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Wage inequality and segregation between native and immigrant workers in Switzerland: evidence using matched employee-employer data

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Structured Abstract

- *Purpose*: We analyze segregation between immigrants and natives at the firm level and explore the connection between segregation and wage inequality in Switzerland.

- *Methodology/approach*: Our approach accounts for the interaction between skill level and immigration status (work permit). First, we calculate exposure rates in order to analyze segregation at the firm level along these two dimensions. Second, we examine the role of segregation in the explanation of wage inequality between different skill-nationality groups. We use data from the Swiss Wage Structure Survey 2002, an employer-employee database which records individual wages among a very large sample of establishments in all industries, covering approximately 42'000 firms and 1 million workers.

- *Findings*: Our results show that interfirm segregation is particularly pronounced for unskilled foreign workers and for recently arrived, highly skilled foreigners. The former earn lower wages than equally skilled Swiss workers and the latter are paid higher wages than highly skilled Swiss workers. In both cases, interfirm segregation accounts for almost the entire wage differential.

- *Originality/value of paper*: This paper presents a generalization of the approach used by Groshen (1991) to the multi-group case by defining segregation with respect to the two dimensions of nationality and skill. The use of multi-group exposure rates is common in studies of neighborhood segregation (e.g., Bayer et al., 2004) but our paper shows that they can also be fruitfully applied in the analysis of interfirm segregation and wage inequality.

Keywords : Firm-level segregation, wage inequality, immigration, exposure rates

Research paper

1 Introduction

In many European countries, immigration policy has undergone major changes in recent years. Even traditional guest-worker countries, such as Germany or Switzerland, try to attract more highly skilled immigrants and to limit the arrival of unskilled workers. While this policy change has been relatively successful in Switzerland, an important number of unskilled workers continue to arrive because of the inertia produced by migration laws (e.g family reunion). As a result, the group of recently arrived immigrants is highly heterogeneous with respect to skill.

What is the situation of this new generation of immigrants in the labor market? In the past, several empirical studies documented the fact that immigrant workers are, on average, paid lower wages than natives. Moreover, it has often been observed that unskilled immigrants hold jobs that native workers would not accept. Does this still hold true with the recent changes in immigration policy?

This paper seeks to answer these questions by analyzing wage inequality and segregation between natives and immigrants. We focus on the role of segregation at the firm level between natives and immigrants and explore the connection between segregation and wage inequality. In order to take the skill heterogeneity of the immigrant population into account, we analyze segregation as a two-dimensional phenomenon, considering the dimensions of skill and nationality (or type of work permit). The interaction between these two dimensions turns out to be crucial for the decomposition of wage inequality.

To our knowledge, there has been little research on the link between segregation and the native / immigrant wage gap. Liu et al. (2004) analyze the link between occupational segregation and wage inequality between immigrants and natives in Hong Kong, using Brown et al.'s (1980) methodology. Several other papers focus on the related issue of segregation between ethnic groups. Neuman and Silber (1996) explore the role of occupational segregation in the wage differential between the two main ethnic groups in Israel. They expand Oaxaca's (1973) decomposition method in order to account also for occupational segregation. Hirsch and Schumacher (1992) and Hirsch and and Macpherson (2004) introduce a racial density variable in Mincer-type wage equations and evaluate its contribution to the racial wage gap. It should be noted that these papers define segregation at the occupational level (Hirsch and Schumacher define segregation within industry-occupation-region cells).

Our approach to segregation is closer to Carrington and Troske (1998) who discuss segregation between black and white workers at the firm level. The concept of interfirm segregation is interesting as it captures the actual interactions between different population groups in the workplace. When decomposing the black/white wage gap, these authors find that interfirm segregation accounts only for a small share of the wage gap. Our paper draws also on the approach adopted by Groshen (1991) and Bayard et al. (2003) in order to

determine the contribution of segregation to the explanation of the male/female wage gap. In her decomposition procedure, Groshen uses a segregation index which turns out to be based on male/female exposure rates.

Our paper generalizes this approach to the multi-group case by defining segregation with respect to the two dimensions of nationality and skill. Exposure rates are particularly well suited for such a generalization since they have a natural interpretation in the multi-group case. The use of multi-group exposure rates is common in studies of neighborhood segregation (e.g., Bayer et al., 2004) but, to our knowledge, they have never been used in the context of interfirm segregation.

Although exposure rates can be aggregated into a single-valued segregation index (James, 1986), the link between segregation and wage inequality can be modeled in a more satisfactory way by using the full information on exposure rates by skill/nationality groups.[1] This is crucial if one wants to model the link between segregation and wage inequality at both ends of the skill distribution. We use data from the Swiss Wage Structure Survey 2002 which records individual wages among a very large sample of establishments in all industries, covering approximately 42'000 firms and 1 million workers.

Our results show that there is segregation both along the skill and the nationality dimensions and point to the existence of two types of firms. Some firms follow the traditional guest-worker strategy and hire mostly unskilled foreign workers. Other firms benefit from the recent bilateral agreements with the EU by employing a great number of highly skilled foreign specialists. In a further step, we relate wage inequality between natives and immigrants to firm-level segregation and find that the skill composition of firms does not account for a significant share of wage differences between individuals of different skill. However, there are important interaction effects at the firm level between skill and nationality. Firms with a great share of unskilled foreign workers pay lower wages to all their employees (whether they are Swiss or immigrants), while firms that employ a large share of highly skilled foreign workers pay higher wages to all their workers.

The structure of our data does not enable us to establish a causal link between segregation and wage inequality but our descriptive evidence helps to shed some light on the relevance of different theories of discrimination and segregation. Our results are difficult to reconcile with an explanation of taste-based discrimination (Becker, 1957) but they could either be consistent with a "quality sorting" explanation (Hirsch and and Macpherson, 2004) or with the existence of rationing of high-wage jobs. From a theoretical viewpoint, sorting of workers across firms according to their skill level can be explained by technological complementarity, as in the competitive labor-market model of Kremer and Maskin (1996). If skill levels are (partially) unobserved, the variables capturing a firm's workforce composition could be

[1] In fact, our database constrains us to a breakdown by work permit rather than by nationality. As the description of the Swiss immigration policy will make clear, this distinction has its own merits. In particular, recently immigrated workers can be distinguished from settled immigrants on the basis of their work permits.

"proxies" of the workers' unobserved characteristics and there would be no causal link between segregation and wage inequality. Although we find some evidence for this view at the low end of the skill spectrum, our results could also be consistent with another view which sees the labor market as being imperfectly competitive, where the most productive firms pay higher wages to all their employees because of rent-sharing motives. In this case, workforce composition variables could be proxies of a firm's productivity.

The remainder of the paper is structured as follows. The next section summarizes the main features of Swiss migration policy and presents the database. Section 3 gives a brief account of the approach we use in a simplified framework where the skill and nationality dimensions are characterized by two alternatives each (skilled / unskilled, Swiss / foreign). Some interesting results can already be derived in this framework. The two following sections generalize the setting to four skill levels and five categories of nationality / work permit. The patterns of segmentation along these two dimensions are discussed in Section 4 and the link between segregation and wage inequality is analyzed in Section 5. The last Section concludes.

2 Institutional context and data

Under the traditional guest-worker policy applied by the Swiss government after World War II, unskilled workers were actively recruited in South European countries. Although active recruitment came to a halt in the 1970s, a temporary migration regime subsisted until the 1990s. This policy has had important consequences for the skill composition of the permanent population in Switzerland until today. Many immigrants were first granted a seasonal work permit, allowing them to work in a limited number of sectors. Because of these severe restrictions, this policy attracted mainly unskilled workers. After several years of uninterrupted seasonal work, these workers were entitled to a more permanent, annually renewable, work permit without sectoral restrictions.

More recently, the Swiss government has reoriented its policy by negotiating bilateral agreements on the free movement of persons between the European Union and Switzerland. The main features of the Swiss migration policy are the following. Foreigners are classified into four main categories which entail different economic rights:

1. seasonal workers and short-term workers : "permit A";
2. annual workers : "permit B";
3. settled workers : "permit C";
4. cross-border workers : "permit G".

The seasonal work permit existed until June 2002 and allowed workers to stay in Switzerland at most nine months during a calendar year. Seasonal workers were constrained to work in industries characterized by seasonal activities (i.e. mainly construction, tourism and agriculture) and were not free to move to another canton. It is important to note that, after four

consecutive years of seasonal work in Switzerland, seasonal workers could apply for an annual permit. The seasonal permit was abolished in June 2002 with the entry into force of the bilateral agreements with the European Union (EU). Nowadays, Swiss authorities issue more often short-term work permits (duration less than 12 months), particularly for skilled workers. The quotas for short-term workers (as was the case for seasonal workers) are set at both the cantonal and federal levels, depending on the size and economic situation of the canton.

Annual permits have to be renewed every year but, since 1993, the holders of such permits are no longer limited in their mobility between cantons. The population possessing an annual permit is very heterogeneous. Many of these workers are highly skilled but a significant number of mostly unskilled workers have obtained their annual permit by "upgrading" a seasonal permit. Finally, settlement permits are delivered to workers who have stayed in Switzerland for several years (citizens of EU, EFTA, US and Canada: 5 years; other countries: 10 years). This category of workers can therefore be characterized as "old" immigrants. Settled workers have the same economic rights as the Swiss and are free to move from one canton to another.

Finally, cross-border workers must live close to the Swiss border and have to return home every day. Obviously, this population of workers has significantly grown since the signing of the bilateral agreements with the EU. The number of cross-border work permits is not limited by the federal legislation. Each canton bordering a frontier can issue such authorizations.

Turn now to the database we use in the analysis of segregation and wage inequality. The Swiss Wage Structure Survey (SWSS) was launched in 1994 by the Federal Office of Statistics (OFS). The survey is repeated every two years. The SWSS records individual wages within a sample of firms of all industries (including the public sector at the federal level exclusively). The sampling has two levels: at the first level, firms are sampled; and at the second level, individuals employed at these sampled units are also sampled. Concerning firms, the universe to be sampled includes all firms with at least two employees. In 2002, almost 1.1 mio of employees from 42'000 firms were included, representing almost one third of the workforce in Switzerland.

For each worker we know whether he or she is Swiss or not and, if not, the type of work permit he or she holds, his or her age, his or her level of seniority in the firm, educational level and marital status and the number of "normal" hours he or she normally puts into the job[2]. In addition, the level of skill required by the job (4 positions), hereafter the "skill", the hierarchical level, as well as a 24-position variable defining the "activity domain" of the job are given. Finally, the information about the firm comprises: 2- and 4-digit industry codes, total employment, post code and the existence or not of a branch agreement (referred to below as a collective agreement) or of a firm-level agreement.

[2] There is, however, no direct information on overtime worked in October, or on night- and shift-work time.

