Segmentation by skills and wage discrimination in a trans-border labor market*†

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Abstract

The restrictive regulation imposed on immigrant workers on the Swiss labor market has been the subject of various recent studies [5] [18][7]. This interest is among else due to the upcoming change in regulation implied in the bilateral treaties. These treaties will significantly liberalize the access of immigrant workers to the Swiss labor market. The present paper models wages in a labor market segregated by skill levels and estimates discrimination in view of the possible impacts of this regulatory change on a micro level in a typical trans-border labor market, i.e. the Canton Ticino.

1 Introduction

Since 1st June 2002 the bilateral treaty on free mobility between the European Union and Switzerland is effective. Speculations abound (especially in border regions) on the impact this might have on wages and other labor market indicators. Given that the "deregulation" concerns changes in the regulation via work permits of immigrant workers, the "natural" instrument to investigate potential impacts seems to be the wage function. This permits to identify discriminatory shifts in wages due to the specific status of immigrant workers and thus to speculate on the impacts of a free mobility.

Wage functions for Switzerland usually show a significant negative shift for the various categories of work permits for foreign labor force with respect to Swiss residents [5][7]. This is then interpreted as institutional (regulatory) discrimination of foreigners. As a consequence, liberalization (bilateral treaties) can be expected to have an equalizing effect on wages (i.e. a negative one on

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the salaries of Swiss residents). This paper re-proposes the argument from a slightly different perspective. First, attention is shifted from a labor supply interpretation of the wage function in a human capital perspective to a more general argument of hedonic markets and equalizing differences [16]. Second, the focus is on the demand side in so far as the attribution of jobs to skill segments by firms is modeled.

The central idea is that the role of permits in wage discrimination has to be disentangled from the argument of labor market segmentation into Swiss and foreign work force. The hypothesis is that wages are not formed (matches are not found) and human capital investments are not evaluated on separate markets for Swiss and for foreign labor force, but that the restrictive regulation for distinct categories of foreign labor force creates a strongly differentiated discrimination based on a process of segmentation by skills. This paper therefore documents the attempt to model the wage formation on the Ticino labor market on the base of a selection process according to three levels of skills and discusses the issue of discrimination and impacts of deregulation on the bases of the estimation results.

In the following, we present the theoretical framework and the empirical model, describe the data used and the sample characteristics. We then present and discuss the empirical findings and draw conclusions on discrimination and the impact of deregulation.

2 Theoretical framework

Wage functions are regressions of market prices on characteristics of the individuals employed, and as such represent typical hedonic functions. As introduced by Rosen 1974 [15], such functions can be interpreted as reflecting the outcome of an implicit market for these characteristics. In this framework, the hedonic function represents "... a joint envelope of a family of value functions and another family of offer functions." (Rosen 1974 p.44). In a labor market context, the offer functions can be interpreted as workers' indifference curves between wage and attribute levels, while the value functions represent the firms' isoprofit curves with respect to labor cost and characteristics [4].

The following simple model of compensating wage differentials can serve as a rationale for our hedonic (switching) regression of wage functions in skill segments.

The regional labor market matches job offers by which firms demand labor services with specific skills and job requests by which individuals offer labor services with specific skills. The matches result in observable market wages and a vector describing the skills. A hedonic wage function (eq. 1) relates wages (w) and skills (S):

$$w = w(S) \tag{1}$$

The vector of first derivatives of this function, w_S returns the implicit (hedonic) prices of the characteristics. The underlying hypotheses about behaviour of firms and individuals are as follows. A firm produces with only labor input[1] in a competitive market, taking the price (p) and is assumed to maximize a profit function defined on the vector of skills (S) of the general form given in eq. 2,

$$\Pi = pf(S) - w_S S \tag{2}$$

$f(.)$ is a production function with the usual properties ($f_S > 0; f_{SS} < 0$), and where fixed cost is absent. The vector S employed in production is acquired on the market renting a vector L of heterogeneous labor at differentiated wages. In analogy to Lancaster's (1966) linear consumption technology the vectors L and S can be thought of as being related via a matrix $\mathbf{B}$ describing the skills by individual[2] as in eq. 3.

$$S = \mathbf{B}L \tag{3}$$

To maximize profit, firms will employ single skills up to where marginal revenue (value of the marginal product) equals marginal cost (eq. 4).

$$w(bid)_S = pf_S = w_S \tag{4}$$

If individual workers are located in a specific segment of the S space, i.e. can vary their skill within certain limits around their actual positions (see below), then the above firm behavior will define a family of isoprofit curves indicating the bids a firm will make for skills in a specific segment. These isoprofit curves (eq. 5) will have the usual properties (concavity and increasing profits towards South-East).

$$w(bid) = w(S; \Pi, f) \tag{5}$$

The model of firm behavior implies in general terms that firms under perfect competition and given the production technology f are forced to pay a positive wage differential for higher skills and are willing to do so as long as profit is ≥ 0. Or in other words, in order to accept lower skills - depreciation of the workforce due to non investment in human capital - firms will lower wages for the individuals concerned to maintain zero profits. The maximum price she must pay for it on the market. Hence, the equilibrium is where $w = w(bid)$ and $w_S = w(bid)_S$ (tangency condition).

