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Changes in the Czech Wage Structure: Does Immigration Matter?*

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Abstract
We find that immigrant workers do not affect changes in the Czech wage structure between 2002 and 2006 despite their substantial inflows. Instead, using the Albrecht et al. (2003) version of the Machado and Mata (2005) decomposition technique along the wage distribution, we find that changes in the wage structure are explained solely by increasing returns of native workers. In particular, we provide evidence on increasing returns to education of native workers along the wage distribution. Next, we suggest that increasing wage dispersion is due to changes in the observed characteristics of native workers, such as a rising level of education, rather than due to immigration inflows. Finally, we find that the negative immigrant-native wage gaps seem persistent along the wage distribution and are explained mainly by differences in observed characteristics.

1. Introduction

The Czech Republic has experienced significant inflows of foreign workers since 2002. According to registry data from the Ministry of Labor and Social Affairs, the number of foreign employees increased from 101,000 at the end of 2002 to 186,000 at the end of 2006, accounting for 4.6% of total employees. Among the key questions one needs to answer in order to understand how this increase in the number of foreign employees affected the Czech labor market are what are the characteristics of immigrants and how much do they earn in comparison to domestic workers with similar skills and experience.

A number of studies have analyzed the impact of immigrants on domestic labor market performance and the wages of native-born workers. As documented by Borjas, Freeman, and Katz (1996), a large body of literature on the effect of migration on the host country has delivered mixed results which seem to be critically affected by the empirical strategy implemented.[1] A large and negative impact of

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[1] In the standard competitive framework, increasing the labor supply decreases the real wage, suggesting that immigrants depress the wages of native workers. But under imperfect substitutability, immigrants complement native workers, raising the marginal product of the domestic workforce. This has important policy implications, as complementarities may raise the wages of native workers. Even though the overall immigration impact would be fairly small, the distributional effects tend to be more significant.

immigration was found, for example, by Borjas, Freeman, and Katz (1996), Borjas (2003), and others. Assuming that native and immigrant workers of different age, experience, and education are only imperfect substitutes, Borjas (2003) finds that the native workers' wages and employment opportunities are lower in sectors penetrated by immigrants. He estimates that over 1960–1990, U.S. workers lost about 3% of the real value of their wages, while the loss of native workers without a high school degree was about 9%. On the contrary, Card (2005) claims that earlier studies are overly pessimistic concerning the impact of immigration on natives' wages and employment opportunities. Using data from the U.S. 2000 Census he shows that the employment opportunities of native low-skilled workers have not been harmed as much as claimed by some other studies.

Introducing labor as a differentiated production input within the general equilibrium framework, Ottaviano and Peri (2012) estimate the elasticity of substitution between comparably skilled immigrants and natives. They find that immigrants are imperfect substitutes for U.S.-born workers within the same education and experience group. As a consequence, it is mainly more educated people who benefit from migration in terms of wages, since they do not compete with foreign workers on the labor market. Indeed, the impact of migration on less educated people is less pronounced and could possibly turn negative. The study shows that overall immigration over 1980–2000 was expected to increase U.S. workers' wages by around 2%. Their findings have been questioned by Borjas, Grogger, and Hanson (2008), who show that the finding on immigrant-native complementarity disappears when high school students are removed from the sample.

In Europe, the evidence of the effect of immigrants on the labor market is less controversial. Applying the same methodology as Ottaviano and Peri (2012) and using UK micro data from the mid-1970s to the mid-2000s, Manacorda, Manning, and Wadsworth (2006) find empirical evidence for a limited impact of immigration on domestic wages and a lack of substitution between native and foreign-born workers. In Spain, Carrasco, Jimeno, and Ortega (2008) fail to find any sizeable effect of immigration on the wages and employment of native workers.

While the above-mentioned studies rely on a structural approach accounting for the interactions of the wages of skilled and unskilled labor, other literature estimates the impact of immigration on the wage structure. In particular, immigrants could have a significant impact on the wage distribution even if the impact on the wages of native workers is small. A number of studies decompose observed wage differences between immigrant and native workers into a deterministic part explained by different observed characteristics and a discriminatory part due to different pay given the same characteristics. Carrasco, Jimeno, and Ortega (2007) find that wage differentials between immigrants and native workers in Spain are mostly explained by differences in observed characteristics. They find that the effects of immigration on wage changes between 1995 and 2002 are negligible. On the contrary, Canal-Domínguez and Rodríguez-Gutiérrez (2008) find that in Spain, the immigrant-native wage differences at the lowest wages are caused by discrimination. Using household data from the Socio-Economic Panel in Germany, Peters (2008) finds that the negative immigrant-native wage gap rises along the wage distribution (i.e., is more negative in the upper part) in 1992 and 2006 and is explained by increasing discrimination against immigrants.

Eriksson, Pytlikova, and Warzynski (2009) have documented a sizeable increase in overall wage inequality in the Czech Republic. Using a linked employer-employee dataset covering the period 1998–2006, they analyze the evolution of the wage structure in the Czech Republic. In addition, they test different hypotheses possibly explaining increasing wage inequality over time. In their study, they concentrate mainly on the role of increased domestic and international competition, increasingly decentralized wage bargaining, and a changing educational composition of the workforce. They find evidence of slightly diminishing gender inequality and increasing returns to human capital. The impact of the increasing number of immigrant workers in the domestic economy, however, is not addressed.[2]

In this paper we document the sizeable inflows of foreign workers into the Czech labor market between 2002 and 2006 and focus on the effect of immigrants on the wage structure in the non-public sector of the economy by decomposing wage differences between immigrant and native workers into deterministic and discriminatory components along the wage distribution. In particular, we analyze the employment composition across skill groups defined by education and age using yearly matched employer-employee datasets for 2002 and 2006. Then we estimate Mincerian equations along the entire wage distribution using quantile regressions (Koenker and Bassett, 1978; Koenker and Hallock, 2001). We use the coefficient estimates to decompose the observed wage differences in 2002 and 2006 into the effect of observed characteristics and returns, employing the Albrecht et al. (2003) version of the Machado and Mata (2005) decomposition technique. This approach extends the standard Oaxaca-Blinder decomposition to explain wage differences along the wage distribution. We show how much of the wage difference between immigrants and natives may be associated with returns, indicating possible discrimination, and observed characteristics.[3]

In the next part we decompose the observed wage changes between 2002 and 2006 into discriminatory and deterministic parts to show the effect of immigrants on changes in the wage structure. We assess how much of the wage change at a particular point of the wage distribution (for example at the median) is due to changes in returns or observed characteristics of native and immigrant workers. This allows us to understand how much immigration affected wage growth between 2002 and 2006. Due to data availability, we focus on legal immigrant and native employment, neglecting possible illegal employment practices.[4]

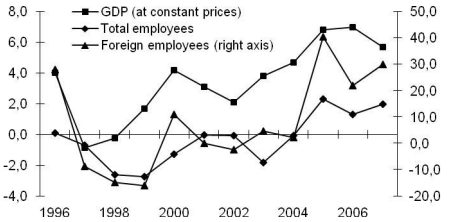
The paper is set out as follows. Section 2 provides stylized facts on migration in Europe and the Czech Republic. In Section 3 we describe the data and show descriptive statistics and changes in employment structure between 2002 and 2006.

