# Employment Polarization and Immigrant Employment Opportunities

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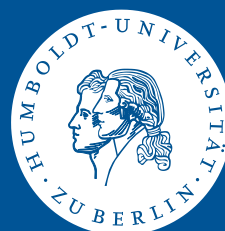
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# Employment Polarization and Immigrant Employment Opportunities *

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**Abstract**

Building on the task-based approach of technological change, this paper discusses the interaction between occupational polarization (e.g. a gradual increase of native employment in the lowest and highest-paying jobs) and employment opportunities of immigrant workers. Using high quality administrative data for Germany, I first show that technological change is positively related to employment growth of natives in low-paying occupations that are also typically held by immigrant workers. In a second step, I show that labor markets in which native employment in those low-paying occupations grew more also experienced a larger decline in immigrant employment rates. The findings are consistent with the idea that the reallocation of natives towards low paying occupations induces stronger competition in the low-skill labor market, a segment in which foreign workers are typically employed. The results suggest that this relationship is more relevant for recent immigrants who have been in Germany for less than 5 years, and that approximately one third of the decline in employment rates could be associated with occupational polarization of native employment.

Key Words: Job Tasks, Polarization, Technological Change, Immigration.

JEL Classification: J24, J31, J62, O33, R23.

# 1  Introduction

A significant and growing share of the population in many countries throughout the world is made up of immigrants and their descendants. According to OECD statistics, Germany has now become the largest destination for immigrants after the United States, and at least 10 percent of the population in Germany is of foreign origin (OECD, 2014). Naturally, the labor market situation of immigrants as well as the integration of immigrants into the German labor market has attracted large public and academic interest. One striking fact is the large difference in the labor market position of immigrant workers compared to natives and its deterioration in recent decades. Figure 1 depicts two key indicators of successful integration into a host country's labor market: employment and wage differentials between native and immigrant workers controlling for differences in the demographic composition, work location and occupational structure. The figure shows that up until the early 1990's, employment rates and wages of immigrant workers were close to those of natives but diverged thereafter. As figure 1 illustrates, the divergence since the early 1990's can only in part be explained by differential initial endowments. Although education, age (dashed line) and occupational composition (dash-dotted line) explain a large part of the gap, a difference still remains. This evolution is not unique to Germany and the deterioration in the labor market performance of immigrants has been studied for other industrialized countries including the United States, Canada and the UK.[1] So far, human capital differences, changes in the country of origin (Boudarbat and Lemieux, 2014; Borjas, 2015) as well as human capital accumulation and language proficiency (Borjas, 2015) have been found to be relevant in explaining a substantial part of the decline. International comparisons also highlight a higher sensitivity of immigrant workers compared to natives with respect to changes in economic conditions (OECD, 2005; Liebig, 2007; Dustmann et al., 2010).

The deterioration of immigrant outcomes coincides with another stylized fact that has been documented in many industrialized countries: the increasing concentration of employment at the tails of the occupational wage (skill) distribution at the expense of employment declines in middle-income jobs (Autor and Acemoglu, 2011). This phenomenon is illustrated in figure 2 that depicts smoothed employment changes in every percentile of the occupational distribution (ranked according to the occupational median wage in 1980) between selected years for the native workforce in Germany. While employment changes have been relatively monotone across the distribution in the 1980's, the occupational structure started to polarize during the 1990's. Since then, employment in occupations that are located in the middle of the wage or skill distribution has declined, while employment at both tails of the distribution has increased. Employment polarization has been documented primarily for the United States (Autor et al., 2006, 2008; Autor and Dorn, 2013) but also for Germany (Spitz-Oener, 2006; Dustmann et al., 2009; Senftleben-König and Wielandt, 2014), the UK (Goos and Manning, 2007) and European countries in general (Goos et al., 2009a,b, 2014; Michaels et al., 2014).

The purpose of this paper is to explore the relationship between employment polarization of the

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[1]See for the United States Chiswick (1978); Borjas (1985, 1995); Borjas and Friedberg (2009) and for Canada Baker and Benjamin (1994); Grant (1999). Dustmann et al. (2010) compare Germany and the UK documenting a long-term gradual decline in immigrant wages and a strong pro-cyclical pattern in unemployment probabilities of immigrants.

Figure 1: Conditional Wage and Employment Rate Differential, 1981-2004
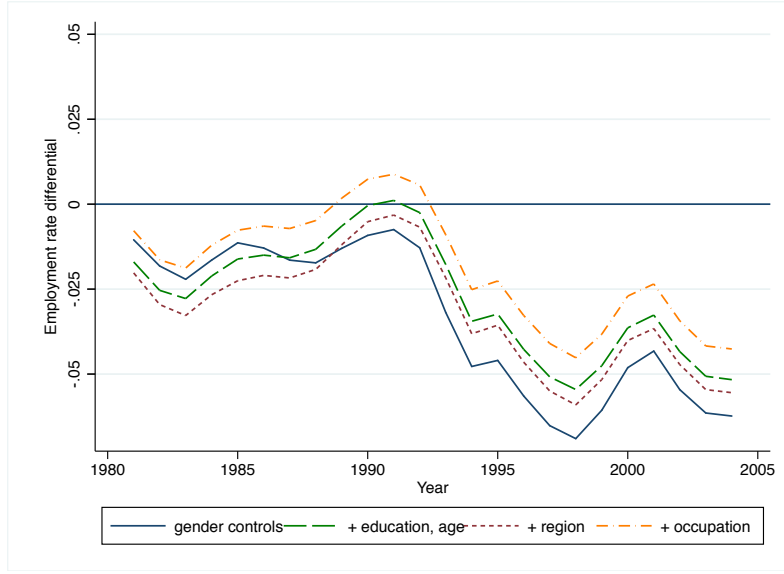


(a) Conditional Employment Rate
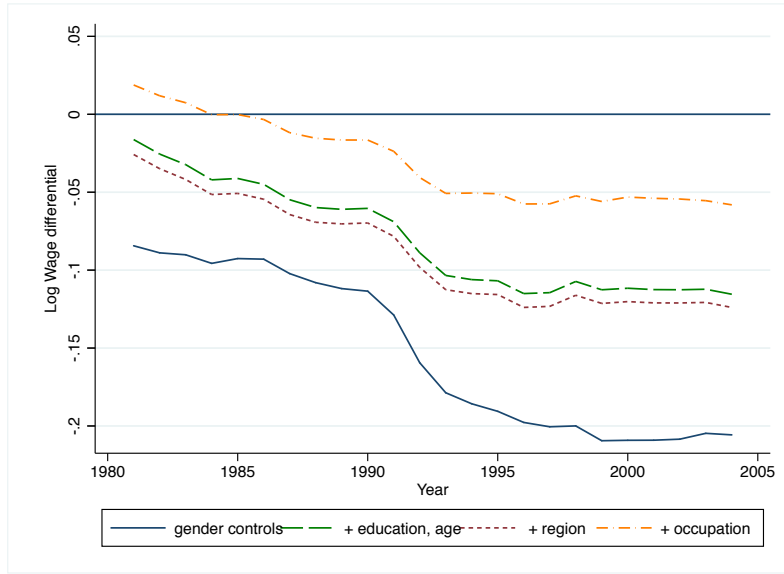


(b) Conditional Wage Differential

Note: The figure is constructed using SIAB-R daily wage and employment information between 1981 and 2004. To obtain conditional employment rates and wages, models of the following form are estimated using the native population as a reference group: $Y_{it}^g = X_{it}^g \alpha + \sum_{t=t_1}^{T} \gamma_t^g T_t^g + \sum_{t=t_1}^{T} \gamma_t d_t + e_{it}^g$, where $Y_{it}^g$ is either an employment indicator or log daily wage of individual $i$ belonging to group $g$ (natives, immigrants) in period $t$, additional controls such as gender, education, age, etc. are included in the vector $X_{it}^g$, and $e_{it}^g$ is an error term. The variables $T_t^g$ represent the interactions of the immigrant dummy and the year dummies $d_t$. Depicted are the estimated parameters $\gamma_t^g$ that represent the mean employment rate of immigrants relative to the native population (picked up by $\gamma_t$) conditional on the demographic variables included in $X_{it}^g$.

