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The Polarization of Employment in German Local Labor Markets

Charlotte Senftleben*
Hanna Wielandt*

* Humboldt-Universität zu Berlin, Germany

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Charlotte Senftleben and Hanna Wielandt

Humboldt-Universität zu Berlin

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Abstract

This paper uses the task-based view of technological change to study employment and wage polarization at the level of local labor markets in Germany between 1979 and 2007. In order to directly relate technological change to subsequent employment trends, we exploit variation in the regional task structure which reflects a region's potential of being affected by computerization. We build a measure of regional routine intensity to test whether there has been a reallocation from routine towards non-routine labor conditional on a region's initial computerization potential. We find that routine intensive regions have witnessed a differential reallocation towards non-routine employment and an increase in low- and medium-skilled service occupations. Our results corroborate the predictions of the task-based framework and confirm previous evidence on employment polarization in Germany in the sense that employment growth deteriorates at the middle of the skill distribution relative to the lower and the upper tail of the distribution.

Key Words: Job Tasks, Polarization, Technological Change, Service Occupations, Regional Labor Markets.

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

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1 Introduction

For many industrialized countries, research has documented a polarizing pattern of the employment structure in recent decades. That is, employment growth of medium-skilled employees has deteriorated relative to employment gains of low- and high-skilled employees. As a main explanation for this development, literature has adopted the view that technological change is task-biased, arguing that ongoing technological progress favors non-routine tasks, performed by high- and low-skilled workers, at the expense of routine tasks, which are mainly performed by medium-skilled employees, leading to employment polarization (Autor et al., 2003).

This study empirically analyzes the forces behind the changing shape of low- and medium-skilled employment in the German labor market. We explore the underlying shifts in the occupational composition and their relation to technological change. In particular, we study whether technological change is related to growth of the less-skilled service sector, which is the main driver of lower tail employment polarization. Our analysis builds on recent work by Autor and Dorn (2011), who are the first to develop a theoretical general equilibrium model 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 their model, human labor performing routine tasks is substituted by computer capital, as the price for information technology declines. This induces a reallocation of labor from routine towards non-routine tasks, whereas the reallocation occurs especially in favor of non-routine manual tasks, as they do not require a high skill level.

Our study contributes to the existing literature on polarization in Germany by providing novel evidence at the level of local labor markets inspired by the analysis of Autor and Dorn (2011). Exploiting regional variation, we are able to directly relate technological change to subsequent regional employment developments. This advances existing literature, which has so far focused on the observation of aggregate trends at the national level. The key idea is that non-routine manual tasks, which are prevalent in less-skilled services, are not tradable across regions and demand shifts can therefore be identified at the regional level. Furthermore, we exploit the fact that local labor markets differ in their industry specialization. These differences are reflected by the regional task structure and capture the extent of being affected by technological progress. To grasp this "automation potential", we generate an index that measures the share of routine labor in a local labor market before technological change has evolved. We then explore the predictions of the model, testing whether regions with a high routine share differentially experienced employment and wage polarization. To our knowledge, we are the first to employ the recently released *Sample of Integrated Labor Market Biographies Regional File (SIAB-R)* in the polarization context, which allows us to extend the time frame until the year 2008.

Our findings suggest that a region's initial routine share contains substantial predictive power for subsequent employment trends. That is, regions have differentially experienced technological progress and displacement of routine labor depending on their initial task structure. Furthermore, service occupations, which are the main drivers of positive employment growth at the lower tail of the wage distribution, have grown stronger in regions with a high initial routine share. In line with a priori expectations, the reallocation of routine labor towards the service sector is most pronounced

for women and older workers.

However, cross-country comparisons indicate that the growth of service occupations is larger in the U.S. than in Germany. One main source of these differences is presumably of institutional nature. Adjustment processes could be inhibited by high payroll taxes and labor costs on the demand side and by a generous unemployment benefit system on the supply side. Indeed, our results show that initially routine intensive regions experienced a larger increase in the unemployment rate. Contrary to results for the U.S., we do not find evidence of wage polarization at the level of local labor markets in our analysis. This result supports the notion that lacking adjustment in prices hampers employment growth and results in higher unemployment instead.

The remainder of the paper proceeds as follows: In section 2, we provide an overview of the task-based framework and discuss the related literature. In section 3, we describe the empirical approach, the data set and the variables used for our analysis. Section 4 presents descriptive evidence on trends in regional task intensity and information technology. Furthermore, we investigate the relationship between the regional routine share and the growth in service sector employment and explore trends in wage inequality on the regional level. Section 5 concludes.

2 The Task-Based Approach and Employment Polarization

In order to analyze employment and wage changes in response to technological progress we build on concepts of the task literature initiated by Autor et al. (2003).[1] The key feature of the task-based approach is that it conceptualizes work into a series of tasks, characterized as *routine* and *non-routine*, depending on their substitutability or complementarity with computer technology. Routine tasks are well-defined and follow explicit rules, hence they are especially amenable to substitution by computer technology. In contrast, computers can neither substitute for *abstract* tasks that involve high complexity and problem-solving nor for *non-routine manual* tasks which require hand-eye-coordination and some degree of interaction. Instead, abstract tasks are complemented by computer technology, as they can be carried out more efficiently, resulting in productivity gains of employees performing these tasks. Non-routine manual tasks are not directly influenced by computerization. Yet, the demand for these tasks can be indirectly affected through a general equilibrium effect, according to which labor flows into a sector where productivity growth is low in order to keep the balance of output stable (Baumol, 1967). Following this argument, routine labor will flow into the non-routine manual "sector", as technology is not applied there.[2]

Employment polarizes because tasks are not evenly distributed across the skill distribution. Figure 1 depicts the distribution of task usage across the skill distribution, which is approximated by the occupational mean wage in 1980. The Figure shows that routine tasks are prevalent in occupations in the middle of the skill distribution, while abstract and manual tasks are mainly

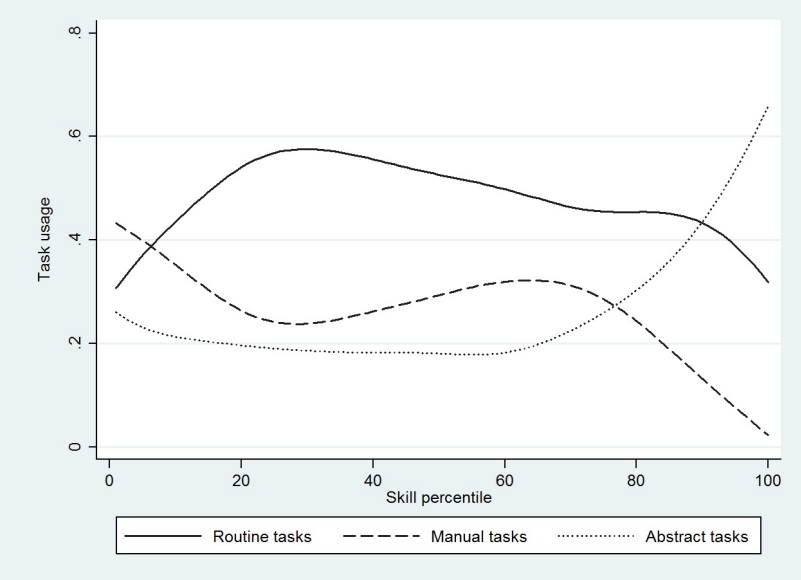
[1] See Autor and Acemoglu (2011) for a comprehensive overview of the task literature and Weiss (2008) for a model of the substitution of human routine tasks by computer capital.

[2] In their model, Autor and Dorn (2011) analyze employment and wage dynamics in a two-sector framework, where non-routine manual labor is exclusively used for the production of services, while the production of goods requires a combination of routine and abstract tasks. They show that as technology replaces routine tasks, low-skilled labor will be drawn from the goods into the service sector, if goods and services are weakly complementary.

performed by either high- or low-skilled employees. Hence, a decline in the demand for routine tasks will result in a polarizing pattern of employment.

This non-monotone growth of employment by skill level is also visible in Germany as illustrated in Figure 2, which depicts employment growth ranked by skill percentile for different subperiods between 1979 and 2007. The typical "U-shaped" pattern is evident in all three decades, but while the 80's are characterized by employment gains mainly at the upper tail of the distribution, employment growth at the lower end has only started to spur during the 90's.