[2] Other papers are devoted to the estimation of returns to schooling in the Czech Republic. See, for example, Chase (1998), Filer et al. (1999), Jurajda (2005), and Münich et al. (2005).

[3] Wage differences are decomposed at different points of the wage distribution, for example, the difference between the wage of the median immigrant and the wage of the median native worker.

[4] We are aware of possible illegal cost-saving practices by employers, including employing immigrants illegally and avoiding paying compulsory health and social security contributions. Those practices may exert downward pressure on the wages of legally employed immigrant and native workers. On the other hand, legal immigrant workers might be more productive and earn higher wages than immigrants employed illegally due to better matching of their skills with employment opportunities. We thank a referee for suggesting this explanation.

Figure 1 Employment and GDP Growth (%)



Note: Year-on-year changes in % (foreign employees: at year-end).
Sources: Czech Statistical Office; Ministry of Labor and Social Affairs; authors' calculations.

Section 4 is then devoted to the estimation and decomposition technique. Section 5 describes the results, while the last section concludes.

2. Stylized Facts on Migration

The inflows of immigrant workers into the Czech Republic are correlated with total employment, and both measures respond to economic growth (see *Figure 1*).[5] The inflow of immigrant workers was high in 1996 due to GDP growth of 4% that year, declined sharply during the recession in 1997–1998, and recovered in 2000. Along with total employees, the number of foreign employees increased significantly in 2005–2007 in the context of GDP growth, which accelerated from 2.1% in 2002 to 7.0% in 2006.[6]

In the Czech Republic, immigrant workers are mainly from Slovakia, Ukraine, and Poland. Hájková (2009) shows that immigrant workers are employed mainly in manufacturing, construction, real estate and renting, and in wholesale and retail trade. While most immigrant workers occupy low-skilled jobs, workers from Slovakia are also often high-skilled due to the absence of a language barrier.[7]

The inflows of immigrant workers are probably associated with economic factors, but administrative measures and institutional changes may also have some effect. However, after EU entry in 2004, administrative measures did not affect the employment of the majority of foreign workers on the Czech labor market, as the measures were not changed for workers from Slovakia and Ukraine, who account for the bulk of immigrant inflows. While Ukrainian citizens still need work permits, Slovak citizens were allowed to work in the Czech Republic without work permits already before EU entry in 2004. Employers were required to post all vacancies at

[5] See Brůha (2011) for a detailed analysis of labor force, employment, nominal wage, and output developments in the Czech Republic between 1996 and 2006. In particular, he finds a close connection between employment and GDP using cyclical components of the time series.

[6] We do not expect differences in the business cycle between 2002 and 2006 to have significantly affected the Czech wage structure. For example, Eriksson, Pytlikova, and Warzynski (2009) find that most of the observed changes in wage inequality between 1998 and 2006 are explained rather by increased sorting.

[7] According to registry data from the Ministry of Labor and Social Affairs, Slovak citizens accounted for 42% of total employment of immigrants at the end of 2007, followed by Ukrainians (26%) and Poles (10%). In Poland the main countries of origin of immigrants are Ukraine, Belarus, and Russia, while in Hungary immigrants arrive mainly from Romania, Ukraine, and Serbia. This suggests that geographical distance and cultural relations are important factors for migration besides labor demand.

district labor offices. A district labor office had to consent to a vacancy being filled by a foreign citizen, whereas employers had to notify the labor office about employment of EU citizens.

While the immigration inflows into the Czech Republic were high until 2007, the structure of immigration is similar as in the other EU countries. In particular, the EU countries attract mainly less educated migrants. This partly reflects past labor demand for low-skilled workers in the manufacturing sector. For example, in Austria, the country with the lowest share of highly educated migrants among the EU countries, the large group of migrants from the former Yugoslavia and Turkey is characterized by a very high share of low-qualified workers, while within Europe the UK, France, Portugal, and Spain attract most of the highly educated people migrating to Europe. At the same time, high-skilled migrants primarily migrate within Europe.[8]

Migration patterns within Europe were affected by the EU accession of Central and Eastern European countries in 2004 and 2007, as the relatively large gap in per capita income between the old and new member states provides a strong incentive to be mobile.[9] In addition, the relatively small geographical distances and the linguistic and cultural similarities between some countries may encourage people to migrate. As many of the old EU countries were afraid of negative effects of massive immigration after EU enlargement, the majority of them introduced periods of up to seven years restricting the access of citizens from the new EU member states to their labor markets. Despite these government protection measures, migration from the new EU states to the old EU-15 countries increased significantly after 2004 and was mainly motivated by economic factors (Kahanec et al., 2009).[10]

3. Data and Descriptive Statistics

We use yearly matched employer-employee datasets for 2002 and 2006 from the Average Earnings Information System (AEIS). The AEIS is administered by a private company for the Czech Ministry of Labor and Social Affairs. It contains more than 3,500 companies with 10 or more employees in the business sector, employing in total about 1.3 million workers. While large companies are all selected, smaller companies are included as a rotating panel based on a stratified random sample. The AEIS collects data on wages, working hours, and other job and worker characteristics of individual workers. In particular, the datasets provide information on gender, citizenship, education, presence of collective agreement, tenure, industry, profession, wage and its components (bonuses, overtime, and other premia), work hours and their components (overtime hours), non-work hours, non-work income, and normal hours per week.[11]

[8] About half of the total immigration flows into the EU arise from family reunification, while labor-motivated migration represents between 10 and 35 percent of immigration flows (Diez Guardia and Pichelman, 2006).

[9] In 2004, the EU was enlarged by 10 countries: the Czech Republic, Poland, Slovakia, Hungary, Estonia, Latvia, Lithuania, Slovenia, Cyprus, and Malta (the so-called EU-10 group, while the old EU countries are often labeled as the EU-15), while two more countries joined the EU in 2007: Bulgaria and Romania.