Our final sample was selected as follows. We use the SWSS data for the year 2002 and exclude public-sector firms, the agricultural sector and firms employing less than 5 workers. We also exclude workers under the age of 20 or over the legal retirement age for men (i.e. 65 years). In the end, once the observations for which information was missing on the variables of interest were excluded, our sample contains 24512 firms and 829'452 workers. Descriptive statistics of main variables are shown in Table A1 in the Appendix. The wage variable we use in the regressions is a full-time equivalent wage rate: the gross monthly earnings linearly standardized at 40 hours per week. For both descriptive statistics and estimations we use individual (probability) weights and the firm's number of identification as cluster.

3 Overview of the decomposition method

In order to analyze the link between segregation at the firm level and wage inequality, we distinguish population groups along two dimensions: skill and nationality. The two-dimensional nature of the analysis enables us to account for the heterogeneity characterizing the group of foreign workers in Switzerland. In this section, we introduce our decomposition method by focusing on the simplified "two-by-two" case where each dimension is characterized by only two alternatives (skilled – unskilled; Swiss – foreign). In the following sections, the method will be expanded to four skill groups and five nationality groups.[3]

In contrast to other studies (Groshen, 1991; Bayard et al., 2003) we are considering segregation as a multigroup phenomenon. In the "two-by-two" case presented in this section, population can be divided into four groups: Swiss skilled, Swiss unskilled, foreign skilled and foreign unskilled workers. Several indices of multigroup segregation have been proposed in the literature (see an overview of these measures in Reardon and Firebaugh, 2002). As we focus on the link between segregation and wage inequality, the use of a single-valued index would, however, be too reductionist in our context.

Instead, we prefer to measure segregation by using a set of "exposure rates" at the firm level. Exposure rates give an intuitive and simple description of the work environment of each individual worker: they measure, from the viewpoint of a representative member of a group, the average composition of his firm's workforce. By using a set of exposure rates rather than a single-valued index, the link between segregation and wage inequality can be specified in a much more flexible way.

Consider first the measurement of segregation. The skill dimension is captured by a dummy variable s_{ij} which takes the value one if individual i in firm j is skilled, and zero otherwise. As to nationality, f_{ij} is a dummy variable indicating whether individual i in firm j is a foreigner. The composition of firm j's workforce in terms of skill and nationality can be described by the following variables:

[3] More precisely, in our data base foreign workers are distinguished by type of work permit.

$\theta_j^f = (1/n_j)\sum_i f_{ij} = f_j / n_j$, the fraction of foreigners in firm *j*'s workforce;

$\theta_j^s = (1/n_j)\sum_i s_{ij} = s_j / n_j$, the fraction of skilled workers in firm *j*'s workforce;

$\theta_j^x = (1/n_j)\sum_i f_{ij} s_{ij} = x_j / n_j$, the fraction of skilled foreigners in firm *j*'s workforce;

where $f_j = \sum_i f_{ij}$, $s_j = \sum_i s_{ij}$, $x_j = \sum_i f_{ij} s_{ij}$ and n_j denotes firm *j*'s total workforce. For later use, we define also the total number of foreign (skilled; foreign skilled) workers: $f = \sum_j f_j$, $s = \sum_j s_j$, and $x = \sum_j x_j$.

Exposure rates can now be defined on the basis of these compositional variables. The exposure rate $e_{m,n}$ measures, in the context of firms, the average exposure of a worker of group *m* to workers belonging to group *n*. Exposure rates are usually defined along a single dimension (e.g. sex, race, nationality, skill). As an illustrative example, we first calculate exposure rates with respect to nationality (Swiss or foreign):

$$e_{foreign,foreign} = \sum_j \sum_i f_{ij} \theta_j^f / f = (1/f)\sum_j f_j^2 / n_j,$$

$$e_{foreign,Swiss} = \sum_j \sum_i f_{ij}(1-\theta_j^f)/f = (1/f)\sum_j f_j (n_j - f_j)/n_j = 1 - e_{foreign,foreign}$$

$$e_{Swiss,foreign} = \sum_j \sum_i (1-f_{ij})\theta_j^f /(n-f) = (1/(n-f))\sum_j f_j (n_j - f_j)/n_j,$$

$$e_{Swiss,Swiss} = 1 - e_{Swiss,foreign}$$

A segregation index can be defined by normalizing the exposure rate of one group to the other (James, 1986):

$$S_{nationality} = 1 - \frac{e_{Swiss,foreign}}{f/n} = 1 - \frac{e_{foreign,Swiss}}{1-(f/n)}, \qquad (1)$$

where the share of foreign workers in population, f/n, can be interpreted as the expected exposure of Swiss workers to foreigners if there were perfect integration. In the case of two population groups, an equivalent definition of the segregation index is based on the "over-exposure" to the own group:

$$S_{nationality} = \frac{e_{foreign,foreign} - (f/n)}{1-(f/n)} = \frac{e_{Swiss,Swiss} - (1-f/n)}{f/n} \qquad (2)$$

Table 1 illustrates the extent of firm-level segregation in Switzerland with respect to nationality. The work environment of Swiss workers is composed, on average, by 78.8 percent Swiss workers; the remaining 21.2 percent are foreign workers. As the share of Swiss

workers in total working population is 70.2 percent, the "over-exposure" of Swiss workers to workers of their own nationality is 8.6 percent and the value of the segregation index is 0.289.

It is instructive to compare these values with segregation measured along the skill dimension. The segregation index calculated from exposure rates in Table 2 indicates that segregation is more pronounced along the skill dimension (0.341) than according to the criterion of nationality (0.289). This analysis can be refined by interacting the skill dimension with the nationality dimension. Table 3 presents exposure rates for the resulting four population groups. James (1986) proposed different generalizations of the segregation index defined in (1) and (2) to the multigroup case. In table 3, we report the index which measures the segregation of one group from all others; it is a straightforward generalization of (2) to the case of several groups. According to this index, segregation is particularly pronounced for the group of unskilled foreigners, as well as for skilled Swiss workers.

Moreover, it seems that unskilled workers tend to be located in the same firms even if they have different nationalities. Indeed, the exposure rate of unskilled Swiss workers to unskilled foreign workers (14.5 percent) is greater than the latter's share in total population (11.8 percent) and the reciprocal exposure rate (15.0 percent) is also greater than the population share of unskilled Swiss workers (12.1 percent).

Turn now to the determination of wages and their link with segregation. We use a wage equation which includes the above defined dummy variables at the individual level and the compositional variables at the firm level:

$$\log w_{ij} = \alpha_0 + \alpha_1 f_{ij} + \alpha_2 s_{ij} + \alpha_3 f_{ij} s_{ij} + \beta_1 \theta_j^f + \beta_2 \theta_j^s + \beta_3 \theta_j^x + \gamma' x_i + \delta' z_j + \varepsilon_{ij}, \qquad (3)$$

where x_i is a vector of individual characteristics (age, age squared, dummy female, dummy never married and interaction terms) and z_j is a vector of other firm characteristics (share of female workers in firm, log-size of the firm). It should be emphasized that this equation allows for the possibility that Swiss and foreign workers face different returns to skill since the individual dummy variables include an interaction term, $f_{ij}\, s_{ij}$. By contrast, the parameters applying to individual demographic characteristics and firm composition variables are constrained to be identical for all groups (this assumption is relaxed in the extensions of the model). Together with z_j, the variables θ_j^f, θ_j^s and θ_j^x give a detailed description of the composition of firm j's workforce.

In order to illustrate our decomposition method in the simple two-by-two case, we estimate equation (3) by OLS. One might be worried by the fact that omitted firm-level variables could induce biased estimates of the individual coefficients α_i. It can be shown that by including the means by firm of all three individual dummy variables, the α_i are estimated without bias (see Skrondal and Rabe-Hesketh, 2004, p. 52).

The difference between the average log-wages of two groups *m* and *n* can be decomposed as follows:

$$\log \bar{w}_m - \log \bar{w}_n = \sum_k \hat{\alpha}_k (\bar{d}_{m,k} - \bar{d}_{n,k}) + \sum_p \hat{b}_p (e_{m,p} - e_{n,p}) + \hat{\gamma}'(\bar{x}_m - \bar{x}_n) + \hat{\delta}'(\bar{z}_m - \bar{z}_n), \qquad (4)$$

where $\bar{x}_m$ and $\bar{z}_m$ are the averages of variables *x* and *z* in group *m*, $\bar{d}_{m,k}$ is a generic notation for the group averages of individual dummy variables (f_{ij}, s_{ij} and the interaction term $f_{ij}s_{ij}$), $e_{m,p}$ denotes the exposure rate of group *m* to group *p* and a hat indicates estimates by OLS.[4]

Equation (4) can be interpreted as an extended Oaxaca (1973) decomposition, with the coefficients on demographic variables (but not on skill) constrained to be identical for all groups.

The first term on the right hand side of (4) includes the individual effects of nationality and skill. In general, this term includes two different effects which are familiar from the traditional Oaxaca decomposition:[5] (i) the estimated effect of the difference in average skill between the two groups; (ii) the unexplained part of the wage difference which reflects differences in returns to skill between Swiss and foreign workers and which is possibly due to discrimination or to group differences in unobserved characteristics.[6] One or the other of these effects might be zero, depending on which groups are compared. For example, if unskilled Swiss workers are compared with unskilled foreigners, the first term on the right hand side of (4) reduces to $-\hat{\alpha}_1$ which can be interpreted as the unexplained part of the wage difference. Table 4 (second panel, column I) shows that this term represents more than half of the mean wage differential (which is equal to 8.4 log points). If the wage comparison is carried out for skilled workers, the first term on the right hand side of (4) is equal to $-\hat{\alpha}_1 - \hat{\alpha}_3$. In this case, almost the entire wage difference between Swiss and foreign skilled workers (equal to 7.9 log points) remains unexplained.

The interpretation of the first term on the right hand side of (4) is different if two groups of the same nationality are compared. For example, if mean wages of skilled and unskilled workers of Swiss nationality are compared, the first term on the right hand side of (4) is equal to $\hat{\alpha}_2$, capturing the contribution of skill differences (more than 70 percent) to the mean log-wage differential of 0.371. The preceding examples make clear that the first term on the right hand side of (4) captures both the "endowment" and the "discrimination" components of the

[4] Note that the average residual is zero for all four population groups as the estimation method is OLS and the model contains dummy variables for all population groups.

[5] In general, the distinction between the two first effects can only be made explicit if a reference group is chosen. For an extensive discussion of this issue see Oaxaca and Ransom (1994). Here we choose the majority group (Swiss workers) as the reference unless otherwise indicated.

[6] In the context of immigration, this second term might in particular reflect unobserved differences in education quality. In our setting, this bias is likely to be rather small since skill is measured by a variable describing the required skill level for the job.

traditional Oaxaca decomposition if the mean wages of two groups of different skill and nationality composition are compared. As Table 4 shows, the endowment effect accounts for 37 percent and the discrimination (or "unexplained") component for 36 percent of the mean log-wage differential between Swiss and foreign workers.

