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The labor market impact of immigration in Western Germany in the 1990s

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ABSTRACT

In this article we estimate the wage and employment effects of recent immigration in Western Germany. Using administrative data for the period 1987–2001 and a labor-market equilibrium model, we find that the substantial immigration of the 1990s had very little adverse effects on native wages and on their employment levels. Instead, it had a sizeable adverse employment effect on previous immigrants as well as a small adverse effect on their wages. These asymmetric results are partly driven by a higher degree of substitution between old and new immigrants in the labor market and in part by the rigidity of wages in less than flexible labor markets. In a simple counter-factual experiment we show that in a world of perfect wage flexibility and no unemployment insurance the wage-bill loss of old immigrants would be much smaller.

1. Introduction

Within Europe, Germany hosts the largest number of immigrants. Workers with foreign origin have represented more than 10% of the total German labor force since the late 1990s.[1] The socioeconomic worries produced by rising immigration led the German government to introduce selective immigration measures and stirred a lively public debate.[2]

The present paper investigates the interactions between immigration, employment and wages in Western Germany by adopting a structural labor market equilibrium approach recently employed, following Borjas (2003), in several national studies. This approach aims at providing a full picture of the adjustment of the labor market to immigration by modeling aggregate production through a multi-level constant elasticity of substitution (CES) production function in which workers with different observable characteristics are imperfect substitutes. Considering explicitly the production structure makes clear that the marginal productivity of workers with certain skills depends not only on the supply of workers with their same skills but also on the supply of other workers. Hence this structure produces a better identification of competition and complementarity effects of immigrants on natives. The assessment of the effects of immigration thus requires a careful

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[1] Authors' calculation using the IAB data.

[2] See, e.g., Zimmermann et al. (2007) for an outline and an economic evaluation of the norms contained in the measured contained Immigration Act of 2004.

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estimation of all the elasticities of substitution between different groups of workers. The original framework proposed by Borjas (2003) and then enriched (adding imperfect native-immigrant substitutability) by Ottaviano and Peri (2008) and Manacorda et al. (2006) focuses only on wage adjustment. This is not enough in the case of Germany, where due to labor market rigidities, persistent changes in employment could be important effects of immigration.

This paper contributes to this recently revived literature in three respects. First, it produces new estimates of very important elasticity parameters: between new and old immigrants, between immigrants and natives and between workers of different age and education. These estimates can be interpreted as short-run elasticities as we use a yearly panel of German workers drawn from a large administrative dataset, representative of all employment spells subject to social security taxation (see Section 3 and the Data Appendix for details). Also new in the identification strategy is the use of the large inflow of Eastern Germans after the fall of the Berlin Wall as an exogenous shock. Second, the paper extends the labor market equilibrium approach to allow for employment as well as wage responses. This is very important especially when we consider short-run effects (as we do here) and when we move beyond the US data analyzing countries characterized by wage rigidities, as it is typical of the German labor market.[3] Third, having identified the actual employment and wage effect of immigration we can produce a counter-factual scenario in which, with perfect wage flexibility, all the inflow of immigrants is absorbed by wage changes (Walrasian markets). Comparing this case with the actual one we can compute the total difference in wage bill and welfare under each scenario and hence the loss in total wages from having the existing rigidities.

In the estimation of the elasticities of substitution, 'new' immigrants are defined as those who have worked in Germany for five years or less whereas 'old' immigrants are those who have worked in Germany for strictly more than five years. Then, for each year we stratify workers in cells defined according to their education, experience and nativity (native-immigrant; new/old immigrant). We allow the relative wage of natives and immigrants (or new/old immigrants) across cells to depend systematically on the year and on their education and experience. We interpret the remaining within-cell variation of immigrants over time as being supply driven. The results reveal stronger competition between new and old immigrants than between immigrants and native workers: while natives and new immigrants are imperfect substitutes, new and old immigrants are close to perfect substitutes. In particular, we estimate a significant elasticity of substitution between natives and immigrants of around 20 (close to what Ottaviano and Peri, 2008; Card, 2009, find between native and immigrants in the US and somewhat larger than what Manacorda et al., 2006, found for the UK) and an elasticity of substitution between new and old immigrants around 60 and not significantly different from the one implied by perfect substitutability.

Previous work by Ottaviano and Peri (2008) on the US and Manacorda et al. (2006) on the UK not only did not distinguish between new and old immigrants but only focussed on the effects of immigration on wages neglecting its effects on employment levels. The reason for this is that the US and the UK labor markets can be reasonably considered as fully flexible with wages adjusting to their market clearing level. In those countries the employment effects of immigration are negligible. This is not the case for Germany where labor market institutions are characterized by generous unemployment benefits and other sources of wage rigidities leaving room for possible employment effects (Angrist and Kugler, 2003; Schmidt et al., 1994).[4] To detect the presence of these effects, we regress the cell specific year-to-year variation in the number of immigrants (new immigrants) on the same measure calculated for the total workforce (total immigrant workforce). The corresponding results reveal the presence of significantly negative impacts of new immigrants on previous immigrants but not on native workers. In particular, our estimates suggest that, for any 10 new immigrants in the German labor market, three to four old immigrants are driven out of employment, whereas no native is affected.

Combining the estimated elasticities of substitution between different types of workers with data on immigration and with the related employment response in each cell, it is finally possible to recover the full impact of migration on wages. Our estimated elasticities imply that over the period 1992–2001 new immigrants to Western Germany reduced the average wages of old immigrants by 0.5%, with highly educated old immigrants losing around 1.1% of their wages. Approximately half of the negative wage effect on the highly educated was due to immigration from Eastern Germany. As for the effects of new immigration on natives, there is essentially a null average effect: negative on highly educated (-1%) and positive on the less educated ($+1\%$).[5]

[3] See Dickens et al. (2007) for a recent cross-country comparison of wage rigidity levels. In this study, the fraction of workers potentially affected by real wage rigidity in Germany is estimated to be twice the United States' one.

[4] The importance of the employment effects of migration in Germany is stressed by Pischke and Velling (1997) who, using data on 167 German regions for the 1985–1989 period, show evidence of displacement of the native workforce by immigration. More recently, Glitz (2006), analyzing the specific issue of the impact of *ethnic German* immigration on the relative skill-specific employment and wage rates of the resident population, finds evidence of adverse employment effects but no detrimental effects on average wages.

[5] Bonin (2005) recently applied a skill-based analysis of immigration to the German labor market using IAB data for a different time period (1975–1997). His approach, however, is a reduced-form one. He identifies the partial effect of immigration on wages of each skill group but, since he does not specify a structure of labor demand and supply he cannot identify the total effects of immigration on wages and employment. Moreover, the analysis defines immigrants simply as foreign nationals in the IAB and therefore omits the very important inflow of Eastern Germans and Ethnic German immigrants. Nevertheless, his results do not systematically differ from ours: he finds small wage effects of migration on native workers and no effects on unemployment.

We conclude the paper with some simple calculations in which we use our estimated elasticities to discuss the aggregate wage effects of immigration in the presence of wage rigidities compared to the case of fully flexible wages and no negative employment effects. In particular, assuming that the negative employment effects are due to labor market frictions present in the German labor market, we calculate the sum of foregone production (equal to the wage bill of displaced workers) and unemployment benefits paid to displaced workers. We then simulate a counter-factual scenario in which wages are free to adjust to their market clearing level and no adverse employment effects arise and we calculate the total wage effect of immigrants. We find that the adverse effect of immigration on the total wage bill is much larger under the scenario with wage rigidity and unemployment benefits than under perfect wage flexibility.

Following the working paper version of the present work (D'Amuri et al., 2008), other studies have analyzed the impact of immigration on employment and wages of West German workers. Those studies have either used different data (such as the GSOEP used in Felbermayr et al., 2008) or focused on different policy experiments (as Brucker and Jahn, 2008). While generally confirming our results those studies provide interesting extensions, robustness checks and alternative policy analyses that complement the present work.

The rest of the paper is organized as follows. Section 2 describes the theoretical framework behind our evaluation of the wage and employment effects of immigration. Section 3 presents the data used for our econometric analysis and presents summary statistics. Results from the econometric analysis of the employment effects of immigration are presented in Section 4, which also discusses important empirical issues, estimates the relevant elasticities of substitution and uses these estimates to calculate the equilibrium effects of immigration on employment and wages. Section 5 discusses the implications of our findings in terms of the aggregate wage impact of immigration comparing the actual scenario with a counter-factual of perfect wage flexibility. Section 6 concludes.

2. Theoretical framework

2.1. Production

The production side of our economy is similar to Ottaviano and Peri (2008) and Borjas (2003). Firms employ labor and physical capital (K) to produce a homogeneous final product, which is sold in a perfectly competitive market and is taken as numeraire good. Technology is such that physical capital and a labor composite are combined in a Cobb–Douglas production function to produce output under constant returns to scale. The labor composite is itself a CES aggregator of employees with different work experience nested within educational groups. We allow for further degrees of imperfect substitutability between natives and immigrants and also between old and new immigrants to Western 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

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

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, $k = 1,2,3$, corresponding to workers with no vocational degree, workers with vocational degree and workers with tertiary education. The parameter $\delta \geq 0$ measures the elasticity of substitution among the three educational groups.

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

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

where $j = 1,2,\ldots,8$ is an index capturing five-year intervals of potential experience, spanning from a minimum of 0 to a maximum of 40 years. The term $\eta \geq 0$ 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 (2008), native and immigrant workers are allowed to be imperfect substitutes in production since the two groups may have different abilities and skills which affect their comparative advantages and hence their choices of occupation (Peri and Sparber, 2009). Consequently, L_{kjt} is defined as

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

where H_{kjt} and M_{kjt} denote, respectively, native ('Home') and immigrant ('Migrant') workers; $\sigma \geq 0$ is their elasticities of substitution; θ_{Hkjt} and θ_{Mkjt} are their specific productivity levels, with $\theta_{Hkjt} + \theta_{Mkjt} = 1$. Finally, we also allow M_{kjt} to be a CES

aggregator of old and new immigrants:

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

where M_{kjt}^{OLD} (M_{kjt}^{NEW}) denotes migrants with education k and experience j who are observed working in Western Germany for five years or less (strictly more than five years). In (5) the parameter $\lambda \geq 0$ denotes their elasticity of substitution while θ_{kjt}^{OLD} and θ_{kjt}^{NEW} represent their specific productivity levels standardized so that $\theta_{kjt}^{OLD} + \theta_{kjt}^{NEW} = 1$.

In all expressions, the relative efficiency parameters, θ, and the total factor productivity, A_t, depend on technological factors only and are thus independent of the supply of migrant workers.

