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Why to employ both migrants and natives? A study on task-specific substitutability

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Abstract

This paper analyzes the performance of migrants on the German labor market and its dependence on the tasks performed on their jobs. Recent work suggests quantifying the imperfect substitutability relationship between migrants and natives as a measure for the hurdles migrants have to face. Our theoretical work adopts that migrant shares are very heterogeneous across firms which is hard to reconcile with an aggregate production function. We argue that the ability to integrate migrants may form a competitive advantage for firms. We show in a Melitz-type framework that the output reaction to wage changes varies across firms. Hence, substitution elasticities of an aggregate production function can be quite different from those individual firms are faced with. Finally we estimate elasticities of substitution for different aggregate CES-nested production functions for Germany between 1993 and 2008 using administrative data and taking into account the task approach. We find significant variation in the substitutability between migrants and natives across qualification levels and tasks. We show that especially interactive tasks seem to impose hurdles for migrants on the German labor market.

Keywords: Heterogeneity, Migrants, Substitution Elasticity, Tasks,

JEL: J 15, J 24; J 31

Introduction

The current labor market performance of migrants in Germany has stirred a lively public debate how policy could foster and improve the integration of immigrants into the labor force. Until 1973, during the economic boom, German firms focused on the recruitment of foreign labor without demanding special (formal) skill or job prerequisites. Many of these "guest-workers" did not remigrate back as initially planned. Hence they settled down, some family members followed from the country of origin for the purposes of family reunion. In general equal job opportunities do not prevail anywhere, workers with an immigration background face a risk to become unemployed nearly twice as high as Germans, work in different jobs as natives, and mostly earn lower wages.

Various studies analyze the effects of immigration, how immigrants adapt to the labor market, and how they perform in terms of wages (Borjas 1992, 2003, Borjas and Katz 2007, Card 2001, 2007, Bruecker and Jahn 2011, Suedekum et al. 2009, D'Amuri et. al. 2010). Despite discrimination, imperfect substitutability between migrants and natives in the same task is a possible reason for persistently lower wages. With regard to the size of the elasticity of migrant-native substitution, evidence for the German labor market is however ambiguous. Discrepancies in estimates yielded with almost equal data and equal periods call for further explanation.

The recent study by Peri and Sparber (2009) addresses the topic of comparative advantages as an explanation for different choices of occupation by migrants versus natives even with the same formal qualification level. They observe that in the US migrants with graduate degrees specialize in occupations demanding cognitive and analytical skills, whereas their native-born counterparts specialize in occupations requiring interactive and communication skills. Similarly, Borjas concludes for the US*: "(…) the growing divergence between immigrants and natives does not lie in which sector of the economy they are employed. Rather, the divergence is occurring in the* ***kinds of tasks*** *that immigrants and natives perform on the job"* (Borjas 1992, pp28-29).

Our interest is to investigate the elasticity of substitution between migrants and natives considering various qualifications and with a special focus on the task dimension, and our contribution to this is twofold.

First, we extend the model by Borjas (2003) by considering task heterogeneity across firms in a general equilibrium framework. This has particular importance in the German case because the labor market is organized by occupation specific skills, so that a certain level of formal education is required for most occupations. The standard theory of equilibrium wages predicts that an inflow of immigrant labor into a certain skill group will reduce the relative wage of native workers belonging to that group, with the size of the wage reduction determined by the degree of substitution between skill groups as well as between immigrant and native workers with similar skills. Immigrant labor supply shocks are captured by changes in the share of foreign-born workers within each cluster, and wages of individual native workers might be affected by immigrants working in different firms and different skill/task groups. In our model, however, the labor market is segmented in a way that there are two kinds of jobs, and one job type is dominated by natives. Immigration affects not only factor prices, as in the neoclassical model of immigration, but also employment opportunities of natives.

Second, whereas we keep the theoretical model as simple as possible with only two tasks as different labor inputs, we augment the empirical standard model for migrant-native substitutability which distinguishes labor by qualification and experience (as used by Card and Lemieux 2001 and D'Amuri et al. 2010) by the task dimension. Our estimations indeed highlight the importance of differentiation by task and qualification, and of properly accounting for their heterogeneity.

However, we are aware of the fact that even if qualification, task, job experience, language skills are comparable there might be relevant discrimination aspects that also manifest in the wage structure. As well, task issues play not only a role with regard to the wage differential; for example, the occupational choice and the occupation-specific human capital are crucial for the labor market performance and the risk to become unemployed over the whole working life (Kambourov and Manovskii 2009, Longhi and Brynin 2010, Schmillen and Moeller 2012).

The paper is structured as follows. First, we present some empirical evidence to motivate our research question. Secondly, we extend the model by Borjas (2003) by considering heterogeneous firms in a general equilibrium framework to show that looking only on the firm side might be misleading, and thirdly, we estimate elasticities of substitution between migrants and natives for different task and qualification groups. To our knowledge, no prior

study has addressed this question differentiated by skill groups using the task approach to distinguish different types of occupation.

Related literature and empirical evidence

Recent work (Ottaviano and Peri 2005, 2007, 2012, Card 2007) points at a positive and significant effect of immigration on the average wage of US natives across US states and metropolitan areas. Research on the links between migrants and economic outcomes has to date focused primarily on the aggregate level. Most studies do not consider that migrants concentrate in different occupations and firms with heterogeneous requirements of skills. However, the occupational classification is a central dimension of the German labor market: on the one side the choice of occupation determines earnings and career opportunities to a large extent, on the other side firms try to select the "best matching" worker by including vocation and job in the advertisement of the vacancy. Abraham et al. (2011) state that especially in Germany the vocational dimension is a key element for theoretical explanations of the labor market. The authors interpret occupations as a kind of ideal typical indicator and description of tasks of vacant jobs. Every occupation paraphrases a spectrum of tasks that requires specific knowledge and skills. There are plausible arguments that recruiting behavior or matching processes might differ across occupational groups (Stops and Mazzoni 2010).