native labor market - i.e. a technology driven change in labor demand inducing a gradual increase in native employment in the highest and lowest paying occupations - and employment opportunities

Figure 2: Smoothed Employment Changes by Skill Percentile, 1980-2010
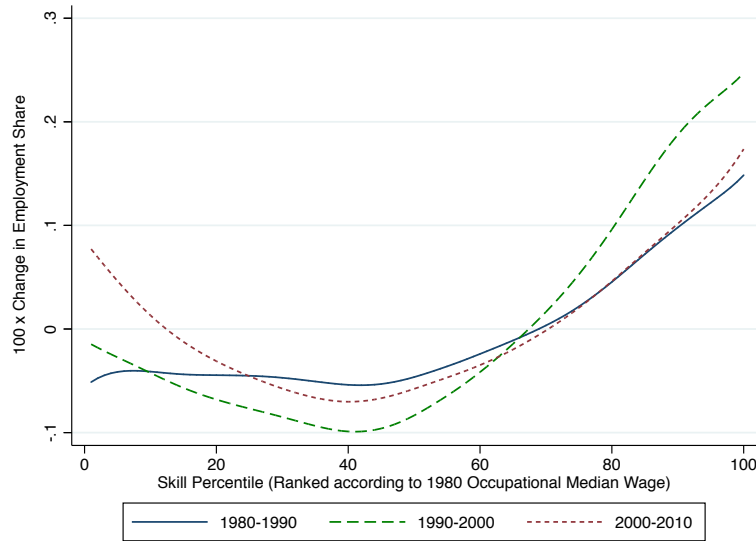
of immigrant workers. Using high-quality administrative data, I document a negative relationship between technology induced polarization in the native labor market - as measured by the share of natives employed in traditionally low-paying occupations - and employment rates and wages of immigrant workers in local labor markets. First, I show that technological change partly drives native employment growth in lower-paying occupations that are typically held by immigrant workers. Second, I use cross-regional, over-time variation in the employment of natives in these occupations to document a negative relationship between polarization and immigrant employment rates and wages. To control for potential endogeneity, I apply a Bartik style instrument (Bartik, 1991) by interacting occupational employment growth at the national level with the regional start-of-period occupational composition to predict local outcomes. Depending on the specification, the results imply that around 12 per cent of the overall decline in immigrant employment rates of 8 percentage points is associated with polarization of native employment. The negative relationship between native employment polarization and employment rates & wages is more pronounced for recent immigrants who have resided in Germany for less than five years. For this sub-sample, employment polarization can account for approximately one third of the overall decline in employment rates.

The findings can be rationalized by applying a local labor market model introduced by Autor and Dorn (2013), that builds on the task-based framework and links employment polarization to technological progress.[2] The task-based approach suggests that technological progress in the form of declining prices of computer capital leads to a substitution of well-codifiable (routine) tasks which

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[2]See Acemoglu and Autor (2011) for an extensive literature overview.

are mainly performed by medium-skilled employees while it benefits the productivity of non-routine cognitive tasks performed mainly by high-skilled workers. The model also explicitly leaves room for employment growth in occupations that are intensive in non-routine manual tasks which are typically lower-paying, service-sector jobs.[3] The decline in middle-skill employment especially during the 1990's and 2000's and the reallocation of those workers who were (or would be) in routine intensive occupations towards lower-skill, lower-paying non-routine manual occupations potentially induces additional competitive pressure, thereby influencing employment opportunities of workers who are traditionally employed in this labor market segment.

This research complements the literature on labor market polarization by shifting the focus from describing and explaining the phenomenon of polarization to exploring the effects of polarization on groups of workers who have traditionally been employed in lower wage occupations. Building on the task-based framework, a number of studies started to examine the differential impact of technological change on underrepresented groups. Black and Spitz-Oener (2010) and Bacolod and Blum (2010) show that changing skill demands particularly benefit women, and can explain a substantial fraction of the closing of the gender pay gap in Germany and the United States. In a similar way, Borghans et al. (2014) document that the growing importance of people-skills in the labor market (presumably driven by technology induced demand shifts) has contributed to the decline in the gender wage gaps in the United States, Great Britain and Germany. The study also argues that the stagnating white-black wage-gap in the U.S. can be explained by changing demand for people skills in the workplace. Smith (2011) explores the effect of the polarization of the adult labor market on employment outcomes of teenage workers showing that a higher share of adults in teen occupations is related to the decline in youth employment in the United States.

This research is also related to the work by Peri and Sparber (2009) who use occupational task requirements to study native task adjustments in response to immigration. The authors show empirically that inflows of low-educated immigrant workers cause comparably-educated natives to switch to more communication-intensive occupations, while immigrants specialize in occupations intensive in manual and physical labor skills. This imperfect substitutability in production between native and foreign-born workers can explain the small wage consequences of immigration for less educated natives. In contrast, changing task requirements due to technological progress and its relevance for immigrant performance, the results in this paper point in the direction that comparably skilled immigrant and native workers are perfect substitutes.

The paper continues as follows: section 2 discusses changes in the occupational structure over recent decades and documents the divergent evolution of immigrant outcomes. It also discusses the immigration structure in the German labor market. Section 3 lays out the empirical strategy, elaborates the instrumental variables approach, and describes the data set employed in the analysis. Section 4 interprets the empirical findings, first discussing the extent to which technological change can explain polarization as measured by cross-regional variation in native employment in

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[3]Studies for the United States (Autor and Dorn, 2013) and Germany (Senftleben-König and Wielandt, 2014) verify that the declining demand for middle-paying occupations due to technological change indeed induces a reallocation of less-educated workers who were (or would be) in those middle-paying occupations towards lower-skilled non-routine manual occupations (e.g. service occupations).

low-paying occupations. Second, I analyze the link between measures of polarization and employment opportunities and average wages of immigrants. Section 5 concludes.

## 2 Immigration Structure in Germany and Employment Polarization

The foreign born population in West Germany excluding ethnic Germans increased from 4.6 million in 1980 to 6.2 million in 2013, making up approximately 10 percent of the total population. Germany is now the second most popular destination for immigrants after the United States recently attracting many job-seekers from Southern European countries driven from the ravages of the euro zone financial crisis (OECD, 2014). Several phases of immigration to West Germany can be distinguished (see Bauer et al. (2005) for detailed information on German migration). Between 1955 and 1973, Germany recruited so called "guestworkers" that mainly took unskilled and semi-skilled jobs to support Germany's postwar economic boom and alleviate labor shortages.[4] Since the breakdown of the Soviet Union in 1989, immigration patterns have been dominated by inflows of ethnic Germans from Eastern Europe, asylum seekers, and refugees. Triggered by free-mobility flows for employment, new immigrants from Central and East European countries have entered the German labor market since 2004. Reflecting the migration history of Germany, the composition of immigrants is rather diverse. The largest group of immigrants are Turks, followed by immigrants from Yugoslavia and Italy. Figure 3 reports the share of days worked by workers with foreign citizenship in total employment (solid line) between 1980 and 2010 and reflects the slowdown of immigration during the 1980's due to the recruitment ban and the subsequent increase related to the breakdown of the Soviet Union. Further, figure 3 is broken down by skill level and shows reflects the educational upgrading of immigrant workers since 1980. While immigrants were predominantly low-skilled (dashed line) in the early 1980's by now the vast majority has medium skill levels (dash-dotted line). Although the level of high-skilled immigrants (dotted line) is still low, growth has picked up since the mid 1990's.[5]

Table 1 provides selected descriptive statistics for the native and immigrant workforce in 1981 and 2004, the first and the last year of the observation period in the subsequent analysis. Consistent with figure 1, table 1 documents rising employment rate and wage differentials between native and immigrant workers.[6] While employment rates and wages amongst natives and immigrants were largely similar in the early 1980's, by 2004 the employment rate for immigrants had fallen further

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[4]Germany signed the first recruitment treaty with Italy in 1955. In the following years, agreements with Greece and Spain (1960), Turkey (1961), Morocco (1963), Portugal (1964), Tunisia (1965) and Yugoslavia (1968) followed (Liebig, 2007). Because of the oil crisis and the worsening economic situation, the government ordered a halt to recruitment in the early 1970's. Trend towards subsequent immigration of family members since the early 1970's, accelerating after the recruitment ban. Although recruitment halt, subsequent immigration because of family reunification visas was still possible so that immigrants from former guestworker countries account for around 60% of the foreign population in Germany today.