2.2. Wage rigidity and employment effects

We account for wage rigidities by assuming that the wage of natives with education k and experience j has to satisfy the following reduced-form constraint:

$$H_{kjt} = [w_{Hkjt}(1-r)]^{\xi_H}\overline{H}_{kjt} \tag{6}$$

where $\overline{H}_{kjt}$ is the native labor force, w_{Hkjt} is the native wage rate, $\xi_H \geq 0$ measures the elasticity of native employment with respect to wages, and $0 \leq r \leq 1$ is the unemployment insurance replacement rate.

Expression (6) captures the fact that native employment and the uninsured portion of the wage they receive are linked. Hence a change in wages (produced by a change in the supply of some type of labor) may induce an employment response for natives. An analogous expression holds for old immigrants:

$$M_{kjt}^{OLD} = [w_{Mkjt}^{OLD}(1-r)]^{\xi_M}\overline{M}_{kjt}^{OLD} \tag{7}$$

where $\xi_M \geq 0$ measures the elasticity of immigrant employment with respect to their wage. The elasticities ξ_H and ξ_M are allowed to be different for natives and immigrants.

The theoretical underpinnings of (6) and (7) are simply stated. If there was unemployment in a perfect labor market, unemployed workers would bid the wage down until labor demand meets labor supply. In (6) and (7) that happens when $\xi = 0$. Different theories of unemployment suggest reasons why this mechanism fails to operate.[6]

In presence of the positive relation between native and old immigrant workers' wages and employment levels captured by (6) and (7), wage changes due to immigration may give rise to employment effects:

$$\left(\frac{\Delta H_{kjt}}{H_{kjt}}\right)_{response} = \xi^H \frac{\Delta w_{Hkjt}}{w_{Hkjt}}$$

$$\left(\frac{\Delta M_{kjt}^{OLD}}{M_{kjt}^{OLD}}\right)_{response} = \xi^M \frac{\Delta w_{Hkjt}^{OLD}}{w_{Hkjt}^{OLD}}$$

$$\frac{\Delta M_{kjt}}{M_{kjt}} = \frac{\Delta M_{kjt}^{OLD} + \Delta M_{kjt}^{NEW}}{M_{kjt}^{OLD} + M_{kjt}^{NEW}} \tag{8}$$

where $(\Delta H_{kjt}/H_{kjt})_{response}$ and $(\Delta M_{kjt}^{OLD}/M_{kjt}^{OLD})_{response}$ represent the changes in labor supply of native and old immigrant workers.

The population of new immigrants is subject to exogenous shocks. In particular, since new immigrants appear in our dataset only upon finding their first job in Germany, we assume that the employment of new immigrants M_{kjt}^{NEW} coincides with their level in the labor force $\overline{M}_{kjt}^{NEW}$. Accordingly, M_{kjt}^{NEW} is exogenous whereas H_{kjt} and M_{kjt}^{OLD} are determined as wages adjust to the inflow of M_{kjt}^{NEW}. Then, since we observe $\Delta H_{kjt}/H_{kjt}$ and $\Delta M_{kjt}^{OLD}/M_{kjt}^{OLD}$, we can estimate their responses to the exogenous changes $\Delta M_{kjt}^{NEW}/M_{kjt}^{NEW}$. In particular, (as in Card, 2007), we can assess the possible employment effects of new immigrants on old immigrants by implementing the following regression:

$$\frac{\Delta M_{kjt}}{M_{kjt-1}} = D_k + D_j + D_t + \gamma \frac{\Delta M_{kjt}^{NEW}}{M_{kjt-1}} + u_{kjt} \tag{9}$$

where D_k, D_j and D_t are, respectively, education, experience and year fixed effects included in order to control for systematic differences in employment growth across education groups, experience groups and years and u_{kjt} a zero-mean cell-specific random shock in employment of immigrants. Eq. (9) is the basis for the empirical analysis implemented in Section 4.2.1. Similarly, in order to assess the effect of immigrant on native employment, we can implement

$$\frac{\Delta EMPL_{kjt}}{EMPL_{kjt-1}} = D_k + D_j + D_t + \rho \frac{\Delta M_{kjt}}{EMPL_{kjt-1}} + u_{kjt} \tag{10}$$

[6] Three main reasons have been highlighted in the literature (see, e.g., Romer, 2001, for a survey): efficiency wages, contracting, search and matching.

Using the notation from the model, the variable $EMPL_{kjt-1} = M_{kjt-1} + H_{kjt-1}$ 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_k, D_j and D_t are the usual education, experience and time dummies and u_{kjt} is a zero mean cell-specific random shock. The parameter ρ captures the impact of immigration on total employment. Eq. (10) is estimated in Section 4.2.2.

An estimated coefficient $\gamma\,(\rho)$ equal to one entails the absence of any employment effects on natives, since the increase in immigrant workers (new immigrants) adds to total employment (immigrant) without crowding out existing workers, while values below (above) one would entail negative (positive) employment effects of migration on natives.

Once we have identified the employment effect of new immigrants on old immigrants and natives we plug those effects into the demand condition for each skill group to find the wage effects.

2.3. Labor market equilibrium

In equilibrium wages and employment levels are such that firms maximize profits (i.e., they are on their labor demand curves) and the two constraints (6) and (7) bind. The production function (1) can be used to calculate the demand for each type of labor at a given period t. Specifically, profit maximization requires that 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:

$$\ln(w_{Hkjt}) = \ln(\alpha A_t \kappa_t^{1-\alpha}) + \frac{1}{\delta}\ln(L_t) + \ln(\theta_{kt}) - \left(\frac{1}{\delta} - \frac{1}{\eta}\right)\ln(L_{kt}) + \ln(\theta_{kjt}) - \left(\frac{1}{\eta} - \frac{1}{\sigma}\right)\ln(L_{kjt}) + \ln(\theta_{Hkjt}) - \frac{1}{\sigma}\ln(H_{kjt}) \tag{11}$$

where $\kappa_t = K_t/L_t$ is the capital–labor ratio. Taking the ratio between Eq. (11) and the similar expression for the wage of immigrant workers yields Eq. (12) below that we use in Section 4.3.2 to estimate the inverse elasticity of substitution $1/\sigma$ by considering the variation of M_{kjt} and H_{kjt} as exogenous, once we control for education, experience and time fixed effects:

$$\ln\left(\frac{w_{Hkjt}}{w_{Mkjt}}\right) = \ln\left(\frac{\theta_{Hkjt}}{\theta_{M_kjt}}\right) - \frac{1}{\sigma}\ln\left(\frac{M_{kjt}}{H_{kjt}}\right) \tag{12}$$

Similarly, the natural logarithm of the wage of old immigrants with education k and experience j is

$$\ln(w_{Mkjt}^{OLD}) = \ln(\alpha A_t \kappa_t^{1-\alpha}) + \frac{1}{\delta}\ln(L_t) + \ln(\theta_{kt}) - \left(\frac{1}{\delta} - \frac{1}{\eta}\right)\ln(L_{kt}) + \ln(\theta_{kjt}) - \left(\frac{1}{\eta} - \frac{1}{\sigma}\right)\ln(L_{kjt}) + \ln(\theta_{Mkjt}) - \left(\frac{1}{\sigma} - \frac{1}{\lambda}\right)\ln(M_{kjt}) + \ln(\theta_{kjt}^{OLD}) - \frac{1}{\lambda}\ln(M_{kjt}^{OLD}) \tag{13}$$

By taking the ratio between (13) and the analogous expression for w_{Mkjt}^{NEW}, we recover Eq. (14) that we use in Section 4.3.1 to estimate the inverse elasticity of substitution $1/\lambda$ by considering the variation of M_{kjt}^{OLD} and M_{kjt}^{NEW} as exogenous, once we control for education, experience and time fixed effects:

$$\ln\left(\frac{w_{Mkjt}^{OLD}}{w_{Mkjt}^{NEW}}\right) = \ln\left(\frac{\theta_{kjt}^{OLD}}{\theta_{kjt}^{NEW}}\right) - \frac{1}{\lambda}\ln\left(\frac{M_{kjt}^{OLD}}{M_{kjt}^{NEW}}\right) \tag{14}$$

Aggregating the marginal pricing conditions for each education–experience group implies the following relationship between the compensation going to the composite labor input L_{kjt} and its supply:

$$\ln(\overline{W}_{kjt}) = \ln\left(\alpha A_t^{1/\alpha}\kappa_t^{(1-\alpha)/\alpha}\right) + \frac{1}{\delta}\ln(L_t) + \ln\theta_{kt} - \left(\frac{1}{\delta} - \frac{1}{\eta}\right)\ln(L_{kt}) + \ln\theta_{kj} - \frac{1}{\eta}\ln(L_{kjt}) \tag{15}$$

where $\overline{W}_{kjt} = w_{Mkjt}(M_{kjt}/L_{kjt}) + w_{Hkjt}(H_{kjt}/L_{kjt})$ is the average wage paid to workers in the education–experience group k,j and can be considered as the compensation to one unit of the composite input L_{kjt}. Aggregating the production function one level further, together with marginal cost pricing, implies that the compensation going to the labor input L_{kt} satisfies the following expression:

$$\ln(\overline{W}_{kt}) = \ln\left(\alpha A_t^{1/\alpha}\kappa_t^{(1-\alpha)/\alpha}\right) + \frac{1}{\delta}\ln(L_t) + \ln\theta_{kt} - \frac{1}{\delta}\ln(L_{kt}) \tag{16}$$

where $\overline{W}_{kt} = \sum_j (L_{kjt}/L_{kt})\overline{W}_{kjt}$ is the average wage in education group k.[7] The two equations (15) and (16) are the basis for the empirical estimation of the elasticity $1/\eta$ and $1/\delta$ once we absorb with education by year and year fixed effects the variation of the aggregate indices and productivity and we consider the remaining variation of supply (L_{kjt} and L_{kj}) as exogenous.

2.3.1. Wage effects

Finally, when calculating the effects of new immigration on wages, we will take into account that physical capital adjusts to changes in the labor supply so as to keep its real rate of return constant. This is a reasonable assumption since

[7] The weight for the wage of each group equals the size of the composite input for that education–experience cell, L_{kjt}, relative to the size of the composite input for the whole education group L_{kt}. This is measured by the share of group k,j in educational group k.

