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The causal effect of partial retirement on older workers' labor force participation

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Abstract

In this study, I investigate the effect of partial retirement at the firm level on older workers' labor participation. Thereby, I contribute to the controversial debate about the effects of partial retirement. Using detailed administrative employer-employee data from Germany, I exploit the introduction of partial retirement options in Germany related to the law on PR of 1996 within a difference-in-differences framework. My results show that older workers' labor participation responds to the introduction of partial retirement and reveals substantial effect heterogeneities with regard to the specific partial retirement arrangement. Overall, I find evidence that partial retirement has the potential to extend older workers' labor participation and thereby to serve as an instrument to lower the financial burden of governments struggling with the economic costs of demographic aging.

JEL classification: J14, J22, J26

Keywords: older workers, partial retirement, retirement decision, difference-in-differences

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This study uses the Linked-Employer-Employee Data (LIAB) (LIAB LM1 9007) from the IAB. Data access was provided via on-site use at the Research Data Centre (FDZ) of the German Federal Employment Agency (BA) at the Institute for Employment Research (IAB) and subsequently remote data access. My special thanks go to the FDZ for the remote data access and the support in handling the data.

1 Introduction

In Germany, as in many other European countries, an increasing life expectancy combined with a lower fertility has yielded an aging society. Demographic aging has raised financial pressure on the pay-as-you-go pension system in which today's retirees receive transfers from today's workers (OECD 2019). Furthermore, the workforce aging is feared to result in a skilled labor shortage and thereby in lower international competitiveness (Deutscher Bundestag 2010). From the governments' perspective, these developments have drawn attention to the potential of old-age employment.[1] Since the 1990s, policy makers have undertaken various labor market and pension reforms aiming at longer working lives and postponing retirement entries. These reforms included inter alia the reduction of unemployment benefit payout duration, increases of retirement entry ages with full benefits, and introductions of deductions for early retirement[2] (OECD 2017, BMGS 2003).

With the law on partial retirement of 1996 (*Altersteilzeitgesetz (AtG)*), the German policy makers have undertaken a further measure that generally has the potential to promote old-age employment. Partial retirement includes an agreement between employer and employee to reduce working hours at the employee's end of working life; the law on partial retirement has set the legal framework for these arrangements. The framework allows to arrange partial retirement in two different ways: with the part-time model, the employee is given the option to reduce working hours for the whole partial retirement period, and with the block model, the employee performs 100 percent of the former working hours in the first half of the partial retirement period (work phase) and does not work in the second half (release phase).

Within labor market research, partial retirement in form of the part-time model is seen as an effective instrument to promote old-age employment by maintaining the workers' employability (Barkholdt 2006). The part-time model gives older workers, who would

[1] Promoting longer employment of older workers yields an increase in the working-age population that equals an increase in the number of pension contributors on the one hand and lower expenses due to a decrease in the number of pension recipients on the other hand.

[2] Early retirement is defined as retirement before reaching the eligibility age for the regular old-age retirement (*Regelaltersrente*) which, in Germany, is 65 for birth cohorts 1946 and older and increased to 67 for younger cohorts.

probably not be able to work full-time until the regular old-age retirement, the option to choose their workload flexibly. Thereby, workers stay employed in an extent they are able to provide instead of abruptly stop working by unemployment or early retirement (Brussig et al. 2009).

Within German labor market policy, the law on partial retirement is often not seen as a measure to promote old-age employment but as a measure to promote early retirement by giving employers the opportunity to introduce partial retirement in form of the block model. With the block model, employees get the option to withdraw from employment at relatively low costs and firms obtain an option for a socially acceptable workforce reduction (Wanger 2009, Brussig et al. 2009). This negative image is confirmed by the observation that firms mainly use the block model and that workers in partial retirement leave the labor market on average 2 years earlier compared to workers having no access to partial retirement (Wanger 2009).

The criticism of partial retirement caused by the block model has covered the potential of the part-time model of partial retirement to serve as an instrument to exploit the potential of old-age employment. With this study, I reveal this potential by analyzing the effects of partial retirement differentiated by the model of partial retirement. I exploit the introduction of partial retirement in German firms related to the law on partial retirement of 1996 and use a difference-in-differences approach which compares differences in labor market outcomes of older employees over time between firms which introduced partial retirement and firms that did not introduce partial retirement. The study is of high political relevance as population aging will further increase in the next years in all advanced economies (OECD 2019) that further increases financial pressure on the pension system and thereby the political pressure to increase old-age employment (SVR 2020).

The international literature on the effects of partial retirement is characterized by conflicting evidence on the effects of partial retirement. For Sweden, Sundén (1994) and Wadensjö (2006) investigate the effect of a subsidized part-time pension scheme and observe a net increase in labor supply of older workers. In contrast, Graf et al. (2011) find crowding out effects of partial retirement on full-time employment in the Austrian labor

market. Equally, an analysis of a partial retirement program for faculty members of the University of North Carolina indicates that the availability of partial retirement can be linked to a reduction of full-time work (Ghent et al. 2001). Machado and Portela (2014) show that voluntary reductions in working hours are associated with earlier retirement of Portuguese workers. However, the heterogeneous results are not very surprising looking at a study by (Haan and Tolan 2017). Their simulation of a Dutch partial retirement scheme shows that the effects of partial retirement strongly depend on the concrete arrangement. Since the partial retirement schemes vary from country to country, a comparison of the results is very difficult.