[1] Adding other production factors does not change the arguments made here.

[2] Note that this linearity assumption permits repackaging on a firm level (e.g. one worker with 6 years of schooling and 1 with 12 years of schooling are the same as 2 workers with 9 years of schooling. However, the firm still has to buy packages of S tied in single individuals).

Turning to the households, behavior can be modeled in analogy. According to the human capital literature [2][17], individuals are only willing to invest in human capital i.e. improve their skills, if they can hope for a reward in form of a positive wage differential. This is due to the fact that investments in human capital are costly (forgone wages or leisure). This view of skills as a "bad" that is necessary for satisfying the strong desire to substantially increase income, seems to be, as Piore 1973 [14] notes, quite accurate if one relies on the common judgements by workers and managers.

From a human capital perspective, benefits of increased skills consist in a positive wage differential to compensate the costs of the investment in the form of foregone earnings [6]. Translated into our context, utility maximizing individuals will offer S so that at the margin the wage differential w_S exactly compensates the foregone earnings (eq. 6).

$$w_S = w(offer)_S \tag{6}$$

Individuals are located at a certain position on the skills axes and can decide whether to invest in human capital (increase skills), disinvest (loose skills through depreciation) or maintain the present level of skills. From this marginalist perspective on human capital, individuals will seek matches on the labor market in the neighborhood of their actual position. Therefore it is possible to describe individual offer behavior on the labor market with respect to their skills by a family of indifference curves, indicating the acceptable bids for given utility levels (U) and tastes (t) (see eq. 7).

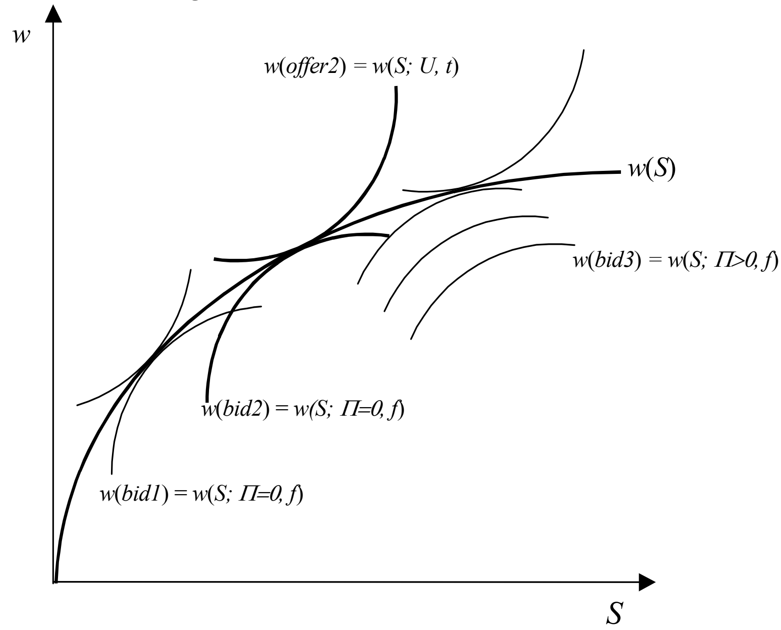
$$w(offer) = w(S; U, t) \tag{7}$$

The indifference curves are convex and utility is increasing towards North-West. The minimum wage an individual is willing to accept at the given skill level is the sum the market will pay for it. Hence, the equilibrium is where $w = w(offer)$ and $w_S = w(offer)_S$ (tangency condition). In general terms, individuals will be interested to improve their skill only, if the market is offering a positive wge differential, or, in other terms, they are willing to maintain their skills, if depreciation is penalized with a negative wage differential.

At market clearing implicit prices, bids and offers will match and the hedonic function will delineate this market outcomes[3]. In market equilibrium $w(bid) = w = w(offer)$ and $w(bid)_S = w_S = w(offer)_S$. Figure 1 illustrates the hedonic function and elements of the family of bid and offer functions.

[3] For a discussion of market clearing conditions see the original paper by Rosen 1974.

Figure 1: The implicit market for skills



3 The empirical model

In this paper the relevance of the immigrant worker status for wage discrimination is measured via market wages for differents skills. Therefore the empirical program does not foresee second stage estimation of the bid and offer functions[4]. Instead, the focus is on the estimation of the wage function. The theoretical argument made so far has left out any consideration on labor market status of individuals on purpose. According to the above, immigrant workers with a specific permit will take different salaries from resident workers only in so far as they have significantly different skills, i.e. are offering in different segments. In other words; if skill driven wage differentials can be isolated, remaining wage differentials will have to be explained on an ad-hoc basis, but not by segmentation according to labor market status. In this sense, work permits are simply an individual characteristic[5].