The impact of firm-level segregation on wage differences is captured by the second term on the right hand side of (4). This term is a weighted sum of the differences in exposure rates of the two groups being compared (i.e. the rows in Table 3). The estimated weights $\hat{b}_p$ are linear combinations of the coefficients $\hat{\beta}_k$ in the wage regression and are reported in the last row of Table 3.[7] According to these estimates, workers in firms with a high share of foreign unskilled workers are highly disadvantaged in terms of wages, especially in comparison to individuals working in firms with a high share of skilled foreign workers. The exposure rates given in the last column of Table 3 indicate that foreign unskilled workers are likely to experience the most important wage losses due to their work environment. Indeed, the exposure rate of unskilled foreign workers to workers of their own group is 25.7 percentage points higher than their share in population. For this group of workers, segregation at the firm level translates (with an estimated $\hat{b}_{unskilled,\,foreign}$ equal to -0.257) into a wage loss of 6.6 log points. This simple calculation can be refined by calculating the decomposition given in Table 4. Of the total wage differential between Swiss and foreign unskilled workers, amounting to 8.4 log points, almost three quarters can be explained by firm-level segregation.

The contribution of segregation to the wage differential between skilled Swiss and skilled foreign workers turns out to be much smaller: only about one fifth of the wage differential is explained by segregation. This result should, however, be taken with a grain of salt because the category of "skilled" workers is an aggregate of three different skill levels. As the more detailed analysis carried out in the next section will make clear, segregation accounts for an important fraction of wage differentials between equally skilled Swiss and foreign workers.

When evaluating wage differentials by skill (see column II of Table 4), the contribution of segregation seems to be rather modest in relative terms, especially for Swiss workers.

4 Segregation by skill and by work permit

In this section we apply the approach outlined in Section 3 to a more detailed breakdown of skill levels and of the immigration status (work permits). For each employee, employers were

[7] Because of the linear dependence of exposure rates, these coefficients must be normalized. Setting $\hat{b}_{Swiss,unskilled} = c$ yields $\hat{b}_{Swiss,skilled} = \hat{\beta}_2 + c$, $\hat{b}_{foreign,skilled} = \hat{\beta}_1 + \hat{\beta}_2 + \hat{\beta}_3 + c$, and $\hat{b}_{foreign,unskilled} = \hat{\beta}_1 + c$. In table 3, c is chosen in such a way that the population-weighted sum of the b coefficients is zero.

asked to define the skill level required for the job. The four skill levels are defined as follows:[8]

- skill 1: job involving the most demanding and most difficult tasks ;
- skill 2: job requiring independent and qualified work ;
- skill 3: job requiring specialized professional knowledge ;
- skill 4: job involving simple and repetitive tasks.

Our database does not provide any information on the workers' nationality. However, we are able to distinguish foreign workers by work permit. This distinction enables us to analyze the impact of different types of migration. Foreigners with seasonal or short-term permits (permit A) can be considered as temporary migrants. In contrast, holders of settlement permits (permit C) can be seen as permanent immigrants because these permits are granted only after five or ten years of uninterrupted stay in Switzerland. Annual permits (permit B) are held by recently arrived immigrants; this category might include both temporary and permanent immigrants. The category of cross-border workers (permit G) differs from the others by the fact that these workers are hired only in regions close to the border. These permits are handled by authorities in a quite flexible way.

Firm-level segregation is particularly strong for cross-border workers and seasonal/short-term permits (see segregation indicators in Table 5). Although the skill profile of cross-border workers is similar to the skill structure of Swiss workers (see Table A1), there is a large fraction of firms (75 percent in our sample) who do not hire any of these workers, obviously for geographical reasons. Seasonal and short-term workers are hired predominantly in certain sectors, implying that more than 87 percent of firms in our sample do not employ any of these, largely unskilled, workers. Settled workers have a similar skill profile, but they are distributed much more evenly among firms: only 34 percent of firms do not employ any of them. The James (1986) index of segregation is even lower for annual permits than for settlement permits. This is probably due to the fact that both ends of the skill distribution are well represented in this category of recently arrived immigrants who occupy jobs in very different types of firms.

The heterogeneity of the category of annual permits – including temporary and permanent immigrants – is also reflected by the exposure rates to other foreign worker categories. In particular, the exposure rate of annual workers to seasonal and short-term workers (4 percent), on the one hand, and to settled workers (22 percent), on the other hand, is higher than the average population share of the two latter groups. Turning to segregation by skill (see Table 6), a similar close link exists between the two most highly skilled population groups. More generally, the degree of segregation, as measured by James' (1986) index, seems to diminish with skill.

[8] Note that in the aggregated version of the model presented above, "unskilled" corresponds to "skill 4" and the "skilled" category is an aggregation of skill levels 1 to 3.

Before turning to the analysis of the impact of firm-level segregation on wage inequality, it is useful to take a closer look at the interaction between segregation by skill and by work permit. Here the approach proposed by Bayer et al. (2004) turns out to be useful. They notice that exposure rates can be calculated by regressing the fraction θ_j^p of workers of type p in a worker's firm on individual dummy variables characterizing the worker's type. For example, the first column of Table 5 can be obtained by regressing the fraction of Swiss workers in an individual's firm on a set of dummy variables characterizing nationality and work permits (omitting the constant term). Besides being a convenient way of calculating standard errors, this method can be usefully extended by including other explanatory variables in the regression.[9]

We use this approach to explore first the influence of skill on segregation by nationality or work permit. Table 7 shows the marginal impact of skill on the exposure of workers of a certain nationality (work permit) to other workers of the same nationality (work permit).[10] The first column of Table 7 indicates that unskilled Swiss individuals work in firms with 3.7 percentage points less Swiss workers than Swiss workers with specialized professional knowledge ("skill 3", the reference in the regression). For Swiss workers, the other skill categories do not have a marked influence on the exposure rates to other Swiss workers. For foreign workers, the effect of skill on segregation is much more pronounced. In the case of settled workers and cross-border workers, a clear pattern emerges: the exposure of these workers to other workers of their group is strongly decreasing with skill. For highly skilled foreigners with a settlement permit, the exposure to other settled foreign workers is 12.5 percentage points lower than for unskilled foreign workers with a settlement permit. Recently arrived immigrants (with annual permits) show a rather different pattern: the highest exposure rates to workers of their own type are measured at both extremes of the skill distribution. In other words, not only unskilled foreigners tend to work predominantly with other foreigners, but also highly skilled immigrants (with annual permits) tend to work with other foreigners.

The analysis can be refined by taking the opposite perspective, analyzing the influence of work permits on segregation by skill (see Table 8). Segregation by skill seems to be more pronounced for foreign workers, especially for recently arrived immigrants (holding annual or short-term permits). This holds true both for highly skilled and unskilled workers, but not for jobs requiring specialized professional knowledge (Skill 3) where most Swiss workers are located. For example, unskilled foreign workers holding an annual permit work in firms with 7.5 percentage points more unskilled workers than unskilled Swiss workers (the reference category). Conversely, the work environment of highly skilled foreign workers with an annual permit is characterized by a 9.0 percentage points greater share of highly skilled workers than the work environment of highly skilled Swiss workers.

[9] Bayer et al. (2004) develop this approach in order to analyze neighborhood segregation patterns in the San Francisco Bay Area.

[10] These "own-group" exposure rates can be estimated by running separate regressions for each group. This is the approach taken in Tables 7 and 8.

These results point to the existence of two very different types of firms employing mostly foreign workers. On the one hand, some firms hire predominantly unskilled foreign workers, on the other hand, there are firms that employ a great share of highly skilled foreign workers who have been recruited recently, possibly as a consequence of the bilateral agreements with the EU. Whether these firms pay different wages than other firms is the question we turn to now.

5 Wage inequality and segregation

In this section, we explore the link between segregation and wage inequality in more detail. By taking all four skill levels into account, we are able to analyze the roles of the unskilled and the truly high-skilled individuals. The disaggregation by work permit enables us to distinguish in particular between "old" immigrants (with settlement permits) and "new" immigrants (with annual permits) and to analyze the specific role of cross-border workers and workers with short-term/seasonal permits. We modify equation (3) by replacing the three individual dummy variables (nationality, skill) by a set of dummy variables describing the four levels of skill and the five categories of nationality/ work permit. Possible links between skill and nationality are captured by a full set of interaction dummies. Similarly, the three variables describing the composition of the workforce are replaced by share variables capturing the structure of each firm's workforce in terms of all skills and work permits (and their interactions). Moreover, we add sectoral dummy variables in order to account for unobserved factors at the sector level.[11] Together with the same set of demographic variables as in the "two-by-two" case, this forms our basic wage equation.

In the estimation of the wage equation, we have to account for the possibility that our firm-level variables do not include all relevant information that helps to explain wage differences between firms. In the presence of unobserved factors at the firm level, the parameters associated with individual characteristics can be estimated consistently if firm fixed effects are included in the regression. Unfortunately, it is impossible to include in the same equation firm fixed effects and variables that are defined at the firm level. As our main focus is on estimating the impact of workforce composition variables on wage differences, we use two approaches, each one having its advantages and disadvantages.[12]

One possibility (labeled Model I) is to adopt a two-step estimation procedure, as suggested by Hsiao (2003, p.52).[13] First, we regress the log-wage on individual variables and firm

[11] As every firm belongs to one sector, there is a problem of collinearity between sectoral dummies and variables capturing the composition of a firm's workforce. For a detailed discussion of how we address this issue, see section 5.4 below.
[12] Because of data limitations, we are not able to account for the possibility of endogenous sorting. Therefore our empirical results should be interpreted in a descriptive manner; they do not necessarily reflect a causal link between segregation and wage inequality. See the Conclusion for some more discussion on this issue.
[13] For applications of this approach, see Kramarz et al. (1996) and Ramirez (2000).

dummies. In a second step, we regress the firm fixed effects on the firm-level variables and on dummy variables capturing sectors at the two-digit level. As mentioned above, the advantage of this estimation procedure is that coefficients of individual characteristics are consistently estimated. The disadvantage is that standard errors of the second-step estimates should be corrected because the dependent variable in the second-step regression is generated.[14]

Another possibility (Model II), following Wooldridge (2002, p.331), is to estimate the complete wage equation by pooled OLS and to adjust standard errors for clustering at the firm level. This procedure allows also consistent estimation of the effects of both individual characteristics and workforce composition variables. As it turns out, the two approaches yield very similar results for the entire sample (see Table A2 in the appendix). For practical purposes, the estimates of the effects of skill and nationality/work permit are undistinguishable in the two approaches, both at the individual and at the firm level. Moreover, the estimated standard errors of the coefficients of firm-level variables are almost identical.[15] We are therefore confident that our decomposition of wage differences along the dimensions of skill and nationality / work permit does not depend on the estimation method.

