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Technological change and labor market integration

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Abstract:

Could the industrialization reduce social inequalities? We use the rise of office employment in the early 20th century as a historical experiment to study the effect of technological change on labor market access for vulnerable groups. In regions with industries that were strongly connected to the modern office, we find a higher regional labor force participation of disabled people which is explained by better access to the job market for people with physical impairments due to the new office technology. The beneficial employment effect is not distributed equally across gender but is restricted to disabled men. The composition of the workforce in the new white-collar jobs shows no significant differences, implying that vulnerable groups benefitted in similar proportions to workers without health issues. In sum, the second industrialization started to lower labor market entry barriers which gives proof of a market-based leverage effect to foster social inclusiveness.

JEL classifications: J14, J22, J23, O33

Keywords: Technological change, labor demand, disability, social inequality

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1 Introduction

In the context of inequality, the topic of balanced growth is high on the policy agenda; whether industrialization can have a positive impact on social inclusiveness, decreasing inequality, has not only been of interest today (Kuznets, 1955; Lindert, 2000; Hoffman et al., 2002; Piketty, 2014; Lindert and Williamson, 2016; Naudé and Nagler, 2015, 2017). Indeed, already in 1893 wondered whether the structural transformation initiated during the industrial revolution would challenge, instead of fostering, social inclusiveness (Durkheim, 1984). To our knowledge, this question is still waiting for an answer. Thus, we address this topic by investigating the relationship between industrialization and labor market inclusiveness. Although the analysis takes as a starting point the second industrial revolution, the unique historical setting allows drawing important conclusions for today, namely on how technological change increases labor market access of groups of the workforce underrepresented in the labor market. A modern example for this could be the use of flexible home office models that have become possible due to ICT innovations and that have increased opportunities to work from home for individuals with health issues.

In the early 20th century, white-collar work was on the rise due to the emergence of the modern office.[1] Compared to blue-collar factory work, it had always been less demanding with respect to health and body strength. On top of that, office work now became more routinized due to technological innovations (e.g., typewriter, cash register, mimeograph, dictaphone, stenotype, adding machine) which reformed job tasks and lead to more standardized, less costly office work. The modern office also contributed to the creation of other white-collar jobs that supported office activities, such as cash messengers, ushers, liftboys, copyboys, concierges, janitors, or gatekeepers. On the demand side, the development of modern corporate cultures, vertical integration, internationalization, and increasing regulation, with regard to tax recording and book keeping, increased demand for office workers. The new job content combined with the increased labor demand improved labor market access for groups who back then were underrepresented in the labor force. For instance, there was an increase in the female share of employees who had previously mostly worked in the domestic labor market (Rotella, 1981; Costa, 2000; Wyrwich, 2018).

Against this backdrop, our paper thus investigates how the second industrial revolution – via the emergence of the modern office – influenced labor market participation of people with disabilities. Although the new jobs were originally not designed for people with impairments (Harn, 1987; Krause, 1976), they became attractive to this group due to the lower physical requirements compared to jobs that involved working at workshop benches. Taking further into account the increased labor demand of firms, we hypothesize that the rise of the modern office is positively related to the labor force participation of disabled people.

The chosen time period provides a historical experiment to investigate how social inclusiveness can be achieved in the absence of a close-knit but rather rudimentary safety net for disabled people. Put differently, the cultural and institutional environment of the industrialization entailed very difficult conditions for disabled individuals on the job search. Rising employment rates of this group are driven by market powers of demand and supply and not by government action, allowing a cleaner identification of the effect of technological change (modern office technologies and economic growth) on labor market inclusion. In this context, inclusiveness is captured via the diversity of the workforce which reflects the accessibility to jobs, for instance, for vulnerable groups.

[1] For a detailed definition of the modern office, see Section 3.

We test our hypothesis with unique data from a full census on people with impairments which was conducted in the German Reich in 1925 (*Reichsgebrechlichenzählung*). The census has detailed regional information on demographic characteristics (including employment status and occupation) of all disabled people living in the German Reich and is merged with regional information on the industry and population structure in 1925 (*Berufszählung*). The data distinguish between five types of disabilities (blindness, deafness, deaf-muteness, "weak" and "strong" physical impairments). In the empirical analysis, we exploit spatial variation in the size of office employment during the industrialization in the early 20th century. Following the arguments above, in regions with industries with a higher share of office work, more people with disabilities should take up employment as compared to regions with industrial structures that are dominated by blue-collar work, conditioned on regional factors that may additionally affect the labor force participation of disabled people.

As hypothesized, the empirical results confirm that labor force participation of disabled people is larger in regions with higher levels of office employment relative to other regions. We can also identify this pattern for specific office-related occupations. We find gender differences as these positive relationships do not exist for disabled women. There is also no significant relationship between regional office employment and the share of individuals with health problems in the total workforce. This reveals that the regional prevalence of the office sector did not affect labor force participation of disabled people any more than it did other groups of the population. Our findings prove to be robust in different tests. First, they are not affected by alternative explanations for the employment share of disabled people, including regional conditions like population density or aggregate socioeconomic characteristics of disabled persons (age, schooling, war-related impairments, rudimentary social welfare provision). Second, the causal effect of the level of office jobs on the number of disabled people in employment is confirmed when applying an instrumental variables analysis. To this end, we use the geographical distance between a region and the city of Wittenberg as an instrument for the employment share in office work in two and also four stages least squares regressions. In the 19th century, this distance was negatively related to the spread of Protestantism. The Protestant faith, in turn, was positively associated with pre-industrial literacy levels, the subsequent degree of industrialization (Becker and Woessmann, 2008; 2009; Becker et al., 2011), and the regional number of manufacturing firms, which can be expected to be highly correlated with the regional size of the office sector. The distance to Wittenberg should only affect the labor market prospects of disabled persons via its effect on the local level of employment opportunities in the office sector, making it a valid instrument for our analysis.