[4] The available data contain very little production relevant information to estimate the bid functions. The estimation of the individual offers function would seem to be more promising. The second step issues will be discussed in a forcoming paper.

[5] This is of course not satisfactory because regulation in form of contingents, preferential treatments and the like have an immediate impact on supply shortages, elasticities and hence on wage differentials. But as the implementation of the regulation is in the hands of the (cantonal) political authorities this behaviour would have to be endogenized using public choice instruments. This, however, would go beyond the scope of this paper.

The formulation of the empirical model contains only one challenge: the level of skills is multidimensional and not directly observable. What is observable on the labor market are education, experience, tenure, professions, industries, hierarchical levels etc. All these variables are usually included together with further individual characteristics in the wage function - and this paper makes no exception. In our hedonic interpretation, the market will therefore reveal implicit prices for these multiple characteristics and not for skills measured along one dimension. From a firm's perspective the characteristics of the individuals (e.g. education) are signals for the underlying level of skills offered; and from an individual's perspective, the characteristics required (e.g. hierarchical level) are signals as well, but for the level of skills that are required.

The level of skills required by firms becomes the driver of market segmentation in our empirical model. Firms define the level of skills required by the production context for a specific job either explicitely[6].They are willing to pay higher wages for higher skills not observables by them. This will normally induce them to identify specific market segments through a specific search mechanism (e.g. job hunter or advertisements in top business newspapers for high skills as compared to an advertisement in a local newspaper). This will translate on the labor market into higher bids for the same level of a characteristic (e.g. years of schooling) in the high skill segment.

Given this constellation it seems useful to rely upon a switching regression model for the empirical analysis of the implicit prices of characteristics in a labor market segmented by skill levels. The switch function will capture the influence of production technology and process indicators on the attribution of jobs to required skills levels and hence to segments. Hedonic wage functions for each segments will then be use to estimate the implicit price of characteristics in the different segments.

As skill is an ordered phenomenon an ordered probit procedure is applied to estimated the attribution of jobs to skills level (regimes). The ordered probit equation that determines the firm's probability to express a labor demand for skill level i is:

$$SD_i^* = \omega\prime Z_i + \varepsilon_i \tag{8}$$

SD_i^* describes the skill demanded by firms on the labor market, Z_i is a vector of characteristics describing the production context, $\omega\prime$ is the associated coefficient vector to be estimated and ε_i is a normally distributed error with mean μ_ε and variance σ_ε^2.

SD_i^* is not directly observable, so what we do observe is SD_i, a multinomial ordered choice variable taking the value of 1 for low skill (LS), 2 for medium skill (MS) and 3 for high skill (HS).

[6] Our data contain a skills variable where for example highest skills required are defined as "job that implies the most demanding activities and the most difficult tasks".

$$SD_i = \begin{cases} 1 & if \quad SD_i^* \leq \gamma_1 \\ 2 & if \quad \gamma_1 < SD_i^* \leq \gamma_2 \\ 3 & if \quad \gamma_2 < SD_i^* \end{cases} \tag{9}$$

γ_1, γ_2 are limits points to be estimated by the ordered probit model.

Therefore we have the following probabilities:

$$\begin{array}{lll} Pr(SD_i = 1) & = Pr(SD_i^* \leq \gamma_1) & = \Phi(\alpha_1) \\ Pr(SD_i = 2) & = Pr(\gamma_1 < SD_i^* \leq \gamma_2) & = \Phi(\alpha_2) - \Phi(\alpha_1) \\ Pr(SD_i = 3) & = Pr(\gamma_2 < SD_i^*) & = 1 - \Phi(\alpha_2) \end{array} \tag{10}$$

$\Phi(.)$ is the normal standard cdf, $\alpha_1 = \frac{\gamma_1 - \omega' Z_i - \mu_\varepsilon}{\sigma_\varepsilon}; \alpha_2 = \frac{\gamma_2 - \omega' Z_i - \mu_\varepsilon}{\sigma_\varepsilon}$.

As said before our focus is on the estimation of the wage functions. Taking the natural logarithm of wage the function become:

$$lnW_{Si} = \beta\prime_S X_i + \upsilon_{Si} \tag{11}$$

W_{Si} is the wage observed for each individual i working in the skill segment S, X_i is a vector of individual socio-economic characteristics and of job descriptors in the tradition of Mincer 1974 [13] of the observation i, $\beta\prime_S$ is the associated coefficient vector and υ_{Si} is a normally distributed error relative to the skill segment S and individual i with mean and variance μ_{υ_S} and $\sigma^2_{\upsilon_S}$.

