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## Tightening Access to Early Retirement: Who Can Adapt?

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# Tightening access to early retirement: who can adapt?

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**Abstract:** We study heterogeneity in the effects of two pension reforms that closed pathways into early retirement, the abolition of old-age pension for women and the abolition of old-age pension after unemployment or part-time work. We focus on effect heterogeneity with respect to occupational tasks, job strain exposure, PC use at work and new technological developments. Both reforms had significant effects on individuals' employment states and in both cases the effects differ significantly by groups of employees. Most prominently, the effects are larger in occupations with higher job strain and, in case of the old-age pension for women, a higher effect on unemployment. This suggests that job strain prevents workers from carrying on up to the increased retirement age. Effects differ by performed tasks and PC use, too; although the effects are less uniform than those for job strain. Our analysis shows that longer employment participation is not equally feasible for all employees. This highlights the importance of targeted support to maintain employability and to create jobs which correspond to the demands of older employees.

**Keywords:** Pension reforms, effect heterogeneity, occupational demands, occupational tasks

**JEL-Classification:** J18, J22, J26

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# 1 Introduction

In many industrial countries, the employment rate of older workers has increased substantially over the last two decades (OECD 2021). In Germany, for instance, the employment rate in the age group 60 to 65 has doubled from the early 2000s to 2014 (Steiner 2017). In addition, working time has increased among older workers and the incidence of unemployment has declined.

These changes are often attributed to a paradigm shift in pension policy. Early retirement opportunities were reduced and the promotion of older peoples' employment strengthened. Numerous studies analyse the causal effects of pension reforms on older workers' labour market outcomes (Geyer & Welteke (2021), Lalive et al. (2022), Riphahn & Schrader (2022)). However, the causal relationships in this area are extraordinarily complex. Demographic, socio-structural, cultural, health and economic causes interact with institutional changes (Brussig et al. 2016).

In this paper, the focus is on the role of job strain and tasks in influencing and moderating the impact of pension reforms on employment and retirement transitions of older workers. We consider two reforms of the pension system which closed down favourable pathways into early retirement. We ask whether individuals were differently affected by these reforms dependent on tasks they perform or job strain they are exposed to.

We find significant differences in effect sizes with respect to different levels of occupational demand as well as different occupational tasks. For both pension reforms analysed, the effect on employment is smaller for those working in highly demanding occupations or performing more non-routine manual tasks, while the effect on unemployment is higher for those performing more cognitive tasks. We also find significant differences regarding other task measures, which however differ between the reforms.

The remainder of the paper is organised as follows: Section 2 briefly summarizes the existing literature, section 3 introduces the German pension system and the details of the reforms considered, section 4 describes our dataset, section 4.1 lays out our estimation approach, sections 5 and 5.3 present our results and finally, section 6 concludes.

## 2 Previous literature

Numerous studies analyse behavioural responses to benefit-cutting reforms of the U.S. Social Security system, e. g. Coile & Gruber (2007), Blau & Goodstein (2010), Mastrobuoni (2009), or Behaghel & Blau (2012). In addition, several studies focus on unintended effects of retirement reforms such as increased claiming behaviour at distinct ages (Song & Manchester 2007) or the spillover effects on other schemes like disability pensions (Duggan et al. 2007, Panis et al. 2002).

Findings for European countries are generally close to those for the US. Hanel & Riphahn (2012) and Lalive et al. (2022), for example, find delayed pension claiming in response to reduced retirement benefits and an increased retirement age in Switzerland. Similar findings exist for Austria (Manoli & Weber 2016, Staubli & Zweimüller 2013). Staubli & Zweimüller (2013) find considerable spillover effects on both unemployment and disability insurance. Bönke et al. (2018) show for Germany that decrements effectively influence retirement behaviour. Engels et al. (2017) find increased employment rates in response to a German pension reform exclusively affecting women, while they do not find any substitution into unemployment. Geyer & Welteke (2021), analysing the same reform, show that it preserves both employment and unemployment rather than it causes active programme substitution. Riphahn & Schrader (2022) analyse early retirement reforms and find strong behavioural responses, i. e. postponed retirement, employment later in life, postponed unemployment and the use of other pathways into retirement.

There is also some evidence on heterogeneous effects of pension reforms. Hanel (2012), Staubli & Zweimüller (2013), Geyer et al. (2020) or Oude Hengel et al. (2021) show different reform effects with respect to health status and/or income. Hanel & Riphahn (2012) and Buchholz et al. (2013) differentiate their analyses with respect to education.

A second area of research paramount to our research question analyses the relationship between working conditions and retirement. Berg et al. (2010) conclude from their literature review that high physical and psychosocial work demand are important factors for early retirement. Blekesaune & Solem (2005) find that low autonomy in job tasks and psychological job stress are associated with early retirement. Robroek et al. (2013) also identify low job control as a risk factor for early retirement. The authors do however not find a relation between physical job demands and exit from work. In contrast, Brussig (2016) shows that those who retire early had been exposed to strenuous work conditions to a larger extent than those who quit their job at the

regular retirement age. This result does however not hold for early retirement after unemployment or part-time work.

Besides job demand, other characteristics, such as tasks performed, might favour either prolonged employment or early retirement. Velde (2017) finds a significant, but quantitatively small relationship between routine tasks and early retirement. Applying a duration model, Radl (2013) shows that skilled manual workers, lower sales and service workers and higher-grade blue-collar workers retire earlier than routine workers.

Friedberg (2003) shows that workers who use computers exit from the labour market later than workers who do not use computers. This is in contrast to what Biagi et al. (2013) find. According to their results, neither computer literacy nor computer use on the job per se significantly impact the probability to retire. However, the joint effect of computer literacy and computer use significantly reduce the probability to retire. Hudomiet & Willis (2022) find that older workers' delayed onset of computer use significantly increased their transition from work to non-participation. Technical change as a whole can have different effects on early retirement. Bartel & Sicherman (1993) and Burlon & Vilalta-Bufí (2016) for example find that in industries with high technical change the probability for later retirement is higher than in industries with low technical change. Ahituv & Zeira (2011) show in a general equilibrium model that aggregate technical change induces individuals to work longer, while sector-specific technical change has the opposite effect.

A small but growing strand of literature analyses heterogeneous effects of pension reforms with regard to job demands and job tasks. Among them, Mertens & Romeu-Gordo (2021), Giesecke (2018) and Ardito (2021) find that the reaction to pension reforms differs by occupational tasks. Geyer et al. (2022) do not find different reactions to pension reforms due to differences in job demands. Carrino et al. (2020) also do not find different employment effects of a pension reform between routine, intermediate and managerial workers. However, their results suggest that prolonged exposure to high-strain jobs characterised by high demands and low control lead to negative health effects of an increasing retirement age.

## 3 Pension reform in Germany

### 3.1 Overview over the German pension system

The German public pension insurance belongs to the oldest public pension systems worldwide.<sup>1</sup> It is constructed as a pay-as-you-go system for dependent employees with contributions paid by both individuals and their employers.<sup>2</sup> Benefits are roughly proportional to average lifetime labour market income, adjusted by the number of years of contributing to the system. There are three different types of benefits individuals can claim: old-age pensions (from the age of 60), disability pensions (paid to those younger than 60<sup>3</sup>) and surviving dependants' pensions (paid to widows and orphans). As regards old-age pensions, there are several pension types with different eligibility criteria. Besides the regular old-age pension, which cannot be claimed early, there are specific old-age pension types, e. g. for women, unemployed or disabled persons, which allow for early retirement. In this paper, we will focus on two specific old-age pension types, the old-age pension for women and the old-age pension after unemployment or part-time work.

Throughout its history, the German public pension system has already undergone many far-reaching reforms – not only in the past two decades (see Börsch-Supan et al. 2020). In the 1970s an early retirement possibility was introduced for individuals who had contributed to the pension system for at least 35 years. From then on, they could retire at the age of 63 (instead of 65) without facing any deductions. Furthermore, special old-age pension opportunities existed for older disabled workers or unemployed individuals (with fairly easy-to-fulfil eligibility criteria), such that retirement as early as at the age of 60 was possible. In the following, early retirement became very popular, such that the average retirement age reached a minimum of just above 62 years for men in the early 1980s (see Börsch-Supan & Schnabel 1998). From the mid-1980s on, the increasing fiscal burden due to an ageing population in combination with early retirement became more and more apparent and contribution rates were projected to skyrocket. This started an era of reforms aiming at securing the long-run sustainability of the pension system. In 1992,

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<sup>1</sup>A detailed description of the German public pension system can be found in Börsch-Supan & Wilke (2012).

<sup>2</sup>This does not hold for the majority of self-employed and for civil servants. The former have to save for their retirement themselves and the latter are insured in an entirely separate system.

<sup>3</sup>These pensions are converted to old-age pensions at the regular retirement age.

decrements for early retirement were introduced and eligibility rules tightened.<sup>4</sup> In 2007, the regular retirement age was legislated to increase from 65 to 67 years. This increase will take place stepwise between 2012 and 2031 and affects cohorts born in 1947 and thereafter. The reform process will transform the once monolithic public regime into a multi-pillar system of public, occupational, and private pensions. In the end, securing one's standard of living will most likely depend on getting benefits from several or all of these pillars.

### 3.2 Pension reforms analysed

The pension types we will be considering in the following were introduced in 1957 and restricted to individuals born before 1952 in 1999. The first one is the **old-age pension for women**. The reasoning behind an advantageous pension type for women was a compensation for the twofold burden women faced by employment and domestic work. However, as credits for periods of raising children were introduced by the 1992 reform, this argumentation became less important.<sup>5</sup> Women could retire from the age of 60, but this threshold was increased to 65 for cohorts born in the end of 1944 and later.<sup>6</sup> Early claiming from age 60 remained possible with decreased benefits. Prerequisites for being able to claim this pension type were having paid contributions for at least ten years after the age of 40 and having fulfilled a qualifying period of 15 years.

