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Summary

We adopt a general equilibrium approach in order to measure the effects of recent immigration on the Western German labor market, looking at both wage and employment effects. Using the Regional File of the IAB Employment Subsample for the period 1987-2001, we find that the substantial immigration of the 1990's had no adverse effects on native wages and employment levels. It had instead adverse employment and wage effects on previous waves of immigrants. This stems from the fact that, after controlling for education and experience levels, native and migrant workers appear to be imperfect substitutes whereas new and old immigrants exhibit perfect substitutability. Our analysis suggests that if the German labor market were as 'flexible' as the UK labor market, it would be more efficient in dealing with the effects of immigration.

Keywords: Immigration, Skill Complementarities, Employment, Wages

JEL Classification: E24, F22, J61, J31

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1 Introduction

Germany has the largest number of foreign individuals in Europe, and foreign workers represent around 10% of the total labor force.[1] The socio-economic worries produced by rising immigration led the German government to introduce a selective immigration system based on quotas, which was passed by the parliament but declared void by the Federal Constitutional Court in 2002. In 2004 a comprehensive Immigration Act introduced the possibility for migrant workers to change their temporary residence permit for an unlimited one after having paid at least 60 monthly contributions to social security, provided that they pass a German language proficiency test.[2]

German labor market institutions are characterized by rigidity and generous unemployment benefits, which increases the potential for negative consequences due to immigration: newcomers are more likely to stay jobless and impose a cost on society. Such institutional features, specific to Germany, prevent the possibility of a straightforward extension from recent analyses focusing on the United States (Borjas 2003, Ottaviano and Peri 2006), the United Kingdom (Manacorda, et al 2006) and Israel (Friedberg, 2001) to the German case. Those countries all have much more flexible labor markets, lower hiring and firing costs and smaller unemployment insurance vis-a-vis Germany. Two considerations, however, emerge from those studies that should inform the analysis of the effects of immigration in Germany. First, the effects of immigration depend on the composition of native and immigrant workers, in terms of education and experience, and not just on the overall inflow of immigrants. In the case of Germany, this is stressed by De New and Zimmermann (1994) who analyze the wage effects of immigration to Germany for the 1984-1989 period. Segmenting the national labor market across industries, these authors find that immigrant workers substitute for unskilled natives and complement skilled natives. Second, and less obvious, is that even after controlling for education and experience, native and immigrant workers are not perfectly substitutable.

Certainly the labor market effects of immigration are sensitive to the institutional setup.[3] For instance, the importance of labor market institutions in mediating the effects of immigration on wages and employment is stressed by Angrist and Kugler (2003). For a panel of European Economic Area countries for 1983-1999, those authors show that labor market rigidities cause adverse employment effects. This finding echoes the results of Pischke and Velling (1997) who,

[1] Authors' calculation using the IAB data introduced in section 4.

[2] See Zimmermann et al. (2007) for an outline and an economic evaluation of the norms contained in the Immigration Act.

[3] For a theoretical model in which labor market institutions prevent wages from falling to their market clearing level when immigration occurs, see Schmidt et al. (1994).

using data on 167 German regions for the 1985-1989 period, show some evidence of the displacement of the native workforce by immigration. More recently, Glitz (2006) analyzes the specific issue of the impact of *ethnic German* immigration on relative skill-specific employment and wage rates of the resident population in different geographical areas between 1996 and 2001. He finds evidence of adverse employment effects but no detrimental effects on average wages.

The present paper investigates the interactions between immigration, employment and wages in Western Germany using a more structural general equilibrium approach recently employed in several national studies (Aydemir and Borjas, 2006; Borjas, 2003; Manacorda et al., 2006; Ottaviano and Peri, 2006). This approach is based on the aforementioned idea that the average and distributive effects of immigration depend on the exact composition of native and immigrant workers in terms of education and experience. This requires a careful estimation of the complementarities between different groups of workers because the marginal productivity (wages) of each group depends on the supply of workers in each other group. In particular, we allow native and migrant workers to be imperfect substitutes in production, even if sharing the same education and experience levels as in Ottaviano and Peri (2006) and Manacorda et al. (2006). In addition, in contrast to these works, we also allow for a further degree of imperfect substitutability between old and recent immigrant workers. Moreover, to account for the institutional frictions existing in the German labor market, we investigate not only the wage effects of immigration but also its employment effects.

Our results provide a full picture of the adjustment of the Western German labour market to migration in the period from 1987 to 2001. In terms of employment, we find negative but moderate effects of new immigrants on previous immigrants, while we do not find evidence of such effects on native workers. Reinforcing the evidence of stronger competition between new and old immigrants than between immigrants and native workers, we also find that natives and new immigrants are imperfect substitutes in production while new and old immigrants seem to be perfect substitutes. Different estimates for the elasticity of substitution imply different impacts of new immigrants on wages: very small for native workers, and somewhat negative for old immigrant workers. However, while employment effects are absent for all natives regardless of their educational attainment, wage effects show some variation as native workers with medium-low education face rising wages (by 0.36/1.04% from 1987 to 2001) and workers with high education see their wages fall (by -1.49% from 1987 to 2001). This is due to the fact that in the period of observation immigrants are more concentrated in the group with medium-high education than in the group with low education. As for the effects of new immigration on migrant workers already settled in West Germany, focusing

on the effects of post-1992 immigration on pre-1992 immigrants (we call this last group long-term immigrants), we find that on average new immigrants depress long-term immigrants' wages by -1.64% and two long-term immigrants lose their jobs for every ten new immigrants employed. Again, given the educational distribution of new immigrants, wage and job losses are concentrated in the group of long-term immigrants with relatively high educational attainment.

The paper is organized as follows: section 2 briefly outlines the relevant features of the history of immigration in Germany. Section 3 describes the theoretical framework behind our evaluation of the wage and employment effects of immigration. Section 4 presents the data used for our econometric analysis together with some descriptive evidence on the evolution of wage and employment levels in the German workforce. Results from the econometric analysis of the employment effects of immigration are discussed in Section 5 which also estimates the substitutability between natives and migrant workers. Section 6 uses the results of the previous section to calculate the general equilibrium effects of immigration on wages. Section 7 concludes.

2 Immigration to West Germany

After World War II West Germany experienced two large flows of immigrants. First, during the 1950's and 1960's, the country experienced a large inflow of Turks and Southern European (mostly unskilled) workers with no German background. Then, during the early 1990's, so-called *ethnic Germans* (individuals with German ancestry returning from abroad), and East Germans moved en masse to West Germany.[4]

The first inflow of foreign workers began in the mid-1950s. In that period the recruitment of *guest workers* coming mainly from South and South-East European countries started. Guest workers were poorly qualified workers recruited for a limited period of one to two years and then required to return to their countries of origin. The inflow of foreigners steadily increased during the cold war period until the 1973 oil crisis, when the economic downturn induced the government to ban the recruitment of workers from abroad. According to the German Federal Statistical Office, in that year foreign population accounted for around 6.4% of West Germany's total population. Notwithstanding the ban on the recruitment of *guest workers*, the foreign population remained constant, thanks to family reunifications for those workers who managed to settle permanently in Germany.[5]

[4]For a detailed description of immigration flows in Germany and for a survey of empirical results of its labor market impact see Zimmermann et al. (2007).

[5]Even if *guest workers* were formally allowed to spend only a limited time period in Germany, this provision

After the end of the Cold War, Germany resumed the temporary migration policy, mainly attracting workers from Central and Eastern Europe. Over the eleven years following the reunification in 1990, more than 2 millions Germans moved from the East to the West.(Statistisches-Bundesamt-Deutschland (2006a)) Another parallel immigration flow of *ethnic Germans* involved 2.8 million people between 1988 and 2001 (Statistisches-Bundesamt-Deutschland (2006b)). *Ethnic Germans* are a peculiar group of immigrants because they have German nationality but, since they lived abroad for a long period (often more than one generation), their knowledge of the German language and of German habits is not comparable to that of natives. For example, according to Federal Administration Office data reported in Bauer et al. (2005), 62.6% of 133817 *ethnic Germans* applying for admission to Germany between July 1996 and April 1999 failed the German language test. In the words of Zimmermann (1999), "ethnic Germans are basically facing the same difficulties with social and economic integration as foreigners". Overall, in 2001 7.3 million foreigners accounted for 8.8% of the total German population.

3 Theoretical framework

To analyze the wage and employment effects of immigration in West Germany we use a framework similar to the one Ottaviano and Peri (2006); Borjas (2003) adopted to analyze immigration to the US. Output is produced using a combination of physical capital and a labor composite of groups of workers differing in their education, age and national origins. The wage paid to each group is equal to its skill-specific marginal productivity jointly determined by the supplies of the various types of labor and their productivity. However, in the context of the German labor market, we augment the original setup of Ottaviano and Peri (2006); Borjas (2003) with elements used by Saint-Paul (1996), Acemoglu and Angrist (2001) as well as Angrist and Kugler (2003) to study the effects of labor market regulation. In particular, to fit the high flexibility of the US labor market, Ottaviano and Peri (2006); Borjas (2003) assume that the labor supplies of native and previously settled migrant workers ('old immigrants', for brevity) are perfectly inelastic. Hence, in their setup the inflow of new immigrants is entirely absorbed by changing wages. However, in the case of Germany, an additional and potentially relevant adjustment channel is constituted by changes in employment. Thus, following Angrist and Kugler (2003), we allow for some degree of flexibility in the labor supplies of both natives and old immigrants.

Using this framework wage elasticities and employment responses are estimated, focusing on

was not effectively enforced. Moreover, no recruitment halt was possible for foreign workers coming from European Community countries.

the effect of new immigration on old immigrants and natives. The estimated wage elasticities and labor supply responses are then combined in order to reconstruct the overall effect of immigration on the Western German labor market.

