literature and in line with the evidence reported by (Petrongolo and Pissarides, 2001). The bargaining power of employees β is also set to the conservative value of 0.5, as standard in the literature (Boeri and Burda, 2009). The discount rate r is set to 0.002 to match an annual discount rate of 3.5%, as reported by Istat. The average tax rate t is set equal to 0.306 to match the average corporate tax rate and personal income tax rate, as reported by OECD. In our model, the parameter c represents the cost of a vacancy; we set the value of c equal to 0.16 as it reflects the estimate of total start-up costs as a percentage of income per capita (Djankov et al., 2002), converted to a fraction of labour productivity using the average employment rate (Boeri and Burda, 2009). The measures of different categories of employees defined by their skill level and country of origin are

[6]The period is selected as such as we only observe wages starting from 2009 and we have data to estimate the job creation and destruction rates only until 2014.

Table 9. Calibration values for 2009 and sources.

Parameter	Value	Source	Parameter	Value	Source
α	0.5	Petrongolo and Pissarides (2001)	$\kappa_{h,N}$	0.11	To match statistics
β	0.5	Petrongolo and Pissarides (2001)	$\kappa_{h,I}$	0.12	To match statistics
c	0.16	Boeri and Burda (2009)	$\kappa_{l,N}$	0.06	To match statistics
ϕ	0.8	Garibaldi and Violante (2005)	$\kappa_{l,I}$	0.05	To match statistics
r	0.0032	OECD	b	0.21	To match statistics
t	0.30	OECD	ρ	1	To match statistics
$\sigma_{h,N}$	5.5	Istat	F	1.9	To match statistics
$\sigma_{l,N}$	11	Istat	γ	0.41	To match statistics
$\sigma_{h,I}$	0.328	Istat	x_h	0.92	To match statistics
$\sigma_{l,I}$	3.510	Istat	x_l	0.77	To match statistics
χ	5.3	Istat	$W_{h,FC}$	100.89	To match statistics
λ	0.10	OECD	$W_{l,FC}$	54.58	To match statistics
η	0.07	OECD			
τ	0				
$\delta_{h,N}$	0.05	Shimer (2012)			
$\delta_{h,I}$	0.10	Shimer (2012)			
$\delta_{l,N}$	0.11	Shimer (2012)			
$\delta_{l,I}$	0.14	Shimer (2012)			

taken directly from Istat and refer to the number of natives and immigrants with high or low skill levels, in line with our definition reported in Section 2. The measure of employers χ is also taken from Istat and corresponds to the number of firms in the country. The parameters η and λ refer to the rate at which immigrant workers enter and leave the country, respectively; we set the two parameter values equal to the inflow and outflow rates, as reported by OECD. The parameter τ which defines the rate of progressivity of the taxation system is set equal to zero, which we consider to be a neutral value. Finally, the values for the parameters $\delta_{l,N}$, $\delta_{h,N}$, $\delta_{l,I}$, and $\delta_{h,I}$ are estimated following Shimer (2012), as described in Section 2.6.

We are then left with twelve parameters ($\kappa_{l,N}$, $\kappa_{h,N}$, $\kappa_{l,I}$, $\kappa_{h,I}$, ρ, F, γ, b, x_h, x_l, $W_{h,FC}$ and $W_{l,FC}$), which are pinned down by matching the observed wages, job finding rates and unemployment rates for the four different categories of workers. We then repeat the calibration for the years 2010-2014 using the values reported in Table 10. Overall, the parameter's values which we calibrate do not vary significantly across the years. We notice that the mass of immigrant workers increases, particularly if low-skill, as expected. Among the parameters that are pinned down by matching observed statistics, few of them are rather stable, such as the share of goods demanded γ, and the hiring chances κ and the degree of congestion ρ. The volatility of other parameters such as the unemployment benefits b, the firing costs F, the productivity of the employees x and the utilities of living outside the country is instead rather high. Nevertheless, we are able to match quite well the statistics considered in terms of wages, unemployment rates and job creation rates for the four categories of workers considered (Table 11). Particularly in terms of wages the per-

centage differences between the observed and simulate values is always close to zero. The only year in which we have problems matching the observed and simulated values, particularly in terms of unemployment rates and job finding rates is the year 2011. Hence, while commenting our results in the next section, we will keep in mind that the results for 2011 are not very reliable.

Table 10. Parameters of the calibration for year of analysis.