Therefore three wage function have to be estimated, one for each segment of the labor market defined by the skill level:

$$lnW_i = \begin{cases} lnW_{LSi} = \beta\prime_{LS} X_i + \upsilon_{LSi} & if \quad SD_i = 1 \\ lnW_{MSi} = \beta\prime_{MS} X_i + \upsilon_{MSi} & if \quad SD_i = 2 \\ lnW_{HSi} = \beta\prime_{HS} X_i + \upsilon_{HSi} & if \quad SD_i = 3 \end{cases} \tag{12}$$

If the wage determination would be independent of the selection procces, i.e. ε_i would be independent from υ_{Si}, the regression function for each skill segment would take the same formulation as the whole sample. But in general, according to Heckman [11] [8] the conditional expectation of υ_{Si} on ε_i differs from zero, therefore wages and selection procces results respectively non independent. Therefore, least squares regression on wage in a specific skill segment using only data observed in the subsample produces inconsistent estimates of β.

Assuming ε_i and υ_{Si} being both normally distributed, they have a bivariate normal distribution with means ,μ_ε, μ_{υ_S}, variance σ^2_ε, $\sigma^2_{\upsilon_S}$, and correlation $\rho_{\varepsilon\upsilon_S}$. Therfore, following the moments of the incidentally truncated bivariate normal distribution [8] as explained in appendix A, we have, for the first segment:

$$
\begin{aligned}
E(lnW_i \mid SD_i = 1) &= E(lnW_{LSi} \mid SD_i^* \leq \gamma_1) \\
&= \beta\prime_{LS} X_i + E(\upsilon_{LSi} \mid \varepsilon_i \leq \gamma_1 - \omega\prime Z_i) \\
&= \beta\prime_{LS} X_i + \psi_{LS}\lambda_{LSi}(\alpha_1) + \eta_{LSi}
\end{aligned} \tag{13}
$$

where $\psi_{LS} = \rho_{\varepsilon\upsilon_{LS}}\sigma_{\upsilon_{LS}}, \lambda_{LSi} = \frac{-\phi(\alpha_1)}{\Phi(\alpha_1)}$ is the inverse Mill's ratio that corrects the selection bias. For the second segment the expectation is:

$$
\begin{aligned}
E(lnW_i \mid SD_i = 2) &= E(lnW_{MSi} \mid \gamma_1 < SD_i^* \leq \gamma_2) \\
&= \beta\prime_{MS} X_i + E(\upsilon_{MSi} \mid \gamma_1 < \omega\prime Z_i + \varepsilon_i \leq \gamma_2) \\
&= \beta\prime_{MS} X_i + \psi_{MS}\lambda_{MSi}(\alpha_1; \alpha_2) + \eta_{MSi}
\end{aligned} \tag{14}
$$

where $\psi_{MS} = \rho_{\varepsilon\upsilon_{MS}}\sigma_{\upsilon_{MS}}, \lambda_{MSi} = \frac{\phi(\alpha_2)-\phi(\alpha_1)}{\Phi(\alpha_2)-\Phi(\alpha_1)}$ is the inverse Mill's ratio. Finally for the third segment:

$$
\begin{aligned}
E(lnW_i \mid SD_i = 3) &= E(lnW_{HSi} \mid \gamma_2 < SD_i^*) \\
&= \beta\prime_{HS} X_i + E(\upsilon_{HSi} \mid \varepsilon_i > \gamma_2 - \omega\prime Z_i) \\
&= \beta\prime_{HS} X_i + \psi_{HS}\lambda_{HSi}(\alpha_2) + \eta_{HSi}
\end{aligned} \tag{15}
$$

where $\psi_{HS} = \rho_{\varepsilon\upsilon_{HS}}\sigma_{\upsilon_{HS}}, \lambda_{HSi} = \frac{\phi(\alpha_2)}{1-\Phi(\alpha_2)}$ is again the inverse Mill's ratio.

As shown in the equations 13 14 and 15 we correct the selection bias in the conditional expected mean of lnW_i adding λ_{Si} to the specification of the model. The inverse Mill's ratio is, as explained in Heckman 1979 [11], "... a monotone decreasing function of the probability that an observation is selected in the sample". In other words, increasing the probability of an observation to belong to the selected skill segment, the inverse Mill's ratio decreases, implying a lesser corrective effect on the mean of the subsample.

4 Estimation and results

The data at disposal for the estimation of our model consist of 48'472 individual observations of occupied jobs in Ticino in 2000. The information stems from the Federal Statistics on the Structure of Salaries (LSE) survey among a representative sample of 5'675 firms reporting salaries, job characteristics and individual attributes. Descriptive statistics of the variables included in our model can be found in the appendix C.

In the first step ordered probit model the choice variable has three levels according to the three skill segments. The probability of an observation to belong to one of the three levels depends on the industry, the size of the firm, the hierarchical level of the job and the degree of occupation. The type of industry and the size of the firm serve as indicators for the production technology. The hierarchical level and the degree of occupation describe the job in the organisational context.

Table 1 presents the estimation results. Given that our interest in this first step lies mainly in the estimation of the limits between the segments and the estimation of the inverse Mill's ratio to be included in the wage estimation we limit our comments to the interpretation of the signs[7].