[5]I classify workers educational attainment into three groups: employees with no occupational training are considered as having a *low* level of education; employees with a vocational occupation who have completed an apprenticeship or graduated from a vocational college are classified as *medium* educated and employees holding a university or technical college degree are considered *highly* educated. The consistency of the education variable is improved using the imputation algorithm developed by Fitzenberger et al. (2006).

[6]Borjas (1994) and Altonji and Blank (1999) review the extensive literature on earnings differentials between natives and immigrants. See Velling (1995) for the German case.

Figure 3: Share of Employees with Foreign Citizenship, 1980-2010, by Education Level
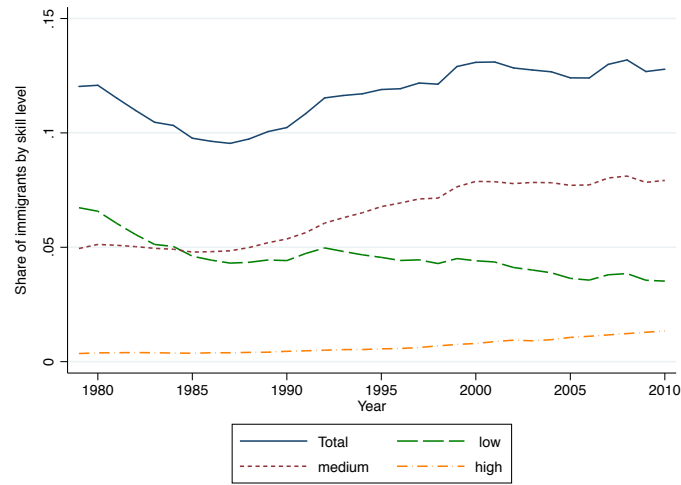


Notes: Calculation based on SIAB-R. Sample includes workers aged 20-60 subject to social security contribution working in West Germany.

than for natives, and wages had grown less. In terms of the demographic composition, the share of full-time working females is higher among natives compared to the immigrant sample, and follows a diverging trend. In comparison to natives, the majority of immigrants have very low education levels. While the share of foreign employees without completed education has declined from 55 per cent in 1981 to 30 per cent in 2004 it is still almost five times as large as in the native sample with only 7 per cent of native-born workers having such low educational levels. The table also illustrates the lower occupational status of immigrants that reflects the importance of blue-collar manufacturing jobs as well as non-routine manual intensive service occupations. Although the recent movement from production occupations to services is observable for both samples, the basic distribution and dominance of certain occupations has remained.

Besides discrimination (Becker, 1971), and differences in endowments, e.g. the lower educational attainment of immigrant workers (Dustmann and Glitz (2011) provide a comprehensive literature overview), worse labor market performance of immigrant workers is related to imperfect international transferability of human capital and less successful job matching. Findings indicate that for immigrants the transferability of occupational skills to their destination country is limited mainly by language proficiency leading to an initial mismatch in skill requirements that is larger for immigrants with less language proficiency.[7] Further, Chiswick (1978) spurred a large literature on immigrants' earnings assimilation, pointing out that the wage differential is most pronounced for recent immigrants while this difference fades out with the time migrants stay in the host country. Constant and Massey (2005) relate earnings differences between natives and guestworkers

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[7]Chiswick and Miller (1995) show that host-country language proficiency is significantly related to higher earnings in Australia, the United States, Canada, and Israel. Aldashev et al. (2009) document that language proficiency significantly increases employment probability and occupational choice for immigrants to Germany. Dustmann et al. (2010) show that employment rate and wage differentials in Germany and the UK are larger for immigrants from non-OECD countries.

Table 1: Descriptive Statistics Labor Market Regions, 1981 and 2004

| | Natives | | Immigrants | |
|---|---|---|---|---|
| | 1981 | 2004 | 1981 | 2004 |
| Sample population (20-60) | 1760 | 2096 | 220 | 292 |
| | (2319) | (2096) | (467) | (581) |
| Log daily wage | 4.188 | 4.348 | 4.154 | 4.185 |
| | (.085) | (.102) | (.096) | (.105) |
| Empl./LF rate | .944 | .906 | .929 | .844 |
| | (.020) | (.025) | (.036) | (.056) |
| Share females | .329 | .332 | .274 | .271 |
| | (.042) | (.036) | (.104) | (.082) |
| Educational composition: | | | | |
|   Low skilled | .194 | .066 | .547 | .300 |
| | (.049) | (.018) | (.138) | (.088) |
|   Medium skilled | .768 | .829 | .415 | .634 |
| | (.043) | (.043) | (.131) | (.088) |
|   High skilled | .038 | .105 | .039 | .067 |
| | (.020) | (.043) | (.044) | (.045) |
| Occupational composition: | | | | |
|   Production | .344 | .298 | .591 | .490 |
| | (.063) | (.060) | (.137) | (.116) |
|   Construction | .124 | .080 | .172 | .090 |
| | (.032) | (.022) | (.094) | (.045) |
|   Service | .209 | .256 | .163 | .266 |
| | (.033) | (.038) | (.094) | (.094) |
|   Admin/Sale | .228 | .256 | .046 | .106 |
| | (.040) | (.041) | (.041) | (.049) |
|   Professional | .095 | .110 | .028 | .048 |
| | (.025) | (.021) | (.030) | (.030) |

Note: Entries based on SIAB-R show means and standard deviations based on the 204 West German labor market regions. Sample includes individuals aged 20-60, working full-time, subject to social security contribution.

in Germany to initial occupational segmentation and differential job mobility and document that guestworkers are less able to transfer their human capital into a first job and face lower job mobility. Similarly, Dustmann et al. (2013) show that immigrants to the UK tend to work in occupations that do not correspond to their skills and require lower levels of education compared to their actual qualification. Imai et al. (2014) analyze migration to Canada and note that male immigrants find initial employment in occupations that require high levels of manual skills. Similarly, Ottaviano et al. (2013) document that occupations characterized by low cognitive intensity, low communication intensity, high manual intensity and low overall complexity have a lager share of hours worked by immigrants. Findings by Peri and Sparber (2009) suggest that immigrants are indeed disproportionately represented in non-routine manual intensive occupations. Especially recent immigrants (those who have been in the United States less than ten years) provide more manual tasks relative to communication tasks compared to long-term immigrants (those who live in the United States more than ten years) and low educated natives. Differences in labor market outcomes between natives and immigrants also arise among second-generation immigrants whose achievements are strongly related to parental characteristics (Dustmann et al., 2012; Riphahn, 2003).