Ortega and Peri (2009) recently found that within OECD countries physical capital fully adjusts to immigration within one year, in order to maintain constant returns to capital. This implies that in expressions (11) and (13), the capital–labor ratio κ_t follows a trend determined only by the growth of total factor productivity A_t so that the overall impact of new immigration on native and old immigrant wages can be obtained by computing the total changes of (11) and (13) with respect to the changes in the labor aggregates (L_t, L_{kt}, L_{kjt}) induced by new immigrants:

$$\left(\frac{\Delta w_{Hkjt}}{w_{Hkjt}}\right)^{Total} = \frac{1}{\delta}\sum_m\sum_i\left[s_{Mmit}\frac{\Delta M_{mit}}{M_{mit}} + s_{Hmit}\left(\frac{\Delta H_{mit}}{H_{mit}}\right)_{response}\right] + \left(\frac{1}{\eta}-\frac{1}{\delta}\right)\frac{1}{s_{kt}}\sum_i\left[s_{Mkit}\frac{\Delta M_{kit}}{M_{kit}} + s_{Hkit}\left(\frac{\Delta H_{kit}}{H_{kit}}\right)_{response}\right] + \left(\frac{1}{\sigma}-\frac{1}{\eta}\right)\frac{1}{s_{kjt}}\left[s_{Mkjt}\frac{\Delta M_{kjt}}{M_{kjt}} + s_{Hkjt}\left(\frac{\Delta H_{kjt}}{H_{kjt}}\right)_{response}\right] - \frac{1}{\sigma}\left(\frac{\Delta H_{kjt}}{H_{kjt}}\right)_{response} \tag{17}$$

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, $s_{kjt} = (w_{Mkjt}M_{kjt}+w_{Hkjt}H_{kjt})/\sum_m\sum_i(w_{Mmit}H_{mit}+w_{Hmit}M_{mit})$ is the share of 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 summations 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 between t and $t+1$. The term $(\Delta H_{kjt}/H_{kjt})_{response}$ represents the change in labor supply of native workers in the same group caused by immigration and estimated by Eq. (10).

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

$$\begin{aligned}\left(\frac{\Delta w^{OLD}_{Mkjt}}{w^{OLD}_{Mkjt}}\right)^{Total} = {} & \frac{1}{\delta}\sum_m\sum_i\left[s^{NEW}_{mit}\frac{\Delta M^{NEW}_{mit}}{M^{NEW}_{mit}} + s^{OLD}_{mit}\left(\frac{\Delta M^{OLD}_{mit}}{M^{OLD}_{mit}}\right)_{response} + s_{Hmit}\left(\frac{\Delta H_{mit}}{H_{mit}}\right)_{response}\right] \\ & + \left(\frac{1}{\eta}-\frac{1}{\delta}\right)\frac{1}{s_{kt}}\sum_i\left[s^{NEW}_{kit}\frac{\Delta M^{NEW}_{kit}}{M^{NEW}_{kit}} + s^{OLD}_{kit}\left(\frac{\Delta M^{OLD}_{kit}}{M^{OLD}_{kit}}\right)_{response} + s_{Hkit}\left(\frac{\Delta H_{kit}}{H_{kit}}\right)_{response}\right] \\ & + \left(\frac{1}{\sigma}-\frac{1}{\eta}\right)\frac{1}{s_{kjt}}\left[s^{NEW}_{kjt}\frac{\Delta M^{NEW}_{kjt}}{M^{NEW}_{kjt}} + s^{OLD}_{kit}\left(\frac{\Delta M^{OLD}_{kjt}}{M^{OLD}_{kjt}}\right)_{response} + s_{Hkjt}\left(\frac{\Delta H_{kjt}}{H_{kjt}}\right)_{response}\right] \\ & + \left(\frac{1}{\lambda}-\frac{1}{\sigma}\right)\frac{1}{s_{Mkjt}}\left[s^{NEW}_{kjt}\frac{\Delta M^{NEW}_{kjt}}{M^{NEW}_{kjt}} + s^{OLD}_{kit}\left(\frac{\Delta M^{OLD}_{kjt}}{M^{OLD}_{kjt}}\right)_{response}\right] - \frac{1}{\lambda}\left(\frac{\Delta M^{OLD}_{kjt}}{M^{OLD}_{kjt}}\right)_{response}\end{aligned} \tag{18}$$

Hence, 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 plug in those terms and calculate the wage effect of immigration for each group.

3. Data and empirical implementation

3.1. The IAB employment sub-sample

The data we employ are from the German Institute for Employment Research (IAB).[8] 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 received unemployment benefits. We limit our analysis to the 1987–2001 period that experienced a steep rise in the number of immigrants. The population includes workers and trainees liable to make social security contributions. The self-employed, civil servants and students enrolled in higher education are not included in the dataset. The IAB dataset is well suited for the analysis of labor market outcomes in the German labor market, especially for people with high attachment to the labor market such as male heads of households. One major advantage of these data is the very large, consistent and continuous coverage over time and the method of collection that guarantees minimum reporting errors. The sample is representative of total (social-security-paying) employment each year. In the Data Appendix we describe in greater detail these data and the refinements that we introduced to identify immigrants, inclusive of Ethnic Germans and Eastern Germans.[9] We also provide a systematic comparison of these data with those from the German Socioeconomic Panel Study (GSOEP, see Haisken-DeNew and Frick, 2005, for a description). While that panel study

[8] The interested reader can also refer to Bender et al. (2000) for a description of the data.

[9] Since country of birth is not available in this dataset, we use nationality as a proxy for migration status. This introduces measurement error since the focus of this paper is on immigration rather than nationality. The problem might be made more severe by the presence of a large pool of second generation immigrants with non-German nationality and of a large group of *Ethnic Germans*. As discussed at length in the Data Appendix, we perform many robustness checks in order to test the robustness of our results to bias arising from this aspect. We think it is important for future analysis of German data to relate more carefully measures of nationality and foreign-born status.

Table 1
Comparison between IAB and GSOEP, Year 1987, 1991 and 2001.

	1987				1991				2001			
	GSOEP		IAB		GSOEP		IAB		GSOEP		IAB	
	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
Natives												
Share females	0.40		0.42		0.40		0.43		0.46		0.44	
No vocational education	0.21		0.26		0.25		0.22		0.16		0.18	
Vocational education	0.66		0.68		0.65		0.71		0.64		0.71	
Higher education	0.12		0.06		0.10		0.07		0.20		0.11	
Years of experience	17.73	11.77	16.90	11.28	17.69	11.40	17.67	11.10	19.58	10.60	19.52	10.72
Less than 20 years of pot. exp.	0.59		0.62		0.60		0.60		0.53		0.53	
Daily wage	69.69	42.41	68.87	33.25	70.60	45.58	75.09	33.56	81.80	52.08	79.15	39.37
Immigrants												
Share of total	0.07		0.09		0.12		0.10		0.13		0.14	
Share females	0.30		0.31		0.33		0.33		0.40		0.37	
No vocational education	0.61		0.62		0.66		0.59		0.29		0.38	
Vocational education	0.36		0.34		0.31		0.37		0.46		0.54	
Higher education	0.03		0.04		0.02		0.04		0.25		0.08	
Years of experience	20.59	10.75	18.64	10.15	20.37	11.98	18.22	10.69	17.88	11.09	18.68	10.56
Less than 20 years of pot. exp.	0.46		0.54		0.47		0.56		0.61		0.58	
Daily wage	62.42	23.36	68.54	26.75	61.27	25.10	70.83	29.10	76.86	52.54	71.85	32.87

Note: The German Socio-Economic Panel GSOEP is a panel of individuals started in 1984 with refreshments (i.e. inclusion of new waves of people) in 1994/1995, 1998 and 2000 over the considered period. The IAB is an administrative dataset including workers of the private sector contributing to social security. Immigrants are defined as foreign-born plus those living in East Germany in 1989 in the GSOEP and as foreign-nationals plus those who report having started to work in East Germany in the IAB. We follow the same selection rules for both datasets (see Section 3). In particular, we include only private sector, not self-employed workers, aged 17–64 and living in West Germany. For GSOEP data we use the cross-sectional weights; as daily wages are not recorded in the GSOEP, we recover them from gross monthly wages assuming that the average individual works a fraction of the month which is equal to the fraction of the days worked in the year as calculated from the IAB sample on a migration status and year basis.

has some desirable features, such as the identification of country of birth (which is better than nationality in identifying immigrants) it also has two serious problems. The first is that it is based on a much smaller sample so that in many education–experience cells (according to our definition) it contains very few observations or none at all, especially for immigrants. Second, it is a panel dataset started in 1984 with infrequent refreshments (1994, 1998 and 2000). During the intermediate years only the sample weights are adjusted to reflect the changing population but no new information on flows and wages is used. Therefore we decided to use the IAB dataset and to address a series of issues by refining and cleaning the data (as described in the Data Appendix). The interested reader can see in Table 1 how some summary statistics compare between the two datasets and read in the Data Appendix a detailed account of the comparison between IAB and GSOEP and of the refinement and robustness checks that we performed.

The supply of labor for each education–experience and nativity cell in a year is calculated as the sum of employees in the cell weighted by their yearly working days. Nominal gross wages are all converted to 2000 Euros using the CPI-based deflator across years before calculating the cell averages. While we do not impose further restrictions on the sector of activity and on work arrangements, we do not include marginal employees, that is workers earning a wage below a really low threshold (approximately 330 euros per month in 1999, according to Wagner, 1999) that are in the IAB sample after 1999.

Fig. 1 reports the share of immigrants on total employment as obtained from the refined IAB dataset (including Ethnic and East–West moving Germans), showing that it climbed from about 9% in 1987 to 14% in 2001. The time period analyzed is particularly interesting for the analysis of the labor market impact of immigration: the inflow of immigrant workers was very large and mostly supply-driven (due to the fall of the Iron Curtain and the uncertainty following the aftermath of the end of socialism in the countries of origin). Indeed, the large and sudden rise in the share of immigrant workers, mostly due to push factors, makes this somewhat of a 'natural experiment'—one which is well suited to assessing the impact of immigration on incumbent workers.[10]

3.2. Stylized facts and descriptive statistics

Let us first describe simple aggregate evidence that points to the existence of significant differences in the labor market performances between immigrants and natives. Fig. 2 shows the evolution of the share of individuals receiving

[10] 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.

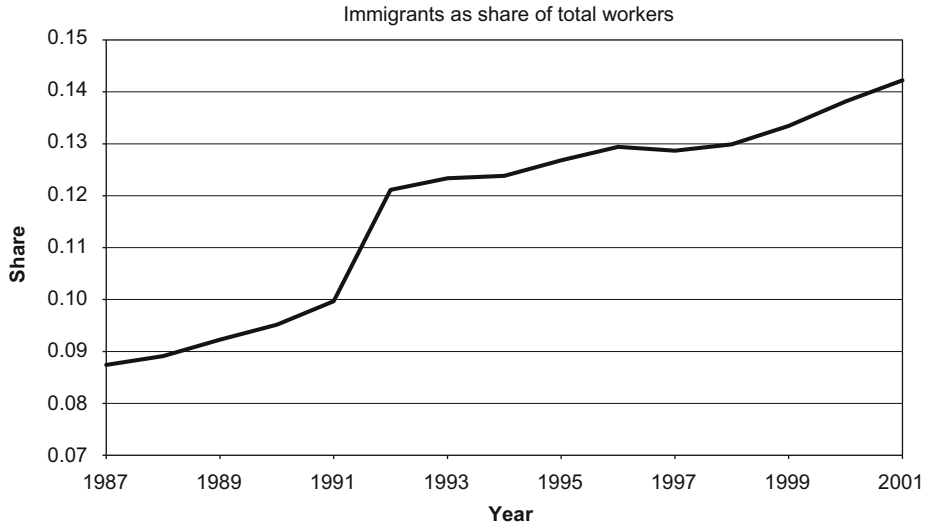

Fig. 1. Immigrants as share of total workers. *Source:* Authors' calculations based on IAB data. Immigrants are the sum of foreign nationals plus workers who immigrated from Eastern Germany plus ethnic Germans who immigrated from abroad.

