The Effects of the Free Movement of Persons on the Distribution of Wages in Switzerland*

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Abstract

This paper combines a wage decomposition method with a structural econometric model in order to determine to what extent the free movement of persons (FMP) can be made responsible for the observed changes in the wage structure of natives in Switzerland. First, we identify the changes in returns to observable and unobservable skills of natives between 2002 and 2010, using non parametric and parametric decomposition techniques. Second, we estimate a structural model of the Swiss labor market in order to simulate the changes in returns to skills that would have been observed in the absence of the FMP. Third, we combine the two types of analyses and discuss whether the FMP can be considered as being a main cause of the increasing polarization of the Swiss wage distribution.

Keywords: Immigration; free movement of persons; wage distribution; decomposition methods

JEL codes: F22, J31, D33.

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1 Introduction

As a consequence of the bilateral agreement on the free movement of persons between the European Union and Switzerland, net immigration flows to Switzerland have increased substantially since 2002. Over the period 2002–2010, the median wage rose only by 2.5% in real terms. Referring to this parallel development, many politicians blame immigration for the weak increase in real wages. This argument was brought to the fore during the political campaign preceding the popular vote of 9 February 2014, which requires the Swiss government to introduce immigration quotas and a national preference clause within the next three years.

This paper addresses the question to what extent the free movement of persons (FMP) can be made responsible for the observed changes in the wage structure of natives in Switzerland. First, we identify the changes in returns to observable and unobservable skills of natives between 2002 and 2010, using non parametric and parametric techniques. Second, we estimate a structural model of the Swiss labor market in order to simulate the changes in the returns to skills that would have been observed in the absence of the FMP. Third, we combine the two types of analyses and discuss whether the FMP can be considered as being a main cause of the increasing polarization of the Swiss wage distribution.

The contribution of the paper to the literature is twofold. First, we combine two strands of the literature that have remained separate until now: the analysis of the wage consequences of immigration, on the one hand, and the decomposition of wage distributions, on the other hand. The structural model that is used to simulate the consequences of the FMP and the wage decomposition technique can be meaningfully combined because in both approaches we use the assumption that the labor market is segmented by skill (i.e. education and work experience). The assumption that workers with different levels of education and work experience are imperfect substitutes in production is commonly used in the recent literature on the wage effects of immigration (e.g. Borjas, 2003; Ottaviano and Peri, 2012) and it can be meaningfully integrated into the "reweighting" approach to wage decompositions (Fortin et al., 2011). Although there is a huge literature on the wage effects of immigration, this is the first paper to our knowledge that evaluates the role of immigration in the observed shifts in the wage distribution, by comparing the wage effects of immigration with the total changes in returns to skills during a period of high immigration.

Second, the Swiss case is interesting in its own right because immigration has recently reached high levels (both in terms of stocks and net flows) and the skill structure of immigration has undergone important changes over the last few years. The foreign-born share in the resident population has reached 28% at the end of 2013 and net yearly inflows are close to 1% of total population on average over the last few years. As to the skill structure of immigration, the share of immigrants with tertiary education has increased from one fifth in the early 1990s to more than one half in recent years.

The decomposition of the changes in the wage distribution between 2002 and 2010 is carried out in several steps. To identify pure wage structure effects, we account for two types of composition effects. First, the arrival of migrants changes the composition of the working population. This type of composition effect can be ruled out by focusing on the wage distribution of native (Swiss) workers.[1] Second, the composition of the native population also changes over time. We use the reweighting approach proposed by DiNardo et al. (1996) and Fortin et al. (2011, section 4.5) in order to control for this second type of composition effect. As a result of this decomposition, we can identify a wage structure effect which characterizes the changes in returns to observable and unobservable skills over the period 2002–2010.[2] What has been the role of increased immigration (due to the FMP agreement) in this evolution?

To answer this question, we use a model of the Swiss labor market in order to simulate the impact of the FMP agreement on the returns to observable skills. This model is based on the skill-cell approach and is built along the lines proposed initially by Borjas (2003) and refined by Ottaviano and Peri (2012) and many others.[3] We simulate the introduction of the FMP by comparing the observed evolution of immigration with a scenario that would have prevailed in the absence of FMP. As there are no econometric estimates of the determinants of migration to Switzerland in the literature, we adopt a very simple assumption which has the advantage of being transparent: we assume that the share of foreign workers would have remained constant for each skill cell in the absence of the FMP agreement.[4] With this assump-

[1]Due to data constraints, the distinction between "migrants" and "natives" used in our analysis is based on nationality, not on the place of birth. In an abuse of terminology, we will use the terms "natives" and "Swiss" as synonyms (as well as "migrants" and "foreigners").

[2]In the decomposition, we also distinguish between the returns to observable skills and the returns to unobservable skills, along the lines proposed by Lemieux (2002). See Section 2 for details.

[3]For applications of this approach to countries other than the US, see for example Manacorda et al. (2012) for the UK; D'Amuri et al. (2010), Brücker and Jahn (2011) and Felbermayr et al. (2010) for Germany, Gerfin and Kaiser (2010), Favre (2011) and Basten and Siegenthaler (2013) for Switzerland.

[4]Skill cells are defined as experience-education cells in the econometric model, as is customary in the literature.

tion, we simulate the impact of the FMP agreement on returns to skills and construct a counterfactual wage distribution that would have prevailed in the absence of the FMP. Finally, we evaluate the contribution of immigration to the observed change in returns to skills by comparing the simulated change in the wage distribution (capturing the effect of the FMP agreement) with the estimated wage structure effect (measuring the total change in returns to skills over the period 2002–2010).

The main results of our decomposition analysis can be summarized as follows. From a descriptive point of view, the native wage structure has become more unequal between 2002 and 2010. Whereas real wages stagnated in the lower part of the distribution, substantial increases could be observed for higher wages. Our decomposition analysis reveals that if we consider only the change in returns to skill (wage structure effect), the wage distribution has become more polarized: returns to low and (especially) high skills increased over time whereas they decreased (in real terms) in the middle of the distribution. The simulation of the FMP agreement shows that its introduction had an equalizing effect on wages. Because of the shift towards more highly skilled immigration, low wages have increased relative to high wages according to our simulations. Therefore, the FMP has contributed to the increase of real wages in the lower part of the native wage distribution and does not explain the polarization of the wage structure.

Our combination of a decomposition analysis with an econometric model is related to the work of Bourguignon et al. (2005) who use a reduced-form econometric model of household income generation in order to decompose changes in income distributions over time. By contrast to their approach, we use a structural model of the labor market in order to simulate the changes in the wage distribution due to immigration.

The remainder of the paper is structured as follows. The next section explains the decomposition method that we use in the paper. Section 3 gives an overview of the labor market model and the assumptions used in the simulation of the FMP agreement. Section 4 reports the results of the decomposition analysis and section 5 concludes.

2 Decomposition method

The main objective of our paper is to identify the changes in returns to observable and unobservable skills over the period 2002–2010 and to evaluate the contribution of the additional immigration that resulted from the FMP agreement between Switzerland and the EU. Our approach combines parametric and non parametric methods. In a first step, we decompose the observed change in the wage distribution of Swiss workers into a composition effect and a "wage structure" effect. This *aggregate decomposition* (following the vocabulary of Fortin et al., 2011) relies on very general assumptions and allows to estimate the changes in returns to observable and unobservable skills (the "wage structure" effect) in a robust way.

In a second step, we decompose the wage structure effect further and distinguish the changes in returns to observable characteristics (education and experience) from changes in returns to unobservable characteristics. This *detailed decomposition* relies on the estimation of a (flexibly specified) wage equation.

In our context, it is useful to identify the changes in returns to *observable* skills because these are directly comparable with the simulations of the impact of the FMP agreement using the econometric labor market model. The labor market model is built on the same basic assumption as the wage equation used in the detailed decomposition: the labor market is segmented by skill. In both frameworks, we assume that skill cells are defined as education-experience cells.[5] The observable component of the wage structure effect can therefore be meaningfully compared to the simulated effects of the FMP agreement. The remainder of this section describes the decomposition method in more detail (a summary of the decomposition procedure is given in Table 1).

Aggregate decomposition. First we use the reweighting method proposed by DiNardo et al. (1996) to carry out the aggregate decomposition of the total change Δ_{tot} in the wage distribution between 2002 and 2010:

$$\Delta_{tot} = \Delta_X + \Delta_S \tag{1}$$

where Δ_X is the composition effect and Δ_S the wage structure effect. The composition effect captures the part of the change in the wage distribution that can be explained by changes in the distribution of employees' characteristics (education, experience, gender...). By contrast, the wage structure effect measures the change in the wage distribution that can be attributed to changes in the return to observable and unobservable characteristics of employees.