Parameter	2009	2010	2011	2012	2013	2014
α	0.500	0.500	0.500	0.500	0.500	0.500
β	0.500	0.500	0.500	0.500	0.500	0.500
ϕ	0.800	0.800	0.800	0.800	0.800	0.800
r	0.002	0.003	0.003	0.003	0.003	0.003
t	0.306	0.308	0.311	0.311	0.312	0.312
c	0.116	0.117	0.104	0.102	0.098	0.089
$\sigma_{h,N}$	5.674	5.430	5.401	5.472	5.490	5.545
$\sigma_{h,N}$	10.911	10.928	10.768	11.143	11.074	11.155
$\sigma_{h,I}$	0.239	0.286	0.228	0.255	0.292	0.364
$\sigma_{l,I}$	2.288	2.630	2.475	2.923	3.312	3.707
χ	5.999	6.023	5.898	5.887	5.750	5.736
λ	0.012	0.011	0.010	0.009	0.008	0.009
η	0.014	0.012	0.012	0.010	0.006	0.005
τ	0.000	0.000	0.000	0.000	0.000	0.000
$\delta_{h,N}$	0.004	0.004	0.004	0.004	0.004	0.004
$\delta_{h,I}$	0.010	0.006	0.007	0.008	0.008	0.007
$\delta_{l,N}$	0.008	0.007	0.009	0.009	0.009	0.009
$\delta_{l,I}$	0.012	0.011	0.013	0.013	0.011	0.012
$\kappa_{h,N}$	0.106	0.140	0.192	0.164	0.133	0.106
$\kappa_{h,I}$	0.122	0.124	0.172	0.133	0.111	0.091
$\kappa_{l,N}$	0.046	0.041	0.034	0.040	0.033	0.037
$\kappa_{l,I}$	0.063	0.056	0.060	0.049	0.042	0.044
ρ	1.135	1.043	0.783	1.165	1.101	1.174
F	1.926	2.231	2.526	2.321	2.635	3.030
γ	0.405	0.393	0.408	0.404	0.402	0.399
b	0.206	0.137	0.245	0.280	0.230	0.176
x_h	0.924	1.067	1.018	1.484	1.604	1.650
x_l	0.779	0.799	0.246	1.186	1.086	1.407
$W_{h,FC}$	100.898	120.579	93.021	87.994	113.623	90.915
$W_{l,FC}$	54.585	46.612	66.427	47.328	44.731	34.905

5 Winners and Losers of Immigration

In this section, we run a counterfactual analysis to study the effect of migration in the period 2009-2014. We choose 2006 as baseline year, as 2006 is the year before the immigration inflow to Italy shows a sudden increase. This exercise allows to describe how a number of economic variables have changed in the period 2009-2014 due to the increased immigration, compared to a

Table 11. The matching between simulated and observed variables for each year of analysis.

	w			u			q(θ)		
	Sim.	Obs.	%diff.	Sim.	Obs.	%diff	Sim	Obs	% diff.
					2009				
h.N.	1.40	1.40	0.00	0.05	0.05	0.06	0.07	0.07	0.06
l.N.	1.00	1.00	0.00	0.13	0.12	0.08	0.05	0.05	0.07
h.I.	1.36	1.36	0.00	0.11	0.11	0.06	0.08	0.07	0.05
l.I.	0.85	0.84	0.00	0.15	0.13	0.13	0.07	0.06	0.11
					2010				
h.N.	1.42	1.42	0.00	0.05	0.06	-0.11	0.07	0.07	-0.10
l.N.	1.00	1.00	0.00	0.13	0.13	-0.01	0.05	0.05	-0.01
h.I.	1.49	1.49	0.00	0.09	0.11	-0.14	0.06	0.07	-0.13
l.I.	0.82	0.82	0.00	0.14	0.14	0.02	0.07	0.07	0.01
					2011				
h.N.	1.43	1.42	0.01	0.07	0.05	0.32	0.05	0.04	0.30
l.N.	1.00	1.00	0.00	0.20	0.13	0.51	0.03	0.02	0.43
h.I.	1.42	1.43	-0.01	0.13	0.09	0.47	0.05	0.03	0.42
l.I.	0.84	0.84	0.01	0.17	0.14	0.26	0.06	0.05	0.22
					2012				
h.N.	1.44	1.43	0.01	0.07	0.06	0.12	0.06	0.05	0.11
l.N.	1.00	1.00	0.00	0.20	0.17	0.16	0.04	0.03	0.13
h.I.	1.35	1.36	-0.01	0.16	0.13	0.22	0.05	0.04	0.19
l.I.	0.84	0.83	0.01	0.22	0.16	0.36	0.04	0.04	0.29
					2013				
h.N.	1.44	1.44	0.00	0.08	0.07	0.08	0.05	0.05	0.08
l.N.	1.00	1.00	0.00	0.21	0.19	0.09	0.03	0.03	0.07
h.I.	1.41	1.41	-0.00	0.15	0.14	0.13	0.04	0.04	0.11
l.I.	0.82	0.82	0.00	0.20	0.20	0.03	0.04	0.04	0.02
					2014				
h.N.	1.45	1.45	0.00	0.07	0.07	-0.05	0.06	0.06	-0.05
l.N.	1.00	1.00	0.00	0.18	0.20	-0.10	0.04	0.05	-0.08
h.I.	1.35	1.35	0.00	0.13	0.13	-0.00	0.05	0.05	-0.00
l.I.	0.80	0.80	0.01	0.19	0.19	-0.03	0.05	0.05	-0.02

