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Migration and the Wage-Setting Curve: Reassessing the Labor Market Effects of Migration

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Abstract

In this paper we examine the labor market effects of migration in Germany on basis of a wage-setting curve. The wage-setting curve relies on the assumption that wages respond to a change in the unemployment rate, albeit imperfectly. This allows one to derive the wage and employment effects of migration simultaneously in a general equilibrium framework. Using administrative micro data we find that the elasticity of the wage-setting curve is particularly high for young workers and workers with an university degree, while it is low for older workers and workers with a vocational degree. The wage and employment effects of migration are moderate: a 1 percent increase in the German labor force through immigration increases the aggregate unemployment rate by less than 0.1 percentage points and reduces average wages by 0.1 percent in the short run. While native workers benefit from increased wages and lower unemployment, foreign workers are adversely affected.

Keywords: Migration, wage-setting curve, labor markets, panel data.
JEL code: F22, J31, J61.

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1 Introduction

High and increasing immigration rates in the US and Europe have fanned fears that migrants reduce wages and limit employment opportunities of the native labor force. Concerns that immigration increases unemployment are particularly widespread in the continental European countries, where unemployment is persistently high. In this paper we apply a wage-setting curve approach to analyze the labor market effects of immigration. The wage-setting curve relies on the assumption that wages respond to changes in the unemployment rate, albeit imperfectly. This allows us to consider institutional and other labor market rigidities, which are particularly relevant in the European context. In contrast to the overwhelming majority of the empirical literature, which addresses the impact of migration on wages and (un-)employment separately, we analyze the wage and employment effects of migration simultaneously in a general equilibrium framework.

Following the seminal contributions of Borjas (2003) and Ottaviano and Peri (2006), we employ a nested production function which assumes that migrant and native workers within the same experience and education group are imperfect substitutes. We moreover consider the imperfect adjustment of capital stocks. Since it is likely that the bargaining power of workers and employers varies in the different segments of the labor market, we allow the wage-setting curve to differ across education and experience groups.

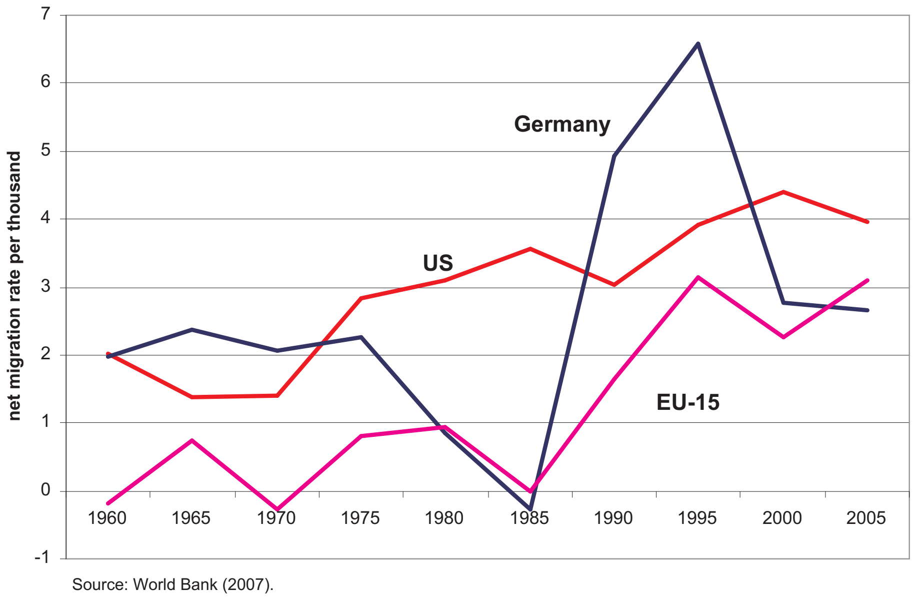

Figure 1: Net migration rate per thousand, 1960-2005

We apply this framework empirically to Germany, which is the third most popular destination for migrants in the world after the US and Russia (Freeman, 2006). With the fall of the Berlin wall, the net immigration rate climbed in Western Germany from about zero at the beginning of the 1980s to about 6 per thousand at the beginning of the 1990s, compared to 3 per thousand in the fifteen member states of the then European Union (EU-15) and 4 per thousand in the US (World Bank, 2007). However, since the beginning of this millennium, the net immigration rate has dropped to less than 3 per thousand in the course of Germany's economic downturn (Figure 1).

Our empirical analysis is based on a 2 percent random sample drawn from the German social security records (IABS) for the period from 1980 to 2004. This data set allows us to identify the elasticities of the wage-setting curve for education and experience groups and to estimate the elasticities of substitution between different types of labor in Western Germany.

We find an average elasticity of the wage-setting curve of -0.15 at the national level, which is somewhat higher than the elasticities found in the regional wage curve literature in other OECD countries (see Blanchflower and Oswald, 1994a; Card, 1995; Nijkamp and Poot, 2005), but substantially higher than that found at the regional level in Germany (Baltagi, Blien, and Wolf, 2007). However, the elasticities of the wage-setting curves fluctuate considerably across skill groups and experience groups. The elasticity between wages and unemployment is particularly large for highly educated workers and workers with little work experience.

We simulate the immigration impact on the German labor market in three scenarios: The first scenario analyzes the effects of a 1 percent immigration at the given skill and age structure of the foreign and native labor force. The second scenario examines the impact of the actual labor immigration during the total 1980-2004 period and the final scenario assesses the effects of the main immigration shock on the German economy during the 1984-1993 subperiod.

At the given skill structure of the foreign workforce, a 1 percent increase in labor supply through the immigration of foreigners increases the unemployment rate by less than 0.1 percentage points in the short run, while it remains almost stable in the long run. Average wages decline by 0.1 percent in the short run, but remain unaffected after the adjustment of capital stocks. While native workers tend to benefit from higher wages and lower unemployment risks, wages of the foreign labor force decline by about 0.7 percent and the unemployment rate increases by about 0.4 percentage points in the short run and by 0.1 percentage points in the long run.

Accordingly, the increase in the foreign labor supply during the period

1980-2004 has increased native wages by 0.2 percent while the wages of foreigners have fallen by 1.8 percent in the long run. The unemployment rate of natives declines slightly, while that of the foreign labor force increases by 0.25 percentage points in the long run. At the aggregate level, the labor market effects are almost neutral in the long run.

The major immigration shock before and after the fall of the Berlin wall is accompanied by a 0.5 percent decline in aggregate wages, while the aggregate unemployment rate increases by 0.4 percentage points in the short run. In the long run, the wage effects of this labor supply shock are neutral, however, while the unemployment rate increases slightly by 0.1 percentage points. Natives tend to gain, while the foreign workforce loses substantially.

The remainder of the paper is organized as follows: Section 2 reviews the empirical literature on the wage and employment effects of immigration. Section 3 outlines the model. Section 4 describes the dataset. Section 5 presents the identification strategy and the estimation results for the elasticities of the wage-setting curves, the capital stock adjustment, and the elasticities of the production function. Section 6 simulates the employment and wage impact of immigration on the German labor market. Finally, Section 7 concludes.

2 Review of the literature

The overwhelming share of the empirical literature uses the variance of foreigner shares across regions for the identification of the labor market effects of immigration. In this literature, both the wage and employment effects of immigration are small and seem to cluster around zero (see the surveys and meta-studies by Friedberg and Hunt, 1995; Longhi, Nijkamp, and Poot, 2005, 2006). This spatial correlation approach may however yield spurious results if migrants are not randomly distributed across locations. Moreover, the adjustment of other labor or capital flows may equilibrate the migration effects across regions. This literature therefore either relies on natural experiments (e.g. Card, 1990; Carrington and DeLima, 1996; Hunt, 1992) or uses instrumental variable estimators to correct for the endogeneity of locational choices of migrants (e.g. Haisken-DeNew and Zimmermann, 1995; Mühleisen and Zimmermann, 1994; Ottaviano and Peri, 2005a,b; Pischke and Velling, 1997). It nevertheless remains controversial whether the wage and employment effects of migration can be properly identified by spatial correlations between migration shares and labor market outcomes.[1]

[1]See Card (2001), Borjas, Freemann, and Katz (1997) and Borjas (2003) for controversial arguments and evidence.

The spatial correlation approach has been challenged in an influential paper by Borjas (2003), which exploits the variance of the foreigner share across education and experience groups at the national level to identify the wage effects of migration. Under the assumption that the education and experience characteristics of the migrant workforce are exogenous, this allows an unbiased estimation of the labor market effects of migration. Borjas (2003) measures the elasticities between wages and labor supply shocks in the different education and experience cells of the US labor market and finds an elasticity of between -0.3 and -0.4. Aydemir and Borjas (2007) obtain the same elasticities for Canada and Mexico. Based on a similar approach, Bonin (2005), however, estimates that immigration of 1 percent reduces wages by less than 0.1 percent in Germany.

Ottaviano and Peri (2006), however, obtain results in a national-level framework that support those of the spatial-correlation studies. Employing a similar dataset as Borjas (2003), they find that immigration has increased native wages on average in the US, while wages of foreigners have tended to decline substantially. Two aspects set their approach apart from the Borjas (2003) study: first, they provide evidence that native and foreign workers within the same education and experience cell of the labor market are imperfect substitutes, while Borjas (2003) assumes perfect substitutionality. In a recent paper, however, Borjas, Grogger, and Hanson (2008) argue that these findings depend on the definition of skill groups and are therefore not robust.[2] Second, they consider the adjustment of capital stocks, while Borjas (2003) treats the physical capital stock as fixed – in line with the overwhelming majority of the literature.[3] Ottaviano and Peri (2006) find that a one percent increase of the labor force through immigration increases native wages by 0.06 percent under the assumption of a fixed capital stock and by 0.16 percent under the assumption of complete capital stock adjustment, while the wages of the foreign-born workforce decline by about 2.1 percent in the short run and by about 1.8 percent in the long run.

Borjas (2003) and Ottaviano and Peri (2006) focus on wages and rely implicitly on the assumption of clearing labor markets. The application of this approach is particularly questionable in the case of economies that are characterized by wage rigidities and involuntary unemployment. There exists a large literature that analyzes the effects of migration on employment op-

[2] Aydemir and Borjas (2007), moreover, could not replicate the results by Ottaviano and Peri (2006). Based on another classification of education groups, they found that native and foreign workers are perfect substitutes in the US and Canadian labor markets, confirming earlier results by Jaeger (1996) for the US.

[3] Aydemir and Borjas (2007) relax this assumption by applying a similar approach to Ottaviano and Peri (2006) for the adjustment of the capital stock.

portunities of natives (see Bonin, 2005; Borjas, Grogger, and Hanson, 2006; Hatizius, 1994; Mühleisen and Zimmermann, 1994; Pischke and Velling, 1997; Longhi, Nijkamp, and Poot, 2006, for a meta-analysis). This literature treats the wage and employment effects of migration separately, however, ignoring the interactions between wage rigidities and the employment effects of migration.[4]

This is the aspect in which the present paper contributes to the state of the literature. We address the labor market effects of migration in a framework where wages and employment are simultaneously determined. We assume that an equilibrium relationship exists between the wage level and the unemployment rate following the wage-setting models by Lindbeck (1993), Layard and Nickell (1986) and others. This sets the wage-setting curve apart from the Phillips (1958) curve, which relates the growth rate of wages to the unemployment rate and considers this relationship as a disequilibrium phenomenon.[5]

We estimate the relationship between wage and unemployment rates at the national level.[6] This distinguishes our approach from the 'wage curve' literature (Blanchflower and Oswald, 1994a, 1995), which uses the variance across regions for the identification of the relation between wage and unemployment rates. The main motivation for measuring a wage-setting curve at the national level is that we are interested in the macroeconomic relationship between wages and unemployment, which is inter alia affected by labor market institutions such as centralized wage setting. This macroeconomic relationship cannot be identified properly in regressions that use the regional variance of the wage and unemployment rates and include time-specific and regional-specific fixed effects. Consequently, we expect that regional and national-level studies find different elasticities between wage and unemployment rates. Indeed, we obtain an elasticity of the wage-setting curve at the national level for Germany which is substantially larger than that found for the wage curve in a recent regional-level study employing a similar data set (Baltagi, Blien, and Wolf, 2007).

D'Amuri, Ottaviano, and Peri (2008) and Felbermayr, Geis, and Kohler

[4]The Borjas, Grogger, and Hanson (2006) paper, which considers the impact of wages on the decision to participate in labor markets and in criminal activities, may be regarded as an exception in this context, although it still assumes that wages are perfectly flexible.