The reweighting method (described in more detail in the appendix) proposed by Fortin et al. (2011) consists in estimating reweighting factors Ψ_x for each observation that can be used to calculate counterfactual sample weights for the year 2010: $\omega^C_{2010} = \Psi_x \, \omega_{2010}$, where ω_{2010} are sample weights for 2010. Together with

[5] We distinguish three education levels and eight experience groups (five-year intervals). Therefore, there are 24 skill groups in the model

Table 1: Decomposition of the wage distribution: summary

Distribution		wage	weight
Wage distribution in 2010	(1)	w_{2010}	ω_{2010}
Counterfactual weights	(2)	w_{2010}	ω^C_{2010}
Counterfactual wages and weights	(3)	w^C_{2010}	ω^C_{2010}
Counterfactual without FMP	(4)	w^N_{2010}	ω^C_{2010}
Wage distribution in 2002	(5)	w_{2002}	ω_{2002}
Decomposition			
Composition effect	(1)-(2)		
Wage structure effect (total)	(2)-(5)		
- *observable*	(2)-(3)		
- *FMP*	(2)-(4)		
- *other*	(4)-(3)		
- *unobservable*	(3)-(5)		

Notes:
– counterfactual weight: $\omega^C_{2010} = \Psi_x \; \omega_{2010}$,
– counterfactual wage: $\ln w^C_{2010} = X_{2010}\hat{\beta}_{2002} + \hat{\varepsilon}_{2010}$,
– simulated wage: $\ln w^N_{2010} = \ln w_{2010} - d \ln w^N_{2010}$

the actual wages observed in 2010, these counterfactual weights allow to construct a wage distribution that would have prevailed in 2010 if the distribution of individual characteristics had remained the same as in 2002. This counterfactual distribution can then be used to distinguish the composition effect from the wage structure effect. The composition effect is given by the difference between the actual wage distribution in 2010 and the counterfactual wage distribution, whereas the wage structure effect is obtained as the difference between the counterfactual distribution and the actual wage distribution in 2002 (see Table 1).

Detailed decomposition. In a second step we further decompose the wage structure effect into an observable and an unobservable component:

$$\Delta_S = \Delta_S^{obs} + \Delta_S^{unobs} \tag{2}$$

where Δ_S^{obs} is explained by changes in the return to *observable* characteristics (education, experience, gender etc.) and Δ_S^{unobs} is due to changes in the return to *unobservable* characteristics.

To carry out the detailed decomposition, we follow Lemieux (2002) and estimate the following wage equation for the years $t = 2002, 2010$:

$$\ln w_t = X_t\beta_t + \varepsilon_t, \tag{3}$$

where w_t is the wage and X_t includes a large set of personal characteristics of employees (dummies for education levels, experience groups and gender, and interactions between all these variables). From these wage equations, we compute a counterfactual wage for 2010

$$\ln w^C_{2010} = X_{2010}\hat{\beta}_{2002} + \hat{\varepsilon}_{2010}, \tag{4}$$

which attributes to each individual the wage she would have received in 2010 if returns to observable characteristics had remained the same as in 2002.

The observable component of the wage structure effect can then be obtained by comparing the distribution of actual wages in 2010 (w_{2010}) with a (counterfactual) distribution where the actual wages are replaced by counterfactual wages w^C_{2010}. In this comparison, the same sample weights are used for both distributions. (As our decomposition is sequential, we use the counterfactual weights ω^C_{2010} for both distributions, see Table 1).[6]

Identifying the contribution of migration (FMP). In a last step we identify the contribution of the FMP agreement to the observable component of the wage structure effect:

$$\Delta^{obs}_S = \Delta^{FMP}_S + \Delta^{other}_S \tag{5}$$

where Δ^{FMP}_S represent the changes in the return to observable characteristics (education, experience) due to migration (FMP) and Δ^{other}_S is a residual component which captures the influence of all other factors (changes in labor supply by Swiss workers, skill-biased technological change, routinization, off-shoring, changes in gender differentials, pay norms etc.).

The wage changes captured by the component Δ^{FMP}_S are simulated using a structural model of the labor market (described in the next section) and assumptions about a *"No FMP"* scenario. A counterfactual wage that would have been observed in the absence of a FMP agreement can be calculated as follows

$$\ln w^N_{2010} = \ln w_{2010} - d\ln w^N \tag{6}$$

where $d\ln w^N$ is the change in log-wages of native workers obtained by simulation with the structural labor market model, as described below in section 3.

[6]The decomposition could be carried out in a different order but the results for the wage structure effect change very little whether actual weights ω_{2010} or counterfactual weights ω^C_{2010} are used.

3 Labor market model

Our model of the labor market follows the structural approach (or skill-cell approach) initiated by Borjas (2003). This approach takes into account both direct and indirect effects of immigration: the arrival of a young highly skilled immigrant decreases the wage of comparably skilled native workers but tends to increase the wage of low-skilled workers through complementarity effects. It is important to take these complementarity effects into account when evaluating the impact of immigration on the wage distribution.

Following Card and Lemieux (2001), Borjas (2003) assumes that workers with different levels of work experience are imperfect substitutes in production, even if they possess the same level of education. Therefore, he distinguishes different labor market segments that are defined by education-experience groups. Labor demand is modeled using an aggregate production function that is specified as a nested CES function. In his analysis, Borjas (2003) assumes that native and immigrant workers are perfect substitutes within an education-experience cell.

This last assumption has been criticized by Ottaviano and Peri (2012) who argue that natives and immigrants are imperfect substitutes (even within an education-experience cell) because they tend to specialize in different tasks. For low-skilled workers, Peri and Sparber (2009) show that natives have a comparative advantage in communication tasks and immigrants specialize in manual tasks. Responding to Ottaviano and Peri (2012), Borjas et al. (2012) emphasize that the question whether native and migrant workers are perfect or imperfect substitutes is an empirical question.

3.1 Structure of the model

The structure of our model follows closely Ottaviano and Peri (2012) but we take the criticism of Borjas et al. (2012) into account when estimating the elasticity of substitution between native and immigrant workers. The structure of the nested CES specification of the aggregate production function is depicted in Figure 1. At the upper level, aggregate output Y_t at time t is modeled using a Cobb-Douglas production function with constant returns to scale:

$$Y_t = A_t K_t^{1-\alpha} L_t^{\alpha}, \tag{7}$$

where K_t is the aggregate capital stock and A_t total factor productivity. The labor aggregate L_t is a CES aggregate of high-skill and low-skill labor:

$$L_t = \left(\gamma_t^{low}(L_t^{low})^{\frac{\sigma_e-1}{\sigma_e}} + \gamma_t^{high}(L_t^{high})^{\frac{\sigma_e-1}{\sigma_e}}\right)^{\frac{\sigma_e}{\sigma_e-1}}, \tag{8}$$

where σ_e is the elasticity of substitution between high-skill (i.e. tertiary educated) and low-skill labor. The latter is a CES aggregate of two education categories (primary and secondary education):

$$L_t^{low} = \left(\sum_{i=1}^{2} \eta_{it} L_{it}^{\frac{\sigma_\ell-1}{\sigma_\ell}}\right)^{\frac{\sigma_\ell}{\sigma_\ell-1}}, \qquad L_t^{high} = L_{3t}, \tag{9}$$

where σ_ℓ is the elasticity of substitution between workers with primary education (L_{1t}) and those with secondary education (L_{2t}).[7] Skill-biased technological change is taken into account by the fact that parameters γ_t^{low}, γ_t^{high} and η_{it} may vary over time. Within an education category i, workers with different levels of experience j are imperfect substitutes:

$$L_{it} = \left(\sum_{j=1}^{8} \theta_{ij} L_{ijt}^{\frac{\sigma_x-1}{\sigma_x}}\right)^{\frac{\sigma_x}{\sigma_x-1}}, \tag{10}$$

where L_{ijt} denotes hours supplied by workers with education level i and belonging to experience group j, σ_x is the elasticity of substitution between experience groups, and θ_{ij} are share parameters that are constant over time. Finally, native and immigrant workers are imperfect substitutes within an education-experience cell:

$$L_{ijt} = \left(\lambda_{ijt}^N N_{ijt}^{\frac{\sigma_m-1}{\sigma_m}} + \lambda_{ijt}^M M_{ijt}^{\frac{\sigma_m-1}{\sigma_m}}\right)^{\frac{\sigma_m}{\sigma_m-1}}, \tag{11}$$

