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DISCUSSION PAPER SERIES

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ABSTRACT

Native-Migrant Differences in Trading Off Wages and Workplace Safety

Applying propensity score reweighting to Italian administrative data covering the period 1994-2012, we study the conditional distributions of injuries by wage of native and foreign workers and distinguish between the component that is explained by observable characteristics and the component that is instead attributable to the immigrant status. Our analyses highlight some stylized facts. Besides a substantial gap in wage and injury risk that cannot be attributed to differences in the characteristics, foreign workers face higher levels of risk by the same level of wages. The gap is significantly above the level predicted by their observable characteristics by remunerations that are close to the minimum wage level set by collective bargaining. After this threshold, injury rates decline, but less steeply for foreign workers than their observable characteristics would predict. We show that the hedonic wage model could explain the first result as a corner solution whereby workers with low wage potential are forced to accept higher levels of risk due to the lower bounds on minimum wage. The second results could simply be explained by assuming different utility functions for natives and foreigners. We also show that the hedonic wage model is compatible with the marked reduction in injury rates and in the gap that we observe in the recession years.

JEL Classification: J28, J70

Keywords: occupational injuries, propensity score reweighting, wage gap, foreign workers, Di Nardo-Fortin-Lemieux decomposition

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1 Introduction

Media reports, official statistics, and a multidisciplinary scholarly literature show that foreign workers are employed in riskier jobs, and that they tend to accept jobs that are remunerated less and that natives reject. An extensive literature has shown that the employment impact of immigration is therefore negligible and that a significant wage gap exists between native and migrant workers. Yet, a fundamental implication of this literature, originally noted by Hamermesh (1997), remains understudied: in presence of a binding minimum wage, immigrants' tolerance of worse working conditions will not so much lead to a reduction of their wages as it will affect a range of job amenities, primarily workplace safety. Hence, if there is a trade-off between safety and wage (Hamermesh, 1999a,b; Boone and van Ours, 2006), a minimum wage threshold may have unintended adverse implications for safety (an argument that is coherent with the results in Hashimoto, 1982; Leombruni et al., 2013). More generally, studying the natives-immigrants wage gap along with the gaps in workplace safety can guide us in the interpretation of observed and unobserved determinants of these gaps; also, it provides an indication of the riskiness of the tasks in which migrants and natives are involved. In spite of the insights that can be drawn from the joint analysis of wages and injuries, the labour economics literature has mainly focused on wage gaps, while the study of the gaps in injury rates has mainly been left to the epidemiological literature - with some notable, though rare, exceptions (e.g. Hamermesh, 1997; Bauer et al., 1998; Hersch and Viscusi, 2010; Orrenius and Zavodny, 2009; Dávila et al., 2011). Among the insights offered by this measure of job quality is that the comparison between severe and less severe injuries provides a measure of underreporting and, thus, of workplace pressure. Indeed, Boone and van Ours (2006) have shown that workers respond to changes in macroeconomic condi-

tions by underreporting their injuries when the risk of remaining unemployed in greater. If foreign workers are disproportionately subject to pressure from employers, they should be more strongly affected by changes in the macroeconomic conditions, as well as by other policy changes altering their working pressure.

The wage gap between immigrants and natives in Italy has been reported to range between 14.7% and 38.7%, (Venturini and Villosio, 2002; Allasino et al., 2004; Falzoni et al., 2004; Piazzalunga, 2015), where a large component is attributable to differences in the characteristics. Similarly, Orrenius and Zavodny (2009) and Orrenius and Zavodny (2013), show that, in most countries, immigrants are overrepresented in occupations and industries with greater injury risks. Whether this also translates in *ceteris paribus* greater injury and fatality rates for immigrants than for natives (as found by Orrenius and Zavodny, 2009; Salminen, 2009; Ahonen and Benavides, 2006; Bena and Giraudo, 2014) is an empirical issue which is heavily affected by the availability of data and by the empirical specification applied. Indeed, some studies find that the gaps in wage and injuries between foreigners and natives should rather be attributed to the the dynamics of labour market segmentation (segregation) than to differential treatment at the workplace (e.g. Hamermesh, 1997; Bauer et al., 1998). In Italy, the workplace safety of immigrants with respect to natives has been investigated by Bena and Giraudo (2014); Bena et al. (2007); Capacci et al. (2005), who documented a significantly increased injury risk for some categories of immigrants, in particular those originating from Morocco and "high migration pressure countries", compared with natives and with immigrants from developed countries. According to their estimates, a foreign worker faces on average a 45% higher risk of workplace injury than a native. Our results show that a substantial gap in wage and injury risk cannot be attributed to differences in the characteristics, and that foreign workers face higher levels of risk by the

same level of wages. They also show that the magnitude of this residual gap in injuries varies along the distribution of wages and over time, with a peak by wages close to the minimum wage threshold, which in Italy is set by collective bargaining. Section 2 presents our theoretical framework, grounded in the hedonic wage model. Section 3 introduces our methodological approach and our data. Section 4 illustrates the results; section 5 discusses the main findings; and section 6 concludes.

2 Theoretical framework

In this paper, we investigate the extent to which the gaps in wages and injuries between natives and foreign workers in Italy can be attributed to differences in the workers' characteristics, and we distinguish it from the extent to which the differential can be attributed to the fact of being an immigrant, studying the evolution of both components over the 1994-2012 period. Addressing the question of whether native and foreign workers would have similar injury rates by similar wages, had they the same profile, implies referring to the relationship between workplace safety and wages, i.e. the extent by which immigrants can be expected to claim a wage differential to compensate for workplace injury risk. In general, for all workers, risk aversion is expected to lead workers to claim higher wages for riskier jobs (Rosen, 1987). However, empirical studies have often observed a negative relation between wages and injury risk. Indeed, more more skilled and better-paid workers may want to trade off part of their earnings for greater safety and sort into safer occupations - i.e. higher skills and salaries would allow them "buy" more safety at work (Hamermesh, 1999a,b; Biddle and Zarkin, 1988).

The economic immigrant status may be associated with less risk aversion, considering the often temporary nature of the project, especially in its early

phases: immigrants may accept risky jobs if these allow them to make fast money, which would locate them in the relatively "high risk" ends of the workplace safety distribution. If this applies, everything else equal, we should observe immigrants to undertake riskier but on average also better paid jobs (cfr. Dávila et al., 2011). However, a number of factors could account for differences in immigrants' demand for a wage premium by more risky jobs (Orrenius and Zavodny, 2013). Essentially, disproportionate market pressure associated with inferior language proficiency, bureaucratic difficulties with the recognition of their skills, institutional constraints on the legal authorizations to stay, smaller social networks and trade union integration can be expected to reduce workers' bargaining power and their ability to claim a higher wage for any given level of risk (Orrenius and Zavodny, 2013; Bena and Giraudo, 2014). For instance, if the residence permit issuance is conditioned on having a job, immigrants may be keen to accept lower-quality jobs or to accept worse working conditions and more demanding tasks within the same occupation. Also, as noted by Dávila et al. (2011), imperfect information may lead foreign workers to underestimate occupational risk and thus accept riskier occupations without claiming compensation for such risk: this could be the case if the average risk level in their home country is greater and leads them to mistakenly underestimate the risk of their occupation in the host country; also, counting on information asymmetries, employers may deliberately misinform them about occupational risk. Short-term immigrants may also have a different perception of the real value of wage, if home country products remain an important component of their consumption bundle; this may increase their purchasing power in real terms and lead them to accept wages that, by native Italian standards, would seem lower.

By segmented labour markets, immigrants are also likely to face flatter wage offer curves (Hersch and Viscusi, 2010; Orrenius and Zavodny, 2013). Immigrants' injury rates compared to those of natives may be higher if injury pre-

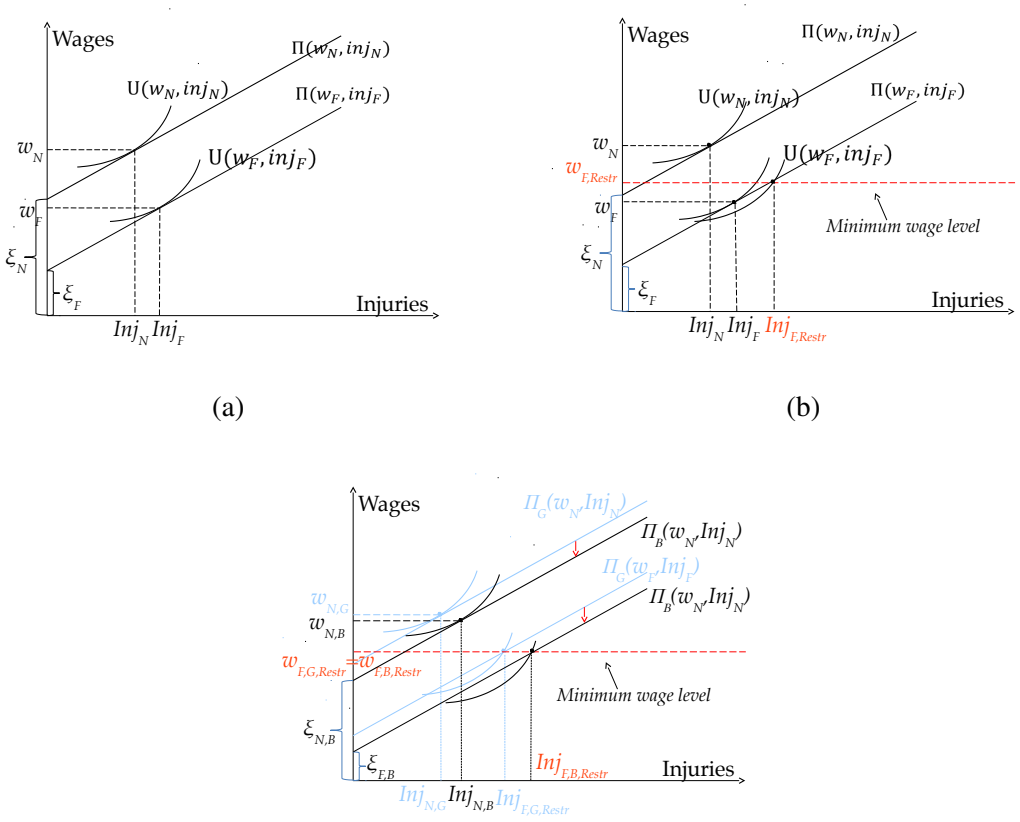
vention programmes and norms promoting the use of safety equipment are less effective for immigrants because of language and cultural barriers. This would comparatively increase the costs of safety training and decrease their "safety-related productivity" (Hersch and Viscusi, 2010, p.752) with respect to natives. Furthermore, perceived racism and race-related stress are *per se* considered as risk factors for a number of diseases[1].

Overall, both demand and supply side considerations lead us to expect that immigrants will have different combinations of risk and wages compared with natives, leading us to observe on average higher levels of occupational risk by the same level of salaries. In previous works addressing the relationship between wage and injury risk, Orrenius and Zavodny (2009) and Dávila et al. (2011) have framed this relationship within the hedonic wage model (Ehrenberg and Smith, 2016; Rosen, 1974).

The model assumes that workers maximize their expected utility, which is a function of wages and of other workplace amenities, among which workplace safety. Among the predictions of the model is that, ceteris paribus, employers offering jobs with high levels of risk should compensate workers for this risk with higher wages. In this framework, in fig. 1a we draw the equilibrium wage for natives N and foreigners F. Let us assume that the isoprofit curves and the indifference curves refer to a specified group of natives and foreigners with homogeneous characteristics (in terms of industry, occupation, age, etc.), for instance young blue collar workers in the manufacturing sector. The straight lines represent the isoprofit curves that guarantee the same profit to the firm that employs native ($\Pi(w_N, inj_N)$) or foreign ($\Pi(w_F, inj_F)$) workers with these characteristics. The curves are upward sloped because the employer has to pay a higher salary if she wants to offer a higher level of disamenity (i.e.

[1]Clark (2004) provides an overview of the literature and a conceptual framework to analyse the role of racism in affecting the health of immigrants. Murray (2003) reviews the methods to uncover the racial/ethnic bias in health.

Figure 1: Hedonic Wage Model



Wages by injury risk. (a) different positioning of foreign and natives on the isoprofit curve; (b) corner solution to the minimum wage constraint; (c) effect of the crisis on the injury-wage combinations.

risk). For simplicity, they are drawn as straight lines, but they could well be concave; they are drawn as parallel to each other, but, as discussed, it is likely that the foreigners' schedule will be flatter (as in Orrenius and Zavodny, 2009). The curves $U(w_N, inj_N)$ and $U(w_F, inj_F)$ represent the indifference curves of natives and foreigners, respectively. Obviously, the worker gets higher utility the higher and the more shifted to the left the curves are, i.e. by higher salary and lower injury risk. Lower isoprofit lines represent greater profits for the firm. The intercepts of the isoprofit lines are ξ_N for the natives and ξ_F for the foreigners. While the two refer to the same job and the same sector for work-

ers with similar characteristics (e.g. age, education, tenure, firm size) the two intercepts may still differ because of one or more of the following:

- lower unobserved productivity of workers (including less education, less language proficiency, etc.);
- discrimination (while the natives and foreigners are equally productive, the employer is only willing to offer to the foreigner worse combinations);
- while we control for sector and occupation, it could be that within each cell, foreign workers are assigned to more dangerous tasks (not necessarily because of discrimination, cfr. Dávila et al., 2011);
- furthermore, possibly, lower unobserved productivity and less unobserved safety investments of firms that hire foreigners;
- finally, as we will see more in detail later, both intercepts also depend on the economic cycle (because in a boom firms offer better conditions, e.g. because of profit sharing) and because with more stressful working times injuries become more likely. It may also be that foreign workers are allocated to tasks which are more subject to cyclical variation in working efforts.