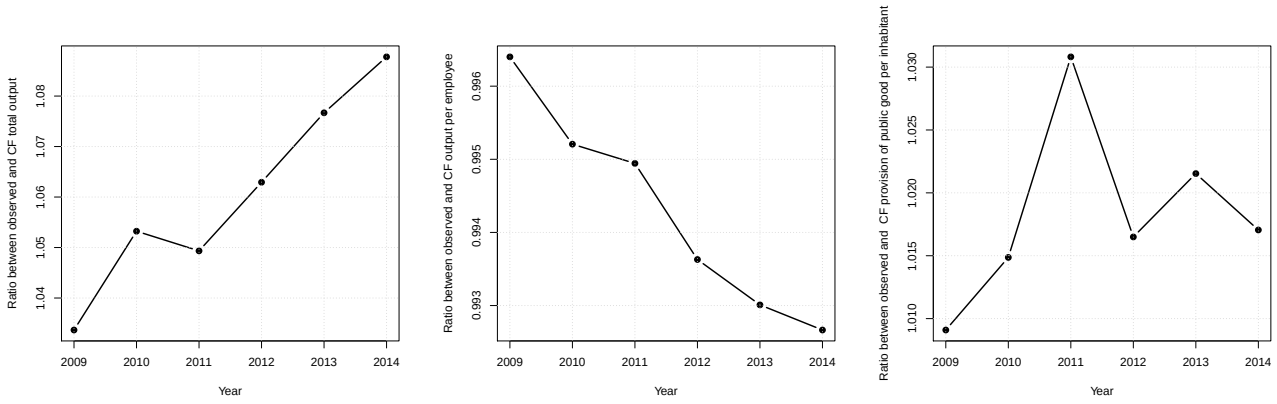
Note: h.N=high-skill natives, l.N=low-skill natives,
h.I=high-skill immigrants, l.I=low-skill immigrants.

counterfactual situation in which the immigration inflow would have been stable to the value of 2006.

Figure 5a reports the impact of the increased immigration relative to the baseline values of 2006 on total production. We notice that immigration has raised total production by 4 to 8 percentage points in the period considered. In order to construct a measure of labour productivity, we compute the ratio between total production and population. As expected given the great prevalence of low-skill immigrant employees, the increased immigration also caused a drop of labour productivity of approximately 1.5 percentage points (Figure 5b). However, the increase in total production also lead to an increase of approximately 2 to 3 percentage points in the provision of public goods per capita in the economy (Figure 5c).

When looking at the effect of immigration on the labour market, we find that the strong prevalence of low-skill immigrant employees among new incoming immigrants in Italy in the period 2007-2009 had a negative effect on the wages of low-skill workers, either natives or immigrants (6a). The magnitude of the impact is similar among the two categories of workers, i.e., between 2 and

Figure 5. The impact of migration on total production, labor productivity, and provision of public good per inhabitant (base year 2006).



(a) Total production. (b) Labour productivity. (c) Utility of public good.

4 percentage points, however, while the effect is persistent for natives, it gets reassorbed quickly among immigrant workers. The wages of high-skill workers, both natives and immigrants, have instead increased of approximately 4 to 8 percentage points. When looking at unemployment rates, we observe a decline in unemployment among all four categories of workers (Figure 6b). The decrease is stronger among low-skill workers (approximately 6 to 8 percentage points), and less significant among high-skill workers (approximately 1 to 2 percentage points). Combining the genral equilibrium effects, we can compute the effect of the increased inflow of low-skill immigrants on the lifetime utility of all four categories of employed workers (Figure 6c). As expected, we find that high-skill workers, both native and immigrants, are better off compared to a situation of no increased flow of immigrants. Their utility is higher by approximately 4 to 6 percentage points. The lifetime utility of low-skill immigrant employed workers is also higher in the period considered. This is due to the fact that even though their wage is slightly lower in the first three years considered (2009-2011), unemployment is also lower, and the provision of the public good is higher. Low-skilled native workers are better off in the first three years (their utility is up by approximately 1 to 2 percentage points), while their lifetime utility is stable and about the same as in a situation with no increased immigration in the following years (2012-2014). This is ascribable to the decrease in unemployment rates and the increase in the provision of the public good, which offsets the decline of their wages. When we compute the lifetime utility of unemployed workers (Figure 6d), we finad that all categories of workers are better off. The ones that benefit the most are low-skill immigrants, with an increased in their utility of up to 10 percentage points. All other three categories of workers (low-skill natives, high-skill natives, and high-skill natives) enjoy a positive jump in their utility in the range of 2 to 4 percentage points.