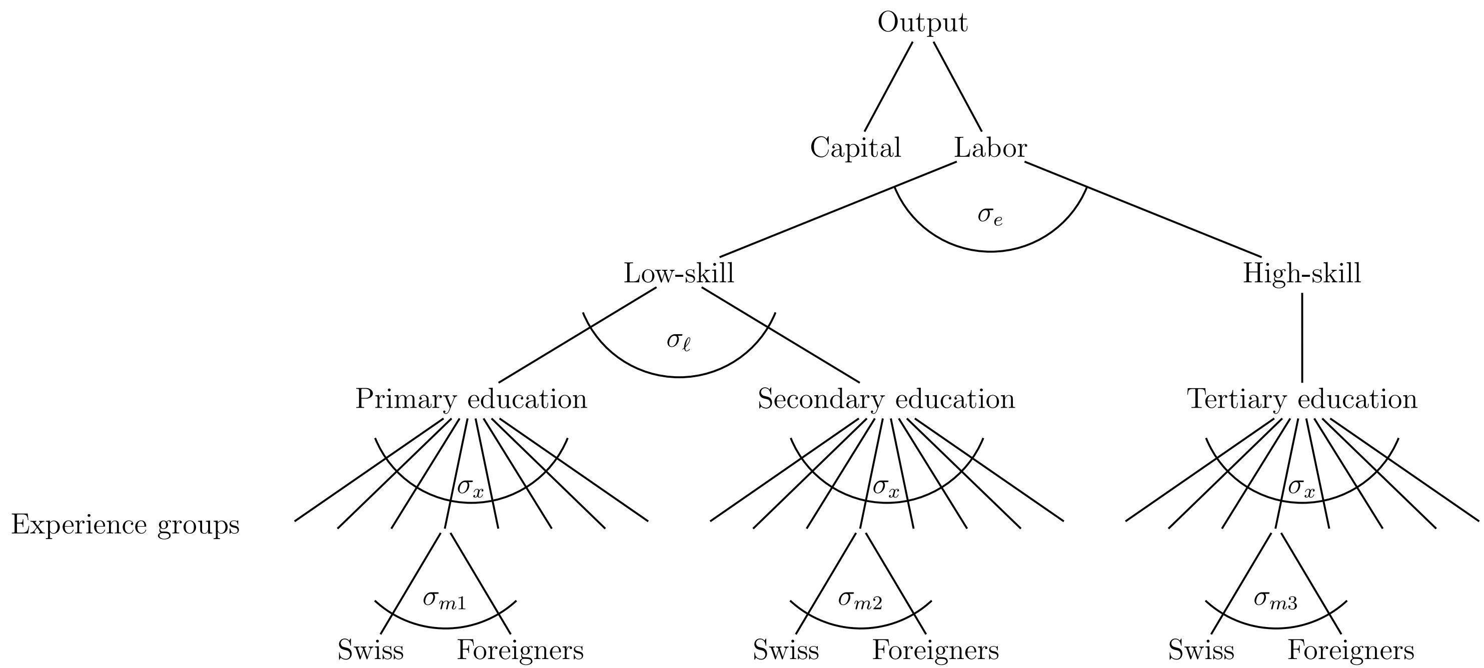
where σ_m is the elasticity of substitution between native and immigrant workers, N_{ijt} (M_{ijt}) denotes labor supply by native (migrant) workers with education i and experience j, and λ_{ijt}^N and λ_{ijt}^M are share parameters that can vary over time and by education and experience.[8]

The wage of a native worker with education level i and experience j is given by

[7]When estimating the elasticities of substitution, we also allow for the case where workers with primary education and those with secondary education are perfect substitutes ($\sigma_\ell \to \infty$). Then the first part of equation (9) can be written as: $L_t^{low} = \sum_{i=1}^{2} \eta_{it} L_{it}$.

[8]For the exact assumptions about parameters λ_{ijt}^N and λ_{ijt}^M, see the discussion of the estimation of σ_m in the next section and in Appendix C.

Figure 1: Structure of the aggregate production function



his (or her) marginal productivity:[9]

$$\begin{aligned}\ln w_{ijt}^{N} &= \ln(\alpha A_t \kappa_t^{1-\alpha}) + \frac{1}{\sigma_e}\ln L_t + \ln\gamma_{it} + \left(\frac{1}{\sigma_x} - \frac{1}{\sigma_e}\right)\ln L_{it} \\ &\quad + \ln\theta_{ij} + \left(\frac{1}{\sigma_m} - \frac{1}{\sigma_x}\right)\ln L_{ijt} + \ln\lambda_{ijt}^{N} - \frac{1}{\sigma_m}\ln N_{ijt}, \qquad (12)\end{aligned}$$

where $\kappa_t = K_t/L_t$ is the capital-labor ratio. The wage of a similarly skilled immigrant worker is

$$\begin{aligned}\ln w_{ijt}^{M} &= \ln(\alpha A_t \kappa_t^{1-\alpha}) + \frac{1}{\sigma_e}\ln L_t + \ln\gamma_{it} + \left(\frac{1}{\sigma_x} - \frac{1}{\sigma_e}\right)\ln L_{it} \\ &\quad + \ln\theta_{ij} + \left(\frac{1}{\sigma_m} - \frac{1}{\sigma_x}\right)\ln L_{ijt} + \ln\lambda_{ijt}^{M} - \frac{1}{\sigma_m}\ln M_{ijt}. \qquad (13)\end{aligned}$$

3.2 Estimation of substitution elasticities

We estimate all elasticities of substitution using data from the Swiss Earnings Structure Survey (SESS) over the period 1996–2010 (see Appendix A for a description of the data and Appendix C for details on the econometric estimation).

As our analysis focuses on the distribution of wages for Swiss workers, the elasticity of substitution between Swiss and foreign workers within an education-experience cell plays a crucial role in the simulation of the impact of the FMP agreement. Our estimations yield the consistent result that natives and immigrants are imperfect substitutes and are robust to the introduction of a rich set of fixed effects (i.e. two-way interactions of education, experience and time) and to the use of different sample weights (number of observations in a cell or an estimate of the inverse sampling variance).

Our preferred specifications include the largest set of fixed effects and yield estimates of the elasticity of substitution between native and immigrant workers (σ_m) of around 20.[10] The interaction between education and time fixed effects is important

[9] To avoid clutter, the following calculations are presented for a slightly simplified version of the nested CES function by assuming that equations (8) and (9) are replaced by:

$$L_t = \left(\sum_i \gamma_{it} L_{it}^{\frac{\sigma_e - 1}{\sigma_e}}\right)^{\frac{\sigma_e}{\sigma_e - 1}}.$$

[10] See specifications (4) and (8) in Table C.2 in Appendix C. To account for possible endogeneity of supplied hours, the ratio of hours worked of the two groups of workers is instrumented by the employment ratio (following Manacorda et al. (2012) who argue that the number of workers is a more exogenous source of variation than total hours supplied). Finally, the use of different weights does not seem to matter for the estimation results.

in the Swiss case because it accounts for compositional changes within the group of highly skilled workers (i.e. tertiary educated immigrants have become more skilled over time than tertiary educated natives). If we estimate substitution elasticities separately by education level, we obtain a substitution elasticity of approximately 10 for low-skilled workers whereas native and immigrant workers with a secondary education turn out to be perfect substitutes. For tertiary-educated workers, the substitution elasticity is estimated close to 20 but the case of perfect substitution can only be rejected at the 10 percent level of significance.[11]

For the estimation of the elasticity of substitution σ_x between different experience groups, we follow D'Amuri et al. (2010) and use fixed effects for time and experience groups and separate time trends for each education level. To account for possible endogeneity, we instrument total hours worked in an education-experience cell by the number of (recently arrived) foreigners. These estimates yield values between 10 and 12 for the elasticity of substitution between experience groups.[12]

The elasticity of substitution between education categories is difficult to estimate with our dataset because of the limited number of observations available at the upper level of the nested CES. Therefore we rely on Gerfin and Kaiser (2010) who use data from the Swiss Labor Force Survey (SLFS) which provides longer time series. In line with Card (2009), they find that workers with primary and secondary education levels are perfect substitutes. Moreover, their estimates of the elasticity of substitution between workers with tertiary education and those with primary/secondary education are between 3.6 and 4. Our limited data yield imprecise estimates but tend to confirm this result: we obtain an elasticity of substitution of 3.6, taking biased technological change into account.[13]

Our preferred estimates of elasticities of substitution are summarized in Table 2. To simulate the impact of the free movement of persons, we use the elasticities of *Model A* where the elasticity of substitution between natives and immigrants is differentiated by education level. A common elasticity is used for all education levels in *Model B*, which can be used as a robustness check for the simulation results.

3.3 Simulation of FMP agreement

To simulate the impact of the FMP agreement on the wage structure, it is necessary to spell out a *"No FMP"* scenario: how would labor supply and the stock of

[11] For estimation results by education level, see Table C.3 in Appendix C.

[12] Estimation results are given in Table C.4 in Appendix C.

[13] Regressing the logarithm of relative wages on relative labor supply (measured in hours) and on a linear time trend yields an estimate for $-1/\sigma_e$ of -0.276 with a robust standard error of 0.179 ($N = 8$).