The literature on the effects of partial retirement for older workers labor force participation in Germany is scarce. So far, there are two studies evaluating the causal effect of partial retirement on the labor market outcomes of older workers in Germany with inconclusive findings on the effects on employment. Huber et al. (2016) investigate the effect of partial retirement on employment, unemployment, and retirement for employees in West and East German firms. Using a matching approach, they compare outcomes of employees between 2002 and 2008 in firms that introduced partial retirement between 2000 and 2002 to employees in firms not introducing partial retirement. They could not find an effect of partial retirement on the timing of retirement for employees in firms in West Germany, but a reduction of unemployment due to employment in partial retirement. A study by Berg et al. (2020) examines the effects of partial retirement by comparing labor market outcomes of 51 year olds to outcomes of 55 to 64 year olds before and after 1999. They claim to find an increase in men's employment duration of more than one year.

With respect to the data and the institutional setting, this study is similar to the study by Huber et al. (2016). The authors also use the same data source for linked employee-employer-data and exploit the effects of the introduction of partial retirement after the AtG came into force as I do. However, Huber et al. (2016) base their identification on the introduction of partial retirement in firms between 2000 and 2002. Thus, they exclude firms that had agreements prior to 2000 which is a substantial number of firms respectively workers. By 2000 alone, already over 300 collective agreements affecting over 12 million

workers had been concluded (Brussig et al. 2009). Furthermore, due to their matching approach, Huber et al. (2016) need to limit their sample of firms to certain industries and firm size. This reduces the representative nature of their sample.

With respect to the estimation model, this study is similar to the study by Berg et al. (2020). The authors also uses a difference-in-differences model to investigate the effects of partial retirement. However, they use 50-54 year olds as the control group for employment and retirement decision of 55 to 65 years old workers. This is problematic since 50-54 year olds do not have access to any retirement pathway except for disability retirement. As a result, the authors are not able to control for general time trends in the labor force participation of 55 to 65 years old that could affect the outcome variables and lead to biased treatment effects.

I contribute to the literature in several ways. First and most important, to the best of my knowledge, this paper gives first evidence on the effects of partial retirement differentiated for the part-time and block model. This unique feature is of high relevance especially for the discussion of the effects of partial retirement options within Germany since most of the criticism of partial retirement refers to the block model and not to partial retirement at all. Second, compared to the study by Huber et al. (2016), my analysis includes a broader and more representative sample of firms. I use firms which introduce partial retirement options in 1999 and thereby observe more firms. In the end, about 1,800 firms are observed in my final sample compared to about 300 firms in the study by Huber et al. (2016). Furthermore, since I use a difference-in-differences model and do not rely on a matching approach, firms in my sample are more diverse concerning size and industry. Third, compared to the study by Berg et al. (2020), I use a control group which allows me to control for time trends in old-age employment and retirement. I compare 59 to 63 years old workers in firms which introduced partial retirement in 1999 to 59 to 63 years old workers in firms which did not introduced partial retirement in the whole observation period. Fourth and lastly, using rich administrative and survey data in

a difference-in-differences framework, I offer insights into causal effects of partial retirement which should be more meaningful than effects deducted in descriptive or correlation studies (e.g., Ghent et al. 2001, Van Solinge and Henkens 2014, Wanger 2009).

My results show that older workers' labor force participation responds to the introduction of partial retirement. Moreover, the results confirm that the effect on employment strongly depends on the model of partial retirement that is offered to the employees: For workers in firms offering solely the block model, I do not find any significant effects on employment. In contrast, for employees having solely access to the part-time model of partial retirement, I find a higher persistence in employment due to the introduction of partial retirement. The positive employment effect is mainly driven by the substitution of unemployment by employment in partial retirement. Since I can show that partial retirement in form of the part-time model does not crowd-out full-time employment, the positive effect on employment stays implies also an increase in the overall employment volume.

The paper is structured as follows. Section 2 describes the institutional setting and derives hypotheses on the expected reform effects. Section 3 first presents details on the data and the identification strategy followed by descriptive statistics and evidence on the validity of my identification strategy. Section 4 discusses the estimation results, analyses effect heterogeneity with respect to education, and provides further robustness checks. Section 5 concludes the paper.

2 Institutional setting and hypotheses

2.1 Partial retirement in Germany

Partial retirement (PR) offers options to reduce working hours at the end of an employee's working life. In Germany, the decision on whether or not a firm offers PR is the result of individual agreements between employee and employer, firm level agreements, or branch collective agreements (Wanger 2009). The Altersteilzeitgesetz (AtG) that came into force

on July 23, 1996 has established a legal framework for arrangements on PR.[3] The policy makers intended to offer older workers a gradual transition from working life into retirement as an alternative to unemployment and/or abrupt (early) retirement. Thereby, the policy makers wanted to deal with increasing practice of employers and employee to agree on using the early retirement and unemployment options given by the statutory pension insurance and the unemployment insurance (Lehndorff et al. 2007). With the AtG, the costs of this early retirement practices as an instrument of adjusting the workforce should be newly distributed from social security to the employers (Deutscher Bundestag 1996). In addition, the AtG should promote the recruitment of unemployed (Lehndorff et al. 2007). Later on, a revision of the AtG in 2000 was also motivated by the purpose to foster the promotion of employment (Deutscher Bundestag 2000).