The second pension type is the **old-age pension after unemployment or part-time work**. Effectively, this pension type insures elderly individuals against the risk of unemployment. However, it was widely misused to make older employees redundant and thus burdened the pension system substantially.<sup>7</sup> Originally, the old-age pension after unemployment or part-time work could be claimed from the age of 60. From 1997, the retirement age was increased to age 65,<sup>8</sup> but incentives to retire early remained strong as early retirement with benefits reduced by decrements was still possible from age 60. The threshold for early claiming was finally also increased to age

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<sup>4</sup>Having fulfilled a qualifying period of 35 years, retirement is possible from the age of 63. However, for every month an individual retires before the regular retirement age, deductions of 0.3% are due. Earlier retirement is only possible for severely disabled workers and miners. Further provisions for women and unemployed are about to expire and apply only to certain cohorts.

<sup>5</sup>See Künzler (2012, 349).

<sup>6</sup>The retirement age was increased in 60 monthly steps for the cohorts born from the beginning of 1940.

<sup>7</sup>See Künzler (2012, 349).

<sup>8</sup>The increment took place in 60 monthly steps from 60 to 65 years for the cohorts born from 1937 until 1941.

63.<sup>9</sup> However, this increase contained an important protection of legitimate expectation clause (so called *Vertrauensschutzregelung*).<sup>10</sup> It was legislated that for individuals who had been unemployed on January 1<sup>st</sup>, 2004 or who had agreed upon old-age part-time work with their employers by that date, early retirement remained possible from the age of 60 on. It was argued that these individuals had planned ahead the end of their career relying on the status-quo of pension legislation and that their reliance upon the pension system had to be protected.<sup>11</sup> To claim this type of pension, individuals had to have fulfilled a qualifying period of at least 15 years and paid contributions for at least eight out of ten years before retirement. Additionally, individuals either had to be unemployed at the time of retirement or have worked part-time for at least two years after the age of 55. Unemployment had to have lasted for at least one year after the age of 58 years and 6 months. It did not matter when unemployment occurred or if several shorter periods of unemployment added up to one year.

We analyse the closing of the pathway to early retirement via both of the pension types described above. From 2015 on, early retirement via the old-age pension for women was not possible any more. Early retirement via the old-age pension after unemployment or part-time work was not possible from 2012 any more. Both reforms affected individuals born after 1951. While the first reform mentioned affected women only, the second reform was directed mainly at male employees; in 2012, 87 percent of claimants to this pension type were male (Deutsche Rentenversicherung Bund 2022, 62). This allows us to implicitly compare the effects of pension reforms between men and women. Table 1 gives an overview over the reforms.

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<sup>9</sup>The increase began with the cohort born in 1946 and was completed for cohorts born from December 1948 on.

<sup>10</sup>The draft legislation can be found in Deutscher Bundestag (2003, 27) (however only available in German). It lays out the aims of the protection of legitimate expectation clause and contains detailed explanations.

<sup>11</sup>In fact, the results will show that the phasing out of the exemption had a much larger effect than the abolition of the early-retirement option itself.



<b>Abolition of old-age pension for women</b>	
Affected	Reform effective from
Women born after 1951	2012 (early retirement)
	2017 (regular retirement)
<b>Abolition of old-age pension after unemployment or part-time work</b>	
Affected	Reform effective from
Individuals born after 1951	2015 (early retirement)
	2017 (regular retirement)

**Table 1** – Pensions Reforms Under Study

## 4 Methods and data

### 4.1 Identification and estimation

Our approach to identify and estimate the average effects of early retirement reforms builds up on the regression discontinuity design used by Geyer & Welteke (2021). The basis of identification is that different birth cohorts are either affected or not affected by a particular reform. We limit attention to individuals who are, due to their birth dates, just affected or just not affected by the reforms. In particular, we consider individuals born in 1951 (controls) or 1952 (treated). Our dataset contains all individuals of the respective cohorts who have ever been insured in the German pension system. It is thus large enough for our analysis and we do not have to include adjacent cohorts. We estimate the effect based on the comparison of these cohorts and differentiate the effects by job strain, tasks and technologies.

As outcome variables, we consider employment and unemployment as distinct individual labour market states. These variables capture whether affected individuals continued in employment up to new retirement age or whether they have an unemployment spell (or several of them) as a bridge between employment and retirement. In a part of the analysis, we also consider entry into retirement (in all possible pension types) and disability pensions. The effect on retirement

shows the degree of compliance with the pension reform, i.e. the share of individuals directly affected. Disability pensions could be a possible substitute for the types of pension abolished by the reforms (Duggan et al. (2007), Staubli & Zweimüller (2013)).

Since the outcomes may vary with birth cohort, age, or time, we account for these (note that there is a linear dependence of the three, so we need to account only for two of them). In the basic regression without further differentiations, we estimate a linear model of the form

$$y_{it} = \alpha + \beta D_i + \gamma_0(1 - D_i)f(z_i - c) + \gamma_1 D_i f(z_i - c) + \mathbf{X}'_{it}\delta + \varepsilon_{it}, \quad (1)$$

where  $y_{it}$  is a (binary) outcome variable,  $D_i$  is a binary treatment indicator, which equals 1 if an individual  $i$  is affected by a reform in period  $t$ ,  $\gamma_0(1 - D_i)f(z_i - c)$  and  $\gamma_1 D_i f(z_i - c)$  capture possibly different time trends around the reform cut-off  $c$ , and the matrix  $\mathbf{X}_{it}$  contains individual characteristics as controls. The main parameter of interest is  $\beta$ , which measures the effect of a specific pension reform on outcome  $y_{it}$ .

The RDD approach hinges on the assumption that we correctly capture trends in the outcome variable before and after the reform cut-off. If the respective trends are non-linear, the linear model in equation 1 is misspecified and a non-linear trend may falsely be interpreted as discontinuity. In order to check for such misspecification, we analyse pre- and post-reform trends graphically by depicting local linear regression estimations of the pre- and post-reform time trends. Figures 3 and 4 show the respective graphs. As pre- and post-treatment trends are reasonably linear and the discontinuities at the cut-off are apparent, we are confident that our RDD approach is valid.

Our objective is to analyse whether reforms of the pension system affected different subgroups of the population heterogeneously. In essence,  $\beta$  measures the average treatment effect and we are interested in how the treatment effect of a pension reform differs along individual-level characteristics  $W_i$ , i.e. we want to estimate treatment effects conditional on given characteristics,

$$\beta(w) = \mathbb{E}[Y(D = 1) - Y(D = 0)|W_i = w]. \quad (2)$$

To assess the overall heterogeneity in  $\beta(w)$ , we use the Sorted Effects Method of Chernozhukov et al. (2018). The main idea is to estimate the entire set of partial effects sorted in increasing order and to rank them according to effect size, rather than to present one measure for the effect

of interest, e.g. the average effect. To that end, we estimate an interactive linear model with an additive error term

$$Y_{ij} = g(Z_{ij}) + u_{ij}, \quad (3)$$

where  $g(Z_{ij}) = Z'_{ij}\tau$ , with  $Z_{ij} = (D_{ij}, Q_{ij})$ , where  $Q$  contains transformations of  $W$  as well as interactions between  $D$  and  $W$  to capture the treatment effect heterogeneity with respect to individual characteristics. The predictive effect (PE) is then given by

$$\beta(q) = (1, q)' \tau - (0, q)' \tau, \quad (4)$$

with  $q$  containing specific values of  $Q$ . Other than in the case of the standard interactive linear model, effect heterogeneity is now accounted for with respect to a number of different individual-level characteristics in the same model. If  $\mu$  is the distribution of  $W$  in the population, aggregation of the PEs over  $\mu$  yields the average treatment effect. However, Chernozhukov et al. (2018) propose to report the entire set of PEs sorted in increasing order and indexed by ranking  $u \in [0, 1]$ . The  $u$ -th quantile of  $\beta(Q)$  is the  $u$ th-Sorted Partial Effect ( $u$ -SPE). Displaying the SPEs at different (increasing) values of  $u$ , i.e. at different quantiles of the estimated effect, yields a one-dimensional representation of the heterogeneity in the PEs.

Empirically, sample analogues of  $\beta$  and  $\mu$  are employed to obtain estimators of the SPEs. In case of the interactive linear model with additive error, the PE estimator  $\widehat{\beta(q)}$  is obtained by replacing  $\tau$  in equation 4 with its ordinary least squares estimator  $\hat{\tau}$ .<sup>12</sup>

To assess specific factors that give rise to treatment effect heterogeneity, we interact the binary treatment indicator  $D_i$  with indicators for the subgroups as well as continuous measures of individual-level characteristics. Based on hypotheses from the literature, our focus is on effect differences between, first, individuals working in occupations with different levels of overall, physical and psycho-social demands; second, individuals performing different types of tasks in their jobs; and, third, individuals using or not using particular technologies. Job demands and tasks can be measured either continuously or discretely. We build discrete indicators from the underlying continuous information. This simplifies the interpretation of the results and allows us to analyse all differences with a similar approach. We estimate interaction effects and report point estimates for  $\beta(w)$  performing tests for equality in the different subgroups.

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<sup>12</sup>For an extensive description see Chernozhukov et al. (2018).

## 4.2 Data and construction of the sample

To examine whether and to which extent eligible individuals reacted to the reforms, we use administrative data of the Rehabilitation Statistics Database (RSDLV, Reha Statistik Datenbasis Verlaufserhebung)<sup>13</sup> provided by the German Pension Insurance (Deutsche Rentenversicherung). Our dataset contains information on all insured individuals born in the years 1951 and 1952. Thus, the number of observations is quite large with more than 1.2 million individuals in every cohort. The data contains information on socio-economic variables such as gender, month and year of birth, place of residence (at the state level). Very importantly, the dataset also includes detailed information on the employment status on a monthly basis for the age span between 56 and 66. The different states contain regular employment, marginal employment, unemployment<sup>14</sup> and part-time work in old-age.<sup>15</sup> Furthermore, the dataset indicates whether an individual receives a pension, the type of pension, as well as month and year of retirement if applicable. Thus, the exact age at retirement can be inferred as well as whether an individual retired before or after the enactment of the reforms.