[10] Almost 70% of the immigrants from the EU-10 were absorbed by the UK and Ireland (Brücker et al., 2009) as a consequence of the immediate opening of their labor markets after EU enlargement. At the same time, migrants from Bulgaria and Romania continued to go mainly to Spain and Italy due to relatively short geographical distances and for linguistic reasons. In addition, bilateral agreements between these countries simplified migration from Bulgaria and Romania to Italy and Spain.

We restrict the sample to the same companies observed in 2002 and 2006 and to workers aged 18 to 60 with at least 160 hours worked during the year and with 30 or more weekly hours. We construct the hourly wage rate as the wage related to work including bonuses and premia divided by the number of hours worked,[12] adjusting the 2002 wage rates to prices of 2006 using the inflation rate. Immigrants are defined as workers with non-Czech citizenship.[13] As a robustness check, we also provide some alternative results treating Slovak citizens as native workers, reflecting the fact that Slovaks have a similar skills level to native workers (see Section 2). We also show some results for full samples in 2002 and 2006, as restricting the samples to the same companies may induce selection bias.

Based on the information on the highest level of education attained, we impute years of schooling (see *Appendix A* for details). This allows us to estimate returns to education in terms of the increase in income per additional year of schooling. On the other hand, we are aware that employers reward employees for having a degree rather than according to years of study, while imputed years of schooling also do not reflect, for example, repeated years of study.[14]

The size of the datasets in 2002 and 2006 is documented in *Table B1* in *Appendix B*. *Table B1* also displays the number of observations by gender and across segments defined by the education and age groups which we use in the paper.[15] We use these skill groups to analyze employment changes for men and women separately. Similar skill groups are used in Jurajda (2005). In particular, the definition of skill groups reflects the low substitutability of young and old workers with the same level of education, as old workers gained their education before the Czech Republic switched to a market economy in 1989. Furthermore, men and women are also low substitutes particularly in low-skilled jobs, while this assumption probably does not hold among high-skilled jobs. Nevertheless, we rely on estimating Mincerian regressions separately for men and women as in, for example, Jurajda (2005).

Summary statistics based on individual data are provided in *Table B2*. Immigrants earn on average less than natives in each year, both for men and women. Immigrants also have a lower level of education and are significantly younger than native workers.[16] A substantial difference is observed in tenure. In particular, men's

[11] The AEIS is based on stratified random sampling within Eurostat's Structure of Earnings Survey. The datasets fully comply with the Structure of Earnings Survey since 2006.

[12] Jurajda (2005) and Eriksson et al. (2009) employ hourly wage rates available in the AEIS, which are reported by employers to determine employees' vacation and absence pay. While these measures are reported quarterly only and contain premia and bonuses which are carried over from previous quarters, we construct more precise yearly hourly wage rates using the wage paid and total number of hours worked.

[13] Foreign citizens may acquire Czech citizenship after five years of permanent residence in the country. Hence, the number of immigrants based on foreign citizenship is undercounted.

[14] Münich et al. (2005) find that the imputation-based returns to education in 1996 are 0.8 percentage point higher than the correct estimates based on reported actual years of schooling. Higher returns to education are also estimated in Filer et al. (1999) using an instrumental variable method correcting for the measurement error caused by imputing years of schooling.

[15] The difference in the number of observations in *Table B1* between 2002 and 2006 is partly due to higher non-reporting of education level and citizenship in 2002 than in 2006. Furthermore, immigration is undersampled in the dataset, as it covers companies with 10 or more employees. While the incidence of immigration is 2.4% in our dataset in 2006, it is 5.8% of total employees at the end of 2007 according to the registry data (see Section 1).

Table 1 Incidence of Immigrants and Changes in Employment Structure

	Men			Women			Total
	age<=25	25<age<=45	age>45	age<=25	25<age<=45	age>45	
Primary education							
Imm. 2006 (%)	6.8	4.9	3.1	6.3	4.7	2.7	4.1
Imm. 2006–02 (p.p.)	2.7	2.2	1.3	1.9	2.8	1.2	1.9
g06-g02 (p.p.)	0.3	0.0	-0.8	0.4	-1.0	-2.0	-0.9
h06-h02 (p.p.)	6.2	1.2	-7.4	4.6	-1.7	-2.8	x
Secondary education							
Imm. 2006 (%)	3.5	2.3	1.2	3.4	1.1	0.9	1.9
Imm. 2006–02 (p.p.)	2.0	0.8	0.5	1.9	0.3	0.1	0.8
g06-g02 (p.p.)	-1.9	3.0	-1.5	-2.5	3.2	0.7	0.2
h06-h02 (p.p.)	-2.2	3.9	-1.7	-3.8	3.5	0.3	x
Tertiary education							
Imm. 2006 (%)	6.4	2.8	1.5	5.5	2.8	1.5	3.3
Imm. 2006–02 (p.p.)	3.4	1.5	0.6	2.9	1.4	0.8	1.8
g06-g02 (p.p.)	0.7	0.4	-0.2	0.9	0.1	0.1	0.8
h06-h02 (p.p.)	4.1	0.3	-4.5	7.3	-4.6	-2.7	x

Notes: "g" is the proportion of employment in each cell over total employment for men and women separately. "h" is the proportion of employment in each cell over total employment in each education group for men and women separately.

(women's) mean tenure is 11.5 (9.6) years for natives but only 6.6 (5.1) years for immigrants in 2002. The mean tenure is even lower in 2006, reaching 10.9 (9.2) years for native men (women) and 4.2 (4.1) years for immigrant men (women). This indicates the existence of significant flows on the Czech labor market until 2006.[17]

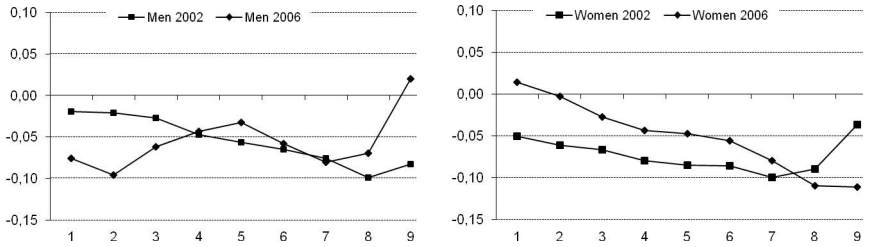
Next, we investigate changes in the employment of native and immigrant men and women within the narrowly defined skill groups. *Table 1* reports the percentage of immigrant workers across the skill groups for men and women. The inflow of immigrants increased in all education-age classes until 2006. Notably, the highest increases are observed mainly for young workers with primary and tertiary education. In particular, the incidence of immigration stands at about 6.8% of employment for male workers and 6.3% for female workers younger than 25 with primary education in 2006, while in 2002 the incidence for men and women was 4.1% and 4.4%, respectively. The proportion of immigrants in total employment is also higher for workers with primary education and aged between 25 and 45, and for workers with tertiary education and aged less than 25. In these skill groups we also observe the highest increases until 2006.[18]

Table 1 also reports how the employment structure changed between 2002 and 2006 by looking at the proportion of employment in each cell over total employment for men and women separately (see the g06–g02 values in *Table 1*). The data indicate that the employment structure changed toward more tertiary-educated and young

[16] The level of educational attainment is often poorly measured for immigrant workers. If it is underreported, then our returns to education are probably overestimated for immigrant workers.