Table 1: Ordered probit etiamtes of the skill levels

Variable	Coefficient	Standard Error
Manufacturing	-0.0783	0.0181
Construction	0.0872	0.0203
Retailing	-0.0029	0.0241
Hotels and restaurants	-0.6268	0.0223
Finance and insurance	0.0419	0.0290
Informatics and R&D	0.1417	0.0233
Educational sector	0.7093	0.0591
Firm size	-0.0002	0.0000
Work time	0.6361	0.0303
Top management	3.8001	0.0364
Middle management	2.2379	0.0361
Lower management	1.5559	0.0261
Employees with limited responsability	1.0620	0.0201
Limit 2	0.6032	0.0295
Limit 3	4.0227	0.0416
N. Observations	48222	
Log likelihood	-28559.85	

Note: Dependent variable is the level of skill required by firms.

The first thing worth noting is that hotels and restaurants, and to a lesser extent manufacturing, have a high probability to find their human resources in the lowest skill segment, while the finance and insurance sector seems to target the three segments alike. The educational sector, as well as informatics, reseach and developement and construction places search preferably in the high skill sector. While this confirms expectations for the first to, it is rather surprising for construction. The firm size has a significant but small impact on the probability to bid for jobs in high skill segments. This implies that the smallest firms - in Ticino, traditionally the consulting firms, lawyers and the like, express the highest demand for high skills. The fact that the probability to end up in the highest skill segment increases with the hierarchical level confirms intuition. Firms offering jobs to part time workers have a significat bias towards low skill jobs. Rather than commenting these results, we will refer to some of the findings in the context with the wage equations.

[7]For interpretation, the coefficients from an ordered probit model would have to be transformed in to marginal effects. This is of limited interest in our case given that the independent variables are dummies variables. The signs of the coefficients can in any case be interpreted in a straightforward way: a negative sign indicates an increasing probability of belonging to segment 1, and a decreasing probability of belonging to segment 3, etc..

Three log-linear hedonic regressions have been performed for the respective segments[8]. The dependent variable is the natural logarithm of the monthly wage, the explanatory variables can be seen from table 2. They measure the impact of human capital indicators (schooling, experience, tenure), martial status and gender, job descriptor (degree of occupation) and, finally the type of permit for the immigrant workers (the reference category being the Swiss labor force). Table 2 presents the estimation results for the three segments.

Table 2: Estimates of the wage function for three skill segments

	Low Skill		Medium Skill		High Skill	
Variable	**Coeff.**	**Std.E.**	**Coeff.**	**Std.E.**	**Coeff.**	**Std.E.**
Constant	7.7331	0.0178	7.8969	0.0206	8.3636	0.1156
Schooling	0.0311	0.0014	0.0501	0.0012	0.0553	0.0052
Experience	0.0110	0.0006	0.0230	0.0007	0.0210	0.0047
$Exp.^2/100$	-0.0183	0.0012	-0.0406	0.0014	-0.0154	0.0083
Tenure	0.0095	0.0007	0.0043	0.0006	0.0049	0.0031
$Tenure^2/100$	-0.0126	0.0027	-0.0023	0.0020	-0.0205	0.0079
Femal	-0.1727	0.0042	-0.1478	0.0041	-0.1316	0.0296
Married	0.0097	0.0043	0.0154	0.0041	0.0968	0.0249
Occup. degree	-0.1783	0.0062	-0.2279	0.0066	-0.5188	0.0401
Unionized	-0.0347	0.0059	-0.0928	0.0062	-0.1536	0.0448
Firm size	-0.00004	0.0000	0.0002	0.0000	0.0011	0.0000
Seasonal	-0.0834	0.0156	-0.0737	0.0211	0.0719	0.2186
Annual	-0.0258	0.0081	0.0387	0.0098	0.4151	0.0497
Resident	-0.0315	0.0047	-0.0384	0.0051	0.0291	0.0309
Cross border	-0.0559	0.0054	-0.0766	0.0052	-0.1268	0.0424
Other permits	-0.0617	0.0195	0.0130	0.0188	-0.0329	0.0597
Inv. Mill's ratio	-0.1621	0.0047	0.2542	0.0050	-0.0932	0.0111
Adj. weigh. R^2	0.9956		0.9908		0.9563	
Observations	17120		25604		2723	

Note: Dependent variable natural logarithm of wage

In accordance with our expectations, the coefficients of the selected variables are significant, conforming a selection process with respect to the skill levels. The signs of the human capital indicators are also according to expectations. The wage differential[9] for an additional schooling year is 3.1% for low skills (mean of "schooling" = 10.5 years) and 5.5% in the high skill segment (mean of "schooling" = 14.5 years). Segmentation by skills seems to result in slightly lower figures than those reported (for earlier years) from wage functions on the whole sample (see [5]). Experience shows significant difference among segments. An additional year in the same profession in the low skill segment returns a

[8] For a systematic discussion of the functional form in hedonic regressions see Cadlini 2001 [1].