In addition, annual information on the so-called task code (Tätigkeitsschlüssel), a combined measure of occupational classification (according to the occupational classification of the German Statistical Office, KldB) and qualification, is contained in the data. For various reasons, the task code is often missing in the data. To analyse the potential for selectivity, we distinguish between plausibly and implausibly missing task codes. The reason for a plausibly missing task code in a particular year is that an employment state for which no task code can be collected last for the whole year (e.g. credit periods because of inability to work, unemployment, voluntary contributions, receipt of unemployment benefits or other benefits). If these employment states

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<sup>13</sup>The official title of the dataset is RSD insurance history survey 2017 and 2018, control group of the 66 year olds, header data, data on pensions and contributions, source: FDZ-RV, abbreviated: SPF.RSDV.2017-2018.1412-KO\_RT\_BY.

<sup>14</sup>As regards unemployment, the data differentiates between short- and long-term unemployment and unemployment with and without benefit reception. This is important as unemployment with benefit reception counts as contribution period for the calculation of pension benefits while unemployment without benefit reception is counted differently.

<sup>15</sup>Actually, part-time work in old-age is merged with other states, but as these states hardly play any role for the population we consider, we can reasonably assume that the vast majority of individuals in this category works part-time in old age. The dataset distinguishes further employment states (e.g. parental leave or military service) which are not important for our analysis.

last for less than a year, but not a single (mandatory) pension contribution was paid during the year, the absence of the task code is also considered to be plausible. All in all, we note that in 19.6% of the cases the task code is plausibly missing, while it is implausibly missing in 13.5% of the cases. Reasons for implausible missings include the transition from the KldB1988 to KldB2010 in 2011. In addition, we asked the Research Data Centre of the German Pension Insurance to identify reasons for implausible missings. They reported that some regional pension agencies did not collect the task code in the years 2015 to 2018; indeed, the share of implausibly missing observations is higher in these years than in all others except 2011. To check for possible selectivity due to missing task codes, we ran a series of regression models. The dependent variable was defined as 0 if the task code was available and 1 if it was missing implausibly (cases with plausible missings were excluded). The independent variables included socio-demographic characteristics and pension information, such as the size of pension entitlements. The regression results can be found in tables 7 and 8. Overall, the results show that the coefficients of the independent variables are small in magnitude. An exception is that foreign nationals have a higher likelihood of a missing task code, which may be due to the difficulty for employers to assign a qualification level. All in all, we conclude that the scope for bias due to systematically missing information in the treatment and control group is very limited.

Our main focus is on heterogeneity in the effect of pension reforms with respect to job demands, occupational tasks and technology. As the pension data themselves do not contain such information, we merge information on tasks and demands on occupational level from external data sets. To measure occupational demands, we employ three demand measures as calculated by Kroll (2011, 2015). Kroll (2011, 2015) employs data from a representative survey conducted by the German Federal Institute for Vocational Education and Training and the German Federal Institute for Occupational Safety and Health (BIBB/BAuA Employment Survey) to calculate aggregate measures of physical, psycho-social, and overall occupational demand. These provide a measure of the relative position of an occupation in the distribution of physical, psycho-social, or overall demand within a respective ranking of all occupations. We define occupations as highly demanding if they are ranked above the 7<sup>th</sup> decile of demand distribution and as not highly demanding otherwise.

Concerning occupational tasks, we use a measure of task intensities on occupational level provided by Spitz-Oener (2006), which is also based on BIBB/BAuA Employment Survey data. We employ her proposed method to calculate measures for occupational skill requirements which are

defined via reported activities in five task categories: routine manual, non-routine manual, analytic, interactive, and cognitive. We employ the waves 2006, 2012, and 2018 of the BIBB/BAuA Employment Survey to calculate the task sets of the occupations. We differentiate the occupations according to whether tasks from a domain are reported *often* or *rarely*. We define a task domain to occur often if the task share is above the 7<sup>th</sup> decile of the distribution and as rarely otherwise.

We follow a similar approach to generate indicators for the intensity of computer use and technological development. Employing BIBB/BAuA Employment Survey data for the years 2006, 2012, and 2018, we calculate the share of individuals reporting to use a computer at work and the share reporting to frequently use a computer at work, by occupation. In order to calculate indicators for technological development, we rely on questions in the BIBB/BAuA Employment Survey data, in which individuals were asked to indicate whether certain changes in their work occurred in the two years previous to the survey. The questions concern the introduction of new techniques or new machines, the use of new products or materials, the provision of new services, or the employment of new computer programmes. As we focus on changes and developments arising previous to the enactment of the reforms, we employ the respective averages over the waves 2006 and 2012 of the BIBB/BAuA Employment Survey. To separate the occupations according to how strongly they are affected by technological change, we again use the 7<sup>th</sup> decile of the corresponding distribution.

We use the same cutoff point, the 7<sup>th</sup> decile, for all the indicators. A graphical analysis of the differential effects shows that the corresponding cutoffs, e.g. between high and low job demand, tend to lie in the upper parts of the distributions.<sup>16</sup> Our results are also broadly robust to the use of other break points (6<sup>th</sup> and 8<sup>th</sup> deciles).

For the analysis, we first of all exclude individuals who are insured under the pension scheme for miners, as for them more favourable early retirement rules apply. We also exclude individuals receiving an old age pension for disabled, as eligibility to this pension type includes suffering from severe health issues, which impedes comparability to other individuals.

Second, we have to distinguish between individuals who fulfil the eligibility criteria for the two pension types we analyse and individuals who do not fulfil these criteria. Individuals who claim

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<sup>16</sup>The respective figures are available upon request.

the respective pension types are eligible by definition. Individuals who claim pension types with stricter eligibility criteria are assumed to be eligible to the pension types under consideration as well. Individuals who claim a regular old-age pension (with very low eligibility criteria) are only assumed to be eligible to the pension types under consideration if they have accumulated at least 30 earnings points. We have to apply this rule of thumb as our dataset does not contain information on how long an individual has contributed to the pension system. However, as long as the individual receives a pension, we can approximate the number of earnings points accumulated via the amount of pension benefits received. As the maximum of earnings points which can be accumulated per year of contribution is at two points, a sum of 30 earnings points corresponds to a contribution period of at least 15 years, which is one of the requirements for claiming the pension types under consideration. Finally, we have to exclude individuals who have not yet retired, as we can not approximate whether or not they fulfil the eligibility criteria for the pension types under consideration.

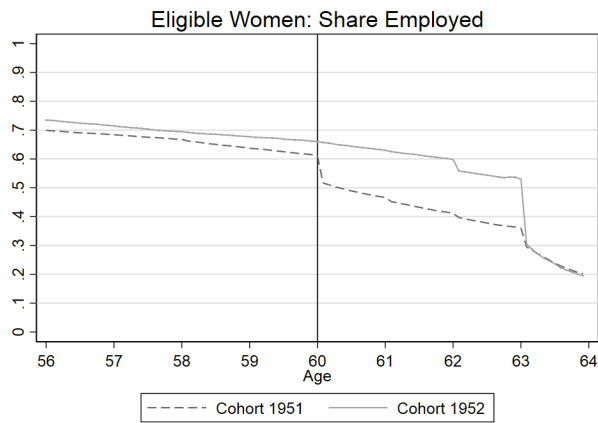
The restricted sample leaves us with almost observations for 560,000 individuals for the analysis of the pension for women. As we do not want effects of different pension reforms to be mixed up, we only consider men when analysing the effects of the reform of the pension after unemployment or part-time work. For this analysis, the restricted sample contains about 215,000 individuals. A description of the relevant variables in our dataset can be found in table 9.

## **5 Results**

### **5.1 Results for the whole population**

Before we analyse how the reform effects differ with respect to occupational characteristics, we analyse the effects of the reforms on the whole affected population. To that end, we first describe the evolution of employment and pension status close to the onset of the reforms before we present estimates of the aggregate reform effects.

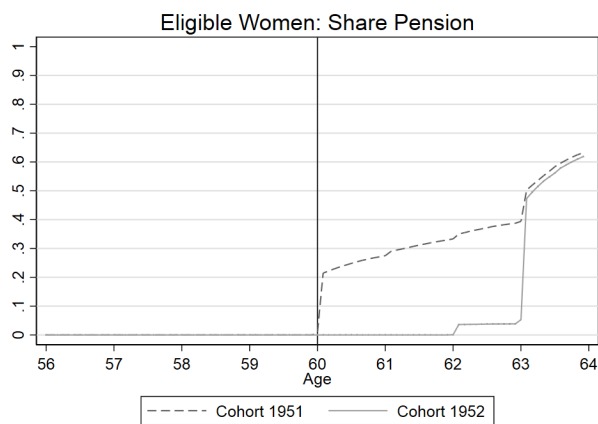
Figure 1 separately displays the share of women, who would have been eligible for early retirement for women born in 1951 and 1952 in different employment states. The figures cover the age bracket from 56 to 64, where we would expect to see reactions to the reforms after age 60. The