Descriptive evidence for Germany shows that foreigners and natives with comparable qualifications work in different occupational segments (Steinhardt 2011). Even after residing in the host country for a long time, immigrants are more likely than natives to work in jobs that require lower qualification, even if they possess higher skill levels. According to empirical evidence, it seems more reasonable to consider different occupational groups as defined by characteristic tasks in addition to the skill dimension. Moreover, studies of recruitment behavior find that one of the reasons why unemployed persons generally face more problems to get a particular job is that they do not meet the job requirements in terms of qualification and experience levels in the immigration country (e.g. Gorter et al. 1993). There is additional evidence that firm size plays a role for the amount of employed migrants (Holzer 1998).

Although the human capital framework illuminates both the determination of skill prices and the incentives for skill investment, there is no further information on what kind of requirements workers have to satisfy, and which task dimension is crucial to hold a certain occupation. Going beyond the common approach by using qualification as a proxy for human capital, Lazear (1999) supports the view of a broader definition of human capital as a vector of different attributes, including physical skills, education or cognitive abilities, language and communication skills.

Recent literature follows the idea of linking tasks and activities workers perform on the job to the skills needed to carry out these activities (Autor et al. 2003, Spitz-Oener 2006, Acemoglu and Autor 2010). This so-called "task based approach" offers a framework to classify jobs according to their core task requirements and then consider the set of formal and informal skills required to carry out these tasks. One asset of this new approach is that it provides a microfoundation for linking the aggregate demand in the labor market to the specific skill demands of given job activities. One stylized fact observed by Autor et al. (2006) is that higher skilled workers perform different and more interactive (or communicative) tasks compared to less skilled workers. In following the task based approach, we use a task classification scheme according to Gathmann and Schoenberg (2010) and Dustmann et al. (2010) to order the occupations by the intensity with which they use each type of attributes. We look deeper into the data to confirm first evidence for comparative (dis)advantages for migrants relative to Germans in certain occupations or tasks. For the US as well as for most European countries there has been an increase in demand for jobs requiring more complex and abstract skills coupled with a decrease in the demand for unskilled jobs in the last decade. In particular, non-routine manual jobs can also be assigned to foreign workers who may have poor native language skills or who may not know the cultural specifics, social norms and institutions of the host country. A central finding by Peri and Sparber (2009) demonstrates that immigrants who do not speak the language of the host country are concentrated in more manual and less interactive tasks (especially unskilled workers) and tend to receive lower wages than natives. Evidence for the UK shows the phenomenon that immigrants downgrade substantially upon arrival and work in jobs and professions that are far beneath where they would be assigned based on their observable skills. For instance, 26% of the highly educated recent immigrants in the UK were employed in routine and semi-routine occupations, the two lowest paid occupation categories (Goos/Manning 2007, Goos

et al. 2009, Dustmann et al. 2009). A special feature of the German labor market is that occupational mobility is not very high compared to other countries.

A heterogeneous firm model with labor market segmentation

Relaxing the assumption of perfect substitutability between natives and migrants is a crucial factor in up to date migration research (Borjas 2003, D´Amuri et al. 2010). These studies measure the relationship by estimation of the parameters of the aggregate production function of the economy and the empirical results indicate that indeed migrants and natives can be seen as imperfect substitutes. On the other hand Martins et al. (2012) recently looked at the Portuguese labor market on the firm level and found that migrants and natives are rather complements than substitutes.

The aim of this section is to give an explanation for these paradox findings. Therefore we develop a heterogeneous firm model based on Melitz (2003), considering firm heterogeneity by varying migrant share which we observe very clearly in our firm data. Firms differ in their ability to integrate migrants. This turns out to be a competitive advantage for the firm when the wage of migrants is lower than the wage of natives, which is usually the case. We show that under these assumptions segmented labor markets evolve. Furthermore the model points out that the aggregate production function captures the competition effect stating that firms might react by adopting their individual production output. This explains the discrepancy between the aggregate and the firm level findings.

Basic framework

There are two kinds of jobs and two types of workers, namely migrants and natives. The first job can be performed by migrants and natives, while only the natives can do job 2. The difference in both jobs might stem from factors like discrimination but also from the bundle of tasks performed at the jobs, e. g. job two might require human interaction in the natives language a lot in which migrants can have a serious disadvantage. Migrants and natives share the same productivity in job 1. Firms cannot choose freely between the utilization of both jobs but use a CES-technology:

$$q_f = A_f \cdot \left(\beta_f^{\frac{1}{\gamma}} \cdot \left(l_1^f\right)^{\frac{\gamma-1}{\gamma}} + \left(1-\beta_f\right)^{\frac{1}{\gamma}} \cdot \left(l_2^f\right)^{\frac{\gamma-1}{\gamma}} \right)^{\frac{\gamma}{\gamma-1}}, \qquad (1)$$

$$l_1^f = l_{1m}^f + l_{1n}^f, \qquad (2)$$

where the parameter $\gamma > 0$ describes the grade of substitutability, A_f is the total factor productivity and $\beta \in [0,1]$ represents the ability to use job 1 (0 = does not utilize job 1, 1 = only job one is used). l_1 is the firms labor demand for job 1, l_2 for job 2. For γ equals zero the Leontieff case holds, for values of γ below one both jobs are usually called complements, for $\gamma = 1$ the firms use Cobb-Douglas technology and for γ approaching to infinity both jobs become perfect substitutes.