Figure 1: Task input by skill percentile

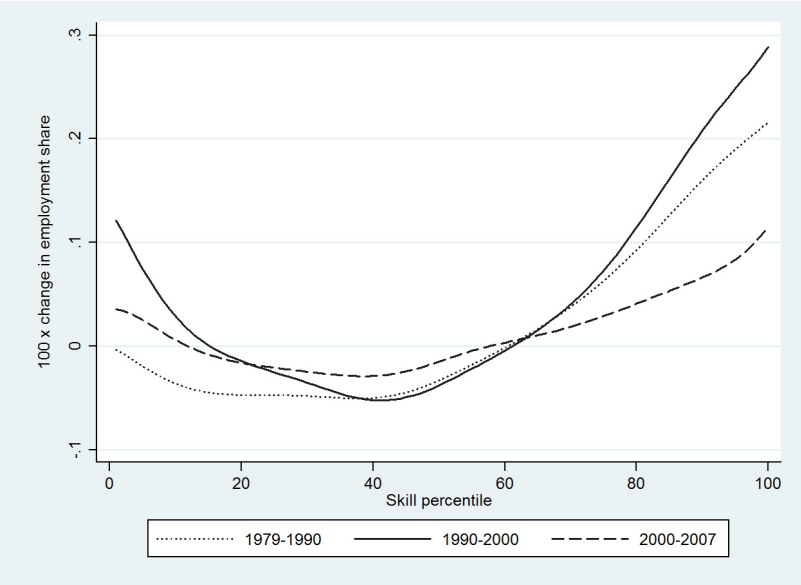


Notes: Shares of workers performing routine, manual and abstract tasks. Occupations are ranked according to their 1979 median wage using the SIAB-R. Task intensity is derived from BIBB/IAB wave 1979 and defined as in equation 2.

So far, existing empirical studies on employment and wage polarization have mainly focused on trends at the aggregate level. Autor et al. (2006) present evidence for the U.S. that medium-skilled employment has deteriorated relative to low- and high-skilled employment starting in the 90's, suggesting that technological change is rather task- than skill-biased. Goos and Manning (2007) find similar trends for Great Britain, showing that employment in occupations with the lowest and highest median wages in 1979 experienced growth in subsequent decades, while employment in the middle of the distribution declined. The authors also analyze job growth by occupation and report that the growth of low-skilled service occupations contributed to the twisting of the employment distribution. Using data from the European Union Labour Force Survey, Goos et al. (2009) present similar evidence for labor market polarization for 13 European countries. Our study heavily draws on recent work by Autor and Dorn (2011) who extend the employment and wage analysis to local labor markets. Their results confirm that the polarizing trend is mostly attributable to the substantial growth of low-skilled service occupations in recent decades.

For Germany, some initial support for labor market polarization has been found by Spitz-Oener (2006) and Dustmann et al. (2009), while Black and Spitz-Oener (2010) show that polarizing

Figure 2: Smoothed changes in employment by skill percentile



Notes: Smoothed changes in employment by skill percentile in indicated periods. Occupations are ranked according to their 1979 median wage using the SIAB-R. Locally weighted smoothing regression with 100 observations and bandwidth 0.8.

trends are more pronounced for women than for men. However, to our knowledge, there is no existing study on Germany that directly relates employment and task changes at the lower tail of the wage distribution to technological progress.

Following the argumentation of the model derived by Autor and Dorn (2011), in a competitive labor market employment polarization should be accompanied by wage developments in the same direction. That is, the deteriorating demand for routine labor should result in an increase in inequality between wages paid to abstract relative to routine labor as well as a decrease in the wage inequality between routine and non-routine manual labor. Hence, given the distribution of tasks across the wage distribution, upper tail inequality (the ratio of some upper quantile to the median) is expected to rise, while lower tail wage inequality (the ratio to the median and some lower quantile) should decrease. For the U.S., evidence for wage polarization after 1985 has been found by Autor et al. (2008).[3] Autor and Dorn (2011) furthermore show that wage increases for low-skilled service jobs have particularly contributed to the polarizing pattern of wage growth.

Evidence on the polarization of wages in Germany has not been found so far. Fitzenberger (1999) shows that mainly upper tail wage inequality has increased during the 80's, while lower tail inequality has remained relatively stable presumably due to strong unions and implicit minimum wages.[4] This is consistent with findings by Dustmann et al. (2009), who report rising lower tail

[3]The evolution of wage and earnings trends for the U.S. during the 1980s has been studied by e.g. Bound and Johnson (1992); Levy and Murnane (1992); Katz and Murphy (1992); Juhn et al. (1993), whereas more recent studies also include the 1990s and 2000s (Autor et al., 2006, 2008). Studies investigating the evolution of wages and earnings in other countries generally document similar patterns, although the timing and extent of the increase in wage and earnings inequality is often different from what is observed for the U.S. (see Gosling et al. (2000) for a study of the evolution of inequality in the U.K. and Boudarbat et al. (2006) for Canada).

[4]Similarly, Gernandt and Pfeiffer (2006) investigate trends in the evolution of wage inequality between 1984 to 2004

inequality starting in the mid 90's, a period that is characterized by strong deunionization trends. Supporting this view, Antonczyk et al. (2009) find evidence that the rise in wage inequality can be attributed to the reduction in bargaining coverage as well as between- and within-industry wage differences. Antonczyk et al. (2010) compare wage trends in Germany and the U.S. and find little evidence for wage polarization in Germany but growing inequality among high- and medium-skilled employees since the 80's and among low- and medium-skilled workers in Germany after 1995. All things considered, studies have found that Germany has experienced wage dispersion rather than a polarization in wages, indicating that technology-driven wage developments suggested by the task-based framework might be countervailed by institutional factors (Kohn, 2006; Antonczyk et al., 2010).

3 Data and Methods

3.1 Empirical Approach and Estimation Strategy

The starting point of our analysis is the observation that, due to location-specific attributes, regions largely differ in their industry specialization pattern and hence in their task structure. That is, depending on the task requirements for the production of goods, a region employs different shares of routine, manual and abstract tasks. Taken these regional differences as given, technological progress in the form of declining prices for computer technology should have a differential effect on regions conditional on their "automation potential", hence task structure, which we measure by the share of routine employment in a specific region. In particular, we test four closely related predictions that can be derived from the theoretical model presented by Autor and Dorn (2011): Regions with a high initial routine employment share should (1) adopt information technology to a larger extent, (2) exhibit a larger decline in routine employment, (3) experience larger growth in the non-routine manual task aggregate in general and larger growth in service sector employment in particular, (4) differentially experience wage developments.

In order to analyze the relationship between the regional task structure in 1979 and subsequent employment and wage changes between 1979 and 2007, we set up an empirical model of the following form:[5]

$$\Delta Y_{r2007,1979} = \alpha + \beta_1 TSH^R_{r1979} + \beta_2 X_{r1979} + \gamma_s + e_r. \quad (1)$$

Depending on which of the aforementioned predictions is tested, the dependent variable $\Delta Y_{r2007,1979}$ represents the change in one of the following measures in region r located in state s between 1979 and 2007: (1) share of employees working with a computer, (2) share of employees performing routine/manual/abstract tasks, (3) share of service employment in overall employment and (4) different wage inequality measures.[6] Our main parameter of interest, β_1, is the coefficient on the

using data from the German Socioeconomic Panel and document an increase in wage inequality for prime age male workers in both parts of Germany starting in the mid 1990's.

[5] We chose the start and end year in such a way that they are similar with respect to their location in the business cycle. As in 2008 the economy was hit by the financial crisis, we use data from 2007 instead.

[6] Autor and Dorn (2011) employ stacked first differences over three time periods to estimate the relationship between

measure of regional routine employment in 1979, TSH^{R}_{r1979}. As is common in this body of literature, we argue that this measure is largely unaffected by technological progress as computerization only started to spur during the 80's.

All regressions include state dummies, γ_s, that control for mean differences in employment and wages across states. The vector X_{r1979} includes additional covariates to control for human capital (share of high/medium/low skilled) and demographic composition (share of women/men, share of foreigners) as well as for economic conditions (fraction of jobs subject to social security contributions in overall population) in 1979.[7]

3.2 Data and Construction of Variables

Our analysis is based on three datasets, the BIBB/IAB Qualification and Career Survey,[8] the Sample of Integrated Labor Market Biographies Regional File (SIAB-R) and the Establishment History Panel (BHP). Information on the task content of occupations is derived from the Qualification and Career Survey in 1979 which covers approximately 30,000 individuals. The dataset contains information on workplace characteristics and educational attainment and is particularly well suited for our research, as it includes detailed information on the activities individuals perform at the workplace and on the tools and machines employees use at work.