In sum, our results show that the rise of the modern office during the second industrialization improved social inclusiveness via providing employment opportunities for people with impairments. The share of workers with disabilities relative to the share of workers without health issues seems to be not affected by the rise of the modern office. This suggests that disabled people did not benefit to a larger degree than other groups underrepresented in the labor market back then or, put differently, disabled profited to the same degree as, for instance, women. This goes contrary to the perception that industrialization increases social inequality.

Our paper contributes to the literature on the socioeconomic impact of the industrial revolution. The time period of the second industrial revolution has been analyzed, for example, with respect to technological change (e.g., Rotella, 1981; Atack, 1985), the introduction of social insurance systems (e.g., Bauernschuster et al., 2017; Guinnane and Streb, 2011; 2015; Fenge and Scheubel, 2014), education (e.g., Ó Gráda 2016; Squicciarini and Voigtländer, 2015; Goldin, 2000), or the labor participation of women (e.g., Costa, 2000; Rotella, 1981); so far disregarding, however, the precarious situation of people with impairments. Work on the skill content of recent technological change illustrates how job tasks related to skills, as becomes evident in the context of computerization where medium-skilled individuals with routine tasks are more prone to lose their jobs than other skill groups (e.g., for computerization see Acemoglu and Autor, 2011; Autor et al., 2003). These analyses have focused on changes in job tasks and their effect on standard qualification groups. We use as skill categorization the health status. Our information on industries and occupational groups then allows understanding potential benefits that arise from the interaction between new tasks (here technologies similar to today's computerization) and skill types.

The topic of our work is of particular relevance due to the overall population ageing which corresponds with an increasing share of workers with disabilities (e.g., Jones 2016; Chen et al., 2016; Aktion Mensch, 2016). In general, there is a negative relationship between disability and labor force participation (e.g., Mussida and Sciulli, 2016). An extensive literature has already assessed the influence of disability insurances (among many others, e.g., Banks et al., 2015; Borghans et al., 2014; Coile et al., 2014; Acemoglu and Angrist, 2001). There are important studies that focus on the influence of workplace conditions (e.g., Hill et al., 2016; Boehm and Dwertmann, 2014). All have in common that they investigate how to increase labor market participation of disabled people as far as possible by setting the right incentives. However, to accurately measure the potential power of lowering entry barriers via technology, it is important that there are no confounding factors such as obligations for employers to fulfill quotas or welfare systems with disability benefits. Our setting provides this unique testbed. Although there was a rudimentary Social Insurance system in Germany in the late 19th century (Fenge and Scheubel, 2014), this did not provide (social) policy protection against the disruptive effects of technological innovations. Instead, it included health, accident, and pension insurances, which were not (yet) large enough to allow for a great share of individuals to stay out of the labor force. Disability benefits only came into being in 1920. Thus, compared to today's welfare system, the incentives (and the likelihood) to live solely on social welfare were low. Furthermore, as the development of the modern office and the institutional changes did not focus on reducing health-related entry barriers, there were no additional (policy) incentives for firms to employ workers with impairments (for instance, via quotas or wage subsidies). In essence, the emergence of the modern office can be regarded a historical experiment for studying the effect of technological change on labor market inclusion of disabled people.[2]

The paper proceeds as follows. Section 2 describes the historical setting. Section 3 explains the empirical framework and Section 4 presents the respective results from our analyses. Section 5 concludes.

2 Historical background

As summarized by Rotella (1981), clerical staff in the late 19th century was typically involved in various company operations. This required a high level of firm-specific skills and contrasted with the situation in the early 20th century. Around this time, the demand for office work as well as the tools used in office jobs changed tremendously. This was primarily driven by exogenous innovations in the field of information technologies, including inventions, such as, the typewriter,

[2] As a word of caution, we want to stress that our study does not allow drawing conclusions regarding the design of today's support programs for disabled persons who are in or out of the labor force. Instead, it sheds light on the power of an enabling channel for increased labor market participation and thereby inclusive growth.

cash register, mimeograph, dictaphone, stenotype, adding machine, Hollerith tabulator, and the billing machine. These allowed the technical standardization of office work, increasing its efficiency and lowering its costs. Office activities carried out with these machines required less on-the-job training, thus lower investments from the employers, and made it attractive to hire employees that were capable of specializing in office work.

The early 20th century also saw a rise of modern industrial corporations (Chandler 1977; Atack 1985) which were in demand for office workers. As another reason for the rise of office employment, Rotella (1981) brings forward the evolving relationship between business and government (e.g., regulation regarding record keeping and tax reporting) as well as organizational change like vertical integration or internationalization. The increasing share of people in office employment in the early 20th century is well-documented. It led to a significant surge in female labor force participation while male workers benefitted to a lesser degree in these and more in other jobs (Costa 2000; Wyrwich, 2018).

Despite the unique historical conditions for an insightful analysis, there is no information on the impact of the modern office on the employment of disabled people, presumably due to a lack of data. The rise of office work should have enhanced the employment opportunities of disabled persons. Factory (blue-collar) work in the early 20th century required physical strengths which implied a lower employability of people with physical impairments. Contrary to that, office work required little physical strength and therefore people with physical impairments should have found it easier to take up employment in white-collar work relative to blue-collar work. Thus, a regional specialization in office work should have been associated with a relatively high share of disabled individuals in employment. The spread of office work should also have increased the demand for jobs dealing with the office organization which, like office work, required little physical skills. Typical jobs of this kind included office and cash messengers, lift operators, or janitors. We understand these jobs as unskilled while clerical jobs that make use of office technologies (e.g., accountants, stenotypists) are regarded as skilled jobs.