6 Conclusions

In this paper we develop a general equilibrium search and matching model where two goods are produced using high-skill and low-skill labour, respectively, and both goods are consumed by all individuals. Both high-skill and low-skill individuals are either native or immigrants. A central authority collects revenues by taxing wages and profits and redistributes the income by providing a public good, unemployment benefits and tax subsides. We analyse the effect of a shock in the supply of immigrant low-skill labour on the wage level, unemployment rate and overall welfare of all categories of workers. The model is calibrated using data from Italy for each year from 2009 to 2015. We find that as a consequence of the supply shock both the aggregate output and the provision of public good increase. While the wage level of low-skill workers decreases, the wage level of high-skill workers increases due to the lower average price level. The unemployment rate is lower for all four categories of workers. The overall effect on the workers' lifetime utility is positive for all categories of workers (on average a gain of approximately 4 to 6 percentage points). The effect is only slightly positive for low-skill native workers and this is ascribable to the fact that the increased provision of the public good and the lower unemployment rate are to able to just compensate for the decline in the wage level.

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Appendix

A The mapping of occupations in skill levels and of education in skill levels according to the International Labor Organization (ILO)

The International Labor Organization (ILO) maps the the International Standard Classification of Occupations (ISCO) in skill levels (Table 12). While the definition of *skill* refers to the ability to carry out the tasks and duties of a given job (ILO, 2012), the definition of *skill level* relates to a function of the complexity and range of tasks and duties to be performed in an occupation. The skill level is measured operationally by considering one or more of the following elements:

- the nature of the work performed in an occupation in relation to the characteristic tasks and duties defined for each ISCO-88 skill level;
- the level of formal education defined in terms of the International Standard Classification of Education (ISCED-97) required for competent performance of the tasks and duties involved; and
- the amount of informal on-the-job training and /or previous experience in a related occupation required for competent performance of these tasks and duties.

In addition, ILO provides a mapping between skill levels and education levels, following the International Standard Classification of Education ISCED-97, as developed by UNESCO (Table 13).

Occupations at Skill Level 1 typically require the performance of simple and routine physical or manual tasks. They may require the use of hand held tools, such as shovels, or of simple electrical equipment, such as vacuum cleaners. They involve tasks such as cleaning; digging; lifting and carrying materials by hand; sorting, storing or assembling goods by hand (sometimes in the context of mechanised operations): operating non-motorised vehicles; and picking fruit and vegetables. Many occupations at Skill Level 1 may require physical strength and/or endurance. For some jobs basic skills in literacy and numeracy may be required. If required, these skills would not be a major part of the job. For competent performance in some occupations at Skill Level 1, completion of primary education or the first stage of basic education (ISCED Level 1) may be

Table 12. Mapping of ISCO-08 major groups to skill levels

ISCO-08 major groups	Skill Level
1 - Managers, senior officials and legislators	3 + 4
2 - Professionals	4
3 - Technicians and associate professionals	3
4 - Clerks	
5 - Service and sales workers	
6 - Skilled agricultural and fishery workers	
7 - Craft and related trades workers	
8 - Plant and machine operators, and assemblers	2
9 - Elementary occupations	1
0 - Military occupations	1 + 4

required. Occupations classified at Skill Level 1 include office cleaners, freight handlers, garden labourers and kitchen assistants.

Occupations at Skill Level 2 typically involve the performance of tasks such as operating machinery and electronic equipment; driving vehicles; maintenance and repair of electrical and mechanical equipment; and manipulation, ordering and storage of information. For almost all occupations at Skill Level 2 the ability to read information such as safety instructions, to make written records of work completed, and to accurately perform simple arithmetical calculations is essential. Many occupations at this skill level require relatively advanced literacy and numeracy skills and good interpersonal communication skills. In some occupations these skills are required for a major part of the work. Many occupations at this skill level require a high level of manual dexterity. Occupations classified at Skill Level 2 include butchers, bus drivers, secretaries, accounts clerks, sewing machinists, dressmakers, shop sales assistants, police officers, hairdressers, building electricians and motor vehicle mechanics.

Occupations at Skill Level 3 typically involve the performance of complex technical and practical tasks which require an extensive body of factual, technical and procedural knowledge in a specialised field. Occupations at this skill level generally require a high level of literacy and numeracy and well developed interpersonal communication skills. These skills may include the ability to understand complex written material, prepare factual reports and communicate with people who are distressed. The knowledge and skills required at Skill Level 3 are usually obtained as the result of study at a higher educational institution following completion of secondary education for a period of 1-3 years (ISCED Level 5b). In some cases extensive relevant work experience and prolonged on the job training may substitute for the formal education. Occupations classified at Skill Level 3 include shop managers, medical laboratory technicians, legal secretaries, commercial sales representatives, computer support technicians, and broadcasting and recording technicians.