In equilibrium, natives, by virtue of their higher intercepts[2], are located on a higher isoprofit line and can buy more safety (which is a normal good); these unobserved differences could explain why foreigners need higher salaries to buy safety. Notice that, throughout, we have assumed that foreigners and natives have the same utility functions. It could however be the case that foreigners accept more risk for comparatively less salary increases, and that their reservation wage and reservation safety (hence slope of the curve) vary with the economic cycle and with policy changes (e.g. with restrictions in the immigration law) (as in Dávila et al., 2011; Orrenius and Zavodny, 2013).

As suggested in the introduction, the minimum wage levels set by collec-

[2]In reality there are obviously multiple values of the unobserved characteristics that determine the intercepts. For simplicity, we only use one for natives and one for foreigners.

tive bargaining may also affect foreign workers differently from natives. Given unobserved characteristics of the worker and of the employer (including discriminatory attitudes), firms may be keen to offer foreign workers the combinations of wage and injuries that we call "unrestricted" ($w_{F,Un}, inj_{F,Un}$), which are located below the minimum wage threshold set by collective bargaining for that specific job. In this case, the equilibrium wage would be a corner solution by which foreign workers get a higher salary than what they would get in the absence of the minimum threshold ($w_{F,Restr}$), but undertake higher risk ($Inj_{F,Restr}$). To restore the unrestricted level of safety $inj_{F,Un}$, the foreign worker's human capital and experience (hence her intercept) would have to increase up to a level where the new isoprofit is tangent to the foreigner's indifference curve. This may however be beyond the worker's capacity.

In fig. 1c, we consider factors that may exogenously shift the intercepts. Assume there are two states of the economy: good (G) and bad (B). When the economy is in a bad state (B), by the same level of risk, firms are willing to pay lower salaries. This implies that the isoprofit curves in state Π_B will be lower. Hence, the firm will offer the same minimum salary it was offering in state G, but the corresponding injury risk will be higher ($Inj_{F,G,Restr}$). This may lead to a further increase in the injury risk for workers at the corner solution; the resulting levels of risk, however, may be unprofitable for the firm and unbearable for the worker.

3 Methodology

In order to analyze the different components of the wage gap, we apply the decomposition introduced by DiNardo et al. (1996) (hereinafter DFL decomposition) as well as its application to discrete data (Biewen, 2001). This methodology allows us creating a counterfactual immigrant population which is em-

ployed in the same sectors, with the same occupation, age, tenure and gender profile as the observed immigrant population, but is paid according to the wage schedule of the natives (or faces an injury risk comparable to those of natives (cfr. DiNardo et al., 1996). This allows us distinguishing the effect of the workers' characteristics on injury and wages from the effect of the remuneration of the workers' characteristics along the whole wage and injury distributions.

In essence, this is done by computing the propensity scores to be an immigrant and to be a native based on a set of characteristics, and by reweighting each observation in the native subsample by the ratio of the two (Hirano et al., 2003)[3]. In this reweighed distribution, those natives who are more similar to immigrants are weighted more; hence, analysing injury rates and wages of this distribution gives a measure of what wages and injury rates natives would display if they had the same characteristics as the immigrants.

This approach is equivalent to viewing the immigration status as a "treatment" (cfr. Barsky et al., 2002; DiNardo, 2002; Brunell and DiNardo, 2004) and to analyze the effect of being an immigrant on the distribution of wages and injuries under a "selection on observables" set of assumptions (e.g. Heckman et al., 1997). In this sense, the DFL decomposition is very similar in its approach to propensity score matching techniques. The main difference is that, instead of looking for the counterfactual by matching treated and non-treated units on the propensity score, we construct the counterfactual by reweighting each individual in the non-treated group to give more weight to individuals that are more similar to the treated. For this reason, the technique is also known as "propensity score reweighting" (DiNardo, 2002) and, similarly to the propensity score, is semiparametric.

More formally, in the DFL framework, we can write the density of an outcome variable y (the wage density, or the distribution of injuries) as a function

[3]This is implemented in practice by including the weights in a kernel density function applied to the observations of the natives.

of the immigration status T, where $T = 1$ if the person is an immigrant and $T = 0$ if the person is not an immigrant, and of a set of characteristics z (see DiNardo, 2002; Brunell and DiNardo, 2004)[4]. This simply derives from the definition of conditional probabilities:

$$f(y|T = 1) = \int f^1(y|z)h(z|T = 1)dz \tag{1}$$

$$f(y|T = 0) = \int f^0(y|z)h(z|T = 0)dz \tag{2}$$

In our case, $f(y|T = 1)$ is either the wage density or the injury density[5] that applies to immigrant workers. $f(y|T = 0)$ is instead the wage density or the injury density that applies to non-immigrant workers. The key contribution of the DFL approach is in showing that the counterfactual distribution of y that would prevail if the natives would have the same distribution of characteristics as the immigrants, can be written as a reweighted distribution of the observed density of natives[6]:

$$\int f^0(y|z)h(z|T = 1)dz = \int w_z f^0(y|z)h(z|T = 0)dz \tag{3}$$

The weights w_z are defined as the ratio of the density of characteristic z in the two subsamples. They can be seen as the ratio of the probability to observe a given characteristic (or combination of characteristics) among immigrants to the probability to observe it among natives. This way of seeing it allows a

[4]Conditioning on a single characteristic is not a very restrictive assumption if we see it as a discrete variable taking as values all the permutations of a set of characteristics.

[5]We can treat injury density as a continuous variable considering that we measure injuries as a ratio of the number of injuries to total person-years worked in a given cell of homogeneous characteristics.

[6]Notice that, as discussed in more details in Barsky et al. (2002), one might be tempted to study the opposite, i.e. the counterfactual distribution of wages and injuries which would prevail if immigrants had the same characteristics as natives. This, however, would imply an extrapolation rather than an interpolation, and would increase the estimation error: a large set of combinations of characteristics that we observe for natives, indeed, are simply not observed among immigrants. This makes natives a natural control group for immigrants, and not the opposite.

convenient simplification:

$$w_z = \frac{h(z|T=1)}{h(z|T=0)} = \frac{P(T=1|z)}{1-P(T=1|z)}\frac{P_0}{P_1} \tag{4}$$

where the second equality derives from applying the Bayes' law. While estimation of $h(z|T)$ is hampered by a dimensionality problem, the conditional probability of being an immigrant given a set of characteristics can be estimated by binary choice models such as logit or probit; P_0 and P_1 correspond respectively to the share of natives and the shares of immigrants in the sample[7]. In essence, w_z give more weight to the native individuals who display characteristics that are more similar to those of immigrants. Plugging the weights into a kernel density function allows estimating the counterfactual densities of y at each point y_t:

$$\hat{f}(y_t) = \sum_{i \in S_y} \hat{w}_{z_i} \frac{1}{Nh} K(\frac{y - y_t}{h})$$

Where h is the bandwidth and K is a kernel function - the gaussian in our application as well as in DiNardo et al. (1996). The reweighting procedure allows constructing a fictitious immigrant population which is employed in the same sectors, with the same occupation, age, tenure and gender profile as the observed immigrant population, but is paid according to the wage schedule of the natives (or has a risk propensity comparable to that of natives) (cfr. DiNardo et al., 1996). This procedure can be straightforwardly extended to construct the counterfactual concentration curves for injuries and wages (as in Razzolini et al., 2014), as well as the counterfactual joint distribution of wages and injuries.

The choice of the characteristics z which we use to estimate the propensity scores is largely data driven (see section 3.1): as regards the work relationship,

[7]If these combinations could be fully explained by discrete data, the nonparametric analogue of this procedure would be to study the relative shares of immigrants and natives within the each of the cells corresponding to each combination of characteristics.

we include firm size, firm age, 18 sectoral dummies, region of work, and type of contract; as regards the individual, we include age, gender, qualification, tenure, and, for the years where the information is available, a binary variable equal to 1 if the person received family allowances or not.

The differences between the observed distribution of natives and the counterfactual give a measure of the gaps due to the difference in characteristics; the differences between the counterfactual and the observed distribution of foreigners give a measure of the "unexplained" or "residual" difference (see DiNardo et al., 1996; Biewen, 2001; Barsky et al., 2002, for a more formal discussion). Hence, the latter can be attributed the "effect" of being an immigrant. As mentioned above, however, this approach does not allow disentangling systematic differences between the natives and the immigrants which are due to observable characteristics that are an exclusive attribute of immigrants - for example, language difficulties - from more subtle differences due, for example, to discrimination. Yet, the dynamics of both the "explained" and "residual" component can be studied and yield useful descriptive insights.

The necessary underlying assumption for this analysis is that, controlling for observable characteristics of the workers, the only systematic differences in the injury rates and expected wages between natives and immigrants are due to the immigration status [8]. This does not rule out, as argued for example by Starren et al. (2013) and Bena and Giraudo (2014), that cultural differences

[8]This is not a neutral assumption. Some works, indeed, argue that the decision to migrate per se implies low risk aversion(Berger and Gabriel, 1991; Bonin et al., 2009); other works underline that immigrants are able to undertake more strenuous jobs because they are on average younger and healthier than the average in their origin populations (the so-called "healthy immigrant effect" Antecol and Bedard, 2006). As to the first critique, we may argue that it is not quite clear how the sort of risk aversion that is needed to undertake a migration project would translate into the workers' safety behaviour at work: exactly because one undertook the (income) risk of migrating, she may want to be more careful at work not to waste an economic opportunity. Hence we consider the effect of this kind of risk aversion as *a priori* ambiguous in determining the injury rates of immigrants with respect to natives. As to the second critique, fortunately, our database allows us controlling for the age of the worker in the empirical analysis. Other kind of systematic differences, such as misperceptions about the level of risk in the host country, can be considered as effects of the immigration status which would not apply if the person did not migrate.

may play a role in determining heterogeneity in the occupational safety perceptions and behaviours within the group of immigrants. Unfortunately, such immigrant-specific characteristics cannot be included in the specification of the propensity scores. Indeed, the weights are constructed as the ratio of the propensity score to be an immigrant to the propensity score of being a native: if the latter is very close to zero, the corresponding weight will be extremely large. This means that the treated and untreated groups must be compared over realisations of characteristics that are observed in both groups - something analogous to the "common support" condition of the propensity score matching (see Heckman et al., 1997, 1998). To avoid extremely large weights, we discarded the observations for which $\hat{P}(T = 1|z) < min[\hat{P}(T = 0|z)]$ (cfr. Dehejia and Wahba, 2002), which typically implied dropping a negligible number of observations every year. Another practical implication of this problem is that we cannot control for variables such as the language abilities of immigrants or their countries of origin. Our factual group is composed of all migrants from "high migration pressure" (HMP) countries - we refer to them as "foreigners" or "immigrants" throughout our discussion; the corresponding "unfactual" group is composed of workers born in Italy and in advanced development countries - which we throughout refer to as "natives" for simplicity. The choice of such factual and unfactual groups is motivated by the need to ensure the largest possible homogeneity among each group of workers[9].

To analyse the relationship between injuries and wages, we study the con-

[9]The results are very similar when we use the whole of the foreign population (including immigrants from advanced development countries) as the factual and the strictly Italian-born population as the "untreated" group, given that the population of foreign workers in Italy is largely composed of workers from HMP countries. For reasons of space, we do not report here an additional set of analyses where we used as factuals the immigrant population from the two most representative countries: Morocco and Romania. The results obtained for the whole of the immigrant population and for HMP countries are confirmed and even more neat when adopting Morocco as a factual group. Instead, the findings for Romania support the hypothesis of heterogeneity across cultural groups, considering that most of the findings are reversed for this subset of workers, which is known to be a group where injury rates are particularly low (e.g. Bena and Giraudo, 2014). These analyses are available upon request.

ditional distribution of injuries by wage deciles in the observed and counterfactual subsamples (in the Appendix we also study concentration curves; see Wagstaff et al., 1991; Kakwani et al., 1997,).

In all cases, we performed the analysis using two measures of injuries: i) all reported and certified injuries; and ii) immediate-care injuries, i.e. the more severe injuries requiring immediate hospitalization[10].

3.1 Data

We use administrative data deriving from the linkage of the Work Histories Italian Panel (WHIP), a 1:15 sample of the Italian social security data, with administrative records from the Italian Workers' Compensation Authority (INAIL) for the years 1994-2012 (Bena et al., 2012). This dataset uniquely offers individual level information on injuries. Overall, the data set includes between 600,000 and 1,400,000 individual records for each of the 18 years in the sample. It provides information on worker and job characteristics (age, sex, place of birth, type of occupation, type of contract, family allowances, tenure, firm age, sector, size of firm, number of weeks worked in a year, part-time job, earnings), as well as on the number of work-related injuries (all of which are certified by physicians), their level of severity, and the lost days of work. Hence, our data set provides an exceptionally rich source of information which we use to analyze the joint distribution of (deflated) weekly earnings and workplace injuries. Despite this wealth of information there are two main limitations in our data. First, a precise estimation of injury risk is only available for employees in the non-agricultural private sector, as employees in other sectors are either not covered (public sector, agriculture and fishing), or the available information is inadequate to measure the exposure to injury risk (hours of work

[10]The results are similar also when using the number of lost workdays as a measure of injuries and are available upon request.

and days of work for self-employed workers are imprecisely measured). Lack of reliable information in the data also forces us to exclude domestic workers, whose exclusion is particularly unfortunate in an analysis of immigrant wage gaps considering the importance of this sector for the employment of female immigrants in the Italian context. Therefore, we opt to focus on male workers. Second, like many administrative records that are used to compute social security benefits, our data set has no information on education, as education does not enter the benefit formula directly. Fortunately, the data does include information on whether the worker is a blue or a white collar, or whether he has managerial tasks, which tends to be highly correlated with education.