It is important to consider the influence of the work (safety) and regulatory (laws targeted at people with disabilities) environment. First, contrary to factory work with its high accident risk, the office sector was a safe work environment due to the different job tasks and machinery. This is further underlined by the fact that Bismarck and his political advisors targeted blue-collar workers with the old age, illness, or invalidity insurance (Lehmann-Hasemeyer and Streb, 2016). Hence, we can rule out that a higher number of disabled employees in that time period and region is caused by the emergence of the modern office.

Second, there was an increasing awareness in the early 20th century that people with impairments were able and willing to work (Biesalski, 1909) but needed to be appropriately educated. This culminated in the law on "cripple welfare" (*Krüppelfürsorgegesetz,* official term back then) in 1920 which aimed to provide vocational training for disabled children and adolescents (Simon, 1927). Since the program was targeted at younger people, its labor market effects should only have become visible after 1925 (the year of the census).

Third, blue-collar workers who became disabled at work were eligible for social insurances that were introduced in the 1880s. These included a health, accident, and pension insurances which, however, were not large enough to stay out of the labor force. The insurance for work-related disabilities (*Invalidenversicherung, 1891*) provided for recipients who could not work anymore. To ensure that access to these insurances does not interfere with our results, we control for the regional share of disabled people receiving benefits. Nonetheless, the welfare system was at best rudimentary and the benefits negligible, without the standards of today's care as found in Western

European countries like Germany. Indeed, for a long-time society did not even consider disabled people as potential employees; the motivation to then integrate disabled people in the workforce was to save money on social welfare (Biesalski, 1909). Thus, the historical environment provides an adequate quasi-experimental setting for our analysis.

3 Empirical framework

3.1 Data sources

The core dataset is the census on the disabled people in the German Reich in 1925 (*Reichsgebrechlichenzählung*, Statistik des Deutschen Reichs, 1929) which provides regional information on the demographic characteristics of all disabled people. The data distinguish between different types of impairment out of which we look at blindness, deafness, deaf-muteness, weak and strong physical impairments.[3] The occupational structure of disabled people is summarized into 35 categories. For selected types of impairment the information on employment status is further broken down by age group and social status (self-employed, dependent employment, home worker and helping family member). The information is available on the spatial level of 31 states and provinces.

Information on the local share of office employment is based on data from the general employment census which was also conducted in 1925 (*Berufszählung*, see Statistik des Deutschen Reichs, 1927). The two data sets are merged by region. This is a full census of the German population, comprising a stratification of employment by industry, occupation, and gender. We identify office employees with the help of manufacturing industries because, in line with the historical background, it is reasonable to assume that white collar-employment in these industries reflects office jobs (for details, see Wyrwich, 2018).[4] In other industry sectors, such as hotels and restaurants, there should have been a higher share of non-office white-collar employment including, for instance, waiters, cooks, trade helpmates, and maids. Therefore, focusing on manufacturing industries should yield a clean measure of office employment; an assumption which we will test in the empirical section.

3.2 Variable descriptions

The main independent variable of interest is the regional number of white-collar employees in manufacturing industries over all employees. As argued above, this employment share indicates the regional employment share in office employment (*LFPALL_OFFICE* from *Berufszählung*).

The data from the census of disabled persons does not directly distinguish between office and factory employment as needed in this analysis. However, we can determine the general labor force participation of disabled persons (henceforth: *LFP_TOTAL*, from *Reichsgebrechlichenzählung*) in German regions. *LFP_TOTAL* is calculated by dividing the number of disabled employees by the number of all disabled people above the age of 14 years by impairment type and gender.

[3] We exclude mental illness because it is unclear to what degree this group could have benefitted from changes in office technologies. Strong physical impairments comprise those people with a permanent disability of limbs (e.g., deformation, amputation), joints (e.g., stiffness, luxation, weakness), spine (e.g., deformation), and/or central and peripheral nervous system (e.g., paresis, paralyses) stemming either from Congenital or trauma related injuries. Other impairments are considered as weak impairments.
[4] Within the group of dependently employed people it is not possible to distinguish between office and non-office jobs.

Following our main argument, we expect that our proxy for the prevalence of office workers *LFPALL_OFFICE* is positively related to *LFP_TOTAL* due to positive direct and indirect effects of the modern office on the labor market inclusion of disabled persons. There should be no or only a modest positive effect of factory employment on the share of disabled employees.

In addition, we are interested in the share of disabled employees relative to the general labor force participation. The outcome variable of interest is the share of disabled employees over all employees.

Apart from these general relationships, our analyses explore specific components of the modern office by disentangling the occupational channels of how the modern office could have affected labor force participation of disabled people. The outcome variables of interest are the share of disabled people in these occupations over all people with disabilities. First, we explore the employment share of disabled people in occupations that should have developed in conjunction with the office sector and that hold a supportive function (*LFP_SUPPORTOFFICE*). Typical jobs of this kind include office and cash messengers, lift operators, or janitors. Second, we analyze the share of disabled employees in high-skilled occupations whose activities were primarily carried out in offices (*LFP_SKILLOFFICE*). This group comprises (1) commercial employees (office and administrative staff) and (2) technical personnel (architects, engineers, technicians, draftsmen and plotter, lab assistants, etc.).

As today, age determines the likelihood of taking up employment but also the likelihood of becoming impaired. We thus control for the age composition of disabled individuals. Our reference group is the share of disabled people aged between 20 and 40 years. Additionally, we control for the age of impairment. More precisely, we include the share of people who became disabled when they were older 60 than years. We also control for the overall population share of disabled people.