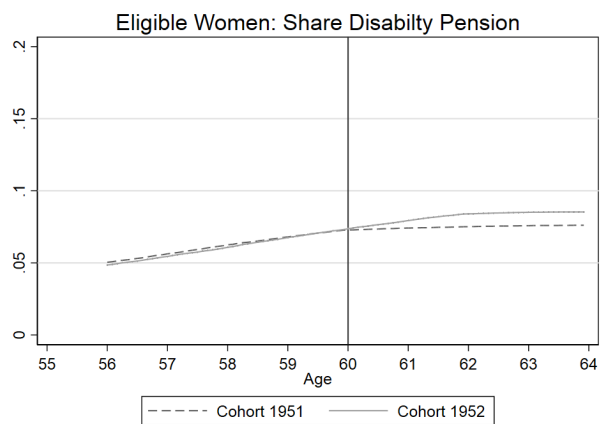
**(a)** Employment



**(b)** Unemployment



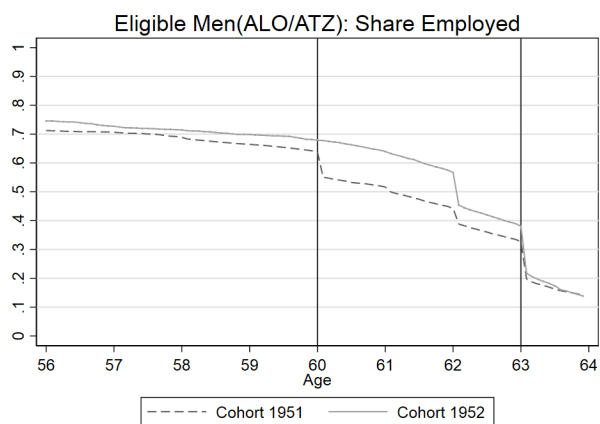
**(c)** Retirement



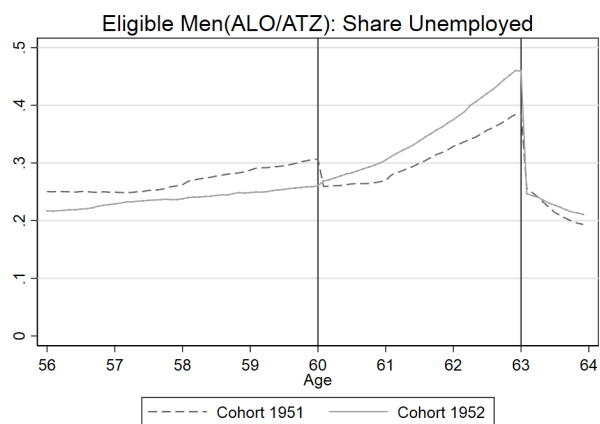
**(d)** Disability Pension

**Figure 1** – Effects of Abolition of Old-Age Pension For Women

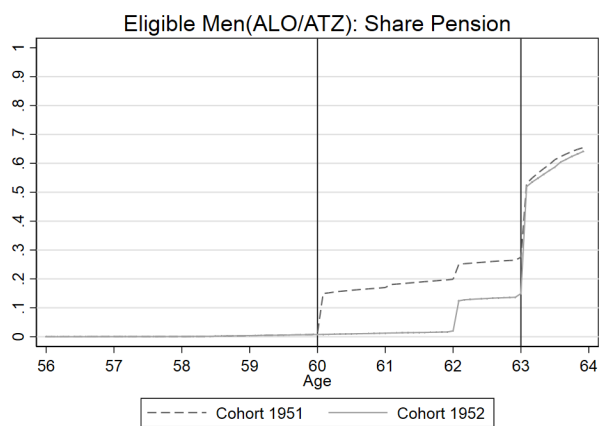




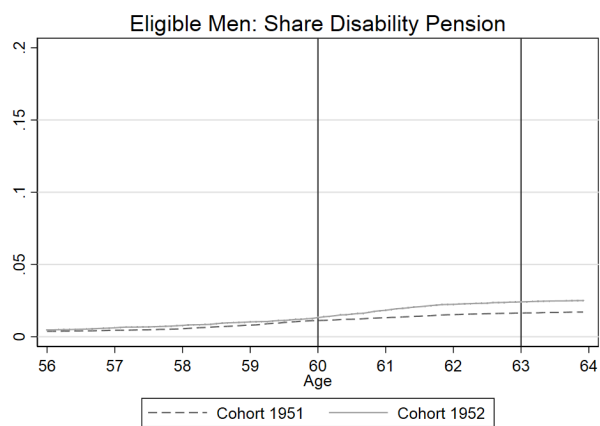
(a) Employment



(b) Unemployment



(c) Retirement



(d) Disability Pension

**Figure 2** – Effects of Abolition of Old-Age Pension After Unemployment or Part-Time - And an Exception

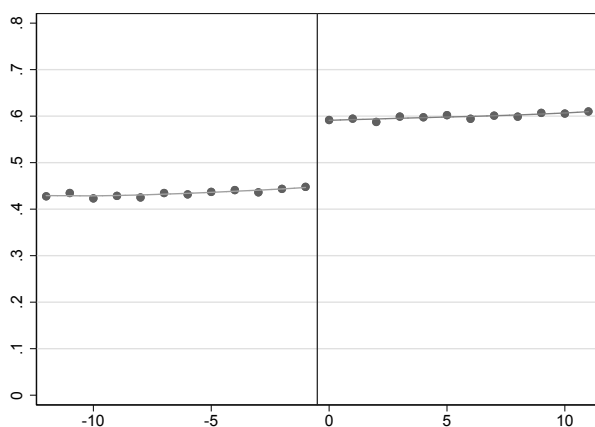
four panels of figure 1 point to clear differences in the fraction of women in different employment states between the two cohorts. The employment rates of women born in 1951 and 1952 follow a similar trend up to age 60. At age 60 the employment rate drops sharply for women born in 1951 but only decreases steadily and rather slowly for women born in 1952. Similarly, the unemployment rate for cohort 1951 drops sharply after the women reach age 60 but rises smoothly for those in the 1952 cohort. On the other hand, the share of women born in 1951 receiving an old age pension exhibits a stark increase at age 60, the respective share is however close to zero for the cohort of 1952 until age 62. Regarding the share of disability pension, no such clear differentiation is visible. Overall we observe distinctive differences in the shares of women in the different employment states before and after the reform. These results are almost identical to those of Geyer & Welteke (2021) who analysed this pension type only.

The sub-panels of figure 2 show the share of men eligible for the old-age pension after unemployment or part-time work in different employment states. As is the case for the reform of early retirement for women, we see clear differences between the two cohorts. Before age 60, the two cohorts exhibit comparable patterns. At the age of 60, eligible men of the 1951 cohort exhibit a drop in employment and unemployment as well as a rise in pension reception which we do not find for the birth cohort of 1952. For the latter cohort, employment rates fall slowly but steadily until the age of 62, the reverse is true for the share of pension reception. At the age of 62, the share of employed exhibits a drop for both birth cohorts, whereas the share of pensioners shows a sudden increase. Unemployment on the other hand rises monotonically until the age of 63 for the birth cohort of 1952. From the age of 63 on, we do not observe any clear differences between the two birth cohorts with regard to their employment states any more. We therefore observe only an effect of the protection of legitimate expectation regulation which allowed individuals of the cohort of 1951 to enter early retirement at age 60 under specific prerequisites<sup>17</sup>, and no effect of the abolition of this option of early retirement for the cohort of 1952.

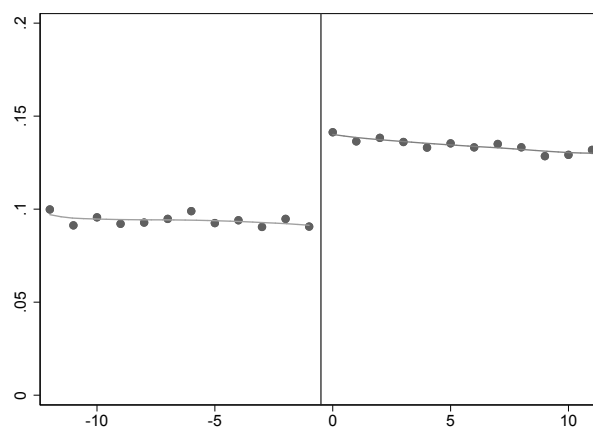
The panels of figures 3 and 4 display mean values of the outcome variables employment, unemployment, retirement, and disability pension reception, for individuals born from 12 months before to 12 months after the cut-off for the abolition of the old-age pension for women and the expiration of the protection of legitimate expectation regulation regarding the old-age pension after unemployment or part-time employment in monthly bins, respectively. All outcome vari-

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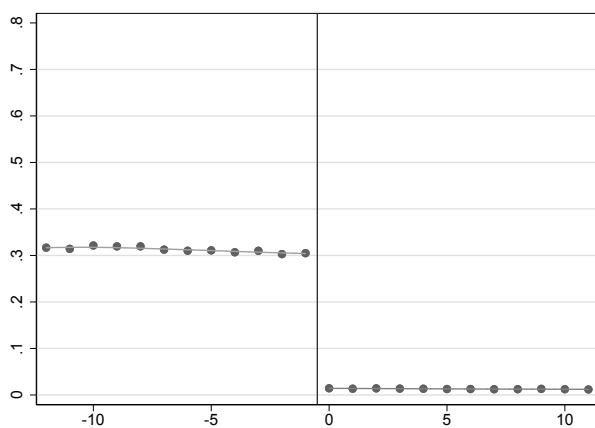
<sup>17</sup>For details about the protection of legitimate expectation regulation see section 3.2.