[9] For the correct computation of the marginal effects of regressors on wage see appendix B.

0.28% increase of wage at the average experience of 22 years, and a similar 0.61% increase in the medium skill segment at an average experience of 21 years. In contrast, the marginal wage increase in the high skill segment amounts to 2% at an average of 26 years. Experience seems to pay above all in the high skill segment. The impacts of an additional year are very similar for tenure, i.e. 0.77% and 0.43% for the low and medium skill segments, respectively, but differ for the high skill segment, where no significant impact is found. Given the high average tenure in this segment, this provides a first evidence for a labor market with low job turnover, and hence with a positive differential for newcomers. A second evidence in the same direction is provided by the dummy for workers with annual permits. This variable returns a negative sign in the low skil segment, but a positve one in the other two segments. First, it is instructive that segmentation by skills helps to contradict the common result that wage discrimination against foreigners prevails, independently from the type of permit. We find this result in the case of annual permits only for the low skill segment. Second, the drastic positive wage differential (about 50%) in the high skill segment indicates that scarce top position are selectively being occupied by mobile immigrant workforce[10]. Further results on immigrant workers show that foreign residents take more or less the same salary as Swiss whereas trans-border commuters are discriminated to an increasing extent with rising skill levels. In their case, the Swiss regulation clearly works in favor of the resident work force, exploiting a very elastic labor supply from neighboring Lombardy provinces with lower cost of living.

Important variation among skill levels is to be observed with respect to firm size. In the first skill segment size is negatively correlated with the wage level, in the medium skill segment it is slightly larger than zero while in the high skill segment, the marginal effect is clearly positive[11]. Similarly, we find that the degree of occupation has a positive impact in the low skill segment, is more or less neutral for medium skills and negative for high skills. Even considering a premium for part time work, this means that part time can be "paying" in the high skill segment only. Finally it is worth noting that wage discrimination by gender is almost constant across skill levels but amounts to only a bit more than half of the importance found without segmentation [7]. This has to be interpreted together with the fact that women have higher probability to take jobs in the low skill segment.

The coefficients of the inverse Mill's ratio are significant in all three equations, indicating a relevant selection bias stemming from firm's identification of skill segments. The negative sign in the low skill segment indicates that the selection proces affects wages negatively and that the lower the probability of a job to belong to this segment, the more the wage should be corrected upwards (the inverse Mill's ratio is negative with truncation from above). In analogy,

[10]Note that discrimination against Swiss labor force implies a shortage also on the labor market at the immigrants' origin. In this case the contingent regulation plays a bad trick to the residnets filling up the jobs first, when thereafter the firms have to pay premiums to attract internationally mobile labor force to the local market.

[11]For the calculation of marginal effects see appendix B.

the negative sign in the high skill segment demonstrates a negative impact of the selection process on wages, indicating that the lower the probability of a job to belong to this segment, the more the wage should be corrected downwards. In other words, observations are allocated correctly to the low and high skill segments. The positive sign in the medium skill segment illustrate a dominance of the "high skill bias", i.e. the selection process biases wages upwards. Hence, the lower the probability of a job to be rightly allocated to this intermediate segment, the more the wage should be corrected upwards. Putting this in different terms it can be said that not considering the selection process, wages would be underestimated in the low and medium skill sectors, and overestimated in the high skill sector.

5 Conclusions

The main aim of this paper was to disentangle segmentation by skills from wage discrimination against immigrant workers in the case of the Ticino labor market. The leading hypothesis was that in the proposed analytical perspective of implicit markets for skills, wage differentials with respect to work permits would have to reflect the very differentiated implementation of regualtion. This expectation is by and large confirmed by the empirical findings. The most stiking result is a positive wage differential in the segment for highly skilled labor in favor of holders of a yearly permit that contrasts with a negative diffenetial for trans-border commuters in this, as well as in the lower skill segments. Finally, foreign residents do not seem to suffer from wage discrimination as compared to residents of Swiss nationality. The very tight contingents on yearly permits seem to play againts the Swiss top managers with a rather high tenure and in favor of internationally sourced but expensive managers and specialists. On the other hand, the restrictions on access an job mobility for trans border commuters allow for a significant discrimination of this highly elastic labor supply.

Speculating about the impact of the liberalization brought about by the bilateral treaty on free mobility our results imply the following: in the market segmentation for top skills, the opening of the market will increase competition among foreigners for the highly paid jobs on the Ticino (Swiss?) labor market. Hence, salaries might fall improving the competitiveness of Swiss industry. Whether a lower discrimination will be considered positive for the residents is left to interpretation. In the quantitatively more important segment of medium skills, the liberalization will tend to have the opposite impact, creating a pressure on the positive differential for the Swiss workforce. Finally, the trans-border commuters, already occupying up to 70% of the jobs in some Ticino industries will above all enjoy the increased job mobility in Switzerland and hence create an upward pressure on salaries via inter-industry migration on the Ticino labor market. For the rest, given the highly elastic and the important share in the low skill labor market, the liberalization will not have a relevant impact on salaries of Swiss residents. It should finally be noted that these speculations do not take into account the eventually reduced demand for lavor in some industries (e.g.

building realted branches) due to direct competition from Italian firms.