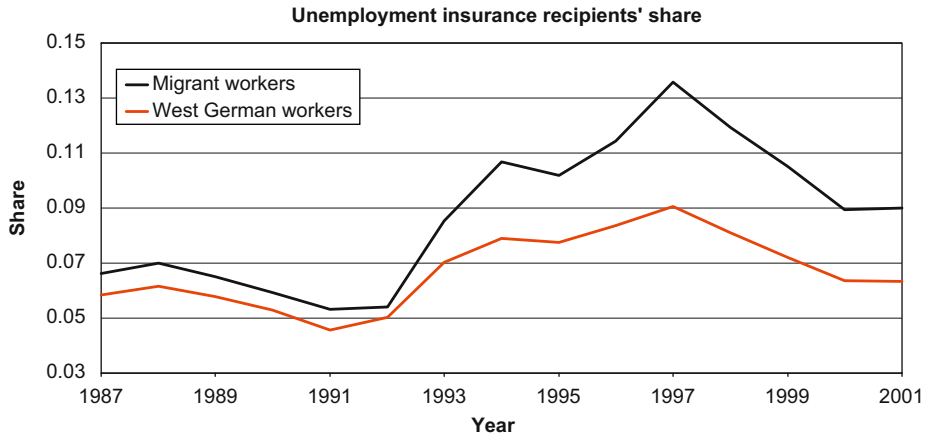

Fig. 2. Unemployment insurance recipients' share. *Source:* Authors' calculations based on IAB data. The 'unemployment insurance recipients' share' is equal to the share of individuals receiving unemployment benefits relative to the sum of workers and individuals receiving unemployment benefits.

unemployment benefits relative to the total workforce, calculated separately for native Germans and immigrant workers for the period 1987–2001 from the IAB dataset. Two tendencies emerge. First, the rates for native German and immigrant workers are quite stable and fairly similar over the period 1987–1991, a period of relatively small inflows of immigrants. Second, beginning in 1991 the unemployment rate for immigrants increases significantly. For native Germans it increases much less, opening a gap that is quite persistent, though it narrows toward the end of the 1990s.

Table 2 reports, for selected years, the shares of immigrants in each of the education–experience cells used in the regressions. Ethnic Germans are classified, as usual, as immigrants following the procedure described in the Data Appendix. In Table 2 we show the percentage of non-Western Germans both from foreign countries and from Eastern Germany. The share of non-native workers in total employment more than doubles in many cells between 1987 and 2001. Large inflows of immigrants took place in all education groups. Interestingly, while Eastern German immigrants were over-represented among those of intermediate and high levels of educations, immigrants from foreign countries were proportionally more numerous among the less educated group. Merging the two groups we obtain a group of immigrants which is fairly balanced among the three education groups.

To summarize, a preliminary look at the data suggests that the substantial increase in the number of immigrant workers over the period of observation has been evenly distributed across educational levels. The performance of migrants has been worse than that of natives in terms of unemployment rates, suggesting stronger competition of new immigrants with existing foreign-born workers.

Table 2
Share of foreign immigrants/Eastern German immigrants in total workers by education and potential experience.

Education	Potential experience	1987		2001	
		Overall share of migrants (%)	Overall share of migrants (%)	Share Eastern Germans (%)	Share foreign immigrants (%)
No vocational education	Up to 4	7.2	8.8	1.0	7.8
	5–9	20.6	22.9	2.9	20.0
	10–14	20.1	42.5	3.7	38.8
	15–19	24.7	39.3	3.4	35.9
	20–24	32.4	35.7	2.5	33.2
	25–29	38.1	27.9	3.0	24.9
	30–34	23.3	26.1	2.4	23.8
	35–40	16.4	33.7	1.5	32.2
Vocational education	Up to 4	4.9	15.4	5.0	10.4
	5–9	4.0	18.2	5.5	12.7
	10–14	4.2	14.1	4.9	9.2
	15–19	5.5	11.1	3.8	7.3
	20–24	7.7	9.6	3.8	5.8
	25–29	4.9	8.4	3.3	5.1
	30–34	3.4	9.1	2.7	6.5
	35–40	2.8	8.7	1.9	6.8
Higher education	Up to 4	4.8	13.7	3.8	10.0
	5–9	4.3	8.9	3.0	5.8
	10–14	5.7	7.9	2.9	5.0
	15–19	7.5	7.7	2.8	4.9
	20–24	6.4	8.2	2.9	5.4
	25–29	4.3	9.4	2.8	6.5
	30–34	4.2	10.1	3.3	6.8
	35–40	0.0	10.0	2.9	7.1

Note: The percentages are calculated from IAB data refined as described in the main text. Immigrants are defined as foreign-nationals and foreign-born ethnic Germans. Eastern Germans are those workers who report having started to work in East Germany.

4. Employment and wage effects

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. We calculate average employment and wage levels for each of the education–experience-year cell. We have considered three educational levels (No Vocational Education, Vocational Education and Higher Education), 8 experience levels (5 year intervals for individuals with a 0–40 year potential experience levels) and 15 years (1987–2001) for a total of 360 cells. The average cell-size in the sample is equal to 7571 for natives and 1006 for migrants (678 and 328, respectively, for *NEW* and *OLD* migrants). The percentage of empty cells, therefore not used for estimation, ranges between zero for natives to a maximum of 3.1% for *NEW* immigrants.

In our empirical analysis we proceed in three steps. First, we estimate the effects of new immigration on the employment levels of native and old immigrant workers in the same skill group implementing Eqs. (9) and (10). Second, implementing empirically Eqs. (12) and (14) we estimate the elasticity of substitution between natives and immigrants for given education and experience (σ) as well as the elasticity between new and long-term immigrants for given education and experience (λ). We then estimate the elasticity of substitution between educational levels (δ) as well as between experience levels for a given educational level (η) by implementing empirically Eqs. (15) and (16). Finally, once we have the estimated employment effects and elasticities of substitution, we use expressions (17) and (18) to compute the impact of the inflow of new immigrants on the wages of natives and old immigrants with different levels of education.

4.1. Empirical issues: demand shocks and estimation bias

Before implementing the empirical specifications let us note that a common feature throughout the estimation procedure is that we consider changes in the employment of new immigrants as a supply shock. In particular, when we estimate either the employment response of previous immigrants and natives, or the response of wages, we rely on the assumption that the inflow of new immigrants is an exogenous supply shock. Therefore, (i) we can consider the employment response of natives as actually caused by the immigrant inflow and (ii) we can consider the wage responses as identifying the relative wage elasticity (elasticity of substitution) of labor demand. This may look like a strong assumption. After all we are essentially regressing (total) employment and wages on immigration and we may be identifying a

parameter that mixes demand and supply changes. We think, however, that considering the estimated parameters in Section 4.2 as genuine measures of the employment response, and those in Section 4.3 as demand elasticities, is reasonable in light of the following three facts.

First, and least important, the entire literature which analyzes the national effects of immigration using this framework makes the same simple assumption that immigrants are an exogenous shock to the national labor supply (e.g., Borjas, 2003; Borjas and Katz, 2007; Ottaviano and Peri, 2008). Second, while the overall flow of immigrants can be driven by demand pull, since we use variations and control for year, education and experience fixed effects we rely on the differential change of immigrant flows within an education–experience cell. This is likely to be driven mostly by demographic factors in the sending country (i.e., the size of a cohort relative to the others). Moreover, in estimating native-immigrant elasticity we use relative native-immigrant wages and relative native-immigrant employment so that any demand shock common to immigrants and natives within education and experience groups would be canceled when taking the ratio. Hence many demand shocks simply affecting highly educated or younger workers would not affect the estimate of that elasticity. Third, and most important, in our estimates we also rely on an IV strategy based on a quasi-natural experiment: the German reunification. In the aftermath of the reunification (1991) a large increase in Eastern German immigrants was observed which was simply due to the fact that migrating became a possibility. Hence, treating the inflow of Eastern Germans as a pure supply shock, post-1991, we perform several 2SLS estimations using that flow as an instrument for all new immigrants. Notice, finally, that if some demand shock, not controlled for, were still driving part of the correlation (between relative wages and relative supply of new immigrants) that would likely bias our estimates of the inverse elasticity of substitution towards 0. Hence, particularly for the elasticity of substitution between native and immigrants, our estimates (around 0.04–0.05) could be a lower bound of the actual inverse elasticity, which would imply even lower substitutability between native and immigrants and certainly less than perfect substitutability.

4.2. Employment effects

We first estimate the response of old (i.e., long-term) immigrants' and natives' employment levels to the inflow of new immigrants in the same education–experience cells. Such an adjustment in employment likely depends on wage rigidities and frictions that prevent full wage adjustment.

4.2.1. New and old immigrants

To estimate the impact of immigrants on the employment of native workers, we estimate the empirical specification (9) described in Section 2.2. 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 new immigrants with education k and experience j equal to 1% of the initial employment in that cell is associated with an increase in total immigrant employment within the same education–experience cell of 1%. In this case, new immigrants add to previous employment without crowding out any old immigrants so there is no response of employment of old immigrants to inflows of new immigrants. In contrast, an estimated value of $\gamma < 1$ implies that new immigrants crowd out the employment of old immigrants inducing a decrease in their employment.

Table 3 reports the estimates of the coefficient γ from estimating Eq. (9). Different columns show estimates from different specifications. Column (1) reports the basic specification: Least Squares estimates, weighting each cell by the total employment in it, spanning the period 1987–2001, including males only in the sample and considering the sum of Eastern Germans, foreign nationals and ethnic Germans born abroad as immigrants. Specification (2) omits the ethnic German imputation, specification (3) includes both men and women in the sample. In specification (4) we assign workers to education cells according to their imputed education (computed as described in the Data Appendix). Specifications (5) and (6) restrict data to subsamples that omit the very early years (pre-unification) or recent years. Finally the last two columns (7) and (8) estimate the coefficient γ using 2SLS with the flow of Eastern Germans as an instrument for total immigrants. Most of the point-estimates of γ are between 0.6 and 0.7, and in all cases the hypothesis $\gamma = 1$ can be rejected at standard confidence levels against the alternative $\gamma < 1$. This constitutes evidence that new immigrants are crowding out old immigrants. The estimates of γ are the lowest when using the 2SLS method, implying the largest crowding out. Notice that the first stage reveals that the inflow of Eastern Germans is a powerful instrument.[11] In the post-1991 period, the inflow of Eastern Germans represented a very sizeable group among new immigrants. A formal test cannot reject the hypothesis that WLS and 2SLS estimates are identical. This suggests that, if we believe that the inflow of Eastern Germans was mainly a supply shock, the largest part of the immigration fluctuations are supply-driven once we control for year and cell fixed effects. Our estimates for γ imply that, on average, when 10 new immigrants find employment in Germany, 3–4 old immigrants lose their jobs.