Table 2: Substitution elasticities used in the simulations

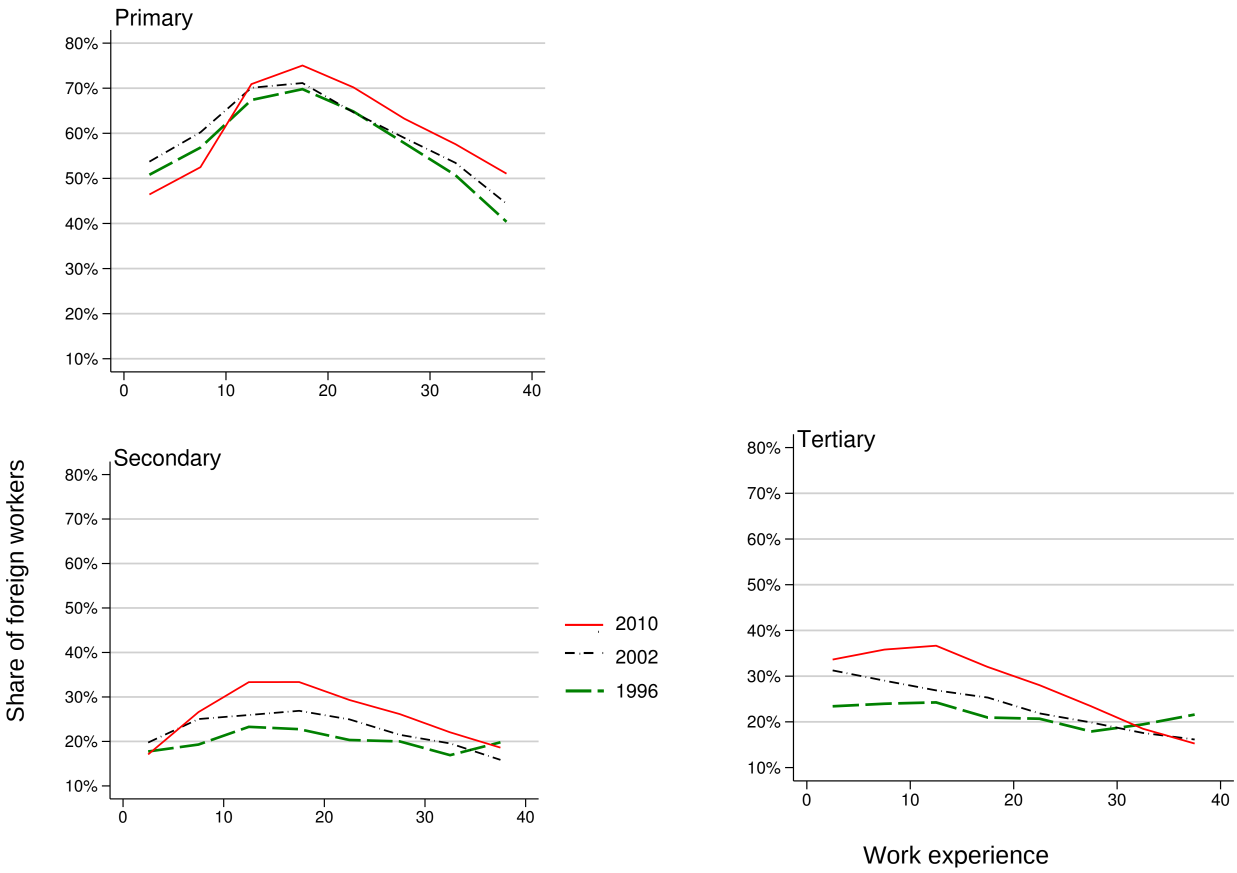
		Model A	Model B
Elasticity of substitution			
— between high-skill and low-skill labor	σ_e	3.6	3.6
— between primary and secondary education	σ_ℓ	∞	∞
— between experience groups	σ_x	10	10
— between Swiss and foreign workers - primary	σ_{m1}	10	20
— between Swiss and foreign workers - secondary	σ_{m2}	∞	20
— between Swiss and foreign workers - tertiary	σ_{m3}	∞	20

capital have evolved in the absence of a FMP agreement? As reliable econometric evidence for Switzerland is lacking, we adopt the following simple and transparent assumptions. First, we assume that the share of foreign workers would have remained constant in each education-experience cell over the period 2002–2010 in the absence of a FMP agreement. Second, we assume that the capital stock would have fully adjusted to its long-run level over this period.

The first assumption seems on the conservative side when we look at the evolution of the share of foreigners before the introduction of the FMP. As Figure 2 makes clear, the share of foreigners increased in most skill cells already before the introduction of the FMP (between 1996 and 2002) although the increase has been stronger since the adoption of the FMP in 2002. It might therefore be reasonable to assume that the share of foreigners would have continued to rise even in the absence of a FMP agreement. We prefer to keep the *"No FMP"* scenario simple and transparent at the risk of exaggerating its impact on wages. In any case, what matters for our analysis is the impact of the FMP on the *structure* of labor supply.

Regarding the evolution of the foreign shares in labor supply, two facts stand out in Figure 2. First, the legacy of the "guest-worker" era is reflected in the high share of low-skill foreigners that persists until today. Second, the recent shift towards more high-skilled immigration is attested by the marked upward shift of the foreign shares among tertiary-educated (and also secondary-educated) workers. Therefore, according to our *"No FMP"* scenario, the free movement of persons has had the largest positive impact on the supply of relatively young tertiary-educated workers. By contrast, among low-skilled workers the FMP increased moderately the supply

Figure 2: Share of foreign workers 1996–2010 (by education and experience)



of older workers and decreased the number of young (unexperienced) workers.[14]

The second assumption follows Ottaviano and Peri (2012) who assume that the capital-labor ratio is not influenced by immigration in the medium to long run. In neoclassical growth models, immigration increases the marginal productivity of capital only in the short run and the capital-labor ratio returns to its long-run trend after a transition period. According to the empirical analysis of Ortega and Peri (2009) for OECD countries, this adjustment of the capital stock takes place very rapidly: the capital-labor ratio returns to its long-run trend within a year.

This assumption has two implications. First, a proportional increase of labor

[14] For the precise shares of foreign workers in each skill cell in 2002 and 2010, see also Table A.1 in the appendix. A negative impact of the FMP agreement on the supply of young low-skilled workers might seem counter-intuitive at first sight. Although we cannot exclude that a decrease in the share of foreign workers in this group of workers would have taken place also in the absence of the FMP agreement, it can be plausibly argued that the FMP tends to increase emigration rates among EU citizens in Switzerland: the FMP agreement opens the possibility of coming back to Switzerland at any moment whereas, before 2002, EU citizens lost their work permit in Switzerland when they returned to their home country. Therefore the FMP agreement might well imply negative net immigration for some categories of the population.

supply in all skill cells does not affect wages. As mentioned above, it is the change in the structure of labor supply that matters for the wage impact of migration. Second, immigration has no effect on the average wage (of all workers) in our simulations. Therefore the introduction of the FMP agreement produces winners and losers among workers. However, native workers might benefit on average from immigration because native and immigrant workers are imperfect substitutes in production.

In the *"No FMP"* scenario, we assume that the share of foreigners in each education-experience cell would have remained the same after the year 2002. This amounts to assuming that immigrants' labor supply would have varied proportionally with labor supply by natives. If we denote the change in immigrants' labor supply over the period 2002–2010 by dM_{ij}, then the counterfactual (*"No FMP"*) immigration in each education-experience cell is equal to

$$\left.\frac{dM_{ij}}{M_{ij}}\right|_{No\ FMP} = \frac{dN_{ij}}{N_{ij}},$$

where dN_{ij} denotes the change in natives' labor supply over the period 2002–2010. Hence, the variation in labor supply that can be attributed to the FMP agreement is given by

$$\frac{dM_{ij}}{M_{ij}} - \left.\frac{dM_{ij}}{M_{ij}}\right|_{No\ FMP} = \frac{dM_{ij}}{M_{ij}} - \frac{dN_{ij}}{N_{ij}} = d\ln M_{ij} - d\ln N_{ij}. \tag{14}$$

The impact of this labor supply "shock" on wages can be obtained by differentiating equations (7) to (13), assuming that the capital-labor ratio κ_t remains constant.[15] For native workers with education i and experience j, the change in wages due to the FMP agreement is

$$d\ln w_{ij}^N = \frac{1}{\sigma_e} d\ln L + \left(\frac{1}{\sigma_x} - \frac{1}{\sigma_e}\right) d\ln L_i + \left(\frac{1}{\sigma_m} - \frac{1}{\sigma_x}\right) d\ln L_{ij}. \tag{15}$$

The relative changes in the different labor aggregates in equation (15) are given by

$$d\ln L = \sum_i s_i d\ln L_i, \quad d\ln L_i = \sum_j s_{ij} d\ln L_{ij}, \quad d\ln L_{ij} = s_{ij}^M (d\ln M_{ij} - d\ln N_{ij}),$$

where s_{ij}^M is the wage cost share of immigrant workers among all workers with education i and experience j, s_{ij} is the wage cost share of workers with experience j among all workers with education level i, and s_i is the wage cost share of workers

[15] As the labor supply shocks are small, we consider only first-order effects on wages by differentiating the marginal productivity schedule. See Manacorda et al. (2012) for a similar approach.

with education level i in total wage costs. Equation (15) provides the basis for the calculation of the contribution of the FMP to observed changes in the wage distribution of Swiss workers over the period 2002–2010 (see equation (6).