These activities are pooled into three task groups: (1) non-routine abstract, (2) routine and (3) non-routine manual tasks for each individual i. In the assignment of tasks, we follow Spitz-Oener (2006) and construct individual task measures TM^{j}_{i1979} for task j according to the definition of Antonczyk et al. (2009):

$$(2)\quad TM^{j}_{i1979} = \frac{\text{number of activities in category } j \text{ performed by } i \text{ in 1979}}{\text{total number of activities performed by } i \text{ over all categories in 1979}} * 100,$$

where $j = A$ (abstract), R (routine), M (non-routine manual).[9] The individual task measures are aggregated to obtain an index for each occupation k, where L_{ik1979} is the individual labor input measured as days worked in occupation k in 1979:

$$(3)\qquad TI^{j}_{k1979} = \frac{\sum_i TM^{j}_{ik1979}}{\sum_i L_{ik1979}}.$$

regional routine intensity and the growth of non-college service employment. In contrast, we restrict our analysis to the single difference based on the routine shares and regional covariates in 1979 as the explanatory variable to focus on the long-run component of differences in regional task structures and thus circumvent the potential endogeneity problem related to the use of subsequent routine shares.

[7] We mainly follow Autor and Dorn (2011) with the selection of control variables. As we are particularly interested in an average effect for local labor markets, we do not weight the regressions by the regional population size. In all regressions, robust standard errors are employed.

[8] This survey is conducted by the German Federal Institute for Vocational Training (Bundesinstitut für Berufsbildung, BIBB) in cooperation with the Research Institute of the Federal Employment Agency (Institut für Arbeitsmarkt und Berufsforschung, IAB) for the years 1979, 1986, 1992 and 1999. The last wave in 2006 was renamed and conducted by the BIBB and the Federal Institute for Occupational Safety and Health (Bundesanstalt für Arbeitsschutz und Arbeitsmedizin, BAuA).

[9] The sample to construct the individual task measures includes West German dependent employees aged 20-60, excluding public sector and agricultural employment.

To generate a task measure at the regional level, the occupational task information is matched 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. The SIAB-R is a two percent random sample drawn from the full population of the Integrated Employment Biographies, which comprises marginal, part-time and regular employees as well as job searchers and benefit recipients covering the years 1975 to 2008 (for details, see Dorner et al. (2010)). It provides detailed information on daily wages for employees subject to social security contributions (wages of civil servants or self-employed workers are not included), as well as information on industry affiliation, location and demographic information on age, gender, nationality and educational attainment.[10] Labor supply is measured by the number of days worked within a respective year. We restrict the sample to prime-aged workers between 20 and 60 living in West Germany and exclude public sector and agricultural workers. As employment in the SIAB-R is measured in full-time equivalents, many studies only consider full-time employees. However, as the share of part-time workers in service occupations is high, an exclusion of this group is not appropriate for our analysis. Hence, we follow Dauth (2010) and weigh part-time employment using information on whether an individual works full-time, major part-time or minor part-time.[11]

Our measure of regional routine intensity builds on the time-consistent definition of 326 administrative districts in West Germany. However, administrative regions have developed as a result of historical circumstances and do not necessarily depict regional economic entities (Eckey et al., 2006). For our analysis it is crucial to consider functionally delineated labor market regions. Hence we further aggregate the 326 administrative districts into 204 labor market regions, following the classification of the "Gemeinschaftsaufgabe *Verbesserung der regionalen Wirtschaftsstruktur*" (Koller and Schwengler, 2000).[12] The advantage of this definition is that commuter flows are taken into account, thus reflecting local labor markets more appropriately (Eckey, 1988; Eckey and Klemmer, 1991).

For each region r and time t the task shares TSH^{j}_{r1979} are then given as:

$$TSH^{j}_{r1979} = \frac{\sum_{k=1}^{K} L_{kr1979} * TI^{j}_{k1979}}{\sum_{k=1}^{K} L_{kr1979}}, \tag{4}$$

where L_{kr1979} is the employment in occupation k in labor market r in 1979. For example, TSH^{R}_{r1979} represents the fraction of routine employment in total employment in labor market r in 1979.[13] Similarly to the task shares, we construct a measure for regional computer usage with information

[10] Workers are classified based on their vocational education using the imputation algorithm developed by Fitzenberger (1999). 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.

[11] Labor supply of individuals working minor part-time (less than 18 hours) is multiplied with 16/39 and major part time (18 to less than 39 hours) is multiplied by 24/39, respectively.

[12] A redefinition of regional labor markets in 2007 affected the regions around Berlin and Brandenburg (Binder and Schwengler, 2006). As our study is only concerned with West Germany, this does not present a problem.

[13] Our measure of regional task intensity differs from that in Autor and Dorn (2011) by exploiting the routine intensity of all occupations. Hence, we measure the share of all regional routine employment instead of using only the top third most routine intensive occupations.

derived from the BIBB/IAB data and matched to the SIAB-R at the occupational level. Regional computer prevalence is measured as the share of employees, using one of the following devices: (1) personal computers, (2) terminals or (3) electronic data-processing machines in region r in 1979.

In order to analyze occupational changes related to technological change, we aggregate the 120 occupations into 12 major occupational groups following Blossfeld (1985). In an effort to build homogeneous occupational groups with respect to their educational requirements and occupational assignments, occupations are classified according to the industrial sector (production, service, administration) and further subdivided by qualification. As we are mainly interested in employment dynamics of low- and medium-skilled employees, we exclude professional occupations that require a university degree or other special training (e.g. engineers, judges or business administrators). Although the model proposed by Autor and Dorn (2011) focuses on employment changes of low-skilled labor exclusively, we consider developments among both low- and medium-skilled workers. This is due to the special nature of the German vocational system, in which there is a vocational degree for the vast majority of existing occupations. Therefore, it is not surprising that the largest fraction of employees in service occupations is medium-skilled (77% in the year 2007), although service occupations also comprise the largest fraction of low-skilled workers among all occupational groups (17% in 2007). It bears emphasis that in the context of our analysis, service *occupations* are to be distinguished from the service *sector*: While service occupations, which is the group of our particular interest, mainly comprise personal services (e.g. hairdressing and table waiting) and similar occupations such as ticket controllers, the service sector represents a broad category of industries that can also be highly knowledge-intensive.

For the analysis of wages, we use information on real gross daily wages of employees available from the SIAB-R to construct different measures of regional wage inequality, the P85/P15, P85/P50 and P50/P15 wage ratios, respectively. For the wage analysis we exclude part-time employment and account for differences in working days by weighing the observations with the number of days worked in a respective year. Furthermore, we correct for the right-censoring of the data at the social security contribution threshold by imputing and replacing the topcoded wages following Gartner (2005): We run a series of tobit regressions of log wages in each year, separately for each education group with several covariates.[14] Topcoded wages are then replaced by draws from normal distributions that are truncated and whose moments are determined from the tobit estimation. 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). We account for this structural break by correcting the wage observations before 1983 following Fitzenberger (1999) and Dustmann et al. (2009): As the mentioned additional payments generally only affect relatively high wages, it is assumed that only wages above the median need to be corrected. Hence, we run a linear regression of wage growth, where wage growth up to the median is assumed to be constant. The percentage difference between the quantile from the upper half of the distribution and the median can be interpreted as "excessive" wage growth and is used to correct wages before 1983.[15]

[14] As additional controls we use four different age categories, industry affiliation and occupational categories.

[15] We thank Bernd Fitzenberger and Christian Dustmann for making the correction program available to us. Results of these regressions are available upon request.

For the construction of regional control variables, we use information from the Establishment History Panel (BHP), a 50 percent sample of all establishments throughout Germany with at least one employee liable to social security, stratified by establishment size. We use information on the number of employees by different labor market segments (women, foreigners, high/medium/low skilled) and aggregate the information at the regional level.