Occupations at Skill Level 4 typically involve the performance of tasks which require complex

Table 13. Mapping of ISCO-08 major groups to education level (ISCED-97) groups

ISCO-08 Skill Level	ISCED-97 groups Education Level
4	6 - Second stage of tertiary education (leading to an advanced research qualification)
	5a - First stage of tertiary education, 1st degree (medium duration)
3	5b - First stage of tertiary education (short or medium duration)
2	4 - Post-secondary, non-tertiary education
	3 - Upper secondary level of education
	2 - Lower secondary level of education
1	1 - Primary level of education

problem solving and decision making based on an extensive body of theoretical and factual knowledge in a specialised field. The tasks performed typically include analysis and research to extend the body of human knowledge in a particular field, diagnosis and treatment of disease, imparting knowledge to others, design of structures or machinery and of processes for construction and production. Occupations at this skill level generally require extended levels of literacy and numeracy, sometimes at a very high level, and excellent interpersonal communication skills. These skills generally include the ability to understand complex written material and communicate complex ideas in media such as books, reports and oral presentations. The knowledge and skills required at Skill Level 4 are usually obtained as the result of study at a higher educational institution for a period of 3-6 years leading to the award of a first degree or higher qualification (ISCED Level 5a or higher). In some cases experience and on the job training may substitute for the formal education. In many cases appropriate formal qualifications are an essential requirement for entry to the occupation.

B Details on the calibration of the parameters

In this section we describe in detail the steps followed to perform the model's calibration and and we report also some robustness checks.

B.1 Robustness check of job finding rates and job exit rates

From Equations (26)-(29) in the model, we derive the following equality:

$$\frac{e_{i,j}}{u_{i,j}} = \frac{\kappa_{i,j}\theta_i^{1-\alpha}}{\delta_{i,j}}, \tag{42}$$

where $i \in \{h, l\}$ and $j \in \{N, I\}$. The right hand side of Equation 42 reports the ratio between the job finding rate and the job exit rate, while the left hand side is the ratio between employed and

Table 14. Check for the calculation of the job finding and exit rate for different skills and country of origin. Source: our calculations oon ELFS.

	Estimate	Std. Error	t value	Pr(>|t|)
$e_{h,N}/u_{h,N}$	1.0302	0.0739	13.93	0.0000
$e_{l,N}/u_{l,N}$	0.9753	0.0857	11.39	0.0000
$e_{h,I}/u_{h,I}$	1.0949	0.0862	12.69	0.0000
$e_{l,I}/u_{l,I}$	1.1940	0.1246	9.58	0.0000

unemployed workers. If our estimates of the job finding rates and the job exit rates for employees by skill level and country of origin are somewhat correct, their ratio should be equal to the ratio of employed and unemployed employees by skill level and country of origin. In Table 14, we report the results of a set of regressions, where the two ratios for Italy for the period 2004-2014 are regressed against each other. The coefficients are all very close to one, confirming the robustness of our estimates.

B.2 The calibration of the inflow rate of immigrant workers

According to our model, the total inflow of immigrants (TII) is given by:

$$TII = \eta \left(\sigma_{h,I} + \sigma_{l,I} \right), \tag{43}$$

which is the product between the rate at which immigrant workers arrive in the home country and the measure of all immigrant workers (high-skill and low-skill). Using the measure of employed immigrant workers in the economy (Equation28) and Equation43, we can derive an expression for the rate at which immigrants workers join the home country, η:

$$\eta = \frac{TII - \lambda \left[e_{h,I} \delta_{h,I} / \kappa_{h,I} \theta_h q\left(\theta_h\right) + e_{l,I} \delta_{l,I} / \kappa_{l,I} \theta_l q\left(\theta_l\right) \right]}{e_{h,I} \left[\kappa_{h,I} \theta_h q\left(\theta_h\right) + \delta_{h,I} \right] / \kappa_{h,I} \theta_h q\left(\theta_h\right) + e_{l,I} \left[\kappa_{l,I} \theta_l q\left(\theta_l\right) + \delta_{l,I} \right] / \kappa_{l,I} \theta_l q\left(\theta_l\right)}, \tag{44}$$

The same rate can be computed using the measure of unemployed immigrant workers (Equation (29) and Equation 43:

$$\eta = \frac{TII - \lambda \left(u_{h,I} + u_{l,I} \right)}{u_{h,I} \left[\kappa_{h,I} \theta_h q\left(\theta_h\right) + \delta_{h,I} \right] / \delta_{h,I} + u_{l,I} \left[\kappa_{l,I} \theta_l q\left(\theta_l\right) + \delta_{l,I} \right] / \delta_{l,I}}. \tag{45}$$

Given, Eqs 44 and 45, we can estimate the arrival rate of immigrant workers in the home country for the period 2005-2014, as reported in Table 15.