Although our decomposition analysis focuses on the distribution of wages of native workers, it is interesting to examine also the impact of the FMP agreement on wages of immigrants:

$$d \ln w_{ij}^{M} = d \ln w_{ij}^{N} - \frac{1}{\sigma_m}(d \ln M_{ij} - d \ln N_{ij}). \qquad (16)$$

Two important transmission mechanisms can be recognized by inspecting equations (15) and (16). First, the wage of a low-skill worker (native or "old immigrant) will be positively affected by the arrival of a "new" high-skill immigrant. Under the assumptions of our model, workers with different education levels are necessarily (Hicks-)complements. More generally, these complementarity effect operate also between workers with different experience levels. Second, as "old" immigrant workers are in direct competition with "new" immigrant workers, their wages are more negatively affected by the FMP than those of native workers. This phenomenon is captured by the last term in equation (16).

3.4 Simulation results

Overall, the wage effects of the FMP agreement are rather limited according to our simulation but there are winners and losers (see Table 3). These effects are determined, on the one hand, by the change in the labor supply structure induced by our FMP scenario and, on the other hand, by the complementarity and substitutability relationships between different skill types. Young workers with a tertiary education and limited work experience (10 to 15 years) suffer the greatest wage losses, mainly due to the increased labor supply of highly skilled immigrants. Their wages decrease by 1.6% as a consequence of the FMP agreement. Similar wage losses (−1.4%) are experienced by older foreign workers with a primary education and more than 35 years of work experience. By contrast, Swiss workers with a primary education tend to benefit from the FMP agreement since their wages increase by 1.1%. On the one hand, they benefit from their complementarity with high-skill workers and, on the other hand, they are partially shielded from the competition with low-skill immigrants because they tend to perform different tasks and are imperfect substitutes.

The wage impact of the FMP agreement is rather limited for workers with a secondary education, who constitute the large majority of the population in Switzerland. The positive impact of the FMP on young foreign workers with a primary education (their wages increase by more than 3%) might seem surprising. This simulation result is obviously due to our scenario assumption that the FMP agreement would have decreased the share of foreign workers in the category of workers with a primary education and less than 10 years of experience.[16] As we pointed out above (see footnote 14), the FMP agreement facilitates circular migration and could therefore be the cause of a rise in return migration of low-skill migrants. However, we cannot exclude that a decrease in the share of foreign workers in this group of workers would have taken place also in the absence of the FMP agreement. Therefore we simulate an alternative FMP scenario where the foreign share remains constant for low-skill workers with less than 10 years of experience. The simulation results show less favorable results for young low-skill foreign workers but wage outcomes of Swiss workers change very little.[17] Therefore, we can safely conclude that our decomposition of the wage distribution of Swiss workers is not affected by this (debatable) assumption in our FMP scenario.

As a robustness check for the simulation results, we use an alternative set of substitution elasticities (*Model B* in Table 2). In *Model B*, Swiss and foreign workers are imperfect substitutes at all education levels whereas *Model A* assumes imperfect substitutability only for workers with primary education. The simulation results of *Model B* for Swiss workers (see Table 4) show similar patterns as *Model A* but the outcome is more positive for Swiss workers with a secondary or tertiary education and more negative for "old" immigrants. For example, the wages of young Swiss workers with tertiary education and 11 to 15 years of experience decrease by only 0.6% (compared to 1.6% in *Model A*) whereas foreign workers with similar skills see their wage decrease by 3.0%.

For the decomposition analysis of the next section, we use the simulation results that are obtained with the parameters of *Model A*. From the discussion above it appears that this simulation might, if anything, overstate the wage effects of the FMP agreement. However, the qualitative conclusions of the decomposition analysis would not be greatly affected by the use of *Model B* or an alternative *"No FMP"* scenario.

[16] See Figure 2 and Table A.1 in the appendix.

[17] For Swiss workers, the results differ from those given in Table 3 by at most 0.1 percentage points, except for young Swiss workers with a secondary education and less than 5 years of experience: their wage increases by 0.9% instead of 1.3% in Table 3. For the complete results of this alternative simulation, see Table 24 in Müller et al. (2013).

Table 3: Impact of the FMP on wages in 2010 (Model A, % changes)

Education		Primary	Secondary	Tertiary
		Swiss workers		
Experience	0-5	1.1	1.3	-0.3
	6-10	1.1	0.7	-1.0
	11-15	1.1	-0.2	-1.6
	16-20	1.1	0.0	-0.9
	21-25	1.1	0.3	-0.8
	26-30	1.1	0.3	-0.3
	31-35	1.1	0.6	0.1
	36-40	1.1	0.6	0.3
		Foreigners		
Experience	0-5	3.4	1.3	-0.3
	6-10	3.5	0.7	-1.0
	11-15	0.8	-0.2	-1.6
	16-20	-0.5	0.0	-0.9
	21-25	-0.6	0.3	-0.8
	26-30	0.0	0.3	-0.3
	31-35	-0.2	0.6	0.1
	36-40	-1.4	0.6	0.3

Table 4: Impact of the FMP on wages in 2010 (Model B, % changes)

Experience groups	Primary	Secondary	Tertiary
Swiss			
0-5	1.7	1.1	0.0
6-10	1.8	0.8	-0.4
11-15	1.0	0.4	-0.6
16-20	0.5	0.5	-0.3
21-25	0.5	0.6	-0.3
26-30	0.7	0.6	0.0
31-35	0.7	0.8	0.2
36-40	0.4	0.8	0.3
Foreigners			
0-5	2.8	2.0	-0.7
6-10	3.0	0.4	-2.0
11-15	0.8	-1.4	-3.0
16-20	-0.3	-1.0	-2.0
21-25	-0.3	-0.4	-2.0
26-30	0.2	-0.6	-1.3
31-35	0.1	0.1	-0.3
36-40	-0.8	-0.2	0.4

4 Decomposition results

In this section, we first decompose the changes in the wage distribution of Swiss workers over the period 2002–2010 in order to distinguish composition effects from wage structure effects. In a second step, we address the question to what extent the changes in the wage structure can be attributed to the FMP agreement, using the simulation results from the econometric model.

By restricting our analysis to the wage distribution of Swiss workers, we exclude composition effects that result directly from immigration and emigration of foreign workers.[18] Figure 3 depicts the changes in the wage distribution since the FMP agreement entered into force. The median wage of Swiss workers increased by 1.7% in real terms over a period of eight years (0.2% per year on average). In the lower parts of the wage distribution the increase was even smaller except for wages between the fifth and the tenth percentile. On the other hand, substantial rises in real wages could be observed in the upper parts of the wage distribution.

To what extent is this increase in wage inequality in the upper part of the distribution driven by changes in the composition of the workforce? Even if our sample only includes Swiss workers, it is likely that older workers leaving the workforce during the eight-year period were less skilled than the new generation entering the labor market. The aggregate decomposition of equation (1) addresses this question without relying on restrictive assumptions.[19]

The results of the aggregate decomposition are depicted in Figure 4. The *composition effect* captures the change in the wage distribution that would have taken place if the returns to education and experience had not changed between 2002 and 2010. As expected, the skill upgrading of the labor force explains part of the observed increase in wage inequality: the composition effect rises almost linearly from zero to approximately 5% at the 90th percentile.

The *wage structure effect* describes the impact of the changes in the returns to education and experience on the observed wage distribution. The U-shaped form of the wage structure effect is striking: only wages below the 15th percentile or

[18]Because of data limitations, we focus on Swiss workers (rather than workers born in Switzerland). The focus on Swiss workers therefore neglects the fact that some foreign workers are naturalized during the period under analysis. Although immigration can change the skill composition of Swiss workers through the process of naturalization, this is not a major problem for our analysis since this composition effect is taken into account in the decomposition analysis. Our estimation of the wage structure effect would be biased only if naturalized workers were discriminated against or if their unobserved characteristics differed systematically from natives'.

[19]The reweighting factors are estimated using a logit specification and a wide set of explanatory variables including 9 education categories, 8 experience groups, gender and interactions between all these categorical variables; interactions between civil status and gender; 16 geographical variables characterizing the local labor market.