It is important to consider the share of disabled people receiving public annuities, namely pensions, accident insurance, and/or disability insurance, because this should be negatively related to incentives to take up employment (Maki, 1993; Mullen and Staubli, 2016) even though the payments were negligible.[5]

For selected groups of disabled people we have information on the number of recipients of "cripple welfare" which comprises vocational training in accordance with the law of "cripple welfare". The law on "cripple welfare", which was introduced in 1920 (*Preußisches Gesetz betreffend die öffentliche Krüppelfürsorge*), encouraged adolescents to take up employment. We consider the share of people receiving support in accordance with this law.[6]

As many men were seriously injured during World War I, there were public policies to promote the reintegration of war veterans into the labor market (Bajohr, 1976). Therefore, we control for regional differences in the share of male veterans with impairments. There were no female veterans.

We add dummy variables for impairment, following the categorization of the data as outlined above. The analyses also include a gender marker, indicating the share of disabled women. We

[5] The low level of annuities implied that receivers continued being active in the labor market. The payment of disability insurance was officially coupled to an inability to work in response to work-related injuries though (Guinnane and Streb, 2015).
[6] Information is available for weakly and strongly "fragile" persons because only these two groups were eligible. As only kids and adolescents who were not yet integrated in the labor market were eligible, the variable should nonetheless play no meaningful role.

introduce regional population density which is a standard “catch-all”-variable for regional conditions. To disentangle the effect of density from white-collar employment, which is typically concentrated in larger cities, only the variation in density that is not related to white-collar employment is considered.[7] Summary statistics can be found in Table A 1.

3.3 Estimation strategy

To investigate our main hypothesis, we start with an OLS estimation with $LFP\_TOTAL_{r,i,g}$ as independent variable, clustering the standard errors by state and impairment type. The analysis is carried out by regions (r), impairment type (i), and gender (g). This implies that we calculate, for instance, the share of female employees who live in the region Berlin and are deaf. The control variables shown in vector $Z_{r,i,g}$ were discussed above.

$$\text{(OLS)}\ LPF\_TOTAL_{r,i,g} = \beta_1 LFPALL\_OFFICE_r + Z_{r,i,g} + \varepsilon_{r,i,g}$$

To rule out endogeneity concerns we also follow a two-stage instrumental variable approach. As instrument in the first stage, we use the distance to the city of Wittenberg on the regional employment share of white-collar employees. Previous research shows that regional differences in education in the 19th century are decisive for the industrialization in Germany. At the same time, spatial variation in education is explained by the spread of Protestantism which, in turn, is explained by distance to Wittenberg; the city where Martin Luther taught (Becker and Woessmann, 2008, 2009; Becker et al., 2011). White-collar employment in manufacturing industries in the early 20th century should be more abundant in areas with a high specialization in manufacturing industries. Thus, distance to Wittenberg should be negatively related to the white-collar employment opportunities in manufacturing industries.

We control for the level of schooling of the disabled population because a certain amount of education was required to engage in office work (Goldin and Katz, 2000). As the educational mark up among Protestants is well-documented (Becker and Woessmann, 2009), not controlling for education might violate the exclusion restriction, given the effect of distance to Wittenberg on the spread of Protestantism found in the literature. That is, Protestantism, which is affected by our instrument, may directly affect the employment share among disabled people due to higher levels of educational attainments among disabled Protestants. Controlling for regional differences in education should thus dispel concerns regarding the validity of the instrument.

The estimations thus have the following structure:

$$\text{(IV\_1)}\ LFPALL\_OFFICE_r = ß_1 DIST\_WITT_r + Z_{r,i,g} + \varepsilon_{r,i,g}$$

$$\text{(IV\_2)}\ LFP\_TOTAL_{r,i,g} = ß_1 LPFA\widehat{LL\_O}FFICE_{r,i,g} + Z_{r,i,g} + \varepsilon_{r,i,g}$$

In the first-stage specification (IV_1) $LFPALL\_OFFICE_r$ represents the regional employment share in the office sector which is measured with white-collar employment in manufacturing. $DIST\_WITT_r$ is the distance to Wittenberg. $LFP\_TOTAL_{r,i,g}$ in the second-stage specification (IV_2) is the regional labor force participation of disabled people. The 2-SLS estimate neglects the additional link between distance to Wittenberg, the population share of Protestants, and the degree of industrialization. This can be captured by estimating a 4-SLS in which the coefficient of interest only measures the effect of the variation in local office employment that is due to regional

[7] To this end, the population density is regressed on the regional white-collar employment share.

differences in manufacturing employment that, in turn, is due to regional differences in Protestantism that are affected by distance to Wittenberg.

4 Results

In this section we start by presenting descriptive evidence for the shifts in the labor force participation of disabled people before discussing our OLS and IV regressions.

4.1 Historical variation in employment shares by groups of impairment

An indicator for a potential effect of the industrialization are changes in the employment shares of people with disabilities between the late 19th century and the early 20th century. There is sparse information on the labor force participation rate of disabled people before 1925. For the German state of Prussia, we digitized data from before the transformation of office work. The data from 1880 stem from the Prussian Statistical Office (Preussische Statistik, 1883). Comparing the labor force participation rates of disabled people between the two years, the results clearly show an increase in employment shares for blind and deaf-mute people (see Table 1). Although lacking earlier data for some impairment types, the large shares of deaf and deaf-mute people, as well as people with weak/strong impairments suggest that the overall working share of disabled individuals was relatively high in 1925. The next step is to understand the driving forces behind this development.