Table 15. The estimate of η.

	η (via empl.)	η (via unempl.)	η (average)
2005	0.17	0.15	0.16
2006	0.13	0.13	0.13
2007	0.25	0.35	0.30
2008	0.18	0.37	0.28
2009	0.14	0.19	0.16
2010	0.15	0.15	0.15
2011	0.10	0.18	0.14
2012	0.07	0.16	0.12
2013	0.07	0.08	0.08
2014	0.06	0.06	0.06

B.3 The calibration of parameters by matching specific moments

The parameters γ, x_h, x_l, $W_{h,FC}$ and $W_{l,FC}$ are calibrated to match the observed values of (relative) wages, unemployment rates and job finding rates for all categories of workers. In particular, we find the parameters' values minimizing score S defined as follows:

$$S = \log\left(\sum_{i\in\{l,h\},j\in\{N,I\}} (\tilde{w}_{i,j}^{EQ}/\tilde{w}_{i,j}^{OBS} - 1)^2\right) + \log\left(\sum_{i\in\{l,h\},j\in\{N,I\}} (UR_{i,j}^{EQ}/UR_{i,j}^{OBS} - 1)^2\right), \quad (46)$$

where $UR_{i,j} \equiv u_{i,j}/(e_{i,j} + u_{i,j})$ is the unemployment rate of the workers of type (i, j).

C The procedure to find the equilibrium levels of θ_h and θ_l

The equilibrium levels of θ_h and θ_l are found by a numerical procedure. In the following, we describe the steps of such a procedure in details:

1. Take θ_h and θ_l from the set of candidate equilibrium prices.

2. Calculate for $i \in \{h, l\}$

$$e_{i,N} = \sigma_{i,N}\left[\frac{\kappa_{i,N}\theta_i q\left(\theta_i\right)}{\delta_{i,N} + \kappa_{i,N}\theta_i q\left(\theta_i\right)}\right] \tag{47}$$

$$u_{i,N} = \sigma_{i,N}\left[\frac{\delta_{i,N}}{\delta_{i,N} + \kappa_{i,N}\theta_i q\left(\theta_i\right)}\right]. \tag{48}$$

$$e_{i,I} = \sigma_{i,I}\left\{\frac{\eta\kappa_{i,I}\theta_i q\left(\theta_i\right)}{\lambda\delta_{i,I} + \eta\left[\kappa_{i,I}\theta_i q\left(\theta_i\right) + \delta_{i,I}\right]}\right\} \tag{49}$$

$$u_{i,I} = \sigma_{i,I}\left\{\frac{\eta\delta_{i,I}}{\lambda\delta_{i,I} + \eta\left[\kappa_{i,I}\theta_i q\left(\theta_i\right) + \delta_{i,I}\right]}\right\}. \tag{50}$$

$$FC_{i,I} = \sigma_{i,I}\left\{\frac{\lambda\delta_{i,I}}{\lambda\delta_{i,I} + \eta\left[\kappa_{i,I}\theta_i q_{i,I}\left(\theta_i\right) + \delta_{i,I}\right]}\right\} \tag{51}$$

3. Find the equilibrium level of prices from:

$$\tilde{p}_h = \left(\frac{\gamma}{1-\gamma}\right)^{1-\gamma}\left[\frac{x_l\left(e_{l,N} + e_{l,I}\right)}{x_h\left(e_{h,N} + e_{h,I}\right)}\right]^{1-\gamma} \text{ and} \tag{52}$$

$$\tilde{p}_l = \left(\frac{1-\gamma}{\gamma}\right)^{\gamma}\left[\frac{x_h\left(e_{h,N} + e_{h,I}\right)}{x_l\left(e_{l,N} + e_{l,I}\right)}\right]^{\gamma}. \tag{53}$$

4. Solve the system of equations in $(\tilde{w}_{h,N}, \tilde{w}_{l,N}, \tilde{w}_{h,I}, \tilde{w}_{l,I}, \nu)$, where the wage of natives is given by:

$$\begin{aligned}
\tilde{w}_{i,N} = & \frac{\left\{(r+\delta_{i,I})\left[(1-t)\pi_{i,N} + c\theta_i\right] - \kappa_{i,I}\theta_i q(\theta_i)(1-\pi_{i,N})(1-t)\right\}\beta\psi\tilde{p}_i x_i}{(1-t)\psi(r+\delta_{i,I})\pi_{i,N}\left[1-(1-\beta)b\right]} + \\
- & \frac{(r+\delta_{i,I})\pi_{i,N}(1-\beta)(1-b)\psi(1-t)\tilde{\tau}\mathbb{1}_i}{(1-t)\psi(r+\delta_{i,I})\pi_{i,N}\left[1-(1-\beta)b\right]} + \\
+ & \frac{\left\{(r+\delta_{i,I})\pi_{i,N}\left[r+\kappa_{i,N}\theta_i q(\theta_i)\right]\left[\beta\psi + (1-\beta)\phi\right] + \beta\psi\kappa_{i,I}\theta_i q(\theta_i)(1-\pi_{i,N})\delta_{i,I}\right\}p_i\tilde{x}_i F}{(1-t)\psi(r+\delta_{i,I})\pi_{i,N}\left[1-(1-\beta)b\right]} + \\
+ & \frac{\beta\psi\kappa_{i,I}\theta_i q(\theta_i)(1-\pi_{i,N})(1-t)\tilde{w}_{i,I}}{(1-t)\psi(r+\delta_{i,I})\pi_{i,N}\left[1-(1-\beta)b\right]};
\end{aligned} \tag{54}$$

the wage of immigrants is given by:

$$\begin{aligned}\tilde{w}_{i,I} &= \frac{\{(r+\delta_{i,N})\left[(1+\lambda/r)(1-t)(1-\pi_{i,N})+c\theta_i\right]-\kappa_{i,N}\theta_i q(\theta_i)\pi_{i,N}(1-t)\}\beta\psi\tilde{p}_i x_i}{(1-t)\psi(r+\delta_{i,N})(1-\pi_{i,N})\left[1+\lambda/r-(1-\beta)b\right]}+\\ &- \frac{(r+\delta_{i,N})(1-\pi_{i,N})(1-\beta)\left[(1+\lambda/r-b)\psi(1-t)\tilde{\tau}\mathbb{1}_i+(\lambda/r)W_{FC}\right]}{(1-t)\psi(r+\delta_{i,N})(1-\pi_{i,N})\left[1+\lambda/r-(1-\beta)b\right]}+\\ &- \frac{(r+\delta_{i,N})(1-\pi_{i,N})(1-\beta)(\lambda/r)\nu}{(1-t)\psi(r+\delta_{i,N})(1-\pi_{i,N})\left[1+\lambda/r-(1-\beta)b\right]}+\\ &+ \frac{\{(r+\delta_{i,N})(1-\pi_{i,N})\left[r+\lambda+\kappa_{i,I}\theta_i q(\theta_i)\right]\left[\beta\psi+(1-\beta)\phi\right]+\beta\psi\kappa_{i,N}\theta_i q(\theta_i)\pi_{i,N}\delta_{i,N}\}p_i\tilde{x}_i F}{(1-t)\psi(r+\delta_{i,N})(1-\pi_{i,N})\left[1+\lambda/r-(1-\beta)b\right]}+\\ &+ \frac{\beta\psi\kappa_{i,N}\theta_i q(\theta_i)\pi_{i,N}(1-t)\tilde{w}_{i,N}}{(1-t)\psi(r+\delta_{i,N})(1-\pi_{i,N})\left[1+\lambda/r-(1-\beta)b\right]}; \qquad (55)\end{aligned}$$

and the level of public goods by:

$$\begin{aligned}\nu &= \frac{t\left[\tilde{p}_h x_h\left(e_{h,N}+e_{h,I}\right)+\tilde{p}_l x_l\left(e_{l,N}+e_{l,I}\right)\right]-(1-t)\tilde{\tau}\left(e_{l,N}+e_{l,I}\right)}{\left(\sigma_{h,N}+\sigma_{l,N}+e_{h,I}+e_{l,I}+u_{h,I}+u_{l,I}+\chi\right)^{\rho}}+\\ &- \frac{(1-t)\,b\left[\tilde{w}_{h,N}u_{h,N}+\tilde{w}_{l,N}u_{l,N}+\tilde{w}_{h,I}u_{h,I}+\tilde{w}_{l,I}u_{l,I}\right]}{\left(\sigma_{h,N}+\sigma_{l,N}+e_{h,I}+e_{l,I}+u_{h,I}+u_{l,I}+\chi\right)^{\rho}} \qquad (56)\end{aligned}$$