[5]Bentolila, Dolado, and Jimeno (2007) examine the effects of immigration in a Phillips curve framework. This paper addresses the question of whether immigration has changed the slope of the Phillips curve in Spain, while we assume – based on the existing empirical evidence – that the slope of the wage-setting curve is rather stable over time.

[6]For national-level estimates of this relationship, see the seminal paper by Sargan (1964) and for a recent contribution, e.g., Guichard and Laffargue (2000). The US evidence at the national level has been summarized by Card (1995).

(2008) recently applied the Ottaviano and Peri (2006) approach to the analysis of the labor market impact of immigration in Germany. Like the present paper, both highlight the importance of wage rigidities for an assessment of the labor market effects of migration. However, the empirical framework of these papers follows the standard approach of the existing literature in estimating separate employment equations, while we apply a structural approach that determines employment and wages simultaneously in a general equilibrium framework.

3 Theoretical background

The model presented here builds on Boeri and Brücker (2005) and Levine (1999) in deriving the wage and employment effects of migration from a wage-setting curve. While these papers focus on the aggregate effects of migration, ours groups the labor force by education, experience, and nationality. Similar to Borjas (2003) and Ottaviano and Peri (2006), we follow Card and Lemieux (2001) in employing a nested CES production function for this purpose.

One can base the wage-setting curve on different theoretical foundations (see Blanchard, 2003; Blanchflower and Oswald, 1994a; Layard, Nickell, and Jackman, 1991, for a discussion). In our context, two modeling traditions are particularly important. First, a wage-setting curve can be derived from bargaining models (see e.g. Lindbeck, 1993; Layard and Nickell, 1986). Suppose that wages are fixed in a bilateral bargaining monopoly between trade unions and employer federations. Once wages are fixed, firms hire workers until the marginal product of labor equals the wage rate. If unions are concerned about both their employed and unemployed members, the negotiated wage is lower when unemployment is higher and vice versa.

Second, in a completely non-unionized environment, the wage-setting curve can be explained by efficiency wage considerations (Shapiro and Stiglitz, 1984), where the productivity of workers is linked to the wage level. Unemployment works here as disciplining device since it determines the difficulties in finding a new job. As a result, firms will reduce workers' pay if the unemployment rate is increasing since they can achieve the same level of productivity at a lower wage.

Both approaches have in common that they replace the conventional labor supply curve with a wage-setting function, and that they rely on standard assumptions about labor demand (Blanchflower and Oswald, 1995; Layard and Nickell, 1986). However, different conclusions regarding the shape of the wage-setting curve emerge from these different theoretical foundations: on the one hand, the bargaining model predicts a flatter wage-setting curve in labor market segments with a higher share of unionized workers. The share of unionized workers is exceptionally high among workers with a vocational training degree in Germany, i.e., workers with a medium skill level. On the other hand, the efficiency wage model expects a flatter wage-setting curve for workers with a higher level of firm-specific human capital, since this drives a wedge between productivity at the current employer and the outside opportunity wages, thereby allowing employers to smooth wages over the business cycle (Card, 1995). Thus, it is likely that the wage-setting curve is flatter for high-skilled workers since they tend to acquire greater levels of firm-specific human capital.

In the following we do not rely on a specific wage bargaining or efficiency wage model. Instead we take up a suggestion by Card (1995) and allow the relationship between wages and the employment rate to vary for different groups in the labor force. This enables us to determine the wage-setting curve empirically without imposing a priori restrictions on its shape from theoretical considerations of one kind or another.

3.1 A structural approach to immigration and unemployment

Suppose that the aggregate output of an economy is produced with different types of labor and physical capital. In general form, we can write the aggregate production function as

$$Y = F\left(\mathbf{L}, K\right), \tag{1}$$

where Y denotes aggregate output, $\mathbf{L}$ a vector of different types of labor inputs, and K the capital stock. We assume that the production function $F(\cdot)$ exhibits constant returns to scale and positive and diminishing marginal products with respect to each input, and satisfies the Inada (1963)-conditions. For the sake of convenience, we have skipped time subscripts.

We distinguish labor inputs by education, experience, and nationality. Wages and the demand for labor are determined sequentially. In the first stage, wages are fixed. The elasticity of the wage with respect to the unemployment rate may differ in each cell of the labor market depending on the bargaining power of the parties in the wage negotiations or the level of specific human capital. In the second stage, profit-maximizing firms hire workers until the marginal product of labor equals the wage rate.

Writing the wage in each cell of the labor market as a function of the respective unemployment rate gives

$$w_{ijk} = \phi_{ijk}(u_{ijk}), \qquad \phi'_{ijk} < 0, \tag{2}$$

where w_{ijk} is the wage of a worker with education i, experience j and national origin k, ϕ_{ijk} is a function that captures the response of the wage to the unemployment rate. The unemployment rate u_{ijk} is defined as

$$u_{ijk} = 1 - \frac{L_{ijk}}{N_{ijk}},$$

where L_{ijk} and N_{ijk} denote the employed workforce and the labor force, respectively, of education i, experience j, and national origin k.

The condition that the wage rate in equation (2) equals the marginal product of labor allows us to solve for the employment response to a change in labor supply. Note that the marginal product of labor in a specific education, experience, and national origin cell of the labor market is affected by the employment changes in all other cells of the labor market. Solving for the employment response thus requires solving a system of equations for all other cells of the labor market, which is determined by the wage-setting curves and the production function. This system has to satisfy in each cell of the labor market the implicit function

$$\Phi_{ijk} = w_{ijk}(\mathbf{L}, K) - \phi_{ijk}(u_{ijk}) = 0, \qquad \forall \ ijk. \tag{3}$$

Differentiating this system implicitly with respect to a marginal migration shock yields for the change in employment

$$\frac{d\mathbf{L}}{dM} = \left(\frac{\partial \mathbf{w}}{\partial \mathbf{L}} - \frac{\partial \phi}{\partial \mathbf{u}}\frac{\partial \mathbf{u}}{\partial \mathbf{L}}\right)^{-1} \times \left(\frac{\partial \phi}{\partial \mathbf{u}}\frac{\partial \mathbf{u}}{\partial \mathbf{N}}\frac{d\mathbf{N}}{dM} - \frac{\partial \mathbf{w}}{\partial K}\frac{dK}{dM}\right), \tag{4}$$

where dM is a scalar that captures the marginal immigration shock to the economy, ϕ a vector of functions that determine as above the wage response to the unemployment rate, and $\mathbf{N}$ a vector of the labor force in each cell of the labor market. We assume that the capital stock may adjust to a labor supply shock through migration, i.e., that $\frac{dK}{dM} \geq 0$.

Finally, having solved for the employment response, it is straightforward to derive the wage effects of migration:

$$\frac{d\mathbf{w}}{dM} = \frac{\partial \mathbf{w}}{\partial \mathbf{L}}\frac{d\mathbf{L}}{dM} + \frac{\partial \mathbf{w}}{\partial K}\frac{dK}{dM}. \tag{5}$$

Equation (4) has an economic interpretation. Consider three cases: first, assume that labor markets are completely flexible, which requires that $\phi'_{ijk} \to -\infty \ \forall \, \phi_{ijk}$. In this case, equation (4) simplifies to

$$\frac{d\mathbf{L}}{dM} \to \frac{d\mathbf{N}}{dM},$$

i.e., the marginal employment response equals the marginal increase in the labor force in each cell of the labor market. This case corresponds to the textbook example of the impact of migration in an economy with clearing labor markets and an inelastic supply of native labor (e.g. Wong, 1995, pp. 628-632).

Second, assume that labor markets are completely inflexible, i.e., that $\phi'_{ijk} \to 0 \ \forall \, ijk$. In this case, equation (4) yields

$$\frac{d\mathbf{L}}{dM} \to \left(\frac{\partial \mathbf{w}}{\partial \mathbf{L}}\right)^{-1} \times \left(-\frac{\partial \mathbf{w}}{\partial K}\frac{dK}{dM}\right),$$

which equals zero if the capital stock does not adjust to the labor supply shock. This case corresponds to the famous Harris and Todaro (1970) model.

Third, in the empirically relevant case, i.e., when $0 > \phi'_{ijk} > -\infty$, employment adjusts partially to a labor supply shock through migration, depending on the elasticities of the wage-setting curve and the elasticities of substitution as determined by the production function.

3.2 Outline of the empirical framework

For the empirical analysis, we have to impose more structure on the economy. We follow Borjas (2003) and Ottaviano and Peri (2006) in assuming that the production function can be approximated by nested CES technologies. The aggregate workforce is decomposed in $i = 1...4$ education groups, $j = 1...8$ experience groups, and $k = 1, 2$ nationality groups, which gives together with physical capital 65 production factors. Although the nested CES function imposes some restrictions on the elasticities of substitution, it has the advantage that it is parsimonious in the parameters. Note that a general specification of the production technologies, such as the translog function, would require estimating 2,016 different parameters of the production function in our case.

Suppose that aggregate production in equation (1) can be represented by a standard Cobb-Douglas production function:

$$Y_t = A_t L_t^{\alpha} K_t^{1-\alpha}, \tag{6}$$

where Y_t denotes aggregate output, A_t total factor productivity, L_t the aggregate labor input, K_t physical capital, α the income share of labor, and t the time index. Assuming a constant elasticity of substitution across education groups gives for the composite labor input

$$L_t = \left[\sum_{i=1}^{4} \theta_{it} L_{it}^{(\delta-1)/\delta} \right]^{\delta/(\delta-1)}, \qquad \sum_{i=1}^{4} \theta_{it} = 1, \tag{7}$$

where L_{it} is an aggregate measure for the employed workforce with education i, θ_{it} a skill-specific productivity level, and $\delta > 0$ a constant parameter which determines the elasticity of substitution between labor of different education levels. We assume the productivity parameter θ_{it} to vary over time since skill-biased technological progress might affect the productivity of various types of labor in different ways.

Analogously, each labor input L_{it} is defined as

$$L_{it} = \left[\sum_{j=1}^{8} \theta_{ij} L_{ijt}^{(\rho-1)/\rho} \right]^{\rho/(\rho-1)}, \qquad \sum_{j=1}^{8} \theta_{ij} = 1, \tag{8}$$

where L_{ijt} denotes an aggregate measure for employed workers of skill group i and experience group j, θ_{ijt} a productivity parameter, and $\rho > 0$ a parameter which determines the elasticity of substitution of labor with similar education but different experience.

Finally, the employment within each education and experience cell is given by the labor composite of native and foreign workers with similar education and experience:

$$L_{ijt} = \left[\sum_{k=1}^{2} \theta_{ijk} L_{ijkt}^{(\sigma_i-1)/\sigma_i} \right]^{\sigma_i/(\sigma_i-1)}, \qquad \sum_{k=1}^{2} \theta_{ijk} = 1, \tag{9}$$

where L_{ijkt} denotes workers of skill group i, experience group j, and national origin k, θ_{ijk} a productivity parameter, and σ_i a parameter which determines the elasticity of substitution between native and foreign workers.

We allow σ_i to differ across education groups, assuming that the elasticity of substitution between native and foreign workers varies across education groups given that the importance of language, culture, and other factors may differ by education.

Our a priori expectation is that workers within each experience group are closer substitutes than those across skill groups, which implies that $\rho > \delta$. Whether foreign and native workers in each education and experience group are imperfect substitutes is the subject of some controversy in the literature.

We simply assume that $\sigma_i \geq 0$, i.e., we do not base our empirical analysis on an a priori assumption as to whether foreign and native workers are perfect substitutes or not.

Assuming that the wage rate equals the marginal product of labor, and choosing output as the numeraire good, we can derive from the production function the log wage of a worker with skill i, education j, and national origin k as

$$\begin{aligned} \ln w_{ijkt} &= \ln(\alpha A_t^{1/\alpha}) + \frac{1}{\delta}\ln L_t + \ln\theta_{it} - \left(\frac{1}{\delta} - \frac{1}{\rho}\right)\ln L_{it} \\ &+ \ln\theta_{ij} - \left(\frac{1}{\rho} - \frac{1}{\sigma_i}\right)\ln L_{ijt} + \ln\theta_{ijk} - \frac{1}{\sigma_i}\ln L_{ijkt} + \frac{1-\alpha}{\alpha}\ln\kappa_t, \end{aligned} \tag{10}$$

where κ denotes the capital-output ratio.

The interest rate is a function of the capital-output ratio, i.e., $r = \frac{1-\alpha}{\kappa}$. Thus, the complete adjustment of the capital stock to an aggregate labor supply shock requires that the capital-output ratio remains constant. Note that a constant capital-output ratio is predicted by neoclassical growth models and one of the stylized facts about economic growth (Kaldor, 1961). Following Ottaviano and Peri (2006) we assume that $\frac{d\kappa}{dM} \leq 0$, which is examined below.