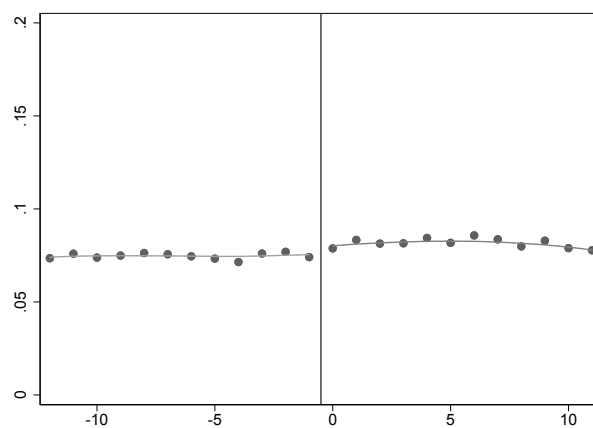
(a) Employment



(b) Unemployment



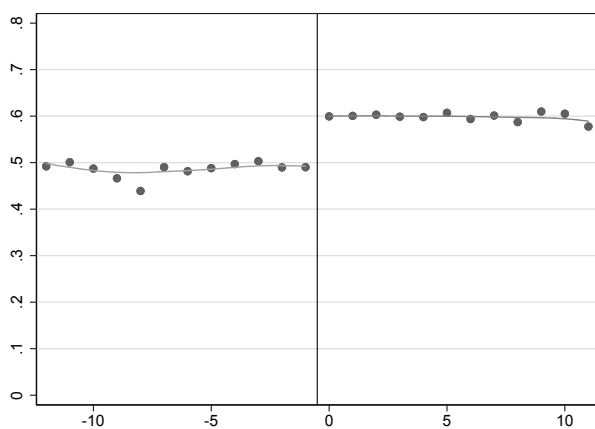
(c) Retirement



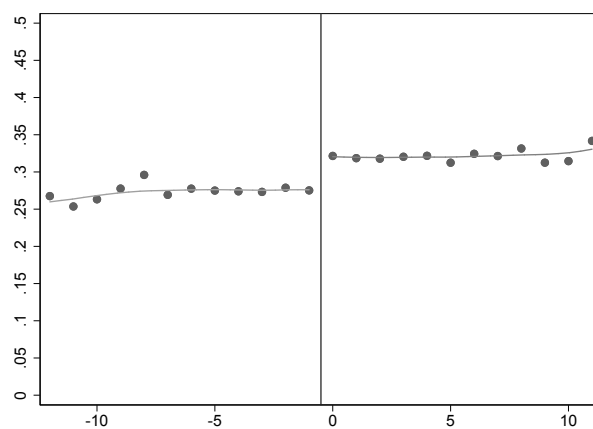
(d) Disability Pension

**Figure 3** – Local Linear Regression Plots of Abolition of Old-Age Pension For Women Relative to Cutoff

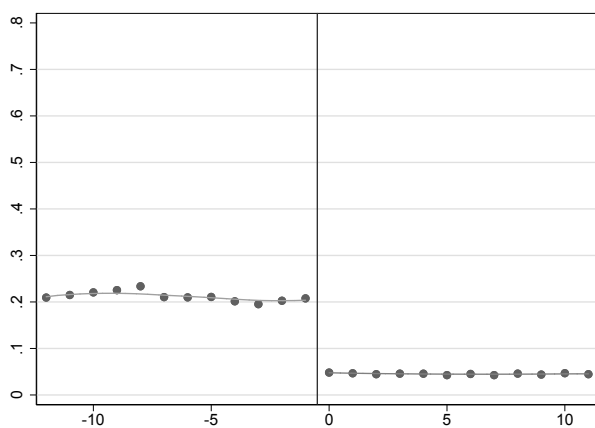
Notes: Scatter plots display mean outcome values using monthly bins. Local linear regression plots are based on triangular kernel functions with a bandwidth of 12 months.



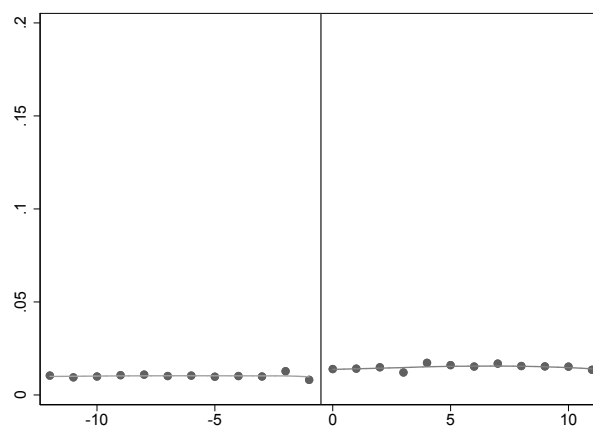
(a) Employment



(b) Unemployment



(c) Retirement



(d) Disability Pension

**Figure 4** – Local Linear Regression Plots of Abolition of Old-Age Pension After Unemployment or Part-Time Relative to Cutoff

Notes: Scatter plots display mean outcome values using monthly bins. Local linear regression plots are based on triangular kernel functions with a bandwidth of 12 months.

ables exhibit a clear discontinuity at the cutoff, though the discontinuity is considerably smaller for the reception of disability pension payments. To provide further evidence for the discontinuity at the cutoff, the panels of figures 3 and 4 additionally display local linear regression plots with bandwidths of 12 months on both sides of the cutoff. Had we confounded a non-linear relationship between the running variable and a dependent variable with the discontinuity, the non-parametric estimation approach should yield evidence for such a relationship. However, the local linear regression plots exhibit clear discontinuities at the cutoff as well. What is more, the local linear regression plots provide further evidence for a roughly linear trend in the dependent variables around the cutoff point. Taken together, we conclude that we can estimate the causal effect of the pension reforms on the displayed outcomes by employing a sharp RDD approach via estimation of a linear model of the form displayed in equation 1.

Early Retirement For Women				
	Employment	Unemployment	Pension	Disability Pension
	0.125***	0.055***	-0.277***	0.002
N	18,980,974			
Old-Age Pension After Unemployment or Part-Time				
	Employment	Unemployment	Pension	Disability Pension
	0.115***	0.030***	-0.149***	0.004***
N	6,347,385			

**Table 2 – Main Reform Effects - RDD Results**

**Notes:** Standard errors are clustered by month of birth. \*\*\*, \*\*, \*: Asterisks indicate significance of coefficients at the conventional significance levels 1%, 5%, 10%, respectively.

Table 2 shows the estimates of the effects of the retirement reforms on individual employment, unemployment, pension reception, and reception of disability pension for the whole population. Tables 7 and 8 in the appendix present the estimates for all variables in the models except for the fixed-effects. Overall the results are in line with the respective depictions in figures 1 and 2. Both reforms had significant effects on share of individuals in employment, unemployment, and receiving pension payments. The employment rates increased and the fraction receiving an old age pension decreased, which can be seen as intended reform effects. However, the reforms also lead to higher shares of unemployment. The abolition of old-age pension after

unemployment and part-time employment further caused a significant, though quantitatively small, increase in reception of disability pensions. The results for the early retirement for women are very close to those obtained by Geyer & Welteke (2021). The effect of the abolition of the old-age pension after unemployment or part-time has not been studied, previously.<sup>18</sup> Notably, the effect of this reform on the reception of old-age pension has been lower than the respective effect of the abolition of the early retirement option for women. This is due to the fact that the eligible women made use of the early retirement option much more frequently than ones eligible for pension after unemployment or part-time work did (see figure 2). The pension after unemployment or part-time work covers two probably different groups, on the one hand those who enter retirement from being unemployed and on the other hand those who retire after having worked part-time. Table 10 in the appendix shows that the reform indeed had different effects on these two groups: Among those entering retirement from unemployment, increases in the employment rate are considerably smaller and increases in the unemployment rate considerably larger than for both groups taken together. Among those having worked part-time, the increase in the employment rate almost exactly mirrors the decrease in old-age pension reception. Disability pension reception only increases among the former group. Individuals in part-time employment therefore simply remained (part-time) employed rather than entering old age pension as a reaction to the reform, whereas the unemployed reacted in a multifaceted way: Only for some a transition to employment was possible, while others remained unemployed.

Taken together, both reforms lead to a longer employment history of the affected individuals, but also to the adverse result of rising unemployment. Thus, affected individuals mainly reacted to the reforms by working longer or becoming unemployed. In contrast, claiming disability pensions does not seem to have been a widely used option. Next, we analyse how this reaction differs with respect to occupational characteristics.

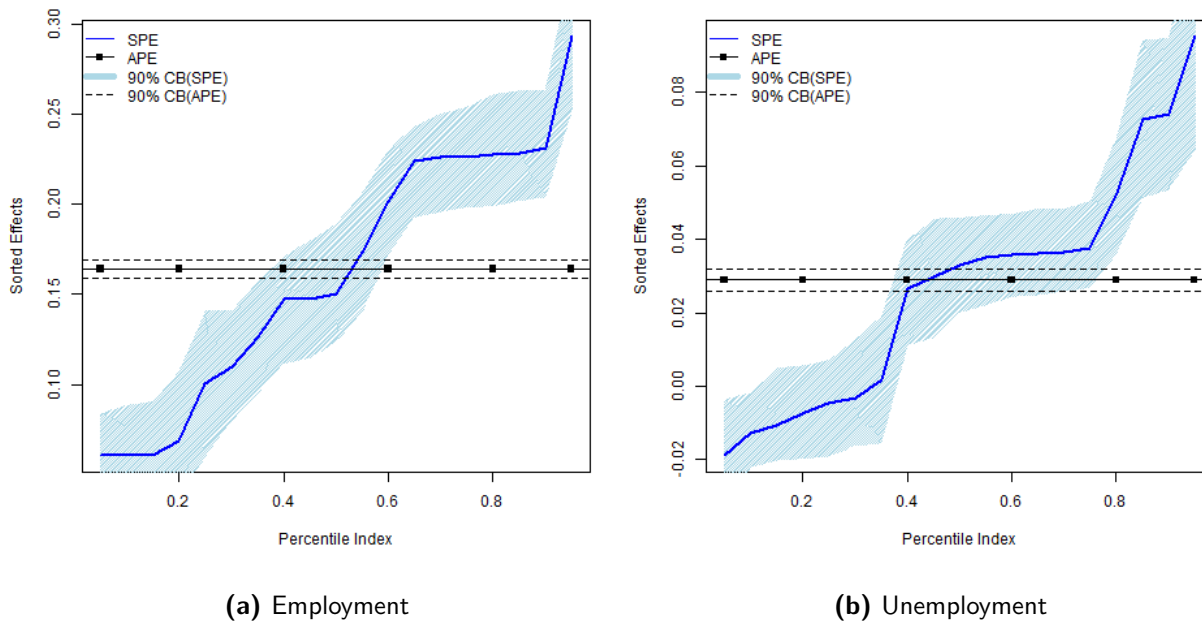
## 5.2 The magnitudes of the effects

To get an impression of the amount of heterogeneity in the treatment effects that can be explained by occupational characteristics, we plot the respective sorted partial effects. Figures 5 and 6