As in the well known Dixit-Stiglitz model of monopolistic competition the representative household maximizes a CES-aggregate over a continuum of product varieties indexed by ω:

$$U = \left(\int_{\omega \in \Omega} c(\omega)^{\rho} d\omega \right)^{1/\rho} \qquad (3)$$

with $0 < \rho < 1$ and thus an elasticity of substitution $\sigma = \frac{1}{1-\rho} > 1$. The optimal demand for variety ω is given by

$$q(\omega) = Q \cdot P^{\sigma} \cdot p(\omega)^{-\sigma} \qquad (4)$$

with an aggregate output $Q \equiv U$ and an aggregate price index $P = \left[\int_{\omega \in \Omega} p(\omega)^{1-\sigma} d\omega\right]^{\frac{1}{1-\sigma}}$.

Profit maximization implies the individual firm pricing behavior

$$p(\phi) = \frac{1}{\rho \cdot \phi} \qquad (5)$$

where ϕ are the inverse marginal costs needed to produce a unit of the symmetric good

$$\phi(\beta_f, A_f) := \frac{A_f}{\left(\beta_f \cdot w_1^{1-\gamma} + \left(1-\beta_f\right) \cdot w_2^{1-\gamma}\right)^{\frac{1}{1-\gamma}}}. \qquad (6)$$

When the wage for job one w_1 is lower than the wage for job 2 w_2, which will normally be the case as we will show in the next section, the marginal costs are lower the higher the total factor productivity or the higher the parameter β_f. What the formula also shows is that a shift of the wages has a different impact on firms with different β_f values. If we abstract from fixed costs the profits π_f will be proportional to the revenues r_f, and it holds for firm f and f':

$$\frac{\pi_f}{\pi_{f'}} = \frac{r_f}{r_{f'}} = \left(\frac{\phi_f}{\phi_{f'}}\right)^{\sigma-1} \qquad (7)$$

This implies that a firm with a higher ability to use job 1 (higher values of β_f) will make more profit compared to another firm with the same total factor productivity.

To model a world where firms differ regarding their productivity and their labor force composition, we assume that the parameter for the parameter of a firm $\beta_f \in [0,1]$ is drawn stochastically at the moment of firm formation from a known distribution $G(.)$ with density $g(.)$. Likewise total factor productivity of a firm is drawn independently from a known distribution $H(.)$ with density $h(.)$. The parameter β_f thus identifies the share of job 1 a_f for every relative wage $\frac{w_2}{w_1}$ uniquely by:

$$a_f = \frac{1}{1 + \frac{1-\beta_f}{\beta_f} \cdot \left(\frac{w_1}{w_2}\right)^{\gamma}} \qquad (8)$$

The firm formation process involves sunken entry costs.[2] A capital market allows financing of market entry costs on the one side; it collects firm profits on the other side, perfectly diversifying the investment risk. The market is risk neutral so that firms form as long as the expected long run profit of a new firm is positive, which is here understood as free entry. Furthermore, every period a negative productivity shock hits the firm with a constant probability and forces it to leave the market instantly.

Labor market equilibrium with heterogeneous jobs

In the simplest labor market model all workers share identical characteristics. There are neither differences in skills of workers nor heterogeneous job demand. In this framework, the role of labor migration appears to be simply one of equilibrating the balance of aggregate labor supply and demand through the responses of potential migrants to differences between attainable (real) incomes. Recognition of various forms of human capital allows an extension of the analysis to encompass heterogeneous categories of both workers and jobs and a whole series of occupational as well as spatial sub-markets. De

[2] These costs prevent the firm founders from cheating the stochastic above by continuously starting and closing firms until they finally draw the best possible factor productivity and migrant share.

New/Zimmermann (1994) document this fact for the "guest-worker" countries Germany and Switzerland, where immigrants are heavily represented in construction and manufacturing, as opposed to the United States, where the sectoral distributions of natives and immigrants are very similar.

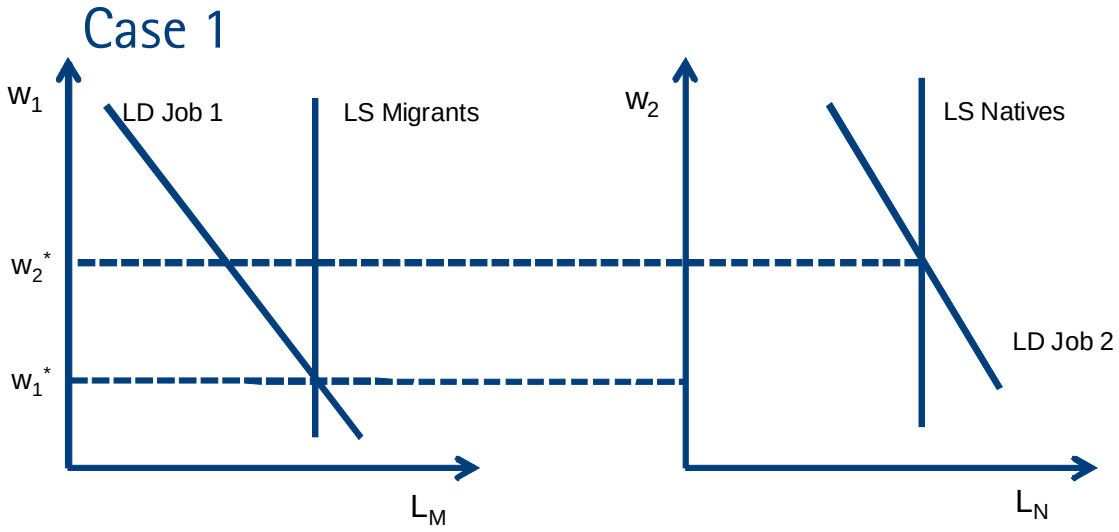

Figure1: Two kinds of jobs; Segregation between migrants and natives

In our simplified model labor supply is inelastic and jobs are somewhat ordered, as job 1 can be performed by everyone while only natives can do job 2. This simplification implies that