5.1 Wage effects of individual characteristics

We discuss first the wage effects of individual characteristics. A first glance at the coefficients of the individual interaction terms (Table A2, upper panel) reveals that the return to skill is slightly higher for foreigners with annual and settlement permits than for Swiss workers. A similar pattern seems to hold for the composition of the workforce (Table A2, lower panel): whereas a large fraction of highly skilled foreign workers in a firm is beneficial for the wages of all their colleagues, a large share of unskilled foreign workers in a firm exercises downward pressure on all wages paid by the firm.

It is instructive to compare these results with those of a simple model without firm-level variables (Model III). The model's adjustment to the data deteriorates markedly since it explains only 48.8 percent of the total variance (compared to 75.0 percent in the first stage of Model I, and 59.5 percent in Model II). The omission of firm-level variables yields biased estimates of the contribution of individual characteristics to wage inequality. Figure A1 in the Appendix uses the estimated coefficients of individual characteristics in Models I and III in order to compare the wage effects of skill for Swiss workers and the two main categories of foreign workers (with annual and settlement permits). According to Model III, the individual return to skill is more pronounced for foreign workers with settlement permits than for Swiss workers, and even greater for the more recently arrived workers with annual permits. Model III estimates that the log-wage differential between the lowest and highest skill is equal to

[14] Because of the large size of our sample, we are unable to carry out the correction suggested by Dumont et al. (2005). However, the comparison of our two estimation methods suggests that this correction would not matter much in our context (see below), presumably because of the large sample size.

[15] The only noticeable difference between the two approaches concerns the effects of gender and civil status. In this context, our first approach yields better results since the use of firm fixed effects can be interpreted as a non parametric specification of firm-level segregation.

0.743 for Swiss workers, 0.882 for settled workers and 1.047 for workers with annual permits. By contrast, the differences in individual returns to skill are greatly attenuated in Model I which takes firm-level variables into account: the log-wage differentials between the lowest and the highest skill are 0.732 for Swiss workers, 0.774 for settled workers and 0.804 for workers with annual permits. These results suggest that firm-level segregation plays an important role in the explanation of these differences.

5.2 Wage effects of segregation and workforce composition

In order to get a clearer idea of the impact of segregation on wages, we calculate the "marginal" effect of changing the work environment of an individual. The underlying idea is the following. The typical work environment of, e.g., a foreign unskilled worker with an annual permit is characterized by a large share of unskilled foreign co-workers and a relatively small share of skilled Swiss co-workers. Individuals (of any skill and any nationality) who work in such an environment receive lower wages than people who work in an "average" work environment. To evaluate precisely this effect, we calculate, for each skill-nationality group, the "marginal" effect on log-wages of moving from the work environment of the average worker in the economy to the work environment of an average member of that specific group.[16] In this calculation, the "over-exposure" of workers to other members of their group plays quantitatively an important role.

An example will illustrate the procedure. Unskilled annual workers represent 2.0 percent of the total workforce in our sample. In the typical work environment of these workers, the share of members of their own group is 16.2 percent and over-exposure is therefore equal to 14.2 percentage points. According to the estimates in Table A2, this over-exposure reduces log-wages by 6.9 log points. The change in exposure rates of unskilled annual workers to other groups moderates this effect slightly, leading to a total log-wage reduction of 6.6 log points.

Figure 1 illustrates these effects for the three main population groups and all skill levels, using the estimates of Model I. A clear pattern emerges. On the one hand, individuals who work in the typical work environment of an unskilled foreign worker receive lower wages than those who work in the average environment.[17] On the other hand, workers who hold jobs in a work environment that is similar to the environment of a highly skilled foreigner are paid higher wages. These effects are stronger for recently arrived migrants (holding annual permits) than for settled foreign workers and are quantitatively important. The typical work environment of a highly skilled annual worker offers a 12.7 log points higher log-wage than the average work environment whereas the work environment of an unskilled annual worker is characterized by a negative wage differential of more than 10 log points. Interestingly, the structure of the Swiss workforce in a firm has relatively little influence on wages.

[16] To carry out this calculation, we compute exposure rates of all skill-nationality/work permit groups to each other (20 by 20 matrix of exposure rates).

[17] As the work environment of an individual is characterized mainly by "over-exposure" to members of his own skill-nationality group, this implies, more simply stated, that firms with a high fraction of unskilled foreign workers pay lower wages than the average firm.

Before we turn to a more systematic decomposition of wage differentials, it is useful to check whether the results obtained so far depend on the assumption that the wage impact of segregation on natives and immigrants is identical. This assumption can be relaxed by estimating the wage equation separately for Swiss and for foreign workers, allowing for a differential impact of the demographic and the workforce composition variables. Figure 2 shows the marginal impact of segregation on wages of Swiss workers; Figure 3 does the same for foreign workers. Interestingly, Swiss workers benefit more than foreigners from working in a professional environment that is typical for highly skilled foreigners. This result suggests that a "quality sorting" argument is probably not the only explanation of this phenomenon. By contrast, the typical work environment of an unskilled foreigner is associated with similar reductions in wages for Swiss and foreign workers.

5.3 Decomposition of wage differentials between skill-nationality groups

A more complete account of the relative importance of individual characteristics and segregation at the firm level can be obtained by decomposing the average log-wage differentials between skill-nationality groups. The differences in average wages of Swiss and foreign workers, differentiated by work permit, are given in the lower part of Table 9. Total log-wage differentials between Swiss workers and different categories of foreign workers vary between 9.0 log points (cross-border workers) and 30.5 log points (seasonal / short-term permits). Observed skill differences explain the greatest share (36 to 59 percent) of the wage differentials. Firm-level segregation, as measured by the composition of the workforce, accounts for 23 to 36 percent of these differences in average wages. Except for border workers, segregation represents a more important share of wage differentials than the Oaxaca/Blinder term (which accounts for 14 to 22 percent of wage differentials for permits A to C, and 45 percent for border workers). Although this aggregate decomposition analysis is useful as a benchmark, only a more disaggregated analysis is able to reveal interesting structural features of the data.

As a first step towards a more disaggregated analysis, we calculate Swiss-foreign wage differentials at different skill levels (see upper part of Table 9). These numbers reveal that highly skilled foreigners with annual or settlement permits earn on average higher wages than comparatively skilled Swiss workers. Interestingly, the composition of the firms' workforce explains 84 to 99 percent of the wage differential between highly skilled workers of different nationality. If foreign workers had the same demographic characteristics as Swiss workers, the estimated wage equation would predict their wages to be lower: this explains the negative contribution of demographic variables to the wage differential. The unexplained "Oaxaca-Blinder" part of the wage differential accounts for respectively 11 percent (settled workers) and 30 percent (annual workers) of the wage differential. This latter term most likely reflects unobserved skill differences between Swiss and foreign workers.

At the other end of the skill distribution, the wage differential – which is always in favor of Swiss workers – is also explained primarily by segregation. Indeed, unskilled Swiss workers

earn 6–18 log points higher log-wages than foreigners, and at least 60 percent of this differential can be attributed to the composition of the firm's workforce. Moreover, differences in firm size explain another 8 to 18 percent of the wage difference which indicates that foreign unskilled workers are in smaller firms than Swiss unskilled workers. The unexplained part of the wage differential, reflecting unobserved differences in skill or discrimination, accounts for 24 to 64 percent of the wage differential (corresponding to 2.8–4.5 log points of the log-wage differential).

Consider now wage differences between different skill levels. Our analysis of segregation revealed that segregation is stronger along the dimension of skill than along the dimension of nationality. For Swiss workers, firm-level segregation by skill does not seem to have important consequences in terms of wages. The first part of Table 10 shows that the composition of a firm's workforce does not contribute to the explanation of the differences in wages between the three highest skill categories. Only unskilled Swiss workers receive slightly lower wages because of firm-level segregation. Closer inspection of exposure rates and of the estimates of the wage equation reveals that this effect is mainly due to the presence of a high fraction of foreign (rather than Swiss) unskilled workers in their firms.

This latter interpretation is confirmed by the fact that the wage gap between skilled and unskilled workers is greater for foreign than for Swiss workers (see Table 10). Interestingly, the fact that the skill wage gap is greater for foreigners can be almost entirely attributed to firm-level variables. For example, the log-wage difference between skill levels 1 and 3 (the reference category), on the one hand, and skill levels 3 and 4, on the other hand, is greater for annual workers (respectively 0.85 and 0.29) than for Swiss workers (0.65 and 0.22). Segregation, as measured by the composition of a firm's workforce, explains almost the entire difference between Swiss and foreign skill wage gaps.

From these decompositions, a more complete picture emerges of the role of firm-level segregation in the explanation of wage inequality between Swiss and foreign workers. Firms with a large share of foreign skilled workers tend to pay higher wages to all their employees, whereas the opposite holds for firms with a large proportion of foreign unskilled workers. As a consequence, segregation at the firm level accounts for almost the entire wage differential between identically skilled Swiss and foreign workers. Moreover, the difference between foreign and Swiss skill wage gaps can also be explained by firm-level segregation.

5.4 Sectoral wage differentials and segregation

To explore further the role of firm-level segregation, we turn now to the analysis of sectoral wage differentials. The literature has documented large and persistent wage differentials between economic sectors. In our context, it is interesting to see to what extent these wage differentials can be explained by the composition of a firm's workforce. This analysis also sheds some light on the sectoral identity of low-wage and high-wage firms. Before we turn to these questions, it is useful to describe our treatment of sectoral variables.

As every firm belongs to one sector, there is a problem of collinearity between our firm composition variables and sectoral dummies. We want to avoid that part of the firm composition effects are captured by the sectoral dummy variables in our wage regression. Therefore we decompose the sectoral dummies into two components: a first component that can be explained by firm composition variables and a second component which is orthogonal to the firm composition variables.[18] It is the latter component that is added to our (second-step) wage equation instead of the original dummy variables. This procedure ensures that the transformed variables capture only sectoral effects that are not correlated with the composition of a firm's workforce.

Sectoral wage differentials at the two-digit level and the role of firm-composition variables are depicted in Figure 4. The vertical axis shows the estimated sectoral wage differentials and the horizontal axis depicts the wage differentials that are predicted by firm-level variables. More precisely, sectoral log-wage differentials are calculated by averaging over sectors the firm fixed effects obtained in the first step of Model I (they are shown on the y-axis of Figure 4). To capture the role of firm composition, we run a regression of firm fixed effects on all firm level variables (firm composition, size of the firm, without sectoral dummies). The sectoral averages of the predicted log-wages are depicted on the horizontal axis of Figure 4.