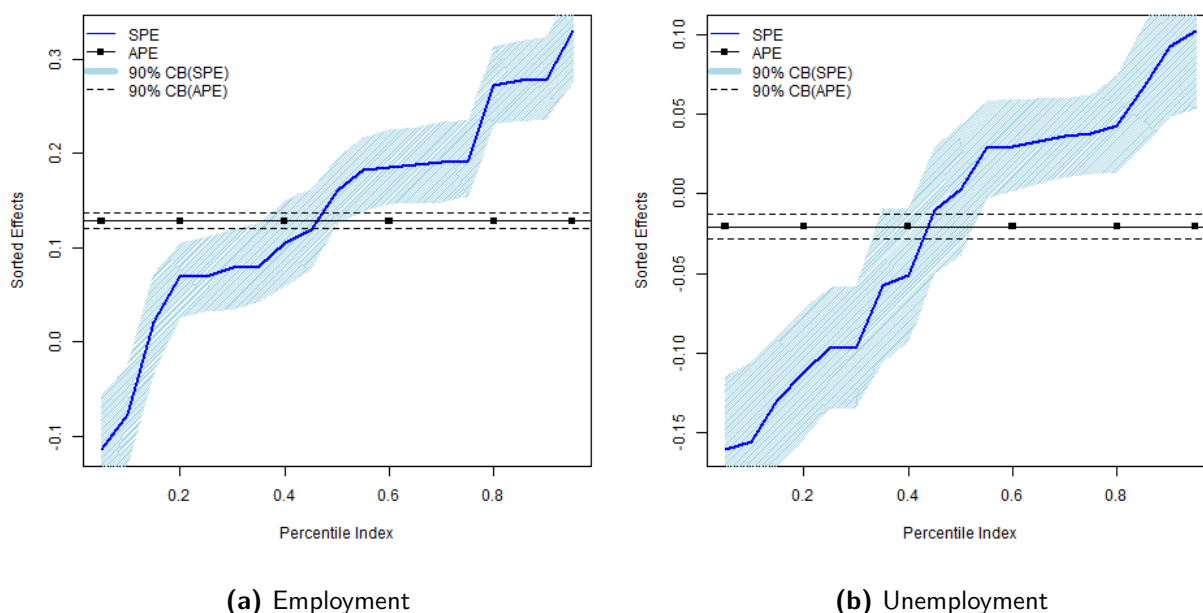
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<sup>18</sup>Riphahn & Schrader (2022) analyse both the increase of the early and the regular retirement age of the old-age pension after unemployment or part-time work. They focus on older cohorts than we do. Comparable to our results, they find increased employment rates and declined retirement rates due to the reforms.

show the plots of the sorted partial effects of the reform of the old-age pension for women and the reform of the old-age pension after unemployment and part-time work on employment and unemployment. In estimating the SPEs, we do not separately account for every single characteristic, but incorporate them simultaneously. The plots show considerable heterogeneity in the effects for both employment states regarding both reforms. The range of the predictive effects clearly differs, however. The estimated SPE for the abolition of the old-age pension for women on employment ranges from around 0.05 to 0.30, a range of 0.25. The range of the effect on unemployment is considerably smaller. It ranges from just over -0.02 to over 0.08. Regarding the ranges of the effects of the abolition of the old-age pension after unemployment or part-time work, we find qualitatively comparable, though quantitatively different results. The effect on employment ranges from -0.1 to 0.3, a range of around 0.4. The effect on unemployment is almost evenly distributed around 0 and ranges from -0.15 to 0.10. Overall, we find a considerable range of effect heterogeneity when accounting for differences in occupational demands, occupational tasks, and technological change on occupational level.



**Figure 5** – Sorted Partial Effects of Abolition of Old-Age Pension For Women



**Figure 6** – Sorted Partial Effects of Abolition of Old-Age Pension After Unemployment or Part-Time

### 5.3 Differences in response by type of work

To study how the effects of the reforms differ with respect to occupational demands, occupational tasks, and technological change, we analyse and compare the effects in the subgroups differentiated by these occupational characteristics. Tables 3 - 6 show the predicted treatment effects of both reforms on the share of eligible individuals who are employed and unemployed in the respective subgroups. The tables comprise of two parts: the left side refers to the effects of the abolition of the early retirement option for women, the right side to the effects of the abolition of the old-age pension after unemployment or part-time work. In all following tables, asterisks point to levels of statistical significance of the predicted effects. If the differences between the estimated effect sizes are statistically different from each other, the respective predictions are given in bold numbers.



	Early Retirement Women				After Unemployment or Part-Time			
	Employment		Unemployment		Employment		Unemployment	
Demand Intensity	Low	High	Low	High	Low	High	Low	High
<b>Overall</b>								
<b>Demand</b>	<b>0.158***</b>	<b>0.127***</b>	<b>0.032***</b>	<b>0.058***</b>	<b>0.115***</b>	<b>0.090***</b>	0.001	0.013
	<b>N = 14,508,448</b>				<b>N = 4,436,018</b>			
<b>Physical</b>								
<b>Demand</b>	<b>0.158***</b>	<b>0.123***</b>	<b>0.031***</b>	<b>0.067***</b>	<b>0.121***</b>	<b>0.091***</b>	-0.001	0.010
	<b>N = 14,622,256</b>				<b>N = 4,460,760</b>			
<b>Psycho-Social</b>								
<b>Demand</b>	<b>0.161***</b>	<b>0.130***</b>	<b>0.029***</b>	<b>0.057***</b>	<b>0.111***</b>	<b>0.098***</b>	0.003	0.009
	<b>N = 14,508,448</b>				<b>N = 4,436,018</b>			

**Table 3 – Reform Effects Differentiated by Occupational Demand**

**Notes:** Standard errors are clustered by month of birth. \*\*\*, \*\*, \*: Asterisks indicate significance of coefficients at the conventional significance levels 1%, 5%, 10%, respectively. Bold coefficients indicate statistical significant difference between effects at low and high levels of occupational demand.

## Heterogeneity with respect to job strain

Table 3 presents the reform effects differentiated with respect to high or low occupational demand. Regarding all types of occupational demands, we find a stronger increase in the employment share for those working in less demanding occupations, possibly because it is harder, or for some individuals even impossible, to keep working within an occupation that is mentally or physically challenging. In the case of the abolition of the old-age pension for women, the employment share increases by around 16 percentage points for those working in less demanding occupations, whereas the share increases by 12 to 13 percentage points for those working in highly demanding occupations, and all differences are statistically significant. Regarding the reaction to the abolition of the old-age pension after unemployment or part-time work, highly physically and highly overall demanding occupations are associated with a two percentage point lower increase in the propensity to become or stay employed after the reform. The estimates for those working under higher and lower psycho-social strain are not statistically distinguishable from each other. Furthermore, table 11 in the appendix reveals that as soon as the both groups covered by this pension type, namely unemployed and those working part-time, are considered separately, differences with respect to high or low occupational demand lose statistical significance.

Regarding the reform effects on unemployment, we only find statistically significant differences

with regard to job strain for the reform of early retirement for women. Conversely to the differences we observe in the employment shares, women working under higher job strain are about one percentage point more likely to become unemployed as a reaction to the reform. Analysing the abolition of retirement after unemployment or part-time work, we find smaller differences, which are not statistically significant. This might be due to the fact that unemployment is much more prevalent among the respective eligible individuals.

Overall, the intended reform effect – prolonging labor force participation – therefore seems to be less effectively achieved for individuals in demanding occupations. At least in the case of the abolition of early retirement for women, individuals working in highly demanding occupations seem, at least in part, to react by becoming unemployed rather than to extend their career.

### Heterogeneity with respect to occupational tasks

Occurrence	Early Retirement Women				After Unemployment or Part-Time			
	Employment		Unemployment		Employment		Unemployment	
	Rarely	Often	Rarely	Often	Rarely	Often	Rarely	Often
<b>Routine Manual</b>	0.147***	0.141***	0.040***	0.043***	0.110***	0.105***	0.004	0.006
<b>Non-Routine Manual</b>	0.159***	0.129***	0.034***	0.049***	0.115***	0.082***	-0.003	0.031***
<b>Analytic</b>	0.135***	0.170***	0.049***	0.024***	0.102***	0.116***	0.010*	-0.000
<b>Interactive</b>	0.143***	0.161***	0.048***	0.016***	0.112***	0.090***	0.007	0.003
<b>Routine Cognitive</b>	0.149***	0.147***	0.032***	0.049***	0.119***	0.084***	-0.007	0.030***
<b>N = 14,753,955</b>					<b>N = 4,622,860</b>			

**Table 4 – Reform Effects Differentiated by Task Measures**

**Notes:** Standard errors are clustered by month of birth. \*\*\*, \*\*, \*: Asterisks indicate significance of coefficients at the conventional significance levels 1%, 5%, 10%, respectively. Bold coefficients indicate statistical significant difference between effects at rare and often occurrence of a respective task.