The derivatives of equation (10) are used for finding the partial derivatives of the wage with respect to the labor supply changes in equation (4). For an explicit solution of the employment response, see the Appendix.

Finally, having solved for the employment response we can express the wage effect of migration in equation (5) as

$$\begin{aligned} \frac{dw_{ijkt}}{w_{ijkt}} &= \frac{1}{\delta}\sum_q\sum_n\sum_m\left(s_{qnmt}\frac{dL_{qnmt}}{L_{qnmt}}\right)_{immigration} \\ &- \left(\frac{1}{\delta} - \frac{1}{\rho}\right)\frac{1}{s_{it}}\sum_n\sum_m s_{inmt}\left(\frac{dL_{inmt}}{L_{inmt}}\right)_{immigration} \\ &- \left(\frac{1}{\rho} - \frac{1}{\sigma_i}\right)\frac{1}{s_{ijt}}\sum_m\left(s_{ijmt}\frac{dL_{qkjt}}{L_{qkjt}}\right)_{immigration} \\ &- \sigma_i\left(\frac{dL_{ijkt}}{L_{ijkt}}\right)_{immigration} + \frac{(1-\alpha)}{\alpha}\left(\frac{d\kappa_t}{\kappa_t}\right)_{immigration}, \end{aligned} \tag{11}$$

where s_{qnmt}, s_{inmt}, s_{ijmt}, s_{ijt} and s_{it} denote the share of the wages paid to workers in the respective labor market cells in the total wage bill.[7] The

[7]Thus, $s_{ijkt} = \frac{w_{ijkt}L_{ijkt}}{\sum_q\sum_n\sum_m w_{qnmt}L_{qnmt}}$, $s_{ijt} = \frac{\sum_m w_{ijmt}L_{ijmt}}{\sum_q\sum_n\sum_m w_{qnmt}L_{qnmt}}$, and $s_{it} =$

change of the labor supply in each cell of the labor market as denoted by the terms in brackets in equation (11) refers to the employment changes as determined by equation (4). Finally, as before, the term $d\kappa_t$ refers to the change in the capital-output ratio triggered by immigration.

Note that we obtain a similar equation for the factor demand compared to those found in the empirical literature since we assume that the wage rate equals the marginal product of employed labor. Thus we can compare our findings regarding the wage effects of a marginal employment shock inter alia with those of Borjas (2003) and Ottaviano and Peri (2006).

4 Data

4.1 Description of the dataset

In our empirical analysis we use the IAB Sample (IABS), a two percent random sample of all German employees registered with the social security system in the period 1975-2004. The IABS provides information on socio-economic and job characteristics at the individual level. Supplementary information on benefit recipients is added to the sample. The IABS is stratified according to nationality and therefore representative for the native and foreign working population. Being of an administrative nature, the IABS provides accurate longitudinal information on the employment and unemployment histories of employees. The dataset is especially suitable for performing analyses taking wages into account since the wage information is used to calculate social security contributions and is therefore highly reliable.

Nevertheless the IABS has also some minor limitations in the context of our analysis: the main shortcoming is that we can identify foreigners only on the basis of citizenship. Some further limitations arise from the wage and qualification information provided by the dataset. This has several implications:

First, there is no information on the year when immigrants entered the country. Due to the *jus sanguinis* tradition of the German law, naturalization rates have been traditionally very low, such that second and third generation migrants often still have foreign citizenship and are therefore recorded as foreign workers in our sample. On August 1, 1999, a new immigration act came into effect that allows German-born children of foreign-born parents living in Germany for at least eight years to decide up to the age of 23 which nationality to adopt. This has increased the naturalization of German-born

$\frac{\sum_n \sum_m w_{inmt} L_{inmt}}{\sum_q \sum_n \sum_m w_{qnmt} L_{qnmt}}$.

individuals whose parents possess a migrant background. Our data may therefore suffer from a structural break.

To mitigate the possible effects of naturalizations, we have classified all individuals as foreigners who are reported as foreign citizens in their first available spell. This does not allow us to control for individuals who were naturalized before entering the sample, but avoids naturalizations from being displayed in our sample as a declining foreigner share.

Second, ethnic Germans – so-called "Spätaussiedler" – are reported in the dataset as Germans, since the concept of citizenship does not allow us to distinguish between home and foreign-born German citizens. However, special benefits have been offered to ethnic Germans, such as language courses and other integration subsidies that should facilitate their labor market integration. These measures are reported in the benefit recipient file added to our dataset. This allows us to identify the majority of ethnic Germans who have entered the German labor force since 1980. In our sample, the cumulative inflow of ethnic Germans achieves 3.2 percent of the labor force in Western Germany (Table A1). Since ethnic Germans' labor market performance and language command resembles that of other foreigners (see e.g. Bauer and Zimmermann, 1997; Zimmermann, 1999), we have classified ethnic Germans as members of the foreign labor force.

Third, the IABS covers only a part of the immigration surge from Eastern Germany. The IABS included Eastern Germany for the first time in 1992. A large part of the East-West migrants in Germany moved immediately after the fall of the Berlin wall. This implies that more than one-third of the 2 million migrants who have moved from Eastern to Western Germany since 1989 are not covered by the dataset (Bundesamt, 2006). In addition, a large number of East-West migrants moved to Western Germany before appearing as employed or unemployed in the IABS, e.g., as students (Burda and Hunt, 2001; Hunt, 2006). The IABS thus not only understates the actual level of East-West migration, it also distorts the skill distribution, since most of the highly educated migrants move from Eastern to Western Germany before their first employment spell (Brücker and Trübswetter, 2007).

For this reason, we decided to classify migrants from East Germany as natives here and focus our analysis on Western Germany. Note that the foreigner share is negligible in Eastern Germany. German reunification also requires excluding Western Berlin, since mobility between Eastern and Western Berlin has been high since the fall of the Berlin wall. Furthermore, local employment offices in Berlin were pooled, which prevents us from distinguishing between unemployed workers in Western and Eastern Berlin since reunification.

Fourth, the dataset reports gross daily wages and does not provide information on the hours worked. We therefore exclude part-time employees, marginal employees, trainees, interns, and at-home workers from the sample since the wage information is not comparable for these groups. For the same reason we exclude workers with wages below the social security contribution threshold although they are coded as full-time workers. These workers are likely to hold a "mini-job". Mini-jobs are attractive to workers because only the employer, not the employee, has to pay social security contributions if total earnings are below a legally defined threshold, which is adjusted on a sporadic basis (400 euros per month in 2007). There is no indication that this creates a source of bias in the empirical analysis since foreigners are proportionally represented in the respective groups.

Fifth, we restrict our analysis to individuals between the ages of 15 and 60. The reasons are that the statutory retirement age for females is the age of 60, for males the age of 65. In addition, there is some empirical evidence of differences in the early retirement behavior between German and immigrant men (Bonin, Raffelhüschen, and Walliser, 2000).

Sixth, our data are right-censored since gross wages can only be observed up to the social security contribution ceiling. About three percent of the employment spells are censored. This may affect the estimation of the wage-setting curves, particularly in the high-skilled segments of the labor market. We have therefore imputed wages above the social security contribution ceiling using a heteroscedastic single imputation approach specifically developed for the IABS data set (Büttner and Rässler, 2007). The regression is run separately for each year and according to nationality for Western German employees. In addition we included the following variables: age, age squared, six educational groups, industry codes, four variables for the occupational status, and thirteen occupational variables, classifying the current position held by the worker.

Seventh, self-employed workers and civil servants do not contribute to the social security system and are therefore not covered by our sample. To the best of our knowledge, there is no indication that foreign workers are disproportionately self-employed compared to native workers. In the case of civil servants, it seems plausible to assume that due to legal restrictions, immigrants do not substitute natives.

Eighth, the employment history of individuals is interrupted if job-seekers are not eligible for unemployment benefits, unemployment assistance, or maintenance allowances. This implies that individuals are considered to be out of the labor force and are therefore not covered in the sample although they might be looking for a job. From administrative data sources of the Federal Employment Agency, we know that about 90 percent of the registered unemployed are eligible for benefits. Therefore the unemployment rate is only slightly downwardly biased (Wagner and Jahn, 2004).

Ninth, the information on education is provided by the employers in the IABS. This means that information on education levels is missing for about 17 percent of the individuals. Foreigners are disproportionately affected by missing information on education levels. We therefore imputed the missing information on education by employing the procedure developed by Fitzenberger, Osikominu, and Völter (2005) for an earlier version of the IABS. In a first step, spells with valid and invalid educational information are identified by classifying the reliability of employers' reporting behavior. In subsequent steps, only valid educational information is used for extrapolation. This procedure also allows us to correct inconsistent educational information on individuals over time. After applying this imputation procedure, we had to drop only 1.6 percent of the individuals because of missing or inconsistent information on education.

Finally, education and work experience acquired in foreign countries may not have the same value in the labor market as education and experience obtained in Germany. Moreover, certain characteristics of foreigners, such as their command of the German language, may prevent them from fully transferring their human capital to the German labor market. However, correcting for the education and experience levels of foreigners by variables related to their labor market performance in Germany involves an endogeneity problem. It may moreover bias our estimates of the elasticity of substitution between native and foreign workers. We therefore employ the same rules for the classification of education and experience groups for foreign and native workers.

Following the model outlined in Section 3, we group the labor force by education and potential work experience. A sensible classification following the characteristics of the German labor market requires us to distinguish four education groups: no vocational degree, vocational degree, high school degree ("Abitur") with vocational degree, and university degree. At first glance, one might consider aggregating the groups "vocational degree" and "high school degree with vocational degree", but in Germany these are separate labor markets. Despite its small size, we therefore decided to treat the group with high school degree separately. The group with a university degree also covers individuals with a degree from a university of applied sciences ("Fachhochschule").

Furthermore, we distinguish eight potential work experience classes following the standard approach by Borjas (2003) in subtracting the typical number of years spent in the educational system from the age of the worker, and splitting the experience in intervals of five years. At the beginning of the sample period, we have only a few observations in some education experience classes. Therefore, we exclude the 1975-1979 period and confine our analysis to individuals who where employed or unemployed on September 30 during the period from 1980 to 2004 (Table A2).

4.2 Immigration trends and descriptive evidence

Figure 2 displays the share of foreigners – including ethnic Germans – in the labor force and the share of foreigners in the employed workforce. During the 1980s, we observe a sharp decline, which is a consequence of tightening migration restrictions after the first and second oil price shock. The sharp increase in the foreigner share during the 1990s is a result of the fall of the Berlin wall and the civil wars in the former Yugoslavia, which triggered large migration flows into Germany. Note that the ethnic Germans who contributed substantially to the increasing labor supply in the 1990s are treated as foreigners. Since the beginning of the 2000s, the foreigner share has plateaued as a consequence of the slowdown in economic growth and tighter restrictions on immigration. Moreover, foreigners tend to be more than proportionally affected by unemployment, such that their share in the employed workforce declined relative to their share in the labor force during the 1990s.

The foreign labor force increased dramatically during the ten year period from 1984 to 1993 as a consequence of the fall of the Berlin wall and the political and economic transition in Central and Eastern Europe. As Table A3 demonstrates, the net increase of the foreign labor force amounts to about 4 percent of the total labor force during the total sample period, and to 5 percent during the 1984-1993 subperiod. We therefore simulate the effects of this particular labor supply shock separately. Note that the education groups have been affected very differently by immigration.

Table A4 presents the share of the foreign workforce by education and experience classes. The foreign workforce is heavily concentrated in the group with no vocational training. The foreigner share is also increasing in this low-skilled segment of the labor market from 24 percent in 1980 to 39 percent in 2004. In the other educational groups, the foreigner share varies between 5 percent and 11 percent. In the high-skilled segment of the labor market, the foreigner share fell from 7.1 percent in 1980 to 5.9 percent in the 1990s and recovered in the early 2000s.

Tables A5 and A6 display the wage levels for natives and foreign workers by education and experience groups. We report gross wages on a daily basis. A consistent consumer price index for the observation period is not available. We therefore employed the GDP deflator for the deflation of wages.