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# 3 Data and Empirical Approach

## 3.1 Empirical Approach and Estimation Strategy

The starting point of the analysis is the observation that the occupational structure in Germany has polarized, with declining employment opportunities in middle paying occupations accompanied by employment growth in low and high-paying jobs. The empirical strategy builds off of the general equilibrium model proposed by Autor and Dorn (2013) that explains employment and wage dynamics at the lower tail of the skill distribution in response to technological change using the task-based framework. In this model, human labor performing routine tasks (e.g. bookkeeping, operating machines) is substituted by computer capital, as the price for information technology declines. This induces a movement of employment from routine towards non-routine tasks, whereas the decline in routine employment is primarily offset by a reallocation of labor towards low-skill non-routine manual tasks (e.g. serving, accommodating, repairing). The model implies that regions that have a larger employment share in routine intensive occupations before computerization started to spur are more prone to occupational shifts induced by technological change. Therefore, I start by establishing a link between the regional variation in the exposure to technological progress and employment polarization of native workers as measured by the share of natives employed in the lower tail of the wage distribution. Specifically, I relate employment shifts in the lower tail of the wage distribution between the base year $t$ and some year $\tau$ in region $r$ to $RSH_{rt}$, a measure that reflects the regional exposure to technological progress in base year $t$:[8]

$$\Delta Share_r = \alpha + \beta_1 RSH_r + \beta_2 Production_r + \mathbf{X'_r}\beta_3 + \gamma_s + e_r. \tag{1}$$

$Share_{rt}$ is defined as the share of low- and medium skilled natives in region $r$ at time $t$ in typical immigrant occupations that combine low wage and skill levels with high non-routine manual task content.[9] Following the task-based approach, technological progress replaces routine cognitive (clerical) as well as routine manual (blue-collar manufacturing) tasks. To disentangle the direct effect of technological progress on the occupational structure, the share of production employment

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[8]To obtain this measure, I match occupational task information from the BIBB/IAB Qualification and Career Survey (QCS) in 1979 to the SIAB-R, exploiting the fact that both datasets employ a time-consistent definition of occupational titles according to the three-digit 1988 occupational classification provided by the Federal Employment Agency. Following the approach of Autor and Dorn (2013), I use the occupational routine task index in 1979, $TI_k^R(1979)$ to identify the set of occupations that are in the upper third of the routine task distribution. Using these routine-intensive occupations, I calculate for each labor market $r$ a routine employment share measure $RSH_r$ for the year 1979, equal to:

$$RSH_r = \left(\sum_k L_{kr} \times \mathbb{I}\left[TI_k^R > TI_k^{R,P66}\right]\right)\left(\sum_k L_{kr}\right)^{-1},$$

where $L_{kr}$ is employment in occupation $k$ in labor market $r$ in 1979, and $\mathbb{I}[\cdot]$ is an indicator function, which takes the value of one if the occupation is routine-intensive. Please refer to Senftleben-König and Wielandt (2014) for more details on how the index is constructed and to Rohrbach-Schmidt (2009) for more information on the QCS.

[9]I define immigrant jobs in the following way: I rank occupations according to their share of immigrant employment and define immigrant occupations as those occupations in which 50 per cent of the immigrant workforce is employed. These jobs include: food preparation and service related occupations, sales and related occupations, stock clerks, grounds maintenance, locksmiths and metal related occupations, construction occupations and various personal service occupations.

($Production_r$) in the base year is separately included since it is itself positively related to routine manual intensity. $X_{rt}$ controls for the demographic and educational composition of the local workforce in the base year, $\gamma_s$ represents state fixed effects.

In the next step, I use the region-year variation in the share of natives in immigrant occupations to analyze the relationship between employment polarization in the native labor market and employment opportunities of immigrants. Therefore, I relate $Y_{rt}$ - either the regional employment rate or average log wages of immigrants - to the share of natives in immigrant occupations in the following way:

$$Y_{rt} = \alpha + \beta_1 SHARE_{rt} + \delta_t + \theta_r + \gamma_{st} + e_{rt}. \tag{2}$$

The specification includes region fixed effects ($\theta_r$) to control for all time-invariant local characteristics and year fixed effects ($\delta_t$) to control for cyclical trends. In some specifications the regression is augmented with state-year fixed effects ($\gamma_{st}$) to remove state-time unobservables.[10]

Although the fixed effects already control for some unobservables, the true effect is presumably more negative than the OLS estimates suggest. For instance, this could occur if technological change induced a reallocation of employees towards regions that are less affected by computerization. However, regional mobility in Germany is low and Senftleben-König and Wielandt (2014) show that migratory responses to polarization are modest in size and significance. To address further threats to causal identification, I instrument for the share of natives in immigrant occupations using a Bartik-style instrument (Bartik, 1991) that has been used in many subsequent studies (Blanchard and Katz, 1992; Katz and Murphy, 1992; Bound and Holzer, 2000; Autor and Duggan, 2003). The basic idea is to use a set of region specific weights together with national level trends. In this case, the beginning-of-period employment share of natives in immigrant jobs within a region is interacted with the employment share in immigrant occupations at the national level in year $t$:[11]

$$\widehat{Share}_{rt} = Share_{r1981} \times Share_{\dot{r}kt} \tag{3}$$

The subscript $\dot{r}kt$ in $Share_{\dot{r}kt}$ indicates that each region's employment is excluded in calculating the national employment share. Since year and region fixed effects are included, the estimates are identified from comparing regions with different initial levels of $Share_{r1981}$ and therefore differential scope for polarization. But, unlike the variation in the share variable, $\widehat{Share}_{rt}$ is only driven by nation wide changes due to employment polarization which should be orthogonal to local labor market conditions. Because regions that had a larger share in immigrant occupations in 1981 have less scope for polarization and therefore less pronounced growth of native employment in immigrant occupations, $Share_{rt}$ should be negatively related to the instrumental variable if its increase is indeed driven by polarization.

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[10]Including region specific time trends instead of state-year fixed effects does not alter the results.

[11]I define baseline as 1981, but the results are robust to this choice.

## 3.2 Data Sources

All information concerning local employment and wages is obtained from the Sample of Integrated Labor Market Biographies Regional File (SIAB-R), a two percent random sample drawn from the full population of the Integrated Employment Biographies provided by the Institute of Employment Research by the German Federal Employment Agency. It provides detailed information on daily wages for employees subject to social security contributions, as well as information on occupation, industry affiliation, workplace location and demographic information on age, gender, nationality and educational attainment.[12] As the data report daily wages yet lack information on hours worked, wages of part-time employees are measured less accurately. Therefore, the sample used in the analysis is restricted to full-time workers between 20 and 60 years of age working in West Germany. Due to data restrictions related to the unemployment spells that are required to calculate employment rates, the analysis is limited to the years 1981 to 2004. On the earlier end, reliable data on unemployment spells is only available from 1981 on, while a change in legislation and a redefinition of unemployment in 2005 yields a structural break in the data following this point.

As other official statistics in Germany, the SIAB only distinguishes between foreign and German citizenship and does not provide information on the place of birth. On the one hand, I will therefore over-count the number of immigrants due to individuals with foreign citizenship who were born in Germany. However, according to administrative statistics the share of second generation immigrants in the 20-65 age bracket, that have not themselves migrated, was only 12% in 2005 (Statistisches Bundesamt, 2009). On the other hand, I will identify workers who were born abroad but have German citizenship as Germans. In the remainder of the paper, I will refer to the sample of workers with foreign citizenship as *immigrants* and the German workers as *natives*.

Since employment rate and wage differences between natives and immigrant workers may in part be explained by observable characteristics, I construct regional employment rates and average wages controlling for observable demographic characteristics. Regional employment rates and average wages for natives and immigrants are obtained by regressing an employment indicator or log daily wage on a vector of observable characteristics, including potential experience and a cubic of it, education fixed effects, region fixed effects and a gender dummy separately by year and nationality. In the analysis, I then use the estimated coefficients on the region dummies as dependent variables in the regressions of equation( 2) to control for differences in observable demographic composition across regional labor markets. The analysis is executed at the level of 204 functionally delineated local labor markets in West Germany that take commuter flows into account and therefore reflect local labor markets most appropriately (Eckey et al., 2006; Eckey and Klemmer, 1991; Koller and Schwengler, 2000).[13]

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[12]Civil servants, self-employed workers and military personnel are not included. In 2001, 77% of all workers in Germany were covered by social security and are recorded in the IAB data (Bundesagentur für Arbeit, 2007). For more details on processing the SIAB data and handling of right-censoring see the appendix. For more details on the data set, see Dorner et al. (2011).

[13]I focus on West Germany (excluding Berlin) since local labor markets in East Germany faced massive structural changes that are difficult to control for. Furthermore, the share of immigrants in the workforce in East Germany was only a mere 1.5% in 2006 (Bundesagentur für Arbeit, 2007).