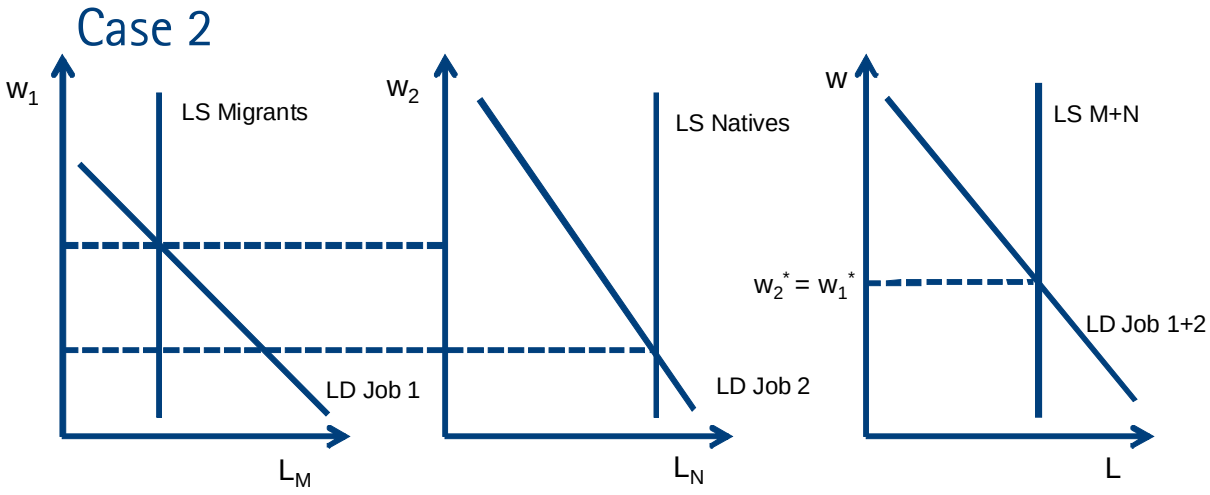

Figure 2: Two kinds of jobs; No segregation between migrants and natives

only two cases may arise depending on the labor demand for both jobs: In the first case the wage for job 2 exceeds the wage for job 1, giving natives an incentive to concentrate in job

2. This leads to segregation of migrants in job 1 and natives in job 2 (see Figure 1).

In the second case hypothetical perfect segregation might lead to a lower wage for job 2. Then natives have an incentive to move to the labor market for job 1 until the wage is equal in both jobs (see Figure 2). Therefore both labor markets merge. In the data we robustly find wage differences between natives and migrants, therefore the first case seems to be more relevant and we constantly assume in the following that job one is only performed by migrants and that the wage of natives exceeds the wage of migrants. The parameter β_f of a firm can then be interpreted as the ability to integrate migrants in the workforce.

As demonstrated in eq. (6), the heterogeneity of firms can be expressed by the inverse marginal costs ϕ_f, which are themselves determined by total factor productivity, the wages, the elasticity of substitution γ between migrants and natives and the firm-specific integrative ability β_f. Inverse marginal costs can now be used to characterize the aggregated firm behavior by the behavior of a weighted average firm. This procedure is similar to the Melitz (2003) model, where the inverse marginal costs are only equal to the total factor productivity. The weighted average of the inverse marginal costs for a symmetric good is defined by:

$$\widetilde{\Phi} = \left(\int_0^1 \int_0^\infty \Phi(\beta, \mathrm{A})^{\sigma-1} \mu(\beta, \mathrm{A}) \mathrm{dA}\, \mathrm{d}\beta \right)^{\frac{1}{\sigma-1}}$$

$$= \left(\int_0^1 \int_0^\infty \mathrm{A}^{\sigma-1} \left(\beta \cdot w_1^{1-\gamma} + (1-\beta) \cdot w_2^{1-\gamma} \right)^{\frac{1-\sigma}{1-\gamma}} \mu(\beta, \mathrm{A}) \mathrm{dA}\, \mathrm{d}\beta \right)^{\frac{1}{\sigma-1}} \qquad (9)$$

with the density of firms in the market defined by $\mu(\beta, \mathrm{A})$. As stochastic firm dropout is uncorrelated with the job 1 shares and the productivities, it has no influence on the long run distribution of firms in the market and therefore holds

$$\mu(\beta, A) = g(\beta) \cdot h(A) \qquad (10)$$

The price index P, total output Q, revenue R and firm profit Π can then be stated, with the number of firms M, as:

$$\mathrm{P} = \mathrm{M}^{\frac{1}{1-\sigma}} \cdot \mathrm{p}(\widetilde{\varphi})\ ;\ \mathrm{Q} = \mathrm{M}^{\frac{1}{\rho}} \cdot \mathrm{q}(\widetilde{\varphi}) \qquad (11)$$

$$\mathrm{R} = \mathrm{P} \cdot \mathrm{Q} = \mathrm{M} \cdot \mathrm{r}(\widetilde{\varphi});\ \Pi = \mathrm{M} \cdot \pi(\widetilde{\varphi}) = \mathrm{M} \cdot \overline{\pi}. \qquad (12)$$

So far the only difference between firms is the share of job 1 on total production. As the wage of migrants is lower than or at most equal to the wage of natives, a firm has cost advantages relative to a firm with a lower share of job 1.