4 Main Results

4.1 Task Specialization and Adoption of Information Technology

We start our analysis by examining the main explanatory variable, the share of routine employment in 1979. Descriptive statistics for the routine share and the covariates in 1979 and 2007 are summarized in Table 1. The average regional routine share in 1979 is 0.564, suggesting that the fraction of routine tasks performed in overall employment in a region at the mean amounts to 56.4%. A region at the 85th percentile of the routine share distribution has a 3.5 percentage points higher routine intensity compared to a region at the 15th percentile. To get an impression of the regional variation in routine intensity, Appendix Figure 1 maps the geographic distribution of the regional routine share in 1979 across Germany. Labor markets with a high share of routine employment are predominantly industrial strongholds, such as Wuppertal (0.609) and Pirmasens (0.621). However, it bears emphasis that also labor markets that are specialized in relatively knowledge-intensive industries, e.g. Düsseldorf and Frankfurt are among the top-ranked routine-intensive labor markets. This is in line with the task-based approach, as these industries typically employ many supporting occupations, such as secretaries, bookkeepers and accountants, which are characterized by a high routine task content. Regions that have a low routine share are mainly specialized in tourism and hospitality, such as Berchtesgaden or Husum (0.532).

The task-based approach suggests that computerization should have occurred differentially across regions conditional on their initial routine employment share, along with a differential displacement of routine labor. To investigate the relationship between the initial routine share and regional computer adoption, we estimate a model according to equation 1, where the dependent variable is the difference in the regional share of computer usage between 1979 and 2007.[16] As the results in column 1 of Table 2 show, the point estimate on the initial routine share is positive and significant at the 10% level, suggesting that a higher routine share in 1979 is associated with larger subsequent computer adoption. To test whether this development is accompanied by a larger displacement of routine labor, we estimate a model with the outcome variable being the difference in the regional routine share between 1979 and 2007.[17] The negative and significant coefficient estimates in column 2 of Table 2 confirm the prediction, indicating that a region at the 85th percentile of the routine share distribution experienced a by 3.3 percentage points higher displacement of routine labor than a region at the 15th percentile.

[16] As additional control, we include a measure of population density (number of inhabitants per square kilometer) to control for differences in the urbanity between regions.

[17] For the construction of the regional routine share in 2007 we build on a task classification by Leuschner (2012).

Table 1: Descriptive statistics for regions

	1979	2007
Full-time employment	81,246	77,487
	(121,040)	(115,908)
Fraction of low & medium skilled service empl.	0.150	0.160
	(0.024)	(0.031)
Fraction employed/pop.	0.252	0.224
	(0.053)	(0.055)
Average log real daily wage	4.162	4.326
	(0.078)	(0.109)
P85-P15 wage ratio	1.185	1.235
	(0.022)	(0.029)
P85-P50 wage ratio	1.074	1.099
	(0.009)	(0.016)
P50-P15 wage ratio	1.103	1.123
	(0.017)	(0.017)
Routine Share	0.565	0.259
	(0.019)	(0.028)
Abstract Share	0.203	0.454
	(0.017)	(0.035)
Manual Share	0.233	0.287
	(0.024)	(0.017)
PC Share	0.045	0.723
	(0.010)	(0.036)
Fraction female employees	0.327	0.319
	(0.039)	(0.035)
Fraction high to low skilled employees	0.030	0.099
	(0.017)	(0.050)
Fraction foreign employees	0.078	0.063
	(0.045)	(0.031)
Unemployment rate[a]	-	0.078
	-	(0.026)
Regional Population	297,494	313,204
	(376,437)	(360,404)
Population Density (Inhabitants per km^2)	301	317
	(418)	(398)

Notes: N=204 labor market regions. All fractions are computed with respect to total full-time employment for a given region. [a]The regional unemployment rate is only available from 1985 on.

Following the argumentation of the task-based framework, the demand for non-routine labor rises in response to technological progress. The displaced mass of employees who initially performed routine tasks can either remain unemployed or reallocate towards non-routine tasks. This reallocation mechanism should work predominantly in the direction of non-routine manual labor rather than towards abstract tasks, as the performance of abstract tasks requires a high skill level, which is not met by workers who formerly performed routine tasks without additional training. Thus, both the manual as well as the abstract employment shares are expected to rise differentially in regions with a high initial routine share. To test whether this prediction holds, we estimate two separate models as described in equation 1, where the dependent variables are the changes in the non-routine manual (column 3) and the abstract employment share (column 4) in region r between 1979 and 2007, respectively. As predicted by the framework, the estimated coefficient of the non-routine manual share is positive and highly significant. Although the results for the ab-

stract employment share are positive, the point estimate is by 80% smaller in magnitude and less significant than its manual counterpart.[18]

Table 2: Regional computer adoption and task contents, 1979-2007

Dependent variable:	Δ PC Share	Δ Routine Share	Δ Manual Share	Δ Abstract Share
	(1)	(2)	(3)	(4)
Routine Share 1979	0.177*	-0.940***	0.840***	0.140
	(0.102)	(0.098)	(0.049)	(0.090)
R^2	0.415	0.503	0.722	0.157

Notes: N=204 labor market regions. All models include dummies for the federal state in which the region is located, a measure of population density (number of inhabitants per square kilometer) as well as a constant. Robust standard errors in parentheses. * Significant at 10%, ** at 5%, *** at 1%.

Having shown that non-routine employment has grown stronger in regions that were initially specialized in routine intensive employment, we now focus on the underlying occupational changes that are related to technological progress. To get a first hint at which occupations contribute to the twisting of employment growth at the lower tail of the wage distribution, Appendix Table 1 lists the 10 least paying occupations in the year 1979. Among these least paying occupations, many belong to the less skilled service sector, such as hairdressers, hosts and innkeepers. Between 1979 and 2007, the share of service employment has grown by roughly 10% and makes up for 17.1% of overall employment in 2007. Table 3, which depicts the aggregate development of employment shares for major occupational groups, indicates that this growth is concentrated around the years 1995 to 2007. Although the growth of service employment at the national level is relatively moderate, regional differences in changes of the service employment shares between 1979 and 2007 are substantial: The 85th/15th percentile range amounts to 5 percentage points, which is equivalent to approximately 2 standard deviations.

The importance of service occupations for employment growth at the bottom of the skill distribution is shown in Figure 3, which illustrates a counterfactual situation with service employment held constant at its 1979 level. Employment polarization would have occurred also in the counterfactual scenario but the positive growth of employment at the lower tail of the wage distribution is almost exclusively attributable to the growth of service occupations. What is crucial is that these service occupations require a disproportionally high input of non-routine manual tasks.[19] If the rising demand for services is indeed a result of technological change, we should see a positive relation between the initial regional routine share and subsequent growth in service sector employment.

[18] It bears emphasis that the sum of the 3 task shares adds up to one by construction. Therefore, as a region's routine employment share declines, the other shares automatically increase. Yet, it is noteworthy that losses in routine employment are not distributed uniformly to both the non-routine manual and the abstract emplyoment share.

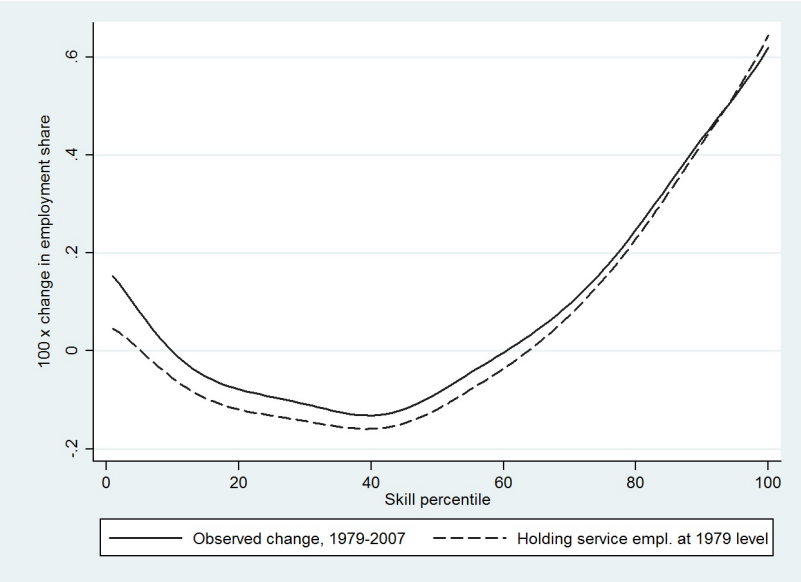
[19] Occupations with a high non-routine manual task content are summarized in Appendix Table 2.