A Incidental truncation in a bivariate normal distribution:

Following the theory of incidental truncation in a bivariate distribution we solve the equations n. 13 14 and 15. Suppose that y and z have a bivariate normal distribution with means μ_y, μ_z variance σ_y^2, σ_z^2 and correlation ρ, then:

$$E(y \mid z > a) = \mu_y + \rho\sigma_y\lambda(\alpha_z) \tag{16}$$

where $\alpha = \frac{a-\mu_z}{\sigma_z}$, $\lambda(\alpha_z) = \frac{\phi(\alpha_z)}{1-\Phi(\alpha_z)}$
if $z < a$, then we have to make a replacement: $\lambda(\alpha_z) = \frac{-\phi(\alpha_z)}{\Phi(\alpha_z)}$
if $a_1 < z \leq a_2$, then we have to make a replacement:$\lambda(\alpha_z) = \frac{\phi(\alpha_2)-\phi(\alpha_1)}{\Phi(\alpha_2)-\Phi(\alpha_1)}$

B The marginal effect of the regressors on the wage functions

The marginal effect of the regressors X on the wage (W_i) is β_S only if the regressor is a continous variable who doesn't apper in the selection function:

$$E(lnW_i \mid SD_i) = \beta\prime_S X_i + \psi_S \lambda_{Si}(\alpha_{Si}) + \eta_{Si} \tag{17}$$

$$E(W_i \mid SD_i) = e^{\beta\prime_S X_i + \psi_S \lambda_{Si}(\alpha_{Si}) + \eta_{Si}} \tag{18}$$

$$\frac{\delta E\left[Wi \mid SD_i\right]}{\delta X_i} = e^{\beta\prime_S X_i + \psi_S \lambda_{Si}(\alpha_{Si}) + \eta_{Si}} \beta\prime_S \tag{19}$$

$$\frac{\delta E\left[Wi \mid SD_i\right]}{\delta X_i} \frac{1}{E(W_i \mid SD_i)} = \beta\prime_S \tag{20}$$

In case that a regressor x_k appears in the ordered probit equation $SD_i = 1, 2, 3$, the marginal effect of x_k on lnW_i consists of two components [8]. The first is the direct effect on the mean of lnW_i, wich is β_S as conventionally; the second is the effect of the presence of λ_{Si} in the corrected equation.

Therefore the full effect of changes in a regressor x_k that appears in both X_i and Z_i in the low skill segment is:

$$\frac{\delta E\left[lnW_{LS} \mid SD_i = 1\right]}{\delta x_k} = \beta_{LSk} - \omega_k \frac{\rho_{\varepsilon \upsilon_{LS}} \sigma_{\upsilon_{LS}}}{\sigma_\varepsilon} \delta_{LSi}(\alpha_1) \tag{21}$$

where $\delta_{LSi}(\alpha_1) = \lambda^2_{LSi}(\alpha_1) - \alpha_1 \lambda_{LSi}(\alpha_1)$.

In the case of the medium skill segment the full marginal effect is represented by:

$$\frac{\delta E\left[lnW_{MS} \mid SD_i = 2\right]}{\delta x_k} = \beta_{MSk} + \omega_k \frac{\rho_{\varepsilon \upsilon_{MS}} \sigma_{\upsilon_{MS}}}{\sigma_\varepsilon} \delta_{MSi}(\alpha_1, \alpha_2) \tag{22}$$

and $\delta_{MSi}(\alpha_1, \alpha_2) = \left[\frac{\alpha_2 \phi(\alpha_2) - \alpha_1 \phi(\alpha_1)}{\Phi(\alpha_2) - \Phi(\alpha_1)} + \lambda^2_{MSi}(\alpha_1, \alpha_2)\right]$.

For the third segment (high skill) we have:

$$\frac{\delta E\left[lnW_{HS} \mid SD_i = 3\right]}{\delta x_k} = \beta_k - \omega_k \frac{\rho_{\varepsilon \upsilon_{HS}} \sigma_{\upsilon_{HS}}}{\sigma_\varepsilon} \delta_{HSi}(\alpha_2) \tag{23}$$

where $\delta_{HSi}(\alpha_2) = \lambda^2_{HSi}(\alpha_2) - \alpha_2 \lambda_{HSi}(\alpha_2)$.