# 4 Results

## 4.1 Occupational Employment Growth and Task Content

In the early 1980's, most immigrant workers were employed in low-skill, blue-collar jobs in the industrial sector (more than 40% in metal processing) which has faced massive employment declines due to technological progress. By now, immigrant workers are also predominantly employed in low-skilled service and construction occupations. Appendix figure 1 illustrates combinations of average wages and non-routine manual task intensity for different occupation groups in which immigrant workers traditionally work: (i) what I define as typical *immigrant* occupations (as defined in footnote 9 on page 9), (ii) low-paying occupations (defined as occupations in the lowest decile of the wage distribution in 1980) and (iii) service occupations. The number in brackets represents the share of immigrant workers in these occupation groups. Those occupations that are predominantly held by immigrant workers combine low wage levels with high non-routine manual task content. hence, native employment growth in these occupations can be understood as a proxy for lower-tail employment polarization in the native labor market. In contrast, professional occupations have a very low share of immigrant employment and are associated with high wages and low non-routine manual task content.

To gauge the relevance of this relationship more rigorously, I combine data on the share of foreign employment by detailed occupation between 1981 and 2004 with information on the occupational skill and task content and average wages in 1981.[14] The correlation coefficient in the first column in table 2 verifies that in 1981, immigrants are predominantly employed in occupations with low average wages, low skill levels and high manual task content. Appendix table 1 provides a more detailed overview on average wages, skills and task content by occupational categories (*Berufsabschnitte*) and growth of immigrant employment between 1981 and 2004. The share of immigrants is generally larger in lower-paying occupations. Although the table reveals no clear picture on the employment growth pattern, low-paying occupations generally experience higher growth rates.

Using these data, I further explore whether task and skill composition are predictive of foreign employment growth. Specifically, I relate the growth in the employment share of foreign employment between 1981 and 2004 to occupational level variables in 1981:

$$\Delta Empl_j = \alpha + \beta_1 Wage_j + \beta_2 Low_j + \beta_3 Task_j + e_j, \tag{4}$$

where $j$ indexes 110 detailed occupations and $\Delta Empl_j$ is the growth of foreign employment between 1981 and 2004. $Wage_j$ is the average wage level and $Low_j$ the average share of low skilled employment in the occupation. Additionally, I control for the occupational task composition by including the share of non-routine cognitive, non-routine manual and routine tasks in $Task_j$. Estimates of equation 4 are found in table 2. Columns 1 to 5 consider each of the variables separately, while the full set of explanatory variables is included in column 6. The results suggest that average wages and skill levels are a statistically and economically significant determinant of foreign employment

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[14]The information on the occupational task content is derived from the 1979 wave of the BIBB/IAB qualification and career survey (QCS). See the appendix for further information on data processing and construction of the task indices.

growth. Relative to routine intensity, non-routine manual and non-routine cognitive task intensity predict employment growth. However, the occupational task content is not significant in the full specification in column 6.

Table 2: Relationship among Occupational Foreign Employment Growth, Job Tasks and Average Wages, 1981-2004

|  | Correlation with share immigrants in 1981 | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|---|
| Average wage | -.318*** | -.051*** |  |  |  |  | -.092*** |
|  |  | (.014) |  |  |  |  | (.017) |
| Share low skilled | .806*** |  | -.029 |  |  |  | -.079*** |
|  |  |  | (.025) |  |  |  | (.024) |
| Share abstract tasks | -.429*** |  |  | -.017 |  |  | .035 |
|  |  |  |  | (.017) |  |  | (.029) |
| Share routine tasks | .172 |  |  |  | -.025 |  |  |
|  |  |  |  |  | (.020) |  |  |
| Share manual tasks | .220** |  |  |  |  | .037* | .019 |
|  |  |  |  |  |  | (.020) | (.021) |
| Adj. $R^2$ |  | .013 | .111 | -.003 | .010 | .032 | .252 |

Note: N= 110 occupations. OLS estimates given, and robust standard errors are in parentheses. Task information is obtained from the QCS wave 1979 (see the appendix for details on the construction of the task indices). Remaining variables are calculated for 1981 and 2004, respectively. * Significant at 10%, ** at 5%, *** at 1%.

## 4.2 Technology Driven Labor Market Polarization

I now turn to the link between regional differences in native employment changes in the lower part of the occupational distribution and technological progress. The model proposed by Autor and Dorn (2013) suggests that regions that more heavily employ routine tasks experience a larger decline in demand for those routine tasks alongside a reallocation of employment towards non-routine manual and cognitive tasks. If technological progress indeed drives the decline in demand for routine occupations and reallocation towards lower paying non-routine manual occupations, we should observe a positive link between the measure of technology exposure ($RSH_{rt}$) and subsequent employment growth in immigrant occupations that combine low skill and wage levels with high non-routine manual task content.

This is verified in table 3 that reports coefficient estimates according to equation 1, relating the change in the share of natives in immigrant occupations between 1981 and 2004 to routine intensity and the employment share in production occupations in the base year. As other local labor market conditions affect native employment growth, regressions are augmented with additional covariates to control for demographic differences across regions as well as state fixed effects to control for unobservable differences across states.[15]

The results in column 1 support the hypothesis that routine intensive regions witnessed a differential increase of native employment in immigrant jobs. The coefficient implies that a one standard

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[15]To make the coefficients comparable, the explanatory variables are standardized to have mean 0 and standard deviation 1.

Table 3: Relationship Between Occupational Structure and Technology Exposure

| | Change fraction natives in immigrant occ. (1981-2004) | | | Change in empl. rate (1981-2004) | | |
|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) |
| Routine Intensity | .036*** (.011) | | .037*** (.011) | -.015 (.016) | | -.012 (.017) |
| Production empl. | | .004 (.003) | -.000 (.003) | | -.005 (.005) | -.004 (.006) |
| Adj. $R^2$ | .227 | .174 | .227 | .208 | .207 | .208 |

Note: N= 204. All models additionally include the share of high-skilled and low-skilled workers, a dummy indicating urbanity and dummies for the federal state in which the region is located. The dependent variable in the OLS regressions for columns 1-3 is the change in the share of natives employed in immigrant occupations (as defined in footnote 9, page 9) between 1981 and 2004. The dependent variable in the OLS regressions for columns 4-6 is the change in immigrant employment rates between 1981 and 2004, regression adjusted for observable differences in gender, education and experience. Robust standard errors in parentheses. * Significant at 10%, ** at 5%, *** at 1%.

deviation increase in the routine share is associated with a 3.6 percentage point increase in the share of natives employed in immigrant occupations between 1981 and 2004. Column 2 suggests that the share of workers employed in production occupations predicts native employment growth, although to a lesser extent. Once routine intensity and the production share enter the regression simultaneously in column 3, the technology measure remains highly significant and similar in size while the production share becomes virtually meaningless.

Columns 4 to 6 report the coefficients from regressing the change in immigrant employment rates between 1981 and 2004 on initial routine intensity and the employment share in production occupations, respectively. A one standard deviation higher routine share in 1979 is associated with a 1.5 percentage point reduction in immigrant employment rates over the time period 1981 to 2004. However, the relationship is measured imprecisely. The share of production employment is also negatively related to the change in employment rates but is smaller in size and insignificant as well. The negative relationship between employment rates and technology exposure hints at the idea that declining demand for middle-paying occupations and a reallocation of employment towards lower-paying occupations potentially increases competitive pressure in the lower-skill labor market, a segment in which immigrants are traditionally employed.