Our dataset allows investigating a relatively long time span of 18 years, during which a number of significant policy changes of relevance to immigration and, in particular, to the access of foreign workers to regular employment occurred: considering that restrictions to regular employment are considered among the legal and institutional risk factors for severe labour exploitation (FRA, 2015), these changes are likely to have an effect on the distribution of wages and injuries among foreign workers.

Based on preliminary year-by-year analysis, in what follows, we will split our data into four periods. The first period covers 1994-1998, and corresponds to the years of the entry into force of the Schengen Treaty establishing free movement of people within the EU, and preceding the entry into force of the first of the two major immigration reforms in Italy, Law nro. 40/1998, popularly known as Turco-Napolitano after its proponents. The second period corresponds to 1999-2002 and lasts from the first entry into force of the Turco-Napolitano law to the introduction of the second major immigration reform, Law nro. 189/2002, which is popularly known as the Bossi-Fini law. The third period that we consider (2003-2006) is the one between the passing of the Bossi-Fini law and the enlargement of the EU to Romania and Bulgaria. The

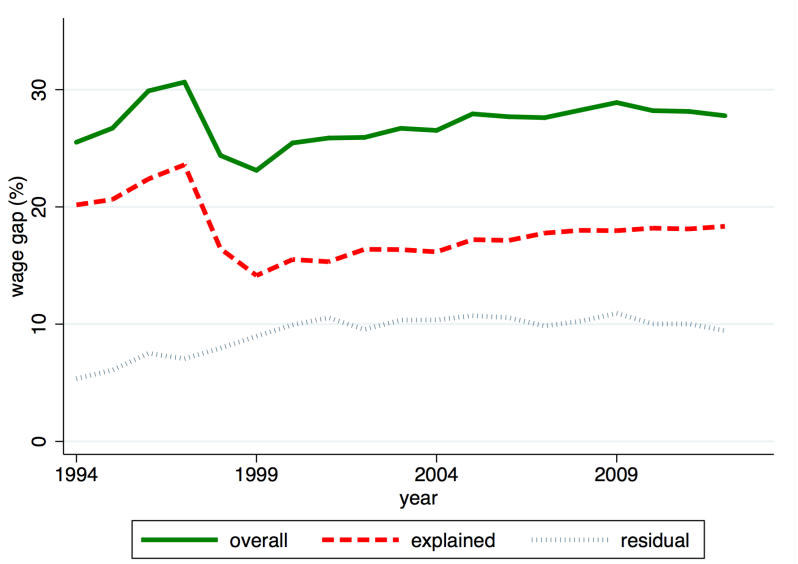
fourth, lasting from 2007 to 2012, is the post-enlargement crisis period during which the great recession took place.

Some descriptive statistics for 1994, 2003 and 2012 are reported in the Appendix in table A.1. While substantial gaps and differences emerge between the groups of natives and foreigners, a tendency towards convergence can be noted for most variables.

4 Results

4.1 Wages

Figure 2: Trends in average native-migrant earning gaps, 1994-2012



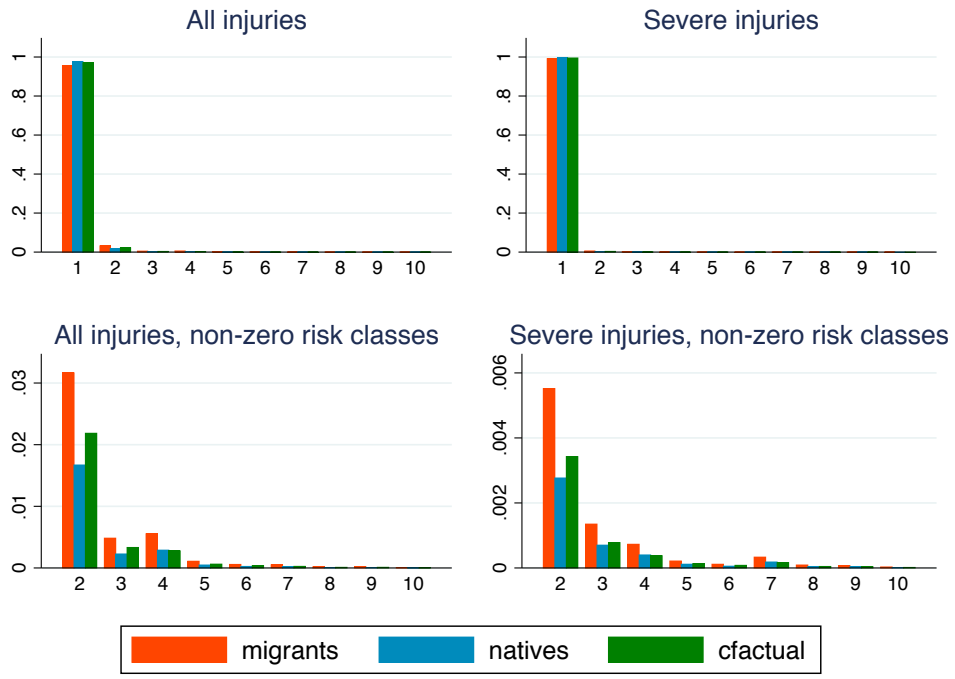
Constant prices, base year 2012. Native-immigrant earning gaps are distinguished into: overall (green solid), explained by observable characteristics (red dashed), and residual (blue dotted). Source: own computations on WHIP 2015.

The time trends of the foreign-native earning gaps are illustrated in figure 2, which reports the overall gap (the green solid line) along with its explained component (red dashed) as well as the residual unexplained component (blue dotted). The average foreign-native gap in weekly wages is slightly below 30%,

with a small but constant increase over time. The figure also reports the component that is "explained" by the difference in characteristics (i.e. the difference between the natives' and the counterfactual curve) and the "residual" component, which is attributable to the effect of being a foreigner - that is, the difference between the counterfactual and the foreigners. In the early years of the period, the differences in characteristics explain the gap almost entirely; since the late nineties, the explained component of the gap has been on a slight increase. The residual component has grown until 2003 and has stabilised around 10% since then; these results are somewhat smaller but in line with the recent findings in the literature on the wage gaps of immigrants (see also table A.3 and Fig. A.1 in Appendix for a closer look at the variation in the explained and residual component along the whole of the distribution).

4.2 Injury risk

Figure 3: Distribution of foreigners, natives and counterfactual by classes of risk.



Data pooled for the 18 years 1994-2012. Risk classes correspond to the first 10 of 80 risk classes of equal size observed over the 18 year period. The underlying injury rates have been calculated for a set of cells of homogeneous characteristics (gender, age class, qualification, family allowances, region of work, semesters of tenure, type of contract, sector, firm size and firm age). The number of natives in each class is reweighed by the DFL to get the counterfactual. Source: own computations on WHIP 2015.

To study the distribution of injury risk we constructed cells of homogeneous characteristics (gender, age class, qualification, family allowances, region of work, semesters of tenure, type of contract, sector, firm size and firm age) and computed the average injury risks per each cell. Based on the observed range of injury rates over the 18-year period, we assigned the injury rates of each cell to 80 risk classes of equal size. Based on the numerosity of the cells, we were in this way able to count the number of natives and of foreigners in each risk class, and their relative shares over their respective subsamples. The counterfactual distribution was obtained by reweighting the count of each cell by the

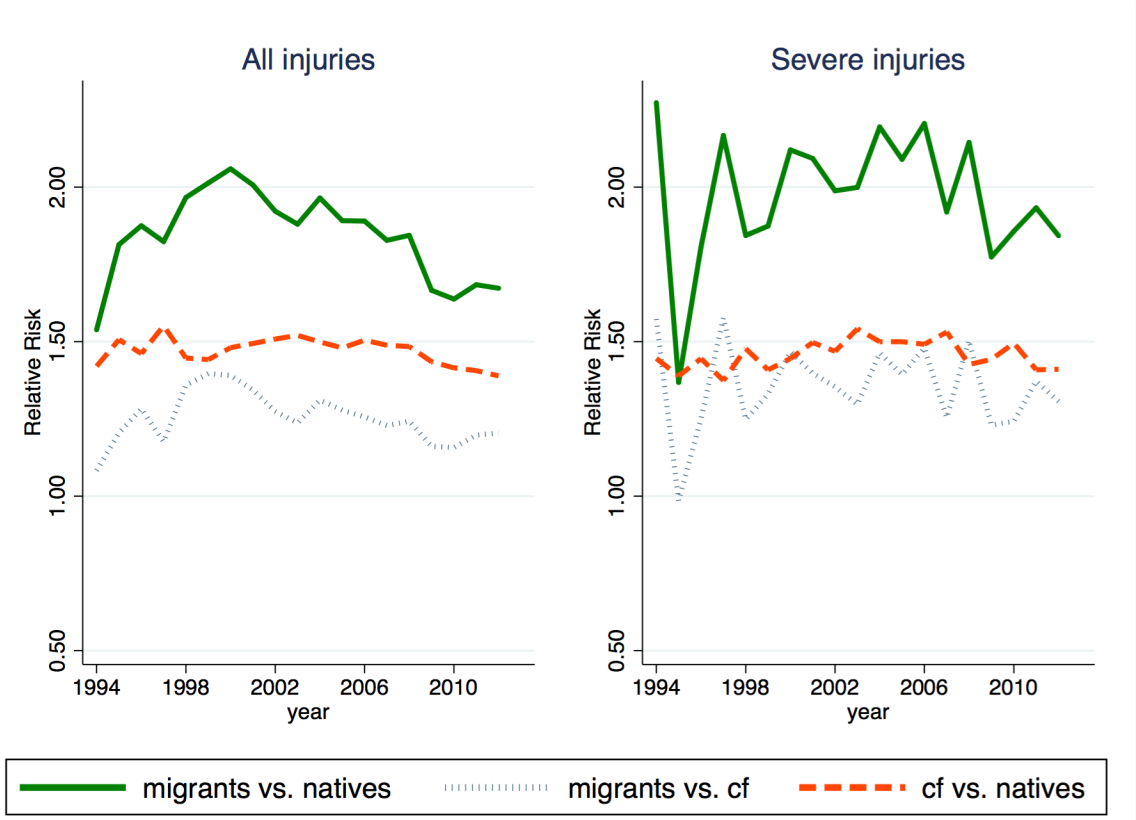
DFL weight, and by computing the share of each class over the counterfactual sample. Because injuries are relatively rare events, the wide majority of our sample concentrates in the lowest risk class. For instance, in 1994, 96.02% of all natives, and 93.73% of all foreigners, were assigned to the lowest risk class. Hence, to ensure statistical power in the higher risk classes, we pooled the data over the 18 years and dropped all classes above 10 (i.e. above an injury risk of 3 injuries per person-year); the yearly distributions closely resemble the pooled distribution. The results are reported in Fig. 3.The upper panel reports the entire distribution for all injuries (left) and severe injuries (right); the lower panel zooms on the non-zero risk classes.

In all cases, the distribution of immigrants by risk classes is right-shifted with respect to the natives'; foreigners are less concentrated than natives in the lowest risk class, and more frequently observed in the immediately higher risk classes. The counterfactual distribution shows that, if natives had the same characteristics as foreigners, the distribution of natives' risk would also be more right-skewed and we would observe an higher average risk of injuries among natives. Interestingly, however, the difference in characteristics is useful in explaining the greater concentration of immigrants in moderately high risk classes (2-3 for all injuries and 2 for IC injuries). The concentration of immigrants in risk classes higher than 3 is instead to be attributed to the effect of being an immigrant (the difference between the figures for natives and for the counterfactual goes to zero in higher risk classes).

Once we can compare the observed distribution with the reweighted distribution, we can also compute the mean of the those distributions; comparing the mean injury rates for immigrants with the mean injury rates of the counterfactual population would provide a measure of the average treatment effect on the treated - i.e. the effect that immigrant status has on immigrants' injury rates (Hirano et al., 2003; DiNardo, 2002). As it is standard in the epidemiological

literature, we opt to compare means by computing relative risks (RR) for the three considered subsamples.

Figure 4: Relative risk trends, 1994-2012



Relative risks calculated based on the ratio of injury rates of the relevant subsamples in each year: overall gap: foreigners to natives; explained: counterfactual to natives; residual: foreigners to counterfactual. Figures relating to all injuries (left) and to severe injuries (right). Source: own computations on WHIP 2015.

Table 1 reports the trends in injury rates for the foreigners, natives, and counterfactual subsamples. According to our calculations, as regards all injuries, injury rates of foreign workers are higher than those of natives. For all subsamples, the injury rates have increased remarkably during the 1998-2001 period, with foreigners experiencing a much steeper increase. Afterwards, both subsamples have seen a gradual reduction in injury rates which became even more marked during the years of the economic crisis, likely due to the strong pro-cyclical nature of injuries (e.g. Asfaw et al., 2011; Boone et al., 2011;

Boone and van Ours, 2006). The injury rates of the counterfactual locate in between the two subsamples and follow a similar hump-shaped trend peaking in 2000.