[17] In *Table B2*, we do not report descriptive statistics of immigrants' employment in industries and occupations. Using administrative data provided by the Ministry of Labor and Social Affairs, Hájková (2009) describes the employment patterns of immigrants across industries and occupations on the Czech labor market (see also Section 2 in this paper).

Figure 2 Immigrant-Native Wage Gap for Men (left) and Women (right)



Notes: Observed log hourly wage gaps at the deciles in the wage distribution. Deciles denote points in the distribution, e.g., the 5th decile is the median.

Table 2 Measures of Wage Dispersion

	2001	2002	2003	2004	2005	2006	2007
D9/D1	2.90	2.95	3.00	3.03	3.10	3.10	3.11
D9/D5	1.74	1.76	1.76	1.75	1.78	1.80	1.80
D5/D1	1.66	1.68	1.70	1.73	1.74	1.73	1.72

Note: Ratio of average wage along the wage distribution (D9 = 9th decile, D5 = median, D1 = 1st decile).
Source: Czech Statistical Office.

workers, while relatively less older and low-educated workers are observed in 2006 compared to 2002. Substantial inflows of primary-educated immigrant workers are observed despite the fact that the relative labor demand for low-skilled workers is on the decline. In particular, the proportion of workers with primary education decreased by 0.9 percentage point in the total sample of men and women between 2002 and 2006, while it increased by 0.8 percentage point for tertiary-educated workers.[19] The other rows in *Table 1* (h06–h02) show changes in the proportion of employment in each education group for men and women. We see that the employment structure changed toward younger workers within primary and tertiary education, while within secondary education the relative employment of workers aged 25 to 45 increased.

While mean real log hourly wages increased between 2002 and 2006 (*Table B2*), *Table 2* documents increasing wage dispersion. *Figure 2* indicates that immigrants earn less than native workers over most of the wage distribution.[20] The evidence illustrated in *Figure 2* also suggests that the immigrant-native wage gaps are per-

[18] We repeated the analysis shown in *Table 1* using an alternative definition of immigrants, treating Slovak citizens as native workers. The results are similar to those reported in *Table 1*, except for young men and women with tertiary education, where the proportion of immigrants is much lower than in *Table 1*. In particular, the incidence of immigration stands at about 3.7% for young men and 3.5% for young women, both with primary education. The proportion of immigrants in total employment is also higher for workers with primary education and aged between 25 and 45. As in *Table 1*, we observe the highest increases in these skill groups until 2006. The results are available from the authors upon request.

[19] We checked the validity of these results against the aggregate statistics from the Labor Force Survey published by the Czech Statistical Office. In particular, the proportion of workers with primary education decreased by 1.5 percentage points between 2002 and 2006, and increased by 1.7 percentage points for workers with tertiary education. This corroborates our results in *Table 2* on changes in the structure of employment.

[20] Throughout the paper, by deciles we mean points in the distribution. For example, the 5th decile is the median.

sistent for both men and women, as they are observed in both 2002 and 2006. The immigrant-native wage gaps are negative and persistent over most of the wage distribution even if Slovak citizens are included among native workers, except for the highest two deciles for men in 2006, where the gaps turn positive (see *Figure B1* in *Appendix B*).[21]

4. Estimation and Decomposition of Wage Differences

In this section we empirically assess the impact of immigration inflows on the Czech wage structure. While observing the immigrant-native wage gap in 2002 and 2006 separately, we also investigate wage differences along the wage distribution between 2002 and 2006. We decompose the observed wage differences into a deterministic part due to observed characteristics and a discriminatory part explained by estimated returns using an extended Oaxaca-Blinder decomposition technique.

In order to perform the decomposition of the observed wage differences, we estimate returns to observed characteristics separately for groups of workers. In particular, we apply quantile regression techniques (Koenker and Bassett, 1978; Koenker and Hallock, 2001) to estimate Mincerian equations for n deciles θ separately for men and women and for immigrant and native workers. The quantile wage equation is specified as follows:

$$w_i = Q^{\theta}\left(w_i \middle| x_i\right) + \varepsilon_i \tag{1}$$

where w_i represents the log of the hourly wage and x_i is the set of explanatory variables. It follows that the conditional expected value of the log wage for each quantile θ is:

$$Q^{\theta}\left(w_i \middle| x_i\right) = x_i' \beta^{\theta} \tag{2}$$

We first estimate parameters β^{θ} controlling for a number of controls x_i such as years of education, age, age squared, tenure, tenure squared, and industry and occupation dummies. However, the choice of occupation may be endogenous, as immigrants often sort into low-earnings occupations until they accumulate specific human capital in the host economy. In order to assess the size of the bias on the estimates and on the decomposition, we estimate (1) without occupation dummies as an alternative.[22]

To quantify the average characteristics of each group of workers, we apply Albrecht et al.'s (2003) version of the Machado-Mata (2005) method. In particular, by applying a bootstrap method we generate a random sample for each group of workers. The method can be described as follows:

[21] The wage gaps at the 8th and 9th decile are substantially lower for men in 2006 in *Figure B1* if we exclude senior officials and managers from the sample, but still higher than those reported in *Figure 2*.

[22] In the estimation of the Mincerian equations using quantile regression, we do not control for sample selection due to participation decisions (particularly of women) or selection into private sector employment, which is covered in our datasets, as opposed to employment in the public sector or self-employment. Münich et al. (2005) show that the estimated coefficients of the returns are not affected by sample selection due to participation in the Czech Republic.

– Estimate for each group *n* quantile regressions.
– Generate for each group a random sample of size *n* with replacement.
– Sort the observations by wages to get an observation for each quantile.
– Repeat this procedure 500 times to obtain the average characteristics for each quantile.