The aggregate labor demand for migrants is given by:

$$L_1^D = \int_0^\infty \int_0^1 M \cdot l_1(\beta, A) g(\beta) h(A) d\beta \, dA$$

$$= M \int_0^\infty \int_0^1 \frac{QP^\sigma \left(w_1^{1-\gamma}\beta + w_2^{1-\gamma}(1-\beta)\right)^{\frac{\gamma-\sigma}{1-\gamma}}}{\left(\frac{\sigma}{\sigma-1}\right)^\sigma A^{1-\sigma} \cdot \frac{w_1^\gamma}{\beta}} g(\beta) h(A) d\beta \, dA$$

$$= MQP^\sigma \rho^\sigma w_1^{-\gamma} \int_0^\infty A^{\sigma-1} h(A) dA \cdot \int_0^1 \beta \cdot \left(w_1^{1-\gamma}\beta + w_2^{1-\gamma}(1-\beta)\right)^{\frac{\gamma-\sigma}{1-\gamma}} g(\beta) d\beta \quad (13)$$

and the demand for native labor by:

$$L_2^D = MQP^\sigma \rho^\sigma w_2^{-\gamma} \int_0^\infty A^{\sigma-1} h(A) dA \cdot$$

$$\int_0^1 (1-\beta) \cdot \left(w_1^{1-\gamma}\beta + w_2^{1-\gamma}(1-\beta)\right)^{\frac{\gamma-\sigma}{1-\gamma}} g(\beta) d\beta \quad (14)$$

Thus, the relative demand evolves as:

$$\frac{L_1^D}{L_2^D} = \left(\frac{w_2}{w_1}\right)^\gamma \cdot \frac{\int_0^1 \beta \cdot \left(\beta + \left(\frac{w_2}{w_1}\right)^{1-\gamma}(1-\beta)\right)^{\frac{\gamma-\sigma}{1-\gamma}} g(\beta) d\beta}{\int_0^1 (1-\beta) \cdot \left(\beta + \left(\frac{w_2}{w_1}\right)^{1-\gamma}(1-\beta)\right)^{\frac{\gamma-\sigma}{1-\gamma}} g(\beta) d\beta} \quad (15)$$

which is independent from individual total factor productivity.

The right side increases – as at least if $\gamma \leq 1$ or $2 \cdot \gamma > \sigma$, therefore $\sigma \leq 2$ is a sufficient condition – in the relative wage $\frac{w_2}{w_1}$ and in the consumers' elasticity of substitution σ. The first information means that the labor demand curve is well-behaved in the sense that an increase in the supply of one labor group decreases the relative wage of this group. The second information implies that ceteris paribus an increase of the consumers' elasticity of substitution leads to a lower wage differential between natives and migrants. The reason for this is that the lessened uniqueness of the individual products puts pressure on the cost structure so that firms with wage cost advantages increase production while the disadvantaged firms have to reduce production. Therefore, the demand for migrant workers increases and the wages have to adjust accordingly because labor supply is inelastic (see Section "Labor market equilibrium with heterogeneous jobs").

Comparison to an aggregate production function

The aggregate relative demand equation (15) looks quite similar to an aggregate relative demand equation of the form

$$\frac{L_M}{L_N} = \left(\frac{w_N}{w_M}\right)^{\gamma_{agg}} \cdot \frac{\theta}{1-\theta} \qquad (16)$$

of a model using a similar aggregate CES production function (see D'Amuri et al. 2010):

$$Y = A_{agg}\left(\theta \cdot L_M^{\frac{\gamma_{agg}-1}{\gamma_{agg}}} + (1-\theta) \cdot L_N^{\frac{\gamma_{agg}-1}{\gamma_{agg}}}\right)^{\frac{\gamma_{agg}}{\gamma_{agg}-1}} \qquad (17)$$

where γ_{agg} now is the aggregate elasticity of substitution between migrants and natives. The comparison of (15) and (16) shows, that under the very special assumptions that all firms share the same elasticity of substitution between migrants and natives γ and that this γ is equal to the consumers elasticity of substitution σ between the different product varieties, then the aggregate elasticity γ_{agg} equals the elasticity of the firms γ and the production parameter θ equals the mean across the integrative ability's distribution $\tilde{\beta} = \int_0^1 \beta \cdot g(\beta) d\beta$.

As there is no plausible reason why this special parameter constellation should be true, the model shows that the aggregate elasticity of substitution does not need to match the elasticity relevant for the firms or heterogeneous aggregations of the labor force across the firms (e.g. sectors, qualification- and task-specific employment). The heterogeneity which we observe in the data regarding the migrant share or the production functions at all can skew the results when we try to describe the firm behavior using the aggregate estimation approach. On the other hand, the model shows that heterogeneous ability to integrate migrants, which is a competitive advantage for firms, can explain why we observe imperfect substitutability in the aggregate variables and even complementarities in firm level data. When the relative wage for migrants decrease, e.g. due to an immigration shock, firms with a high ability to integrate migrants (high values of β) increase production, while firms with a low ability decrease production. This competition effect is not captured in the firm level production function parameter and thus favors the aggregate production function approach for the analysis of the impact of migrants, which we therefore adopt in the empirical part.

Empirical design

Whereas we have kept the theoretical model as simple as possible, with only two tasks as different labor inputs in order to focus on the most relevant issue, it seems appropriate to be less restrictive in the empirical analysis. Thus, when estimating the substitution elasticities between different groups of labor at a certain CES sub-aggregate level – e.g., between migrants and natives in low-skilled employment with manual routine tasks – we employ a strategy similar to Card/Lemieux (2001) and D'Amuri et al. (2010). In the present paper, we modify the overall log-wage equation from D'Amuri et al. (2010) with regard to two aspects. Firstly, we add the task level as an additional intermediate level of disaggregation; here, we test various specifications where to put it in (whether as a substitute for formal qualification, at a level beyond formal qualification but above experience, or at a level below experience). Second, we allow for heterogeneity of the migrant-native substitution elasticity across the CES sub-aggregates.