3.1 Labor Demand

Labor demand is determined by the profit maximizing choices of firms that employ labor and physical capital (K) to produce a homogeneous final output under constant returns to scale and perfect competition. Technology is such that physical capital and the labor composite are combined in a Cobb-Douglas production function to produce output. The labor composite is itself a CES aggregator of employees with different work experience nested within educational groups. We allow for further degrees of possible imperfect substitutability between natives and immigrants and also between old and new immigrants to Germany. The aggregate production function is:

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

where the subscript t indicates the time period, Y_t is output, A_t is total factor productivity (TFP), K_t is physical capital, L_t is the CES aggregator of different types of employees and $\alpha \in (0,1)$ is the income share of labor. The labor composite L_t is in turn defined as:

$$L_t = \left[\sum_{k=1}^{3} \theta_{kt} L_{kt}^{\frac{\delta-1}{\delta}} \right]^{\frac{\delta}{\delta-1}} \tag{2}$$

where L_{kt} is itself a CES aggregator of employees with educational level k and θ_{kt} are education specific productivity levels standardized such that $\sum_k \theta_{kt} = 1$. Workers are grouped in three educational levels, $k = 1, 2, 3$, that, as will be detailed in Section 4.1, correspond to workers with no vocational degree, workers with a vocational degree and workers with tertiary education. The parameter $\delta > 1$ measures the elasticity of substitution between workers with different education. As in (Card and Lemieux, 2001), workers with the same education but different work experience are also considered as imperfect substitutes with L_{kt} defined as:

$$L_{kt} = \left[\sum_{j=1}^{8} \theta_{kj} L_{kjt}^{\frac{\eta-1}{\eta}} \right]^{\frac{\eta}{\eta-1}} \tag{3}$$

where $j = 1, 2, ..., 8$ is an index capturing five-year intervals of potential experience, spanning from a minimum of 0 to a maximum of 40 years. The term $\eta > 1$ measures the elasticity of substitution between workers with the same education but different potential experience and θ_{kj} are their education-experience specific productivity levels, standardized such that $\sum_j \theta_{kjt} = 1$. Following

Ottaviano and Peri (2006), native and immigrant workers are allowed to be imperfect substitutes in production since, at least for the US and the UK, there is evidence that the two groups have different abilities and skills which are likely to affect their comparative advantage and hence their choice of occupation (Peri and Sparber (2007)). Consequently, L_{kjt} is defined as:

$$L_{kjt} = \left[\theta_{Hkjt} H_{kjt}^{\frac{\sigma-1}{\sigma}} + \theta_{Mkjt} M_{kjt}^{\frac{\sigma-1}{\sigma}}\right]^{\frac{\sigma}{\sigma-1}} \tag{4}$$

where H_{kjt} and M_{kjt} denote, respectively, native ('Home') and immigrant ('Migrant') workers; $\sigma > 1$ is their elasticity of substitution; θ_{Hkjt} and θ_{Mkjt} are their specific productivities with $\theta_{Hkjt} + \theta_{Mkjt} = 1$. Finally, we also allow M_{kjt} to be a CES aggregator of old and new immigrants:

$$M_{kjt} = \left[\theta_{kjt}^{OLD} \left(M_{kjt}^{OLD}\right)^{\frac{\lambda-1}{\lambda}} + \theta_{kjt}^{NEW} \left(M_{kjt}^{NEW}\right)^{\frac{\lambda-1}{\lambda}}\right]^{\frac{\lambda}{\lambda-1}} \tag{5}$$

where M_{kjt}^{OLD} and M_{kjt}^{NEW} respectively denote migrants with education k and experience j who migrated to Germany before and after 1992. In Section 4.1 we will argue that 1992 is an interesting watershed to identify 'old' (sometimes also called 'long-term' immigrants) and 'new' immigrants, particularly because German migrants from East to West are reported in the dataset starting with that year. In (5) the parameter $\lambda > 1$ denotes their elasticity of substitution while θ_{kjt}^{OLD} and θ_{kjt}^{NEW} represent their specific productivity levels standardized so that $\theta_{kjt}^{OLD} + \theta_{kjt}^{NEW} = 1$.

The production function (1) can be used to calculate the demand for each type of labor at a given period t. The relative efficiency parameters (θ) and the total factor productivity A_t depend on technological factors and are independent from the supply of migrant workers. In a competitive equilibrium and taking output as the numeraire good, the natural logarithm of the wage of native workers with education k and experience j equals the natural logarithm of their marginal productivity in units of output:

$$\begin{aligned} \ln w_{Hkjt} &= \ln\left(\alpha A_t \kappa_t^{1-\alpha}\right) + \frac{1}{\delta}\ln(L_t) + \ln(\theta_{kt}) - \left(\frac{1}{\delta} - \frac{1}{\eta}\right)\ln(L_{kt}) + \ln(\theta_{kjt}) - \left(\frac{1}{\eta} - \frac{1}{\sigma}\right)\ln(L_{kjt}) \\ &\quad + \ln(\theta_{Hkjt}) - \frac{1}{\sigma}\ln(H_{kjt}) \end{aligned} \tag{6}$$

where $\kappa_t = K_t/L_t$ is the capital-labor ratio. Similarly, the natural logarithm of the wage of old immigrants with education k and experience j is:

$$\begin{aligned} \ln w_{Mkjt}^{OLD} &= \ln(\alpha A_t \kappa_t^{1-\alpha}) + \frac{1}{\delta}\ln(L_t) + \ln(\theta_{kt}) - \left(\frac{1}{\delta} - \frac{1}{\eta}\right)\ln(L_{kt}) + \ln(\theta_{kjt}) - \left(\frac{1}{\eta} - \frac{1}{\sigma}\right)\ln(L_{kjt}) \\ &\quad + \ln(\theta_{Mkjt}) - \left(\frac{1}{\sigma} - \frac{1}{\lambda}\right)\ln(M_{kjt}) + \ln(\theta_{kjt}^{OLD}) - \frac{1}{\lambda}\ln(M_{kjt}^{OLD}) \end{aligned} \tag{7}$$

3.2 Labor Supply

Turning to the supply side of the labor market, we allow for the potential role of labor market regulation by assuming that the labor supply of natives and old immigrants is elastic and determined by unemployment insurance, since this is indeed a key characteristic of our dataset (see Section 4.1 for details). In particular, we assume that the labor supply function of natives with education k and experience j is:

$$H_{kjt} = \left[w_{Hkjt}\left(1-r\right)\right]^{\xi} \overline{H}_{kjt} \tag{8}$$

where $\overline{H}_{kjt}$ is the corresponding population, w_{Hkjt} is the wage rate as defined in the above section, $r \geq 0$ is the unemployment insurance replacement rate and $\xi > 0$ is the labor supply elasticity. Expression (8) captures the fact that employment supply by native workers responds to the uninsured portion of the wage they receive. Hence a change in wages (produced by a change in supply of some type of labor) may induce an employment response from natives. An analogous expression describes old immigrant labor supply:

$$M_{kjt}^{OLD} = \left[w_{Mkjt}^{OLD}\left(1-r\right)\right]^{\xi} \overline{M}_{kjt}^{OLD} \tag{9}$$

While the populations of native and old immigrant workers, $\overline{H}_{kjt}$ and $\overline{M}_{kjt}^{OLD}$, are given, the population of new immigrants is subject to exogenous shocks that map one-to-one into shifts in their labor supply. In particular, since new immigrants appear in our dataset only upon finding their first job in Germany, we assume that the labor supply of new immigrants M_{kjt}^{NEW} coincides with their population. Accordingly, M_{kjt}^{NEW} is exogenous whereas H_{kjt} and M_{kjt}^{OLD} are endogeneusly determined as wages adjust to the inflow of M_{kjt}^{NEW}.

3.3 Effects of Immigration on Wages

While in the short-run physical capital may be sluggish, on average it adjusts to changes in labor supply so as to keep its real rate of return constant. This implies that, in expressions (6) and (7), the capital-labor ratio κ_t follows a trend determined only by the growth of total factor productivity A_t. Hence, the overall impact of new immigration on wages paid to native workers is obtained by taking the total derivative of equation (6) with respect to the changes in all the labor aggregates (L_t, L_{kt}, L_{kjt}) induced by new immigrants in the various education and experience groups. Specifically, we can write:

$$\left(\frac{\Delta w_{Hkjt}}{w_{Hkjt}}\right)^{Total} = \frac{1}{\delta}\sum_m\sum_i\left[s_{Mmit}\frac{\Delta M_{mit}}{M_{mit}} + s_{Hmit}\left(\frac{\Delta H_{mit}}{H_{mit}}\right)_{response}\right] + \left(\frac{1}{\eta}-\frac{1}{\delta}\right)\frac{1}{s_{kt}}\sum_i\left[s_{Mkit}\frac{\Delta M_{kit}}{M_{kit}} + s_{Hkit}\left(\frac{\Delta H_{kit}}{H_{kit}}\right)_{response}\right] + \left(\frac{1}{\sigma}-\frac{1}{\eta}\right)\frac{1}{s_{kjt}}\left[s_{Mkjt}\frac{\Delta M_{kjt}}{M_{kjt}} + s_{Hkjt}\left(\frac{\Delta H_{kjt}}{H_{kjt}}\right)_{response}\right] - \frac{1}{\sigma}\left(\frac{\Delta H_{kjt}}{H_{kjt}}\right)_{response} \quad (10)$$

where the variable $s_{Mkjt} = w_{Mkjt}M_{kjt}/\sum_m\sum_i(w_{Mmit}M_{mit} + w_{Hmit}H_{mit})$ is the share of total wage income paid to migrant workers of education k and experience j in year t and s_{Hkjt} is the share of wage income paid to native workers in the same education-experience group. Similarly, $s_{kjt} = (w_{Mkt}M_{kt} + w_{Hkjt}H_{kjt})/\sum_m\sum_i(w_{Mmit}M_mit + w_{Hmit}H_{mit})$ is the share in wage income paid to all workers of education k and experience j in year t; s_{kt} is the wage share paid to all workers with education k in year t, and so on. The first double summation captures the cross-effects of immigration in groups of any education-experience level, the second summation captures the effects of immigration in groups with the same education at all experience levels, and the third and fourth effects capture the effects of immigrants within the same education-experience group.