The wage differences between immigrant and native workers in 2002 and 2006 are then decomposed for each quantile θ according to the formula:

$$w_I^\theta - w_N^\theta = \left(\overline{x}_I^\theta - \overline{x}_N^\theta\right)' \hat{\beta}_N^\theta + \overline{x}_I^\theta{}' \left(\hat{\beta}_I^\theta - \hat{\beta}_N^\theta\right) + \left(\overline{\varepsilon}_I^\theta - \overline{\varepsilon}_N^\theta\right) \tag{3}$$

where w_I^θ and w_N^θ represent the log wage of immigrant and native workers within each quantile θ in a specific year. The set of explanatory variables representing the average characteristics of immigrant and native workers is $\overline{x}_I^\theta$ and $\overline{x}_N^\theta$, respectively. The coefficients $\hat{\beta}_I^\theta$ and $\hat{\beta}_N^\theta$ correspond to the estimated returns to the observed characteristics. Finally, $\overline{\varepsilon}_I^\theta$ and $\overline{\varepsilon}_N^\theta$ are residuals. Thus, the first term on the right-hand side represents the difference between the characteristics of an average immigrant and native worker when paid as a native worker. On the other hand, the second term reflects the difference between the expected returns to characteristics of immigrant and native workers.[23] The last term represents the unexplained part of the wage gap, reflecting limitations which disappear with more simulations and more observations, and possible specification error caused by estimating a linear quantile regression (Melly, 2005). This type of static decomposition is performed separately for men and women in 2002 and 2006.

In the next step, we decompose the wage changes for each quantile θ between 2002 and 2006. The decomposition takes into account that the wage w^θ within each quantile θ is a weighted average of native and immigrant workers' wages. The proportion of immigrants in each quantile is α^θ. Just as in the previous case, $\overline{x}_I^\theta$ and $\overline{x}_N^\theta$ correspond to the characteristics set for immigrant and native workers and $\hat{\beta}_I^\theta$ and $\hat{\beta}_N^\theta$ correspond to the estimated returns to the workers' characteristics. The lower-case index specifies the year. The observed wage differences between 2002 and 2006 can be divided into the following terms:

$$\begin{aligned} w_{06}^\theta - w_{02}^\theta = & \left\{ \alpha_{06}^\theta \left(\overline{x}_{I,06}^\theta{}' - \overline{x}_{N,06}^\theta{}'\right) \hat{\beta}_{N,06}^\theta - \alpha_{02}^\theta \left(\overline{x}_{I,02}^\theta{}' - \overline{x}_{N,02}^\theta{}'\right) \hat{\beta}_{N,02}^\theta \right\} + \\ & + \left\{ \alpha_{06}^\theta \overline{x}_{I,06}^\theta{}' \left(\hat{\beta}_{I,06}^\theta - \hat{\beta}_{N,06}^\theta\right) - \alpha_{02}^\theta \overline{x}_{I,02}^\theta{}' \left(\hat{\beta}_{I,02}^\theta - \hat{\beta}_{N,02}^\theta\right) \right\} + \\ & + \overline{x}_{N,06}^\theta{}' \left(\hat{\beta}_{N,06}^\theta - \hat{\beta}_{N,02}^\theta\right) + \left(\overline{x}_{N,06}^\theta{}' - \overline{x}_{N,02}^\theta{}'\right) \hat{\beta}_{N,02}^\theta + \left(\overline{\varepsilon}_{06}^\theta - \overline{\varepsilon}_{02}^\theta\right) \end{aligned} \tag{4}$$

[23] The discriminatory part of the wage gap also includes effects not captured in the regression, particularly language skills, reservation wage, working conditions, etc.

The overall change in log wages at each quantile can be broken down into five main terms. The terms in the first curly brackets represent the contribution of change in the characteristics of immigrants between 2002 and 2006 expressed relatively to the characteristics of native workers. Second, the contribution of change in the gap of returns between immigrant and native workers between 2002 and 2006 is represented in the second curly brackets. Third, the first expression in the third line corresponds to the contribution of change in returns to observed characteristics of native workers between 2002 and 2006. Fourth, the second term in the third line represents the impact of change in the characteristics of native workers between 2002 and 2006. Finally, the error term quantifies the part of the overall relative change in wages unexplained by the model.

By introducing static and dynamic decomposition we construct wage distributions which provide hypothetical wages, i.e., counterfactual wage distributions. Consequently, comparison of the factual and the counterfactual wage distributions enables us to draw observations on the effect of immigrants on the Czech wage structure. In fact, we do not generate large distributions as in Machado and Mata (2005), but draw observations for a limited number of quantiles following Albrecht et al. (2003). In particular, we generate random samples of size 99 with replacement and use the 10th, 20th, etc. observations, representing the deciles along with nine quantile regressions.