4.2.2. Immigrants and natives

To analyze the impact of immigration on native employment we estimate Eq. (10) described in Section 2.2. The parameter ρ in (10) captures the impact of immigration on total employment. If it is smaller than 1, it implies that

[11] The F-test is above 200, much larger than the lower bound of 10 suggested by the literature on weak instruments (Bound et al., 1995; Stock and Yogo, 2002).

Table 3
Estimates of γ: the effect of new immigrants on total immigrant employment.

Column	(1) Basic	(2) No ethnic imputation	(3) Males and female	(4) Imputed education	(5) 1992–2001 subsample	(6) 1987–1999 subsample	(7) 2SLS, basic	(8) 2SLS, no ethnic imputation
Estimate of γ	0.6860***	0.668***	0.623***	0.727***	0.658***	0.640***	0.580***	0.590***
	(0.097)	(0.105)	(0.094)	(0.077)	(0.093)	(0.094)	(0.11)	(0.11)
P-value: H_0: $\gamma = 1$	0.004	0.005	0.001	0.002	0.002	0.002	0.00	0.00
Period	1987–2001	1987–2001	1987–2001	1987–2001	1992–2001	1987–1999	1992–2001	1992–2001
Group	Males	Males	Males and females	Males	Males	Males	Males	Males
Ethnics' imputation	Yes	No	Yes	Yes	Yes	Yes	Yes	No
Equivalent education	No	No	No	Yes	No	No	No	No
Observations	313	313	313	313	210	271	210	210
First stage								
East–West migrants							1.01	1.00
Standard error							0.04	0.07
T statistic							25.42	14.47
F-test of exclusion							163.40	209.42

Note: Dependent variable is the yearly change in total immigrant employment in an education–experience cell as a percentage of initial immigrant employment in the cell; the explanatory variable is the change in new immigrant employment as a percentage of the initial immigrant employment. New immigrants are those who have been in the country five years or less. Each regression, weighted by the number of workers in the education–experience–period cell, includes education, experience and year fixed effects. Each observation point is an education–experience cell in a year. In parenthesis we report the heteroskedasticity-robust standard errors, clustered by education–experience group.
***, **, * different from 0 at the 1%, 5%, 10% significance level.

Table 4
Estimates of ρ the effects of immigrants on total employment.

Column	(1) Basic	(2) No ethnic imputation	(3) Males and female	(4) Imputed education	(5) 1992–2001 subsample	(6) 1987–1999 subsample	(7) 2SLS, basic	(8) 2SLS, no ethnic imputation
Estimates of ρ	1.272***	1.327***	1.023***	1.358***	1.280***	1.207***	2.683***	2.819***
	(0.384)	(0.391)	(0.520)	(0.431)	(0.530)	(0.324)	(1.015)	(1.069)
T statistic	3.310	3.393	1.967	3.151	2.416	3.728	2.640	2.640
P-value: H_0: $\rho = 1$	0.487	0.412	0.965	0.415	0.603	0.529	0.097	0.089
Period	1987–2001	1987–2001	1987–2001	1987–2001	1992–2001	1987–1999	1992–2001	1992–2001
Group	Males	Males	Males and females	Males	Males	Males	Males	Males
Ethnics' imputation	Yes	No	Yes	Yes	Yes	Yes	Yes	No
Equivalent education	No	No	No	Yes	No	No	No	No
Observations	359	359	359	359	240	311	238	238
First stage								
East–West migrants							1.29	1.23
Standard error							0.17	0.17
T statistic							7.58	7.34
F-test of exclusion							57.38	53.91

Note: Dependent variable is the yearly change in total employment in an education–experience cell as a percentage of the initial employment in the cell; the explanatory variable is the change in immigrant employment in the same cell as a percentage of the initial employment. Each regression, weighted by the number of workers in the education–experience–period cell, includes education, experience and year fixed effects. In parenthesis we report the heteroskedasticity-robust standard errors, clustered by education–experience group.
***,**,* different from 0 at the 1%, 5%, 10% significance level.

immigrants crowd natives out. If it equals 1, new immigrants have no impact on native employment. Table 4 presents the estimates of the coefficient ρ. The different specifications across columns of Table 4 mirror those of Table 3. In this case, while the estimates are less precise, they are all above one. We can never reject the hypothesis of $\rho = 1$ at any significance level and even the point estimates seem to rule out the possibility of crowding out. The 2SLS estimates, while they are very imprecise in part because the inflow of Eastern Germans is not as good an instrument for the change in employment of total immigrants as it was for new immigrants, confirm this result. All in all, the estimates in Table 4 do not provide any support for the idea that changes in immigrant employment crowd out employment of native Germans. These results seem to preclude the presence of adverse employment effects of new immigrants on natives even in the short run (as we use yearly observations). To further check this result, we run another regression (not in the table) in which we stratify native

and migrant workers according to their education only, instead of using the finer stratification of education–experience cells. If Western German employers valued differently the work experience acquired inside and outside Western Germany, our labor market segmentation along education and experience levels could fail to appropriately identify groups of workers competing for the same jobs. Also, if there are employment effects spilling across experience groups one would not capture them with the above regression. Hence, we group workers according to their education level only and we run the following regression:

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

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 with the usual samples. The point estimate of ρ_{EDU} in the basic specification is 1.48 (standard error 0.51) so that we cannot reject $\rho_{EDU} = 1$. The limit of this regression is that it is run on 45 observations only.

The results from employment regressions imply that *there is no evidence of adverse effects of new immigration on the employment levels of native workers, while long-term immigrants seem negatively affected by newcomers.*

4.3. Elasticities of substitution

4.3.1. New and old immigrants

In order to estimate the elasticity of substitution between immigrants, we estimate Eq. (12) obtained from the labor demand conditions and we capture the relative demand term $\ln(\theta^{OLD}_{kjt}/\theta^{NEW}_{kjt})$ using fixed education (D_k), experience (D_j) and year (D_t) effects. Hence we implement the following specification:

$$\ln\left(\frac{w^{OLD}_{Mkjt}}{w^{NEW}_{Mkjt}}\right) = D_k + D_j + D_t - \frac{1}{\lambda}\ln\left(\frac{M^{OLD}_{kjt}}{M^{NEW}_{kjt}}\right) + u_{kjt} \tag{19}$$

Essentially we allow the relative new/old immigrant productivity to depend systematically on their education, age and on the year. We interpret the remaining within-cell variation of migrants over time as being supply driven. The response of relative wages identifies the inverse elasticity of substitution between new and old immigrants. The corresponding estimates are reported in Table 5. Different specifications check the robustness of results to different definitions of the sample, of immigrants, and of the education groups. Specification (1) adopts the basic specification described above, specification (2) does not include the imputed ethnic Germans among immigrants. Specification (3) includes men and women in the sample, specification (4) includes only people who worked full time during the year (meaning for at least 40 weeks) and specification (5) groups workers according to their occupation-industry imputed schooling. Finally, specifications (6) and (7) consider two sub-samples and (8) and (9) adopt 2SLS as the estimation method using Eastern German immigrants as an instrument for total immigrants. The estimates are quite precise and consistent across specifications. The point estimates of the inverse elasticity are around 0.01 with a standard error also close to 0.01. In most cases we can reject a value for the inverse elasticity larger than 0.03. Hence no evidence of imperfect substitutability between new and old immigrants is found. Thus, new and old immigrants are perfectly substitutable, $\lambda = \infty$ and all immigrants belonging to each education–experience group can be considered as an homogeneous group of workers, which is what we assume in the remainder of the analysis ($M_{kjt} = M^{OLD}_{kjt} + M^{NEW}_{kjt}$).

4.3.2. Natives and immigrants

Following the same strategy we estimate the degree of substitutability between native and immigrant workers within education–experience cells. Specifically, we implement Eq. (12) with education, experience and year fixed effects to control for relative productivity levels. Table 6 reports the values of $1/\sigma$ from estimating the equation below:

$$\ln\left(\frac{w_{Mkjt}}{w_{Hkjt}}\right) = D_k + D_j + D_t - \frac{1}{\sigma}\ln\left(\frac{M_{kjt}}{H_{kjt}}\right) + u_{kjt} \tag{20}$$

Following the same type of specifications as in Table 5 we obtain a range of estimates of $1/\sigma$. All columns show significant values between 0.03 and 0.06 with standard errors around 0.01 and never larger than 0.02. While the values are not too large, they systematically indicate some degree of imperfect substitutability. Moreover, these estimates are perfectly in line with what Ottaviano and Peri (2008) and Card (2009) find for the US (a value around 0.05), and are somewhat smaller than the values estimated for the UK by Manacorda et al. (2006), which range between 0.1 and 0.2. While small, these elasticity values, coupled with the large increase in immigrants relative to natives in most groups, deliver significant effects on the relative native-immigrant wage ratio. In particular, consider that the percentage of immigrants in Germany went from 9% to 14% between 1987 and 2001, implying an increase in the M_t/H_t ratio for the aggregate economy of 64%. This would imply, using the median estimate of 0.045 as the inverse elasticity, an increase in the wage of natives relative to immigrants of $0.045 * 0.64 = 2.8\%$.

Table 5
Estimates of $1/\lambda$, the inverse elasticity of substitution between new and old immigrants.

Column	(1) Basic	(2) No ethnic imputation	(3) Males and female	(4) Full time workers only	(5) Imputed equivalent education	(6) 1992–2001 subsample	(7) 1987–1999 subsample	(8) 2SLS, basic	(9) 2SLS, no ethnic imputation
Estimation method	OLS	OLS	OLS	OLS	OLS	OLS	OLS	2SLS	2SLS
Estimate of $1/\lambda$	0.017	0.014	0.000	0.022	0.004	0.017	0.010	0.02	0.02
	(0.011)	(0.010)	(0.009)	(0.012)	(0.010)	(0.010)	(0.010)	(0.01)	(0.01)
Period	1987–2001	1987–2001	1987–2001	1987–2001	1987–2001	1992–2001	1987–1999	1992–2001	1992–2001
Group	Males	Males	Males and females	Males	Males	Males	Males	Males	Males
Ethnics' imputation	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	No
Equivalent education	No	No	No	No	Yes	No	No	No	No
Wages of FY work. only	No	No	No	Yes	Yes	No	No	No	No
Observations	313	313	313	313	313	210	313	210	210
First stage									
East-West migrants								0.66	0.67
Standard error								0.05	0.05
T statistic								12.10	13.85
F-test of exclusion								146.74	191.91

Note: Dependent variable is the relative new/old immigrant wages in an experience–education cell, explanatory variable is the relative new/old immigrant employment in the cell. Each regression, weighted by the number of workers in the education–experience–period cell, includes education, experience and year fixed effects. In parenthesis we report the heteroskedasticity-robust standard errors, clustered by education–experience group. ***,**,* different from 0 at the 1%, 5%, 10% significance level.