The term $\Delta M_{kjt}/M_{kjt} = (M_{kjt+1} - M_{kjt})/M_{kjt}$ represents the change in the supply of immigrant workers with education k and experience j over the period between t and $t+1$. Analogously, the term $(\Delta H_{kjt}/H_{kjt})_{response}$ represents the change in labor supply of native workers in the same group caused by immigration. These terms account for the employment effects of immigration that arise in the presence of the elastic supplies of native and old immigrant workers as of (8) and (9):

$$\left(\frac{\Delta H_{kjt}}{H_{kjt}}\right)_{response} = \xi\frac{\Delta w_{Hkjt}}{w_{Hkjt}},$$
$$\left(\frac{\Delta M^{OLD}_{kjt}}{M^{OLD}_{kjt}}\right)_{response} = \xi\frac{\Delta w^{OLD}_{Hkjt}}{w^{OLD}_{Hkjt}},$$
$$\frac{\Delta M_{kjt}}{M_{kjt}} = \frac{\Delta M^{OLD}_{kjt} + \Delta M^{NEW}_{kjt}}{M^{OLD}_{kjt} + M^{NEW}_{kjt}} \quad (11)$$

Taken together with (10), expressions (11) imply that employment effects will have consequences for the impact of immigration on wages. A complete analytical solution of the effects of immigration on wages would require substituting expressions (11) into (10) and then solving for $\Delta w_{Hkjt}/w_{Hkjt}$ as a function of the change in new immigrants only, $\Delta M^{NEW}_{kjt}/M^{NEW}_{kjt}$. That would give a reduced form dependence of wages in each group on immigration, incorporating demand and supply parameters. In our empirical implementation, however, since we can observe $\Delta H_{kjt}/H_{kjt}$ and $\Delta M^{OLD}_{kjt}/M^{OLD}_{kjt}$, we will estimate empirically their supply response to $\Delta M^{NEW}_{kjt}/M^{NEW}_{kjt}$ (see equation (14)) and then include such estimation into (10).

Similarly, we can express the long run effect of new immigrants on long-term immigrants' wages as:

$$\begin{aligned}\left(\frac{\Delta w^{OLD}_{Mkjt}}{w^{OLD}_{Mkjt}}\right)^{Total} &= \frac{1}{\delta}\sum_m\sum_i\left[s^{NEW}_{mit}\frac{\Delta M^{NEW}_{mIt}}{M^{NEW}_{mit}} + s^{OLD}_{mit}\left(\frac{\Delta M^{OLD}_{mit}}{M^{OLD}_{mit}}\right)_{response} + s_{Hmit}\left(\frac{\Delta H_{mit}}{H_{mit}}\right)_{response}\right] \\ &+ \left(\frac{1}{\eta}-\frac{1}{\delta}\right)\frac{1}{s_{kt}}\sum_i\left[s^{NEW}_{kit}\frac{\Delta M^{NEW}_{kit}}{M^{NEW}_{kit}} + s^{OLD}_{kit}\left(\frac{\Delta M^{OLD}_{kit}}{M^{OLD}_{kit}}\right)_{response} + s_{Hkit}\left(\frac{\Delta H_{kit}}{H_{kit}}\right)_{response}\right] \\ &+ \left(\frac{1}{\sigma}-\frac{1}{\eta}\right)\frac{1}{s_{kjt}}\left[s^{NEW}_{kjt}\frac{\Delta M^{NEW}_{kjt}}{M^{NEW}_{kjt}} + s^{OLD}_{kit}\left(\frac{\Delta M^{OLD}_{kjt}}{M^{OLD}_{kjt}}\right)_{response} + s_{Hkjt}\left(\frac{\Delta H_{kjt}}{H_{kjt}}\right)_{response}\right] \\ &+ \left(\frac{1}{\lambda}-\frac{1}{\sigma}\right)\frac{1}{s_{Mkjt}}\left[s^{NEW}_{kjt}\frac{\Delta M^{NEW}_{kjt}}{M^{NEW}_{kjt}} + s^{OLD}_{kit}\left(\frac{\Delta M^{OLD}_{kjt}}{M^{OLD}_{kjt}}\right)_{response}\right] - \frac{1}{\lambda}\left(\frac{\Delta M^{OLD}_{kjt}}{M^{OLD}_{kjt}}\right)_{response}\end{aligned} \tag{12}$$

To sum up, once the parameters δ, η, σ and λ are estimated and once we know the employment responses of old immigrants and native workers to new immigrants, we will be able to calculate the wage effects of immigration for each group.

4 Data and Preliminary Evidence

In this section we present our dataset and discuss some preliminary evidence on the effects of immigration on German employment and wages.

4.1 The IAB Employment Subsample

The data we employ are from the German Institute for Employment Research (IAB).[6] The administrative dataset spans the period 1975-2001 and covers all employment spells subject to social security taxation and the unemployment spells during which the individual receives unemployment benefits. The population includes workers and trainees liable to make social security contributions. Self-employed, civil servants and students enrolled in higher education are not included in the dataset. According to Bender et al. (2000), in 1995 the population covers nearly 79.4% of all employed individuals in Western Germany, but the coverage varies across occupations and industries (coverage levels are not declared). The data we use are an annual random sample of 2% of the overall relevant population for a total of around 500,000 employment spells per year.

The IAB dataset is well suited for the analysis of labor market outcomes in the German labor market thanks to its large size (for the period 1975-2001 it records more than 20 million employment

[6] See Bender et al. (2000) for a detailed description .

spells) and to its reliability. For each employment spell, all the relevant information regarding employees liable to pay into social security is collected by the employer and reported directly to the social security agencies. Measurement error is therefore kept to a minimum. Since the transmission of all the relevant information to the employment agency is mandatory, there are no issues arising from unit non-response.

At the same time, the data have some minor limitations. All the available information covers only the period starting in 1975 and, given the administrative nature of the dataset, no recall questions can give information on the working history of each worker prior to that date. As a consequence, for instance, it is not possible to reconstruct the exact working experience of an individual but it will be necessary to impute it. In so doing, we follow the standard assumption that the potential experience is equal to the worker's age minus the typical age at which she is expected to have completed her education (Borjas (2003)).

A second and, for our purposes, more severe limitation of the data is that for immigrants neither the place of birth, nor the year of arrival in West Germany are recorded. What is available for each individual is the exact nationality at the country level. This is consistent with the fact that in Germany, until 2000, citizenship was defined according to the *jus sanguinis* principle.[7] Since the focus of this paper is on immigration rather than nationality, this requires further assumptions about the link between the former and the latter. In particular, we assume that workers with foreign nationality can be considered as immigrants. This approximation is subject to two types of errors. On the one hand, by using foreign nationality to identify immigrants, we may undercount them in the presence of high naturalization rates. This does not seem to be the case for Germany over the considered period. **Table 1** reports our calculations based on the Federal Statistical Office data. The annual naturalization rate, defined as the average of the annual ratio of naturalizations to foreign population, was never higher than 2% during the 1987-2001 period. On the other hand, in the presence of a large second generation of immigrants with foreign nationality, we may overcount the number of immigrants. However, since we identify most of our effects from the changes in a cohort of immigrants, the presence of a constant group of second generation immigrants will not affect the estimates much. Moreover, besides workers with *foreign nationality* we also identify two other groups as immigrants: German workers who migrated *from the East* to the West after reunification (and recorded as East German by the IAB); and *ethnic German*

[7] In year 2000 the principle of birthplace (*jus soli*) was added to the *jus sanguinis* one, allowing individuals born in Germany to naturalize provided that at least one of their parents is German born or has been living legally in the country for 8 years. Dual citizenship may be retained until the 23rd birthday, when the individual has to choose between the German nationality and her parents' one (for details see Zimmermann et al. (2007)).

workers, who primarily immigrated from Eastern Europe and who constitute the largest share of recent immigrant inflows and will be identified as explained in Section 4.2.

Our analysis focuses on the period 1987-2001. During this period an extremely large influx of immigrants substantially increased the share of non-Western German workers in the Western German labor force. **Table 2** reports the share of immigrants in the labor force as reported in the IAB dataset, showing that it climbed from 9.3% in 1987 to 13% in 2001. The time period analyzed is particularly convenient for the analysis of the labor market impact of immigration: the arrival of migrant workers was mostly driven by push factors (namely the fall of the Iron Curtain and the uncertainty following the aftermath of socialism in the countries of origin) rather than pull ones. Indeed, the large and sudden rise in the share of immigrant workers, mostly due to push factors, makes the behavior of the German labor market during our period of observation somewhat of a 'natural experiment'– one which is well suited to assessing the impact of immigration on incumbent workers.[8]

For each relevant year we include in our analysis men aged 17 to 64 who were working and receiving salary income on the 1st of July.[9] Nominal gross wages are all converted to 2000 Euros using the CPI-based deflator across years. As already anticipated, years of potential experience are calculated as current age minus the age at which the worker entered the labor force. This age of entry is assumed to be 16 for high school dropouts with no vocational education, 19 for high school dropouts with vocational education or high school graduates without vocational education, 21 for high school graduates with vocational education, 24 for those who completed non-university higher education and 25 for workers who hold a university degree.

The dataset reports gross daily wages, which are right censored by the upper limit of the social insurance contribution. Right censoring occurs in around 2% of the spells. Censored wages are then imputed using the estimated wage values obtained from the estimation of a Tobit regression model. This is run separately for each year and includes the following independent variables: experience, experience squared, educational attainment, nationality, 17 sectoral dummies and 131 occupational dummies.

The theoretical framework outlined in Section 3 stratifies native and non-native workers in cells defined by different education and experience levels, assuming perfect substitutability among workers within the same cell and imperfect substitution across cells. An important question is whether, in grouping natives and immigrants, one should take education and potential experience

[8] Bauer et al. (2005), p. 217, provide descriptive evidence on the independence between the growth of foreign employment and the business cycle after the fall of the Iron Curtain.