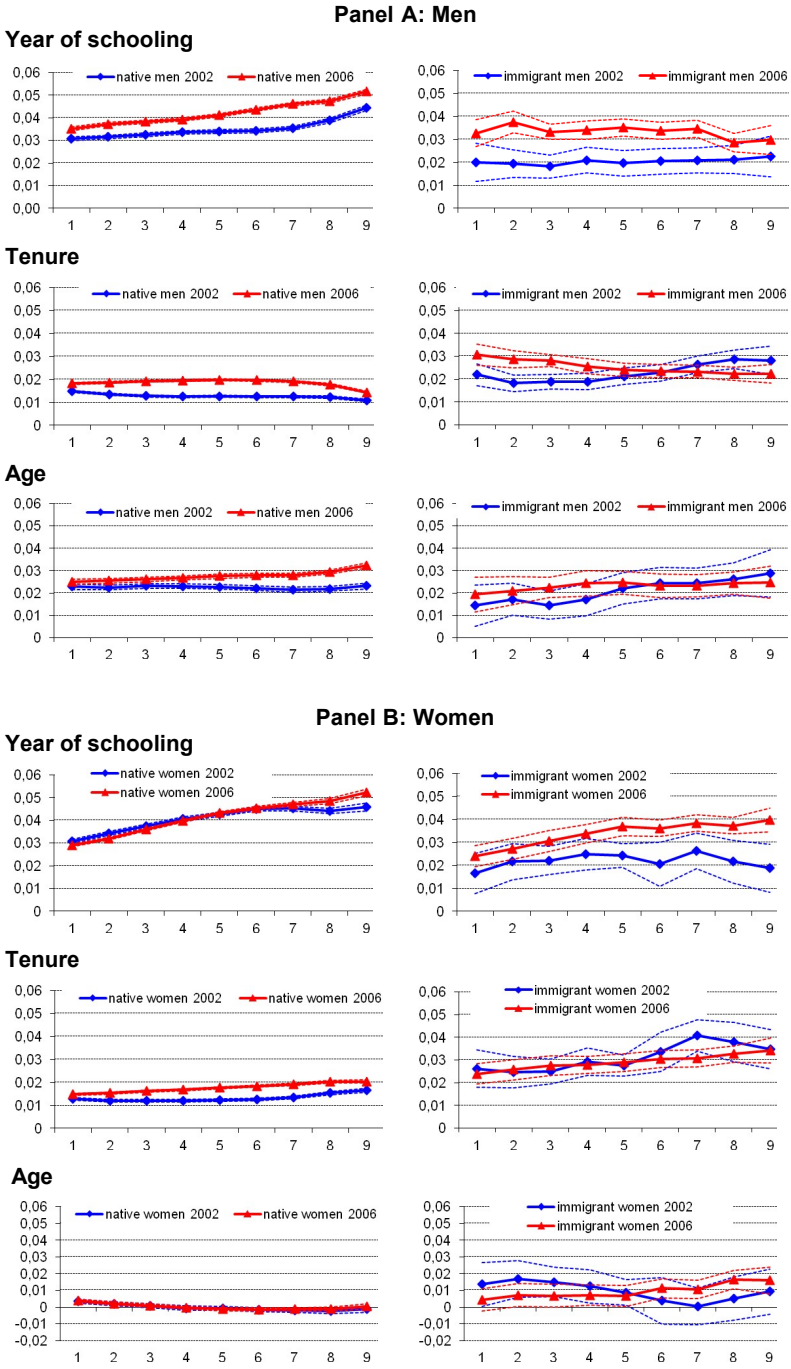
5. Results

Figure 3 shows the coefficient estimates from the quantile regressions in (1) for native and immigrant men and women in 2002 and 2006. Regarding native workers, the returns to education are increasing along the wage distribution, being higher for men in 2006 than 2002. Returns to tenure and age are approximately the same along the wage distribution, except for native men in 2006, where the returns to tenure show a slightly concave pattern and the returns to age are increasing. In the case of immigrant workers, a year of education is less rewarded, as suggested by lower returns to education for immigrant than native men and women. Migrants have a lower return to education than native workers, as human capital acquired abroad is not fully rewarded in the host labor market (Friedberg, 2000). On the other hand, immigrants receive higher remuneration for a year of tenure than natives, as following the underpricing of immigrants' human capital, the immigrants' return to tenure is higher than that of native labor due to the faster accumulation of firm-specific human capital (see also Carneiro et al., 2010).[24]

The estimated returns to education, tenure and age are similar as in the other literature reported for other countries. In particular, Machado and Mata (2005) find increasing returns to education and age along the wage distribution and a concave profile of returns to tenure in Portugal in 1995. Increasing returns to education and age along the wage distribution are also found in Carrasco et al. (2007) for Spain in 2002. Our results on rising returns to education in the Czech Republic in 2002–2006

[24] *Figure 3* shows the regression coefficients from (1) estimated with occupation dummies. Excluding the occupation dummies yields higher coefficient estimates in years of schooling and, for native workers in the highest deciles, also in age. The returns estimated without occupation are available from the authors upon request.

Figure 3 Quantile Regression Coefficients



Note: The points represent 90% confidence intervals in the deciles.

Figure 4a Decomposition of Immigrant-Native Wage Gap for Men (left) and Women (right)

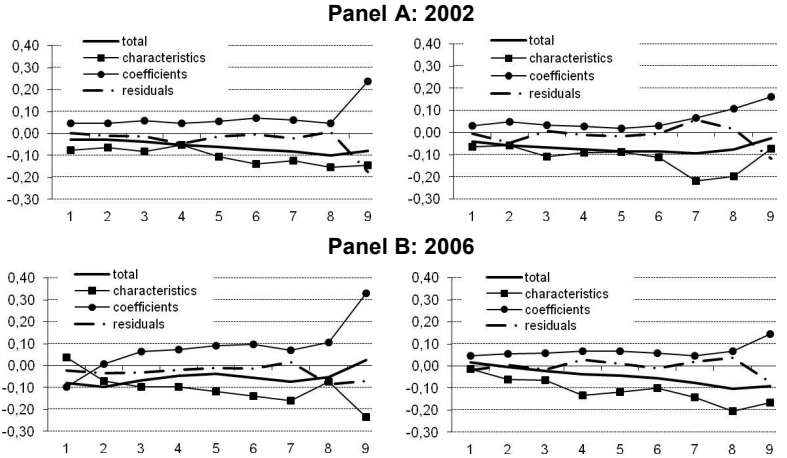
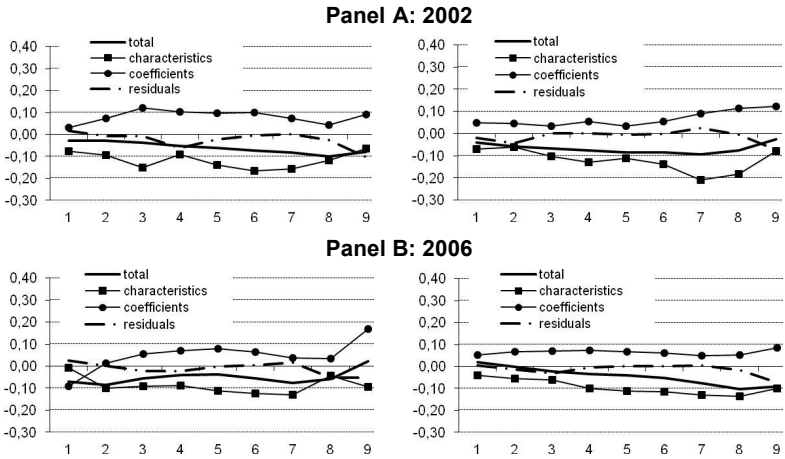


Figure 4b Decomposition of Immigrant-Native Wage Gap for Men (left) and Women (right) Estimates without Occupation Dummies



corroborate findings in previous literature (Münich et al., 2005, for 1991–1996; Eriksson et al., 2009, for 1998–2006). Rising returns to education are also found in Machado and Mata (2005) for Portugal in 1986–1995.

Figures 4a and *4b* show the immigrant-native wage gaps and the decomposition into deterministic and discriminatory parts using equation (3) for men and women in 2002 and 2006, employing the coefficient estimates from (1) with (*Figure 4a*) and without (*Figure 4b*) occupation dummies.[25] The results suggest that the negative wage gaps between immigrant and native workers are largely explained

[25] While *Figure 2* shows the observed wage gaps, the gaps in *Figures 4a* and *4b* are bootstrapped.