The logarithm of average wages for workers with qualification h, task i, experience j and migration status k (with k ∈ {m, n}) at time t is

$$\begin{aligned}\ln w_{hijkt} = {} & \Psi_t + \tfrac{1}{\delta}(\ln L_t - \ln L_{ht}) + \ln \theta_h + \tfrac{1}{\eta}(\ln L_{ht} - \ln L_{hit}) + \ln \theta_i \\ & + \tfrac{1}{\zeta}\left(\ln L_{hit} - \ln L_{hijt}\right) + \ln \theta_j \\ & + \tfrac{1}{\gamma_{hi}}\left(\ln L_{hijt} - \ln L_{hijkt}\right) + \ln \theta_{hik} + \varepsilon_{hijkt} \qquad (18)\end{aligned}$$

where $\Psi_t = -\frac{1}{\delta}\ln\left(M_t Q_t P_t \rho^{\sigma} \int_0^{\infty} A^{\sigma-1} h(A) dA\right)$ results from the (time varying) demand on the goods market , the varying number of firms in the market (a certain fraction closes every period, others enter the market) and the firm-specific total factor productivity aggregated over all firms, taken to the logs; this is constant across labor aggregates within a year and thus can be estimated by time dummies. Likewise, the productivity parameters in the CES sub-aggregates θ are estimated by group identifiers (qualification, task, experience dummies)[3]. Note that $\theta_{him} = \widetilde{\beta}$ and $\theta_{hin} = (1 - \widetilde{\beta})$ in the respective qualification-task

[3] If we would want to account for qualification-specific technological change, we would have to use time-variant (trending) productivity parameters θ_{ht}rather than constant θ_h. With regard to the qualification-task-specific technology parameters of the migrant-native CES nest (not eliminated in eq. 19) which reflect the nest-

segment of the labor market. If at a certain level the respective sub-aggregate encloses more than two groups of labour, the respective parameters $(\theta, \delta, \eta, \zeta)$ need to be estimated from eq. (18). Elasticities of substitution between migrants and natives can be estimated from the log of the wage ratio of w_{hijmt} over w_{hijnt} (that is, from the difference between $\ln w_{hijmt}$ and $\ln w_{hijnt}$). Most components of eq. (18) are equal between both and thus are differenced away; the remainder is

$$\ln\left(\frac{w_{hijmt}}{w_{hijnt}}\right) = \ln\left(\frac{\theta_{him}}{\theta_{hin}}\right) - \frac{1}{\gamma_{hi}} \ln\left(\frac{L_{hijmt}}{L_{hijnt}}\right) + \left(\varepsilon_{hijmt} - \varepsilon_{hijnt}\right) \qquad \textit{(19)}$$

The two equations are estimated by OLS with heteroscedasticity-consistent standard errors. The empirical analogue to eq. 19 includes, besides the log wage-ratio as dependent variable and the log employment ratio as regressor only a constant and the disturbance. As in Card/Lemieux (2001), the labor demand equations are identified from the data only if we abstract from demand-supply interactions by assuming inelastic labor supply.

Data

Our individual employment data are based on the *Sample of Labor Market Biographies* (SIAB), a two percent representative sample of administrative social security records in Germany covering 1975-2008. The sample, which includes more than 200,000 employment spells per year, provides precise information on daily wages, working days, and further individual characteristics for all individuals who contribute to the social security system. This represents about 80 percent of the German workforce; among the excluded groups are the self-employed and civil servants (Dorner et al. 2010). We construct our sample of aggregate employment and wages (by formal qualification, tasks, experience and nationality) considering only persons in regular employment subject to social security from 1993 to 2008; employment before 1993 is used to calculate a person's labor market experience. The presented results use volume data (working days per year and total annual salaries) for all

specific mean integrative ability of firms, it is reasonable to assume a constant parameter rather than a trending.

employees to construct average monthly salaries and employment. As a robustness check we estimate the same equations with data only for full-time male workers, and for total employment with wages for full-time males. In addition, we split the data in two subsamples, the first covering the period from 1993 to 2000, the second the years from 2001 to 2008.

The information on task-specific labor is taken from the Qualification and Career Survey, an employee survey carried out by the German Federal Institute for Vocational Training ("Bundesinstitut fur Berufsbildung, BIBB") and the Research Institute of the Federal Employment Service ("Institut fur Arbeitsmarkt- und Berufsforschung, IAB"). It four cross-sections launched in 1979, 1986, 1992 and 1999, each covering about 30,000 individuals. An alternative, the "BIBB-BAuA survey" launched in 2006, cannot be combined with the previous surveys because of a distinct methodology. We use the 1998/1999 wave for our analysis as we start our analysis in 1993 and this wave is collected approximately in the midst of our sampling period. A major advantage is that these data use a consistent set of occupational classifications; the constant occupational titles thus provide the reference point for the analysis. Another major improvement over previous data is that survey respondents indicated themselves what kind of activities they perform on the job. It is very unlikely that this causes an underestimation of true changes in job content.

Occupational skill requirements are based on the activities that employees have to perform at the workplace. We pool these activities into five task categories, and each occupation has a value for each task category. The task categories are: non-routine analytical tasks, non-routine interactive tasks, routine cognitive/analytical tasks, routine manual tasks, and non-routine manual tasks (for detailed information, see Table 2 in the appendix). We calculate for each occupation (2-digits) the working-time spent within a certain task category and use this as an approximation for all workers in this occupation.