[9] As a robustness check, we also run all the regressions on the sample including both men and women.

data at face value. For instance, recent work on the UK reveals a substantial educational downgrading among immigrants, who tend to accept jobs requiring a lower level of qualifications than the ones actually achieved (Dustmann et al., 2007). In this case the reported level of education can be a poor indicator of the labor market position of immigrants, decreasing the preciseness of our stratification of workers across education-experience cells. In order to address this problem, we group native and immigrant workers according to reported education as well as according to 'adjusted' educational levels. In particular, similar to Card (2001) and Card (2007), for each available year we run an ordered probit regression for the native population with the reported level of education as the dependent variable and 17 sectoral plus 131 occupational dummies as independent variables. This regression estimates for each worker the probability of having each of the six possible educational levels, given his position in the labor market. **Table 3** shows a comparison between the densities of the reported and estimated educational levels of the native population in year 2001. Out of sample predictions are obtained for all immigrant workers and for those natives who failed to report their educational level and should otherwise have been dropped from the sample.[10] The corresponding densities, averaged across individuals in each year, are then used to calculate weighted employment and wage levels for our education-experience cells. In this way migrant workers are assigned a probability distribution for their educational level which is consistent with that of the natives for a given job. Workers in the same 'equivalent education' cell are employed in sectors that require a homogeneous skill level. While this correction should improve the homogeneity of workers' skills within the group, it is more subject to endogeneity bias as immigrants may adjust their occupation in Germany according to sectoral demand. For this reason, we also show the estimates when groupings are defined according to reported education. The six educational levels distinguishable in the dataset are further aggregated in three levels: 'Low Education' includes individuals without vocational education; 'Intermediate Education' includes individuals with vocational education; and 'High Education' includes individuals who completed a university degree or with non-university higher education.

Finally, a worker is considered as Western German if her nationality is German and if she has always been working in West Germany. Migrants moving from East Germany are identified as individuals with German nationality who started working in the East and then moved to the West. Even if German reunification took place in 1990, East Germany is recorded in our data only starting with 1992. Foreign migrants are individuals who have a non-German nationality

[10]The percentage of workers not reporting their educational level is significant (11.3% in 2001) and could bias our sample if the non-response behaviour is not homogeneous across individuals with different education-experience or migration background.

or *ethnic Germans* coming from abroad. Particular attention is devoted to identifying the *ethnic German* group of immigrants. These are immigrants mostly from Eastern European countries and, as discussed in Section 2, tend to behave just like other immigrants from those countries. However, they are barely distinguishable from Western German nationals in the data set. We describe in the next section how we deal with their presence in our empirical strategy.

4.2 Imputing *Ethnic German* immigrants

With the end of the cold war a large number of *ethnic Germans* (slightly less than 3 million over the period 1989-2001 according to Bundesverwaltungsamt (2003)) previously living in Eastern Europe moved to West Germany, settling there permanently.[11] These immigrants, after having successfully applied for a visa in the German embassy of their country of origin, were allowed to enter Germany enjoying unrestricted rights of German citizenship upon arrival.

Since in the dataset only nationality identifiers are reported, we are not able to distinguish *ethnic German* workers from Western German workers in the individual records. However, omitting their inflow would distort our analysis especially as they were correlated over time with that of immigrants from East Germany and from other foreign countries. Indeed, *ethnic Germans* were mostly born abroad and were not able to speak German fluently at their arrival, hence they were in all respects more comparable to immigrants than to Western German nationals. Due to the lack of individual data, empirical studies trying to assess the labor market impact and the integration of the *ethnic Germans* have found a mixed set of results (see Bauer et al. (2005) for a survey). As reported in Section 2, the perception is that "Ethnic Germans are basically facing the same difficulties with social and economic integration as foreigners" (Zimmermann, 1999) and, therefore, they should be considered as foreign immigrants in our context.

As we are unable to recognize their individual identity from our dataset, we estimate their total inflow in each education-experience-year and then identify the impact of such inflow (together with those of East Germans and foreigners) on the employment levels and wages of old immigrants and native Germans. To construct such estimates, we merge different sources of information. First, we obtain the inflow of *ethnic Germans* by year of arrival and country of origin from Bundesverwaltungsamt (2003) and Statistisches-Bundesamt-Deutschland (2006b), respectively. Then, from the IAB data we retrieve the exact information on the characteristics and labor market performance of foreign immigrants coming from the same set of countries in the same year of arrival as *ethnic Germans*.[12] Finally, we assume that, for country of origin x and year of arrival t, the educational

[11] See Bauer and Zimmermann (1997) for an analysis of labor market integration of *ethnic German* workers.

[12] The countries are: Czech Republic, Slovakia, former Soviet Union, former Yugoslavia, Hungaria, Poland, Roma-

and age composition of *ethnic Germans* is identical to that of foreign immigrants and that, within education-experience cells, *ethnic Germans* and foreign immigrants from the same country of origin have exactly the same labor market performance in terms of employment levels and wages. For example, we consider *ethnic Germans* who migrated to West Germany from the Czech Republic in 1994 as exactly mirroring in their observed and unobserved characteristics the group of Czech citizens migrating to West Germany in the same year.

Specifically, as a first step, for each of the major *ethnic Germans*' countries x and each year t, we construct $f_{xkjt} = M_{xkjt}/M_{xt}$ as the share of immigrant workers with education k and experience j in the total immigrant flow. We then calculate the imputed number of immigrant *ethnic German* workers from country x with education k and experience j in year t as:

$$E_{xtkj} = E_{xt} f_{xtkj}$$

where E_{xt} is the total yearly inflow of *ethnic Germans* from country x in year t. Since the inflows of *ethnic German* and foreign immigrants from a specific country x can be highly volatile, our second step is to smooth the imputed values by taking averages over two consecutive years. We then attribute to each group E_{xtkj} the average wage of foreign immigrants coming from the same country x in the same year t and with the same education and age. After those two steps, we obtain a complete education-experience distribution of employment and wages for the *ethnic German* immigrants by country of origin x and year of arrival t. Summing across different years of arrival (starting with 1987) and countries of origin, we finally obtain the employment levels within education-experience cells for each year. Similarly the cell-specific wages are reconstructed using a weighted average of average wages by country of origin and year of arrival. As a final step, we subtract the imputed employment levels by cell from the analogous cells of the native Western German population and we add them to the immigrant population.

To summarize, this procedure allows us to account for the large variations in inflows of *ethnic Germans* across years and country of origin assuming that within year-of-arrival and country-of-origin they are essentially identical to those of the other immigrants.

4.3 Stylized Facts and Descriptive Statistics

Let us first describe simple aggregate evidence that points to the existence of significant differences in labor market performances between immigrants and natives. **Figure 1** shows the evolution of the share of individuals receiving unemployment benefits relative to the total workforce ('unemployment rates'), calculated separately for native Germans and immigrant workers for the period

nia.

1987-2001 from the IAB dataset. Two tendencies emerge. First, the rates for native German and foreign workers are quite stable and fairly similar in the period 1987-1991, a period of relatively small inflow of immigrants. Second, beginning in 1991 the unemployment rate of foreigners increases significantly. For native Germans it increases much less, opening a gap that is quite persistent, though reduced towards the end of the 1990's. At the same time, **Figure 2** shows that, while wages for natives increased in real terms in the period 1987-2001, wages for immigrants decreased. Both facts suggest that the large inflow of immigrants in the early 1990's crowded out and affected more negatively the labor market opportunities of other immigrants rather than opportunities for natives. This could be explained by the existence of skill and occupational differences between natives and immigrants in the spirit of the model proposed in Section 3.

Table 4 reports the shares of immigrants in the total workforce with different educational attainments and potential experience levels for selected years. We always reclassify the *ethnic Germans* as immigrants following the procedure described in the previous section. The share of the non-native workforce in total employment increases by more than 50% from 1987 to 2001. This is the consequence of rising shares of immigrant workers across all educational levels. The largest inflow in relative terms occured among workers with high educational levels, while the least educated immigrants increased as a share of that group from 1987 to 1992 and remained constant thereafter. Migrants' shares in the other two educational groups steadily increased over time. However, the overall differences in the inflows of immigrants across education groups are much smaller than those experienced in the USA during recent decades, where immigration has been remarkably concentrated among very low levels ('high school dropouts') or very high levels ('college graduates') of education with much smaller inflows for intermediate levels ('high school graduates').[13]

Regarding the place of origin of immigrants, a clear pattern emerges. From 1987 to 1992 the increase in migrant workers was caused by a massive inflow of individuals with foreign nationality and *ethnic Germans* from outside Germany. Subsequently, the share of immigrants in the total workforce remained stable as the rise in the number of immigrants from East Germany was almost offset by a fall in the number of workers with foreign nationality. Hence, the most recent wave of immigrants, mostly from East Germany, replaced earlier waves from foreign countries.

To summarize, a preliminary look at the data suggest that there has been a substantial increase in the number of immigrant workers over the period of observation. While this increase has been quite evenly distributed across educational levels, the labor market performance of migrants has

[13]See, e.g., Ottaviano and Peri (2006).

been worse compared to natives both in terms of wage growth and in terms of unemployment rates. This suggests that in the German labor market new immigrants tend to displace old immigrants more than natives. The following econometric analysis will investigate this hypothesis.

5 Employment Effects and Workers' Substitutability

The aim of the present section is to estimate the employment and wage responses of old immigrants and natives to the arrival of new immigrants building on the theoretical framework detailed in Section 3. We proceed in three steps. First, we use empirical specifications of (8) and (9) to estimate the effects of new immigration on the employment levels of native and old immigrant workers in the same skill group. Second, from the production function (1) we derive empirical specifications that allow us to estimate the various elasticities of substitution. In particular, we estimate on our data the elasticities of substitution between native and immigrant statuses for given education and experience (σ) as well as between new and old immigrant statuses for given education, experience and native-vs-immigrant status (λ). We also take from the existing literature consensus estimates of the elasticities of substitution between educational levels (δ) as well as between experience levels for a given educational level (η). Third and last, once we have the estimated employment effects and elasticities of substitution, we use expressions (10) and (12) to compute the impacts of the inflow of new immigrants on the wages of natives and old immigrants.

5.1 Employment Effects

We start by estimating the response of old immigrants' and natives' employment levels to the inflow of new immigrants in the same education-experience cells.