For dummy variables (D_i) appearing in the wage function only (where $j = 1$ if $D = 1$ and 0 otherwise):

$$E(lnW_{ji} \mid SD_i) = \beta\prime_S X_i + \zeta\prime_S D_i + \psi_S \lambda_{Si}(\alpha_S) + \eta_{Si} \tag{24}$$

then the marginal effect on the wage can be explained [9] in the following way:

$$E(W_{1i} \mid SD_i) = e^{\beta\prime_S X_i + \psi_S \lambda_{Si}(\alpha_S) + \eta_i} e^{\zeta_S} \tag{25}$$

$$E(W_{0i} \mid SD_i) = e^{\beta\prime_S X_i + \psi_S \lambda_{Si}(\alpha_S) + \eta_{Si}} \tag{26}$$

$$\frac{E\left[W_{1i} SD_i\right] - E\left[W_{0i} SD_i\right]}{E\left[W_{0i} SD_i\right]} = e^{\zeta_S} - 1 \tag{27}$$

For the specific case of the regressors "experience" and "tenure" (represented by A_i), the variables appear in the wage functions in a quadratic formulation to capture the decreasing rate of return.

$$E(lnW_i \mid SD_i) = \beta\prime_S X_i + \beta\prime_A A_i + \beta\prime_{A^2} \frac{A_i^2}{100} + \psi_S \lambda_{Si}(\alpha_S) + \eta_{Si} \tag{28}$$

This implies that the marginal effect on wage is the following:

$$\frac{\delta E\left[Wi \mid SD_i\right]}{\delta A_i} \frac{1}{E(W_i \mid SD_i)} = \beta\prime_A + \frac{1}{50} \beta\prime_{A^2} A \tag{29}$$

C Variable specification

Variable	Description
Skill	Skill level required by employer.
Ln Wage	Natural logarithm of 2000 October's monthly standardised wage.
Industry:	
Manufacturing	Employed in the manufacturing branch (see NOGA2 15-37).
Construction	Employed in the construction branch (see NOGA2 45).
Retailing	Employed in the retail trade branch (see NOGA2 52).
Hotels and restaurants	Employed in the hotels and restaurants service branch (see NOGA2 55).
Finance and insurance	Employed in the finance or insurance service branch (see NOGA2 70-73).
Informatics and R&D	Employed in the informatics or reserach and developement service branch (see NOGA2 70-74).
Educational sector	Employed in the educational sector (see NOGA2 80).
Firm size	Size of firm, number of empoyees in the firm at 31 October 2000.
Hierarchical level:	
Top manager	Dummy variable: 1 = top management; 0 = otherwise.
Middle manager	Dummy variable: 1 = middle management; 0 = otherwise.
Lower manager	Dummy variable: 1 = lower management; 0 = otherwise.
Employees	Dummy variable: 1 = employee with limited responsability; 0 = otherwise.
Gender	Dummy variable: 1 = femal; 0 = man.
Occup. degree	Individual percentage of occupation in the firm.
Schooling	Years of schooling.
Experience	Years of experience in the labor market.
Tenure	Years spent in the current employment.
Martial status	Dummy variable: 1 = married; 0 = otherwise.
Union	Dummy variable: 1 = unionized worker; 0 = otherwise.

Continuation of variable specification's table

Permits:	
Seasonal	Dummy variable: 1 = seasonal (A) work permit; 0 = otherwise.
Annual	Dummy variable: 1 = annual (B) work permit; 0 = otherwise.
Resident	Dummy variable: 1 = resident (C) work permit; 0 = otherwise.
Cross border	Dummy variable: 1 = cross border (G) work permit; 0 = otherwise.
Other permits	Dummy variable: 1 = other permits (<1 year) work permit; 0 = otherwise.

D Descriptive statistics

Variable	All Sample	Low Skill	Medium Skill	High Skill
Wage*	5'035.20	3'629.40	5'304.15	11'463.60
Schooling*	11.73	10.48	12.29	14.47
Experience*	21.74	22.47	20.80	26.60
Tenure*	8.15	6.88	8.53	12.16
Firm size*	122	134	121	63
Occup. degree*	0.91	0.88	0.93	0.96
Married	28'388	10'948	15'345	2'095
Female	18'632	8'996	9'273	363
Swiss	23'278	5'847	15'404	2'027
Seasonal	683	439	234	10
Annual	2'517	1'403	975	139
Resident	10'357	4'975	4'997	385
Cross border	10'838	5'185	5'470	183
Other permits	498	190	249	59
Unionized	6'402	2'982	3'246	174
Top management	3'518	-	1'248	2'270
Middle management	3'268	-	2'944	324
Lower management	4'854	264	4'514	76
Employees	6'107	951	5'126	30
Other labor	29'159	16'158	12'904	97
Manufacturing	9'999	4'218	5'284	497
Construction	6'598	2'168	4'150	280
Retailing	5'108	2238	2'658	212
Hotels and restaurants	5'439	3'348	1'994	97
Finance and insurance	3'617	755	2'588	274
Informatic, immobile and R&D	3'617	755	2'588	274
Instruction	541	109	399	33
Observations	48'222	18'066	27'351	2'805

Note: The table reported the number of observation each variable.*Average.

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