Table 3: Levels and changes in employment share by occupation groups, 1979 to 2007

	1979	1995	2007	1979-2007	
	Employment share (%pts)			Change (%pts)	Growth Rate (%)
Managers	2.5	3.2	3.7	1.2	54.4
Technicians/Engineers	9.0	11.2	11.7	2.7	36.3
(Semi-) Professions	1.1	1.6	1.6	0.5	59.5
Commercial/Administration	23.5	27.2	29.9	6.4	29.7
Production/Craft	47.9	40.2	35.3	- 12.6	-28.2
Services	15.3	15.7	17.1	1.8	10.3

Notes: SIAB Regional File. Sample includes persons aged 20 to 60 living in West Germany. Public sector and agricultural employment is excluded. Labor supply is measured as the number of days worked in a given year. Part-time work is included and weighted by average working hours according to Dauth (2010).

Figure 3: Observed and counterfactual changes in employment by skill percentile, 1979-2007



Notes: Smoothed changes in employment by skill percentile between 1979 and 2007. Occupations are ranked according to their 1979 median wage using the SIAB Regional File. To construct the counterfactual we keep service employment at its 1979 level. Locally weighted smoothing regression with 100 observations and bandwidth 0.8.

4.2 The Growth of Service Sector Employment

A. Baseline Estimates

As a first pass to analyzing the relationship between routine task intensity and service sector employment growth, we relate the long difference in regional service sector employment (ΔSVC_r) between 1979 and 2007 to the initial regional routine share of employment in 1979. First graphical evidence for this relationship is provided in Appendix Figure 2 which plots the change in the share

of low- and medium-qualified service employment and the initial routine intensity of the respective labor market in 1979. A simple OLS regression according to equation 1 gives the following results:

$$\Delta SVC_{r,1979-2007} = -0.148 + 0.281 * TSH^{R}_{r,1979} + e_{r} \qquad (t = 3.59). \tag{5}$$

The coefficient of 0.281 on the routine share variable suggests that a region at the 85th percentile of the routine share distribution in 1979 experiences a 1.0 percentage points larger increase in the service sector employment share than a region at the 15th percentile.[20] Compared to the relatively moderate mean growth of 1.1 percentage points between 1979 and 2007, the importance of the initial routine share for a region's subsequent service employment growth is substantial.

Panel A of Table 4 provides an overview of different specifications estimating equation 1. The first column additionally includes dummy variables for the federal state in which the region is located. In columns 2-7, the model is step-by-step augmented by control variables that might be related to the development of employment in service occupations. Column 2 includes a measure of population density (number of inhabitants per square kilometer) to control for differences in the urbanity between regions. The inclusion slightly decreases the coefficient on the routine share but is not significant by itself. Columns 3 to 5 add variables that are expected to capture demand side factors for service employment. Column 3 includes the fraction of the population subject to social security contributions that serves as a proxy for the regional employment rate. According to theory, a higher share of working population should be associated with positive employment changes in the service sector, as home-based production is substituted by market-based production of services. This substitution effect is supported by the positive and significant coefficient in column 3. Following the same argument, the regression is further augmented with the share of female employees which is suspected to have a positive impact on service sector growth. The positive albeit insignificant coefficient on the fraction of female employment in column 4 verifies this conjecture. Column 5 adds the ratio of high- to low-skilled workers as a measure to reflect formal educational attainment within regions. The positive sign suggests that a higher relative supply of high-skilled workers is related to larger growth of service employment. Yet, the coefficient is not statistically different from zero and hardly alters the point estimate on the regional routine share. Column 6 adds an indicator that potentially influences the supply of services by including the share of foreign employees. Indeed, the share of foreign employees is positively related to the growth of service employment (consistent with Cortes (2008)), but the point estimate is not statistically different from zero and the inclusion leads to a decline of the coefficient on the regional routine intensity. If we include all covariates in the model (column 7), the estimate on the regional routine share remains robust and still retains 90 percent of the size reported in the base specification in column 1.

Studies have shown that the fraction of part-time employees in the service sector is particularly high (Houseman, 1995).[21] In order to test whether there have been different employment trends

[20] The value of the routine share at the 15th and 85th percentile are 0.548 and 0.583, respectively.

[21] A report by the European Foundation for the Improvement of Living and Working Conditions (2007) emphasizes the importance of part-time employment for overall employment changes.

Table 4: Estimated impact of routine task intensity on regional service sector employment

Dep. variable: Δ SVC employment 1979-2007	(1)	(2)	(3)	(4)	(5)	(6)	(7)
				A. Total employment			
Routine Share 1979	0.252***	0.245***	0.231***	0.219***	0.236***	0.229***	0.227***
	(0.083)	(0.083)	(0.083)	(0.084)	(0.084)	(0.082)	(0.085)
Share employed/pop.			0.103*	0.114**	0.081	0.098*	0.096
			(0.055)	(0.055)	(0.056)	(0.056)	(0.058)
Share female empl./empl.				0.038			0.032
				(0.047)			(0.048)
High/low skilled empl.					0.129		0.119
					(0.108)		(0.108)
Share foreign empl./empl.						0.011	-0.008
						(0.038)	(0.040)
Population density	no	yes	yes	yes	yes	yes	yes
R^2	0.148	0.153	0.170	0.173	0.175	0.170	0.178
				B. Full-time employment			
Routine Share 1979	0.238***	0.231***	0.220**	0.204**	0.225***	0.216**	0.211**
	(0.085)	(0.085)	(0.085)	(0.086)	(0.087)	(0.084)	(0.088)
R^2	0.151	0.155	0.166	0.172	0.171	0.167	0.176
				C. Part-time employment			
Routine Share 1979	0.673*	0.660*	0.613*	0.659*	0.615*	0.636*	0.682*
	(0.350)	(0.353)	(0.354)	(0.361)	(0.355)	(0.351)	(0.360)
R^2	0.127	0.129	0.143	0.147	0.143	0.145	0.149

Notes: N=204 labor market regions. All regressions include dummies for the federal state in which the region is located, regional covariates as indicated as well as a constant. Covariates in all Panels are identical. Robust standard errors in parentheses. * Significant at 10%, ** at 5%, *** at 1%.

for full- and part-time employment, we estimate models for both employment types separately. The results in Panel B of Table 4 suggest that the coefficients for the subsample of full-time employment are somewhat smaller in size compared to the results for the joint sample in Panel A, but remain highly significant. As before, the coefficient estimate declines with the inclusion of additional covariates but remains significant at the 5% level. In contrast, the point estimate on the routine share for the subsample of part-time workers summarized in Panel C indicates that the growth of low- and medium-skilled service employment is particularly pronounced for part-time employees: The coefficient of 0.673 suggests that a region at the 85th percentile experiences a 2.4 percentage points larger growth in part-time service employment compared to a region at the 15th percentile during the period under consideration. However, the coefficient seems to be less precisely estimated and is only significant at the 10% level.

A considerable part of the workforce employed in service occupations is only marginally employed and therefore not subject to social security contributions.[22] If employment possibilities are mainly created among marginally employed, our results will underestimate the relation be-

[22]German law defines employment relationships as "marginal" if individuals work less than 50 days per calendar year or their monthly paycheck does not exceed 400 Euro (mini-job).

tween routine intensity and service sector employment growth as our sample lacks information on marginal employment. In order to test for this possibility, we re-estimate the model using data from the German microcensus, a representative one percent sample survey of all persons in private households and community accommodation in Germany. A major advantage of the microcensus is the fact that it entails employment subject to social security contributions as well as marginal employed workers.[23] The results of the baseline estimation (column 1) and the specification including regional covariates (column 2) are depicted in Table 5. Consistent with expectations, the coefficient estimates are slightly larger compared to the results obtained with the SIAB-R, suggesting that additional labor is partly generated among non-standard employment. The point estimate is less precisely measured, which can be ascribed to a much smaller sample size.[24]

Table 5: Estimated impact of routine task intensity on service sector growth (Microcensus results)

Dependent variable:	All services		Unskilled services		Skilled services	
Δ employment 1982-2006	(1)	(2)	(3)	(4)	(5)	(6)
Routine Share 1982	0.280*	0.304*	0.287**	0.300**	-0.007	0.004
	(0.148)	(0.156)	(0.139)	(0.147)	(0.071)	(0.077)
Regional covariates	no	yes	no	yes	no	yes
R^2	0.066	0.245	0.084	0.272	0.012	0.059

Notes: N=69 planning districts excluding Northern Schleswig-Holstein and Berlin. The routine share in 1982 is constructed using occupational task information from the BIBB/IAB data in 1979 and regional employment by occupation from the microcensus of 1982. All regressions include regional covariates as indicated as well as a constant. Robust standard errors in parentheses. * Significant at 10%, ** at 5%, *** at 1%.