At first glance, firm-level variables seem to predict sectoral wage differentials quite well.[19] Low-wage firms can be found in services (55: *Hotels and restaurants*) and in industry (17: *Textile*, 18: *Wearing apparel*, 19: *Leather*). *Hotels and restaurants* cumulate several unfavorable characteristics: the share of unskilled seasonal and annual workers is high and firms are small. In the *Wearing apparel* industry, there is not only a high share of annual and cross-border workers but also a high share of female employees. At the other extreme, there are high-wage firms in sectors such as *Post and telecommunications* (64), *Financial intermediation* (65) and their *auxiliaries* (67), and *Manufacturing of tobacco products* (16). Whereas the firm-level variables predict high wages for the two former sectors (because of the structure of the workforce and the predominance of large firms), this is not the case for the two latter sectors, mainly because of the much smaller average firm size (67) and the mainly unskilled workforce (16). A plausible explanation of the high wages paid in *Manufacturing of tobacco products* might be compensatory differences.

5.5 Robustness tests

The observed pattern of segregation and wage inequality could be consistent with two types of explanations. On the one hand, it is possible that firms choose their employees on the basis of unobserved (by the analyst) productivity characteristics. If this is the case, the variables capturing a firm's workforce composition are "proxies" of the workers' unobserved

[18] Technically speaking, the second component is obtained as the residuals of a linear regression of each sectoral dummy variable on all firm composition variables.

[19] In a weighted regression of firm fixed effects (sectoral averages) on the predicted firm-level fixed effects (sectoral averages), the R^2 is equal to 0.50.

characteristics. Our results could also be consistent with another view which sees the labor market as being segmented, with rationing of high-wage jobs because of frictions in the labor market. The data at our disposal do not enable us to discriminate clearly between these two views. However, it is possible to test the validity of the first view by following the procedure proposed by Hirsch and Macpherson (2004).

The "quality sorting" explanation given by Hirsch and Macpherson (2004) in their analysis of the black-white wage gap in the US relies on the assumption that the proportion of black workers in a job is correlated with observed and unobserved productivity of workers.[20] In our context, the "quality sorting" hypothesis could be interpreted as follows. Highly skilled foreign and Swiss workers are sorted into firms that employ a large proportion of highly skilled foreigners but the correlation between this proportion and wages does not reflect a causal relationship. According to the quality sorting hypothesis, the share of highly skilled foreigners is simply an indicator of the unobserved skills of the firm's employees.

If this hypothesis is correct, the introduction of job characteristics in the wage equation should diminish the effect of firm-level variables since job characteristics are presumably correlated with unobserved characteristics of workers. In order to check this hypothesis, we add three sets of dummy variables to the wage equation: (i) variables describing the occupation of the worker (our data base includes a two-digit classification of occupations); (ii) variables describing the hierarchical position of the employee (5 positions); (iii) variables describing the type of collective agreement.

Figure A2 in the Appendix summarizes the results for the two main groups of foreign workers. Both for annual and settled workers, the introduction of job characteristics lowers the effect of segregation on wage inequality, but not drastically. At the lower end of the skill distribution, the effect of segregation is reduced by respectively one half (settled workers) and one third (annual workers). This result suggests that the low wages paid by firms with a large share of foreign unskilled workers can in part be explained by the fact that they hire mostly workers with a low level of unobserved skills. At the other end of the skill spectrum, the introduction of job characteristics in the wage equation hardly reduces the effect of segregation. Therefore, the quality sorting explanation does not find much support for highly skilled foreigners.

6 Summary and conclusions

In this paper, we analyze segregation at the firm level between native and immigrant workers in Switzerland and explore the link between segregation and wage inequality. We argue that in the Swiss context it is crucial to measure segregation along the two dimensions of skill and nationality. To take the multidimensional aspect of segregation into account we use exposure rates – a concept borrowed from the literature on residential segregation – in order to analyze

[20] By contrast to our analysis of segregation at the level of the firm, Hirsch and Macpherson (2004) consider segregation by industry-occupation-region groups ("jobs").

segregation between Swiss and foreign workers of different skill levels. Exposure rates are an intuitively appealing concept and can be easily incorporated in the analysis of wage inequality. We propose a simple decomposition method which allows to evaluate the role of segregation in the explanation of wage inequality between Swiss and foreign workers.

In a first step, we calculate exposure rates by nationality and by skill and we analyze interaction effects between these two dimensions, using a regression method proposed by Bayer et al. (2004). Our results show that there is segregation both along the skill and the nationality dimensions and that the most segregated groups can be found among recently arrived foreign workers at both extremes of the skill distribution. This result points to the existence of two types of firms which reflect the recent evolution of Swiss immigration policy. On the one hand, some firms follow the traditional guest-worker strategy and hire mostly unskilled foreign workers. On the other hand, there are firms that benefit from the recent bilateral agreements with the EU by employing a great number of highly skilled foreign specialists.

The second step of our analysis relates firm-level segregation to wage inequality between natives and immigrants. We estimate wage equations that account for the composition (in terms of skill and nationality) of the firm's workforce to which an individual belongs. On the basis of these wage equations, we propose a simple decomposition method which relates differences in average wages between skill-nationality groups to the exposure rates of these groups to other groups in the workforce. It turns out that the skill composition of firms does not explain a significant share of wage differences between individuals of different skill. However, there are important interaction effects at the firm level between skill and nationality. On the one hand, firms with a great share of unskilled foreign workers pay lower wages to all their employees (whether they are Swiss or immigrants). On the other hand, those firms that employ a large share of highly skilled foreign workers with an annual or settlement permit pay higher wages to all their workers. These effects are significant both from a statistical and an economic viewpoint. Highly skilled foreign workers with an annual permit earn on average 13 percent higher wages than highly skilled Swiss workers and this difference is almost entirely explained by the difference in work environments of these workers (i.e., firm-level segregation). By contrast, unskilled foreign workers get paid lower wages, on average, than unskilled Swiss workers (15 percent for recently arrived workers with annual permits, 6 percent for settled workers). Two thirds of these differences in mean wages are explained by segregation at the firm level.

From a theoretical viewpoint, our descriptive evidence is difficult to reconcile with an explanation of taste-based discrimination (Becker, 1957) since both foreign and Swiss workers receive lower wages if they work in a firm with a high share of low-skill foreign workers. Moreover, the fact that highly skilled foreign workers are paid higher wages than highly skilled Swiss workers is also at odds with this theory. Our results could either be consistent with a "quality sorting" explanation or with the existence of rationing of high-wage jobs in an imperfectly competitive labor market. In our data, we find some support for the first

view, but only at the lower end of the (measured) skill spectrum. One interpretation of our results is that unskilled workers with low unmeasured skills tend to be hired in specific firms and that unskilled foreigners have lower unmeasured skills, on average, than unskilled Swiss workers, perhaps because of lacking language proficiency. For highly skilled employees, we do not find evidence for such a “quality-sorting” effect. Due to the limitations of our data, we would like to emphasize that these conclusions can only be tentative and that further research is warranted in this area.

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Appendix

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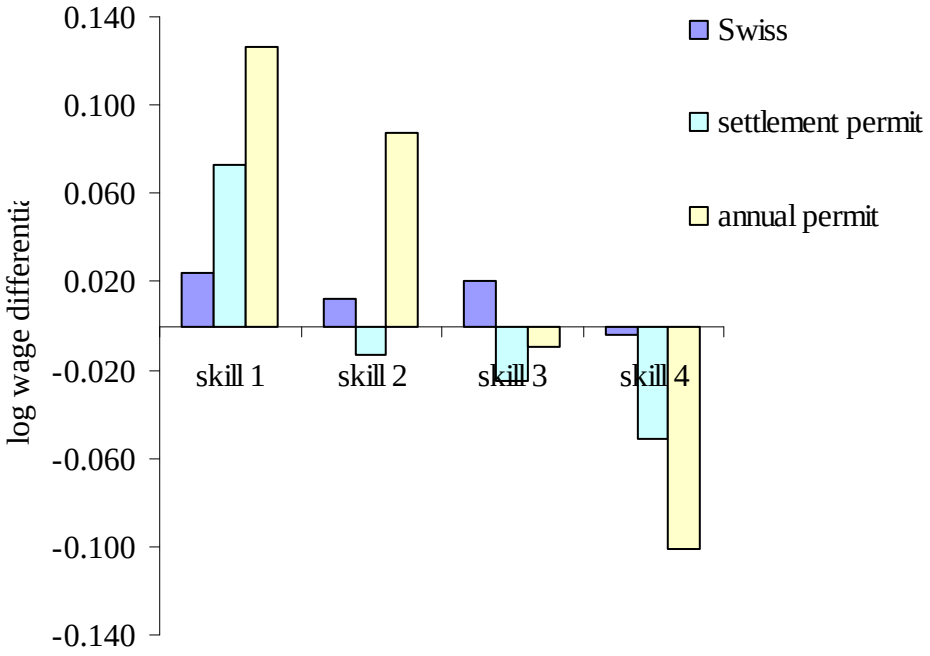
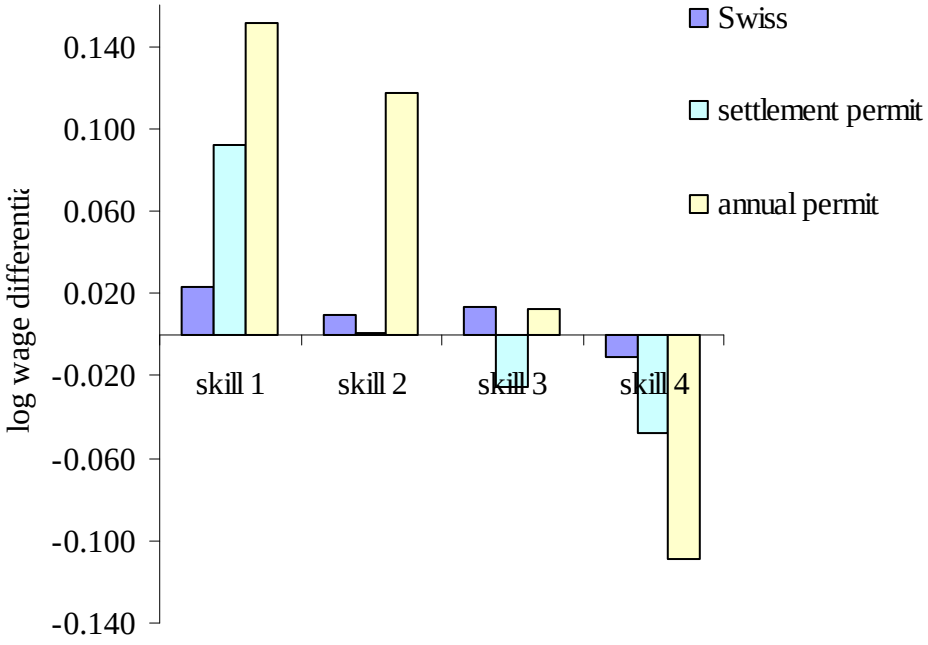
Figures