## 4.3 Polarization and Employment Opportunities of Immigrant Workers

The previous section established a link between technological change and polarization as measured by changes in the employment share of natives in immigrant occupations. This section turns to the question of how polarization of the native labor market relates to immigrant employment opportunities and average wages as described by equation 2. The estimates of $\beta_1$ from OLS and IV

regressions are presented in table 4. The coefficient of .133 in column1 indicates that a 1 percentage point higher share of natives in immigrant occupations reduces the employment rate of immigrant workers by .13 percentage points. The point estimate increases with the inclusion of state-year fixed effects in column 2 and becomes significant. Column 3 presents the coefficient from the IV regression applying the instrument for the share of natives in immigrant occupations described by equation 3. As the first stage results in the lower panel of the table suggest, the instrumental variables approach leads to a strong predictor for local employment changes across regions. The significantly negative first-stage results imply that regions with a higher initial share of natives in immigrant occupations (and less scope for polarization) experienced lower growth in these occupations over the next 24 years. The results from the IV regressions confirm the OLS estimates but are in general more negative. Since the share of natives in immigrant occupations only modestly increased at the aggregate level by 2.1 percentage points between 1981 and 2004, the direct impact on immigrant employment is modest. Depending on the specification, the coefficient estimates suggest that native employment polarization can explain between 0.3 and 1 percentage points of the overall decline in immigrant employment rates of 8 percentage points. However, the aggregate trends mask extensive regional variation across labor markets ranging from a decline in native employment in immigrant occupations of 5% to an increase of 13%.

Columns 4 to 7 of table 4 compare estimates of $\beta_1$ from regressions similar to equation 2, where the employment rate is bifurcated between recent and long-term immigrants.[16] The coefficient in column 4 suggests a negative and significant link between employment rates of immigrants who have been in Germany for less than five years and the share of natives in immigrant occupations. The coefficient from the IV regression (column 5) is even larger although less precisely estimated.[17] Although the implied effect is similar in size, the relationship is more relevant for this subsample since around 1 percentage point of the overall 3 percentage point decline in employment rates of recent immigrants may be related to polarization in the native labor market. For immigrants that have been in Germany longer than five years, the estimate from the OLS regression (column 6) is smaller in size and insignificant. However, the IV results (column 7) reveal a similar pattern as with the more recent immigrants. In contrast to these, employment rates of long-term immigrants declined by almost 10 percentage points. Therefore, the direct impact of native employment polarization for this sub-sample is negligible.

## 4.4 Polarization and Average Wages

Next, I turn to the question how wage patterns might be related to native employment polarization. Table 5 compares estimates of $\beta_1$ from regressions similar to 2 where the dependent variable is the average regional log wage of immigrant workers adjusted for observable characteristics.

The findings for wages are much more inconclusive. In general, there is a negative relationship between the share of natives in immigrant occupations and average wages of immigrant workers.

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[16]To conserve space, I only display OLS results including state-year controls and the corresponding IV results. However, OLS results excluding state-year controls are in general more negative and have higher significance levels.

[17]One possible explanation is the smaller variation in the instrumental variable compared to the original variable.

Table 4: Relationship between Employment Opportunities and Native Occupational Structure

| Explanatory variable: Share natives in | Dependent variable: Immigrant employment rates (regression adjusted for observable characteristics) | | | | | | |
|---|---|---|---|---|---|---|---|
| | All | | | recent | | long-term | |
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) |
| Immigrant occ. | -.133 | -.196** | -.499** | -.479*** | -.540* | -.159 | -.560** |
| | (.088) | (.087) | (.196) | (.148) | (.303) | (.111) | (.244) |
| Adj. $R^2$ | .870 | .875 | | .713 | | .961 | |
| *Implied effect* $\Delta 8104 = .021$ | -.003 | -.004 | -.010 | -.010 | -.011 | -.003 | - .012 |
| *Method of estimation* | OLS | OLS | IV | OLS | IV | OLS | IV |
| *Additional controls* | | | | | | | |
| Region & year FE | x | x | x | x | x | x | x |
| State-year FE | | x | x | x | x | x | x |
| *First stage* | | | -38.073*** | | -38.073*** | | -38.073*** |
| | | | (5.399) | | (5.399) | | (5.399) |
| F-test on excl. instruments | | | 49.73 | | 49.73 | | 49.73 |

Note: $N = 4896$ (204 labor market regions x 24 years). Table displays regression coefficients from region-year level regressions for which the dependent variable is the employment rate of workers with foreign citizenship (and separated by years since migration). Employment rates are regression adjusted for observable differences in the age and education structure and gender. Each regression includes state and year fixed effects and state-year fixed effects in the indicated columns. Standard errors clustered at the regional level are in parentheses. * Significant at 10%, ** at 5%, *** at 1%.

However, the coefficients are imprecisely estimated and not significantly different from zero. Nevertheless, the negative coefficient from the OLS regressions is consistent with the idea that declining demand for middle paying occupations results in higher competitive pressure in the low skill sector. In contrast, the coefficient from the IV regression in column 3 becomes positive but remains insignificant. Columns 4 to 7 display results bifurcated by years since migration and illustrate that the negative relationship is most pronounced for recent immigrants while average wages of long-term immigrants seem to be in part positively related to the share of natives in immigrant occupations. IN light of endogeneity concerns as discussed in section 3.1, the IV models of columns 5 and 7 are preferred.

The results suggest that the growing earnings differential between natives and immigrants is not significantly related to native employment polarization. However, the evolution at the mean could hide a much larger influence at the low end of the wage distribution as shown for Canada by Boudarbat and Lemieux (2014). Because the German labor market is characterized by a high degree of unionized wage bargaining and generous unemployment benefits, employment dynamics are a better indicator for the labor market performance of immigrants than earnings.

Table 5: Relationship Between Average Wages and Native Occupational Structure

| | Dependent variable: | Average log real wages of immigrants (regression adjusted for observable characteristics) | | | | | |
|---|---|---|---|---|---|---|---|
| | | All | | | recent | | long-term |
| Explanatory variable: Share natives in | (1) | (2) | (3) | (4) | (5) | (6) | (7) |
| Immigrant occ. | -.115 | -.209* | .047 | -.288 | -1.035* | -.301** | .137 |
| | (.154) | (.126) | (.294) | (.205) | (.533) | (.141) | (.332) |
| Adj. R$^2$ | .789 | .812 | | .694 | | .855 | |
| *Implied effect* $\Delta 8104 = .021$ | -.002 | -.004 | .001 | -.006 | -.022 | -.006 | .002 |
| *Method of estimation* | OLS | OLS | IV | OLS | IV | OLS | IV |
| *Additional controls* | | | | | | | |
| Region & year FE | x | x | x | x | x | x | x |
| State-year FE | | x | x | x | x | x | x |

Note: $N = 4896$ (204 labor market regions x 24 years). Table displays regression coefficients from region-year level regressions for which the dependent variable is the average log daily wage of workers with foreign citizenship (and separated by years since migration). Average wages are regression adjusted for observable differences in the age and education structure and gender. Each regression includes state and year fixed effects and state-year fixed effects in the indicated columns. Standard errors clustered at the regional level are in parentheses. First-stage as in table 4. * Significant at 10%, ** at 5%, *** at 1%.

## 4.5 Robustness

The results so far suggest a negative link between native employment polarization and employment opportunities and average wages of immigrant workers, especially those working in Germany less than five years. Table 6 summarizes different robustness checks of this relationship related to the sample selection. For comparison, panel I depicts the coefficient estimates of the base regression from panel I of table 4.

Since the labor force participation of women is very low and follows a reverse trend for the native and immigrant sample, I re-estimate the model restricting the sample to men only.[18] The point estimates presented in panel II are similar in size and imply that polarization potentially accounts for around 1.3 percentage points of the 6.5 percentage point decline in male employment rates. As before, relative to the overall employment decline the relationship is more relevant for recent immigrants. Instead of considering low- and medium skilled labor jointly, in the regressions in panel III the explanatory variable is restricted to native low skilled employment. The coefficients are smaller in magnitude but the overall effect is similar in size as the change in the share of low skilled natives in immigrant occupations over time is larger. Again, the link between the share of natives in immigrant occupations and employment rates is more pronounced for immigrants who have been in Germany for less than five years.

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[18] Since the number of immigrant women in the sample is rather small, there are not enough observations in region/year cells to perform the analysis for females only.