5.1.1 Effects of New Immigrants on Employment of Old Immigrants

Following a standard specification (see, e.g., Card 2007), we assess the possible employment effects of new immigrants on old immigrants by regressing the increase in the total employment of immigrants on the increase in employment due to new immigrants. In so doing we identify 1992 as a watershed between previous immigration waves and more recent ones driven mostly by the inflows of *ethnic Germans* and immigrants from East Germany. Accordingly, we call 'new immigrants' those entering West Germany after 1992 and 'old immigrants' those entering West Germany before 1992. The reason is that immigrants from East Germany are present in our dataset starting with 1992. Moreover, in contrast to previous immigration waves, their massive inflow is primarily

driven by *push factors* and thus provides an interesting natural experiment with which to study the effects of a positive, exogenous migration-driven supply shock on the labor market performance of incumbent workers.

To estimate the impact of new immigrants on the employment of old immigrants, we estimate the following specification derived from (9):

$$\frac{\Delta M_{kjt-1}}{M_{kjt-1}} = D_{kj} + D_{kt} + \gamma \frac{\Delta M^{NEW}_{kjt-1}}{M_{kjt-1}} + u_{kjt} \tag{13}$$

where $\Delta M_{kjt-1} = (M_{kjt} - M_{kjt-1})$, $\Delta M^{NEW}_{kjt-1} = \left(M^{NEW}_{kjt} - M^{NEW}_{kjt-1}\right)$. In (13) D_{kj}, and D_{kt} are, respectively, education-experience and education-year interactions included in order to control for systematic differences in employment growth across the two dimensions and u_{kjt} is a zero mean cell-specific random shock. Since the data used are yearly data, the coefficient γ captures the short-run employment effect of recent immigration on the employment of previous immigrants. A value of $\gamma = 1$ implies that an inflow of post-1992 immigrants with education k and experience j equal to 1% of the initial employment in that group is associated with an increase in total migrant employment within the same education-experience cell of 1%. In this case, new immigrants add to previous employment without crowding out any old immigrants. In contrast, an estimated value of $\gamma > 1$ ($\gamma < 1$) implies that new immigrants increase (crowd out) the employment of old immigrants.

Note that the group of pre-1992 immigrants with less than 10 years of experience steadily declines from 1992 to 2001 leaving us with few or no observations in the corresponding cells for the last years of the sample. This happens by definition since we classify workers according to their potential experience, which increases by one unit every year. For example, in 1997 there are no pre-1992 workers with less than 5 years of experience, and so on. To take this into account, we estimate (13) excluding the 0-5 year experience cell for the whole 1992-2001 period and the 5-10 year cell for the 1997-2001 sub-period.

Table 5 reports the results obtained in estimating equation (13). The first row reports the estimates of γ obtained by a Least Squares regression in which cells have been weighted by total employment. In column I we report the results based on the sample of male workers stratified across cells of experience and 'equivalent education'. The estimated γ equals 0.804 and is statistically different from 1 at the 1% level. As a robustness check, we run the same regression also on the full sample including male and female workers, obtaining an estimated γ equal to 0.847, as reported in column II. Columns III and IV show the estimation results when workers are classified according to their reported education. In this case, the estimated γ's are very close to 1, both when the sample is restricted to men only ($\gamma = 0.980$) and when it is unrestricted ($\gamma = 1.001$). Hence, while no

employment effects can be found when workers are classified according their reported education, evidence of crowding out emerges when they are classified in terms of 'equivalent education'. This can be explained as long as our reclassification allows for better identification of workers competing for jobs having a similar skill content. To summarize, when equivalent education is used to stratify workers, our estimates for γ imply that on average *when 10 new immigrants join the German labor force, 2 old immigrants lose their jobs.*

5.1.2 Effects of New Immigrants on Employment of Natives

To estimate the impact of recent immigrants on the employment of native workers, we use an empirical specification based on (8):

$$\frac{\Delta EMPL_{kjt-1}}{EMPL_{kjt-1}} = D_{kj} + D_{kt} + \rho \frac{\Delta M_{kjt}}{EMPL_{kjt-1}} + u_{kjt} \tag{14}$$

where $EMPL_{kjt-1} = M_{kjt-1} + H_{kjt-1}$ is total employment (immigrants plus natives) with education k and experience j at time $t-1$ and $\Delta EMPL_{kjt} = [(M_{kjt} + H_{kjt}) - (M_{kjt-1} + H_{kjt-1})]$ is its variation from $t-1$ to t. The variables D_{kj}, D_{kt} are the usual interactions and u_{kjt} is a zero mean cell-specific random shock. The parameter ρ captures the impact of immigration on total employment. If it is smaller (larger) than 1, it implies that new immigrants crowd natives out of (attract natives into) the labor market. If it equals 1, new immigrants have no impact on native employment.

Table 6 reports the regression results based on (14). As before, column I shows the results coming from a Least Squares regression on male workers classified according their 'equivalent education' and experience. Robustness checks are carried out including adding female workers (column II) and using reported education to stratify workers (columns III and IV). The estimates for ρ are quite different from the estimates of γ in the previous section. In particular, the parameter estimates are now always strictly larger than 1 in absolute value, and never significantly different from 1 at any standard confidence level, implying essentially no crowding out of native employment.

These results seem to preclude the presence of adverse employment effects of new immigrants on natives even in the short run (recall that we use yearly observations). To further check this result, we run another regression in which we stratify native and migrant workers according to their education only, instead of using the finer stratification in education-experience cells. If Western German employers valued differently the work experience acquired inside and outside West Germany, our labor market segmentation along education and experience levels could fail to appropriately identify groups of workers competing for the same jobs. To see whether this is the case,

we group workers only according to their education level and we run the following regression:

$$\frac{\Delta EMPL_{kt-1}}{EMPL_{kt-1}} = D_k + Trend_k + \rho_{EDU}\frac{\Delta M_{kt-1}}{M_{kt-1}} + u_{kt}$$

where $EMPL_{kt-1} = \sum_j EMPL_{kjt-1}$, $M_{kt} = \sum_j M_{kjt-1}$ and u_{kt} is a zero mean education-specific shock. This regression controls for education fixed effects (D_k) as well as education-specific trends ($Trend_k$) and is estimated on the usual samples. The corresponding results are reported in **Table 7**. Even using this specification, no adverse employment effect is identified. Estimates for ρ_{EDU} lie between 1.078 and 1.515, and are never significantly different from one.

All in all, the results from employment regressions imply that *we can safely rule out the presence of any adverse effect of new immigration on the employment levels of native workers.* These results are consistent with those obtained using a similar framework by Peri (2007). His analysis of the impact of migration on the California labor market stressed the absence of any significant employment effects of migrants on natives. In the German case, however, the time horizon is much shorter (one year) and labor markets are more rigid than in the California analysis, hence the lack of an effect on natives seems to imply a strong segmentation of the labor market, possibly due to differences between immigrants and natives.

5.2 Elasticities of Substitution

We turn now to the estimation of the elasticities of substitution. The empirical evidence discussed so far highlights the presence of different employment effects of recent immigration on the German labor market: significant negative effects on old immigrants and positive effects on natives. These differences seem to confirm that immigrant workers compete more between themselves than with natives, even within groups of similar observable skills. Indeed, if the only relevant variables for identifying similar workers were their education and experience, we would not observe such different employment effects due to workers' origins. In line with this consideration, the theoretical framework outlined in Section 3 allows for imperfect substitutability in production between natives and immigrants as well as between old and recent immigrants. It also suggests how to estimate the elasticities of substitution between these groups of workers.

5.2.1 Elasticity of Substitution between New and Old Immigrants

In order to estimate the elasticity of substitution between immigrants, we use the logarithmic wages given by expression (7) for old immigrants and its analogue for new ones. Taking the ratio within education-experience cells gives:

$$\ln\left(\frac{w_{Mkjt}^{OLD}}{w_{Mkjt}^{NEW}}\right) = \ln\left(\frac{\theta_{kjt}^{OLD}}{\theta_{kjt}^{NEW}}\right) - \frac{1}{\lambda}\ln\left(\frac{M_{kjt}^{OLD}}{M_{kjt}^{NEW}}\right)$$

Following Ottaviano and Peri (2006) and Manacorda et al. (2006), we estimate the parameter λ, implementing the following specification that controls for the relative demand term $\ln\left(\theta_{kjt}^{OLD}/\theta_{kjt}^{NEW}\right)$ with fixed effects:

$$\ln\left(\frac{w_{Mkjt}^{OLD}}{w_{Mkjt}^{NEW}}\right) = D_k + D_j + D_t - \frac{1}{\lambda}\ln\left(\frac{M_{kjt}^{OLD}}{M_{kjt}^{NEW}}\right) + u_{kjt} \tag{15}$$

where the set of education (D_k), experience (D_j) and year (D_t) dummies controls for any systematic component of the relative efficiency parameter $\ln\left(\theta_{kjt}^{OLD}/\theta_{kjt}^{NEW}\right)$.[14] The corresponding results are reported in **Table 8**. Column I shows an estimate of $1/\lambda$ equal to 0.021 with a standard error of 0.018, implying that the value of $1/\lambda$ is not statistically different from zero at any confidence level. Accordingly, *new and old immigrants appear to be perfect substitutes.* This result holds when the regression is estimated on the sample including both male and female workers as well as when workers are stratified according to their reported education (columns II, III and IV). Thus, new and old immigrants are perfectly substitutable and all immigrants belonging to each education-experience group ($M_{kjt} = M_{kjt}^{OLD} + M_{kjt}^{NEW}$) can be considered as forming a homogeneous group of workers.