Figure 1: Wage effects of firm-level segregation (by work permit and by skill)



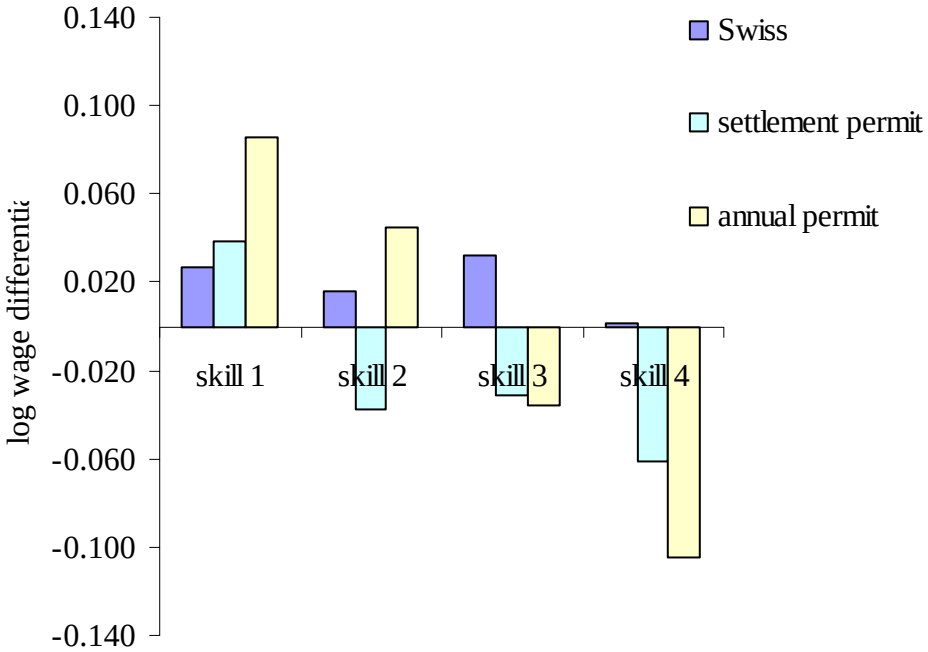
Note: This figure depicts the "marginal" effect on log-wages of moving from the work environment of the average worker in the economy to the work environment of an average member of a specific skill-nationality (work permit) group. Marginal effects are calculated using exposure rates by skill-nationality group and estimates of the wage equation (second stage of Model I) for all workers, Swiss and foreign.

Figure 2: Wage effects of firm-level segregation for Swiss workers (by work permit and by skill)



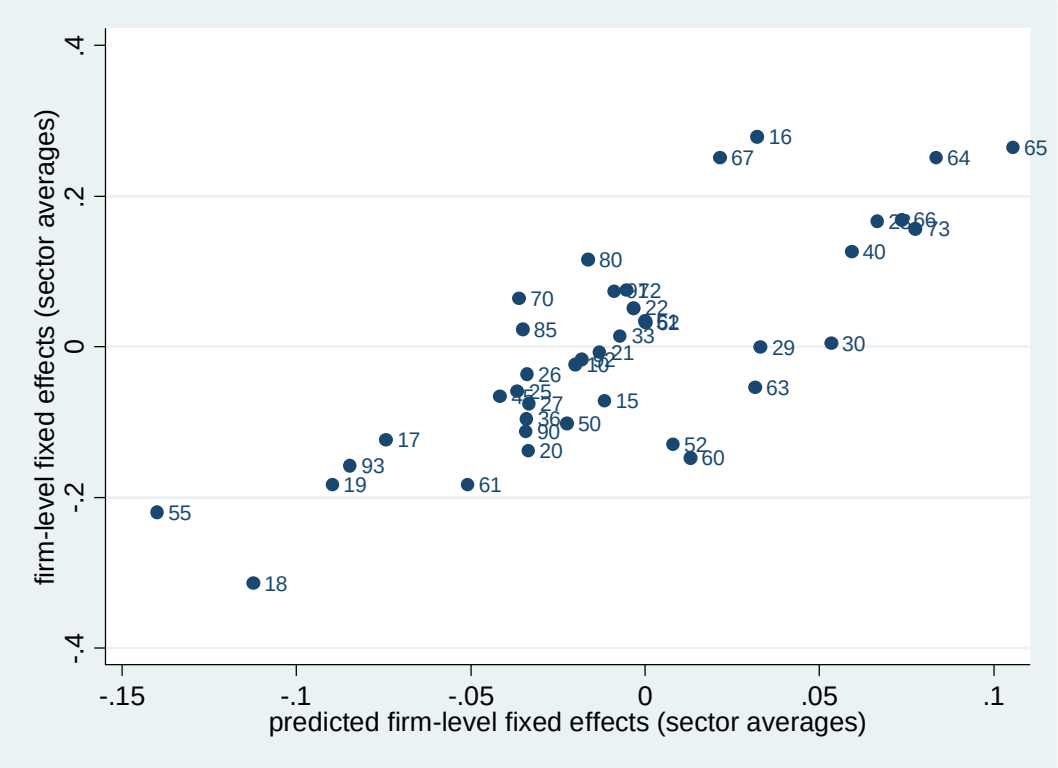
Note: See Figure 1 for details. Marginal effects are calculated using exposure rates by skill-nationality group and estimates of the wage equation (second stage of Model I) for Swiss workers only.

Figure 3: Wage effects of firm-level segregation for foreign workers (by work permit and by skill)



Note: See Figure 1 for details. Marginal effects are calculated using exposure rates by skill-nationality group and estimates of the wage equation (second stage of Model I) for foreign workers only.

Figure 4: Sectoral wage differences and composition of firms' workforce



Note: Labels in the graph refer to the two-digit NOGA classification. On the y-axis, we plot sectoral averages of firm-level fixed effects (as estimated in the first stage of model 1 in Table A2). On the x-axis, we plot sectoral averages of firm-level effects that are "predicted" by variables capturing the composition of the firms' workforce (predictions are obtained from the estimation of the second-stage of model 1 in Table A2).

Tables

Table 1: Exposure rates by nationality (Switzerland, 2002)

	Average composition of firms	
	Share Swiss	Share foreigners
Swiss	0.788 (0.006)	0.212 (0.006)
Foreigner	0.499 (0.007)	0.501 (0.007)
Overall composition	0.702	0.298
	Swiss	Foreigners
Over-exposure to own group	0.086	0.203
James' index	0.289	0.289

Note : . Standard errors (in parentheses) are adjusted for clustering at the firm level.

Table 2: Exposure rates by skill (Switzerland, 2002)

	Average composition of firms	
	Share skilled	Share unskilled
Skilled	0.843 (0.007)	0.157 (0.007)
Unskilled	0.501 (0.009)	0.499 (0.009)
Overall composition	0.761	0.239
	Skilled	Unskilled
Over-exposure to own group	0.082	0.260
James' index	0.341	0.341

Note : Standard errors (in parentheses) are adjusted for clustering at the firm level.

Table 3: Exposure rates by skill and by nationality (Switzerland, 2002)

	Average composition of firms			
	Share Swiss skilled	Share Swiss unskilled	Share foreigners skilled	Share foreigners unskilled
Swiss skilled	0.705 (0.009)	0.089 (0.005)	0.142 (0.004)	0.063 (0.003)
Swiss unskilled	0.427 (0.011)	0.329 (0.009)	0.099 (0.004)	0.145 (0.005)
Foreigner skilled	0.457 (0.008)	0.066 (0.005)	0.369 (0.008)	0.107 (0.003)
Foreigner unskilled	0.312 (0.007)	0.150 (0.008)	0.165 (0.004)	0.374 (0.012)
Overall composition	0.581	0.121	0.180	0.118
	Swiss skilled	Swiss unskilled	Foreigners skilled	Foreigners unskilled
Over-exposure to own group	0.125	0.208	0.188	0.257
Segregation index (James)	0.298	0.237	0.230	0.291
$\hat{b}_p$	0.059	-0.012	-0.013	-0.257

Note : Standard errors (in parentheses) are adjusted for clustering at the firm level.

Table 4: Decomposition of wage differentials by nationality and by skill

Wage differential:	(I) Swiss-Foreigners	(II) Skilled-Unskilled
Sub-sample:	**Skilled**	**Swiss**
Delta log wage	0.0786	0.3711
[% sex, age, civil status]	[-22.37]	[16.13]
[% nationality/unexplained]	[87.20]	-
[% skill]	-	[73.47]
[% firm composition]	[33.48]	[12.14]
[% firm size]	[1.68]	[-1.74]
Sub-sample:	**Unskilled**	**Foreigners**
Delta log wage	0.0835	0.3759
[% sex, age, civil status]	[-36.83]	[12.42]
[% nationality/unexplained]	[53.18]	-
[% skill]	-	[72.65]
[% firm composition]	[73.12]	[21.10]
[% firm size]	[10.54]	[0.27]
Sample:	**All**	**All**
Delta log wage	0.1628	0.3935
[% sex, age, civil status]	[-5.84]	[12.42]
[% skill]	[37.19]	[69.40]
[% nationality/unexplained]	[36.26]	[1.42]
[% firm composition]	[30.66]	[17.39]
[% firm size]	[1.74]	[-0.62]

Table 5: Exposure rates by nationality and work permit

	Average work permit composition of firms				
	Share Swiss	Share Permit A	Share Permit B	Share Permit C	Share Permit G
Swiss	0.788 (0.006)	0.014 (0.001)	0.034 (0.001)	0.128 (0.004)	0.036 (0.002)
Permit A	0.424 (0.027)	0.300 (0.035)	0.081 (0.005)	0.150 (0.011)	0.044 (0.004)
Permit B	0.500 (0.009)	0.040 (0.003)	0.185 (0.006)	0.220 (0.006)	0.055 (0.003)
Permit C	0.537 (0.008)	0.021 (0.001)	0.062 (0.002)	0.324 (0.006)	0.056 (0.002)
Permit G	0.422 (0.010)	0.017 (0.002)	0.044 (0.002)	0.155 (0.004)	0.362 (0.011)
Overall composition	0.702	0.023	0.047	0.167	0.060
	Swiss	Permit A	Permit B	Permit C	Permit G
Over-exposure to own group	0.086	0.277	0.137	0.157	0.302
James' index	0.289	0.284	0.144	0.189	0.321

Notes : Standard errors (in parentheses) are adjusted for clustering at the firm level. Permit A: seasonal and short-term workers. Permit B: annual work permit. Permit C: settlement permit. Permit G: cross-border workers.