Table 6
Estimates of $1/\sigma$, the inverse elasticity of substitution between immigrants and natives.

Column	(1) Basic	(2) No ethnic imputation	(3) Males and females	(4) Full time workers only	(5) Imputed education	(6) 1992–2001 subsample	(7) 1987–1999 subsample	(8) 2SLS, basic	(9) 2SLS, no ethnic imputation
Estimation method	OLS	OLS	OLS	OLS	OLS	OLS	OLS	IV	IV
Estimates of $1/\sigma$	0.046***	0.046***	0.038***	0.035***	0.037*	0.029**	0.060***	0.030**	0.030**
	(0.011)	(0.011)	(0.011)	(0.011)	(0.020)	(0.013)	(0.013)	(0.016)	(0.013)
Period	1987–2001	1987–2001	1987–2001	1987–2001	1987–2001	1992–2001	1987–1999	1992–2001	1992–2001
Group	Males	Males	Males and females	Males	Males	Males	Males	Males	Males
Ethnics' imputation	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	No
Equivalent education	No	No	No	No	Yes	No	No	No	No
Wages of FY work. only*	No	No	No	Yes	Yes	No	No	No	No
Observations	359	359	359	359	359	240	359	238	238
First stage									
East-West migrants								0.80	0.80
Standard error								0.05	0.05
T statistic								16.24	17.29
F-test of exclusion								263.67	298.86

Note: The dependent variable is the relative native/immigrant wages in an experience–education cell; the explanatory variable is the relative native/immigrant employment in the cell. Each regression, weighted by the number of workers in the education–experience–period cell, includes education, experience and year fixed effects. In parenthesis we report the heteroskedasticity-robust standard errors, clustered by education–experience group. ***,**,* different from 0 at the 1%, 5%, 10% significance level.

4.3.3. *Across experience and education groups*

Following the implications of the model in Section 2 we can use the expressions (15) and (16) to estimate $1/\eta$ and $1/\delta$, the inverse elasticity of substitution between experience and education groups. In particular, following Ottaviano and Peri (2008) we implement regressions (21) and (22) below:

$$\ln(\overline{W}_{kjt}) = D_t + D_j + Time\ Trend_k - \frac{1}{\eta}\ln(\hat{L}_{kjt}) + u_{kjt} \tag{21}$$

$$\ln(\overline{W}_{kt}) = D_t + Time\ Trend_k - \frac{1}{\delta}\ln(\hat{L}_{kt}) + u_{kt} \tag{22}$$

Table 7
Estimates of the inverse elasticity of substitution between workers with different potential experience ($1/\eta$) and education ($1/\delta$).

Estimated parameter	$1/\eta$		$1/\delta$	
Column	(1) Using the model to calculate (L_{kj}) as a CES composite	(2) L_{kj} calculated as simple employment count	(3) Using the model to calculate L_k as a CES composite	(4) L_k calculated as simple employment count
Coefficient	0.31***	0.33***	0.34***	0.37***
Standard error	(0.11)	(0.13)	(0.14)	(0.16)
Education trend	Yes	Yes	Yes	Yes
Experience dummies	Yes	Yes	–	–
Year dummies	Yes	Yes	Yes	Yes
Observations	359	359	45	45

Note: In columns 1 and 2 the dependent variable is the average daily wage in real terms for the education–experience group. In column (1) the explanatory variable is log of L_{kj} obtained as a CES composite of natives and immigrants for a value of $1/\sigma = 0.046$. In column (2) the explanatory variable is the log of the L_{kj} obtained as the simple sum of native and immigrant employment. The method of estimation used is 2SLS using as instrumental variable for $\ln(L_{kj})$ the variable $\ln(M_{kj})$, that is the log of immigrant employment in the cell. In columns 3 and 4 the dependent variable is the average daily wage in real terms for the education group. In column (3) the explanatory variable is log of L_k obtained as a CES composite of different experience groups for a value of $1/\eta = 0.31$. In column (4) the explanatory variable is the log of the L_k obtained as the simple sum of employment across experience groups. The method of estimation is 2SLS using as instrumental variable for $\ln(L_k)$ the variable $\ln(M_k)$, that is the log of immigrant employment in the education cell. Standard errors are heteroskedasticity-robust clustered at the education–experience level. Regressions are weighted with the number of workers in each cell.
***,**,* different from 0 at the 1%, 5%, 10% significance level.

The dependent variable is the log average wage in the education–experience group ($\overline{W}_{kjt}$) or in the education ($\overline{W}_{kt}$) group. In (21) we control for an education-specific time trend (*Time Trend*$_k$) and for year (D_t) and experience (D_j) fixed effects, while in (22) we use time dummies and education-specific time trends (*Time Trend*$_k$) to control for the change in cell-specific productivity. In both regressions we allow for a zero-mean disturbance. Instrumenting for the change in the cell labor-composites, $\hat{L}_{kjt}$ and $\hat{L}_{kt}$, with the inflow of immigrants (assumed to be supply-driven once we control for the fixed effects), we can obtain consistent estimates of the coefficients $1/\eta$ and $1/\delta$.

Table 7 reports the estimates of $1/\eta$, which are between 0.31 and 0.33. In column (1), the supply index $\hat{L}_{kjt}$ is constructed using a CES aggregator of native and immigrant employment with $1/\sigma = 0.046$. In column (2) the supply index is the simple sum of native and immigrant employment. Similarly, columns 3 and 4 present the estimates of $1/\delta$ which range, respectively, between 0.34 when the supply index is constructed as a CES aggregate and 0.37 when the supply index is constructed as the sum of employment across education cells. These estimates imply an elasticity of substitution between education groups of around 2.9 and across experience groups of 3.3. The first is a bit larger than the corresponding estimates for the US (usually ranging between 1.5 and 2.5) and the second is smaller than its US counterpart, usually estimated between 5 and 10 (see, e.g., Card and Lemieux, 2001). On the other hand, using a comparable sample Brucker and Jahn (2008) report estimated values for the parameter $1/\delta$ close to 0.3. While this is similar to ours, they estimate a lower value of $1/\eta$ around 0.06. The elasticity across age groups, however, does not play much of a role in our simulations in which we aim at characterizing the wage effect across education groups and between natives and immigrants. Hence, we use our estimated elasticity $1/\eta$ in simulating the wage effects of immigration and reassure the reader that using the Brucker and Jahn (2008) elasticity estimates of $1/\eta$ would give essentially identical results.

4.4. Wage effects

Based on the expressions (17) and (18) of Section 2 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 4.2 and the elasticities of substitution σ, λ, η and δ estimated in Section 4.3. Section 4.4.1 analyzes the impact of the inflow of new immigrants between 1992 and 2001 on average wages and the total wage income of old (pre-1992) immigrants.[12] Then Section 4.4.2 focuses on the impact of the same flow of immigrants on wages of native workers.

4.4.1. Wage effects on long-term immigrants, 1992–2001

The effects of new immigration on the wages of long-term immigrants are given by expression (18). Following Ottaviano and Peri (2008) and Ortega and Peri (2009) we also assume adjustment of capital to keep return to capital constant. This is an appropriate long-run assumption and Ortega and Peri (2009) show that this seems to be the case also for yearly inflow of immigrants into European countries.[13]

[12] We define as post-1992 (pre-1992) immigrants who appear in our dataset 1992 or later (strictly before 1992).
[13] A slower short-run adjustment of capital would imply a negative short-run additional impact for all wages.

Table 8
Simulated long-run effects of immigration, 1992–2001.

Educational level		No vocational edu.	Vocational edu.	Higher edu.	Average edu.
Long term immigrants					
Percentage changes in real wages					
Due to east–west movers	Direct immigration effect (A)	0.17	−0.54	−1.08	−0.22
	Response effect (B)	−0.04	0.37	0.59	0.18
	Total effect (A+B)	0.14	−0.17	−0.49	−0.04
Due to foreigners	Direct immigration effect (A)	−1.63	−0.34	−1.57	−1.07
	Response effect (B)	0.79	0.32	0.95	0.60
	Total effect (A+B)	−0.84	−0.02	−0.62	−0.47
Total	Direct immigration effect (A)	−1.46	−0.88	−2.65	−1.29
	Response effect (B)	0.76	0.69	1.54	0.78
	Total effect (A+B)	−0.70	−0.19	−1.11	−0.51
Percentage changes in real wage bill					
Due to east–west movers		−0.93	−9.74	−14.37	−5.71
Due to foreigners		−10.11	−11.86	−25.12	−11.93
Total		−11.04	−21.60	−39.49	−17.64
Native workers					
Percentage changes in real wages					
$\sigma = 21.5$		1.68	−0.14	−1.01	−0.02
$\sigma =$ Infinite		1.85	−0.25	−1.26	−0.11

Note: Long-run simulations, assuming that capital adjusts over the period to keep the real return constant. The columns labeled 'direct immigration effects' show the real wage impact of a change in supply due to new immigrants, while those labeled 'indirect effect' show the wage impact of the reduction in labor supply of old immigrants in response to new immigration. The reported values express changes in share of initial wages so that 1 means a change of 1% of the initial wage. Parameters used for the simulation: $\delta = 2.9$, $\eta = 3.3$; $\sigma = 21.5$ (unless differently specified); $\lambda = 58.1$; $\gamma = 0.69$.