Table 1: Injury rates (percent)

	All injuries			Immediate-care injuries		
Year	Migrants	Natives	Cfactual	Migrants	Natives	Cfactual
1994	7.52	5.12	6.91	0.76	0.42	0.56
1995	7.81	4.80	6.92	0.53	0.42	0.56
1996	7.73	4.69	6.64	0.79	0.40	0.53
1997	7.96	4.60	6.75	0.75	0.40	0.53
1998	10.73	5.82	8.06	0.88	0.51	0.71
1999	11.24	5.96	8.23	0.92	0.53	0.71
2000	11.48	5.93	8.39	1.06	0.53	0.73
2001	11.09	5.83	8.35	1.05	0.53	0.76
2002	10.11	5.47	7.98	0.98	0.51	0.71
2003	9.50	5.24	7.68	0.92	0.47	0.70
2004	9.58	5.06	7.34	1.00	0.47	0.69
2005	9.02	4.91	7.02	0.90	0.45	0.65
2006	8.90	4.88	7.10	0.95	0.45	0.64
2007	8.05	4.55	6.57	0.84	0.45	0.66
2008	7.63	4.26	6.15	0.85	0.41	0.58
2009	6.37	3.92	5.47	0.66	0.38	0.53
2010	6.23	3.91	5.39	0.64	0.36	0.51
2011	5.92	3.61	4.94	0.65	0.35	0.48
2012	5.28	3.28	4.45	0.59	0.33	0.45

Rates computed yearly as the ratio of the number of injuries by exposure in person-years (1994-2002). Figures relating to all injuries (left) and to severe injuries (right). Source: own computations on WHIP 2015.

Relative risk trends of immigrants versus natives follow a similar trend, showing a marked increase up to 2000, and a relatively constant decline afterwards, suggesting that, while the increase in injury rates up to 2000 has affected both subsamples, foreign workers have been much more strongly affected. Fig. 4 shows this graphically by including the average injury rate of each subgroup (see also Table A.2 in the Appendix). The declining trend in the overall gap (solid green) remains largely unexplained by the observable characteristics until 2007; it mainly follows the dynamics of the unexplained component (the blue dotted line). In 2012, about 30% of the increased risk of injury faced by foreigners was attributable to the immigrant status. Instead, the explained com-

ponent (the red dashed line) of the workers has remained relatively stable over time - between 1.35 and 1.47 - and has only slightly been declining in recent years due to the economic crisis.

The decline in the explained component during the recession suggests some convergence in the observable characteristics of natives and foreigners: natives go back into jobs that were previously left to foreigners only (as even more cleary shown in the concentration curves for the sub period 2007-2010, see section A.2 in Appendix).

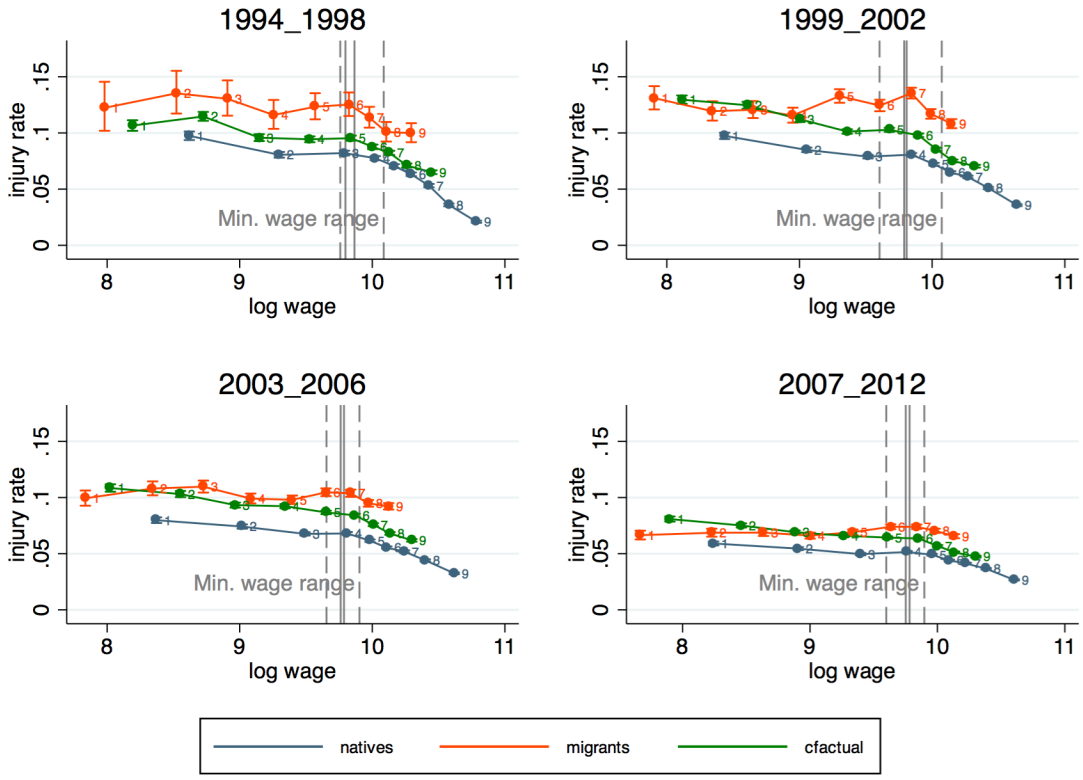
The reduction in the unexplained component may partly be attributed to the change in the composition of the immigrant population by nationality. Over the 2000s, the immigrant population has seen an increasing share of workers to originate from Eastern European countries, who are found to display particularly low injury rates (see also Bena and Giraudo, 2014).

Turning to severe injuries, no comparable reduction in the residual component can be observed. The more erratic pattern is obviously due to the lower numerosity of immediate-care injuries, but still, no time variation in this component is recognizable. This implies a fairly stable excess of risk of severe injuries among foreigners, of which about 45-50% can be attributed to immigrant-specific factors (a figure which is comparable to the findings in Bena and Giraudo, 2014, for stratified samples). Drawing on Boone and van Ours (2006), the finding that aggregate injuries display a decline while severe injuries don't could be attributed to the underreporting of less severe injuries. To gain further insights on this issue, we now turn to the joint analysis of injuries and wages.

4.3 Conditional distributions of risk by wage

In studying the relationship between wages and injuries, we may be interested in studying the social gradient in ill-health, i.e. the extent to which injuries are

Figure 5: Injury rates by annual wage decile; all injuries

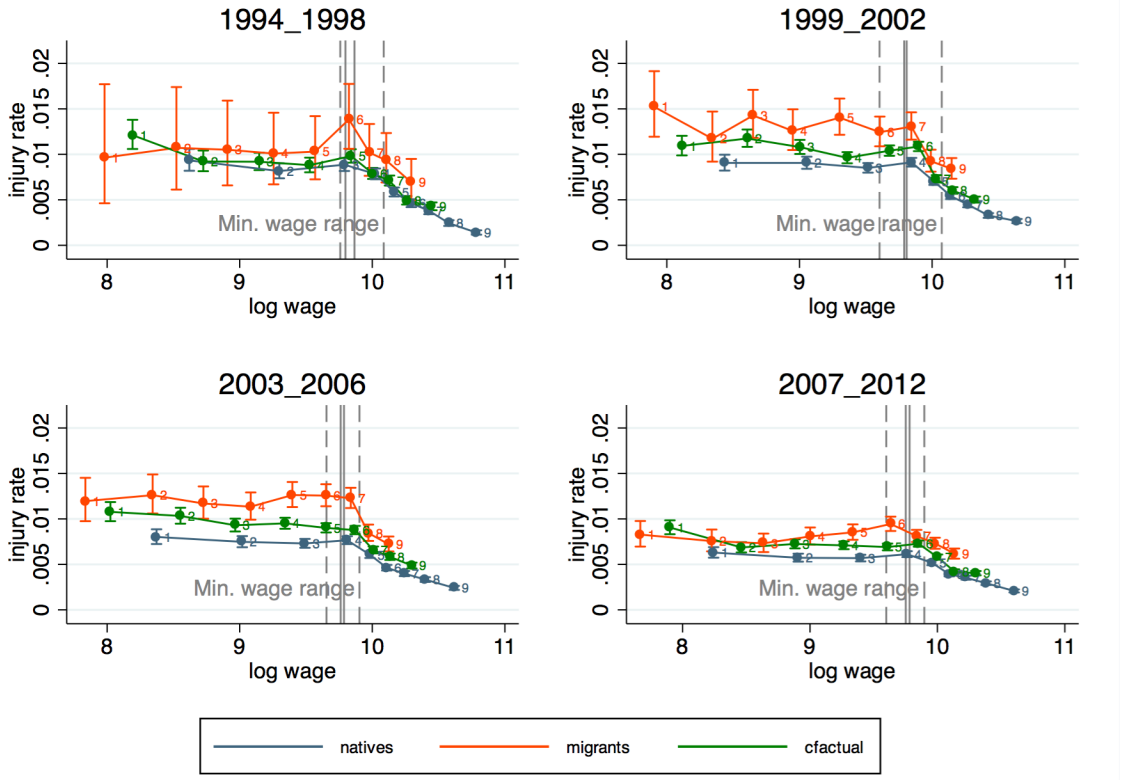


Male blue collar workers in the manufacturing sector. Deciles of the counterfactual distribution obtained by reweighting the distribution of wages prior to calculating the deciles. Injury rates and 95% Poisson confidence intervals computed for each decile and each subsample. Minimum wage ranges relevant for the sub period (constant prices, base year 2012) for all manufacturing sectors reported as dashed gray lines, as solid lines for metal-mechanic subsector. Source: own computations on WHIP 2015.

concentrated by lower salaries. In Fig. 5 and 6, we explore the functional form of the relationship between injuries and annual wages by splitting our subsamples into deciles[11]. To obtain the counterfactual distributions, we reweigh the

[11] Another tool for the analysis of the social gradient in health is the represented by concentration curves (Wagstaff et al., 1991; Kakwani et al., 1997). However, concentration curves are constrained to analyse within-group inequalities and are thus of limited insightfulness, when analysing the wage and injury gaps. Because they are deterministically associated with the slope index of inequality, which is in turn related to the regression coefficient of injury rates by wage quantiles, we focus in what follows on the relationship between injury rates and wage quantiles in each subgroup, and report the concentration curves (constructed for our three subgroups over the four sub periods for all and severe injuries) in appendix section A.2. The main message deriving from the concentration curves analysis is

Figure 6: Injury rates by annual wage decile; severe injuries



Male blue collar workers in the manufacturing sector. Deciles of the counterfactual distribution obtained by reweighting the distribution of wages prior to calculating the deciles. Injury rates for severe injuries and 95% Poisson confidence intervals computed for each decile and each subsample. Minimum wage ranges relevant for the sub period (constant prices, base year 2012) for all manufacturing sectors reported as dashed gray lines, as solid lines for metal-mechanic subsector. Source: own computations on WHIP 2015.

native population by the DFL weight and compute quantiles accordingly. For each decile, we then compute the injury rates for both all injuries and severe injuries. We plot the injury rates for immediate-care injuries of the three subsamples (natives, foreigners and counterfactual) against the log of wage in each quantile. In this way, we get an insight on the within-group distribution of injuries but we can also show the relative position of the three subgroups in terms of wage. In an attempt to mitigate unobserved heterogeneity, we focus in this

that the distribution of injuries with respect to annual wages within the group of foreigners is much less unequal - in fact, it is almost perfectly equal in the later years - than the one of natives. The analysis that follows helps explaining this result.

analysis on male blue collar workers in the manufacturing sector.

These figures provide a number of insights.

First, the schedule for foreigners lies always above the schedule for natives and in many cases also above the counterfactual. This implies that, by the same level of wage, immigrants have higher injury rates, as expected by for instance by Orrenius and Zavodny (2013). Nevertheless, the role of observable characteristics in affecting injury rates is substantial, as shown by the difference between the natives' and the counterfactual curve. Second, the natives and foreigners' schedules show quite different socio-economic conditions of the two subsamples: just to make an example, in the 2003-2006 sub period, the 4th decile of the natives' wage distribution corresponded in absolute value to the 6th decile of the counterfactual, and to the 7th quantile of the foreigners' wage distribution; the injury rates corresponding to this wage level were significantly higher for foreigners compared to the counterfactual, and for the counterfactual compared to natives. Third, while the difference is not always significant, the empirical conditional injury rate schedule for foreigners is usually located above the counterfactual schedule, suggesting that by the same level of wage, characteristics would predict similar or lower injury rates than are observed. Fourth, the decline in the overall injury rates observed above translates into a gradual reduction of the slopes of the curves over time, leading to a very flat distribution in the recession sub period of 2007-2012. This sub-period is marked by a substantial reduction in the injury rates for all subsamples and in particular for foreigners. This pattern is the same for immediate care injuries and for all injuries.