Experience (in the same occupation in the German labor market) is coded in 5-year groups, with all persons with more than 20 years working experience in one class. We use an approximation for persons firstly reported in the sample in Eastern Germany in 1993 since we do not know their working experience before German re-unification: Medium-qualified persons are considered to have age minus 20 years working experience, high-qualified persons' experience is set to age minus 28 if their experience would be lower otherwise.

We consider individuals as migrant -person with migration history - if they are reported at least once with foreign nationality, the standard (albeit problematic) proceeding to define migrants in the SIAB data. Descriptive evidence for the migrant-native wage differential is provided in the appendix in Table 3.

Results

In the present research we focus on estimating and discussing the elasticity of substitution between migrants and natives heterogeneously across qualification levels and tasks. The inverse elasticities in Table 1 report eq. (16) estimated across all experience groups and years. The first row reports estimates where we aggregate the qualification levels, the second row estimates where we pool the observations across the qualification levels. Likewise, the first column shows inverse elasticities estimated in a pooled regression across all task groups.

Table 1: Inverse Substitution Elasticities between Migrants and Natives, by Qualification and Task

Qualification	**Tasks**					
	All tasks	Analytical routine	Analytical non-routine	Manual routine	Manual non-routine	Interactive (non-routine)
Aggregated (across skill levels)	0.0622	0.0884	0.0808	0.0696	0.0915	0.1036
	(0.0025)	(0.0048)	(0.0051)	(0.0071)	(0.0053)	(0.0055)
Skill groups jointly	0.0197	0.0260	0.0150	-0.0043	0.0352	0.0382
	(0.0028)	(0.0054)	(0.0047)	(0.0058)	(0.0054)	(0.0051)
Lowskilled	0.0095	0.0073	0.0331	0.0130	0.0205	0.0506
	(0.0069)	(0.0106)	(0.0131)	(0.0168)	(0.0144)	(0.0115)
Medium skilled	0.0548	0.0771	0.0741	0.0533	0.0600	0.0827
	(0.0074)	(0.0082)	(0.0096)	(0.0080)	(0.0071)	(0.0092)
Highskilled	0.0592	0.0796	0.0356	0.0795	0.0523	0.0233
	(0.0077)	(0.0111)	(0.0087)	(0.0144)	(0.0159)	(0.0084)

Standard errors in parenthesis.

The estimations in the first column build on 400 (16 years x 5 experience groups x 5 tasks) observations (in the second line of the second column on 1200), the estimations in the second to sixth column on 80 observations (240 in the second line).

When we look at labor demand aggregated over all formal qualification groups (but disaggregated by year, task and experience), we estimate an overall inverse elasticity of substitution between migrants and natives of 0.0622, which corresponds to an elasticity of roughly 16. The task-specific elasticities of substitution are in the range between 9.6 and 14.4. These estimates are close to the threshold between perfect and imperfect substitutes which frequently in the literature is assumed to be at a value of 10 (though sometimes higher values are still considered as imperfect substitutes). We find that migrants and natives are better substitutable in manual routine tasks and somewhat worse substitutable when carrying out interactive tasks. However, when we consider only aggregates over all qualification levels, it is not clear whether the elasticities really reflect the substitutability between migrants and natives. These estimates may be affected to some extent by the different assignment of migrants and natives to qualification groups.

Hence, we disaggregate the labor-demand quantities by formal qualification in the next step. However, we still estimate a homogeneous elasticity of substitution across the qualification-task-experience cells. These estimations are, with regard to the specification, closest to those used in D'Amuri et al. 2010 though we consider another period (till 2008 rather than 2001); they report estimates in the same value range as the elasticities found by us. The results indicate (almost) perfect substitutability between migrants and natives throughout all tasks. Actually, our estimate for substitution in manual routine task is (insignificantly) negative, i.e. below the lower bound at zero (1 over infinity) as the value for which the inverse elasticity indicates absolutely perfect substitutability. Inverse elasticities of employees in both non-routine manual and interactive tasks are higher than those in other tasks, even if they are far from imperfect substitutability.

In the following, we relax the assumption of a homogeneous elasticity of substitution between migrants and natives over formal qualification levels. Indeed, we are able to reject homogeneity: migrants and natives with low formal qualification show - with an elasticity of approximately 0.01 across all tasks, and a significantly higher value only in interactive tasks - higher substitutability than migrants and natives with medium or high formal qualification level. For migrants and natives with medium formal qualification, we find that they are relatively better substitutes in manual tasks and relatively worse substitutes in interactive tasks. This comes hardly at a surprise. Supposedly, formal degrees and certificates are pretty

important when carrying out certain manual tasks (e.g. a German high-voltage certificate for an electrician as a prerequisite for insurance protection; a migrant with the German vocational degree has proven these formal requirements. For interactive tasks, (German) language competence and behavior according to social and cultural norms seem more relevant. Here, natives have a natural advantage. Among the high-qualified, interactive tasks are often bi- or multilingual, dealing with international affairs and teams under various cultural backgrounds; thus, it is not clear if natives have an advantage at this qualification level. Surprisingly, we find relative to the non-routine and interactive tasks, less elastic migrant-native substitution among high-skilled in routine tasks (both, analytical routine and manual routine). A reason for this finding could be that these tasks are of particular importance in highly complex occupations characterized either by strongly limited access (e.g. pharmacists and physicians) or by particular knowledge of German law (jobs in public administrations or related to the court). Overall, we provide evidence that migrants and natives are more or less perfect substitutes in most tasks if we account adequately for formal qualification. Further, they are not far from imperfect substitutability in interactive tasks requiring medium formal qualification, analytical tasks with medium qualification, as well as analytical-routine and manual-routine tasks carried out by employees with college/university degree.