Table 1: **The average labor force participation of disabled people over time by groups of impairment in Prussia**

	Women			Men		
	LFP_TOTAL	LFP_TOTAL	Δ	LFP_TOTAL	LFP_TOTAL	Δ
	1880	1925	1925/1880	1880	1925	1925/1880
Blinds	0.066	0.152	2.312	0.341	0.394	1.155
Deafs	-	0.216	-	-	0.674	-
Weak impairments	-	0.306	-	-	0.855	-
Strong impairments	-	0.172	-	-	0.667	-
Deaf-Mutes	0.268	0.328	1.226	0.582	0.786	1.350

4.2 Determinants of regional employment structures (OLS)

4.2.1 The overall employment rate of disabled individuals

First, we use as dependent variable the employment rate of disabled people, that is, the number of disabled persons in employment over all disabled individuals above the age of 14 years ($LFP\_TOTAL_{r,i,g}$). Table 2 presents the results from OLS estimations with control variables where with each regression we narrow down the definition of the main independent variable.

The joint employment share of white-collar (WC) and blue-collar (BC) workers is positively related to the overall employment rate of disabled individuals (Column I). The coefficient increases when blue-collar workers are not considered in the measure (Column II). Additional specifications reveal that the concentration of white-collar activities *in manufacturing* is decisive for the relationship. The employment share of white-collar and blue-collar employees in manufacturing (Column III) is positively associated with the overall employment rate of disabled people and slightly higher than the previous estimate for all industries (Column I). The coefficient for the regional white-collar employment share in manufacturing (Column IV) is more than four times larger than the respective estimate for general white-collar employment (Column II).

White-collar employment in manufacturing captures primarily office employment that emerged due to the regional degree of industrialization. Thus, the results confirm that the rise of the modern office increased the overall employment rate of disabled people. Furthermore, including the regional share of white-collar employment along with the respective share for blue-collar employment reveals that the former plays a much more important role for the employment rate of disabled people (see Appendix, Table A 2). This is particularly pronounced in manufacturing.

Table 2: The relationship between regional employment structures and the labor force participation of disabled people – Main analyses

Dep Var: $LFP\_TOTAL_{r,i,g}$	I	II	III	IV
(Employees WC + BC)$_r$ /Employees$_r$	0.332***			
	(0.0499)			
Employees WC$_r$/Employees$_r$		0.611***		
		(0.0812)		
(Employees WC + BC manufacturing)$_r$ /Employees$_r$			0.404***	
			(0.0694)	
(Employees WC manufacturing)$_r$/Employees$_r$				2.514***
($LFPALL\_OFFICE_r$)				(0.366)
Controls	Y	Y	Y	Y
Observations	309	309	309	309
R^2	0.862	0.864	0.855	0.862

Notes: Ordinary least square regressions. Standard errors (in parentheses) are clustered by state and impairment type. White-collar (WC) and blue-collar (BC) workers are abbreviated as indicated.
*** p<0.01, ** p<0.05, * p<0.1

The coefficients for the control variables from the results in Table 2 are reported in the Appendix (see Table A 3). The share of recipients of accident or health insurance reduces the employment participation while the share of disabled people who are older than 60 years at the disabling event shows the opposite relationship. Individuals who are blind or have strong physical impairments show significantly lower labor force participation against the baseline group of deaf mute people. Women work significantly less often than men.[8]

In the models of Table 3 we take into account potential gender differences by interacting all independent variables with a female dummy. This is important because of the large increases in female labor force participation around that time. The analysis follows the same steps as in Table

[8] The relevance of the office sector for employment opportunities of people with disabilities is also revealed by an assessment of migration behavior. The local presence of the office sector spurs net migration of disabled people which we captured by comparing the regional population share of people with impairments to the share of people with impairments according to their birthplace region. The results indicate that jobs related to the office sector attracted people with disabilities who might find it difficult to work in other sectors (results are available upon request).

2, revealing a significant negative interaction term for the measures of female white-collar employment. In all specifications, the interaction term remains negative but smaller in size than the baseline variables. This finding shows that the effect of the white-collar sector on employment of disabled people was positive for men and women but much stronger for men.[9]

Table 3: The relationship between regional employment structures and the labor force participation of disabled people – Gender differences

Dep Var: $LFP\_TOTAL_{r,i,g}$	I	II	III	IV
$(\text{Employees WC + BC})_r / \text{Employees}_r$	0.556***			
	(0.0800)			
$[(\text{Employees WC + BC})/\text{Employees}]_r$ * Female	-0.466***			
	(0.101)			
$\text{Employees WC}_r/\text{Employees}_r$		0.872***		
		(0.105)		
$(\text{Employees WC}/\text{Employees})_r$ * Female		-0.571***		
		(0.122)		
$(\text{Employees WC + BC manufacturing})_r / \text{Employees}_r$			0.551***	
			(0.0997)	
$[(\text{Employees WC + BC manufacturing}) / \text{Employees}]_r$ * Female			-0.362***	
			(0.112)	
$\text{Employees WC manufacturing}_r/\text{Employees}_r$ ($LFPALL\_OFFICE_r$)				3.333***
				(0.503)
$(\text{Employees WC manufacturing}_r/\text{Employees}_r)$ * Female ($LFPALL\_OFFICE_r^{female}$)				-2.008***
				(0.567)
Controls	Y	Y	Y	Y
Controls * Female	Y	Y	Y	Y
Observations	309	309	309	309
R^2	0.927	0.922	0.913	0.919

Notes: Ordinary least square regressions. Standard errors (in parentheses) are clustered by state and impairment type. White-collar (WC) and blue-collar (BC) workers are abbreviated as indicated.
*** p<0.01, ** p<0.05, * p<0.1

Table 4 repeats the analysis another time but uses as the independent variable the share of disabled employees among all employees, providing an understanding of whether the detected positive relationships also affected the relative employment share of disabled people in the workforce. The results show that the presence of the white-collar sector did not change the relative share of disabled people in the labor market. Thus, the disabled did not benefit disproportionately to other groups, for example women, from the rise of the modern office in terms of employment. There are no gender-specific effects among disabled people in the analysis of Table 4 (Columns V to VIII).

[9] There are also some gender differences among the control variables which we do not report and discuss for the sake of brevity.