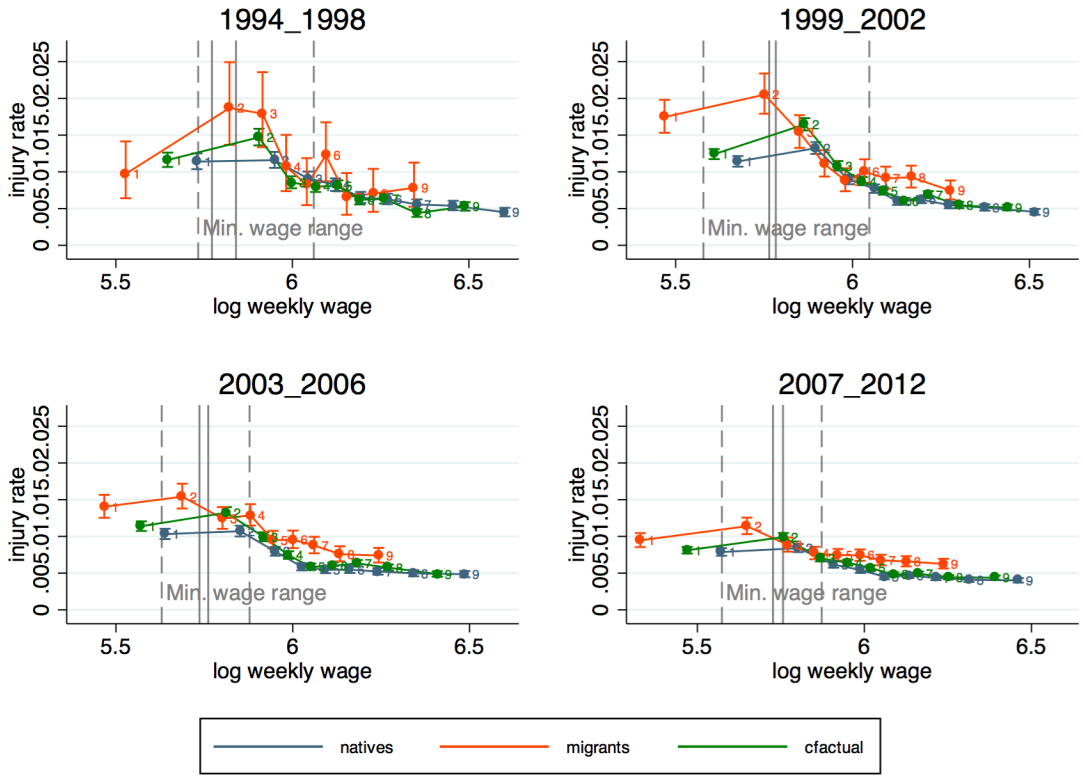
More generally, all figures show the negative relationship between wages and injury risk that is discussed in the literature. However, they also show that the schedules are highly non-linear. In both Fig. 5 and 6, we observe a marked change in the slope of the curves at wage levels corresponding to ca.

18,000 euros yearly, an amount compatible with the minimum level of earnings set by collective bargaining for most manufacturing subsectors, whose range is indicated by the gray bars in the figures[12]. This applies to both all injuries and severe injuries. By lower wages, the injury rates are fairly constant or only smoothly declining. By higher wages, we observe a clearly negative and almost linear relationship between wages and injury rates. Interestingly, within the range of the minimum wages, we observe the largest and most significant differences in injury rates between foreigners and counterfactual. It is also worth noticing that the empirical threshold evidenced by our data corresponds to a very different decile across subsamples.

As we are studying annual wages, the large share of workers located below the threshold actually shows the substantial amount of workers, and of foreign workers in particular, who have not worked the whole year. Hence, to make the comparison more accurate, in Figures 7 and 8 we focus on weekly wages (in Figure A.6 in Appendix we report the data for annual wages on the subsample of workers having worked the whole year; in addition, in Appendix Figures A.7 and A.8 we report the figures for the metal-mechanic sector only, which is subject to a single collective contract, hence the definition of the threshold values for minimum wages can be more precise). Similarly to the above, the foreigners' schedules dominate those of the counterfactual, which dominate

[12]Because no single minimum wage is available in Italy, but it depends on collective bargaining in different subsectors, we could only include ranges in our figures even if we would look at a single year. The values of the minimum wages set by collective bargaining are drawn by Card et al. (2014) for the years 1995-2001, and updated for the following years with the publicly available data on minimum retributions provided yearly by the information website on Italian labour law *Dottrina per il Lavoro*, `www.dottrinalavoro.it`. For each sub period, the lower bound (dotted gray line) corresponds to the lowest minimum wage level set by collective bargaining for blue collar workers in manufacturing sectors (i.e., level 2 of earning foreseen by collective bargaining for hand-made and hand-woven productions in small-sized textile firms); the upper bound (dotted gray line) corresponds to the highest minimum wage level set by collective bargaining for manufacturing sectors (i.e. level E3 of earning foreseen by collective bargaining for the large-sized chemical firms). Because a majority of workers subject to contracts in collective bargaining are in the metal-mechanic subsector, we also include their minimum wage ranges as solid gray line to allow a more precise appraisal. All wage levels are constant prices, base year 2012.

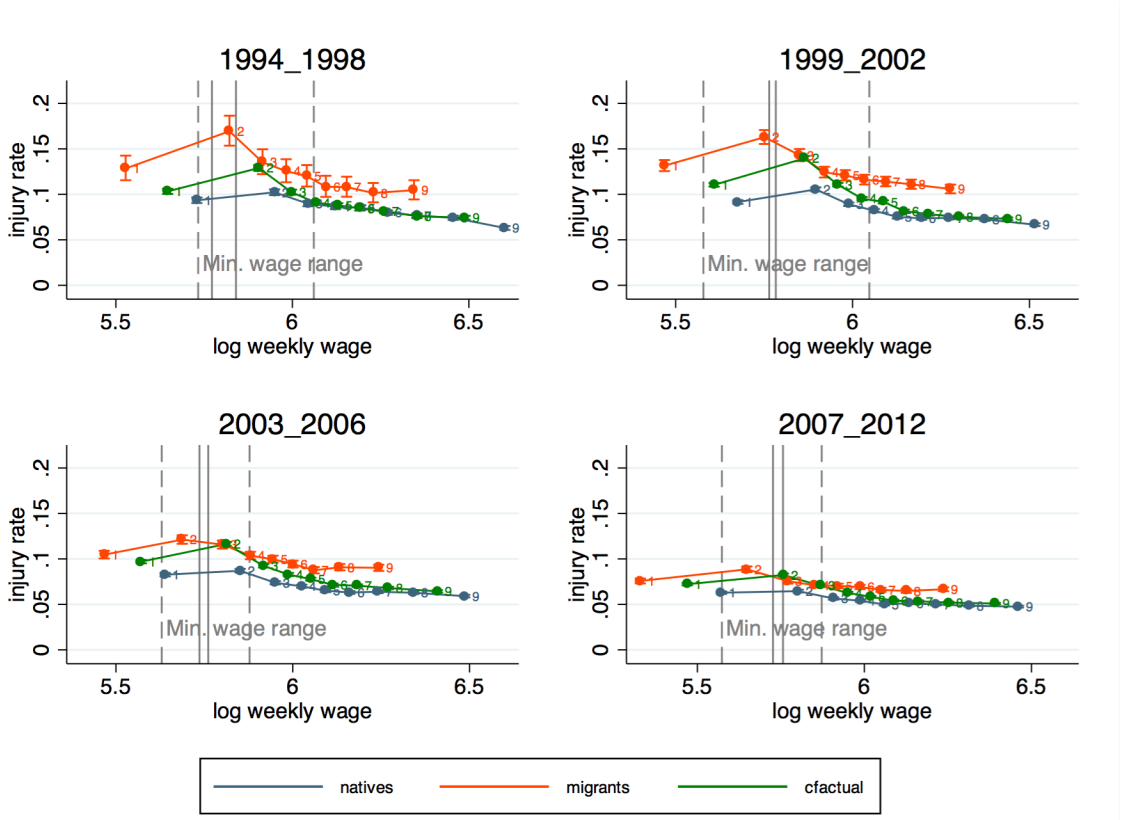
Figure 7: Injury rates by weekly wage decile; all injuries



Male blue collar workers in the manufacturing sector.Deciles of the counterfactual distribution obtained by reweighting the distribution of wages prior to calculating the deciles. Injury rates and 95% Poisson confidence intervals computed for each decile and each subsample. Minimum wage ranges relevant for the sub period (constant prices, base year 2012) for all manufacturing sectors reported as dashed gray lines, as solid lines for the metal-mechanic subsector. Source: own computations on WHIP 2015.

the natives'; however, the differences are only significant for the extreme quantiles. A similar threshold as evidenced above appears to intervene at around the third decile of the foreigners' earnings distribution, before which the largest differences in terms of injury rates are observed between the foreigners and the counterfactual. As above, the threshold seems to apply to natives, too, even if less markedly. In addition, by wages above the median level of salaries for natives, the injury rates based on weekly wages become constant. In spite of the likely higher human capital of the workers in these deciles, the injury rates of foreigners are significantly higher than the other. The weekly wage curves

Figure 8: Injury rates by weekly wage decile; severe injuries



Male blue collar workers in the manufacturing sector.Deciles of the counterfactual distribution obtained by reweighting the distribution of wages prior to calculating the deciles. Injury rates and 95% Poisson confidence intervals computed for each decile and each subsample. Minimum wage ranges relevant for the sub period (constant prices, base year 2012) for all manufacturing sectors reported as dashed gray lines, as solid lines for metal-mechanic subsector. Source: own computations on WHIP 2015.

also show a similar gradual flattening of the slopes over time[13].

The above-threshold peak in the difference between foreigners and counterfactual schedule is also observed when comparing figures 7 and 8 with Figure A.6 in Appendix, which refer to annual wages and injury rates of workers having worked the whole year, and is even more marked when looking at workers in the metal-mechanic subsector only (Figures A.7 and A.8).

Overall, the injury gaps between foreigners and natives seems to be mainly

[13]The results are robust to the exclusion of the workers having been hired during the last month of the year and to different decile specifications.

driven by two facts: the excess of injury rates observed in the before-threshold quantiles and the persistently higher injury rates observed for higher quantiles. The difference seem to be largest and most significant in the 1998-2002 and 2003-2006 sub periods. The graphs for severe injuries suggest a very similar picture as the one found for all injuries, notwithstanding the lower statistical power due to the more rare phenomenon at stake.

5 Discussion

The above-conducted analysis confirmed that the injury and wage gap faced by foreigners is not entirely due to differences in the observable characteristics, and that a non-negligible component in the wage and injury rate gap remains attributable to the specificities of being an immigrant - for instance, lower language proficiency, lower bargaining power, discrimination, different cultural perception of the workplace risk.

Our results show that the foreign workers earning gap that is not explained by observable characteristics amounted in the more recent years to ca. 10% of average wages, and that foreign workers face an overall risk of injury that is between 16% and 37% higher than that of natives. The picture is even more serious when looking at immediate-care injuries, for which immigrants are found to face a risk that is between 24 and 47% higher than natives and which is not attributable to observable characteristics.

The analysis of the injury rate conditional on wage showed that the greatest and most significant component of the gap is localised close to the threshold that corresponds to the minimum wage level set by collective bargaining. Before this threshold, the injury rates of immigrants result significantly higher than the injury rates that their characteristics would predict. After this threshold, a clearly negative relationship between earnings and injury risk can be

identified. This is aligned with the established finding in the literature that higher-paid and more skilled workers may trade-off part of their wage to "buy" more safety at work (see, for instance, Hamermesh, 1999a,b).

The excess of injuries of foreign workers in proximity of the threshold could be explained within the framework of the hedonic wage model introduced in section 2. As we discussed, for different reasons, the "unrestricted" wage that employers would offer in absence of minima would possibly be located below the threshold. However, they are forced by collective bargaining to pay them at least the minimum (which, by the way, foresees automatic increases over time). Hence, they need to move to a higher bundle of wage and injury risk - for instance, because their increased expenditure for wages needs to be counterbalanced by a lower expenditure for safety, or because the discriminating employer cannot exploit the information asymmetries at the level of wages, so she may do it at the level of safety. Notice that this unintended risk-increasing effect of the minimum wage is compatible with previous findings by Leombruni et al. (2013), studying displaced workers, showed that human capital losses due to displacement translate into greater risk and not into wage losses due to the downward rigidity of wages.

Moreover, the theoretical arguments presented in section 2 could also explain why we observe a flattening of the curves over time. Consider the case made in Fig. 1c where, by a bad state of the economy, the bundles of wages and injury risk that the firm has to offer shift to lower wages and higher risk. If foreign workers were already in equilibrium at the corner solution, their job may no longer be profitable for the firm - as the costs to secure the worker could be too high, or the increase in injury risk may be unacceptable to foreign workers. Hence, the flattening of the curves may be due to a selection effect which destroys the jobs located at the corner solutions - compared to the scheme in Figure 1c, clearly, different jobs have different unobserved produc-

tivity/intercept. Only the jobs for more productive workers would remain; as the less productive and more risky jobs within each sector/occupation cell have been destroyed, the negative relation between salary and risk is less evident than it was in previous years.

The decrease in the slopes of the curves during the crisis years could also be explained by the fact that, during the crisis, the working pace gets lower. As mentioned above, foreigners could be assigned to tasks (not captured by our variables) with more intense working times when the economy is going well. During a recession, the injury rates decrease comparatively more for foreign workers (and particularly so in the lower deciles, up to the point that they become lower than the counterfactual. The alternative argument that during recessions severe injury rates remain unchanged but underreporting increases (Boone and van Ours, 2006) seemed compatible with the differential dynamics of aggregate injuries versus severe injuries (see section 4.2); however, the conditional distributions of injury rates by wage display very similar patterns for aggregate and severe injuries. A limitation of this work is that within the present design we cannot tell the effects of potentially opposing factors, such as the change in the composition of the immigrant population by nationality (which after 2006 saw a major increase in the foreign-born population with Romanian origin, known to have peculiarly low injury rates) from the effects of the crisis which may actually increase the incentives to underreport, as suggested by Boone and van Ours (2006). Future research should address this point.