To check for robustness we test for stability regarding time period and working time. The patterns are fairly stable across time. When we restrict the estimations to the earlier subsample from 1993 to 2000, the inverse elasticities are in general slightly smaller (between 0.005 and 0.01); in the period from 2001 to 2008, estimates increase by roughly the same amount relative to the inverse elasticities reported in the table. If we restrict both wages and employment only to full-time male workers, we find hardly any deviation from perfect substitutability. The estimated inverse elasticities are much smaller than those reported in the table; the corresponding elasticities are between twice and ten times higher than those which can be derived from Table 1. On the other hand, if we consider the wages for full-time male workers and contrast them with total employment, the estimated inverse elasticities of substitution are somewhat higher than those shown above.

Conclusion

In this paper we have investigated to what extent migrants are substitutes to natives in the German labor market with a particular focus on the task dimensions. Our study has been motivated by the fact that migrants earn on average less than natives. Despite discrimination, imperfect substitutability is a possible reason for persistently lower wages. Recent research on the German labor market is ambiguous regarding the question whether migrants and natives are perfect (D'Amuri et al. 2010, with elasticities between 16 and 35) or imperfect (Brücker and Jahn 2011, with an overall elasticity of 7) substitutes in the labor market. Though the relations are conditional on comparable qualification and experience and almost equal data is employed in the analysis. However, migrants and natives – albeit possessing equal qualification level – frequently work in distinct occupational segments. They may have different language competence, and they will specialize on tasks in which they have comparative advantages. This suggests augmentation of the qualification-experience-nativity model employed in the previous literature by an additional dimension reflecting different tasks.

In the first part of our analysis, we compare the standard model derived from an aggregate production function with a model where we aggregate over heterogeneous firms. The firms utilize two types of jobs as inputs in the production process; one type of job can be filled by both natives and migrants. The firms are heterogeneous with regard to total factor productivity and their ability to integrate migrant workers in this certain job (task). We have shown that the reaction of the migrant-native labor demand ratio to a change in relative wages is in general distinct between the aggregate production function and the aggregation across heterogeneous firms. The latter depends on the firms' average ability to integrate migrants, that is, to utilize the work of a migrant in the respective job/task. Hence, we have to distinguish three conceptionally different substitution elasticities: First, there is the elasticity in an aggregate production function neglecting heterogeneity across firms. Second, we have numerous micro elasticities at firm level which do not capture interaction effects between firms, e.g. due to competition; hence, estimating these in a linear model will be misleading in measuring the aggregate impact of migrants, but may be interesting for further research addressing the question why certain firms employ migrants whereas others do not.

Third, we can aggregate over firms utilizing similar jobs or task combinations, in order to receive heterogeneous task-related elasticities of substitution at the macro level which incorporate interaction effects.

In the second part we augment the empirical standard model by the task dimension. In general, we find substitution elasticities between migrants and natives above ten, that is, in a range typically considered to indicate perfect substitution but not too far away from imperfect substitution. Our estimations highlight the importance of differentiation by task and qualification, and of properly accounting for their heterogeneity. Qualification is crucial, indeed, if we consider different task groups: migrants and natives with low formal qualification show higher substitutability than migrants and natives with medium or high formal qualification. With regard to migrants and natives with medium qualification, we find that they are better substitutes in manual tasks and relatively worse substitutes in interactive tasks. Surprisingly, in interactive tasks highly qualified migrants and natives are good substitutes.

What are the economic implications of our results? If the wage gap between migrants and natives declines e.g. because minimum wages are introduced (and thus the wage ratio becomes closer to one), we would expect an enormous effect amongst the low qualified (with a large number of migrant workers replaced by natives), and less strong effects amongst natives and migrants with medium and high formal qualifications. If, on the other hand, the wage ratio between migrants and natives is not affected by an immigration shock, we would expect hardly an effect on native labor demand in the respective qualification level if the migrants have low formal qualification and a slightly positive effect if they have medium or high formal qualification.

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Appendix

Table 2: Assignement of activities to task classification scheme

Task Classification	Activities
Non-routine analytic	Researching/analyzing/evaluating and planning, making plans/constructions/designing and sketching, working out rules/prescriptions, using and interpreting rules
Non-routine interactive	Negotiating/lobbying/coordinating/organizing, teaching/training, selling/buying/advising customers/advertising, entertaining/presenting, employ/manage personnel
Routine cognitive	Calculating/bookkeeping, correcting of texts/data, measuring of length/weight/temperature
Routine manual	Operating/controlling machines, equipping machines
Non-routine manual	Repairing/renovation of houses/apartments/machines/vehicles, restoring art/monuments, serving or accommodating

Note: Overview of how activities asked for in the Qualification and Career Survey are grouped into the task categories

Source: Black/Spitz-Oener (2007)

Table 3: mean log wage difference between Germans and natives (conditional to same experience group, task, qualification, and years)

$\ln\left(\frac{w_{hijmt}}{w_{hijnt}}\right)$ see equation (19)

	Low skilled	Medium skilled	High skilled
mean	-0.0131	-0.0051	-0.0013
s.d.	0.0178	0.0080	0.0075
min	-0.0526	-0.0269	-0.0244
max	0.0206	0.0117	0.0194
Analytical routine	-0.0157	-0.0097	0.0002
Analytical non-routine	-0.0156	-0.0069	0.0006
Manual routine	-0.0235	-0.0097	0.0001
Manual non-routine	-0.0041	0.0015	-0.0046
Interactive	-0.0066	-0.0008	-0.0030