5.2.2 Elasticity of Substitution between Natives and Immigrants

Following the same strategy outlined in the previous section, we now estimate the degree of substitutability between native and immigrant workers in the same education-experience cell. Specifically, we regress the logarithm of the relative wages of natives and immigrants on their relative employment levels with fixed effects, using education-experience cells as observations. Regressions are run on the whole sample from 1987 to 2001 and the corresponding results are reported in **Table 9**. All columns show that the estimated values for $1/\sigma$ are both positive and significant, ranging between 0.045 (column IV: males and females, reported education) to 0.061 (column I: males only, equivalent education), which implies an estimated elasticity of substitution ranging between 16 and 21. In other words, *natives and immigrants are not perfect substitutes.*

These estimates are somewhat smaller in absolute value than those reported in national studies by Ottaviano and Peri (2006) for the US and Manacorda et al. (2006) for the UK. Many reasons may lie behind this result. First of all, as mentioned in Section 4, we identify foreign workers

[14] As in the case of (13), we estimate (15) excluding the cells of workers with less than 10 years of experience.

as those having foreign nationality. This group includes also second (and later) generation immigrants, who are likely to be much more similar to the native Western German workforce than first generation immigrants on which the above-mentioned US and UK studies focus. Moreover, the IAB data include only employees covered by social security. This may compress the variability among workers, increasing the estimated degree of substitutability. Finally, many of the immigrants to West Germany were and are from Europe and share educational-cultural systems that are more similar to those of natives than those of Mexican immigrants in the US. Hence, when compared with the US, it is reasonable to expect less diversification in skills and therefore less complementarity in the German labor market between immigrants and natives. The degree of imperfect substitutability, however, is sufficient to produce a significant average positive wage effect on natives from overall immigration.

6 Wage Effects

Based on the theoretical framework of Section 3 and, in particular, on the implied expressions (10) and (12), we are now able to evaluate the total impact of immigration on the wages of native and old migrant workers. In so doing, we rely on the employment effects estimated in Section 5.1 and the elasticities of substitution σ and λ estimated in Section 5.2. As for the elasticities of substitution between workers with different education (δ) and experience (η), we adopt the standard estimates that have proved to be robust across various studies. Specifically, we impose a value of δ around 2 (Katz and Murphy, 1992; Hamermesh, 1993; Angrist, 1995; Ciccone and Peri, 2005) and a value of η around 4 (Borjas, 2003; Card and Lemieux, 2001; Ottaviano and Peri, 2006).

6.1 Wage Effects on Long-Term Immigrants, 1992-2001

The effects of new immigration on the wages of old (long-term) immigrants are given by expression (12). This allows us to compute the overall impact of post-1992 immigration on the wages of pre-1992 immigrant workers taking into account both the degree of substitutability between different groups of workers (δ, η, σ and λ) and the role of employment effects (γ).

Table 10 reports the results obtained imposing $\sigma = 16$ and $\gamma = 0.804$. The terms on the right hand side of (12) can be sorted into two groups. The first group includes the terms that determine a direct change in the wages of old immigrants for given supplies of natives and old immigrants ('direct effect'). The second group includes the terms that determine an indirect change in the wages of old immigrants through changes in the supplies of native and old immigrants ('indirect effect'). While the terms belonging to the latter group bear the label '*response*', those belonging

to the former bear no label. In Table 10 the direct and indirect effects of new immmigration are denoted by A and B respectively. The table shows the direct, indirect and total wage effects of new immigration from East Germany (columns I-III), from the rest of the world (columns IV-VI) and from both (columns VII-IX). Notice, intuitively, that the 'indirect effect', driven by the reduced employment of old immigrants, attenuates the negative wage impact of new immigrants. This is because the reduction in old immigrants' employment is a partial offset for the increased supply of new immigrants.

Column IX shows that the overall effects of new immigration on the wages of old immigrants are negative, implying an average loss for the pre-1992 immigrant workers of 1.6% of their real wage. This is not a particularly large number but it is certainly not negligible. In particular, old immigrant workers with a high level of education suffer the highest losses (4%), which is explained by the fact that post-1992 immigration to West Germany is relatively high-skilled. The comparison between columns VII and VIII reveal that the reduction in the employment levels of old immigrants attenuates the negative impact of immigration on wages by half of a percentage point, on average.

Decomposing the overall wage effect with respect to the origin of immigrants, columns III and VI show that immigration from East Germany accounts for almost one third of the average negative wage effect and almost one half of the negative wage effect for highly educated workers. This is due to the fact that East German immigrants are on average more educated than immigrants from the rest of the world.

Hence, *new immigrants penalize old immigrants both in terms of employment and in terms of wages*, especially in the case of highly educated workers due to a relatively large inflow of this group of immigrants after 1992.

6.2 Wage Effects on Natives, 1987-2001

Turning to the effects of immigration on native wages, we use expression (10). Following our findings in Sections 5.1.1 and 5.2.2, we impose the absence of employment effects for natives ($\rho = 1$) as well as imperfect substitutability between native and immigrant workers.

Table 11 reports the corresponding results for two cases: imperfect (column I) and perfect (column II) substitutability between natives and immigrants. In the former case, the elasticity of substitution between the two groups of workers is set to our estimated value $\sigma = 16$. In the latter case, it is set to infinity. With imperfect substitutability, column I shows a small, positive average impact (+0.33%) of immigration on native wages over the period 1987-2001. Across educational levels, relatively low educated workers experience a small improvement in their wage levels, while

highly educated ones suffer a small loss. This is again due to the fact that, during the period of observation, immigration to Germany was relatively skilled.

These small positive wage effects are consistent with the absence of negative employment effects found in Section 5.1.2. Moreover, even when in column II we impose perfect substitutability ($\sigma = \infty$) between natives and immigrants, the overall effect on wages becomes negative but still very close to zero, with the same distributional pattern across educational groups as in the case of $\sigma = 16$.

Hence, *new immigrants do not penalize native workers either in terms of employment or in terms of wages*. Indeed, native workers with medium and low education see their wages rise.

6.3 The Cost of Rigidity

There is a growing consensus that the reaction of a country's labor market to immigration depends on its institutional features and, in particular, that more 'flexible' labor markets are more efficient in absorbing the supply shocks arising from migrant inflows. In this section we use the framework developed so far to quantify the monetary costs of labor market 'rigidity' by asking how much Germany would gain from a more 'flexible' labor market.

To give operational content to the concepts of 'rigidity' and 'flexibility', we note that, in the case of the UK, which is traditionally considered a more 'flexible' labor market than the German labor market, Manacorda, et al, (2006) conclude that, absent any employment effect, the only sizeable effect of increased immigration is on the wages of those immigrants who are already there. Accordingly, we interpret 'rigidity' as leading to employment effects and 'flexibility' as the absence of those effects. Then we ask whether or not the fall in immigrant wages, which would occur if employment effects were removed from the German labor market, would be compensated for by the corresponding savings in unemployment insurance payments.

In our thought experiment we focus on the year 2001 and allow the wages of pre-1992 immigrants to adjust downward until any adverse employment effect disappears[15]. The results of the thought experiment are reported in **Table 12** where all the values are expressed in real terms at year 2000 prices. According to (10) and (12), for employment effects to disappear, on average pre-1992 immigrants' wages have to fall by 0.66% and natives' wages have to increase by 0.01%.[16] Multiplying the above variations first by the average wage levels prevailing in 2000, then by the correspoding employment levels and finally by a uniform weight equal to 50 (since our sample is a

[15]We implicitly assume that wages do not fall below their reservation level for any group, so that their decline does not affect labor supply in a world with no labor market rigidities.

[16]This happens due to the increase in the employment level of the complementary migrant workforce.

2% simple random sample of the overall population), we calculate an overall decrease in the wages paid to old immigrant workers equal to approximately 261.7 million euros per year.

In the last row of Table 12 we also calculate the cost sustained by the German government to finance the payment of the unemployment insurance benefits to the displaced immigrant workers. According to our calculations, based on an estimate of $\gamma = 0.804$, approximately 21,700 old immigrants have been displaced by the 2001 inflow of new immigrants. We multiply this value by the average yearly cost of unemployment benefits, which, following Adema et al. (2003), we set at 15,000 euros per displaced worker. This is just a lower bound estimate of the overall cost borne by the government because the full cost should also include unemployment assistance (for the long-term unemployed), housing benefits, active labor market policies, etc. The result is overall expenditures equal to 313.5 million euros per year. Though a lower bound, this amount is still larger than the total wage losses old immigrant workers would suffer in the absence of employment effects.

Hence, if the German labor market were as 'flexible' as the UK one, there would be room for a Pareto-improving compensation scheme. In this sense, a more 'flexible' German labor market would be more efficient in dealing with the effects of immigration. Interestingly, however, the main beneficiary of such flexibility would be those old immigrants who get displaced by new immigrants as, under more flexibility, they would retain their jobs, although at a lower wage. The benefit to citizens would be in the form of lower taxes if one thinks that unemployment insurance is funded by a general tax.

7 Conclusion

This paper contributes to the recently revived literature analyzing the impact of immigration within a general equilibrium framework which is able to take fully into account the interactions between production factors and the overall effects of immigration on the economy (Aydemir and Borjas, 2006; Borjas, 2003; Manacorda et al., 2006; Ottaviano and Peri, 2006; Peri, 2007).

With respect to the existing literature, we believe we have made some progress in the empirical methodology employed. First, the elasticity parameters necessary to disentangle the wage effects of immigration are estimated on a yearly basis instead of on 5 or 10 year intervals, thus enabling better identification. Second, the stratification of workers depending on their 'equivalent education' (i.e., the skill level required for the job they actually perform rather than their formal educational achievement) makes it possible to identify groups of workers who should actually compete for the same jobs.

Third, for the first time, we employ a general equilibrium framework including a labor supply response to estimate explicitly the impact of new immigrants on old ones. The fact that we find perfect substitutability between old and new immigrants but imperfect substitutability between immigrants and natives provides indirect support for the idea that native and immigrant workers do not compete for the same occupations. This result is confirmed when we look at the employment effects of immigration, which is a necessary step given the rigidity of the German labor market. In this respect, we find that new immigration has a negative impact on the employment level of old immigrants and no impact on that of natives.

Fourth, in calculating the wage effects of immigration we take the aforementioned employment effects into account. In so doing, we distinguish between the 'direct effect' of immigration, which refers to the change in wages taking place for given supplies of natives and old immigrants, and the 'indirect effect', which refers to the change in wages due to changes in the labor supplies of different groups of workers. The estimated wage effects of new immigrants are on average positive but modest for natives and negative for old immigrants.