Wage levels increase with educational levels and with experience in all

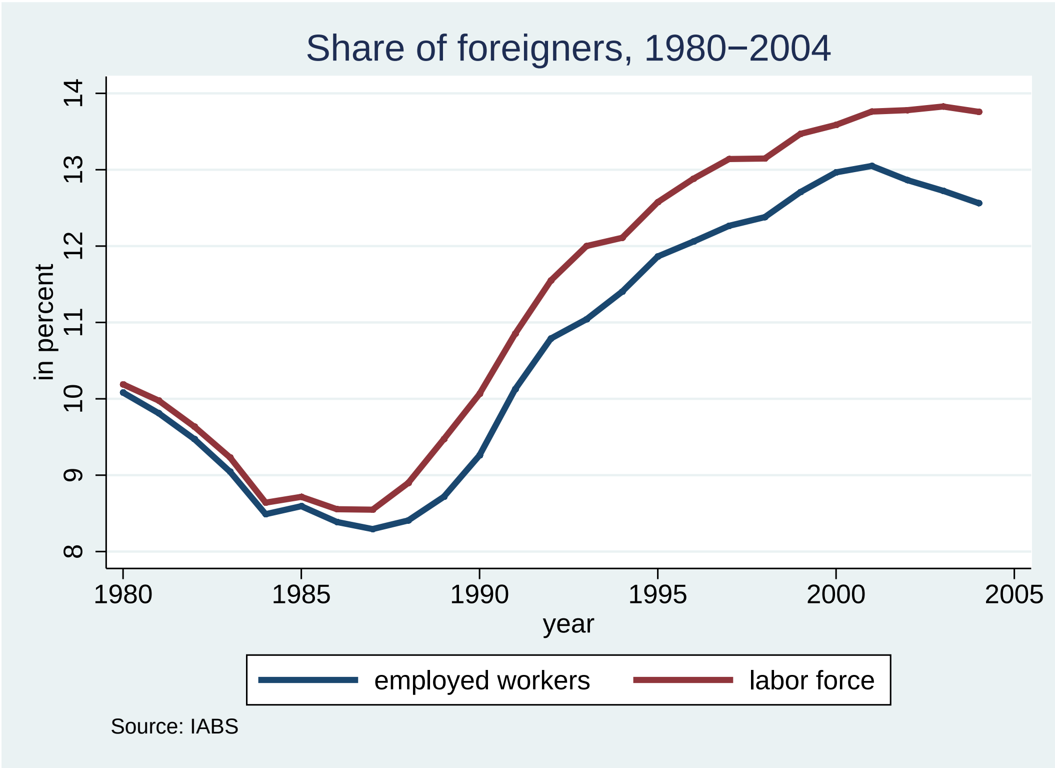

Figure 2: Share of foreign labor force and workers

education groups. The wage levels of foreign workers are in all education groups below those of the native labor force. While these differences are fairly small in the education groups with no vocational degree, they are as high as 20 percent in the other education groups.

5 Estimation

5.1 Wage curves

A large empirical literature estimates wage curves using the variance of wages and unemployment rates across regions and branches (see Blanchflower and Oswald, 1994a, 1995; Card, 1995). Based on this approach Baltagi and Blien (1998) have estimated the elasticity of the wage curve at about -0.07 for Western Germany, which matches the average elasticity of about -0.08 found in several OECD countries (see Nijkamp and Poot, 2005). However, in a recent study for Germany, Baltagi, Blien, and Wolf (2007) estimate the long-run elasticity between the wage and the unemployment rate at between -0.02

and -0.03 employing a dynamic fixed effects model.

Based on the model outlined in Section 3, we deviate here from the standard approach by using the variance of wages and unemployment rates over time and across education and experience groups for the identification of the wage-setting curve instead of the variance across regions. Note that our dataset contains 25 time-series observations that can be used for identification. Moreover, we specify the model in dynamic form following Blanchard and Katz (1997), Blanchflower and Oswald (2005) and Bell, Nickell, and Quintini (2002) for the US and Baltagi, Blien, and Wolf (2007) for Germany. This allows to disentangle the short-run and long-run wage and employment effects of migration if labor markets do not respond instantaneously to labor supply shocks.

More specifically, we estimate the elasticity of the wage with respect to the unemployment rate by experience and education groups as

$$\ln w_{ijt} = \beta_{ij} \ln w_{ij,t-1} + \eta_{ij} \; \ln u_{ijt} + \gamma_{ij} \; \tau_{ijt} + e_{ijt}, \tag{12}$$

where η denotes the elasticity between the wage and the unemployment rate and τ a deterministic time trend. We consider a linear and a squared trend here. The error term e_{ijt} is specified as a one-way error component model with fixed effects for each education-experience group. Since unemployment might be endogenous, we follow Blanchflower and Oswald (2005) and Baltagi, Blien, and Wolf (2007) and instrument the unemployment rate with the first, second, and third lag of the unemployment rate.

The model is estimated separately for each education and experience cell. In each regression we have pooled two experience groups together to achieve more stable results. We have not distinguished between natives and foreigners, assuming that the wage-setting mechanism provides equal wages in each education-experience cell.

Table 1 about here

The estimation results are displayed in Table 1. All regressions have the expected negative sign for the coefficient on the unemployment rate. The autoregressive parameter on the lagged wage is well below 1, supporting a wage-setting curve rather than a Phillips curve. Moreover, in most regressions, the short-run and the long-run elasticities between the wage and the unemployment rate are highly significant. We obtain only insignificant results in the group of workers with a high school degree and university degree and the most extensive work experience, suggesting that the responsiveness of wages to the unemployment rate is close to zero in this segment of the labor market.

The first regressions provide estimates of the wage-setting curve for all groups and for each education group separately. In the regression where all education-experience groups are pooled, we find a short-run elasticity of about -0.08 and a long-run elasticity of about -0.15. This is somewhat higher than the average elasticity of -0.1 found by the regional-level wage curve literature in other OECD countries, but much higher than the elasticity of -0.03 estimated by Baltagi, Blien, and Wolf (2007) at the regional level in Germany.

Interestingly enough, the long-run elasticities are high at both ends of the skill spectrum: in the labor market segment without a vocational degree, we find a long-run elasticity of about -0.17, and in the high-skilled segment of individuals with a university degree a long-run elasticity of -0.19. The elasticity is particularly low in the segment with a vocational training degree, i.e., the labor market segment with a high share of unionized workers.

Even more intriguing is our finding of extremely high elasticities in segments with low work experience. Here we obtain long-run elasticities of between -0.24 and -0.37. They decline monotonously with increasing work experience in all cells of our sample and are particularly low in the labor segment with work experience of more than 30 years. The results for the 1984-1993 subperiod do not differ largely from the total period (Table A7). We therefore base our simulations for the subperiod on the more stable parameter estimates for the total period.

The fixed effects specifications reported in Table 1 are subject to the Nickell (1981) bias of order $1/T$. $T = 23$ in our sample. Monte Carlo simulations suggest that the coefficients for the unemployment rate are slightly overstated in samples of this time dimension. We have also employed the Arellano and Bond (1991) GMM estimator for obtaining unbiased and consistent results. The GMM estimates yield slightly lower results than the standard fixed effects model, but are generally in line with the previous findings (see Table A8). The overall elasticity is, at -0.09, lower than our findings, but the elasticities for the individual education groups are comparable with the IV-estimation results. Since the Sargan test statistics indicate that the GMM model suffers from overidentification, we use the standard IV-fixed effects estimation results for the simulation of the migration effects.

Altogether, our empirical findings support the hypothesis that wages respond to an increase in the unemployment rate, and, hence, to labor supply shocks.

5.2 Capital adjustment

The impact of migration on aggregate wages depends largely on the adjustment of the capital stock. The Kaldor (1961) stylized facts on economic growth suggest that the capital-output ratio remains constant over time, indicating that capital stocks adjust to changes in labor supply.

The OECD data on capital stocks indeed demonstrate that the capital-output ratio has increased only slightly from about 3.0 to 3.15 in Germany during the four decades since 1960. Moreover, the fluctuations around the long-run ratio of 3.1 are relatively small.

German unification involves a break in the time series on capital stocks. For the calculation of the capital-output ratio we employ the net fixed capital stock series provided by the OECD. Since the OECD reports only data on the unified Germany from 1991 on, we use the share of Western Germany in the gross fixed assets provided by the Statistical Offices of the Federal States for the calculation of the share of Western Germany in Germany's total capital stock. This does not involve any visible break in the time series.

The unit root tests indicate that the capital output ratio and the labor force follow different stochastic processes over time. We can reject the hypothesis of a unit root for the capital-output ratio at the 1 percent level if we include only a constant, and at the 5 percent level if we include a constant and a deterministic time trend. Thus, the capital output ratio seems to be stationary. In contrast, the unit root test results suggest that the labor force is a non-stationary variable which is integrated of first order. The levels of the capital-output ratio and the labor force hence cannot form a long-run equilibrium relationship. This may be interpreted as support for the Kaldor (1961) facts.

For analyzing the short-run effects of labor supply shocks on the capital-output ratio we estimate the following model:

$$\ln \kappa_t = \beta_0 + \sum_{s=1}^{s=Z} \gamma_s \ln \kappa_{t-s} + \beta_1 \Delta \ln N_t + \beta_2 \ln \tau_t + \varepsilon_t, \qquad (13)$$

where κ_t denotes, as above, the capital-output ratio, N_t the total labor force, τ_t a deterministic time trend, ε_t disturbances which are assumed to be white noise, and $s = 1, ..., Z$ an index for the autoregressive terms considered by the model.

The number of autoregressive terms is determined by the Breusch-Godfrey test for serial correlation. The test results suggest a second-order autoregressive specification. We have moreover added a dummy variable that controls for a structural break after German reunification, which is present in our data according to the Chow-breakpoint test.

Table 2 about here

The results are displayed in Table 2. In the simple OLS specification we find a coefficient on $\Delta \ln(N_t)$ in the vicinity of about -0.7. A change of the capital-output ratio of this size would be expected if the labor share in national income is 0.7 and if physical capital remains fixed in the short run. The sum of the coefficients for the autoregressive terms suggest that adjustment is fairly fast, i.e., that two-thirds of the labor supply shock disappears within one year.

The simple OLS regression suffers, however, from the endogeneity of labor supply shocks. We therefore instrumented the labor force variable with the first and second lag of the population in Western Germany. In this case the impact of labor supply shocks becomes insignificant and shrinks to -0.2. Although we cannot exclude that the actual impact of short-run labor supply shocks on the capital-output ratio is zero, we use this value for the short-run simulations, while we assume that labor supply shocks have no impact in the long run.

5.3 Elasticity of substitution between natives and foreigners

The model outlined in Section 3 relies on the assumption that firms hire workers until the marginal product of workers equals the wage rate. This allows us to identify the parameters of the production function analogously to Borjas (2003) and Ottaviano and Peri (2006) by the elasticities of relative labor demand.

Let us start with the identification of the elasticity of substitution between native and foreign workers. The relative demand of native and foreign workers of education i and experience j can be expressed as

$$\ln\left(w_{ijht}/w_{ijft}\right) = \ln\left(\theta_{ijh}/\theta_{ijf}\right) - \frac{1}{\sigma_i} \ln\left(L_{ijht}/L_{ijft}\right).$$

For identifying the ratio $\theta_{ijh}/\theta_{ijf}$, we employ dummy variables for each education-experience cell. Conditional on these controls, we assume that changes in the relative employment of natives and foreigners in each education-experience cell are due to random shocks in the labor supply. We thus estimate the following regression to identify σ_i:

$$\ln\left(w_{ijht}/w_{ijft}\right) = D_{ij} - \frac{1}{\sigma_i}\ln\left(L_{ijht}/L_{ijft}\right) + \nu_{ijt}, \tag{14}$$

where the error term ν_{ijt} is a zero-mean random disturbance. In total we have $i \times j \times t = 800$ observations. We estimate the equations by OLS and weighted OLS using total employment in each cell as a weight.

Table 3 about here

The results are reported in Table 3. We ran the regressions separately for the total period 1980-2004 and for the subperiod 1984-1993, when Germany experienced a particular labor supply shock. In the total period, the coefficient for σ_i is significantly different from zero in all regressions except for the groups of workers with a university degree, providing support for the hypothesis that native and foreign workers are imperfect substitutes in the first three education groups. However, the estimated coefficients for $1/\sigma_i$ are, at between 0.05 and 0.07, relatively small. This indicates that the elasticity of substitution between native and foreign workers lies between 15 and 20, which is relatively high.

For the subperiod 1984-1993, we obtain very similar results, although the estimated coefficients are slightly larger and the standard errors slightly higher.

These results contrast with the relatively low elasticities found by Ottaviano and Peri (2006) for the US, but do not support the finding that natives and migrants are perfect substitutes (Aydemir and Borjas, 2007). The estimates by D'Amuri, Ottaviano, and Peri (2008) for Germany are, at between 0.04-0.06, very close to ours. Similarly, Felbermayr, Geis, and Kohler (2008) estimate this elasticity based on another dataset at between 0.07 and 0.1.