Table 4 presents the reform effects differentiated along the occurrence of occupational tasks. We find qualitatively comparable effect differences with regard to non-routine manual tasks. After both reforms, the share employed increased less for individuals working in occupations, in which

non-routine manual tasks play a larger role. In the case of early retirement for women, the difference amounts to three percentage points, an increase by 16 rather than 13 percentage points. In the case of retirement after unemployment or part-time work, the difference amounts to around four percentage points, i. e. an increase of 8 compared to 12 percentage points. On the other hand, unemployment increased stronger: By 5 rather than 3 percentage points after the abolition of the early retirement option for women, by 3 rather than 0 percentage points after the abolition of retirement after unemployment or part-time work. With regard to cognitive tasks, we find qualitatively comparable results with regard to the reaction of unemployment; in both cases unemployment increases stronger if more cognitive activities are being performed, around 5 instead of 3 percentage points and around 3 percentage points instead of no increase, regarding the retirement for women and after unemployment or part-time work, respectively. The differences in the effects on employment, on the other hand, are only significant in the case of the latter reform. Regarding the other tasks domains, results are more mixed. We do not find statistically significant differences in the reactions if we focus on the occurrence of routine manual tasks. Regarding interactive and analytic tasks, the results differ between the two reforms. Occupations with a stronger concentration on analytic tasks are associated with a stronger increase in employment, 17 rather than 14 percentage points, and a lower increase in unemployment, 2 rather than 5 percentage points. We find these, significant, differences only in the reaction to the abolition of early retirement for women, however. Occupations in which interactive tasks play a larger role are associated with a three percentage points smaller increase in unemployment after the abolition of the retirement option for women, while we do not find significant differences for the other reform analysed. More interactive tasks are associated with a two percentage points smaller increase in the employment share after the abolition of the old-age pension after unemployment or part-time work, while the other reform does not display any different effects.

In summary, the reactions to both reforms differ along the occurrence of tasks from several task domains. Possible explanations lie in the combination of cognitive and physical strain e.g. cognitive or non-routine manual tasks may demand from employees. Remarkably, the occurrence of routine manual tasks does not seem to prevent a longer participation in the labor market – at least we do not find any statistical significant indication. Differences between the results for the two reforms may lie in differences in the distinct groups affected, in the case of retirement after unemployment or part-time mainly (and in our sample, purely) men, in the other case, obviously,

only women.<sup>19</sup>

## Heterogeneity with respect to computer and technological changes

Occurrence	Early Retirement Women				After Unemployment or Part-Time			
	Employment		Unemployment		Employment		Unemployment	
	Rarely	Often	Rarely	Often	Rarely	Often	Rarely	Often
<b>PC Use At All</b>	0.144***	0.160***	<b>0.046***</b>	<b>0.016***</b>	0.106***	0.106***	0.008*	0.002
<b>PC Use Frequently</b>	<b>0.135***</b>	<b>0.168***</b>	<b>0.049***</b>	<b>0.025***</b>	0.103***	0.114***	0.009*	0.002
N = 14,753,955					N = 4,622,860			

**Table 5 – Reform Effects Differentiated by Computer Use**

**Notes:** Standard errors are clustered by month of birth. \*\*\*, \*\*, \*: Asterisks indicate significance of coefficients at the conventional significance levels 1%, 5%, 10%, respectively. Bold coefficients indicate statistical significant difference between effects with and without (frequent) computer use.

Last, we analyse differences with respect to computer use and technological change in an individual's occupation. Table 5 gives the reform effects differentiated along the occurrence of computer use in an occupation – either at all or frequently – table 6 differentiates along the occurrence of new techniques, machines, products and materials, services, and PC-programmes.<sup>20</sup> We interpret these as measures of technological change. Though the specific results differ quantitatively, the results as a whole point to stronger increases in employment and weaker increases in unemployment where technological change is more prevalent.

<sup>19</sup>Furthermore, the two groups affected by the former reform, namely those who enter retirement after unemployment and those who retire after having worked part-time, show different reactions as can be seen from table 12 in the appendix. In some cases (e. g. changes in unemployment regarding occupations in which non-routine tasks occur rarely or often), differences remain significant even if both groups are considered separately. In other cases, significant differences are visible only if the two groups are considered separately. Yet in other cases, the significance vanishes for a separate consideration. This is again a hint that the two groups affected by the reform, namely those who enter retirement after unemployment and those who retire after having worked part-time, are quite distinct from each other and in consequence are not equally capable to react to the reform.

<sup>20</sup>Tables 13 and 14 in the appendix separately show the results for those entering retirement from unemployment and those having worked part-time before retirement. Again, the results differ quantitatively. Statistically significant differences point to a stronger increase in employment and weaker increase in unemployment in cases in which technological change is more prevalent.

Occurrence	Early Retirement Women				After Unemployment or Part-Time			
	Employment		Unemployment		Employment		Unemployment	
	Rarely	Often	Rarely	Often	Rarely	Often	Rarely	Often
<b>New Techniques</b>	<b>0.146***</b>	<b>0.166***</b>	<b>0.041***</b>	<b>0.026***</b>	<b>0.097***</b>	<b>0.128***</b>	<b>0.012***</b>	<b>-0.006</b>
<b>New Machines</b>	0.148***	0.142***	0.040***	0.039***	0.109***	0.105***	0.008*	-0.001
<b>New Products or Materials</b>	0.147***	0.150***	0.040***	0.033***	0.100***	0.120***	<b>0.012***</b>	<b>-0.004</b>
<b>New Services</b>	<b>0.140***</b>	<b>0.177***</b>	<b>0.045***</b>	<b>0.021***</b>	<b>0.101***</b>	<b>0.126***</b>	0.006	0.001
<b>New PC-Programs</b>	<b>0.138***</b>	<b>0.173***</b>	<b>0.048***</b>	<b>0.016***</b>	<b>0.096***</b>	<b>0.118***</b>	0.013**	-0.001
<b>N = 14,728,802</b>					<b>N = 4,609,324</b>			

**Table 6** – Reform Effects Differentiated by Technological Progress Indicators

**Notes:** Standard errors are clustered by month of birth. \*\*\*, \*\*, \*: Asterisks indicate significance of coefficients at the conventional significance levels 1%, 5%, 10%, respectively. Bold coefficients indicate statistical significant difference between effects with and without the presence of a respective technological progress indicator.

There are different potential explanations for this finding. Employers may be less prone to economic strain if they are producing with newer technologies. As a consequence, job in occupations where more innovative technology is employed may be safer. Employees who learned to work with the newest technology may, on the other hand, be more valuable to their employers due to higher stock of the relevant human capital. Also, employees who are not working with newer technologies may already have left the labor market earlier.

Overall we find significant differences in the effects of both reforms on employment states. Differences in some occupational characteristics result in similar effect heterogeneity for both reforms, while differences in others leads to different results not only in size but also in direction. Latter differences may be attributed to different sub-populations under research as well as tackled by the reform.

## 6 Conclusions

We study heterogeneity in the effects of two reforms of the pension system which closed pathways into early retirement with respect to occupational characteristics. More precisely, we analyse whether individuals were differently affected by these reforms dependent on tasks they perform or job strain they are exposed to. According to our results, and in case of the early retirement for women in line with previous work by Geyer & Welteke (2021), we find significant effects of the reforms on the share employed, unemployed, retired, and receiving a disability pension. We also find significant differences in effect sizes with respect to different levels of occupational demand as well as different focus areas of occupational tasks. Regarding some measures, these heterogeneities are comparable between reforms. In both cases, the effect on employment is smaller for those working in highly demanding occupations or performing more non-routine manual tasks, while the effect on unemployment is higher for those performing more cognitive tasks. We find significant differences regarding other task measures, too. These differ between the reforms, however. Differences in effect size along occupational differences are also confirmed by a SPE analysis. Simultaneously accounting for differences in all measures of occupational tasks and occupational demand, we find a broad range of effect sizes.

Our results provide relevant implications for future research. Though a proper identification strategy, as in our case the RDD, can yield reliable estimations of average effects of pension reforms, differentiation along occupational characteristics can uncover whether and how such effects differ by occupational features. What is more, such differences can point to economically comprehensible fact patterns, i.e. that individuals in highly demanding occupations are less inclined or even unable to stretch their working lifetime. And, although our subgroup analyses can not be interpreted causally, they uncover areas where analysis for a causally interpretable heterogeneity analysis could be fruitful.

Our results further provide implications for suitable policy measures that could accompany future pension reforms as well as labour market policy. In case of both analysed reforms, the political goal of longer employment periods has been reached. However, our results show that it is not equally possible for all employees to adapt to the new circumstances. This highlights the importance of creating jobs which are adequate to the demands of elderly employees, especially with regard to their health status. Furthermore, labour market programmes should also be

targeted to the needs of employees in their late career, as a certain share of them – depending on their occupation, as our results show – has to bridge the time to delayed retirement entry with unemployment. Additionally, unions and employers should have an analogue interest in keeping those at work longer who are able due to their occupation and offer different opportunities for those in occupations which become problematic to work in at an increasing age.

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	Employment	Unemployment	Pension	Disability Pension
$D_i$	0.125*** [0.003]	0.055*** [0.002]	-0.277*** [0.003]	0.002 [0.002]
$D_i * (z_i - c)$	0.006*** [0.000]	-0.001*** [0.000]	-0.003*** [0.000]	-0.000 [0.000]
$(1 - D_i) * (z_i - c)$	0.006*** [0.000]	-0.000 [0.000]	-0.006*** [0.000]	-0.000 [0.000]
East Germany	-0.078*** [0.005]	0.064*** [0.005]	0.046*** [0.009]	0.002** [0.000]
Non-German Nationality	-0.126*** [0.011]	0.075*** [0.004]	-0.017*** [0.005]	0.077*** [0.004]
Wage Group 0 (Base)				
Wage Group 1	0.162*** [0.011]	-0.068*** [0.002]	-0.104*** [0.020]	0.101*** [0.001]
Wage Group 2	0.239*** [0.020]	-0.095*** [0.002]	-0.127*** [0.027]	0.072*** [0.001]
Constant	0.481*** [0.009]	0.136*** [0.003]	0.213*** [0.011]	0.010*** [0.002]
$R^2$	0.079	0.029	0.196	0.029
N	18,980,974			

**Table 7** – Main Reform Effects, Extended - RDD Results For Early Retirement For Women

**Notes:** Standard errors are clustered by month of birth and given in brackets. \*\*\*, \*\*, \*: Asterisks indicate significance of coefficients at the conventional significance levels 1%, 5%, 10%, respectively. All regression further include month fixed effects, respective coefficients are omitted due to reasons of clarity. The wage groups are ordered in ascending sequence of wages. The groups are generated so as to contain an identical share of eligible individuals.