5. Calculate the prices from job-creation curve of Equation 35.

$$\tilde{p}_h\left(JCC\right)=$$
$$\frac{q(\theta_h)[\pi_{h,N}\kappa_{h,N}\tilde{w}_{h,N}(r+\delta_{h,I})+(1-\pi_{h,N})\kappa_{h,I}\tilde{w}_{h,I}(r+\delta_{h,N})]}{x_h\{q(\theta_h)[\pi_{h,N}\kappa_{h,N}(1-t-\delta_{h,N}F)(r+\delta_{h,I})+(1-\pi_{h,N})\kappa_{h,I}(1-t-\delta_{h,I}F)(r+\delta_{h,N})]-c(r+\delta_{h,N})(r}$$

and

$$\tilde{p}_l\left(JCC\right)=$$
$$\frac{q(\theta_l)[\pi_{l,N}\kappa_{l,N}\tilde{w}_{l,N}(r+\delta_{l,I})+(1-\pi_{l,N})\kappa_{l,I}\tilde{w}_{l,I}(r+\delta_{l,N})]}{x_l\{q(\theta_l)[\pi_{l,N}\kappa_{l,N}(1-t-\delta_{l,N}F)(r+\delta_{l,I})+(1-\pi_{l,N})\kappa_{l,I}(1-t-\delta_{l,I}F)(r+\delta_{l,N})]-c(r+\delta_{l,N})(r+\delta_l}$$

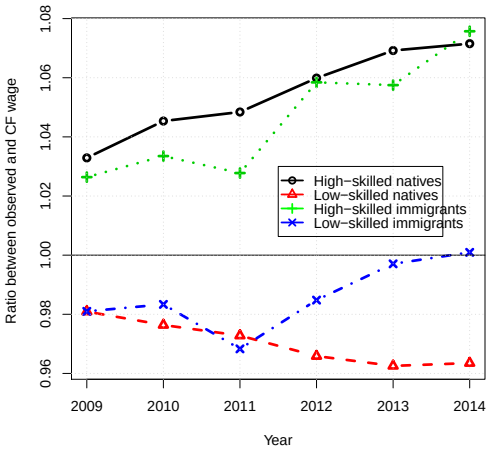
6. Calculate from Eqq. (52), (53), and (57), (58) the score D as follows:

$$D=\log\left(\left[\tilde{p}_h-\tilde{p}_h\left(JCC\right)\right]^2+\left[\tilde{p}_l-\tilde{p}_l\left(JCC\right)\right]^2\right)$$

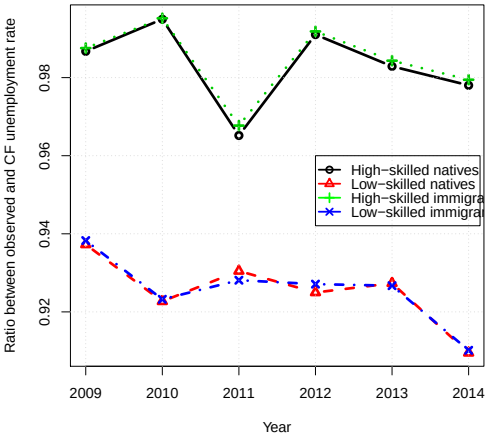
7. Iterate Steps 1-6 for all couples of θ_h and θ_l in the set of candidate equilibrium prices to find

the couple minimizing D.

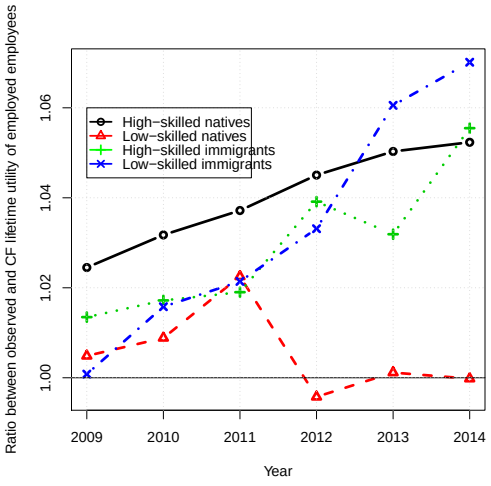
Figure 6. The effect of migration on wages, unemployment rates and lifetime utility of employed and unemployed workers by skill level and country of origin (base year 2006).



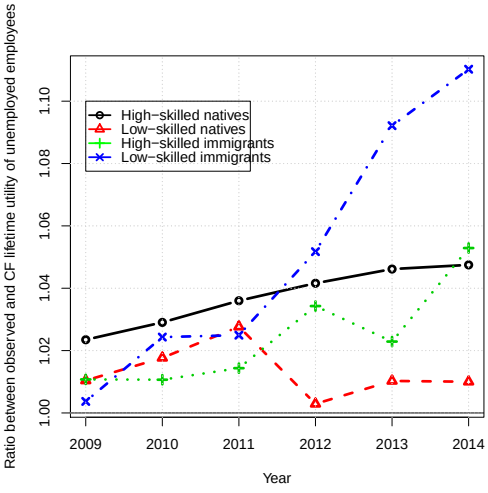
(a) Wages.



(b) Unemployment rates.



(c) Lifetime utility of employed workers.



(d) Lifetime utility of unemployed workers.