For the further analysis, we use the education-specific estimates of the parameter σ_i since the F-test rejects the null hypothesis that the coefficients are of equal size.

5.4 Elasticity of substitution between experience groups

In the next step we estimate the elasticity of substitution between experience groups. We first calculate the productivity-weighted labor composite L_{ijt}.

The estimates for the productivity parameters of native and foreign workers can be derived from the estimated fixed effects as

$$\hat{\theta}_{ijh} = \frac{exp(\hat{D}_{ij})}{1 + exp(\hat{D}_{ij})}, \qquad \hat{\theta}_{ijf} = \frac{1}{1 + exp(\hat{D}_{ij})},$$

where we have used the restriction that the productivity terms add up to one. We can then employ the estimates for $\hat{\theta}_{ijh}$ and $\hat{\theta}_{ijf}$ and of $\hat{\sigma}_i$ to calculate $\hat{L}_{ijt}$ as

$$\hat{L}_{ijt} = \left[\hat{\theta}_{ijh} L_{ijht}^{(\hat{\sigma}_i - 1)/\hat{\sigma}_i} + \hat{\theta}_{ijf} L_{ijft}^{(\hat{\sigma}_i - 1)/\hat{\sigma}_i}\right]^{\hat{\sigma}_i/(\hat{\sigma}_i - 1)}.$$

From the production function we obtain the wage for the labor composite L_{ijt}

$$\ln w_{ijt} = \ln\left(\alpha A_t^{1/\alpha} \kappa_t^{\frac{1-\alpha}{\alpha}}\right) + \frac{1}{\delta} \ln L_t + \ln \theta_{it} - \left(\frac{1}{\delta} - \frac{1}{\rho}\right) \ln L_{it} + \ln \theta_{ij} - \frac{1}{\rho} \ln L_{ijt}.$$

We identify the elasticity of substitution ρ by estimating

$$\ln w_{ijt} = D_t + D_{it} + D_{ij} - \frac{1}{\rho} \ln \hat{L}_{ijt} + \upsilon_{ijt}, \tag{15}$$

where the time-specific fixed effects D_t control for the variance of $\ln\left(\alpha A_t^{1/\alpha} \kappa_t^{\frac{1-\alpha}{\alpha}}\right) + \frac{1}{\delta} \ln L_t$, and the time by education-specific fixed effects D_{it} for the variation in $\ln \theta_{it} - \left(\frac{1}{\delta} - \frac{1}{\rho}\right) \ln L_{it}$ and the education-experience group fixed effects D_{ij} for the productivity term $\ln \theta_{ij}$, which is assumed to be constant over time. This allows us to consistently estimate the parameter $-\frac{1}{\rho}$ by 2SLS, where we use the log of employed native workers in each experience-education group as an instrument.

Table 4 about here

We find an elasticity of substitution of about 30 in the regressions that refer to the total period, which is substantially higher than the elasticity of substitution of between 4 and 5, which Borjas (2003), Card and Lemieux (2001) and Ottaviano and Peri (2006) obtain in their studies for the US.[8] Interestingly enough, Felbermayr, Geis, and Kohler (2008) obtain similar

[8] In their recent study on Germany, D'Amuri, Ottaviano, and Peri (2008) do not provide estimates for the elasticity of substitution across experience and education groups but use the US estimates.

elasticities for Germany to ours, although they employ another dataset for their analysis. As a robustness check we have also assumed an infinite elasticity of substitution between native and foreign workers in the calculation of L_{ijt}, which yields very similar results. In the subperiod 1984-1993 we estimate a coefficient 0.064, which corresponds to an elasticity of substitution in the vicinity of 16 (see Table 4).

5.5 Elasticity of substitution between education groups

Analogously to the previous section, we use the estimated fixed effects $\hat{D}_{ij}$ to calculate the efficiency parameters θ_{ij} as

$$\hat{\theta}_{ij} = \frac{exp(\hat{D}_{ij})}{\sum_j exp(\hat{D}_{ij})},$$

which in turn allows us to compute the estimated value of the productivity-weighted labor composite L_{it} as

$$\hat{L}_{it} = \left[\sum_{j=1}^{8} \hat{\theta}_{ij} \hat{L}_{ijt}^{(\hat{\rho}-1)/\hat{\rho}_i}\right]^{\hat{\rho}/(\hat{\rho}-1)}.$$

From the production function we have

$$\ln w_{it} = \ln\left(\alpha A_t^{1/\alpha} \kappa_t^{\frac{1-\alpha}{\alpha}}\right) + \frac{1}{\delta}\ln L_t + \ln\theta_{it} - \frac{1}{\delta}\ln L_{it},$$

which enables us to identify the parameter $\frac{1}{\delta}$ as

$$\ln w_{it} = D_t + D_i + \lambda_i \tau_i - \frac{1}{\delta}\ln \hat{L}_{it} + \vartheta_{it}. \tag{16}$$

The time-specific fixed effects D_t control for the variance in $\ln\left(\alpha A_t^{1/\alpha} \kappa_t^{\frac{1-\alpha}{\alpha}}\right) + \frac{1}{\delta}\ln(L_t)$ and the education-specific fixed effects D_i and the education-specific deterministic time trend τ_i for the variance in the skill-specific efficiency parameter θ_{it}. ϑ_{it} is assumed to be a zero-mean random disturbance. To estimate the parameter $-\frac{1}{\delta}$ consistently, we again employ the 2SLS estimator and use the log of employed native workers within each education group as an instrument for $\ln \hat{L}_{it}$.

Table 5 about here

We receive for $1/\delta$ an estimated parameter of about 0.15 in the total sample period, which corresponds to an elasticity of substitution between education groups of 6.5 (see Table 5). This elasticity is about twice as high as the elasticities found in US studies (e.g. Katz and Murphy, 1992; Ottaviano and Peri, 2006), but again matches the findings by Felbermayr, Geis, and Kohler (2008) for Germany. As a robustness check we apply the assumption that the elasticity ρ tends to infinity for the calculation of L_t, which yields a similar elasticity of substitution. In the subperiod 1984-1993 we find an elasticity of substitution of about 3, which is similar to the findings in the US literature (Table 5).

Finally, the parameter α has been calculated from the labor share in national income, which yields an average value of 0.67.

6 Simulation results

We now use the estimated parameter values for the simulation of the impact of migration on (un-)employment and wages. In each scenario, we distinguish between the short-run and the long-run effects of migration. For the simulation of the short-run effects we employ the short-run coefficients for the elasticity $\hat{\eta}_{ij}$ from the wage-setting curve estimates and the (small) negative effect of an increase in the labor force on the capital-output ratio. The long-run effects are calculated by using the long-run elasticities of the wage-setting curve and by assuming that the capital-output ratio remains constant.

We simulate the following scenarios here. First, we simulate the effects of a one percent increase of the labor force through immigration using the average distribution of foreigners across the education-experience cells of the labor market. This implies that the overwhelming majority of the increase takes place in the education group of those with no vocational training, while the increase in the other education groups is modest. This scenario provides an indication as to the marginal effects of immigration at the given structure of the workforce.

In the next step we simulate the wage and employment effects of immigration for the total sample period, i.e., 1980-2004. We consider the actual changes in each cell of the labor market here. Finally, we simulate the labor market effects of the labor supply shock during the ten-year period 1984-1993.

The employment and wage effects are calculated for native and foreign workers for each education-experience group. For the aggregation, we weighted the wage changes by the income share in each cell, and the changes in the unemployment rate by the share in the labor force in each cell. In the tables, we report the average effects for the total labor force, the native labor force, and the foreign labor force by educational levels.

A one percent immigration of workers with the same education and experience characteristics as the existing foreign workforce reduces average wages by 0.1 percent and increases the average unemployment rate by less than 0.1 percentage points in the short run, while the long run impact is neutral. Particularly negatively affected are workers with no vocational training degree, where the share of the foreign workforce is relatively high. The native workforce is only slightly negatively affected in the short run and benefits from both increasing wages and declining unemployment in the long run. However, native workers lose slightly in the segment with no vocational degree. In contrast, wages of foreign workers tend to decline by about 0.7 percent in the short run and by 0.6 percent in the long run, while the unemployment rate increases by 0.4 percentage points in the short run and by 0.1 percentage points in the long run (Table 6).

Table 6 about here

The real labor supply shock during the 1980-2004 period changed the structure of the foreign workforce. The total workforce increased by 4.1 percent through an increasing number of foreign workers, but the individual education groups where affected in different ways: The change in the foreign labor supply increased the workforce with an university degree and – to a lesser extent – with a vocational training degree more than proportionally, while it reduced the labor supply in the group without a vocational degree substantially. Particularly affected by the increasing foreign labor supply is the rather small group with a high school degree (Table A3). Note that the changing skill structure of the foreign workforce reflect an overall trend of increasing educational levels in the German workforce. As a consequence, the foreigner share in the skill group without vocational training has increased albeit the absolute number of foreigners has declined in this segment of the labor market (Table A4).

Table 7 shows that the 1980-2004 foreign labor supply shock reduces average wages by a mere 0.4 percent in the short run. In the long run, average wages remain stable due to the adjustment of capital stocks. The unemployment rate increases by less than 0.1 percentage points in the short run, and stay almost stable in the long run. Particularly affected are the groups with a high school degree and a university degree, since the immigration shock was large compared to the other groups here.

The wage impact of migration on the native labor force is almost neutral, but natives tend to benefit by increasing wages and a slightly decreasing unemployment rate in the short run. However, the rather small group with a high school degree experiences a substantial, and the group with a university degree a small loss in terms of lower wages and higher unemployment.

The foreign labor force suffers from a substantial wage loss of about 2.3 percent in the short run and 1.8 percent in the long run. The unemployment rate declines in the short run by about 0.1 percentage points, but increases in the long run by 0.25 percentage points. Note that the unemployment rate of foreign workers without a vocational degree declines substantially by 3.3 percentage points in the short run, but this decline shrinks to 1.0 percentage points when wages adjust in the long run. As a consequence, the reduced unemployment of less skilled foreigners is outpaced by higher unemployment in the other education groups in the long run. Altogether, wages of foreign workers are adversely affected by the increasing labor supply, while the impact on unemployment is ambiguous due to the change in the skill composition of the foreign workforce.

Table 7 about here

Finally, we simulated the effects of the immigration shock during the 1984-1993 period, i.e. the period which covers inter alia the fall of the Berlin wall. In this period, the German labor force increased by about 5 percent through immigration, which implies that the foreign workforce increased by 57 percent. Particularly affected was the group with a high school degree, while workers without a vocational training degree were less than proportionally affected by this labor supply shock.

The additional labor supply and changing skill composition of the foreign workforce reduced average wages by 0.5 percent in the ten year period surrounding the fall of the Berlin wall, while the average unemployment rate increases by 0.4 percentage points in the short run. Nevertheless, the wage impact of migration is neutral in the long run, while the unemployment rate increases by about 0.1 percentage points. Interestingly enough, the native workforce tends to gain in terms of both higher wages (+ 0.3 percent) and lower unemployment (-0.1 percentage points) in the long run, but suffers slightly from declining wages and higher unemployment in the short run. The groups with no vocational degree and a high school degree tend to lose, while those with a vocational degree and a high school degree tend to benefit. In contrast, wages of the foreign labor force decline by almost 4 percent. The unemployment rate of the foreign workforce increases by 1.6 percentage points in the short run and by 1.4 percentage points in the long run. Particularly affected are the groups with a high school degree and a university degree (Table 7).

7 Conclusions

In this paper we presented a general equilibrium framework that allowed us to analyze the wage and employment effects of migration simultaneously. We modeled wage rigidities in form of a wage-setting curve, which assumes that wages respond imperfectly to an increase in the unemployment rate. In the empirical application of the model we found that the elasticities of the wage-setting curve differ widely for the different segments of the labor market. While the elasticity of the wage with respect to the unemployment rate is relatively high in the segments of the labor market with a university degree and limited work experience, it is particularly low in the labor market segment with a vocational degree and extensive work experience.

At the given structure of the foreign workforce, migration reduces average wages and increases unemployment of the total workforce slightly in the short run, while it is neutral in the long run. More interesting are the structural effects: while native workers tend to benefit, the foreign workforce tends to suffer from lower wages and increasing unemployment, at least in the short run.

The analysis of the German immigration shock surrounding the fall of the Berlin wall demonstrates that natives have suffered from this immigration episode only in the short run if at all. In the long run they tend to benefit both from higher wages and slightly declining unemployment. The increase of the foreign workforce by almost 60 percent during the ten year period surrounding the fall of the Berlin wall has however increased the unemployment rate of the foreign workforce by about 1.5 percentage points according to our simulations. This may have contributed to the increasing unemployment risk of the foreigners compared to that of natives which can be observed in Germany.