Table 8 reports the simulated wage effects of immigration obtained using the average point estimates for the elasticity parameters, namely $\delta = 2.9$, $\eta = 3.3$, $\sigma = 21.5$, $\lambda = 58.1$ and $\gamma = 0.69$. The terms on the right-hand side of formula (18) can be sorted into three groups, contained in each square bracket. The first terms (containing the expressions $\Delta M_{kjt}^{NEW}/M_{kjt}^{NEW}$) capture the *direct* effect of the change in the supply of new immigrants on wages. The second and third terms, containing the expressions $(\Delta M_{kjt}^{OLD}/M_{kjt}^{OLD})_{response}$ and $(\Delta H_{kjt}/H_{kjt})_{response}$ capture the *indirect* wage effects, due to the change in supply of old immigrants and natives triggered by the inflow of new immigrants. In light of the estimates of Tables 3 and 4 the terms $(\Delta H_{kjt}/H_{kjt})_{response}$ are essentially 0 while $(\Delta M_{kjt}^{OLD}/M_{kjt}^{OLD})_{response}$ is around -0.4% for an increase in new immigrants equal to 1% of the cell employment. In Table 8 the direct and indirect effects of new immigrants are reported and denoted by A and B, respectively. The table shows the direct, indirect and total wage effects of new immigration from Eastern Germany, from the rest of the world including Ethnic Germans and the total effects, obtained by adding the two flows. Notice, intuitively, that the indirect effects, driven by the reduced employment of old immigrants, attenuate the negative wage impact of new immigrants on previous immigrants. This is because the reduction in old immigrants' employment is a partial offset of the increased supply of new immigrants. Table 8 shows that the overall effects of 10 years worth of new immigration on the wages of old immigrants are negative, implying an average loss for the pre-1992 immigrant workers of 0.5% of their real wage. This is not a particularly large number for two reasons: first, the inflow of new immigrants between 1992 and 2001 increased the share of foreign-born in employment by only 2.2 percentage points, which is a 20% increase in the initial level; second, the elasticity of substitution between natives and immigrants, while not infinite, is fairly large so that the effect of new immigrants on wages spreads in part to natives too. Old immigrant workers with a high level of education suffer the largest wage losses (-1.11%), which is explained by the fact that post-1992 immigration to Western Germany is relatively high-skilled, mainly due to Eastern Germans (see in column 1 the direct effect of Eastern German immigration on wages of the highly educated). The reduction in the employment levels of old immigrants, in response to immigration, attenuates the negative impact of immigration on the wages of those who keep their job by 0.78% on average, and by 1.5% for the highly educated.

Eastern German immigrants account for almost half of the negative wage effect on highly educated workers while they account for none of the negative effect on less educated workers. This is due to the fact that Eastern German immigrants are on average more educated than immigrants from the rest of the world.

Overall, Table 8 shows that the wage response of old immigrants to new immigrants is not too large. This leads us to inquire more carefully into the employment effect and to quantify it in terms of aggregate wage income lost. One way of doing this is to consider the effect of immigration on the wage bill of old immigrants: while the average wage of old immigrants is not much affected, their employment is and this would show in the wage bill. Table 8 reports the simulated effect of immigration 1992–2001 on the total wage bill of old immigrants. Such effect combines the decrease in employment and the decrease in the average wages of each worker who keeps her job. Combining employment and wage losses, immigration from Eastern Germany reduced the total wage bill of old immigrants by 5.7% while immigration from

the rest of the world added a further negative effect of 11.9%. Immigration from Eastern Germany penalized only the highly educated, while immigration from the rest of the world had a more balanced effect. Overall, the wage bill of old immigrants was reduced by a substantial 17.6%, and this loss was mainly driven by lost employment. These simulations already suggest that the loss in employment for long-term immigrants was the most costly consequence of immigration. In particular, such an employment response, combined with generous unemployment benefits (as we will illustrate below) constituted a large burden on the German welfare system. The question is whether the aggregate cost of employment losses (lost production) and unemployment benefits was larger than the cost in terms of wage losses that old immigrants would have experienced in a flexible labor market in which wages would have adjusted to absorb the full inflow of immigrants without a reduction in the employment of old immigrants. These counter-factual calculations will be performed in Section 5.

In summary, we can say that *new immigrants penalized old immigrants primarily in terms of employment*, *and only a small amount by decreasing their wages*. In terms of wages, old immigrants with high education and old immigrants with no vocational education were the groups hurt the most.

4.4.2. Wage effects on natives, 1992–2001

Turning to the effects of immigration on native wages, we use expression (17) with no employment effects for natives ($\rho = 1$) and imperfect substitutability between native and immigrant workers. The lower panel of Table 8 reports the simulated wage effect for natives with three different educational attainments over the period 1992–2001. We report the results when we consider imperfect substitutability between natives and immigrants and, for reference, those obtained assuming perfect substitutability between natives and immigrants. With imperfect substitutability, no average impact of immigration on native wages is found over the period 1992–2001. Across educational levels, relatively low educated workers experience a moderate improvement in their wage levels ($+1.68\%$), while highly educated ones suffer a small loss (-1%). This is again due to the fact that, during the period of observation, immigration to Germany (mostly from Eastern Germany) was relatively skilled. These small wage effects are consistent with the absence of negative employment effects found in Section 4.2.2. Moreover, even when we impose perfect substitutability ($\sigma = \infty$) between natives and immigrants, the overall effect on wages is negative but still very close to zero, with the same distributional pattern across educational groups as in the case of $\sigma = 21.5$. Hence, *new immigrants did not penalize native workers much either in terms of employment or in terms of wages*. Indeed, native workers with low education experienced a rise in their wages.

5. Comparison with the scenario of full wage flexibility

The main finding of the previous section is that new immigrants did not affect native workers much in terms of either employment or wages, while they did have a negative impact on old immigrants, mostly in terms of employment and only a little in terms of wages. In this section we propose a simple calculation whose aim is to compare the loss in the wage-bill of native and old immigrants between the actual scenario and one in which all the adjustment takes place only through wage changes. First, we calculate the impact of immigrants on natives and old immigrants in terms of foregone wage income and unemployment insurance, assuming that all old immigrants displaced by new immigrants are indeed covered by insurance. Second, we calculate the changes that natives' and immigrants' wages would undergo if wages adjusted to completely eliminate the employment effects on old immigrants. Then we compare the two aggregate amounts.

Our calculations focus on the year 2001. The results of the first calculation are shown at the bottom of Table 9 where all values are expressed in constant Euros at year 2000 prices. Column (1) shows that, based on an estimate of $\gamma = 0.69$, approximately 25,600 old immigrants were displaced by the inflow of new immigrants in 2001. This number of displaced workers can be multiplied by the average yearly wage of old immigrants (equal to 25,996 as shown in column (3)) to obtain the 665 million Euros of foregone wage income reported in column (5). On top of this, the total yearly cost sustained to fund the unemployment insurance is shown in column (4), which multiplies the number of displaced old immigrant workers by unemployment insurance payments. Following Adema et al. (2003), these payments are set at 14,449 Euros per displaced worker, leading to the total value of 370 million Euros.[14] Thus, in the presence of employment effects associated with wage rigidity, in 2001 the overall yearly cost of new immigration in foregone wages and unemployment benefits was around 1 billion Euros.

Table 10 reports what would have happened to the wages of natives and old immigrants if they had been allowed to fall to preserve full employment. Based on (17), (18) and parameter estimates, column (3) shows that the employment effects on old immigrants would have disappeared if their average wage had fallen by 0.15% relative to its actual level, with a corresponding rise of 0.016% in native wages.[15] These percentage variations are first multiplied by the average yearly wages in column (2), then by the employment levels in column (1) to obtain the overall changes in the wage bills paid to native and old immigrant workers.[16] These are reported in column (5) where old immigrants suffer in aggregate a wage

[14] This is just a lower bound estimate of the overall cost borne by taxpayers because the full cost should also include unemployment assistance (for the long-term unemployed), housing benefits, active labor market policies, etc.

[15] The wages of natives rise thanks to the imperfect substitutability between natives and immigrants.

[16] Average yearly wages are computed from our sample by multiplying the average daily wages by the average number of days worked in a year.

Table 9
Estimated effects of new immigrants on natives and old immigrants with displacement.

Column	(1) Number of displaced old immigrants	(2) Cost for unemployed worker	(3) Average yearly wage	(4) = (1 * 2) Absolute yearly cost of unemployment insurance	(5) = (1 * 3) Absolute yearly wage loss from displacement
Unemployment insurance for displaced workers	25,586	14,449		369,694,682	
Foregone production	25,586		25,996		665,129,807

Note: Parameter used for the simulation of the employment effect: $\gamma = 0.69$.

Table 10
Policy experiment: redistributive effects.

Column	(1) Number of employed workers	(2) Average yearly wage	(3) (4) = (2 * 3) (5) = 1 * 4) Wage losses under wage flexibility			(6) (7) = (1 * 6) Unemployment insurance cost[a] in wage-rigid markets	
			Percentage wage variation	Absolute variation in yearly wage	Total yearly variation	Average yearly cost per worker[a]	Total yearly cost[a]
Total natives	8,519,550	30,917	0.016	5.0	42,758,744	38.0	324,023,685
No vocational education	1,448,750	18,993	−0.006	−1.2	−1,708,739	23.4	33,849,305
Vocational education	5,972,550	31,619	0.031	9.8	58,333,987	38.9	232,310,814
Higher education	1,098,250	42,829	−0.029	−12.6	−13,866,505	52.7	57,863,566
Total old immigrants	1,428,150	25,996	−0.153	−39.7	−56,633,145	32.0	45,670,997
No vocational education	573,700	22,310	−0.117	−26.1	−14,951,133	27.4	15,745,620
Vocational education	747,150	26,818	−0.124	−33.1	−24,756,151	33.0	24,649,383
Higher education	107,300	39,970	−0.395	−157.7	−16,925,860	49.2	5,275,994
Total	9,947,700	30,210	−0.005	−1.4	−13,874,401	37.2	369,694,682

Note: Parameters used for the simulations: $\delta = 2.9$, $\eta = 3.3$; $\sigma = 21.5$; $\lambda = 58.1$; $\gamma = 0.69$. Employment is calculated as the total count of workers employed as of 1 July of year 2000. Average yearly wages are expressed in 2000 Euros.

[a] The average yearly cost sustained by each type of worker to finance the unemployment insurance scheme assumed to be proportional to her wage.

decrease of 57 million Euros whereas natives enjoy a wage increase of slightly less than 43 million Euros. Hence, the immigration of 2001, with no employment response and full wage adjustment would have implied a decrease in the total wage bill of natives and old immigrants equal to 14 million Euros (last row of column (5)). Table 10 column (4) shows also the wage effect for each education group in the presence of no employment effects. The group receiving the biggest loss is that of highly educated old immigrants who still would only experience a decrease of 158 Euros per year. Column 5 shows the total wage losses by education and nativity group under the scenario of no employment effect (and full wage adjustment). Column 7 shows, by comparison, the overall costs sustained to finance unemployment benefits for displaced immigrants (in the case of wage rigidities) if those were funded by a tax proportional to the wage level of each worker, thus penalizing the relatively better educated. The cost of immigration on the employed old immigrants and on natives is much (20 times) larger under the scenario of wage rigidity and unemployment insurance than in the scenario with full wage flexibility and no effect on employment (from the comparison of the last row of column (5) and column (7) of Table 10).