Table 6: Exposure rates by skill levels

	Average skill composition of firms			
	Percent skill 1	Percent skill2	Percent skill3	Percent skill4
Skill 1	0.235 (0.008)	0.289 (0.008)	0.340 (0.010)	0.136 (0.007)
Skill 2	0.084 (0.003)	0.458 (0.006)	0.314 (0.007)	0.144 (0.005)
Skill 3	0.058 (0.003)	0.185 (0.007)	0.588 (0.007)	0.169 (0.009)
Skill 4	0.042 (0.002)	0.153 (0.006)	0.306 (0.008)	0.499 (0.009)
Overall composition	0.074	0.254	0.432	0.239
	Skill 1	Skill 2	Skill 3	Skill 4
Over-exposure to own group	0.161	0.204	0.156	0.260
James' index	0.174	0.273	0.274	0.341

Note : Standard errors (in parentheses) are adjusted for clustering at the firm level. Skill levels range from highest (Skill 1) to unskilled (Skill 4).

Table 7: The influence of skill on exposure rates by nationality / work permit

Dependent variable	Share of Swiss in firm	Share of short-term permits in firm	Share of annual permits in firm	Share of settlement permits in firm	Share of cross-border permits in firm
			Skill level (reference = skill 3)		
Skill 1	-0.013	-0.094	0.041	-0.070	-0.045
	(0.006)	(0.050)	(0.020)	(0.007)	(0.013)
Skill 2	-0.001	-0.048	0.010	-0.036	-0.036
	(0.004)	(0.033)	(0.008)	(0.005)	(0.010)
Skill 4	-0.037	-0.088	0.022	0.055	0.075
	(0.006)	(0.040)	(0.008)	(0.009)	(0.015)
Sub-sample	Swiss	Short-term	Annual	Settlement	Cross-border
Sample size	591,513	16,725	37,583	133,169	50,462
R^2	0.059	0.154	0.213	0.134	0.130

Notes: The table shows the results of regressing the share of a work permit or nationality in a firm's total workforce on dummy variables indicating skill levels. Other explanatory variables in the regression are: female, age, age^2, never married, female*age, female*age^2, female*(never married), ln (firm size), ln^2 (firm size). Sample weights are used in regressions and standard errors (in parentheses) are adjusted for clustering at the firm level.

Table 8: The influence of work permits on exposure rates by skill

Dependent variable	Share of skill 1 in firm	Share of skill 2 in firm	Share of skill 3 in firm	Share of skill 4 in firm
		Work permit (reference = Swiss)		
Short-term	0.070	0.022	0.072	0.047
	(0.027)	(0.025)	(0.026)	(0.018)
Annual	0.090	0.027	-0.003	0.075
	(0.021)	(0.010)	(0.009)	(0.015)
Settlement	0.039	0.009	-0.013	0.040
	(0.008)	(0.006)	(0.006)	(0.012)
Cross-border	0.039	-0.003	-0.002	0.083
	(0.014)	(0.009)	(0.010)	(0.013)
Sub-sample	Skill 1	Skill 2	Skill 3	Skill 4
Sample size	58,113	202,021	366,097	203,221
Adj. R^2	0.130	0.122	0.019	0.028

Notes: The table shows the results of regressing the share of a skill level in a firm's total workforce on dummy variables indicating nationality / work permit. Other explanatory variables in the regression are: female, age, age^2, never married, female*age, female*age^2, female*(never married), ln (firm size), ln^2 (firm size). Sample weights are used in regressions and standard errors (in parentheses) are adjusted for clustering at the firm level.

Table 9: Decomposition of wage differentials by nationality and work permit

	Swiss-Permit A	Swiss-Permit B	Swiss-Permit C	Swiss-Permit G
Skill 1 : Delta log wage	0.687	-0.1268	-0.0494	0.0331
[% sex, age, civil status]	[18.20]	[-29.84]	[-2.07]	[-11.21]
[% nationality / unexplained]	[86.92]	[29.95]	[10.66]	[259.97]
[% firm size]	[-2.68]	[16.17]	[-7.47]	[-34.13]
[% total firm composition]	[-2.44]	[83.72]	[98.88]	[-114.63]
Skill 2 : Delta log wage	0.1749	-0.0581	0.0590	0.0370
[% sex, age, civil status]	[15.48]	[-48.97]	[-15.21]	[-46.73]
[% nationality / unexplained]	[29.94]	[10.26]	[68.09]	[143.99]
[% firm size]	[-0.26]	[9.80]	[9.09]	[-7.69]
[% total firm composition]	[54.84]	[128.91]	[38.03]	[10.43]
Skill 3 : Delta log wage	0.1748	0.0714	0.0574	0.0259
[% sex, age, civil status]	[4.27]	[5.12]	[-52.11]	[-170.48]
[% nationality / unexplained]	[38.66]	[42.22]	[77.11]	[138.50]
[% firm size]	[0.43]	[13.96]	[7.30]	[19.26]
[% total firm composition]	[56.64]	[38.70]	[67.70]	[112.72]
Skill 4 : Delta log wage	0.1779	0.1407	0.0571	0.0714
[% sex, age, civil status]	[3.77]	[1.64]	[-48.77]	[-46.69]
[% nationality / unexplained]	[25.10]	[24.25]	[63.72]	[39.57]
[% firm size]	[10.15]	[8.13]	[13.78]	[17.55]
[% total firm composition]	[60.99]	[65.98]	[71.28]	[89.57]
Mean : Delta log wage	0.3050	0.1319	0.1780	0.0900
[% sex, age, civil status]	[8.25]	[13.76]	[-6.04]	[-29.96]
[% skill]	[36.48]	[46.47]	[58.88]	[48.41]
[% nationality / unexplained]	[18.17]	[14.06]	[21.55]	[45.03]
[% firm size]	[1.60]	[2.40]	[1.74]	[3.13]
[% total firm composition]	[35.50]	[23.31]	[23.88]	[33.38]
of which: [% women]	*[-2.08]*	*[-0.07]*	*[-1.44]*	*[-6.71]*
[% skill-work permit]	*[37.58]*	*[23.38]*	*[25.32]*	*[40.09]*

Notes: Permit A: seasonal and short-term workers. Permit B: annual work permit. Permit C: settlement permit. Permit G: cross-border workers.

Table 10: Decomposition of wage differentials by skill

	Skill1-Skill3	Skill2-Skill3	Skill3-Skill4
Swiss : Delta log wage	0.6511	0.2445	0.2179
[% sex, age, civil status]	[13.94]	[15.68]	[7.16]
[% skill]	[86.23]	[91.82]	[78.45]
[% firm size]	[-1.55]	[-5.76]	[-0.60]
[% firm composition]	[1.38]	[-1.74]	[14.99]
Permit A : Delta log wage	0.7572	0.2444	0.2210
[% sex, age, civil status]	[11.32]	[7.66]	[6.71]
[% skill]	[75.19]	[98.07]	[66.97]
[% firm size]	[-0.99]	[-5.27]	[7.24]
[% firm composition]	[14.48]	[-0.47]	[19.07]
Permit B : Delta log wage	0.8494	0.3741	0.2871
[% sex, age, civil status]	[6.66]	[3.62]	[4.96]
[% skill]	[74.13]	[69.68]	[60.91]
[% firm size]	[2.40]	[0.43]	[0.05]
[% firm composition]	[16.81]	[26.28]	[34.07]
Permit C : Delta log wage	0.7580	0.2429	0.2176
[% sex, age, civil status]	[7.89]	[7.17]	[8.11]
[% skill]	[80.61]	[94.11]	[74.93]
[% firm size]	[-1.27]	[-6.28]	[1.05]
[% firm composition]	[12.76]	[5.01]	[15.86]
Permit G : Delta log wage	0.64394	0.2337	0.2634
[% sex, age, civil status]	[7.82]	[4.87]	[10.01]
[% skill]	[79.40]	[88.80]	[62.01]
[% firm size]	[0.96]	[-2.69]	[2.37]
[% firm composition]	[11.82]	[9.02]	[25.61]
Mean : Delta log wage	0.6768	0.2530	0.2428
[% sex, age, civil status]	[12.04]	[12.51]	[5.21]
[% skill]	[84.42]	[90.39]	[72.99]
[% firm size]	[-1.11]	[-5.12]	[0.95]
[% total firm composition]	[4.65]	[2.23]	[20.85]
of which: [% women]	*[0.57]*	*[1.01]*	*[2.76]*
[% skill-work permit]	*[4.08]*	*[1.23]*	*[18.09]*

Notes: Permit A: seasonal and short-term workers. Permit B: annual work permit. Permit C: settlement permit. Permit G: cross-border workers.

Appendix: Tables and Figures

Table A1: Descriptive statistics (Switzerland, 2002)

Variable	All	Swiss	Permit A	Permit B	Permit C	Permit G
N observations	829'452	591'513	16'725	37'583	133'169	50'462
% Sub-population	100%	70.20%	2.33%	4.75%	16.71%	6.01%
Female	40.95%	42.96%	30.91%	38.44%	38.01%	32.37%
Never married	31.29%	34.36%	41.00%	25.12%	19.98%	28.40%
Skill1 (higher)	7.43%	8.56%	2.67%	8.97%	3.77%	5.06%
Skill2	25.45%	29.02%	13.81%	19.92%	14.61%	22.07%
Skill3 (lower)	43.22%	45.13%	38.69%	28.60%	37.68%	49.59%
Skill4 (unskilled)	23.90%	17.29%	44.83%	42.51%	43.94%	23.28%
Age	40.08	40.61	34.73	39.87	39.87	40.46
Wage (SFR 2002)	5763.49	6050.52	4459.98	5302.85	5063.43	5529.76

Notes:Permit A: seasonal and short-term workers. Permit B: annual work permit. Permit C: settlement permit. Permit G: cross-border workers.