Our empirical analysis has produced a number of further intriguing results. Compared to the findings from the US studies, the elasticity of substitution between natives and foreigners is relatively high in Germany. This implies that the labor market effects of migration are relatively similar for natives and migrants within the same education and experience cells. However, native and foreign workers remain imperfect substitutes.

The elasticity of substitution across education groups is about twice as high in Germany as in the US, and the elasticity of substitution across experience groups is substantially larger. As a consequence, the effects of migration are more evenly distributed across the education and experience groups of the labor market in Germany than in the US.

Finally, we found strong evidence that capital stocks adjust to labor supply shocks. We found no negative relationship between labor supply and the capital-output ratio in the long run, and only small and insignificant effects for short-term supply shocks. This supports one of the famous stylized facts on economic growth by Nicholas Kaldor (1961) and the evidence that Ottaviano and Peri (2006) found for the US. This again has important implications for the wage effects of migration: at least in the long run, an increasing labor supply through migration does not reduce the average wage level in the economy.

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A Appendix

The general solution for the marginal employment response is given by equation (4), i.e. by

$$\frac{d\mathbf{L}}{dM} = \left(\frac{\partial \mathbf{w}}{\partial \mathbf{L}} - \frac{\partial \phi}{\partial \mathbf{u}}\frac{\partial \mathbf{u}}{\partial \mathbf{L}}\right)^{-1} \times \left(\frac{\partial \phi}{\partial \mathbf{u}}\frac{\partial \mathbf{u}}{\partial \mathbf{N}}\frac{d\mathbf{N}}{dM} - \frac{\partial \mathbf{w}}{\partial \kappa}\frac{d\kappa}{dM}\right),$$

where we have used the definition of κ. Using the nested structure of the production function we can write

$$\begin{aligned}
\mathbf{w} &= [w_{111}, w_{112}, w_{121}, ..., w_{211}, ..., w_{ijk}, ..., w_{482}],\\
\mathbf{L} &= [L_{111}, L_{112}, L_{121}, ..., L_{211}, ..., L_{ijk}, ..., L_{482}],\\
\mathbf{N} &= [N_{111}, N_{112}, N_{121}, ..., N_{211}, ..., N_{ijk}, ...N_{482}],\\
\mathbf{u} &= [u_{111}, u_{112}, u_{121}, ..., u_{211}, ..., u_{ijk}, ..., u_{482}],\\
\phi &= [\phi_{111}, \phi_{112}, \phi_{121}, ..., \phi_{211}, ...\phi_{ijk}, ..., \phi_{482}].
\end{aligned}$$

The term $\frac{\partial \mathbf{w}}{\partial \mathbf{L}}$ is the 64×64 matrix

$$\frac{\partial \mathbf{w}}{\partial \mathbf{L}} = \begin{bmatrix} \frac{\partial w_{111}}{\partial L_{111}} & \cdots & \frac{\partial w_{111}}{\partial L_{ijk}} & \cdots & \frac{\partial w_{111}}{\partial L_{482}} \\ \vdots & & \vdots & & \vdots \\ \frac{\partial w_{ijk}}{\partial L_{111}} & \cdots & \frac{\partial w_{ijk}}{\partial L_{ijk}} & \cdots & \frac{\partial w_{ijk}}{\partial L_{482}} \\ \vdots & & \vdots & & \vdots \\ \frac{\partial w_{482}}{\partial L_{111}} & \cdots & \frac{\partial w_{482}}{\partial L_{ijk}} & \cdots & \frac{\partial w_{482}}{\partial L_{482}} \end{bmatrix}. \tag{A.1}$$

Note that we have from the nested structure of the production function four types of partial derivatives of any wage w_{ijkt}:

$$\begin{aligned}
\frac{\partial w_{ijk}}{\partial L_{ijk}} &= \frac{w_{ijk}}{L_{ijk}}\left[s_{ijk}\left\{\frac{1}{\delta} - \frac{1}{s_i}\left(\frac{1}{\delta} - \frac{1}{\rho}\right) - \frac{1}{s_{ij}}\left(\frac{1}{\rho} - \frac{1}{\sigma_i}\right)\right\} - \frac{1}{\sigma_i}\right],\\
\frac{\partial w_{ijk}}{\partial L_{ijk'}} &= \frac{w_{ijk}}{L_{ijk'}}\left[s_{ijk'}\left\{\frac{1}{\delta} - \frac{1}{s_i}\left(\frac{1}{\delta} - \frac{1}{\rho}\right) - \frac{1}{s_{ij}}\left(\frac{1}{\rho} - \frac{1}{\sigma_i}\right)\right\}\right],\\
\frac{\partial w_{ijk}}{\partial L_{ij'm}} &= \frac{w_{ijk}}{L_{ij'm}}\left[s_{ij'm}\left\{\frac{1}{\delta} - \frac{1}{s_i}\left(\frac{1}{\delta} - \frac{1}{\rho}\right)\right\}\right],\\
\frac{\partial w_{ijk}}{\partial L_{i'nm}} &= \frac{w_{ijk}}{L_{i'nm}}\left[s_{i'nm}\frac{1}{\delta}\right],
\end{aligned}$$

where $\frac{\partial w_{ijk}}{\partial L_{ijk}}$ is the partial derivative of the wage with respect to labor in the same education, experience and nationality cell of the labor market, $\frac{\partial w_{ijk}}{\partial L_{ijk'}}$ the partial derivative of the wage with respect to labor of the same education and experience, but different nationality, $\frac{\partial w_{ijk}}{\partial L_{ij'm}}$ the partial derivative of the wage with respect to labor of the same education, but different experience, $\frac{\partial w_{ijk}}{\partial L_{i'nm}}$ the partial derivative of the wage with respect to labor of different education, and s_{ijk}, s_{ij}, s_i, etc. denote the share of wages paid to workers in the respective cells of the labor market in the total wage bill.

The term $\frac{\partial \mathbf{f}}{\partial \mathbf{u}}\frac{\partial \mathbf{u}}{\partial \mathbf{L}}$ is given by the 64 × 64 matrix

$$\frac{\partial \mathbf{f}}{\partial \mathbf{u}}\frac{\partial \mathbf{u}}{\partial \mathbf{L}} = \begin{bmatrix} \frac{\partial f_{111}}{\partial u_{111}}\frac{\partial u_{111}}{\partial L_{111}} & \cdots & 0 & \cdots & 0 \\ \vdots & \ddots & & & \vdots \\ 0 & & \frac{\partial f_{ijk}}{\partial u_{ijk}}\frac{\partial u_{ijk}}{\partial L_{ijk}} & & 0 \\ \vdots & & & \ddots & \vdots \\ 0 & \cdots & 0 & \cdots & \frac{\partial f_{482}}{\partial u_{482}}\frac{\partial u_{482}}{\partial L_{482}} \end{bmatrix}. \tag{A.2}$$

Finally, we can write the term $\frac{\partial \mathbf{f}}{\partial \mathbf{u}}\frac{\partial \mathbf{u}}{\partial \mathbf{N}}\frac{d\mathbf{N}}{dM}$ as the 1 × 64 vector

$$\frac{\partial \mathbf{f}}{\partial \mathbf{u}}\frac{\partial \mathbf{u}}{\partial \mathbf{n}}\frac{d\mathbf{N}}{dM} = \begin{bmatrix} \frac{\partial f_{111}}{\partial u_{111}}\frac{\partial u_{111}}{\partial N_{111}}\frac{dN_{111}}{dM} \\ \vdots \\ \frac{\partial f_{ijk}}{\partial u_{ijk}}\frac{\partial u_{ijk}}{\partial N_{ijk}}\frac{dN_{ijk}}{dM} \\ \vdots \\ \frac{\partial f_{482}}{\partial u_{482}}\frac{\partial u_{482}}{\partial N_{482}}\frac{dN_{482}}{dM} \end{bmatrix} \tag{A.3}$$

and the term $\frac{\partial \mathbf{w}}{\partial \kappa}\frac{d\kappa}{dM}$ as the 1 × 64 vector

$$\frac{\partial \mathbf{w}}{\partial \kappa}\frac{d\kappa}{dM} = \begin{bmatrix} \frac{\partial w_{111}}{\partial \kappa}\frac{d\kappa}{dM} \\ \vdots \\ \frac{\partial w_{ijk}}{\partial \kappa}\frac{d\kappa}{dM} \\ \vdots \\ \frac{\partial w_{482}}{\partial \kappa}\frac{d\kappa}{dM} \end{bmatrix} = \begin{bmatrix} \frac{1-\alpha}{\alpha}\frac{w_{111}}{\kappa}\frac{d\kappa}{dM} \\ \vdots \\ \frac{1-\alpha}{\alpha}\frac{w_{ijk}}{\kappa}\frac{d\kappa}{dM} \\ \vdots \\ \frac{1-\alpha}{\alpha}\frac{w_{482}}{\kappa}\frac{d\kappa}{dM} \end{bmatrix}. \tag{A.4}$$

Substituting (A.1) to (A.4) for the individual terms in equation (4) yields the explicit solution for the employment response which we have used for our simulation of the employment response to migration.

Table 1: **The wage-setting curve: IV-estimation results**

education	$\ln w_{ij,t-1}$			$\ln u_{ijt}$ short-run			$\ln u_{ijt}$ long-run			
degree	coeff.	se		coeff.	se		coeff.	se		R^2
				all experience groups						
all	0.480	(0.029)	***	-0.077	(0.007)	***	-0.148	(0.014)	***	0.88
no vocational	0.649	(0.050)	***	-0.061	(0.007)	***	-0.172	(0.031)	***	0.94
vocational	0.535	(0.052)	***	-0.055	(0.007)	***	-0.119	(0.019)	***	0.96
high school	0.508	(0.064)	***	-0.081	(0.023)	***	-0.164	(0.048)	***	0.82
university	0.356	(0.064)	***	-0.120	(0.019)	***	-0.186	(0.026)	***	0.86
				experience group 1 and 2						
no vocational	0.776	(0.102)	***	-0.059	(0.013)	***	-0.265	(0.142)	*	0.820
vocational	0.778	(0.086)	***	-0.053	(0.009)	***	-0.238	(0.114)	**	0.980
high school	0.807	(0.110)	***	-0.072	(0.018)	***	-0.372	(0.266)		0.970
university	0.531	(0.100)	***	-0.132	(0.020)	***	-0.281	(0.067)	***	0.900
				experience group 3 and 4						
no vocational	0.464	(0.122)	***	-0.104	(0.023)	***	-0.194	(0.057)	***	0.950
vocational	0.303	(0.114)	***	-0.092	(0.017)	***	-0.132	(0.027)	***	0.960
high school	0.405	(0.143)	***	-0.094	(0.050)	*	-0.159	(0.076)	**	0.930
university	0.481	(0.102)	***	-0.138	(0.045)	***	-0.266	(0.088)	***	0.890
				experience group 5 and 6						
no vocational	0.460	(0.111)	***	-0.080	(0.018)	***	-0.149	(0.033)	***	0.960
vocational	0.428	(0.124)	***	-0.067	(0.020)	***	-0.117	(0.030)	***	0.860
high school	0.507	(0.159)	***	-0.122	(0.060)	**	-0.247	(0.110)	**	0.500
university	0.316	(0.133)	**	-0.094	(0.036)	***	-0.137	(0.044)	***	0.820
				experience group 7 and 8						
no vocational	0.394	(0.115)	***	-0.090	(0.019)	***	-0.148	(0.024)	***	0.980
vocational	0.215	(0.147)		-0.076	(0.019)	***	-0.097	(0.021)	***	0.960
high school	0.412	(0.137)	***	-0.069	(0.069)		-0.117	(0.113)		0.430
university	0.290	(0.238)		-0.081	(0.075)		-0.114	(0.075)		0.850

Notes: Dependent variable is $\ln w_{ijt}$, i.e. the log wage in each education-experience group. White-heteroscedasticity robust standard errors in parentheses. ***, **, * denote the 1%-, 5%-, and 10%-significance levels. The model is estimated by 2SLS. The unemployment rate is instrumented by its first, second and third lag. The model is specified as a one-way error component model with group specific fixed effects and contains a deterministic time trend and a squared deterministic time trend for each experience group. The regressions for each education-experience group are based on 44 observations, the regressions in each education group on 176 observations, and the overall regression on 704 observations. Within R^2 are reported.