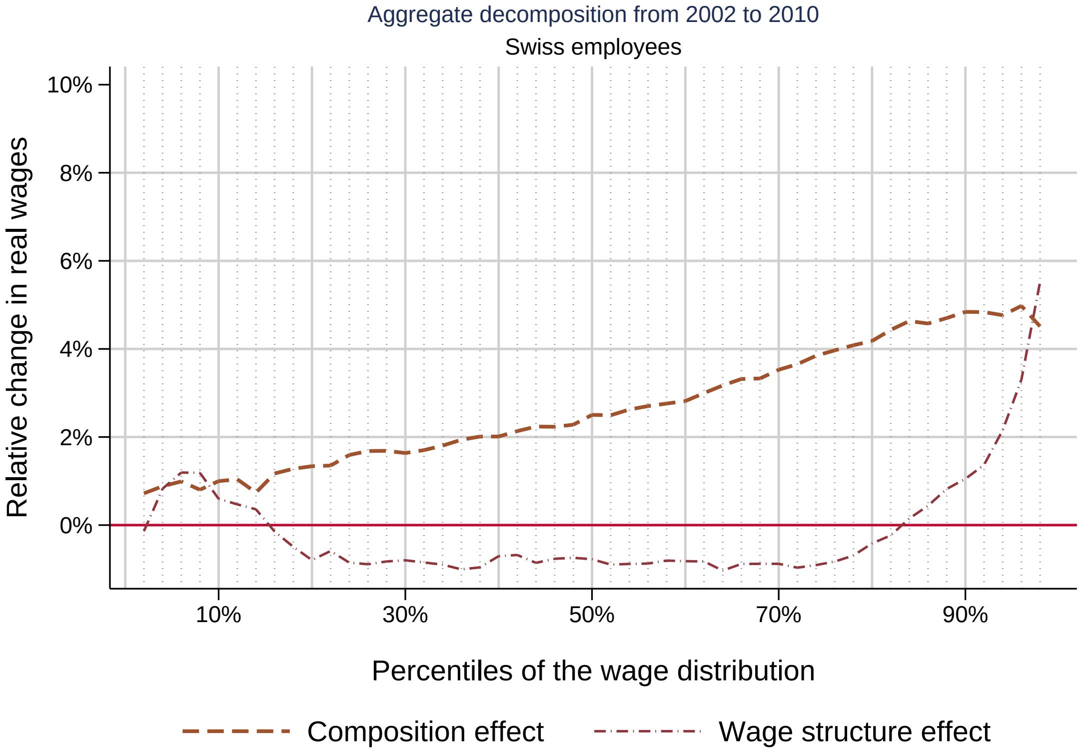
Figure 3: Evolution of the wage distribution (2002–2010)

above the 85th percentile increased in real terms over the period 2002–2010 whereas wages in the middle of the distribution (for 70 percent of the population) decreased slightly in real terms. Hence the returns to education and experience decreased for a majority of Swiss workers, reflecting an increasing polarization of the wage structure.

To what extent did the FMP agreement contribute to this polarization of the wage structure? Before answering this question, it is useful to examine whether the U-shaped form of the wage structure effect can be explained by changes in the returns to observable factors such as education, experience and gender. This *observable component* of the wage structure effect might be a better benchmark for comparison with the simulated impact of the FMP agreement since the econometric model captures the changes in returns to observable skills (education and experience) that are caused by immigration.

The comparison between the total wage structure effect and the *observable component* of the wage structure effect (respectively Δ_S and Δ_S^{obs} in equation (2)) is shown in Figure 5. The observable component captures the general U-shape of the wage structure effect but underestimates the degree of polarization of the wage

Figure 4: Aggregate decomposition



structure. In particular, the wage changes at both extremes of the distribution are underestimated. However, the qualitative conclusions of our analysis should not be affected by these approximations.

In a last step, we confront the total changes in returns to education and experience between 2002 and 2010 with those changes that can be attributed to the FMP agreement. This amounts to comparing the observable component of the wage structure effect (depicted in Figure 5) with the simulated impact of the FMP agreement (shown in Figure 6). The difference between the two is a residual effect which captures the changes in returns to education and experience that are caused by other factors (see Figure 6).

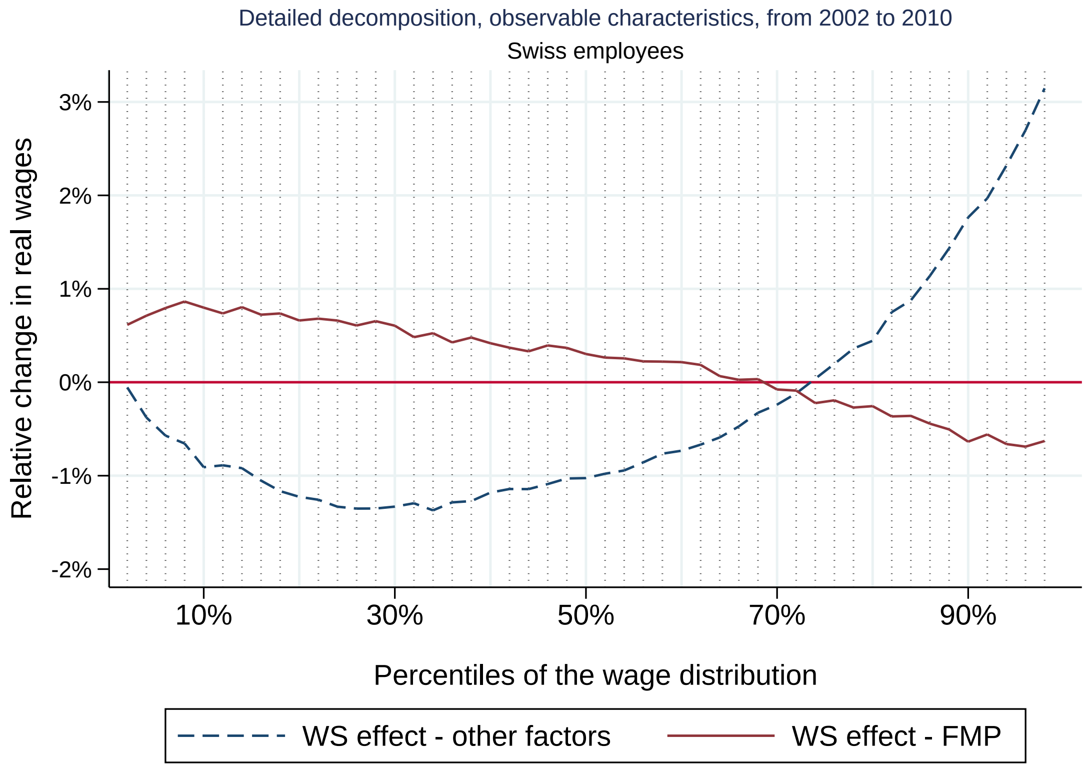
As the downward-sloping curve in Figure 6 shows, the FMP agreement had a positive but small impact on earnings below the 70th percentile of the wage distribution of Swiss workers. This result reflects the fact that for most Swiss workers with primary and secondary education, the FMP had a positive impact on their real wages (see Table 3). By contrast, the FMP had a negative impact on earnings of most workers with a tertiary education. This shows up in Figure 6 as negative wage effects above the 70th percentile.

Figure 5: Detailed decomposition: wage structure effect

These results make clear that the FMP cannot be made responsible for the stagnation of real wages in the middle of the wage distribution of Swiss workers. In the upper part of the wage distribution, the FMP even seems to have partially offset the strong wage increases that were driven by other factors. These other factors are represented by the U-shaped curve in Figure 6 (the "residual effect" Δ_S^{other} in equation (5)).

Our decomposition analysis does not provide any direct evidence as to what factors might have driven this polarization of the Swiss wage structure. The U-shaped increase in wages in Switzerland is consistent with evidence for the US in the 1990s and 2000s (Acemoglu and Autor, 2011; Firpo et al., 2011; Autor and Dorn, 2013). This polarization of the wage distribution can be linked to the "routinization" hypothesis according to which technological change is biased against jobs that involve routine tasks. This phenomenon is reinforced by the off-shoring of routine tasks that do not require personal interactions, leading to a fall in demand for occupations in the middle of the skill distribution. This job polarization has been documented not only for the US but also for Europe (Goos et al., 2014) and for Switzerland (Oesch and Rodriguez Menes, 2011).

Figure 6: Detailed decomposition: impact of free movement of persons (FMP)



We can therefore conjecture that the residual effect in our decomposition is the result of the combined effect of technological change and off-shoring, lowering the demand for occupations that are intensive in routine tasks. As a result, wages in the middle of the distribution tend to decrease relative to wages at the lower and upper ends of the distribution. Further analysis of these issues goes beyond the scope of this paper and is left for future work.

5 Conclusion

In this paper, we combine a wage decomposition method with a structural econometric model in order to address the question to what extent the (additional) migration due to the FMP has contributed to the observed changes in the wage distribution in Switzerland over the period 2002–2010. Our results show that the immigration of mostly high-skill workers tended to reduce wage inequality among Swiss workers over that period. The FMP agreement cannot be made responsible for the strong polarization of the wage structure. If anything, is has helped to increase wages at the bottom of the wage distribution.

Our decomposition results raise several questions that we were not able to address in this paper. First, some immigrants accept jobs that do not correspond to their formal level of education and work experience. Although this problem of "downgrading" seems rather limited in Switzerland at first sight, further analysis of this issue would be useful. Second, our decomposition method does not provide an explanation of the factors that drive the "residual effect" which reveals a polarizing tendency of the wage structure. Further analysis of the change in tasks performed by natives and immigrants would be helpful in order to understand these shifts in the wage structure.