The other insight deriving from our analysis relates to a significantly higher injury risk for above-threshold foreign workers, which exceeds the injury rate predicted by the observable characteristics. Immediately above the threshold, injury rates decline as salary increases, consistently with the interpretation presented above. However, around the sixth decile of the foreign workers' wage,

the curve for foreign workers becomes much less steep than the other. The effect of being a foreigner, thus, would reduce the ability of the worker to buy safety in exchange of wage. It is unobservable in our data whether this is due to a greater risk propensity, whereby workers would self-select into more risky and more rewarding tasks within observable occupations and sectors, or whether this is due to a greater risk at the baseline, due for instance to less language proficiency, imperfect matching between skills and tasks, discrimination and lower bargaining power. Whatever the specific interpretation, this result could be predicted within the hedonic wage model by different indifference curves for foreigners and natives, assuming that foreign workers are, for different reasons that are unobservable in our data, more keen to accept risk by the same level of wage (e.g. Dávila et al., 2011). An implication of this result is that the within-group distribution of injuries by wage among foreigners is fairly equal and close to perfect equality in the 2007-2012 sub period (see the concentration curves in section A.2 in Appendix).

6 Conclusions

Using propensity score reweighting, we constructed counterfactual marginal distributions of injuries and wages and counterfactual conditional distributions of injuries on wages. The analysis has shown that, besides a substantial gap in wage and injury risk that cannot be attributed to differences in the characteristics, foreign workers face higher levels of risk by the same level of wages. In particular, foreigners' injury rates are found to be significantly above the level predicted by their observable characteristics by wages that are close to the minimum wage level set by collective bargaining. After this threshold, injury rates decline for all subsamples, but less steeply for foreign workers. We show that the hedonic wage model could explain the first result as a corner solution

whereby workers with low wage potential are forced to accept higher levels of risk due to the lower bounds on minimum wage. The second result could simply be explained by assuming different utility functions for natives and foreigners. We also showed that the hedonic wage model is compatible with the marked reduction in injury rates and in the gap that we observe in the recession years, while other factors, primarily the massive inflows of workers from Central and Eastern European countries and particular Romanians, are certainly at play. A first follow up to this analysis should thus be an exploration of the determinants of the "residual" components of the gap that can be explained based on the characteristics of immigrants that are observable but not comparable with those of the native population - primarily immigrants' rights nationality, language proficiency, and their cultural closeness to the Italian, which can be seen as proxies of the mastery of the Italian language. Secondly, a more targeted exploration of the effects of institutional factors such as immigration reforms and EU enlargement in exerting or uplifting market pressure seems warranted: these institutional factors could affect the bargaining power of foreign workers on salaries as well as the workplace stress they face which are considered as risk factors for injuries.

Another stylised fact highlighted by the present paper is that recent dynamics associated with the global financial crisis have seen a convergence between the characteristics of the less wealthy natives and those of immigrants. It should be more closely addressed in order to examine whether the effect is temporary or more likely to bear long-lasting results, considering its potential implications for the post-crisis recovery and for the longer-term dynamics of labour markets.

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A Appendix

A.1 Descriptive statistics

Table A.1: Summary statistics

	Natives			Migrants		
year	1994	2003	2012	1994	2003	2012
Annual Wage (avg.)	16954.09	17120.11	21441.39	11528.06	10432.38	13444.52
Injuries						
Injury rate: all injuries	6.47	6.52	3.78	9.30	10.97	5.47
Injury rate: immediate-care injuries	0.57	0.67	0.42	1.10	1.15	0.67
Lost days of work (avg.)	1.57	2.24	1.38	2.15	3.37	1.90
Sector (%)						
Mining & quarrying	0.46	0.41	0.36	0.65	0.29	0.22
Manufacturing	40.65	40.84	35.62	40.41	37.76	33.63
Electricity, gas, water supply	4.68	1.41	1.25	1.31	0.09	0.09
Construction	12.68	15.08	12.73	16.32	25.04	19.20
Wholesale & retail trade; repair	9.40	14.11	16.23	8.22	7.16	8.91
Accommodation & food service	2.96	4.22	5.82	13.16	7.00	10.85
Transporting & storage	11.55	7.98	7.93	7.02	7.27	7.99
Financial & insurance	10.74	9.56	12.77	5.43	11.51	14.28
Real estate, ICT, professional, scientific	1.64	1.35	1.12	2.79	1.48	1.43
Education	0.77	1.04	1.63	0.67	0.48	0.81
Human health & social work	1.20	1.20	1.42	0.94	0.55	0.71
Administration	2.23	1.96	2.27	2.22	1.06	1.50
Age (avg.)	39.11	37.61	40.86	34.44	34.57	37.91
Tenure (avg.)	5.40	5.52	7.14	2.63	1.63	3.37
Firm age (avg.)	0.19	3.44	3.61	3.46	2.83	3.00
Type of contract (%)						
10	95.87	84.04	80.18	94.68	79.51	72.86
21		0.82	0.70		1.01	1.20
22		6.41	12.98		10.96	18.51
23	2.12	1.70		3.53	0.86	
24		1.50	1.69		3.94	2.83
25	2.00	5.53	4.44	1.79	3.71	4.60
Firm size (%)						
0-9	16.78	27.67	28.19	31.99	40.58	37.41
10-19	6.92	12.63	12.32	11.60	15.03	15.42
20-199	21.41	31.24	30.46	26.80	30.46	32.24
200-999	15.24	13.42	13.55	11.85	6.93	8.28
>=1000	39.65	15.04	15.49	17.76	7.00	6.65
Region of work (%)						
North	36.38	44.15	43.06	50.26	60.59	56.67
Centre	28.41	27.22	27.43	32.39	31.06	32.80
South and Islands	35.21	28.63	29.51	17.36	8.35	10.53
Qualification (%)						
Apprentice	2.00	5.53	4.44	1.79	3.71	4.60
Blue collar	60.90	66.68	65.30	79.95	92.32	90.96
White collar	37.10	27.80	30.26	18.26	3.97	4.45
Nro. of observations	120634	470343	434505	5098	111085	135292
(% of the sample)	95.95	80.89	76.26	4.05	19.11	23.74

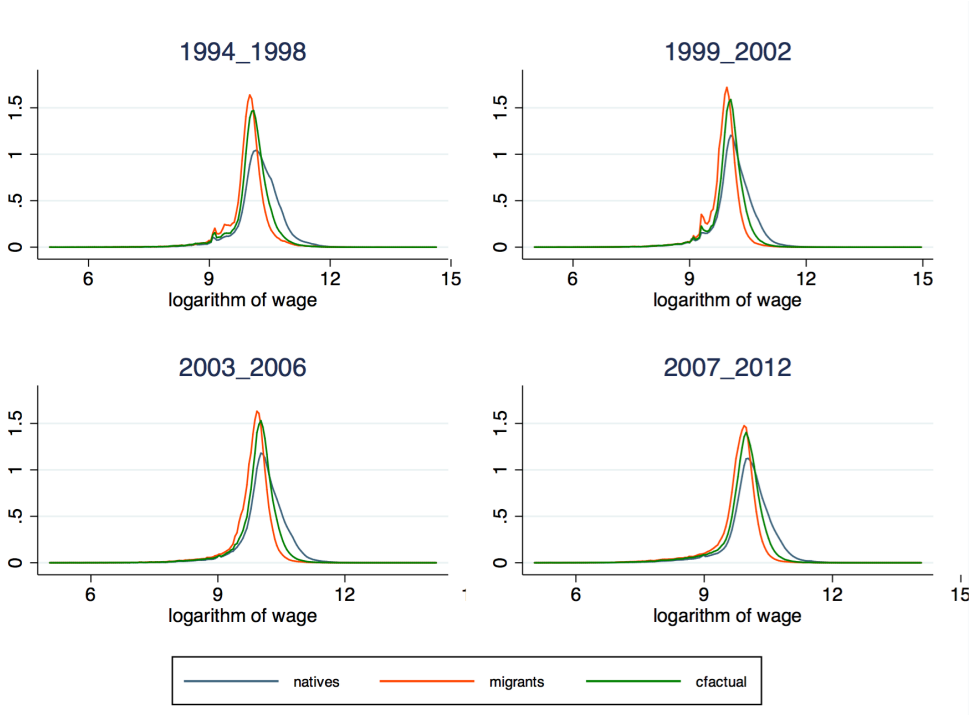
Source: own computations on WHIP 2015

Table A.2: Relative risk (1994-2012)

	All injuries			Immediate-care injuries		
Year	Migrants-natives	Migrants-cf.	Cf.-Natives	Migrants-natives	Migrants-cf.	Cf.-Natives
1994	1.47	1.09	1.35	1.35	1.79	1.32
1995	1.63	1.13	1.44	0.95	1.26	1.33
1996	1.65	1.16	1.42	1.50	2.00	1.33
1997	1.73	1.18	1.47	1.41	1.87	1.32
1998	1.85	1.33	1.39	1.24	1.73	1.39
1999	1.88	1.37	1.38	1.29	1.74	1.35
2000	1.93	1.37	1.41	1.45	1.99	1.37
2001	1.90	1.33	1.43	1.38	1.97	1.43
2002	1.85	1.27	1.46	1.37	1.94	1.41
2003	1.81	1.24	1.46	1.31	1.93	1.47
2004	1.89	1.30	1.45	1.46	2.11	1.45
2005	1.84	1.29	1.43	1.38	1.98	1.43
2006	1.82	1.25	1.46	1.47	2.11	1.43
2007	1.77	1.23	1.44	1.26	1.85	1.46
2008	1.79	1.24	1.44	1.47	2.06	1.40
2009	1.63	1.17	1.40	1.25	1.74	1.40
2010	1.59	1.16	1.38	1.25	1.80	1.44
2011	1.64	1.20	1.37	1.37	1.88	1.37
2012	1.61	1.19	1.36	1.30	1.79	1.37

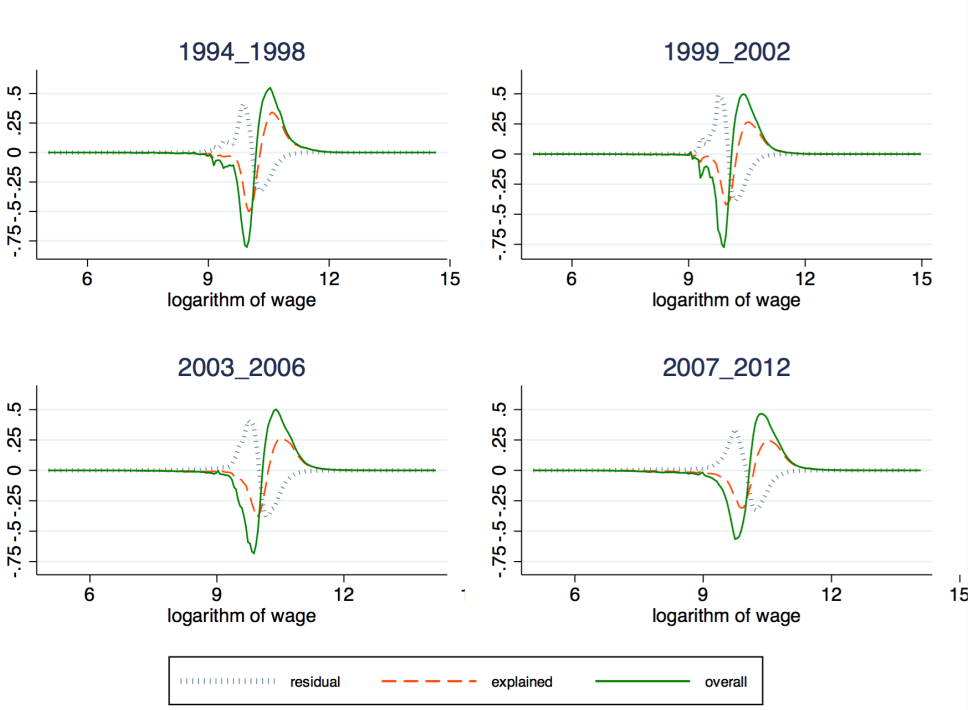
Trends in relative injury risks. Source: own computations on WHIP 2015

Figure A.1: Wage densities



Kernel density functions for weekly wages for foreigners and natives; counterfactual distribution obtained through DFL-reweighted Kernel density functions for weekly wages.

Figure A.2: Differences in wage densities



Differences in wage densities as Kernel density functions of the differences in the Kernel wage density functions between foreigners and natives (overall); natives and counterfactual (explained); counterfactual and foreigners (residual).