B. Allowing for Heterogeneity

The estimates for overall employment presented in Table 4 suggest a positive relationship between the initial share of regional routine employment and the subsequent growth in service employment. Yet, this overall trend might mask differences between distinct labor market segments. To gain further insight, we run the OLS regressions described by equation 1 separately for different subgroups distinguished by gender and age.

We first consider the possibility of differential employment changes by gender. As argued by Black and Spitz-Oener (2010) the polarization pressure has been more pronounced for female employees as women have experienced a stronger decline in routine tasks compared to men. We therefore expect a larger effect for women which is confirmed by the results of the two specifications presented in Panel A of Table 6. For both genders the point estimate is positive which supports the idea that regions with a higher routine share experience a larger reallocation of routine intensive labor towards service occupations. However, the point estimates suggest that a higher routine share

[23] A more detailed discussion of the data set and the empirical procedure is provided in the Data Appendix.

[24] Due to data availability reasons we have to restrict the analysis based on the microcensus to the years 1982 and 2006. To check the robustness of our baseline results in Table 4, we re-estimate the specification for the change in low- and medium-skilled service sector employment between 1982 and 2006. Results remain virtually unchanged.

is mainly related to service occupation growth among female employees, while the point estimates for men are only 50 percent as large as the coefficient estimated for women and not statistically different from zero.

Panel B of Table 6 considers another subset of the labor market and distinguishes between young (age 20-40) and old (age 40-60) employees. Economic theory suggests that younger workers have a higher incentive to invest in further education allowing them to upgrade and reallocate towards abstract rather than non-routine manual tasks. In contrast, older workers are less likely to invest in further training and are therefore expected to engage in the performance of non-routine manual tasks with a higher probability. Following this reasoning we expect a larger effect for older workers, which is confirmed by our results. While the coefficient for young workers (columns 5 and 6) is positive but insignificant, the point estimate for older workers in columns 7 and 8 is large in magnitude and highly significant.

Table 6: Estimated impact of routine task intensity by gender and age
Dependent variable: Δ SVC employment 1979-2007

	A: Females vs. Males				B: Young vs. Old			
	Females		Males		Young (20-40)		Old (40-60)	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
RSH 1979	0.365***	0.328**	0.172	0.153	0.121	0.089	0.495***	0.460***
	(0.131)	(0.141)	(0.106)	(0.110)	(0.122)	(0.125)	(0.118)	(0.121)
Regional cov.	no	yes	no	yes	no	yes	no	yes
R^2	0.093	0.106	0.151	0.175	0.134	0.161	0.138	0.166

Notes: N=204 labor market regions. All regressions include dummies for the federal state in which the region is located, regional covariates as indicated as well as a constant. Robust standard errors in parentheses. * Significant at 10%, ** at 5%, *** at 1%.

All things considered, our results suggest that the importance of the relationship between the measure of routine intensity and changes in the employment share of service occupations differs substantially across subsets of overall regional employment. Evidence of polarization is found for women and men and young and older workers, alike. The largest and most significant increases in the share of service employment however are witnessed among female and older workers.

C. Robustness

As a first attempt to test the robustness of our results, we repeat the OLS estimation using contemporaneous changes of the regional covariates instead of their 1979 levels. The resulting coefficients presented in Panel A of Table 7 are comparable in magnitude to our prior specifications. Nevertheless, it should be clear that some of these contemporaneous changes are a result of technological change themselves (Autor and Dorn, 2011).[25] Panel B displays estimation results replacing the number of days worked with the number of jobs in the service sector as employment variable. The coefficient is slightly larger in magnitude and significance. This supports previous results on the

[25]Most covariates enter with the expected sign: positive for share of working population, female labor force participation and fraction of high- to low- and medium-skilled but negative for the share of foreign employees. However, the coefficient estimates are not individually significant.

importance of part-time employment in the service sector, suggesting that the share of jobs in this sector in total employment is larger than the share of days worked. We furthermore experimented with different subsamples depending on the size and the region type of the specific labor market. Yet, we obtain similar results considering urban or rural regions separately or estimating separate models for large (population>200 T in 1979) and small (population<=200 T in 1979) regions. However, results seem to be more significant in rural and smaller regions.[26]

Table 7: Estimated impact of routine task intensity on regional service sector employment: robustness checks

Dependent variable: Δ SVC employment 1979-2007	(1)	(2)	(3)	(4)
	Panel A: Alternative classifications			
	Covariates in cont. changes		Alternative employment class.	
Routine Share 1979	0.252***	0.227***	0.305***	0.295***
	(0.083)	(0.088)	(0.091)	(0.094)
Regional covariates	no	yes	no	yes
R^2	0.148	0.178	0.149	0.172
	Panel B: Spatial Error Weighting Matrices			
	Inverse Distance		Contiguity	
Routine Share 1979	0.252***	0.230***	0.255***	0.231***
	(0.081)	(0.082)	(0.081)	(0.082)
Regional covariates	no	yes	no	yes
Wald-Test	3.916	1.792	0.145	0.174
p-value	(0.048)	(0.181)	(0.703)	(0.701)

Notes: N=204 labor market regions. All regressions include dummies for the federal state in which the region is located, regional covariates as indicated as well as a constant. The covariates enter with the expected sign but are mostly not individually significant. Robust standard errors in parentheses. * Significant at 10%, ** at 5%, *** at 1%.

The definition of service occupations that we employ in our analysis does not coincide 1:1 with the U.S. census classification adopted by Autor and Dorn (2011), which mainly comprises unskilled personal services. Although a confinement to low-skilled services does not seem appropriate for the German setting, it is still interesting to further narrow down the group of occupations driving the employment changes at the lower tail of the wage distribution. In order to test for differential trends, we further subdivide service occupations into unskilled (all unskilled personal services) and skilled (essentially order and security occupations as well as skilled service occupations) and estimate the employment trends separately for both occupation groups. Again, we rely on data from the German microcensus, as it is particularly well suited to analyze trends in low-skilled employment since the data is not limited to employment information subject to social security contributions.[27] Results are presented in columns 3 to 6 in Table 5 and reveal a positive and significant relationship

[26] Results are available from the authors upon request.

[27] An additional advantage of the microcensus data it the detailed occupational classification that allows us to consider specific occupation groups.

between regional routine intensity and the growth of unskilled personal services (columns 3 and 4) and a rather weak association with the growth of more skilled services (columns 5 and 6). This is in line with findings for the U.S. and suggests that the relation between a region's routine share and subsequent employment growth is more pronounced for unskilled services.

We also considered the possibility that local labor market regions are spatially correlated to each other and re-estimated spatial error models with contiguity and inverse distance weighting. While the contiguity matrix only consists of zeros and ones, the inverse-distance weighting matrix assigns weights that are inversely related to the distance between regions. Distance-based weight matrices are in general better suited to account for spatial dependency among regions than contiguity-based matrices as they describe the regional integration more accurately. However, as the results for the base specification (columns 1 and 3) in Panel B of Table 7 suggest, both weighting methods yield very similar point estimates compared to previous results. The coefficient on the routine share 1979 further decreases with the inclusion of additional control variables (columns 2 and 4) but remains highly significant. Moreover, there is only minor evidence of significant spatial autocorrelation as suggested by the Wald test statistic and the associated p-value.[28]

4.3 Unemployment

So far, our empirical findings on changes in service sector employment related to technological progress confirm findings for the U.S. by Autor and Dorn (2011) and for Germany as presented by e.g. Spitz-Oener (2006) and Dustmann et al. (2009). However, when comparing the magnitude of our coefficient estimates to results from the U.S., it bears notice that this relationship is of less economic significance in Germany. One potential explanation for this finding is that labor market institutions differ substantially across both countries. Rising demand for services in Germany is likely to be depressed by high payroll taxes, resulting in more home-based than market based production (Freeman et al., 2005; Burda et al., 2007). This argument is in line with several other studies, which document that many European countries seem to be "missing" personal services such as retail trade or hotel and restaurant employment (Piketty, 1997). Studies by Bertrand and Kramarz (2002), Messina (2005) and Rogerson (2007) have brought up the explanation that missing services both reflect and reinforce lower rates of employment and work hours in Europe relative to the United States. Apart from demand side differences, institutions might adversely affect the supply of services. The unemployment benefit system in Germany is by far more generous than the system in the United States. Hence, a reallocation from routine labor towards less paying manual labor might be less profitable than remaining in unemployment.