Finally, we have demonstrated a very simple first step as to how our general equilibrium framework can be used to quantify the effects of labor market reforms. In particular, through a simple thought experiment, we have been able to show that a labor market reform that removes the negative employment effects of immigration (and increases its wage impact) would generate a reduction of unemployment insurance payments large enough to more than compensate the wage losses of old immigrants. In other words, such reform would generate enough resources to support a Pareto-improving compensation scheme.

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Tables and Figures

Table 1
Annual Naturalization Rates in Germany

Number of annual naturalizations divided by foreigner population, 1987-2001	
Year	**Ratio**
2001	0.024
2000	0.026
1999	0.02
1998	0.015
1997	0.011
1996	0.012
1995	0.01
1994	0.009
1993	0.006
1992	0.006
1991	0.004
1990	0.004
1989	0.004
1988	0.004
1987	0.003
Average	0.008

Source: Authors' calculations on German Federal Statistical Office data

Table 2
Immigrant Workers in West Germany as a Percentage of the Total Workforce
from the IAB dataset

Year	Share of migrant workforce
1987	9.3%
1988	9.1%
1989	9.0%
1990	9.1%
1991	9.5%
1992	10.0%
1993	10.9%
1994	13.5%
1995	14.0%
1996	14.0%
1997	14.0%
1998	14.2%
1999	13.7%
2000	12.6%
2001	13.0%

Note: Author's calculations on IAB data. We consider as immigrants all foreign-born workers plus East Germans who moved to the West. Foreign-born are defined as those individuals without German nationality.

Table 3
Reported and Predicted Educational Levels for Native Population, Year 2001

Education group	Percentage of workers in each of 6 education groups, according to reported education	Percentage of workers in each of 6 education groups, according to the estimated probabilities
Column	**I**	**II**
HSD, no vocational edu	18.1	17.4
HSG, no vocational edu	2.0	2.1
HSD, vocational edu	63.0	64.0
HSG, vocational edu	4.2	4.6
Higher, non university, edu	5.1	5.1
University degree	7.7	6.8
Total	100	100

Note: Column II, distribution of "equivalent education" levels, obtained as a weighted average using as weights the estimated probabilities of each worker having each of the educational levels. These probabilities are estimated via an ordered probit in which the dependent variable is the reported level of education and the independent variables are 17 industry and 131 qualification variables.

Table 4
Share of Foreigners and Eastern Germans in the West German Labor Force 1987-2001

Group		Year		
Equivalent Education	**Years of potential experience**	**1987**	**1992**	**2001**
Low Education	Up to 4	14.2%	27.8%	23.9%
	5 to 9	10.6%	18.8%	20.8%
	10 to 14	9.3%	19.4%	21.9%
	15 to 19	11.7%	16.3%	19.3%
	20 to 24	17.3%	16.9%	17.2%
	25 to 29	15.7%	20.0%	14.2%
	30 to 34	13.3%	17.1%	14.5%
	35 to 40	10.0%	14.1%	17.0%
	Total	12.9%	19.5%	19.3%
Intermediate Education	Up to 4	10.0%	20.0%	18.4%
	5 to 9	6.4%	12.0%	15.1%
	10 to 14	5.8%	12.4%	14.0%
	15 to 19	7.6%	10.1%	12.1%
	20 to 24	10.8%	10.7%	11.3%
	25 to 29	8.9%	12.6%	9.6%
	30 to 34	7.9%	10.0%	9.7%
	35 to 40	6.5%	8.7%	10.9%
	Total	8.1%	12.5%	13.1%
High Education	Up to 4	6.5%	11.6%	14.0%
	5 to 9	3.8%	6.0%	10.3%
	10 to 14	4.8%	6.3%	8.4%
	15 to 19	6.2%	7.6%	7.1%
	20 to 24	5.8%	7.2%	6.8%
	25 to 29	3.8%	7.0%	6.4%
	30 to 34	3.3%	4.7%	5.9%
	35 to 40	2.5%	3.3%	6.1%
	Total	4.9%	7.0%	8.4%
Overall Total		9.0%	13.5%	13.8%

Note: Authors' calculation on IAB data.

Table 5
Effects of New Immigrants on Total Immigrant Employment, Education-Experience Groups

Column	I	II	III	IV
	Main Specification	Robustness checks		
Sample	Males only	Males and females	Males only	Males and females
Gamma	0.804***	0.847***	0.980***	1.001***
Std. Error	(0.087)	(0.108)	(0.100)	(0.110)
Education-experience interactions	Yes	Yes	Yes	Yes
Education-time interactions	Yes	Yes	Yes	Yes
Equivalent Education	Yes	Yes	No	No
R2	0.83	0.85	0.78	0.84
Observations	174	174	174	174
H0: gamma=1, p-value:	0.03	0.16	0.84	0.99

* significant at 10%; ** significant at 5%; *** significant at 1%

Note: dependent variable is the percentage increase in employment of all immigrant workers in the education-experience group. Explanatory variable is the inflow of new immigrant workers as percentage of the initial employment in the education-experience cell. The method of estimation is least squares with each observation weighted by the employment of the cell. Heteroskedasticity robust standard errors are reported in parenthesis. We estimate the equation excluding the 0-5 year experience cell for the whole 1993-2001 period and the 5-10 year cell for the 1997-2001 sub-period. Period 1993-2001.

Table 6
Effects of New Immigrants on Total Employment

Column	I	II	III	IV
	Main Specification	Robustness checks		
Sample	Males only	Males and females	Males only	Males and females
Rho	1.333***	1.068***	1.410***	1.311***
Std. Error	(0.445)	(0.519)	(0.304)	(0.411)
Education-experience interactions	Yes	Yes	Yes	Yes
Education-time interactions	Yes	Yes	Yes	Yes
Equivalent Education	Yes	Yes	No	No
R2	0.49	0.54	0.4372	0.48
Observations	360	360	360	360
H0: rho=1, p-value:	0.45	0.90	0.18	0.45

* significant at 10%; ** significant at 5%; *** significant at 1%

Note: dependent variable is the percentage increase in overall employment in the education-experience group. Explanatory variable is the change of immigrant workers as percentage of the initial employment in the education-experience cell. The method of estimation is least squares with each observation weighted by the employment of the cell. Heteroskedasticity robust standard errors are reported in parenthesis. Period 1987-2001. Three education by eight experience groups.

Table 7
Effects of New Immigrants on Natives' Employment, Education Groups Only

Column	I	II	III	IV
	Main Specification	Robustness checks		
Sample	Males only	Males and females	Males only	Males and females
Rho	1.098***	1.438***	1.024***	1.275***
Std. Error	0.371	0.477	0.318	0.4
Education dummies	Yes	Yes	Yes	Yes
Education specific time trend	Yes	Yes	Yes	Yes
Equivalent Education	Yes	Yes	No	No
R2	0.513	0.552	0.511	0.556
Observations	45	45	45	45
H0: rho=1, p-value:	0.79	0.36	0.94	0.50

* significant at 10%; ** significant at 5%; *** significant at 1%

Note: dependent variable is the percentage increase in overall employment in the education-experience group. Explanatory variable is the change of foreign-born workers as percentage of the initial employment in the education cell. The method of estimation is least squares with each observation weighted by the employment of the cell. Heteroskedasticity robust standard errors are reported in parenthesis. Period 1987-2001. Three education groups.

Table 8
Estimates of the Substitutability between New and Old Immigrants

Column	I	II	III	IV
	Main Specification	Robustness checks		
Sample	Males only	Males and females	Males only	Males and females
1/lambda	0.021	0.000	-0.012	-0.036
Std error	0.018	0.023	0.012	0.021
Educational Dummies	Yes	Yes	Yes	Yes
Experience Dummies	Yes	Yes	Yes	Yes
Year Dummies	Yes	Yes	Yes	Yes
Equivalent Education	Yes	Yes	No	No
Observations	195	195	195	195
R2	0.59	0.68	0.82	0.85

* significant at 10%; ** significant at 5%; *** significant at 1%

Note: Dependent variable is the wage of old relative to new immigrants and the explanatory variable is the employment of old relative to new immigrants within each education-experience cell. Period 1992-2001. The method of estimation is least squares with each observation weighted by the employment of the cell. Heteroskedasticity robust standard errors are reported in parenthesis. We estimate the equation excluding the 0-5 year experience cell for the whole 1993-2001 period and the 5-10 year cell for the 1997-2001 subperiod.

Table 9
Estimates of the Substitutability between Natives and Immigrants

Column		I	II	III	IV
		Main Specification	Robustness checks		
Sample		Males only	Males and females	Males only	Males and females
$1/\sigma$		0.061***	0.056***	0.054***	0.045***
	Std error	0.019	0.018	0.014	0.013
Educational Dummies		Yes	Yes	Yes	Yes
Experience Dummies		Yes	Yes	Yes	Yes
Year Dummies		Yes	Yes	Yes	Yes
Equivalent education		Yes	Yes	No	No
Observations		360	360	360	360
R2		0.88	0.88	0.85	0.83

* significant at 10%; ** significant at 5%; *** significant at 1%

Note: Dependent variable is the wage of native workers relative to immigrants and the explanatory variable is the employment of natives relative to immigrants within each education-experience cell. Period 1987-2001. The method of estimation is least squares with each observation weighted by the employment of the cell. Heteroskedasticity robust standard errors are reported in parenthesis. Period 1987-2001. Three education by eight experience groups

Table 10
Percentage Changes in Real Wages of Old Immigrants Due to Recent Immigration. Long-Run Simulations 1992-2001

Column	I	II	III	IV	V	VI	**VII**	**VIII**	**IX**
	Due to East-West movers			Due to foreigners			**Overall**		
	True immigration effect (A)	Response effect (B)	Total effect (A+B)	True immigration effect (A)	Response effect (B)	Total effect (A+B)	**True immigration effect (A)**	**Response effect (B)**	**Total effect (A+B)**
Effects with full capital adjustment									
Low education	-0.42%	0.10%	-0.32%	-1.78%	0.41%	-1.37%	**-2.20%**	**0.51%**	**-1.69%**
Intermediate education	-0.67%	0.15%	-0.52%	-1.14%	0.25%	-0.90%	**-1.82%**	**0.40%**	**-1.41%**
High education	-2.20%	0.49%	-1.71%	-3.00%	0.65%	-2.35%	**-5.20%**	**1.14%**	**-4.06%**
Average	-0.68%	0.16%	-0.53%	-1.43%	0.32%	-1.11%	**-2.11%**	**0.47%**	**-1.64%**

Note: The entries in the table represent the real wage effects of immigration on old immigrants obtained using the formula (12) in the main text applied to each education-experience group and then aggregating within education group. The parameter values used for the simulations are as follows: $\delta=2$, $\theta=4$; $\sigma=16$, $\lambda=\infty$ and $\gamma=0.084$.