	Employment	Unemployment	Pension	Disability Pension
$D_i$	0.115*** [0.006]	0.030*** [0.004]	-0.149*** [0.004]	0.004*** [0.001]
$D_i * (z_i - c)$	0.010*** [0.007]	-0.006*** [0.001]	-0.005*** [0.000]	-0.000 [0.000]
$(1 - D_i) * (z_i - c)$	0.009*** [0.001]	-0.003*** [0.000]	-0.006*** [0.001]	-0.000 [0.000]
East Germany	-0.107*** [0.001]	0.118*** [0.013]	-0.006*** [0.003]	0.004*** [0.000]
Non-German Nationality	-0.087*** [0.011]	0.113*** [0.009]	-0.024*** [0.004]	0.000 [0.001]
Wage Group 0 (Base)				
Wage Group 1	0.192*** [0.009]	-0.246*** [0.013]	0.045*** [0.005]	-0.001 [0.001]
Wage Group 2	0.280*** [0.008]	-0.344*** [0.012]	0.078*** [0.004]	-0.013*** [0.001]
Constant	0.558*** [0.015]	0.352*** [0.014]	0.049*** [0.009]	0.011*** [0.001]
$R^2$	0.128	0.154	0.088	0.004
N	6,347,385			

**Table 8 – Main Reform Effects, Extended - RDD Results For Old-Age Pension After Unemployment or Part-Time**

**Notes:** Standard errors are clustered by month of birth and given in brackets. \*\*\*, \*\*, \*: Asterisks indicate significance of coefficients at the conventional significance levels 1%, 5%, 10%, respectively. All regression further include month fixed effects, respective coefficients are omitted due to reasons of clarity. The wage groups are ordered in ascending sequence of wages. The groups are generated so as to contain an identical share of eligible individuals.

	Early Retirement Women						After Unemployment or Part-Time					
	Age 59.5		Age 60		Age 60.5		Age 59.5		Age 60		Age 60.5	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Employed	0.65	[0.48]	0.63	[0.48]	0.57	[0.50]	0.72	[0.45]	0.71	[0.46]	0.64	[0.48]
Unemployed	0.13	[0.33]	0.13	[0.33]	0.11	[0.31]	0.24	[0.43]	0.25	[0.43]	0.23	[0.42]
Retired	0.00	[-]	0.00	[0.06]	0.13	[0.33]	0.00	[-]	0.00	[0.05]	0.09	[0.29]
Diab. Pens.	0.07	[0.26]	0.07	[0.26]	0.08	[0.26]	0.01	[0.09]	0.01	[0.10]	0.01	[0.10]
Ret. Age (months)	760.98	[27.73]	761.01	[20.73]	761.06	[20.73]	759.14	[17.29]	759.16	[17.30]	759.18	[17.30]
Earnings Points	37.40	[14.21]	37.40	[14.22]	37.40	[14.23]	47.30	[16.24]	47.30	[16.24]	47.29	[16.24]
Non German	0.05	[0.22]	0.05	[0.22]	0.05	[0.22]	0.05	[0.22]	0.05	[0.22]	0.05	[0.22]
East German	0.31	[0.46]	0.30	[0.46]	0.30	[0.46]	0.28	[0.45]	0.28	[0.45]	0.28	[0.45]
Treated	0.49	[0.50]	0.49	[0.50]	0.49	[0.50]	0.46	[0.50]	0.46	[0.50]	0.46	[0.50]

**Table 9 – Summary Statistics**

**Notes:** Abbreviations: *SD*: Standard deviation. Average retirement age in months: 756 months equal to 63 years.

After Unemployment				
	Employment	Unemployment	Pension	Disability Pension
	0.058***	0.082***	-0.146***	0.009***
N	3,348,897			
After Part-Time				
	Employment	Unemployment	Pension	Disability Pension
	0.146***	-0.000	-0.147***	-0.000
N	3,001,332			

**Table 10 – Main Reform Effects - RDD Results**

**Notes:** Standard errors are clustered by month of birth. \*\*\*, \*\*, \*: Asterisks indicate significance of coefficients at the conventional significance levels 1%, 5%, 10%, respectively.

Demand Intensity	After Unemployment				After Part-Time			
	Employment		Unemployment		Employment		Unemployment	
	Low	High	Low	High	Low	High	Low	High
<b>Overall</b>								
<b>Demand</b>	0.052***	0.064***	0.039***	0.034***	0.126***	0.110***	-0.000	-0.000
	<b>N = 2,053,358</b>				<b>N = 2,383,452</b>			
<b>Physical</b>								
<b>Demand</b>	0.062***	0.053***	0.031***	0.041***	0.130***	0.108***	-0.000*	0.000
	<b>N = 2,064,672</b>				<b>N = 2,396,880</b>			
<b>Psycho-Social</b>								
<b>Demand</b>	0.053***	0.062***	0.040***	0.035***	0.123***	0.119***	-0.000	-0.000
	<b>N = 2,053,358</b>				<b>N = 2,383,452</b>			

**Table 11 – Reform Effects Differentiated by Occupational Demand**

**Notes:** Standard errors are clustered by month of birth. \*\*\*, \*\*, \*: Asterisks indicate significance of coefficients at the conventional significance levels 1%, 5%, 10%, respectively. Bold coefficients indicate statistical significant difference between effects at low and high levels of occupational demand.

Occurrence	After Unemployment				After Part-Time			
	Employment		Unemployment		Employment		Unemployment	
	Rarely	Often	Rarely	Often	Rarely	Often	Rarely	Often
<b>Routine Manual</b>	0.057***	0.057***	0.037***	0.037***	0.127***	0.123***	-0.000	0.000
<b>Non-Routine Manual</b>	0.058***	0.058***	<b>0.026***</b>	<b>0.054***</b>	0.126***	0.114***	<b>0.000</b>	<b>-0.001***</b>
<b>Analytic</b>	0.052***	0.074***	<b>0.045***</b>	<b>0.012</b>	0.126***	0.124***	-0.000	-0.000
<b>Interactive</b>	0.059***	0.047***	<b>0.042***</b>	<b>0.010</b>	<b>0.135***</b>	<b>0.103***</b>	-0.000	-0.000
<b>Routine Cognitive</b>	<b>0.068***</b>	<b>0.048***</b>	<b>0.017***</b>	<b>0.057***</b>	0.124***	0.125***	-0.000	0.001
	<b>N = 2,154,448</b>				<b>N = 2,469,240</b>			

**Table 12 – Reform Effects Differentiated by Task Measures**

**Notes:** Standard errors are clustered by month of birth. \*\*\*, \*\*, \*: Asterisks indicate significance of coefficients at the conventional significance levels 1%, 5%, 10%, respectively. Bold coefficients indicate statistical significant difference between effects at rare and often occurrence of a respective task.



Occurrence	After Unemployment				After Part-Time			
	Employment		Unemployment		Employment		Unemployment	
	Rarely	Often	Rarely	Often	Rarely	Often	Rarely	Often
<b>PC Use At All</b>	0.058***	0.049***	0.041***	0.019	0.126***	0.120***	-0.000	-0.000
<b>PC Use Frequently</b>	0.053***	0.071***	<b>0.044***</b>	<b>0.014</b>	0.124***	0.126***	-0.000	-0.000
<b>N = 2,154,448</b>					<b>N = 2,469,240</b>			

**Table 13** – Reform Effects Differentiated by Computer Use

**Notes:** Standard errors are clustered by month of birth. \*\*\*, \*\*, \*: Asterisks indicate significance of coefficients at the conventional significance levels 1%, 5%, 10%, respectively. Bold coefficients indicate statistical significant difference between effects with and without (frequent) computer use.

Occurrence	After Unemployment				After Part-Time			
	Employment		Unemployment		Employment		Unemployment	
	Rarely	Often	Rarely	Often	Rarely	Often	Rarely	Often
<b>New Techniques</b>	0.052***	0.070***	<b>0.046***</b>	<b>0.010</b>	<b>0.117***</b>	<b>0.142***</b>	-0.000	-0.000
<b>New Machines</b>	<b>0.047***</b>	<b>0.072***</b>	<b>0.050***</b>	<b>0.016</b>	0.129***	0.116***	-0.000	-0.000
<b>New Products or Materials</b>	<b>0.049***</b>	<b>0.071***</b>	<b>0.047***</b>	<b>0.019</b>	0.123***	0.131***	-0.000	-0.000
<b>New Services</b>	0.058***	0.052***	0.037***	0.038**	<b>0.118***</b>	<b>0.140***</b>	-0.000	-0.000
<b>New PC-Programs</b>	0.054***	0.066***	<b>0.046***</b>	<b>0.011</b>	0.119***	0.129***	-0.000	-0.000
<b>N = 2,154,448</b>					<b>N = 2,469,240</b>			

**Table 14** – Reform Effects Differentiated by Technological Progress Indicators

**Notes:** Standard errors are clustered by month of birth. \*\*\*, \*\*, \*: Asterisks indicate significance of coefficients at the conventional significance levels 1%, 5%, 10%, respectively. Bold coefficients indicate statistical significant difference between effects with and without the presence of a respective technological progress indicator.