Institutional factors and the rigidities they introduce should translate into a rise in unemployment instead of employment growth in the service sector. To test for this alternative hypothesis, we explore the relationship between the initial routine share of a region and subsequent changes in the unemployment rate. We receive information on the unemployment rate (with respect to the civil labor force) at district level from the Statistics Department of the German Federal Employment

[28] As the coefficient estimates in our baseline analysis do not differ from the results obtained from the spatial weighting we are not concerned by the relatively low p-value in column 1 that hints at potential spatial correlation.

Table 8: Estimated impact of routine task intensity on regional unemployment

Dependent variable:		
Δ Unemployment rate 1985-2007	(1)	(2)
Routine Share 1979	0.380***	0.221**
	(0.119)	(0.087)
Regional covariates	no	yes
R^2	0.309	0.567

Notes: N=204 labor market regions. All regressions include dummies for the federal state in which the region is located, regional covariates as indicated as well as a constant. Robust standard errors in parentheses. * Significant at 10%, ** at 5%, *** at 1%.

Agency (*Bundesagentur für Arbeit*). As this information is only available since the year 1985, the dependent variable is the change in the unemployment rate between 1985 and 2007. The results of this estimation are presented in Table 8. Confirming the predictions, the baseline specification presented in column 1 indeed predicts a higher increase in the unemployment rate in routine intensive regions. With the inclusion of additional covariates (column 2), the magnitude of the point estimate drops by 30% but remains statistically significant at the 5% level.[29]

4.4 Regional Wage Inequality

So far, our analysis has documented that regions differentially experienced employment polarization depending on their initial routine employment share. In this section we explore, whether the observed employment polarization is accompanied by wage trends in the same direction. Given the mapping between the specific tasks and their location on the wage distribution, the expected changes in the relative task prices should translate into a polarization of earnings. Wages paid to routine tasks will decline as information technology becomes more affordable, since computer capital perfectly substitutes for routine labor. Due to q-complementarity between abstract and routine tasks, the wages of high-skilled workers will rise, resulting in increasing upper-tail wage inequality. If goods and services are weekly complementary, wages paid to low-skilled manual labor rise relative to wages for routine tasks, eventually compressing lower-tail inequality.

We measure upper tail wage inequality by the P85/P50, lower tail inequality by the P50/P15 and overall wage inequality by the P85/P15 log wage ratio for full-time workers. The unconditional evolution of the three wage measures at the national level is illustrated in Appendix Figure 3. Overall wage inequality remained relatively stable until the mid 90's, but rose steeply thereafter. Upper tail wage inequality continued growing over the observed period, whereas lower tail wage inequality declined until the mid 90's but started growing again with a steep rise at the beginning of the 2000's. Wage inequality grew within and between regions as indicated by the increasing standard

[29] As the information on district unemployment is only available as of 1985, we re-estimate our baseline specification in Table 4 for the change in low- and medium-skilled service sector employment between 1985 and 2007. The coefficient estimates are slightly larger compared to our previous results but remain highly significant.

deviation of the wage ratios in Table 1. Thus, first descriptive evidence suggests that economy-wide wage developments at the upper tail of the distribution are in line with the polarization hypothesis, while trends at the lower tail are not consistent with the predictions.

Table 9: Estimated impact of routine task intensity on regional wage inequality

	A: All		B: Males		C: Females	
	(1)	(2)	(3)	(4)	(5)	(6)
			I. Outcome variable: Δ P85-P15			
Routine share 1979	-0.019	-0.050	0.089	0.034	-0.235	-0.202
	(0.113)	(0.104)	(0.102)	(0.086)	(0.206)	(0.205)
Regional covariates	no	yes	no	yes	no	yes
R^2	0.050	0.347	0.037	0.454	0.074	0.133
			II. Outcome variable: Δ P85-P50			
Routine share 1979	0.022	-0.004	0.037	-0.001	0.010	0.014
	(0.059)	(0.055)	(0.065)	(0.060)	(0.086)	(0.086)
Regional covariates	no	yes	no	yes	no	yes
R^2	0.056	0.264	0.082	0.355	0.031	0.044
			III. Outcome variable: Δ P50-P15			
Routine share 1979	-0.039	-0.041	0.043	0.030	-0.221	-0.195
	(0.084)	(0.087)	(0.059)	(0.059)	(0.148)	(0.150)
Regional covariates	no	yes	no	yes	no	yes
R^2	0.090	0.275	0.088	0.302	0.108	0.166

Notes: N= 204. All models include dummies for the federal state in which the region is located, regional covariates as indicated as well as a constant. Robust standard errors in parentheses. * Significant at 10%, ** at 5%, *** at 1%.

To explore the relationship between wage inequality and regional routine intensity in more detail, we estimate separate models according to equation 1 for each measure of wage inequality, where the dependent variable is the change in the respective log wage ratio between 1979 and 2007. The coefficient estimate on the P85/P15 wage ratio in Panel I of Table 9 is negatively (column 1) associated with the initial regional routine intensity 1979. However, this relationship is not significant and remains insignificant with the inclusion of regional covariates (column 2). If we consider men (columns 3 and 4) and women (columns 5 and 6) separately, the results suggest an opposing trend. While routine intensity seems to predict increasing overall wage inequality in the male sample, routine intensity is negatively related to increasing wage inequality for the female sample. However, the coefficients are statistically insignificant, regardless of the inclusion of additional covariates. Panel II and III further explore the relationship by separately analyzing upper and lower tail wage inequality. As for the overall wage inequality, the coefficients are not statistically different from zero in all specifications. If anything, wages of women have slightly polarized at the lower tail of the wage distribution, while wage developments for males follow a rather dispersing pattern.

Our results show that despite changes on the quantity side of the labor market, the rise in

employment has not come along with accordant wage adjustments. This contradicts findings for the U.S. presented by Autor and Dorn (2011) where wage dynamics do mirror the employment trends. However, our results at the regional level are consistent with existing studies on aggregate wage trends in Germany arguing that the task-based approach alone cannot explain recent wage developments in the German labor market (Dustmann et al., 2009; Antonczyk et al., 2009). Yet, there are two possible explanations for the diverging patterns related to the non-competitiveness of the German labor market. First, wage bargaining in Germany usually takes place on the state or federal level and this lack of flexibility at the regional level might hamper wage adjustments, which should be induced by technological progress. Second, in the presence of unemployment an upward shift of the demand curve might lead to quantity adjustments rather than wage changes.

5 Conclusion

This paper examines the dynamic patterns of employment and wage polarization in Germany in recent decades at the level of local labor markets. We build on concepts of the task-based view of technological progress, according to which technological change favors labor market outcomes at the lower as well as at the upper tail of the wage distribution relative to the middle. In order to test the predictions of the task-based framework, we directly relate employment outcomes to technological change by exploiting regional variation in the "computerizability", that is the potential to be affected by technological change.

Our results suggest that the variation in routine intensive employment between regions has indeed some explanatory power for subsequent regional employment changes. Regions that were initially specialized in routine tasks adopted information technology faster and witnessed a larger decline of routine employment. At the same time, these regions witnessed a differential growth of non-routine manual occupations, where particularly the growth in service occupations contributed to employment polarization. The results indicate that the growth of low- and medium-skilled service employment is most pronounced for women and older workers. Furthermore, there is a substantial difference in the magnitude of the relationship for full-time versus part-time employment.

When comparing recent employment trends in Germany to developments in the U.S., we find that the overall polarization phenomenon as well as the relationship between the task structure and service sector employment on the regional level is less pronounced than in the US. In line with other studies, we find that the "boom" in service sector employment that has been found for the U.S. has not occurred in Germany to the same extent. One potential explanation could be that institutions introduce rigidities and hamper adjustment processes. Indeed, the unemployment rate differentially increased in routine-intensive local labor markets between 1985 and 2007.