Table 6: Robustness: Employment Opportunities and Occupational Structure - Sample Selection

| Explanatory variable: Share natives in immigrant occ. | Dep. variable: Employment rates adjusted for observable characteristics | | | | | |
|---|---|---|---|---|---|---|
| | All | | recent | | long-term | |
| | (1) | (2) | (3) | (4) | (5) | (6) |
| I. Base | -.196** | -.499** | -.479*** | -.540* | -.159 | -.560** |
| | (.087) | (.196) | (.148) | (.303) | (.111) | (.244) |
| Adj. R$^2$ | .875 | | .713 | | .961 | |
| *Implied effect* ($\Delta 8104 = .021$) | -.004 | -.010 | -.010 | -.011 | -.003 | - .012 |
| II: Males only | -.178 | -.601** | -.642*** | -.525 | -.077 | -.648** |
| | (.113) | (.234) | (.149) | (.330) | (.150) | (.271) |
| Adj. R$^2$ | .878 | | .652 | | .944 | |
| *Implied effect* ($\Delta 8104 = .021$) | -.004 | -.013 | -.013 | -.011 | -.002 | -.014 |
| III: Low-skilled natives | -.138*** | -.175 | -.203*** | -.232 | -.138*** | -.152 |
| | (.038) | (.134) | (.071) | (.186) | (.043) | (.178) |
| Adj. R$^2$ | .877 | | .686 | | .957 | |
| *Implied effect* ($\Delta 8104 = .077$) | -.011 | -.013 | -.016 | -.018 | -.011 | -.012 |
| *Additional controls* | Region, year and state-year fixed effects | | | | | |
| *Method of estimation* | OLS | IV | OLS | IV | OLS | IV |

Note: $N = 4896$ (204 labor market regions x 24 years). Table displays regression coefficients from region-year level regressions for which the dependent variable is the employment rate of workers with foreign citizenship (and separated by years since migration). Employment rates are regression adjusted for observable differences in the age and education structure and gender. Each regression includes state and year fixed effects and state-year fixed effects in the indicated columns Standard errors clustered at the regional level are in parentheses. * Significant at 10%, ** at 5%, *** at 1%.

The results could also be driven by selective in- or out-migration. In regressions not shown here, I account for in-migration and select a sample composed of those immigrants who were already living in Germany prior to 1981. Although smaller in size and less precisely estimated, the results reveal the same pattern. Given the longitudinal nature of the data set, I can also control for out-migration by further restricting the immigrant sample to those that are observed in the data before 1981 and after 2004. This additional restriction reduces the sample size considerably but the general pattern remains.

Table 7 continues the robustness checks and compares alternative definitions of $Share_{rt}$. Panel II re-estimates the model employing the share of natives in service occupations as a measure of lower-tail polarization. Research for the United States (Autor and Dorn, 2013) and Germany (Senftleben-König and Wielandt, 2014) has shown that employment growth in service occupations is the main driver of the twisting of the lower tail of the employment and wage distribution. In line with these findings, panel II reports a significantly negative relationship between the share of natives in service

Table 7: Robustness: Employment Opportunities and Occupational Structure - Alternative Definitions

| Explanatory variable: Share natives in immigrant occ. | Dep. variable: Employment rates adjusted for observable characteristics | | | | | |
|---|---|---|---|---|---|---|
| | All | | recent | | long-term | |
| | (1) | (2) | (3) | (4) | (5) | (6) |
| I. Base | -.196** | -.499** | -.479*** | -.540* | -.159 | -.560** |
| | (.087) | (.196) | (.148) | (.303) | (.111) | (.244) |
| Adj. $R^2$ | .875 | | .713 | | .961 | |
| *Implied effect* ($\Delta 8104 = .021$) | -.004 | -.010 | -.010 | -.011 | -.003 | -.012 |
| II: Service occupations | -.378*** | -.405 | -.189 | -1.327* | -.426*** | -.013 |
| | (.109) | (.564) | (.146) | (.776) | (.133) | (.643) |
| Adj. $R^2$ | .876 | | .711 | | .957 | |
| *Implied effect* ($\Delta 8104 = .047$) | -.018 | -.019 | -.009 | -.062 | -.020 | -.001 |
| III: Low-wage occupations | -.431*** | -.513 | -.256* | -1.551*** | -.504*** | -.062 |
| | (.128) | (.430) | (.148) | (.597) | (.164) | (.469) |
| Adj. $R^2$ | .876 | | .683 | | .957 | |
| *Implied effect* ($\Delta 8104 = .017$) | -.007 | -.009 | -.004 | -.026 | -.009 | -.001 |
| IV. Share natives in production occupations | -.036 | -.006 | -.423*** | -.156 | .127 | .138 |
| | (.081) | (.310) | (.140) | (.409) | (.081) | (.313) |
| Adj. $R^2$ | .875 | | .713 | | .961 | |
| *Implied effect* ($\Delta 8104 = -.046$) | .002 | .000 | .020 | .007 | -.005 | -.006 |
| *Additional controls* | Region, year and state-year fixed effects | | | | | |
| *Method of estimation* | OLS | IV | OLS | IV | OLS | IV |

Note: $N = 4896$ (204 labor market regions x 24 years). Table displays regression coefficients from region-year level regressions for which the dependent variable is the employment rate of workers with foreign citizenship (and separated by years since migration). Employment rates are regression adjusted for observable differences in the age and education structure and gender. Each regression includes state and year fixed effects and state-year fixed effects in the indicated columns. Standard errors clustered at the regional level are in parentheses. * Significant at 10%, ** at 5%, *** at 1%.

occupations and employment opportunities of immigrants. The implied effect is slightly larger compared to the baseline specification since the share of natives in service occupations increased twice as much in comparison to the change in immigrant occupations. Panel III considers the share of natives in low-paying occupations (occupations in the bottom decile of the wage distribution in 1980) as a measure of lower-tail employment polarization. Again, the general pattern remains and the implied effect is similar in size. In panel IV, the explanatory variable is the share of low- and medium skilled native employment in production occupations which is not significantly related to employment outcomes of immigrants. This relationship becomes positive once the sample is restricted to long-term

immigrants which is consistent with previous findings and in line with the task-based approach.

There is a large branch of the urban economics literature that is concerned with spatial inequality in employment growth. Although region fixed effects already pick up part of this variation, including native employment levels in the regression leaves the results unchanged. Furthermore, restricting the sample to urban or rural areas yields comparable results. While this study focuses on West German labor markets, the time period includes German reunification in 1990. For regions in close proximity to the former East-West border, results could be driven by exogenous increases in the labor supply due to migration flows following the fall of the wall. Excluding labor markets along the border in the regressions yields results consistent with the baseline specification. I further test the generality of the results by experimenting with alternative definitions of immigrant and low-paying occupations yet obtain similar results. Further, the conclusions of the analysis remain unaltered by the selection of different start and end dates.[19]

In summary, the presented results from this section suggest that there is a negative relationship between employment opportunities of immigrant workers and the share of natives in immigrant jobs. This relationship is robust to the sample selection, the choice of time period and how the share variable is defined. Although the results seem to be very robust, they probably hide considerable hetereogeneity according to country of origin and language proficiency, factors that have been proven to be important predictors of immigrant labor market outcomes. Unfortunately, the data at hand allow no further distinction by country of origin due to data protection reasons. However, tabulations using later QCS waves in which foreign-born workers are included suggest that non-EU country immigrants have a higher probability of working in manual intensive low-paying occupations in comparison to EU immigrants implying a higher risk for these workers.