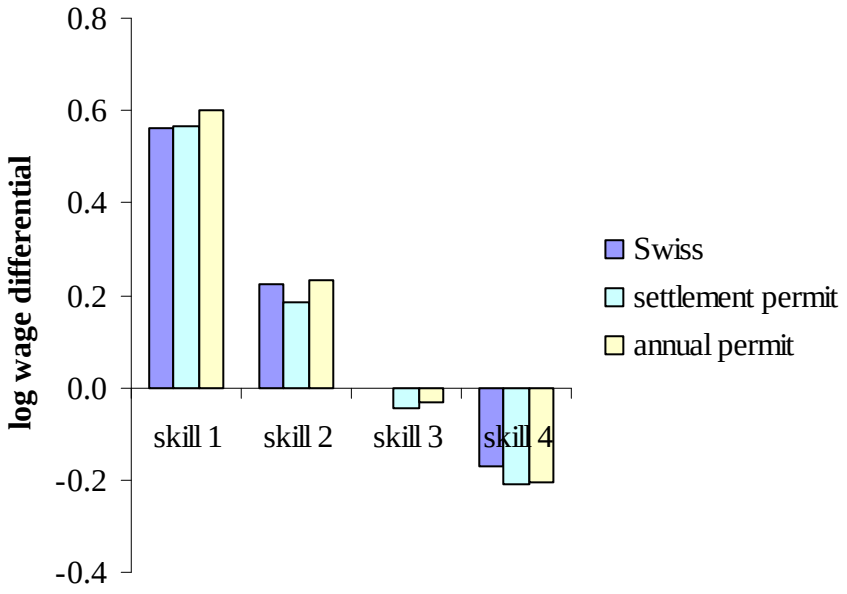
Table A2: Estimated log-wage equation

	Model I		Model II	
Variable	**coefficient**	**std error**	**coefficient**	**std error**
		Individual variables		
Female	-0.0606	0.0106	-0.0453	0.0200
Age	0.0311	0.0004	0.0354	0.0009
Age^2 (/1000)	-0.2962	0.0042	-0.3429	0.0109
Never married	-0.0537	0.0011	-0.0531	0.0023
Female*age	-0.0023	0.0005	-0.0034	0.0010
Female*age^2	-0.0026	0.0064	0.0093	0.0116
Female*Never married	0.0692	0.0017	0.0908	0.0033
Permit A	-0.0676	0.0048	-0.0664	0.0125
Permit B	-0.0302	0.0033	-0.0286	0.0075
Permit C	-0.0443	0.0014	-0.0441	0.0030
Permit G	-0.0358	0.0020	-0.0375	0.0045
Skill 1 (highly skilled)	0.5615	0.0024	0.5580	0.0177
Skill 2	0.2245	0.0011	0.2226	0.0065
Skill 4 (unskilled)	-0.1709	0.0012	-0.1700	0.0054
Permit A*skill 1	0.0079	0.0243	0.0070	0.0328
Permit A*skill 2	0.0152	0.0098	0.0149	0.0205
Permit A*skill 4	0.0229	0.0061	0.0243	0.0114
Permit B*skill 1	0.0681	0.0092	0.0673	0.0367
Permit B*skill 2	0.0361	0.0053	0.0353	0.0087
Permit B*skill 4	-0.0040	0.0041	-0.0026	0.0076
Permit C*skill 1	0.0496	0.0078	0.0494	0.0111
Permit C*skill 2	0.0041	0.0030	0.0042	0.0045
Permit C*skill 4	0.0079	0.0021	0.0083	0.0043
Permit G*skill 1	-0.0502	0.0076	-0.0489	0.0194
Permit G*skill 2	-0.0170	0.0034	-0.0161	0.0082
Permit G*skill 4	0.0076	0.0032	0.0075	0.0065
		Firm-level variables		
% of permit A in firm	-0.3316	0.0375	-0.3307	0.0379
% of permit B in firm	-0.0241	0.0622	-0.0234	0.0602
% of permit C in firm	-0.2364	0.0314	-0.2360	0.0315
% of permit G in firm	-0.1097	0.0348	-0.1088	0.0349
% of skill 1 in firm	-0.0475	0.0348	-0.0460	0.0369
% of skill 2 in firm	-0.0681	0.0209	-0.0670	0.0222
% of skill 4 in firm	-0.0488	0.0254	-0.0487	0.0260
% of permit A skill 1 in firm	0.5063	0.2804	0.5035	0.2698
% of permit A skill 2 in firm	-0.1183	0.0845	-0.1171	0.0869
% of permit A skill 4 in firm	-0.0512	0.0678	-0.0537	0.0675
% permit B skill 1 in firm	0.6636	0.2987	0.6642	0.2666
% permit B skill 2 in firm	0.7692	0.1169	0.7653	0.1146
% permit B skill 4 in firm	-0.4831	0.0965	-0.4815	0.0949
% permit C skill 1 in firm	0.7431	0.1267	0.7398	0.1242
% permit C skill 2 in firm	0.0576	0.0665	0.0581	0.0661
% permit C skill 4 in firm	0.1129	0.0579	0.1122	0.0575
% permit G skill 1 in firm	0.4363	0.1848	0.4344	0.1792
% permit G skill 2 in firm	0.0961	0.0587	0.0968	0.0576
% permit G skill 4 in firm	-0.1175	0.0552	-0.1192	0.0548
% women in firm	-0.0959	0.0091	-0.0942	0.0095
Log firm size	0.0251	0.0020	0.0250	0.0020
Adjusted R squared	1^{st} step: 0.750; 2^{nd} step: 0.420		0.595	

Notes : N = 829'452. Model 1 is estimated in two steps. First, the log-wage is regressed on individual variables and on fixed effects at the firm level. Second, fixed effects are regressed on firm-level variables. Model 2 is estimated in one step (pooled OLS). Sample weights are used in all estimations and standard errors are adjusted for clustering within firms. Permit A: seasonal and short-term workers. Permit B: annual work permit. Permit C: settlement permit. Permit G: cross-border workers. Other firm-level variables used in the regressions: sectoral variables (i.e. residuals obtained from regressions of 2-digit NOGA dummies on all firm-level variables)

Figure A1: Wage effects of individual skill by nationality

(a) Model I: individual characteristics and fixed firm effects



(b) Model III: individual characteristics only

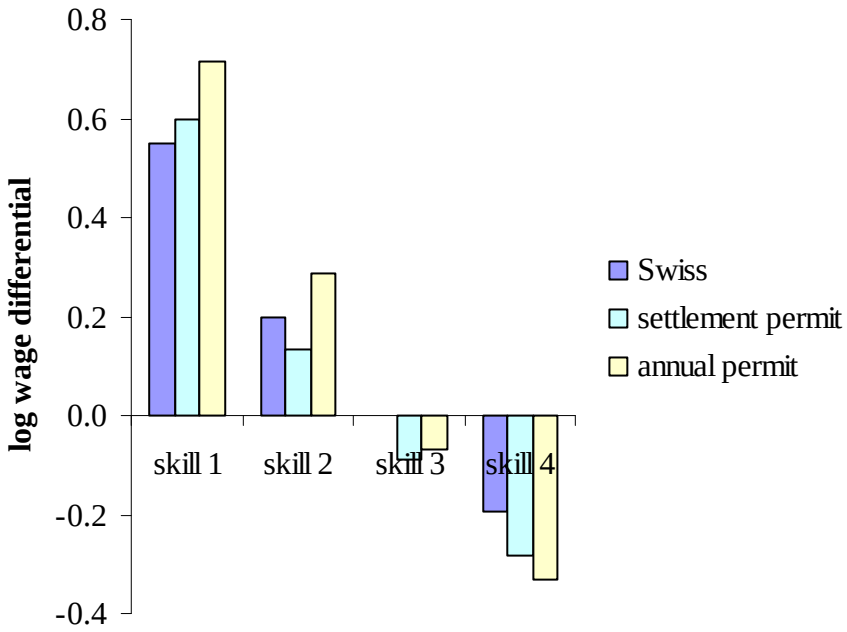
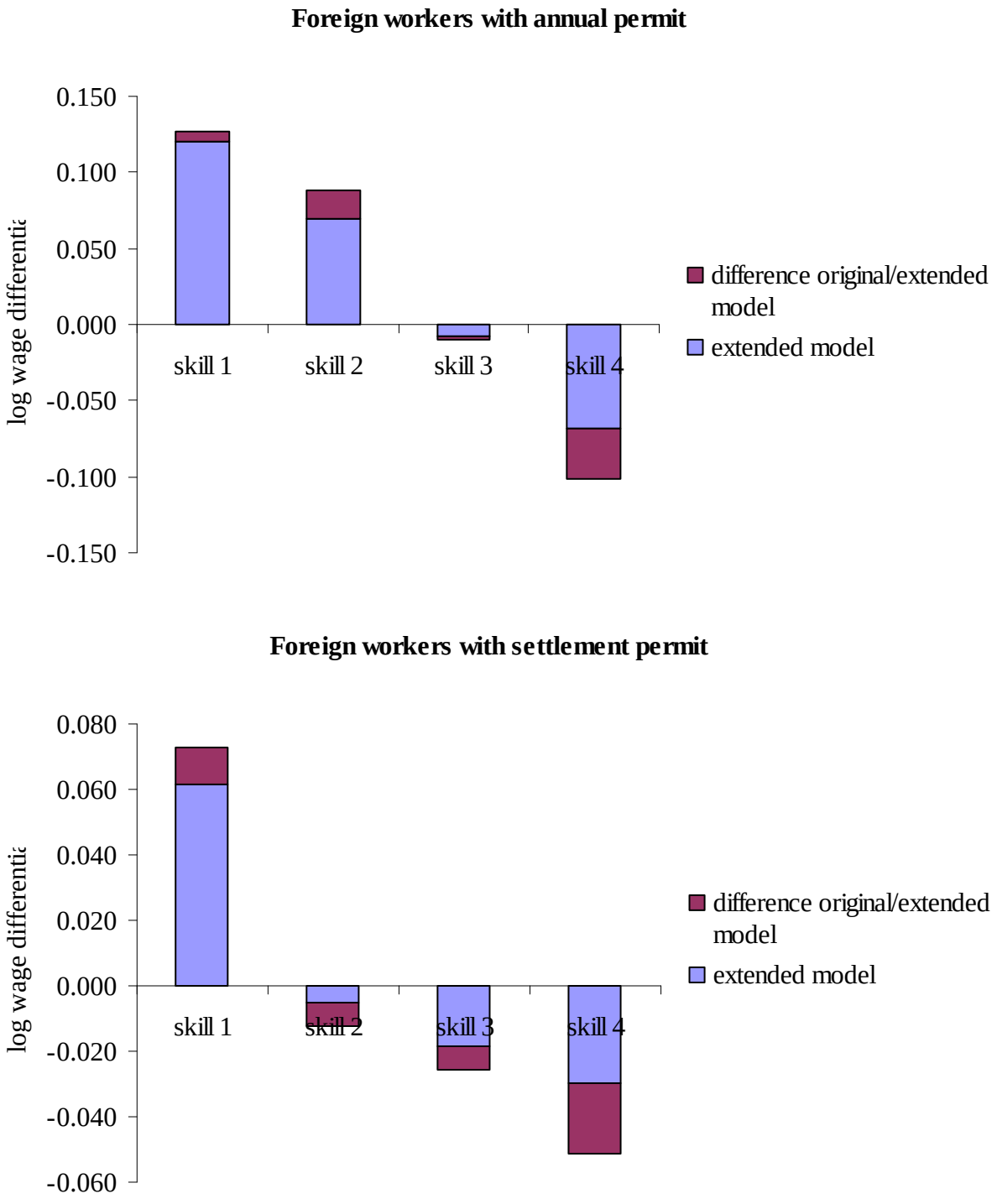


Figure A2: Wage effects of firm-level segregation – introducing job characteristics



Note : This figure depicts the "marginal" effect on log-wages of moving from the work environment of the average worker in the economy to the work environment of an average member of a specific skill-nationality (work permit) group. The bars show the effect of segregation in the original model (Model II) and the blue part depicts the effect in the extended model (Model II augmented by job characteristic variables, see text).