Table 2: **Impact of labor supply shocks on the capital-output ratio**

dependent variable: $\ln \kappa_t$	**OLS**		**IV**		
$\ln \kappa_{t-1}$	0.745	***	0.911	***	
	(0.165)		(0.275)		
$\ln \kappa_{t-2}$	-0.393	***	-0.500	***	
	(0.153)		(0.211)		
$\Delta \ln N_t$	-0.692	**	-0.205		
	(0.278)		(0.698)		
observations	44		44		
adjusted R^2	0.66		0.64		
Durbin-Watson statistics	1.54		1.73		
	ADF test for unit roots				
	constant		constant and trend		
	t-statistic		t-statistic		lags
$\ln \kappa_t$	-3.89	***	-3.82	***	1
$\ln N_t$	0.13		-2.49		1
$\Delta \ln N_t$	-4.20	***	-4.25	***	0

Notes: White-heteroscedasticity robust standard errors in parentheses. ***, **, * denote the 1%-, 5%-, and 10%-significance levels. Each regression includes a constant and a logarithmic deterministic time trend.– The Log Likelihood statistic of Chow-breakpoint test for the year 1990 is 19.2, which rejects the Null of no statistical break at the 1 percent level. We included therefore a dummy variable which has for all years from 1991 onwards a value of 1 and of 0 otherwise.– The Breusch-Godfrey test rejects the Null of no serial correlation for the first-order autoregressive model, but does not reject the Null for the second-order autoregressive model which is reported here.– The IV-regressions use the first and the second lag of the (log) population as an instrument for the change in the labor force.– The Augmented Dickey Fuller test results for unit-roots applies the MacKinnon (1996) critical values. The lag length has been determined by the Schwarz-information criterion.

Table 3: **Partial elasticity of native - foreign wages**, $1/\sigma_i$

	1980 - 2004				**1984 - 1993**			
	all workers		weighted		all workers		weighted	
	$1/\sigma_i$		$1/\sigma_i$		$1/\sigma_i$		$1/\sigma_i$	
all	0.060	***	0.053	***	0.073	***	-0.056	***
	(0.006)		(0.003)		(0.016)		(0.007)	
no vocational	0.084	***	0.070	***	0.076	***	-0.058	***
	(0.009)		(0.008)		(0.013)		(0.013)	
with vocational	0.048	***	0.051	***	0.049	***	-0.053	***
	(0.004)		(0.004)		(0.007)		(0.008)	
high school	0.046	***	0.051	***	0.077		-0.132	***
	(0.016)		(0.014)		(0.048)		(0.034)	
university	0.072	***	0.012		0.114	*	-0.022	
	(0.023)		(0.023)		(0.069)		(0.063)	
observations	800		800		320		320	
F-test	17.08		9.29		4.27		5.67	
p-value	0%		5%		37%		22%	

Notes: White-heteroscedasticity robust standard errors in parentheses. ***, **, * denote the 1%-, 5%-, and 10%-significance levels. Dependent variable is $\ln(w_{ijht}/w_{ijft})$, i.e. the relative daily wage of native to foreign workers within the same education-experience cell. The explanatory variable is the relative employment of native and foreign workers within the same education-experience cell. All regressions include education-by-experience group fixed effects. Observations in specification 2 are weighted by total employment in the cell. The F-statistic tests the Null hypothesis that all coefficients $1/\sigma_i$ are identical across educational groups.

Table 4: **Partial wage elasticity across education-experience cells**, $1/\rho$

	1980-2004				**1984-1993**			
	CES-weighted labor composite (using estimated σ_i)		sum native and foreign labor force ($\sigma_i \to \infty$)		CES-weighted labor composite (using estimated σ_i)		sum native and foreign labor force ($\sigma_i \to \infty$)	
$\ln L_{ijt}$	0.031	***	0.031	***	0.064	***	0.063	***
	(0.006)		(0.006)		(0.016)		(0.016)	
obs.	800		800		320		320	

Notes: White heteroscedasticity robust standard errors in parentheses. ***, **, * denote the 1%-, 5%-, and 10%-significance levels. Dependent variable is $\ln w_{ijt}$, i.e. the log daily wage in each education-experience cell. The equation is estimated by 2SLS using the log of employed native workers in the respective education-experience group as an instrument for the variable $\ln L_{ijt}$. All regressions include education by experience fixed effects and education by year fixed effects and time fixed effects.

Table 5: **Partial wage elasticity across education cells,** $1/\delta$

	1980-2004				**1984-1993**			
	CES-weighted labor composite (using estimated ρ)		sum native and foreign labor force ($\rho \to \infty$)		CES-weighted labor composite (using estimated ρ)		sum native and foreign labor force ($\rho \to \infty$)	
$\ln L_{it}$	0.152	**	0.146	**	0.308		0.299	
	(0.076)		(0.072)		(0.214)		(0.202)	
obs	100		100		40		40	

Notes: White heteroscedasticity robust standard errors in parentheses. ***, **, * denote the 1%-, 5%-, and 10%-significance levels. Dependent variable is $\ln w_{it}$, i.e. the log wage in each education cell. The equation is estimated by 2SLS using the log of employed native workers in the respective education group as an instrument for the variable $\ln L_{it}$. All regressions include fixed time effects, education group fixed effects and education-specific time trends.

Table 6: **Simulation of migration effects on wages and unemployment**

	short-run results		long-run results	
education degree	wages	unemployment rate	wages	unemployment rate
	wages: change in % at an immigration of 1% *unemployment rate: change in %-points*			
	total labor force			
all	-0.10	0.07	0.00	0.01
no vocational	-0.31	0.19	-0.23	0.03
vocational	-0.04	0.02	0.07	0.00
high school	-0.05	0.08	0.05	0.03
university	-0.07	0.03	0.03	0.01
	native labor force			
all	-0.04	0.02	0.07	-0.01
no vocational	-0.13	0.07	-0.03	0.01
vocational	-0.02	0.00	0.09	-0.02
high school	-0.02	0.01	0.08	-0.02
university	-0.02	0.01	0.08	-0.02
	foreign labor force			
all	-0.71	0.42	-0.64	0.11
no vocational	-0.87	0.54	-0.81	0.12
vocational	-0.47	0.20	-0.37	0.10
high school	-0.45	0.51	-0.36	0.23
university	-0.70	0.28	-0.60	0.17

Notes: The short-run simulations are based on the short-run semi-elasticities of the wage curve and consider the short-run impact of migration on the capital-output ratio. The long-run results are based on the long-run elasticities of the wage curve and a constant capital-output ratio. The effects have been calculated for natives and foreigners at each education-experience level separately. Aggregate wage figures are calculated by weighting each cell with the income share, aggregate unemployment figures by weighting each cell with the share in the labor force.

Table 7: **Simulation of migration effects, 1980-2004 and 1983-1993**

	1980 - 2004				**1984 - 1993**			
	short-run results		long-run results		short-run results		long-run results	
education degree	wage	unempl. rate	wages	unempl. rate	wages	unempl. rate	wages	unempl. rate
	wages: change in %, unemployment rate: change in %-points							
	total labor force							
all	-0.42	0.07	0.00	0.05	-0.50	0.39	0.00	0.14
no vocational	1.12	-0.83	1.63	-0.31	-0.90	0.84	-0.57	0.18
vocational	-0.65	0.29	-0.25	0.13	-0.32	0.36	0.17	0.11
high school	-4.83	3.79	-4.65	2.59	-2.97	-3.73	-1.03	-0.16
university	-1.60	0.62	-1.22	0.37	-0.46	0.32	0.07	0.19
	native labor force							
all	-0.22	0.05	0.19	-0.03	-0.21	0.12	0.29	-0.13
no vocational	0.75	-0.27	1.23	-0.18	-0.43	0.54	-0.08	0.06
vocational	-0.33	0.10	0.07	-0.01	-0.13	0.06	0.36	-0.17
high school	-3.19	1.76	-2.97	0.92	-2.18	-1.17	-0.47	-0.41
university	-0.67	0.22	-0.28	0.07	0.02	0.02	0.54	-0.18
	foreign labor force							
all	-2.30	-0.09	-1.83	0.25	-3.93	1.56	-3.45	1.42
no vocational	2.23	-3.30	2.83	-0.99	-2.48	2.23	-2.21	1.10
vocational	-6.84	0.88	-6.49	0.39	-4.37	1.91	-3.91	1.58
high school	-32.00	3.14	-32.48	1.18	-16.44	-21.72	-10.50	-1.01
university	-13.61	1.86	-13.35	1.14	-7.88	1.42	-7.21	1.95

Notes: The short-run simulations are based on the short-run semi-elasticities of the wage curve and consider the short-run impact of migration on the capital-output ratio. The long-run results are based on the long-run elasticities of the wage curve and a constant capital-output ratio. The effects have been calculated for natives and foreigners at each education-experience level and then aggregated.

Table A1: **Ethnic German labor force as a percentage of total labor force (Western Germany, 1980 - 2004)**

year	**arrivals**	**stock**	**year**	**arrivals**	**stock**	**year**	**arrivals**	**stock**
1980	0.08	0.24	1990	0.59	1.78	2000	0.03	3.23
1981	0.06	0.29	1991	0.41	2.06	2001	0.02	3.23
1982	0.03	0.29	1992	0.32	2.24	2002	0.01	3.20
1983	0.04	0.32	1993	0.39	2.46	2003	0.00	3.21
1984	0.04	0.35	1994	0.26	2.47	2004	0.00	3.20
1985	0.06	0.40	1995	0.30	2.71			
1986	0.06	0.44	1996	0.21	2.84			
1987	0.11	0.53	1997	0.20	3.02			
1988	0.33	0.84	1998	0.11	3.09			
1989	0.56	1.33	1999	0.08	3.21			

Source: Authors' calculations based on the IABS.

Table A2: **Description of dataset (Western Germany, 1980 - 2004)**

	1980 - 2004 observations	percent	**1984 - 1993** observations	percent
all spells	11,769,872	100.0	4460654	100.0
minus part time workers / trainees	2,543,869	21.6	783808	17.6
minus age (below 15 and above 60)	166,262	1.4	56664	1.3
minus missing nationality	1098	0.0	216	0.0
minus missing education	183070	1.6	68,847	1.5
minus wages below social security contribution threshold	81712	0.7	15,031	0.3
total	8,793,861	74.7	3,536,088	79.3

Source: Authors' calculations based on the IABS.

Table A3: **Change of foreign labor force by education**

	change in percent of total labor force		**foreign labor force**	
educational degree	1980-2004	1984-1993	1980-2004	1984-1993
all	4.14	4.94	41	57
no vocational	-6.13	6.54	-26	30
vocational	6.79	4.35	134	91
high school	38.75	9.47	597	159
university	12.52	4.37	176	71

Source: Authors' calculations based on the IABS.

Table A4: **Share of foreigners by education and experience**

education	**experience**	**1980**	**1984**	**1985**	**1990**	**1993**	**1995**	**2000**	**2004**
no vocational	0-5	0.177	0.151	0.136	0.249	0.368	0.305	0.175	0.122
	6-10	0.275	0.180	0.189	0.223	0.349	0.393	0.315	0.202
	11-15	0.379	0.286	0.267	0.304	0.370	0.389	0.457	0.396
	16-20	0.458	0.351	0.340	0.350	0.402	0.421	0.415	0.473
	21-25	0.344	0.402	0.408	0.376	0.427	0.434	0.428	0.435
	26-30	0.227	0.261	0.291	0.410	0.420	0.436	0.442	0.428
	31-35	0.176	0.185	0.196	0.292	0.391	0.427	0.436	0.451
	36-40	0.081	0.117	0.128	0.181	0.224	0.253	0.383	0.451
	all	0.240	0.219	0.224	0.279	0.346	0.370	0.395	0.388
vocational	0-5	0.030	0.026	0.027	0.049	0.095	0.122	0.095	0.062
	6-10	0.043	0.034	0.034	0.049	0.067	0.083	0.138	0.104
	11-15	0.074	0.052	0.052	0.065	0.078	0.081	0.106	0.154
	16-20	0.090	0.078	0.074	0.080	0.094	0.095	0.097	0.111
	21-25	0.057	0.078	0.084	0.088	0.095	0.103	0.107	0.108
	26-30	0.049	0.047	0.052	0.088	0.102	0.102	0.112	0.111
	31-35	0.037	0.044	0.046	0.054	0.074	0.092	0.110	0.116
	36-40	0.021	0.029	0.032	0.045	0.051	0.054	0.084	0.112
	all	0.051	0.048	0.049	0.064	0.080	0.088	0.106	0.113
high school	0-5	0.040	0.019	0.021	0.021	0.034	0.051	0.065	0.049
	6-10	0.082	0.044	0.035	0.037	0.035	0.039	0.069	0.074
	11-15	0.118	0.098	0.086	0.058	0.057	0.050	0.056	0.077
	16-20	0.076	0.112	0.127	0.111	0.090	0.077	0.071	0.069
	21-25	0.083	0.090	0.085	0.151	0.146	0.126	0.090	0.081
	26-30	0.064	0.075	0.083	0.083	0.123	0.156	0.145	0.110
	31-35	0.030	0.061	0.064	0.074	0.086	0.097	0.163	0.148
	36-40	0.019	0.031	0.035	0.076	0.074	0.075	0.088	0.140
	all	0.065	0.059	0.057	0.058	0.063	0.066	0.078	0.082
university	0-5	0.060	0.033	0.031	0.045	0.048	0.054	0.093	0.113
	6-10	0.084	0.052	0.045	0.041	0.050	0.046	0.044	0.082
	11-15	0.088	0.081	0.072	0.058	0.052	0.050	0.049	0.055
	16-20	0.078	0.081	0.083	0.087	0.074	0.067	0.058	0.057
	21-25	0.060	0.077	0.078	0.084	0.099	0.096	0.072	0.062
	26-30	0.050	0.054	0.055	0.076	0.075	0.085	0.100	0.078
	31-35	0.048	0.047	0.045	0.057	0.075	0.077	0.082	0.104
	36-40	0.025	0.028	0.049	0.042	0.045	0.049	0.047	0.062
	all	0.071	0.062	0.059	0.061	0.063	0.063	0.063	0.071

Notes: Individuals included in the sample are between 15 and 60 years old and are either employed or unemployed on September 30 of the respective year.