Figure 5a Decomposition of Total Wage Changes for Men (left) and Women (right) between 2002 and 2006

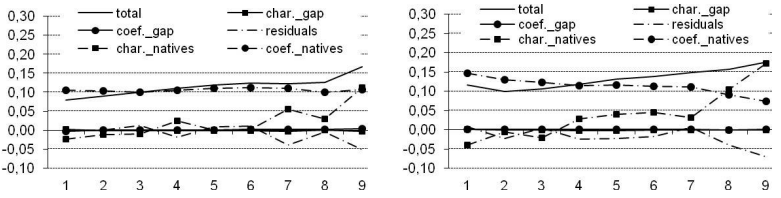
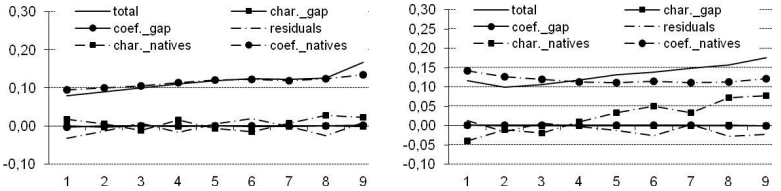


Figure 5b: Decomposition of Total Wage Changes for Men (left) and Women (right) between 2002 and 2006, Estimates without Occupation Dummies



Note: Total wage changes refer to native and immigrant workers.

by observed characteristics along the entire wage distribution. In particular, an immigrant worker at a particular decile earns less than a native worker at the same decile due to different observed characteristics. On the other hand, the contribution of returns (the discriminatory part) is small and positive, while a negative discriminatory part is only observed in the first decile for men in 2006. The discriminatory part is higher at the highest deciles as it contains effects due to unobserved heterogeneity which are not captured in the regression. The results in *Figure 4b* are similar to those in *Figure 4a*, suggesting that the decomposition is not significantly affected by the bias in the coefficient estimates in (1) due to the probably endogenous choice of occupation.

We repeated the analysis from *Figure 4a* using all firms in 2002 and 2006. The results in *Figure B2* in *Appendix B* support our finding that the negative native-immigrant wage gaps are explained mainly by differences in observed characteristics, so that the selection bias due to restricting the samples to the same companies in 2002 and 2006 does not affect the decomposition results. On the other hand, the observed wage gaps are more negative at the lowest deciles in 2006 than the gaps reported in *Figure 4a*.

Figures 5a and *5b* show the wage changes between 2002 and 2006 along the wage distribution and the decomposition of these changes using equation (4). We see that wages increased at all deciles for men and women until 2006, with a relatively more pronounced change observed with increasing pay, indicating rising wage dispersion.[26] The decomposition suggests that the wage change until 2006 is explained mostly by increasing returns of native workers (discriminatory part). The increasing wage dispersion along the distribution until 2006 is due to a positive

[26] The increasing wage dispersion is reported in *Table 2*.

contribution of observed characteristics (deterministic part) of native workers above the median. This may be due to an increasing level of education, reflecting firm hiring policies or increasing educational attainment in the population. The average years of schooling of native men (women) increased from 12.6 (12.1) in 2002 to 12.7 (12.3) in 2006 (see *Table B2*). On the other hand, the contribution of the discriminatory and deterministic parts of immigrant workers is negligible in explaining the observed differences in the wage structure between 2002 and 2006.[27] Again, the results in *Figure 5b* are similar to those in *Figure 5a*, so that neglecting the endogenous choice of occupation in the estimation of (1) does not change our decomposition results.

In sum, immigrant-native wage gaps are largely explained by different observed worker and job characteristics such as education, tenure, age, occupation, and industry. However, the overall impact of immigration on changes in the wage distribution is negligible. Instead, the observed differences in the wage structure between 2002 and 2006 are explained mostly by increasing returns to observed characteristics of native workers, while observed characteristics of native workers above the median of the wage distribution, particularly rising education, are responsible for increasing wage dispersion.

6. Conclusions

We use yearly matched employer-employee datasets to investigate the effect of immigration on the Czech wage structure, and particularly on its changes between 2002 and 2006. Applying the Albrecht et al. (2003) version of the Machado and Mata (2005) decomposition technique, we decompose the wage differences between 2002 and 2006 at different parts of the wage distribution into deterministic and discriminatory components for native and immigrant workers. This allows us to assess to what extent the wage differences are due to observed characteristics, such as education, tenure, age, occupation, and industry, or due to different returns given the observed characteristics, indicating possible discrimination.

Although the inflow of foreign workers into the Czech labor market was substantial, its impact on changes in the wage structure was negligible between 2002 and 2006. Immigration thus does not moderate wage growth along the wage distribution, probably due to the still low number of immigrants. We find that changes in the Czech wage structure are instead driven mostly by increasing returns to observed characteristics of native workers. Changes in the observed characteristics of native workers, particularly an increasing level of education, which are significant above the median in the wage distribution, explain increasing wage dispersion.

Comparing the wage distributions of immigrant and native workers, we find that immigrants earn less than native workers for most of the distribution, while the observed negative wage gaps are persistent. We decompose the wage gaps along the wage distribution into deterministic and discriminatory parts in 2002 and 2006. We find that immigrants' wages are lower than wages of native workers mainly due to different observed characteristics.

[27] To be more precise, the contributions of immigrants' returns and characteristics relative to the natives' returns and characteristics are negligible, as they are expressed as gaps—see the first and second curly brackets in equation (4).

The sizeable inflows of foreign workers into the Czech labor market in the sample years are mainly due to rising labor demand and are concentrated particularly among young workers with primary education. The substantial inflow of primary-educated immigrant workers is observed despite the fact that the relative labor demand for low-skilled workers is on the decline.

We provide evidence that the returns to education of native workers are increasing along the wage distribution, while they are also higher for men in 2006 than in 2002. Returns to education are lower for immigrant than for native workers, while immigrants have higher returns to tenure. Our estimates of returns to observed characteristics are in line with other literature for other countries and for the Czech Republic.

Our decomposition results are robust to neglecting possible biases due to the endogenous choice of occupation and to restricting the sample to the same companies in 2002 and 2006. Nevertheless, the decomposition of wage changes should still be interpreted with caution, particularly in the upper part of the wage distribution, as the discriminatory part contains effects due to unobserved heterogeneity which are not controlled for in the regressions. Furthermore, our results are limited to employment reported in matched employer-employee datasets which are restricted to companies in the business sector with 10 or more employees. We thus do not account for employment in very small firms. Finally, we also do not capture unofficial practices of employers, which might be common in the employment of immigrant workers.