Table 4: The relationship between regional employment structures and the share of disabled employees among all employees

Dep Var: (Share of disabled employees/ Employees)	II	II	III	IV	V	VI	VII	VIII
(Employees WC + BC)$_r$ /Employees$_r$	-0.000401				-0.000959**			
	(0.000262)				(0.000477)			
[(Employees WC + BC) /Employees]$_r$ * Female					0.000251			
					(0.000609)			
Employees WC$_r$/Employees$_r$		0.000377				-0.000888		
		(0.000425)				(0.000649)		
(Employees WC/Employees)$_r$ * Female						0.000448		
						(0.000674)		
(Employees WC + BC manufacturing)$_r$ /Employees$_r$			0.000145				-0.000228	
			(0.000347)				(0.000420)	
[(Employees WC + BC manufacturing) /Employees]$_r$ * Female							-0.000278	
							(0.000496)	
Employees WC manufacturing$_r$/Employees$_r$				0.00193				-0.00118
($LFPALL\_OFFICE_r$)				(0.00208)				(0.00226)
(Employees WC manufacturing/Employees)$_r$ * Female								-0.000958
($LFPALL\_OFFICE_r^{female}$)								(0.00217)
Controls	Y	Y	Y	Y	Y	Y	Y	Y
Controls * Female	N	N	N	N	Y	Y	Y	Y
Observations	309	309	309	309	309	309	309	309
R^2	0.965	0.965	0.965	0.965	0.976	0.975	0.975	0.974

Notes: Ordinary least square regressions. Standard errors (in parentheses) are clustered by state and impairment type. White-collar (WC) and blue-collar (BC) workers are abbreviated as indicated. *** p<0.01, ** p<0.05, * p<0.1

Table 5: The share of disabled employees in office-related jobs (SUPPORTOFFICE)

Dep Var: $LFP\_SUPPORTOFFICE_{r,i,g}$	I	II	III	IV	V	VI	VII	VIII
$(\text{Employees WC + BC})_r / \text{Employees}_r$	0.0282*				0.0347			
	(0.0141)				(0.0235)			
$[(\text{Employees WC + BC}) / \text{Employees}]_r$ * Female					-0.0293			
					(0.0238)			
$\text{Employees WC}_r / \text{Employees}_r$		0.0650***				0.132***		
		(0.0213)				(0.0394)		
$(\text{Employees WC/Employees})_r$ * Female						-0.131***		
						(0.0404)		
$(\text{Employees WC + BC manufacturing})_r$ $/\text{Employees}_r$			0.0297**				0.0352	
			(0.0133)				(0.0234)	
$[(\text{Employees WC + BC manufacturing}) / \text{Employees}]_r$ * Female							-0.0337	
							(0.0240)	
$\text{Employees WC manufacturing}_r / \text{Employees}_r$				0.204**				0.313**
($LFPALL\_OFFICE_r$)				(0.0857)				(0.148)
$(\text{Employees WC manufacturing/Employees})_r$ * Female								-0.312**
($LFPALL\_OFFICE_r^{female}$)								(0.148)
Controls	Y	Y	Y	Y	Y	Y	Y	Y
Controls * Female	N	N	N	N	Y	Y	Y	Y
N	124	124	124	124	124	124	124	124
R^2	0.759	0.765	0.755	0.760	0.864	0.882	0.862	0.870

Notes: Ordinary least square regressions. Standard errors (in parentheses) are clustered by state and impairment type. White-collar (WC) and blue-collar (BC) workers are abbreviated as indicated. *** p<0.01, ** p<0.05, * p<0.1

Table 6: The share of disabled employees in high-skilled office jobs (SKILLOFFICE)

Dep Var: $LFP\_SKILLOFFICE_{r,i,g}$	I	II	III	IV	V	VI	VII	VIII
$(\text{Employees WC + BC})_r / \text{Employees}_r$	0.00629**				0.0108*			
	(0.00276)				(0.00600)			
$[(\text{Employees WC + BC}) / \text{Employees}]_r$ * Female					-0.0104*			
					(0.00606)			
$\text{Employees WC}_r / \text{Employees}_r$		0.00846*				0.0110		
		(0.00459)				(0.01000)		
$(\text{Employees WC}/\text{Employees})_r$ * Female						-0.0102		
						(0.00995)		
$(\text{Employees WC + BC manufacturing})_r / \text{Employees}_r$			0.00785**				0.0143*	
			(0.00381)				(0.00785)	
$[(\text{Employees WC + BC manufacturing}) / \text{Employees}]_r$ * Female							-0.0138*	
							(0.00786)	
$\text{Employees WC manufacturing}_r / \text{Employees}_r$ ($LFPALL\_OFFICE_r$)				0.0525***				0.0859**
				(0.0192)				(0.0419)
($\text{Employees WC manufacturing}_r / \text{Employees}_r$ * Female ($LFPALL\_OFFICE_r^{female}$)								-0.0825*
								(0.0421)
Controls	Y	Y	Y	Y	Y	Y	Y	Y
Controls * Female	N	N	N	N	Y	Y	Y	Y
N	309	309	309	309	309	309	309	309
R2	0.440	0.436	0.438	0.442	0.546	0.538	0.546	0.547

Notes: Ordinary least square regressions. Standard errors (in parentheses) are clustered by state and impairment type. White-collar (WC) and blue-collar (BC) workers are abbreviated as indicated. *** p<0.01, ** p<0.05, * p<0.1

4.2.2 The employment rate of disabled people by occupational groups

To understand whether jobs that were related to the emergence of the modern office experienced significant increases in the share of disabled employees, we focus our regression analysis on two occupational groups.