In view of the public debate on immigration in Switzerland, we draw the following conclusions from our analysis. First, it would be important to acknowledge that, for given personal characteristics, real wages stagnated over the period 2002–2010 for a majority of Swiss workers. In other words, returns to education and experience decreased for workers located in the middle of the wage distribution (wage structure effect). This result is not apparent from a superficial look at wage statistics since it tends to be obscured by the improved skill composition of the working population (composition effect). Therefore, the results of the decomposition analysis provide a potential explanation for the gap between individual perceptions of stagnant real wages and the discourse of public officials who rely on descriptive statistics and proclaim that living standards have improved since the introduction of the free movement of persons.

Second, it should be emphasized that immigration (or the free movement of persons) does not play a major role in that evolution. If anything, immigration has decreased the inequality of the wage structure in Switzerland according to our simulations. Most political representatives seem to hold a different view in the recent political debates in Switzerland. The populist right-wing parties tend to emphasize and exaggerate the negative effects of immigration. On the left, many politicians react by acknowledging the dangers of immigration for wages of Swiss workers and use this argument to advocate the reinforcement of collective agreements and the introduction of sectoral minimum wages. As a consequence, unrealistically negative views of the wage impact of immigration dominate the political debate in Switzerland. We hope that our paper will contribute to a more objective view of the effects of the free movement of persons on the wage distribution.

Appendix

A Data

For our analysis, we use data from the Swiss Earnings Structure Survey (SESS). The SESS is a very large survey that was launched in 1994 by the Federal Statistical Office (FSO/OFS) and is repeated in two-year intervals. The SESS records individual wages within a representative sample of firms of all industries. Our sample is limited to employees in the private sector, aged 19 to 65 years old. For the estimation of the econometric model, we use data for the period 1996–2010. For the decomposition analysis, our starting point is the year 2002, when almost 1.1 million employees from 42'000 firms in the private sector were included in the survey, representing almost one third of the workforce in Switzerland. In 2010, 1.4 million employees were part of the survey, representing almost half of the workforce in the private sector.

The wage used in the analysis is a full-time equivalent wage rate: the gross monthly earnings linearly standardized at 40 hours per week. The level of education of each individual is captured by a categorical variable in the survey. For the econometric analysis, we aggregate the nine education categories of the survey into three broad education categories: tertiary, secondary and primary (for details see Müller et al., 2013, Table 6). Potential experience is measured by (age − years of schooling − 6) and aggregated into eight experience groups (0 to 5 years, 6 to 10 years,..., 36 to 40 years). Individuals with more than 40 years of experience were dropped from the sample.

The survey does not provide the country of birth of individuals. Therefore we rely in our analysis on the criterion of nationality (Swiss or foreign) of workers. As the wage and employment information in the SSES is collected from firms operating in Switzerland, our sample includes cross-border workers living in neighboring countries. This is an important aspect of our analysis because the employment of cross-border workers has increased substantially in border regions of Switzerland as a consequence of the liberalization of rules for cross-border work included in the FMP agreement.

Our *"No FMP"* scenario is based on the assumption that the share of foreign workers would have been constant in each skill cell over the period 2002–2010 in the absence of a FMP agreement. Table A.1 shows the evolution of these shares (by education-experience cell) between 2002 and 2010.

Table A.1: Share of foreign workers in skill cells in 2002 and 2010

Education level		Primary	Secondary	Tertiary
Experience groups				
	2002	57.6	20.3	33.3
0-5 years	*2010*	52.0	17.4	36.5
	Difference	-5.6	-2.9	3.2
	2002	64.5	25.4	29.5
6-10 years	*2010*	58.9	27.0	36.7
	Diffrence	-5.7	1.6	7.2
	2002	72.2	26.6	27.4
11-15 years	*2010*	72.8	34.2	37.6
	Difference	0.7	7.6	10.2
	2002	73.5	28.6	26.0
16-20 years	*2010*	76.6	34.9	33.0
	Difference	3.0	6.4	7.1
	2002	68.7	27.0	22.0
21-25 years	*2010*	72.2	31.4	28.7
	Difference	3.5	4.4	6.7
	2002	63.6	23.4	19.9
26-30 years	*2010*	66.3	28.1	24.2
	Difference	2.6	4.7	4.2
	2002	57.9	21.2	17.4
31-35 years	*2010*	61.0	23.7	18.9
	Difference	3.1	2.5	1.5
	2002	48.6	17.2	16.1
36-40 years	*2010*	54.9	20.0	15.7
	Difference	6.3	2.8	-0.4

B The reweighting method

This appendix gives an overview of the reweighting method (due to Fortin et al., 2011) that we use in the aggregate decomposition of the wage distribution of Swiss workers. Consider a situation where observations are drawn from the joint distribution of w (wage), x (vector of individual characteristics) and t (year, $t = 0, 1$) The density of wages at time $t = 1$ can then be written as

$$f^1(w) = \int f(w, x \mid t = 1)dx$$

By definition of the conditional density, we have

$$f^1(w) = \int f(w \mid x, t = 1)f_x(x \mid t = 1)dx$$

where

- $f(w \mid x, t = 1)$: conditional distribution of wages in $t = 1$
- $f_x(x \mid t = 1)$: distribution of individual characteristics in $t = 1$

We can construct a counterfactual: the density that would have prevailed in $t = 1$ if the distribution of individual characteristics had remained the same as in $t = 0$:

$$f^C(w) = \int f(w \mid x, t = 1)f_x(x \mid t = 0)dx$$

This can be rewritten as

$$f^C(w) = \int f(w \mid x, t = 1)\Psi_x(x)f_x(x \mid t = 1)dx$$

where $\Psi_x(x) = f_x(x \mid t = 0)/f_x(x \mid t = 1)$ is a "reweighting factor" which can be rewritten, using Bayes' theorem:

$$\Psi_x(x) = \frac{P(t = 0 \mid x)P(x)}{P(t = 0)} \frac{P(t = 1)}{P(t = 1 \mid x)P(x)}$$

Rearranging the terms:

$$\Psi_x(x) = \frac{P(t = 0 \mid x)}{P(t = 1 \mid x)} \frac{P(t = 1)}{P(t = 0)}$$

where $P(t = 0 \mid x)$ and $P(t = 1 \mid x)$ can be estimated by logit or probit. This can be done by pooling all data and estimating the probability of belonging to period 0 or 1.

The difference between distributions $f^1(w)$ and $f^0(w)$ can then be decomposed as follows

- composition effect (Δ_X): difference between $f^1(w)$ and $f^C(w)$
- wage structure effect (Δ_S): difference between $f^C(w)$ and $f^0(w)$

C Estimation of substitution elasticities

This appendix describes the estimation of the elasticities of substitution (i) between natives and immigrants and (ii) between experience groups.

Elasticity of substitution between natives and immigrants: σ_m

Taking the difference between equations (12) and (13) yields the logarithm of the relative wage of immigrant and native workers within an education-experience cell:

$$\ln\left(\frac{w_{ijt}^M}{w_{ijt}^N}\right) = \ln\lambda_{ijt} - \frac{1}{\sigma_m}\ln\left(\frac{M_{ijt}}{N_{ijt}}\right) \tag{C.1}$$

where $\lambda_{ijt} = \lambda_{ijt}^M/\lambda_{ijt}^N$. When estimating equation (C.1), Ottaviano and Peri (2012) parameterize λ_{ijt} by using experience-education and time fixed effects, i.e. $\lambda_{ijt} = \delta_{ij} + \delta_t$. Borjas et al. (2012) criticize this formulation as being too restrictive and suggest to use the following fixed effects: $\lambda_{ijt} = \delta_{ij} + \delta_{it} + \delta_{jt}$.

In our estimations of σ_m reported in Table C.2, we use either fixed effects for education, experience and time (without interactions) or the more flexible two-by-two interactions proposed by Borjas et al. (2012). Moreover, we use alternatively two different sample weights: the total number of hours worked (*hours*) or an estimate of the inverse sampling variance (*invvar*) and, in some specifications, we instrument total hours worked by the employment in the education-experience cell.

In Table C.3, we report estimates of σ_{mi} that are carried out separately for each education level.

Elasticity of substitution between experience groups: σ_x

The marginal productivity of labor (with education i and experience j) is given by:

$$\ln w_{ijt} = \ln(\alpha A_t \kappa_t^{1-\alpha}) + \frac{1}{\sigma_e}\ln L_t + \ln\gamma_{it} + \left(\frac{1}{\sigma_x} - \frac{1}{\sigma_e}\right)\ln L_{it} + \ln\theta_{ij} - \frac{1}{\sigma_x}\ln L_{ijt}$$

The estimating equation for the log-wage in skill cell (i, j) is:

$$\ln w_{ijt} = \delta_t + \delta_{it} + \delta_{ij} - \frac{1}{\sigma_x} \ln L_{ijt} \tag{C.2}$$

where $\delta_t = \ln(\alpha A_t \kappa_t^{1-\alpha}) + \frac{1}{\sigma_e} \ln L_t$, $\delta_{it} = \ln \gamma_{it} + \left(\frac{1}{\sigma_x} - \frac{1}{\sigma_e}\right) \ln L_{it}$, and $\delta_{ij} = \ln \theta_{ij}$.