A.2 Concentration curves

A way to look at the distribution of injury rates by wage is to construct a concentration curve, which ranks individuals by wages and associates the cumulative share of injuries to the cumulative share of the individuals ranked by their wage[14]. Concentration curves are in essence a two-variable modification of the Lorenz curve which allow comparing the distribution of the cumulative shares of "ill health" (e.g., injuries) with the corresponding quantiles of population ranked by wage. As with the Lorenz curve, the further away the concentration curve is from the 45-degree line, the more concentrated is the distribution. As we are measuring "ill health", a concentration curve that lies above the diagonal indicates concentration of ill-health among the lower wages, while a

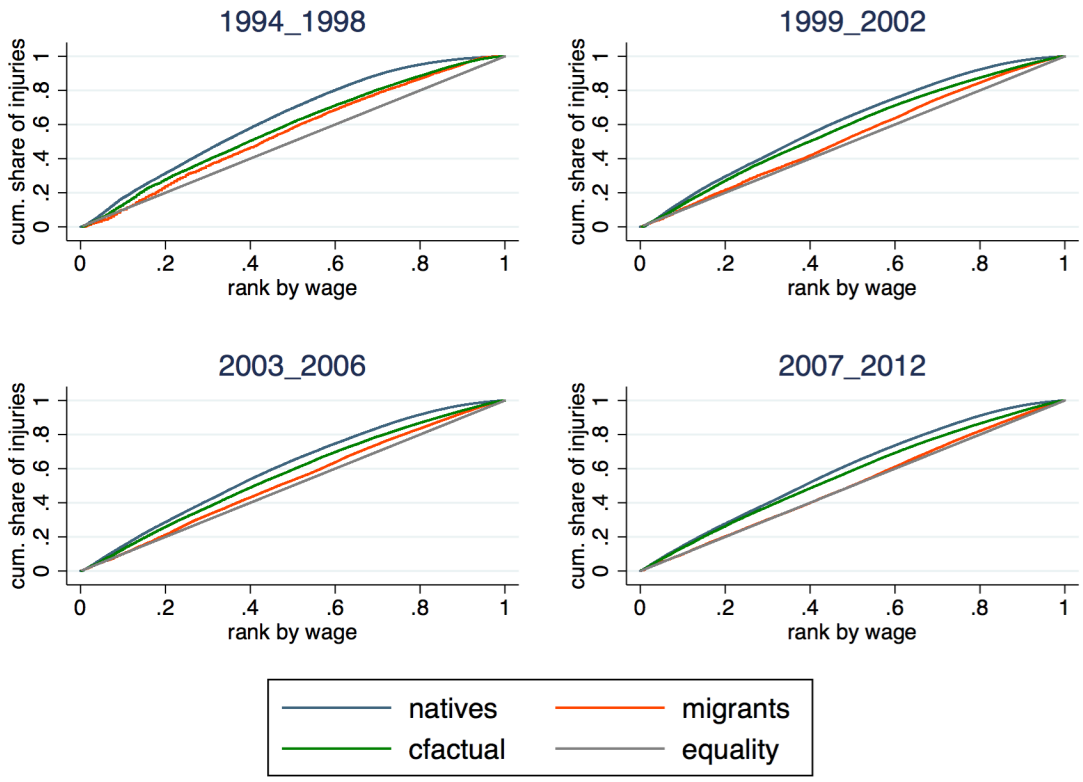
[14]In order to compare wages across time, all wages are reported at constant 2012 prices.

Table A.3: Average weekly wages and wage gaps, 1994-2012

	Average weekly wage (EUR)			Wage gap (%)		
Year	Migrants	Natives	Cfactual	Overall	Explained	Residual
1994	25775.75	34606.04	27625.49	25.52	20.17	5.35
1995	24816.29	33862.59	26875.67	26.71	20.63	6.08
1996	22765.45	32473.00	25204.00	29.89	22.38	7.51
1997	22950.92	33091.29	25284.80	30.64	23.59	7.05
1998	22444.71	29683.15	24805.75	24.39	16.43	7.95
1999	21947.18	28546.14	24508.19	23.12	14.15	8.97
2000	20875.04	28002.95	23658.96	25.45	15.51	9.94
2001	20540.53	27709.97	23462.82	25.87	15.33	10.55
2002	20279.81	27378.27	22893.15	25.93	16.38	9.55
2003	19917.27	27172.54	22727.27	26.70	16.36	10.34
2004	20035.62	27268.65	22860.43	26.53	16.17	10.36
2005	19301.14	26782.79	22173.46	27.93	17.21	10.72
2006	19650.16	27175.43	22517.24	27.69	17.14	10.55
2007	19406.77	26808.96	22046.19	27.61	17.77	9.85
2008	19402.74	27045.52	22176.91	28.26	18.00	10.26
2009	19241.84	27063.18	22199.31	28.90	17.97	10.93
2010	19339.51	26938.70	22039.45	28.21	18.19	10.02
2011	19097.57	26576.83	21761.15	28.14	18.12	10.02
2012	18713.58	25911.50	21159.32	27.78	18.34	9.44

Constant prices, base year 2012. Immigrants vs. natives vs. counterfactual. Gaps are distinguished into: overall (natives-migrants), explained by observable characteristics (natives-counterfactual), and residual (counterfactual-migrant). Source: own computations on WHIP 2015.

Figure A.3: Concentration curves, all injuries

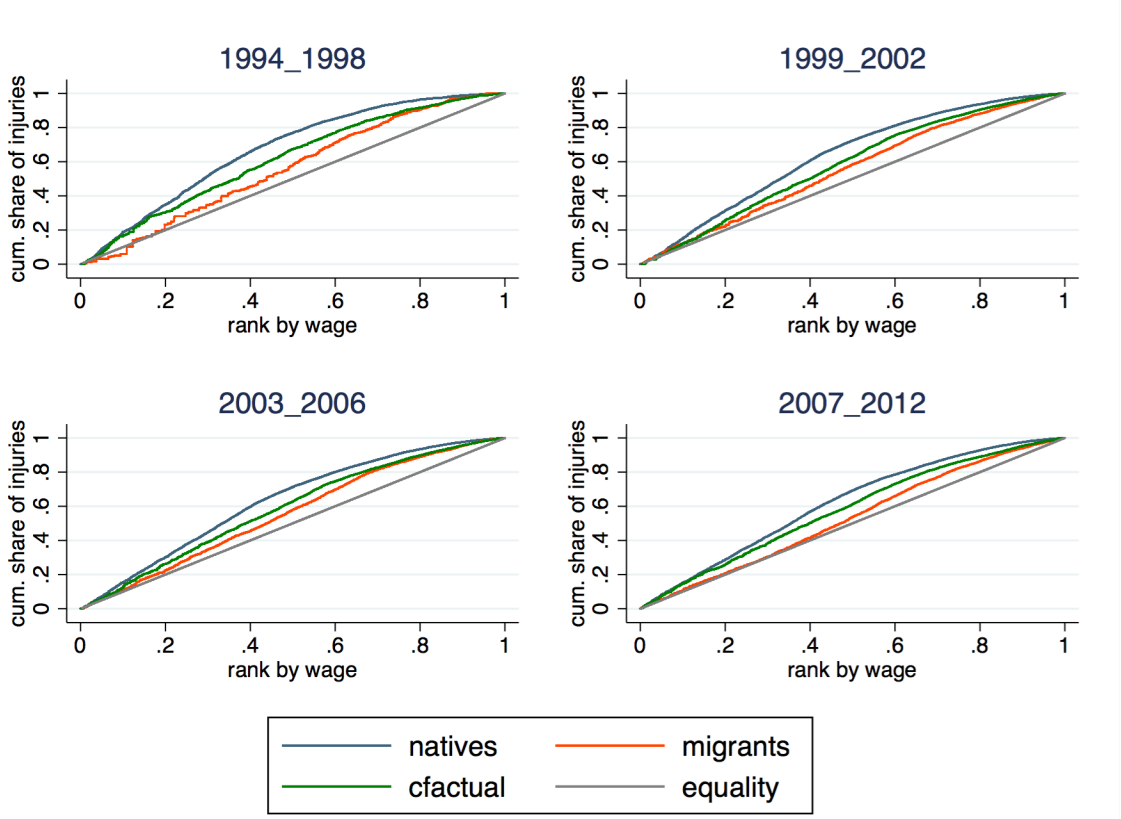


Cumulative share of individuals ranked by annual wage plotted against their cumulative share of exposure-weighted injuries. Greater areas between each curve and the diagonal indicate more inequality. Constant prices, base year 2012. Source: own computations on WHIP 2015

concentration curve lying below the diagonal indicates concentration among the high wages. The corresponding concentration index can be computed as twice the area between the concentration curve and the diagonal. The counterfactual concentration curve was obtained by reweighting the observations by the DFL weight. Fig. A.3 refers to all injuries and reports the concentration curves of the injury rates for the subsamples of natives, foreigners, and for the counterfactual over the four time periods that we consider: 1994-1998, 1999-2002, 2003-2006, and 2007-2012. Fig. A.4 reports the same curves for severe injuries only. In all cases, the curves are located at or above the 45° line, which, unsurprisingly, implies that injuries are more concentrated among

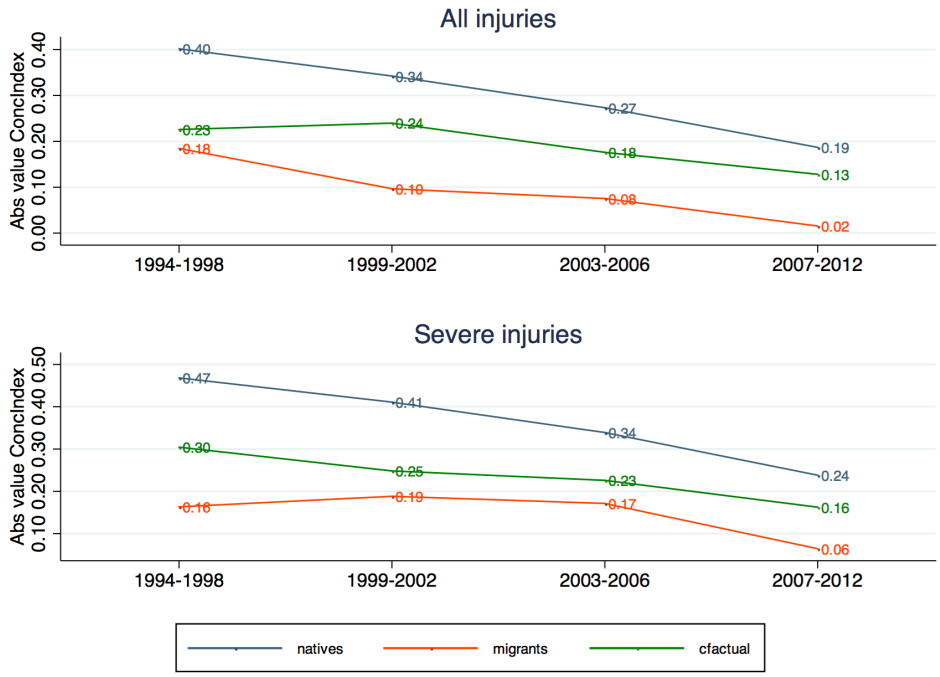
the lower salaries. The concentration curve of natives dominates the one of foreigners foreigners, indicating greater inequality in the distribution of injuries by wages in the native population; if natives had the same characteristics as the foreigners, they would show greater concentration - the concentration curve for the counterfactual also dominates the one of foreigners.

Figure A.4: Concentration curves, severe injuries



Cumulative share of individuals ranked by annual wage plotted against their cumulative share of exposure-weighted injuries. Constant prices, base year 2012. Greater areas between each curve and the diagonal indicate more inequality. Source: own computations on WHIP 2015

Figure A.5: Concentration indices trends



Absolute values of the concentration indices calculated on the concentration curves for each sub-period. Concentration indices for ill-health are negative by inequality; hence, larger absolute values indicate more inequality. Source: own computations on WHIP 2015

The dominance of the natives' curve with respect to the foreigners' decreases over time (cfr. also fig. A.5. The concentration curve of foreigners gets closer and closer to diagonal. In part, this is due to the characteristics of foreigners: the counterfactual curve is below the natives' in all cases, implying that sectoral and demographic characteristics in part contribute to a more rigid relationship between salaries and injury rates, as could be expected. Comparing the counterfactual with the observed curve, however, it is apparent that the mechanism hindering the trade off between salaries and wages trade-off remains to a large extent due to the specificity of being a foreign worker, as the counterfactual curve is in turn neatly dominating the foreigners' in all cases.

A final insight offered by the concentration curves refers to the latter time slot: the increasing dominance of the natives' concentration curve with respect to that of foreigners is less and less due to differences in the observable char-

acteristics of the foreign workers: indeed, the counterfactual concentration of injuries by salaries is quite similar, especially in the lower quantiles of the wage distributions, to the observed curve of natives. In other words, if in recent years natives had the same characteristics as foreigners... they would have a very similar concentration curve as the one we actually observe: this is likely because natives in the lower quantiles of wage have moved to the same sectors and work contracts which were previously reserved to immigrants. Hence, the difference in characteristics explains a negligible portion of the difference in the two concentration curves and the residual difference increases.

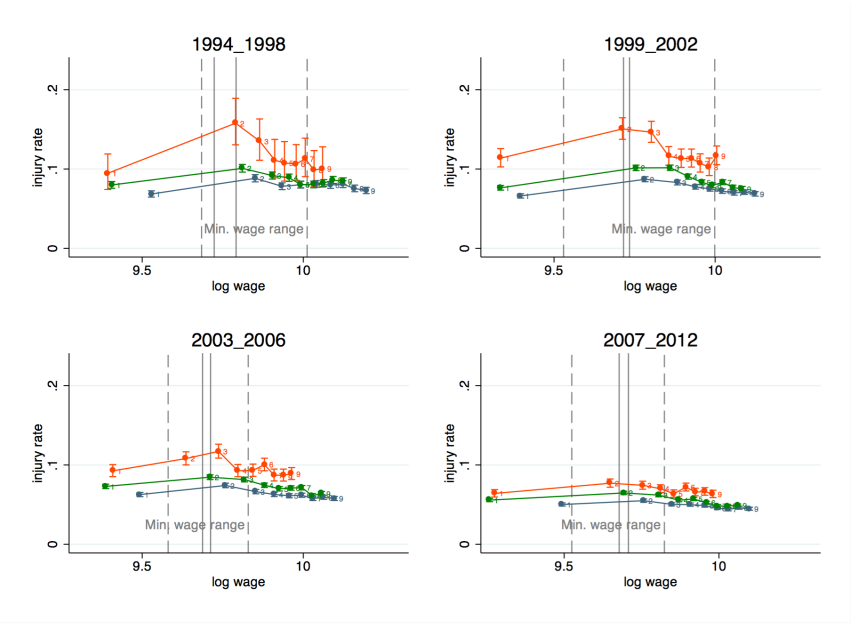
In Fig A.4, we report the same pictures for immediate-care injuries. Comparing this with fig. A.3, the foreigners' curve for severe injuries displays greater concentration than the curve for all injuries, suggesting that foreign workers with lower salaries may underreport less severe injuries. Still, the patterns sketched for the whole of injuries are observed also for immediate-care injuries.