Table 11
Percentage Changes in Real Wages of Native Workers Due to Immigration, 1987-2001

	Full capital adjustment	
Column	**I**	**II**
σ	*16*	∞
Low education	1.04%	0.80%
Intermediate education	0.36%	0.03%
High education	-1.49%	-2.08%
Average	0.33%	-0.01%

Note: The entries in the table represent the simulated real wage effects of immigration on native workers obtained using the formula (10) in the main text applied to each education-experience group and then aggregating within education group. The parameter values used for the simulations are as follows: $\delta=2$, $\theta=4$; $\sigma=16$, $\lambda=\infty$ and $\rho=1$.

Table 12
Policy Experiment
Daily Real Wages in 2000 Euros

	A	B	C	D	E	F=A*B*C*D	G=F*365
	Units	*Sampling Weight*	*Average wage*	*% wage increase due to rigidities*	*Absolute increase in salary due to rigidities*	*Total, daily wages*	*Total, yearly wages*
West German native workers	192657	50	90	-0.01%	-0.0095	-91234	**-33300364**
Migrants	29944	50	74	0.66%	0.4888	731826	**267116465**
	Units	*Sampling Weight*	*Average UI cost*				*Total cost*
Displaced pre-1992 migrants	434	50	14449				**313543300**

Note. Simulation adopting the following technological parameters: $\delta=2$, $\theta=4$; $\sigma=16$, $\lambda=\infty$ and $\gamma=0.084$.

Figure 1

Evolution of the Unemployment Insurance recipient rate

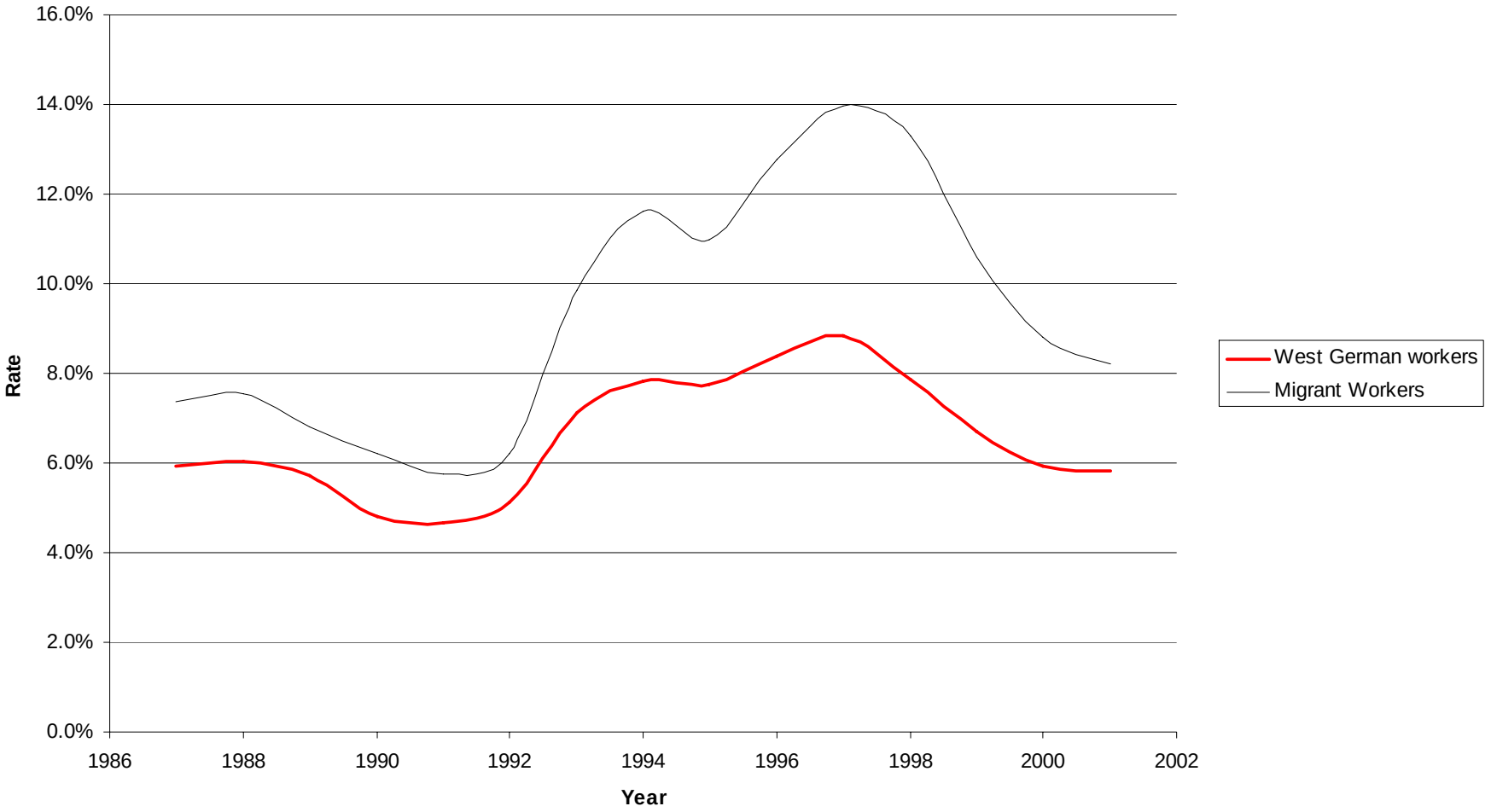
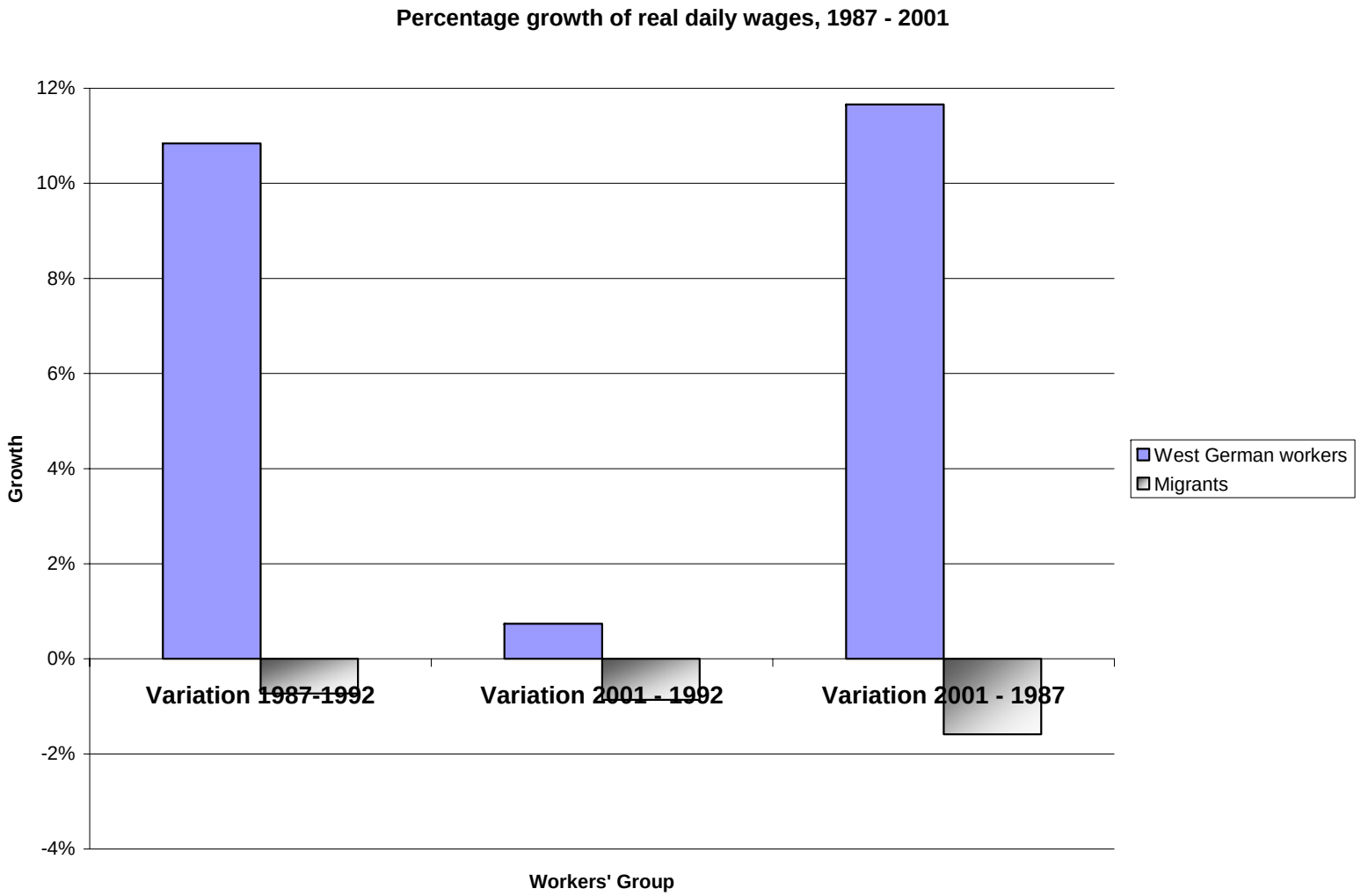


Figure 2


Percentage growth of real daily wages, 1987 - 2001
12%
10%
8%
6%
4%
2%
0%
-2%
-4%
Growth
Variation 1987-1992
Variation 2001 - 1992
Variation 2001 - 1987
Workers' Group
West German workers
Migrants

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