Table C.4 reports the results of the estimation of equation (C.2) using OLS and IV regressions with two different instruments. The logarithm of the total hours worked in the education-experience cell ($\ln L_{ijt}$) is instrumented by the logarithm of (i) the number of foreign workers in the skill cell ($foreign$) or (ii) the number of recently arrived immigrants in the skill cell ($immrec$).

Table C.2: Elasticity of substitution between Swiss and foreign workers (σ_m): estimation results

Specification	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Estimation method	OLS	OLS	IV	IV	OLS	OLS	IV	IV
$-1/\sigma^m$	-0.022*	-0.045*	-0.026**	-0.050***	-0.022*	-0.044*	-0.026**	-0.050***
	(0.012)	(0.023)	(0.012)	(0.017)	(0.012)	(0.021)	(0.012)	(0.016)
Weight	hours	hours	hours	hours	invvar	invvar	invvar	invvar
Fixed effects								
education, experience, year	yes	yes	yes	yes	yes	yes	yes	yes
edu×exp, edu×year, exp×year	no	yes	no	yes	no	yes	no	yes
IV: 1st stage								
t-stat			26.30	10.75			24.66	10.18
Observations	192	192	192	192	192	192	192	192

Notes: Significant at the 10% (*), 5% (**), 1% (***) level. Robust standard errors, clustered at the education-experience level. IV: log(ratio of hours worked) is instrumented by log(employment ratio of the two groups). In specifications (1) to (4), the weight is the total number of hours worked in the cell ($H_m + H_n$). In specifications (5) to (8), the weight is $H_m H_n/(H_m + H_n)$.

Table C.3: Elasticity of substitution between Swiss and foreign workers (σ_{mi}): estimation results by education level

Education level	PRIMARY		SECONDARY		TERTIARY	
Specification	(9)	(10)	(11)	(12)	(13)	(14)
Estimation method	OLS	IV	OLS	IV	OLS	IV
$-1/\sigma_{mi}$	-0.076***	-0.094***	-0.003	0.000	-0.045	-0.045*
	(0.015)	(0.014)	(0.012)	(0.011)	(0.033)	(0.027)
Weight	hours	hours	hours	hours	hours	hours
Fixed effects						
experience, year	yes	yes	yes	yes	yes	yes
IV: First stage						
t-stat		7.73		73.18		91.11
Observations	64	64	64	64	64	64
$-1/\sigma_{mi}$	-0.075***	-0.093***	-0.004	0.001	-0.047	-0.048*
	(0.014)	(0.015)	(0.013)	(0.011)	(0.033)	(0.026)
Weight	invvar	invvar	invvar	invvar	invvar	invvar
Fixed effects						
experience, year	yes	yes	yes	yes	yes	yes
IV: First stage						
t-stat		7.73		74.44		100.14
Observations	64	64	64	64	64	64

Notes: Significant at the 10% (*), 5% (**), 1% (***) level. Robust standard errors, clustered at the education-experience level. IV: log(ratio of hours worked) is instrumented by log(employment ratio of the two groups).

Table C.4: Elasticity of substitution between experience groups (σ_x): estimation results

Specification Estimation method	(1) OLS	(2) IV	(3) IV	(4) OLS	(5) IV	(6) IV
$-1/\sigma_x$	-0.049* (0.027)	-0.075*** (0.018)	-0.097*** (0.028)	-0.082*** (0.011)	-0.082*** (0.010)	-0.081*** (0.010)
Fixed effets						
education, experience, year	yes	yes	yes	yes	yes	yes
education × year	yes	yes	yes	yes	yes	yes
educ2 × experience	no	no	no	yes	yes	yes
IV: 1st stage						
Instrument		foreign	immrec		foreign	immrec
t-stat		11.22	4.07		12.04	6.82
Observations	192	192	192	192	192	192

Notes: Significant at the 10% (*), 5% (**), 1% (***) level. Robust standard errors, clustered at the education-experience level. Fixed effects: "educ2" denotes a dummy variable which is equal to 1 if the education level of the cell is tertiary, and 0 else. IV: the logarithm of total hours worked is instrumented by the logarithm of the number of foreigners (foreign) or recent immigrants (immrec).

References

Acemoglu, Daron and David Autor (2011) "Skills, Tasks and Technologies: Implications for Employment and Earnings," in David Card and Orley Ashenfelter eds. *Handbook of Labor Economics, Vol. 4B*: Elsevier, pp. 1043 – 1171.

Autor, David H. and David Dorn (2013) "The Growth of Low-Skill Service Jobs and the Polarization of the US Labor Market," *American Economic Review*, Vol. 103, pp. 1553–97.

Borjas, George J. (2003) "The Labor Demand Curve Is Downward Sloping: Reexamining The Impact Of Immigration On The Labor Market," *Quarterly Journal of Economics*, Vol. 118, pp. 1335–1374.

Borjas, George J., Jeffrey Grogger, and Gordon H. Hanson (2012) "Comment: On Estimating Elasticities Of Substition," *Journal of the European Economic Association*, Vol. 10, pp. 198–210.

Bourguignon, François, F. Ferreira, and N. Lustig (2005) *The Microeconomics of Income Distribution Dynamics in East Asia and Latin America*: Oxford University Press.

Brücker, Herbert and Elke J. Jahn (2011) "Migration and Wage-setting: Reassessing the Labor Market Effects of Migration*," *Scandinavian Journal of Economics*, Vol. 113, pp. 286–317.

Card, David (2009) "Immigration and Inequality," *American Economic Review*, Vol. 99, pp. 1–21.

Card, David and Thomas Lemieux (2001) "Can Falling Supply Explain the Rising Return to College for Younger Men? A Cohort-Based Analysis," *Quarterly Journal of Economics*, Vol. 116, pp. 705–746.

D'Amuri, Francesco, Gianmarco I. P. Ottaviano, and Giovanni Peri (2010) "The labor market impact of immigration in Western Germany in the 1990s," *European Economic Review*, Vol. 54, pp. 550–570.

DiNardo, John, Nicole Fortin, and Thomas Lemieux (1996) "Labor Market Institutions and the Distribution of Wages, 1973-1992: A Semiparametric Approach," *Econometrica*, Vol. 64, pp. 1001–44.

Favre, Sandro (2011) "The Impact of Immigration on the Wage Distribution in Switzerland," Working Paper Series 22, Department of Economics, University of Zurich.

Felbermayr, Gabriel, Wido Geis, and Wilhelm Kohler (2010) "Restrictive immigration policy in Germany: pains and gains foregone?" *Review of World Economics*, Vol. 146, pp. 1–21.

Firpo, Sergio, Nicole M. Fortin, and Thomas Lemieux (2011) "Occupational tasks and changes in the wage structure," IZA Discussion Paper 5542, Institute for the Study of Labor (IZA).

Fortin, Nicole, Thomas Lemieux, and Sergio Firpo (2011) "Decomposition Methods in Economics," in O. Ashenfelter and D. Card eds. *Handbook of Labor Economics, Vol. 4A*: Elsevier, pp. 1–102.

Gerfin, Michael and Boris Kaiser (2010) "The Effects of Immigration on Wages: An Application of the Structural Skill-Cell Approach," *Swiss Journal of Economics and Statistics*, Vol. 146, pp. 709–739.

Goos, Maarten, Alan Manning, and Anna Salomons (2014) "Explaining Job Polarization: Routine-Biased Technological Change and Offshoring," *American Economic Review*, Vol. 104, pp. 2509–26.

Lemieux, Thomas (2002) "Decomposing changes in wage distributions: a unified approach," *Canadian Journal of Economics*, Vol. 35, pp. 646–688.

Manacorda, Marco, Alan Manning, and Jonathan Wadsworth (2012) "The Impact of Immigration on the Structure of Wages: Theory and Evidence from Britain," *Journal of the European Economic Association*, Vol. 10, pp. 120–151.

Müller, Tobias, Noé Asensio, and Roman Graf (2013) "Les effets de la libre circulation des personnes sur les salaires en Suisse," Rapport final, mandat de recherche, Secrétariat d'Etat à l'économie SECO, Département fédéral de l'économie, Berne.

Oesch, Daniel and Jorge Rodriguez Menes (2011) "Upgrading or polarization? Occupational change in Britain, Germany, Spain and Switzerland, 1990-2008," *Socio-Economic Review*, Vol. 9, pp. 1–29.

Ortega, Francesc and Giovanni Peri (2009) "The Causes and Effects of International Migrations: Evidence from OECD Countries 1980-2005," NBER Working Papers 14833, National Bureau of Economic Research.

Ottaviano, Gianmarco I. P. and Giovanni Peri (2012) "Rethinking the Effect of Immigration On Wages," *Journal of the European Economic Association*, Vol. 10, pp. 152–197.

Peri, Giovanni and Chad Sparber (2009) "Task Specialization, Immigration, and Wages," *American Economic Journal: Applied Economics*, Vol. 1, pp. 135–169.