Overall, the concentration curves as well as the concentration indices for the time slots in which we split our sample, (see fig. A.5) show that inequalities in the injury distribution by wage have been noticeably decreasing over the 18 years of our sample.

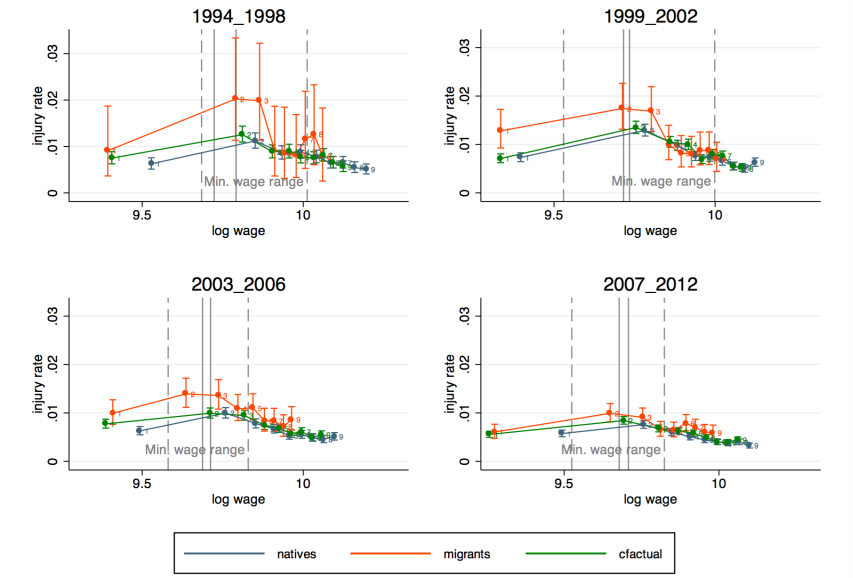
A shortcoming of the concentration curves as an analytical tool lies in that each curve refers to within-group inequality and *per se* does not provide information about where the lower and upper tail of foreigners' salaries is located with respect to the natives' wage distributions. Indeed, because the range of salaries is substantially different between the natives and the foreigners' population, it would be misleading to draw conclusions solely on the basis of concentration curves; and the concentration index is insensitive to the mean level of salaries and injuries in each subpopulation.

A.3 Injury rates by wage deciles - Robustness checks

Figure A.6: Injury rates by wage decile, workers having worked 12 months



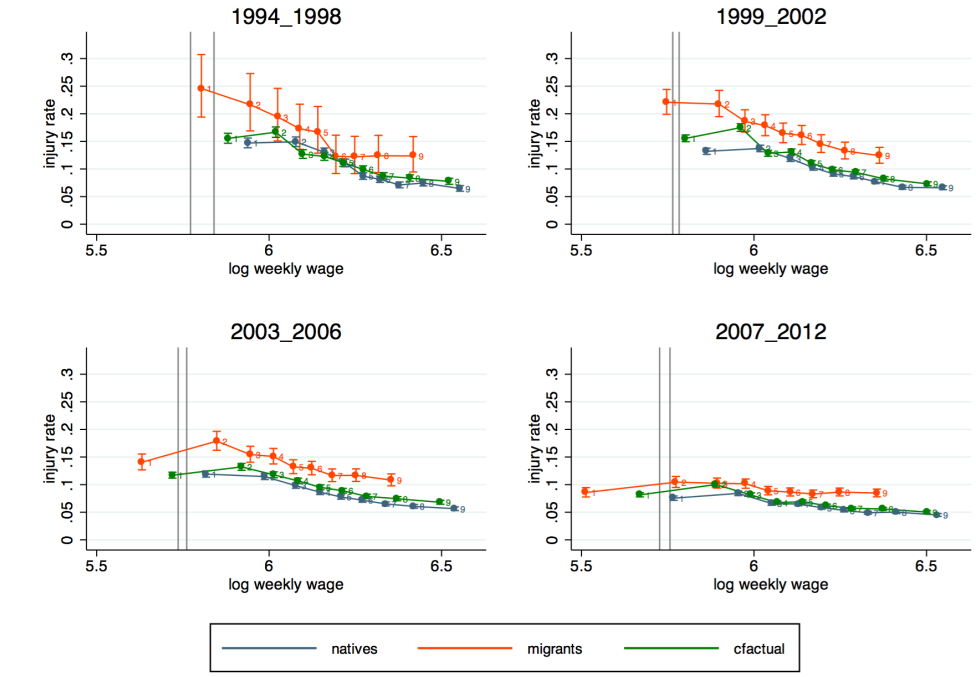
(a) All injuries



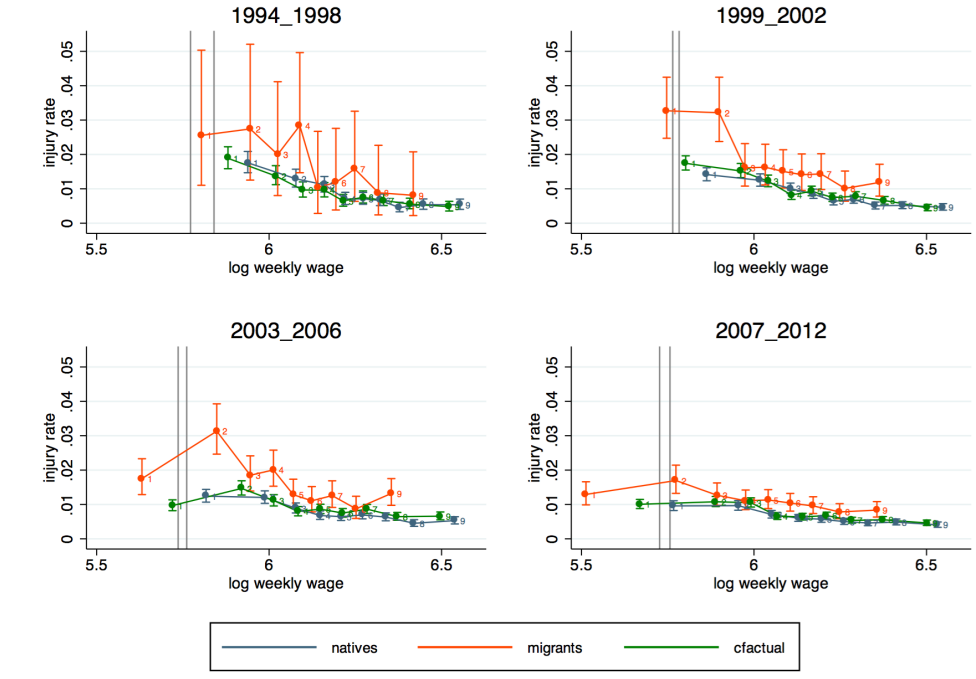
(b) Severe injuries

Overall and severe injury rates by weekly wage decile. Male blue collar workers in the manufacturing sector having worked the whole year. Deciles of the counterfactual distribution obtained by reweighting the distribution of wages prior to calculating the deciles. Injury rates and 95% Poisson confidence intervals computed for each decile and each subsample. Minimum wage ranges relevant for the sub period (constant prices, base year 2012) for all manufacturing sectors reported as dashed gray lines, as solid lines for the metal-mechanic subsector. Source: own computations on WHIP 2015.

Figure A.7: Workers in the metal-mechanic sub-sector (weekly wages)



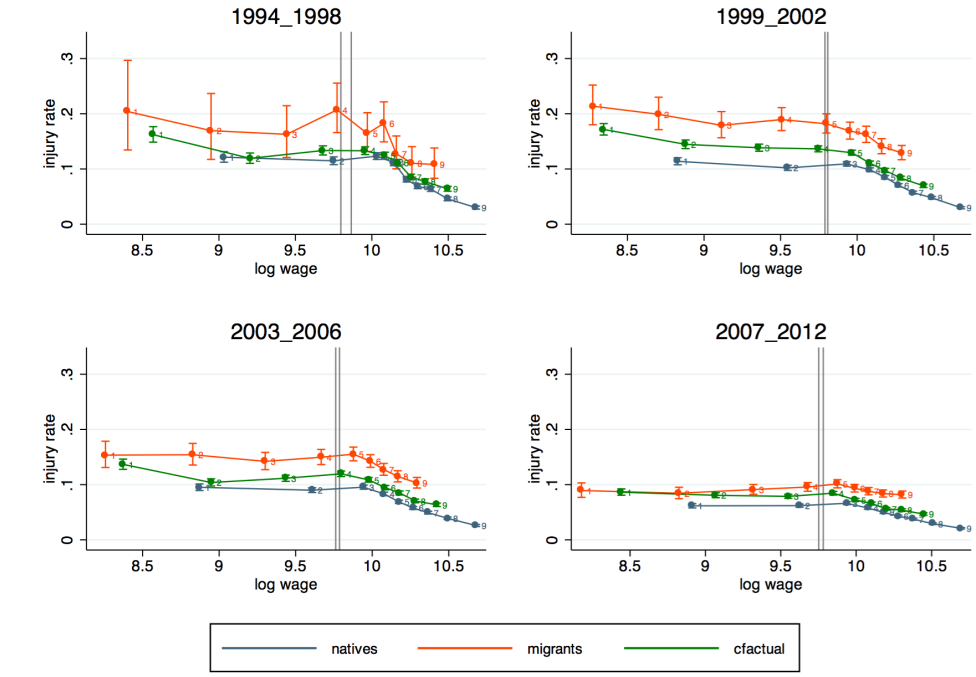
(a) All injuries



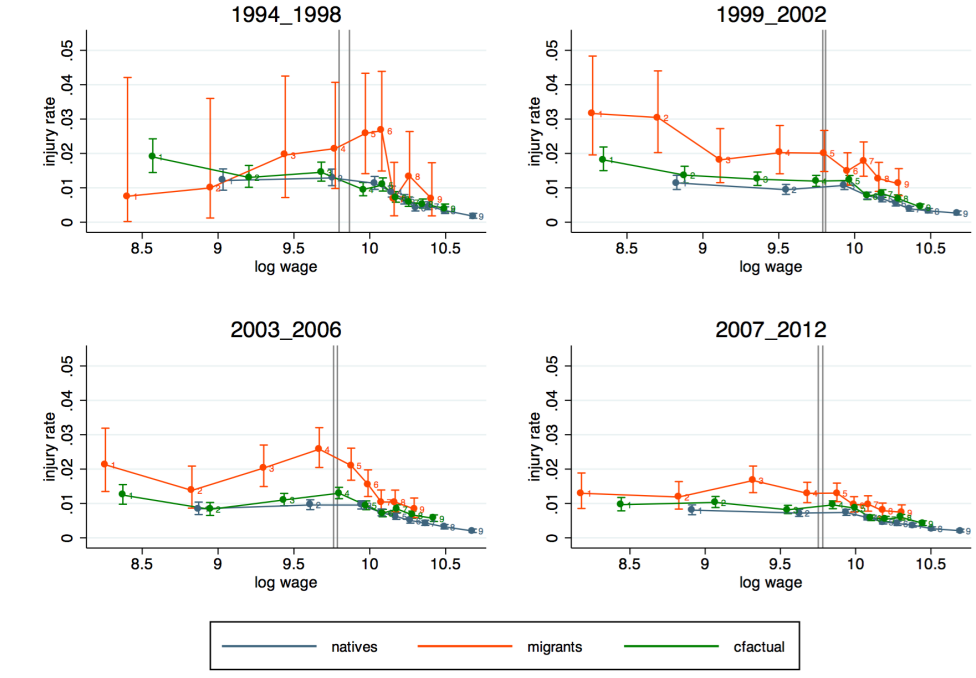
(b) Severe injuries

Injury rates by annual wage decile of male blue collar workers in the metal-mechanic subsector over the four sub periods (workers having worked the whole year only). Deciles of the counterfactual distribution obtained by reweighting the distribution of wages prior to calculating the deciles. Injury rates and 95% Poisson confidence intervals computed for each decile and each subsample. Minimum wage ranges relevant for the sub period (constant prices, base year 2012) for the metal-mechanic subsector reported as solid gray lines. Source: own computations on WHIP 2015.

Figure A.8: Workers in the metal-mechanic sub-sector (annual wages)



(a) All injuries



(b) Severe injuries

Injury rates by annual wage decile of male blue collar workers in the manufacturing sector over the four sub periods (workers having worked the whole year only). Deciles of the counterfactual distribution obtained by reweighting the distribution of wages prior to calculating the deciles. Injury rates and 95% Poisson confidence intervals computed for each decile and each subsample. Minimum wage ranges relevant for the sub period (constant prices, base year 2012) for the metal-mechanic subsector reported as solid gray lines. Source: own computations on WHIP 2015.