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A Appendix

Replication using the German Microcensus

The microcensus is a representative one percent sample survey of all persons in private households and community accommodation in Germany provided by the Federal Statistical Office and covers approximately 370,000 households with 800,000 individuals. It has been collected for West Germany since 1957 and extended to the new Federal States in 1991. In 2005 the survey design changed from data collection during a fixed reference week (usually the last holiday-free week in April) to a continuous survey design. It contains detailed information on the demographical background (age, sex, nationality etc.), the labor market status (employment status, employment characteristics, job search), education and training, income and the household and family context (children, living conditions).

A major drawback of the data is the limited availability of regional information due to data security regulation. As a result, the microcensus only provides information on the level of 97 German planning districts (Raumordnungsregionen, ROR) that are defined according to commuting ranges and comprise labor market regions that are relatively self-contained. A reallocation of districts in 1996 resulted in a new assignment of planning districts and unfortunately, the statistical office does not provide a time consistent definition of this regional classification. As a result, we need to group some ROR's together in order to ensure comparability over time. In addition, we exclude the region "Northern Schleswig-Holstein" from our regressions as its routine share is more than one standard deviation larger compared to the second largest regional routine share. Out of the 74 ROR in West Germany we are than left with 69 planning districts excluding Berlin.

Due to data availability reasons we have to restrict our analysis to the years 1982 and 2006. To construct the regional routine share on the level of planning districts, we use the occupational task information from the 1979 BIBB/IAB wave and weight it with regional employment in 1982 using the detailed occupational employment information entailed in the microcensus. We restrict our sample to the West German civil labor force population from the age of 20 to 60 excluding agricultural and public sector employment. Labor supply is measured as the number of hours worked and includes full-time and part-time employment as well as marginally employed workers. We then relate the growth in low- and medium-skilled service employment between 1982 and 2006 to the initial regional routine intensity in 1982 and present the results in Table 5. To make the results comparable we include a similar set of regional covariates and are furthermore able to include the elderly share of population ($>$ 65 years) which is considered to be a potential demand shifter. Most covariates enter with the expected sign: positive for fraction of high to low and medium skilled, share of foreign employees, female labor force participation, elderly share of population but negative for the share of working population. However, the coefficient estimates are not individually significant in the specification including all regional covariates and are not tabulated in Table 5 to conserve space. The detailed occupational classification in the microcensus allows us to further subdivide service occupations into unskilled (all unskilled personal services) and skilled (essentially order and security occupations as well as skilled service occupations) services.

Table Appendix

Table 1: Top ten occupations with lowest median wage in 1979

Occupation	Log Mean Wage
Hairdressers*	3.79
Attending on guests*	3.82
Household cleaners*	3.99
Innkeepers, Hotel keepers*	4.05
Building laborers	4.07
Cooks*	4.10
Laundry workers	4.12
Cutters	4.13
Gardeners	4.13
Booksellers	4.13

Notes: Wage information derived form SIAB-R for 120 occupation groups. Asterisk denotes service occupations following the occupational classification in Blossfeld (1985).

Table 2: Ranking of occupations according to their task content in 1979

High routine task content	High manual task content	High abstract task content
Cashiers	Electrical appliance, parts assemblers	Technical draftsperson
Stenographers, typists	Household, building cleaners*	Teachers
Post masters, deliverers	Housekeeping managers, attendants*	Mechanical, motor engineers
Accountants	Nursing assistants*	Manufacturing engineers
Office auxiliary workers	Nurses, midwives	Architects, civil engineers
Salespersons	Doormen, caretakers*	Electrical engineers
Sheet metal pressers, metal moulders	Mechanics (no further specification)	Scientists
Iron, metal producers, melters	Innkeeper, bar keepers, waiters*	Musicians, artists
Gardeners, garden workers	Roofers	Technicians
Ceramics workers, glass processors	Motor vehicle drivers*	Other teachers

Notes: Routine intensity is derived from BIBB-IAB data in 1979 and defined as in equation 2. Asterisk denotes service occupations following the occupational classification in Blossfeld (1985).

Figure Appendix

Figure 1: Distribution of routine share 1979

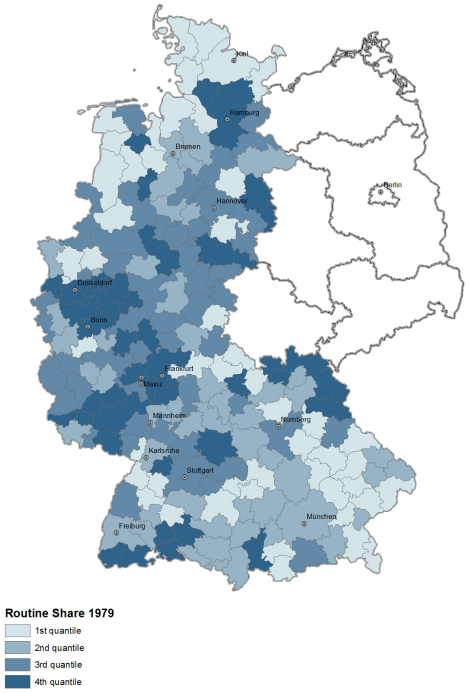


Figure 2: Change in low and medium skilled service sector employment 1979-2007

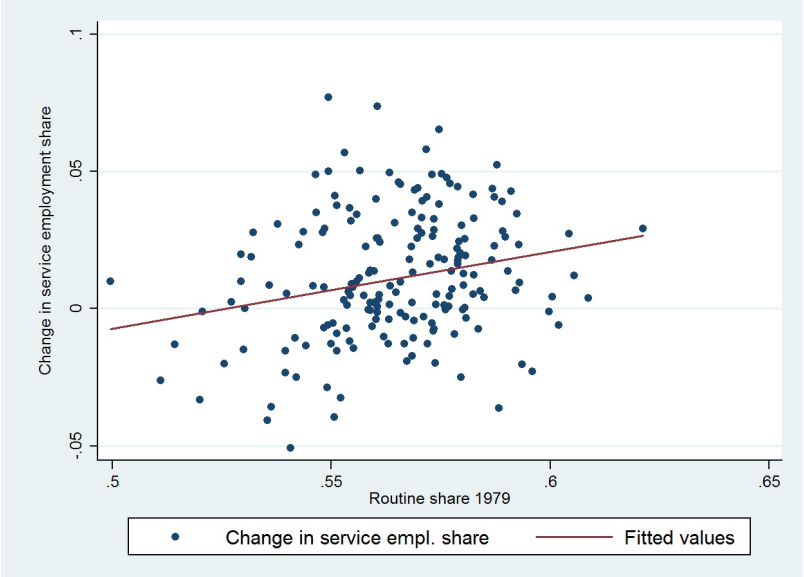
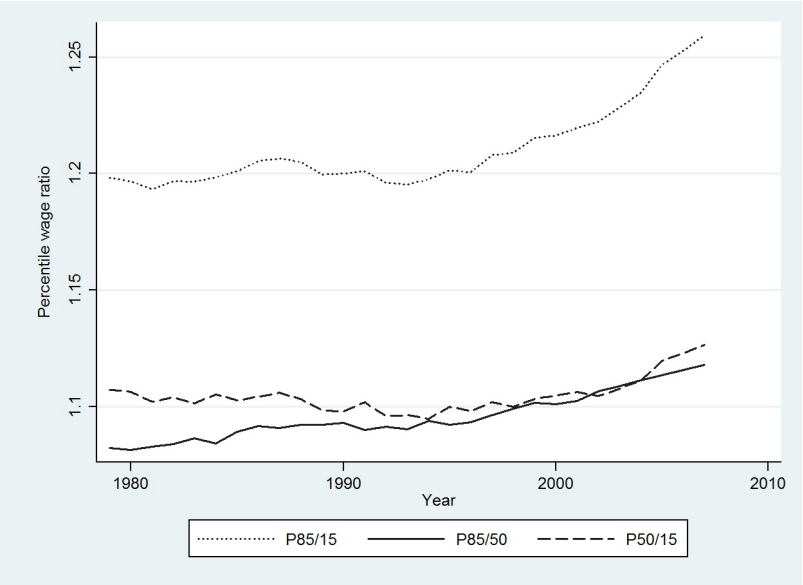


Figure 3: Evolution of the P85/P15, P85/P50 and P50/P15 log wage ratio 1979-2007



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