To sum up, immigration seems to be much more costly when labor market adjustment happens mostly via the employment margin rather than through the wage margin. The institutional characteristics of the German labor market, such as the very generous unemployment benefits scheme (virtually open-ended, long-term unemployment assistance, '*Arbeitslosenhilfe*', was abolished only in 2005), hurt the efficient absorption of the migration supply shock occurred in that period. This result is in line with Angrist and Kugler (2003), who argue 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 effective in absorbing the supply shocks arising from migrant inflows. In recent times, a series of reforms have increased the flexibility of the German labor market. In 2002, the Job-Aqtiv Act increased the sanctions on the unemployed for refusing a job offer. Starting in 2003, the so-called Hartz reforms reduced the level, as well as the duration, of unemployment benefits, rationalized the overall social assistance scheme in order to increase the incentives to work, further restricted the acceptable reasons for rejecting a job offer without losing benefits, and liberalized employment services (Ebbinghas and Eichhorst, 2009; Eichhorst and Kaiser, 2006). In general, the aim of these reforms was to accelerate labor market flows (Fahr and Sunde, 2006)

and to increase the incentives to work. Coupled with the diffusion of opening clauses from collective contracts (OECD, 2006), these reforms have increased the flexibility of the German labor market and thus the capacity to deal efficiently with labor supply shocks due to migration. Interestingly, in our context, among the beneficiaries of such flexibility are the long-term immigrants: with more flexibility they can retain their jobs (not be displaced), although at a lower wage. The benefit to other citizens is in the form of lower taxes, under the assumption that unemployment insurance is funded by a general tax.

6. Conclusion

This paper contributes to the recently revived literature analyzing the impact of immigration within a labor market equilibrium framework fully accounting for the interactions between production factors (Aydemir and Borjas, 2007; Borjas, 2003; Manacorda et al., 2006; Ottaviano and Peri, 2008; Peri, 2007). With respect to this literature, we have three novel contributions. First we produced new estimates of the elasticity parameters necessary to disentangle the wage effects of immigration on natives and old immigrants exploiting a large yearly panel of German workers, using yearly variations and relying on the (exogenous) large inflow of Eastern Germans after the fall of the Berlin Wall. Second, in order to better estimate the impact of new immigrants on old ones, we have extended the labor market equilibrium approach to allow for employment responses driven by wage rigidities. Taking these responses into account, we have been able to distinguish between the 'direct effect' of immigration, which refers to the change in wages taking place for given employment levels of natives and old immigrants, and the 'indirect effect', which refers to the change in wages due to changes in those employment levels. Third, using this model we have compared the aggregate wage-bill and unemployment insurance costs of the actual scenario, compared with a counter-factual scenario of full wage flexibility that preserves full employment.

Looking at the employment effects of immigration, we have found that new immigration had a negative impact on the employment of old immigrants and no impact on the employment of natives, suggesting closer competition between new and old immigrants than between immigrants and natives as well as different insider–outsider status of natives and immigrants. The estimated wage effects of new immigrants are on average very small for natives and small and negative for old immigrants. The most statistically and economically significant impact of new immigration is the negative employment effect on old immigrants driven by wage rigidities.

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Appendix A. Data appendix

A.1. Data refinements and comparison with the GSOEP

The IAB dataset is well suited for the analysis of labor market outcomes in the German labor market, especially for people with high attachment to the labor market such as male heads of households. One major advantage of these data is the very large, consistent and continuous coverage over time. For each employment spell, all the relevant information regarding the employees is collected by the employer and reported directly to the social security agencies. Measurement error is therefore kept to a minimum. The transmission of all the relevant information to the employment agency is mandatory, so that there are no issues arising from non-response. At the same time the sample is representative of total (social-security-paying) employment each year in the sample.

To obtain a representative sample of days worked in a year in the economy, in each relevant year we include men aged 17–64 who were working and receiving salary income on the 1st of July. Apart from seasonal fluctuations in employment, the probability of working that day (and hence being in the sample) is proportional to the number of days worked in a year. Hence the probability works as a weight for each worker by days worked. The number of hours worked per day is another possible dimension to look at. Unfortunately, daily hours worked are not reported in this dataset. Nevertheless, National Accounts data (available at http://www.sourceoecd.org.) show little year-to-year variations in hours worked per dependent worker for the period 1991–2001, controlled for by the year dummies which we employ in our regressions.

The IAB dataset has some limitations. We try to carefully address each one of them to produce a dataset that is as good and as representative as possible for our purposes. In Table 1 we compare systematically some summary statistics obtained from our refined dataset with summary statistics from a subsample of GSOEP for years 1987, 1991 and 2001 (the initial, an

intermediate and the final year for our empirical analysis), accurately selected in order to have an underlying population consistent with the IAB one.[17]

A first limitation of the IAB data is that there are no recall questions on the working history of each worker prior to the date of entry in the dataset. Hence we impute experience as potential experience that is equal to the worker's age minus the typical age at which she is expected to have completed her education (Borjas, 2003). The age of entry in the labor force is assumed to be 16 for individuals without A-level (in the German system, A-level corresponds with the completion of the second phase of the secondary school, see Carey, 2008) and without vocational education, 19 those without A-levels with vocational education or with A-levels without vocational education, 21 for A-levels with vocational education, 24 for those who completed non-university higher education and 25 for workers who hold a university degree. While this method can introduce some error, Table 1 shows the comparison of population mean and standard deviation of imputed experience (IAB) with actual experience from the GSOEP (worker history is available in these data). There is usually less than one year difference in the averages and standard deviations for both natives and immigrants.

A second and, for our purposes, more severe limitation of the IAB data is that for immigrants neither the place of birth, nor the year of arrival in Western Germany are recorded. What is available for each individual is the exact nationality at the country level. 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 that declare *at least once* to be foreign nationals are immigrants. Hence, people who naturalize during the period under consideration (notice that since 2000 the naturalization laws have become less strict) are still considered immigrants. Also, there are very few people naturalized before 1975. On the other hand, the presence of a large second generation of immigrants with foreign nationality may produce an over-count of the number of immigrants. However, our main results are unaffected when we instrument total migrants' shares using only Germans who moved from the East to the West after reunification, a recent flow of migrants for which the second generation group does not exist. 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 are recorded as Eastern German by the IAB); and *Ethnic German* workers, who primarily immigrated from Eastern Europe and who constitute a large share of recent immigrant inflows. The imputation of 'Ethnic' German workers has been done using external data sources and is described in detail in the Section A.2 below.

After these imputations we compare the share and characteristics of immigrants (including ethnic and Eastern Germans) in the IAB and in a subsample of the GSOEP (see Table 1). Notice again that their share in total employment is similar (in the IAB we have if anything a slight over-count) and their gender, experience and educational distribution are very close, except for a much larger share of highly educated immigrants in 2001 according to the GSOEP. The surge in the share of highly educated workers in GSOEP in 2001 is not due to a change in the definition of the relevant variable. As a robustness check we calculated the same statistic using the German data of the EU-LFS (EUROSTAT, 2008) on a sample selected approximately as the ones used in this comparison (data refer to 2002, we could not exclude the public sector and some Eastern regions) and found a slightly lower share of highly educated workers compared to the IAB. As this over-representation of the highly educated in the GSOEP is also present for natives it may be worth inquiring as to the cause, but it should not affect the procedures by which we impute immigrants nor should it affect much the measure of immigrants as percentage of the group among highly educated.

A third refinement on the data is that we impute the daily wage data which are right censored by the upper limit of the social insurance contribution in the IAB. Right censoring occurs in around 2% of the spells. Censored wages are imputed using the estimated wage values obtained from a Tobit regression model. This is run separately for each year and includes the following independent variables: experience, experience squared, educational attainment, nationality, 17 sector dummies and 131 occupational dummies. Table 1 shows that the average wages in IAB are 10–15% higher for all groups relative to those in GSOEP, and their standard deviation is similar in the two groups. As daily wages are not recorded in the GSOEP we recover them from gross monthly wages assuming that the average individual works a fraction of the month which is equal to the fraction of the days worked in the year as calculated from the IAB sample on a migration status and year basis. These fractions are equal to 0.98, 0.98 and 0.90 (natives) and 0.91, 0.89 and 0.85 (migrants) for the years 1987, 1991 and 2001, respectively.

A fourth refinement that we use in some regressions is to allow for educational downgrading. Immigrants, in fact, may accept jobs requiring a lower level of qualification than they have (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 precision 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, 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 sector plus 131 occupational dummies as independent variables. This regression estimates, for each worker, the probability of having each of the possible educational levels, given his position in the labor market. 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. The corresponding densities,

[17] In particular, we select only non-marginal, private sector employees residing in the West, aged 17–64 and earning a positive wage. We use the cross-sectional weights to calculate all the reported statistics.

averaged across individuals in each year, are then used to calculate weighted employment and wage levels for our education–experience cells. 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 sector demand. For this reason, we only use it as a robustness check.

A.2. The Ethnic Germans' imputation

A worker is considered as Western German if her nationality is German and if she has always been working in Western Germany. All the others are considered as immigrants. Eastern Germans are considered as immigrants. They are identified as individuals with German nationality who started working in the East and then moved to the West within the considered period. Foreign migrants are individuals without German nationality at least in one observation or are *ethnic Germans* coming from abroad. Particular attention is devoted to identifying the consistent *ethnic German* group of immigrants,[18] not distinguishable from Western German nationals in the dataset since their nationality is German. These are foreign born immigrants mostly from Eastern European countries. 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. However, they are.

We estimate the total inflow of *ethnic Germans* in each education–experience-year group merging different sources of information. First, we obtain E_{xt}, the total yearly inflow of *ethnic Germans* by year of arrival t and country of origin x from Bundesverwaltungsamt (2003) and Statistisches-Bundesamt-Deutschland (2006), 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*.[19] Finally, we assume that, for country of origin x and year of arrival t, the educational 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 Western Germany from the Czech Republic in 1994 as exactly mirroring the observed and unobserved characteristics of the group of Czech citizens migrating to Western Germany in the same year.

Specifically, as a first step, for each of the major *ethnic Germans*' countries of origin 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. Notice that the total inflow of immigrants from country x and year t, M_{xt} is obtained from Bundesverwaltungsamt (2003) and Statistisches-Bundesamt-Deutschland (2006) while the number in each education-specific group M_{xkjt} is taken from the IAB. Hence the share f_{xkjt} corrects for the employment/population ratio and allows us to impute employment in each group from the total population of immigrants. We then calculate the imputed number of immigrant *ethnic German* workers from country x with education k and experience j in year t as $E_{xtkj} = E_{xt}f_{xtkj}$.

Since the inflows of *ethnic Germans* 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.

The procedure may systematically alter the education structure of ethnic immigrants if for each country of origin regular immigrants have a systematically different education than ethnic Germans. We confirm in two different ways that this potential mis-classification does not alter our findings. First, we run some regressions using the 'imputed' education of immigrants obtained from their occupation-industry rather than from their schooling. If ethnic Germans have a systematically different educational level they would choose appropriate occupations and the imputing of education should address this problem. Second, we specify some regressions omitting the ethnic Germans' imputation to see if it drives the results. While certainly imperfect, we think that our procedure uses the available data in its most efficient way and does not seem to introduce a systematic bias in the results.

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[18] 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 Western Germany, settling there permanently.

[19] The countries are: Czech Republic, Slovakia, former Soviet Union, former Yugoslavia, Hungary, Poland, Romania.

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