APPENDIX A

The highest level of education reported in the AEIS datasets is based on the Classification of Basic Branches of Education (CBBE). *Table A1* shows the imputed years of schooling for each CBBE category. We also show the international ISCED 1997 classification for comparison.

Table A1 Classification of Basic Branches of Education and Imputed Years of Schooling

	Classification of Basic Branches of Education	Years of schooling	ISCED 1997
A	No education	4	0
B	Incomplete primary	5	1
C	Primary	9	2
D	Lower secondary	9	2
E	Lower secondary vocational	11	2
H	Secondary vocational with certificate of apprenticeship	12	3C
J	Secondary or secondary vocational without school leaver's certificate and certificate of apprenticeship	11	3C
K	Complete secondary general	13	3A
L	Complete secondary vocational with certificate of apprenticeship and school leaver's certificate	13	3A, 4
M	Complete secondary vocational with school leaver's certificate (without certificate of apprenticeship)	13	3A, 4
N	Upper vocational	16	5B, 4
R	Bachelor's	16	5A, (5B)
T	University	18	5A
V	University doctoral	21	6

Notes: Imputed years of schooling based on the CBBE. We show the international ISCED 1997 classification for comparison.

Source: Own calculations. The transformation of the CBBE to ISCED 1997 is from the Czech Statistical Office.

APPENDIX B

Table B1 Number of Observations

Panel A: 2002

	Men			Women		
	age<=25	**25<age<=45**	**age>45**	**age<=25**	**25<age<=45**	**age>45**
			Primary education			
native	5,445	6,625	11,793	3,798	9,957	22,651
immigrant	231	181	221	174	198	348
			Secondary education			
native	68,402	88,923	96,390	41,045	59,841	52,594
immigrant	1,030	1,336	686	597	500	401
			Tertiary education			
native	7,061	15,324	13,615	4,393	5,577	3,641
immigrant	220	195	117	119	82	26
Total natives	313,578			203,497		
Total immigrants	4,217 (1.3%)			2,445 (1.2%)		

Panel B: 2006

	Men			Women		
	age<=25	**25<age<=45**	**age>45**	**age<=25**	**25<age<=45**	**age>45**
			Primary education			
native	7,231	7,277	10,644	6,297	10,766	25,341
immigrant	529	372	342	425	535	703
			Secondary education			
native	70,437	112,046	104,975	48,487	91,238	74,413
immigrant	2 522	2655	1 272	1 690	1 041	677
			Tertiary education			
native	10,134	18,753	14,707	8,410	7,884	5,230
immigrant	692	532	217	494	230	82
Total natives	356,204			278,066		
Total immigrants	9,133 (2.6%)			5,877 (2.1%)		

Note: Standard deviations in italics.

Table B2 Summary Statistics

Panel A: 2002

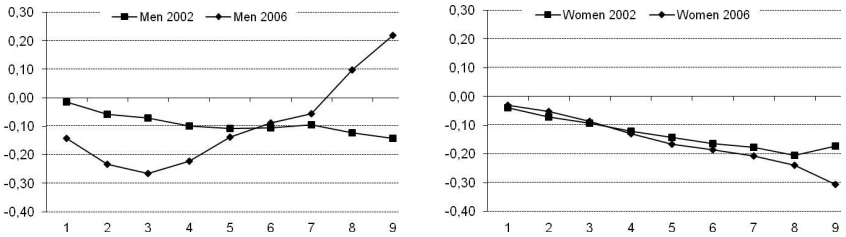
	Men			Women		
	nat.	**imm.**	**imm.-nat.**	**nat.**	**imm.**	**imm.-nat.**
Log hourly wage	4.756	4.717	-0.039	4.467	4.409	-0.058
	0.452	*0.480*		*0.413*	*0.434*	
Years of schooling	12.653	12.357	-0.295	12.140	11.807	-0.333
	2.186	*2.505*		*2.092*	*2.525*	
Age	40.454	36.703	-3.751	40.112	37.269	-2.843
	11.356	*10.640*		*10.685*	*11.181*	
Tenure	11.505	6.628	-4.877	9.641	5.067	-4.574
	11.143	*9.043*		*9.707*	*6.863*	
Number of observations	313,578	4,217		203,497	2,445	

Panel B: 2006

	Men			Women		
	nat.	**imm.**	**imm.-nat.**	**nat.**	**imm.**	**imm.-nat.**
Log hourly wage	4.877	4.838	-0.040	4.604	4.565	-0.040
	0.481	*0.527*		*0.440*	*0.434*	
Years of schooling	12.733	12.623	-0.110	12.296	12.152	-0.144
	2.194	*2.640*		*2.091*	*2.723*	
Age	40.267	35.323	-4.943	40.424	35.339	-5.085
	11.570	*10.391*		*10.954*	*11.252*	
Tenure	10.905	4.235	-6.670	9.221	4.065	-5.155
	10.595	*6.367*		*9.391*	*6.244*	
Number of observations	356,204	9,133		278,066	5,877	

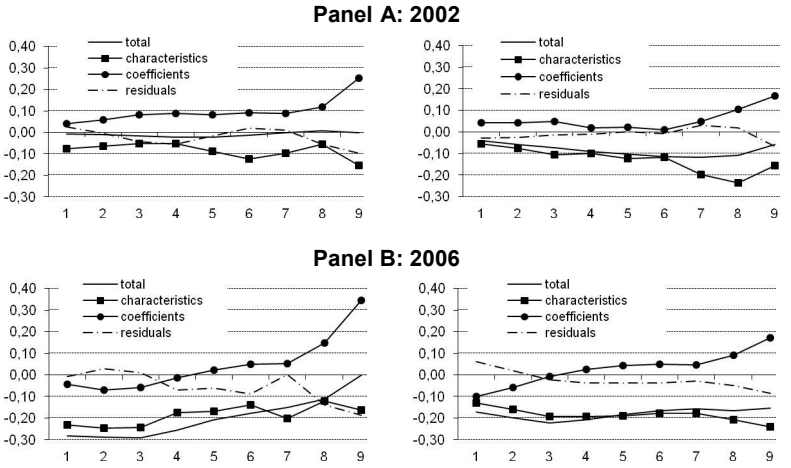
Note: Standard deviations in italics.

Figure B1 Immigrant-Native Wage Gap for Men (left) and Women (right), Alternative Definition of Immigrants



Notes: Slovak citizens are treated as native workers.
Observed log hourly wage gaps at the deciles in the wage distribution.
Deciles denote points in the distribution, e.g., the 5th decile is the median.

Figure B2 Decomposition of Immigrant-Native Wage Gap for Men (left) and Women (right), Full Sample



Note: All firms in 2002 and 2006.

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