The first group $LFP\_SUPPORTOFFICE_{r,i,g}$ captures jobs that are indirectly created and demanded by a rising office sector. These are not typical clerical occupations but instead the group comprises, for instance, janitors, cash messengers, lift boys, and ushers. Information is available for individuals with major and minor physical impairments. The second occupational group is $LFP\_SKILLOFFICE_{r,i,g}$ which captures skill-intensive white-collar jobs.

The models of Table 5 and Table 6 repeat the same steps as in the previous analyses but focusing the dependent variable on the share of disabled employees in high-skilled and more low-skilled office-related jobs. In both occupational groups, the results tell the same story in terms of size and signs of the coefficients (Columns I to IV). The assessment of gender-specific effects confirms again that there was a close-to-zero employment rate effect for disabled women, even though the negative interaction effect for $LFP\_SKILLOFFICE_{r,i,g}$ is only weakly significant (Table 5 & 6, Column VIII). The size of the coefficients is obviously smaller because the occupational groups captured by the independent variable represent a smaller share of the labor market. However, comparing the coefficients across models shows the same pattern as for the overall labor force participation of disabled people; namely that a general specialization in white-collar or manufacturing employment is strongly related to labor force participation of disabled people and that the effect is much stronger for disabled men than for disabled women. The similarity of the results from Table 3, 5, and 6 confirm the validity of our empirical models.

4.3 The causal effect of the modern office

We run instrumental variables regressions to assuage concerns that our baseline results presented in Table 2 are driven by endogeneity. A potential bias could be that regions with a high proportion of office employment differ significantly from other regions in terms of their integration potential, for instance, due to different education levels or attitudes towards disabled people. To isolate the true effect of the second industrialization without such interfering factors, we rely on a two-stage least squares approach with distance to the city of Wittenberg as instrument. If our concerns were justified, we should see a change in the size of coefficients – most likely a decrease.

The first stage results in Table 7 (Columns I to III) confirm a negative relationship between distance to Wittenberg and $LFPALL\_OFFICE_r$. In the second stage there is a clear positive effect of office sector specialization ($LFPALL\_\widehat{OFFICE}_{r,i,g}$) on the general employment rate ($LFP\_TOTAL_{r,i,g}$) for the complete sample (Column IV). When separating the sample by gender, the positive effect is only visible for men (Column V) and not for women (Column VI).[10]

[10] There is a slight upward bias of the coefficients in the specifications for disabled men. This pattern seems to be driven by the vector of control variables. The coefficient in the IV model is lower than in OLS when excluding the vector of controls. Note that we control for education levels of people with impairments to account for the potential influence of distance to Wittenberg on education levels.

When extending the analysis to a 4-SLS estimation, the historical narrative on the proposed link between distance to Wittenberg and white-collar employment in manufacturing (spread of Protestantism, industrialization) can again be confirmed (see Table A 4).[11]

Table 7: The causal effect of the office sector (2 SLS)

	I	II	III	IV	V	VI
	First stage Dep Var: *LFPALL_OFFICE*$_r$			Second stage Dep Var: *LFP_TOTAL*$_{r,i,g}$		
	All	Men	Women	All	Men	Women
Distance to Wittenberg (log, $DIST\_WITT_r$)	-0.0137***	-0.0137***	-0.0135***	-	-	-
	(0.00122)	(0.00172)	(0.00183)			
Employees WC manufacturing$_r$/Employees$_r$ ($\widehat{LFPALL\_OFFICE_{r,i,g}}$)	-	-	-	2.070***	3.887***	0.229
				(0.588)	(0.763)	(0.586)
Controls	Y	Y	Y	Y	Y	Y
First Stage F-Statistics	289.619***	161.207***	126.375***	-	-	-
Observations	309	155	154	309	155	154
R^2	0.517	0.595	0.552	0.862	0.883	0.522

Notes: Two stages least squares regressions. Standard errors (in parentheses) are clustered by state and impairment type. *** p<0.01, ** p<0.05, * p<0.1

5 Conclusions

A prerequisite for the employment of disabled individuals is that job requirements match (dis)abilities. Although there has been a massive change in job content in recent decades due to computerization, which could have raised the employment share of people with disabilities, the share has remained relatively stable. This feeds into the question how technological change influences social inequality. We take advantage of a time period of massive technological change and weak social security benefits and use this as an historical experiment for our analysis: the second industrial revolution and the emergence of the modern office.

Our results show that the modern office—understood as a new working environment that was shaped by innovative office technologies—increased the employment of individuals with impairments. The employment effect showed up for male, instead of female, workers with disabilities. Our findings are robust to various specifications. This suggests that, although the industrialization lowered entry barriers to office jobs, thereby increasing social inclusiveness in absolute terms, the benefits were not equally distributed across the population of disabled individuals. However, in comparison with the overall workforce, disabled people benefitted to a similar degree like non-disabled people. Hence, whereas the workforce composition became more inclusive, social inequalities, reflected by the lower effect for disabled women, continued to persist.

[11] There is no data on for Germany as a whole on pre-industrial literacy levels. Therefore, this variable is not considered in the analysis. The population share of Protestants and the employment share of manufacturing are taken from the 1925 census. We assume that there is persistence in both shares from the 19th to the early 20th century. This justifies this choice instead of shares for the 19th century which are also not available for Germany as a whole.