## 5   Conclusion

With the caveats discussed above, the results presented in this paper suggest that a portion of the decline in employment rates of immigrants are associated with a technology driven decline in demand for middle paying occupations associated with an increase of substitutable labor in low paying occupations. From the empirical investigation, the following findings stand out: first, technological change has explanatory power for employment changes of natives in the lower tail of the wage distribution. Second, employment polarization in the native labor market is negatively related to employment opportunities of immigrant workers while wages are generally found to be unresponsive to native employment levels. The reallocation of natives towards low paying occupations has not been dramatic over the period and the share of natives in immigrant occupations has increased on average by 2 percentage points. Therefore, the implied effects are only modest, and depending on the specification, polarization potentially explains around 12 per cent of the decline in immigrant employment rates. Third, this relationship is more relevant for recent immigrants that have been in Germany for less than five years. For this sub-sample, polarization potentially accounts for up to one third of the decline in employment rates. Employment opportunities of immigrants that have

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[19]Results of all robustness checks not included in table 6 and table 7 are available upon request.

been in the country for longer periods of time do not seem to be affected as much.

The presented results are consistent with the possibility that declining employment rates of immigrant workers are in part related to increased labor market competition from natives. The results support the idea that the technology driven declining demand for routine task occupations and the reallocation of employment towards lower-paying jobs induces competitive pressure in the lower-paying segment of the labor market causing foreign employment and wages to decline. Due to data limitations, the most recent changes in employment and wages cannot be considered. However, it seems that polarization is still a relevant factor related to immigrant labor market outcomes.

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# Appendix

## Processing SIAB and BIBB Data

All information concerning local employment and wages are obtained from the Sample of Integrated Labor Market Biographies Regional File (SIAB-R), a two percent random sample drawn from the full population of the Integrated Employment Biographies that provides detailed information on daily wages for employees subject to social security contributions. To ensure consistency over the years, the analysis excludes workers in marginal employment as this information is only available from 1999 onwards and parallel employment spells. If available, missing values for nationality, occupation and location of an individual are imputed based on the most recent spells of the same individual. The sample is restricted to full-time employment as employment and wage information is reported on a daily basis and lacks information on hours worked. Therefore, wages for part-time employment are measured less accurately. Whenever I construct aggregate or average outcomes, each employment spell is weighted by the number of days worked. For the analysis of wages I use information on real gross daily wages of employees. All wages are converted in Euros at constant 2000 prices using the German consumer price index (CPI) for all private households. As price level data and price indices are not available at the regional level, a common deflator for all labor market regions is applied. I correct for the right-censoring of wage records at the social security contribution threshold by imputing and replacing the topcoded wages following Gartner (2005). Since 1984, one-time and bonus payments have been included in the wage measure, resulting in a spurious increase in earnings inequality (Steiner and Wagner, 1998). I account for this structural break by correcting the wage observations before 1983 following Fitzenberger (1999) and Dustmann et al. (2009).

The information on task requirements of employees is derived from the BIBB/IAB Qualification and Career Survey (QCS) in 1979 which covers approximately 30,000 individuals (see Rohrbach-Schmidt (2009) for details). The dataset is particularly well suited for this line of research as it includes detailed information on the activities individuals perform at the workplace. For each individual $i$, these activities are pooled into three categories: (1) non-routine cognitive, (2) routine and (3) non-routine manual tasks. The assignment of tasks follows Spitz-Oener (2006) and individual task measures $TM_i^j$ for task $j$ in the base year 1979 are constructed according to the definition of Antonczyk et al. (2009):

$$TM_i^j(1979) = \frac{\text{\# of activities in category } j \text{ performed by } i \text{ in 1979}}{\text{total \# of activities performed by } i \text{ over all categories in 1979}} \times 100,$$

where $j = C$ (non-routine cognitive), $R$ (routine) and $M$ (non-routine manual). To obtain task intensities on the occupational level, the individual task measures are aggregated, where the task input of individual $i$ in occupation $k$ in 1979 is weighted by its respective weekly working hours $L_{ik}(1979)$:

$$TI_k^j(1979) = \left( \sum_i \left[ L_{ik}(1979) \times TM_{ik}^j(1979) \right] \right) \left( \sum_i L_{ik}(1979) \right)^{-1}.$$

# Table Appendix

Table 1: Average Wages, Share Immigrants and Task Structure 1981, Employment Growth 1981-2004

| Occupational category (KldB-88 *Berufsabschnitte*) | Log Wage | Task Structure | | | Share Immi. | Empl. Growth |
|---|---|---|---|---|---|---|
| | | non-routine cognitive | routine | non-routine manual | | |
| General services | 3.73 | 7.92 | 28.81 | 63.27 | 18.36 | 8.22 |
| Textile and apparel occupations | 3.85 | 11.51 | 54.02 | 34.47 | 20.38 | 3.06 |
| Food Preparation | 3.98 | 14.43 | 66.22 | 19.35 | 17.45 | 7.39 |
| Merchants | 4.03 | 22.32 | 70.72 | 6.96 | 2.79 | 4.72 |
| Inspectors and distribution workers | 4.05 | 14.72 | 65.14 | 20.15 | 16.19 | 1.76 |
| Machine operators and related occupations | 4.07 | 3.57 | 67.87 | 28.56 | 28.51 | -3.79 |
| Assemblers and metalworking | 4.07 | 9.22 | 65.32 | 25.46 | 34.15 | -8.89 |
| Ceramicist, glassmakers | 4.10 | 25.83 | 74.17 | 0.00 | 16.59 | 2.73 |
| Woodworking occupations | 4.10 | 5.88 | 83.31 | 10.81 | 22.55 | -1.72 |
| Chemical and plastic processing | 4.16 | 14.65 | 74.84 | 10.51 | 24.38 | -3.86 |
| Security and public order | 4.17 | 19.87 | 34.33 | 45.80 | 5.85 | 2.05 |
| Health professions | 4.18 | 20.57 | 68.01 | 11.42 | 14.68 | 1.13 |
| Paper processing, printing | 4.19 | 9.03 | 39.43 | 51.54 | 14.18 | 1.70 |
| Transportation | 4.19 | 17.20 | 30.24 | 52.56 | 4.36 | 5.92 |
| Painters, lacquerers | 4.19 | 14.58 | 52.16 | 33.26 | 9.38 | 4.69 |
| Construction | 4.22 | 15.93 | 36.31 | 47.76 | 18.68 | -2.36 |
| Administrative and office workers | 4.26 | 21.26 | 75.48 | 3.26 | 2.42 | 3.17 |
| Interior decorators, carpenters, upholsterers | 4.26 | 14.87 | 43.89 | 41.24 | 10.04 | 1.20 |
| Electricians | 4.27 | 16.65 | 27.48 | 55.87 | 6.23 | 1.19 |
| Metal producers, processors | 4.28 | 8.21 | 74.06 | 17.73 | 28.03 | -4.17 |
| Locksmiths, mechanics | 4.29 | 13.07 | 40.28 | 46.65 | 7.98 | 1.43 |
| Miners, shaped brick/concrete block makers | 4.31 | 7.67 | 57.55 | 34.78 | 22.85 | -5.01 |
| Education, social sciences | 4.32 | 62.91 | 22.32 | 14.77 | 5.15 | 0.85 |
| Generator machinists; construction machine attendants | 4.35 | 10.00 | 54.42 | 35.58 | 8.19 | 3.63 |
| Service merchants and related occupations | 4.37 | 32.20 | 64.39 | 3.42 | 2.07 | 2.51 |
| Writers and producers of art | 4.40 | 51.14 | 38.03 | 10.84 | 9.29 | -0.03 |
| Technicians | 4.54 | 49.18 | 38.94 | 11.87 | 2.74 | 2.12 |
| Engineers, chemists, physicists, mathematicians | 4.93 | 65.96 | 29.10 | 4.95 | 5.18 | 1.21 |

Note: SIAB-R. Shaded occupations combine above average level of task intensity, below median wages and employment share of immigrants. Task structure refers to the 1979 wave of the QCS (see the data appendix for details on the construction). English names of all KldB-88 categories are own translations by the author.

# Figure Appendix

Figure 1: Wage Level and Manual Task Intensity by Occupation Group



Notes: Numbers in brackets represent the share of immigrant workers in the respective occupation group. The occupation groups are not exclusive and therefore overlap. Manual task intensity is obtained from the 1979 wave of the QCS (see the appendix for details on the construction of this variable).

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