Table A5: **Daily wages of native workers by education and experience**
(constant 2000 Euros)

education	**experience**	**1980**	**1984**	**1985**	**1990**	**1993**	**1995**	**2000**	**2004**
no vocational	0-5	41	39	41	44	46	45	43	45
	6-10	55	54	54	57	59	60	57	58
	11-15	60	61	62	64	67	68	73	69
	16-20	62	62	64	68	70	70	76	78
	21-25	64	65	65	67	71	72	75	80
	26-30	64	66	67	69	70	71	78	77
	31-35	64	65	67	70	72	71	76	80
	36-40	63	65	66	70	71	72	77	76
	all	60	61	62	65	68	69	71	72
vocational	0-5	49	48	49	53	56	56	58	59
	6-10	63	61	62	65	66	66	68	67
	11-15	72	72	72	74	76	76	79	78
	16-20	79	79	80	81	81	82	86	86
	21-25	81	84	85	86	86	86	89	90
	26-30	81	85	87	90	89	89	93	93
	31-35	81	84	87	92	93	93	96	96
	36-40	80	85	86	91	93	94	100	98
	all	73	74	75	78	81	81	86	87
high school	0-5	58	57	57	61	64	65	68	68
	6-10	78	75	75	78	82	81	85	85
	11-15	92	93	94	93	95	95	104	102
	16-20	105	103	104	104	104	104	112	114
	21-25	111	114	114	109	109	109	114	115
	26-30	112	119	120	118	114	112	119	119
	31-35	117	126	126	120	123	120	125	121
	36-40	111	127	131	128	122	119	130	120
	all	90	89	88	87	91	91	101	103
university	0-5	87	92	92	94	96	93	105	95
	6-10	110	119	118	121	125	122	141	138
	11-15	129	141	144	137	144	144	160	168
	16-20	139	160	159	156	154	153	175	180
	21-25	143	166	166	166	168	166	181	186
	26-30	143	171	173	170	174	175	195	188
	31-35	139	171	170	177	179	177	204	199
	36-40	127	154	164	169	171	171	207	187
	all	123	140	141	140	144	144	164	168

Notes: Individuals included in the sample are between 15 and 60 years old, receive non-zero income and work at least on September 30 of the respective year. Wages are calculated in real Euro using the GDP deflator (base year: 2000). Wages above the social security ceiling are imputed.

Table A6: **Daily wages of foreign workers by education and experience**
(constant 2000 Euros)

education	**experience**	**1980**	**1984**	**1985**	**1990**	**1993**	**1995**	**2000**	**2004**
no vocational	0-5	47	47	47	50	46	46	44	43
	6-10	58	56	57	59	56	55	55	53
	11-15	61	61	63	64	61	60	62	62
	16-20	65	63	64	66	63	64	65	66
	21-25	67	66	68	67	65	65	68	70
	26-30	67	67	68	71	67	66	68	70
	31-35	65	65	67	72	71	71	70	71
	36-40	64	64	65	70	70	70	74	74
	all	63	62	64	67	64	64	66	68
vocational	0-5	54	51	52	55	55	57	59	57
	6-10	63	61	62	65	62	63	67	67
	11-15	70	68	68	70	68	68	71	75
	16-20	74	73	75	73	70	71	74	75
	21-25	75	76	77	78	73	73	76	78
	26-30	74	76	77	81	78	77	76	78
	31-35	72	73	75	81	80	80	80	78
	36-40	71	73	75	77	79	80	84	82
	all	70	71	72	74	71	71	74	76
high school	0-5	63	64	62	65	61	56	65	65
	6-10	75	74	79	79	74	73	81	78
	11-15	78	78	76	92	82	81	87	90
	16-20	103	96	96	86	86	78	89	89
	21-25	92	103	108	97	78	85	86	88
	26-30	97	82	86	103	100	93	86	91
	31-35	102	99	141	90	93	86	101	85
	36-40	106	127	91	114	85	86	95	113
	all	84	86	89	89	81	79	85	87
university	0-5	97	107	119	109	102	105	115	107
	6-10	114	127	135	124	140	132	135	141
	11-15	141	140	190	150	143	144	151	147
	16-20	135	157	172	153	152	157	149	164
	21-25	132	162	173	166	165	163	155	153
	26-30	138	149	167	175	162	189	151	173
	31-35	159	151	158	166	172	165	177	166
	36-40	134	191	147	149	185	151	175	212
	all	126	144	164	150	150	151	147	151

Notes: Individuals included in the sample are between 15 and 60 years old, receive non-zero income and work at least on September 30 of the respective year. Wages are calculated in real Euro using the GDP deflator (base year: 2000). Wages above the social security ceiling are imputed.

Table A7: **The wage-setting curve: IV-estimation results, 1984 - 1993**

education degree	$\ln w_{ij,t-1}$ coeff.	se		$\ln u_{ijt}$ short-run coeff.	se		long-run coeff.	se		R^2
				all experience groups						
all	0.236	(0.048)	***	-0.100	(0.015)	***	-0.130	(0.024)	***	0.84
no vocational	0.245	(0.134)	*	-0.091	(0.013)	***	-0.121	(0.025)	***	0.95
vocational	0.371	(0.084)	***	-0.089	(0.010)	***	-0.141	(0.028)	***	0.97
high school	-0.095	(0.147)		0.029	(0.040)		0.026	(0.035)		0.80
university	0.245	(0.066)	***	-0.118	(0.025)	***	-0.157	(0.041)	***	0.69
				experience group 1 and 2						
no vocational	0.677	(0.353)	*	-0.096	(0.026)	***	-0.296	(0.343)		0.94
vocational	0.780	(0.294)	***	-0.096	(0.023)	***	-0.434	(0.625)		0.97
high school	0.430	(0.296)		-0.052	(0.023)	**	-0.092	(0.074)		0.98
university	0.189	(0.112)	*	-0.108	(0.023)	***	-0.133	(0.038)	***	0.91
				experience group 3 and 4						
no vocational	-0.100	(0.219)		-0.101	(0.021)	***	-0.092	(0.019)	***	0.97
vocational	0.118	(0.160)		-0.091	(0.018)	***	-0.103	(0.026)	***	0.94
high school	0.141	(0.490)		-0.249	(0.451)		-0.290	(0.543)		-
university	0.525	(0.290)	*	-0.250	(0.177)		-0.526	(0.646)		-
				experience group 5 and 6						
no vocational	0.119	(0.288)		-0.088	(0.037)	**	-0.100	(0.049)	**	0.87
vocational	0.301	(0.116)	***	-0.080	(0.016)	***	-0.115	(0.034)	***	0.91
high school	0.024	(0.356)		0.009	(0.080)		0.009	(0.080)		0.80
university	0.092	(0.108)		-0.028	(0.032)		-0.031	(0.037)		0.38
				experience group 7 and 8						
no vocational	0.067	(0.151)		-0.081	(0.011)	***	-0.087	(0.016)	***	0.99
vocational	0.356	(0.130)	***	-0.082	(0.015)	***	-0.127	(0.039)	***	0.98
high school	-0.460	(0.318)		0.122	(0.084)		-0.524	(0.046)	*	0.59
university	0.169	(0.159)		-0.145	(0.057)	***	-0.175	(0.080)	**	0.64

Notes: Dependent variable is $\ln w_{ijt}$, i.e. the log wage in each education-experience group. White-heteroscedasticity robust standard errors in parentheses. ***, **, * denote the 1%-, 5%-, and 10%-significance levels. The model is estimated by 2SLS. The unemployment rate is instrumented by its first, second and third lag. The model is specified as a one-way error component model with group specific fixed effects and contains a deterministic time trend and a squared deterministic time trend for each experience group. The regressions for each education-experience group are based on 44 observations, the regressions in each education group on 176 observations, and the overall regression on 704 observations. Within R^2 are reported.

Table A8: **The wage-setting curve: GMM-estimation results***

education	$\ln w_{ij,t-1}$		$\ln u_{ijt}$ short-run		long-run		Wald-$\chi^2(3)$-stat.	obs.
			1980 - 2004					
all [1]	0.623	***	-0.034	***	-0.090	***	413354	736
	(0.002)		(0.001)		(0.003)			
no vocational [2]	0.606	***	-0.044	**	-0.111		28	184
	(0.228)		(0.019)		(0.080)			
vocational [3]	0.743	***	-0.041	***	-0.161	***	184	184
	(0.086)		(0.010)		(0.059)			
high school [4]	0.644	***	-0.044	***	-0.122	*	46	184
	(0.188)		(0.007)		(0.071)			
university [5]	0.668	***	-0.028		-0.084		39	184
	(0.183)		(0.032)		(0.070)			
			1984-1993					
all [6]	0.448	***	-0.044	***	-0.080	***	55212	320
	(0.005)		(0.001)		(0.002)			
no vocational [7]	0.369	***	-0.050	***	-0.079	***	523	80
	(0.096)		(0.006)		(0.020)			
vocational [8]	0.722	***	-0.048	***	-0.174	***	343	80
	(0.063)		(0.009)		(0.055)			
high school [9]	-1.200		-0.041	**	-0.018	**	75	80
	(0.966)		(0.020)		(0.016)			
university [10]	0.441	***	-0.032		-0.058		244	80
	(0.038)		(0.021)		(0.040)			

Notes: The dependent variable is $\ln w_{ijt}$. * Arellano-Bond (1992) two-step estimation. [1] The Sargan-$\chi^2(276)$-test statistics rejects the H0 of no over-identification with 31.7***. The Arellano-Bond z-statistics rejects the H0 of AR(1) at -3.3***, and of AR(2) at 0.7. [2] Sargan-$\chi^2(156)$-test statistics: 5.9***. Arellano-Bond z-statistics: AR(1) -1.2, AR(2) 0.8. [3] Sargan-$\chi^2(155)$-test statistics: 6.6***. Arellano-Bond z-statistics: AR(1) -2.1**, AR(2) -2.0**. [4] Sargan-$\chi^2(156)$-test statistics: 6.0***. Arellano-Bond z-statistics: AR(1) -2.0**, AR(2) 0.02. [5] Sargan-$\chi^2(155)$-test statistics: 7.7***. Arellano-Bond z-statistics: AR(1) -2.2**, AR(2) 0.7. [6] Sargan-$\chi^1(75)$-test statistics: 31.9***. Arellano-Bond z-statistics: AR(1) -2.9***, AR(2) 0.04. [7] Sargan-$\chi^2(65)$-test statistics: 7.6***. Arellano-Bond z-statistics: AR(1) -0.7, AR(2) -1.3. [8] Sargan-$\chi^2(64)$-test statistics: 7.6***. Arellano-Bond z-statistics: AR(1) -2.1**, AR(2) -2.1**. [9] Sargan-$\chi^2(65)$-test statistics 1.9***. Arellano-Bond z-statistics: AR(1) 1.3, AR(2) -0.6. [10] Sargan-$\chi^2(64)$-test statistics 7.7***. Arellano-Bond z-statistics AR(1) -2.1**, AR(2) 0.2. GMM two-step standard errors are biased.

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