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7 Annex

Table A 1: Summary Statistics

	Mean	S.D.	Min	Max
Share of disabled employees among all disabled people ($LFP\_TOTAL_{r,i,g}$)	0.28	0.21	0	0.85
Share of disabled employees among all employees	0	0	0	0.01
Share of disabled employees in office-related jobs among all disabled people ($LFP\_SUPPORTOFFICE_{r,I,g}$)	0.02	0.02	0	0.07
Share of disabled employees in high-skilled office jobs among all disabled people ($LFP\_SKILLOFFICE_{r,i,g}$)	0	0.01	0	0.05
Employees WC manufacturing/Employees ($LFPALL\_OFFICE_r$)	0.03	0.02	0.01	0.07
White/blue collar worker among all employees (in %)	0.6	0.1	0.32	0.76
Employees WC/Employees	0.16	0.06	0.07	0.32
(Employees WC + BC manufacturing) /Employees	0.21	0.08	0.07	0.41
ln_dist_wb ($DIST\_WITT_r$)	5.52	0.52	4.04	6.43

Table A 2: The relationship between regional employment structures and the share of disabled employees among all employees: Robustness checks

Dep Var: $LFP\_TOTAL_{r,i,g}$	I	II	III	IV
Employees BC_r/$Employees_r$	0.292***	0.159**		
	(0.0651)	(0.0606)		
Employees WC_r/$Employees_r$		0.557***		
		(0.0801)		
Employees BC $manufacturing_r$/$Employees_r$			0.0636*	-0.199***
			(0.0325)	(0.0374)
Employees WC $manufacturing_r$/ $Employees_r$				4.090***
($LFPALL_{OFFICE_r}$)				(0.571)
Controls	Y	Y	Y	Y
Observations	309	309	309	309
R^2	0.848	0.866	0.842	0.871

Notes: Ordinary least square regressions. Standard errors (in parentheses) are clustered by state and impairment type. *** p<0.01, ** p<0.05, * p<0.1

Table A 3: The relationship between regional employment structures and the labor force participation of disabled people: Table 2 with coefficients for control variables

Dep Var: $LFP\_TOTAL_{r,i,g}$	I	II	III	IV
$(\text{Employees WC + BC})_r$ /Employees_r	0.332***			
	(0.0499)			
Employees WC_r/Employees_r		0.611***		
		(0.0812)		
$(\text{Employees WC + BC manufacturing})_r$ /Employees_r			0.404***	
			(0.0694)	
$\text{Employees WC manufacturing}_r$/$\text{Employees}_r$				2.514***
($LFPALL\_OFFICE_r$)				(0.366)
Disabled people aged >15 with >3 years of schooling (in %)	0.194*	0.230*	0.148	0.166
	(0.113)	(0.119)	(0.115)	(0.120)
Disabled people aged 20-40 (in %)	0.267	0.291	0.266	0.262
	(0.178)	(0.180)	(0.190)	(0.182)
People with war-related impairments (in %)	-0.00326	-0.0405	-0.00364	-0.0157
	(0.0921)	(0.0924)	(0.104)	(0.0947)
Recipients accident insurance (in %)	-0.677***	-0.556***	-0.726***	-0.606***
	(0.182)	(0.165)	(0.201)	(0.181)
Recipients health insurance (in %)	-0.314**	-0.317**	-0.305**	-0.299**
	(0.143)	(0.135)	(0.133)	(0.135)
Recipients pensions (in %)	-0.428**	-0.291*	-0.301	-0.348*
	(0.181)	(0.159)	(0.186)	(0.181)
Disabled people aged >60 at disabling event (in %)	0.237***	0.290***	0.284***	0.297***
	(0.0855)	(0.0821)	(0.0869)	(0.0852)
Population share of disabled people	12.26*	15.49**	12.38*	14.62**
	(6.434)	(6.572)	(6.943)	(6.337)
Female (Yes=1)	-0.309***	-0.307***	-0.313***	-0.309***
	(0.0252)	(0.0256)	(0.0245)	(0.0253)
Deaf Mute (Yes=1)	Ref	Ref	Ref	Ref
Blind (Yes=1)	-0.178***	-0.195***	-0.196***	-0.204***
	(0.0262)	(0.0277)	(0.0279)	(0.0270)
Deaf (Yes=1)	-0.0422*	-0.0447*	-0.0515**	-0.0536**
	(0.0233)	(0.0227)	(0.0233)	(0.0218)
Weak physical impairment (Yes=1)	0.0120	-0.00400	0.0180	0.00388
	(0.0315)	(0.0312)	(0.0309)	(0.0306)
Strong physical impairment (Yes=1)	-0.129***	-0.156***	-0.130***	-0.148***
	(0.0258)	(0.0273)	(0.0268)	(0.0269)
Adj. population density (log)	0.0201**	0.0116	-0.0113	-0.0130
	(0.00931)	(0.00916)	(0.0124)	(0.0110)
Area is located in Prussia	-0.00237	0.000358	0.00414	-0.00227
	(0.00942)	(0.00966)	(0.00982)	(0.00910)
Observations	309	309	309	309
R^2	0.862	0.864	0.855	0.862

Notes: Ordinary least square regressions. Standard errors (in parentheses) are clustered by state and impairment type. *** p<0.01, ** p<0.05, * p<0.1. The characteristics of disabled people are measured by region, impairment, and gender.

Table A 4: The causal effect of the office sector (4 SLS)

	I	II	III	IV
Dep Var	*$PROTS_r$*	*LFS_MANU_r*	$LFPALL\_OFFICE_r$	*$LFP\_TOTAL_{r,i,g}$*
Distance to Wittenberg (log $DIST\_WITT_r$)	-0.249***			
	(0.0317)			
Population share of Protestants ($PROTS_r$)		0.292***		
		(0.0526)		
Employment share in manufacturing (LFS_MANU_r)			0.189***	
			(0.0135)	
Employees WC manufacturing$_r$/Employees$_r$ ($\widehat{LFPALL\_OFFICE}_{r,\iota,g}$)				2.070***
				(0.592)
Controls	Y	Y	Y	Y
Observations	309	309	309	309

Notes: Four stages least squares regressions. Standard errors (in parentheses) are clustered by state and impairment type. *** p<0.01, ** p<0.05, * p<0.1. Wald Chi^2=232568.46.