The AtG defines employment of workers aged 55 and older who worked at least 1,080 days in employment with social security contributions in the last 5 years, reduce their working hours by 50 percent and still be employed with mandatory social security contributions as employment in PR. The employer has the choice to offer PR in form of the part-time model where employees reduce former working hours by at least 50 percent for the whole PR period, and/or in form of the block model where employees perform 100 percent of their former working hours in the first half of the PR period and do not to work in the second half.[4] Subsequent to the PR, employees need to be eligible for old-age retirement.[5] Employees in PR have to receive 50 percent of the former gross pay and a further premium of 20 percent of the halved former gross pay, i.e., the employee receive a minimum of 60 percent of the former gross pay. Additionally, employers have to pay pension contributions for the halved gross pay and an additional premium such that in the end pension contributions on 90 percent of the former gross pay are paid. The premium to the pay and pension contributions reduce losses of income and pension contributions and thereby make the difference between PR and "normal" part-time work (Brussig et al.

[3] Already in 1989, a law on partial retirement was in force, but expired by 1992. For details see Lehndorff et al. (2007).

[4] In the beginning, only full-time workers could take-up PR. Since a reform of the AtG in 2000, also part-time worker can be employed in PR.

[5] There is no need to enter old-age retirement, only the eligibility has to exist. The employee could also stay employed or apply for unemployment.

2009). Both premiums are exempt from tax and social security contributions. Until 2009, firms could apply for the refund of the premiums by the German Federal Employment Agency if they replaced the reduced working hours of the PR employee by hiring an unemployed worker or trainee. These public subsidies expired by the end of 2009 (BA 2015b).

The AtG does not implement a legal right to claim PR, but defines the legal frame and the minimum for the compensation of wage and pension contribution. Like the decision on offering PR, the precise design is the result of individual agreements between employee and employer, firm level agreements, or branch collective agreements (Wanger 2009).[6] In the first years after the introduction of the AtG, the number of arrangements on PR as well as the take-up of PR rapidly increased from year to year. From 1996 to 1999, the number of employees being in PR grew from about 2,000 to over 120,000 (DRV 2011). In 2000, more than 300 branch collective agreements affecting over 12 million workers existed (Brussig et al. 2009).

A survey by Klammer (2003) in 2003 shows that the majority of firms favored the block model over the part-time model. Almost 50 % of all firms that have offered partial retirement restricted partial retirement to the use of the block model. Only 5 % of the firms have offered only the part-time model of partial retirement. Moreover, the survey reveals that even in those firms where block and part-time model is offered, employees choose the block model of partial retirement more often. From employers' perspective, the block model shows high attractiveness due to the possibility to reduce the workforce. From employees' perspective, the block model respectively the release phase of the block model offered the option to leave the labor market before reaching the regular old-age retirement age at relatively low costs. The low use of the part-time model at firm level is explained by a lack of interest to invest in restructuring measures that would be required to supply part-time workplaces. This lack of interest can also explain a lower interest of employees to use the part-time model as the employees had to fear to be switched to jobs

[6] Available data on the take-up of PR in Germany do not allow to distinguish between the different models of PR.

that do not require any restructuring and were often related to simpler tasks (Lehndorff et al. 2007).

Despite the obvious general interest in partial retirement, the share of workers in PR related to all 55 to 64 years old employees paying mandatory social security contributions has decreased since 2009, from its maximum of around 18 percent in 2009 to 4 percent in 2018 (DRV 2020, BA 2020b). The majority of branch collective agreements on PR expired with the subsidies in 2009 although the subsidies were used only by a minority of firms.[7] Some branches extend their agreements beyond 2009, but already in 2010, only 6.4 million employees were included in these branch collective agreements compared to 12 million workers in 2000 (Brussig et al. 2009, Wanger 2010).

2.2 Related institutions: Pension reforms

With the passing of the AtG, workers in partial retirement (PR) received the opportunity to retire earlier than through the regular old-age retirement. In general, the German statutory pension insurance offers various pathways to retirement with different requirements and entry ages. Besides the regular old-age retirement, old-age retirement for unemployed (unemployment pathway), for women (women pathway), for long term employed, and severely handicapped people exist.[8] Additional to old-age pensions, the system offers retirement due to disability (disability pathway; for an overview of German retirement pathways, see Table A.1 in the appendix).

For all retirement pathways, except for the regular old-age retirement, two different entry ages exist; the normal retirement age (NRA) and the early retirement age (ERA). The NRA denotes the earliest age at which an individual can retire with full benefits. With

[7] The share of employees in subsidized PR relative to all employees in PR reached a maximum of 21 percent in 2013 (BA 2015a). The low importance of subsidies may be explained by the observation that PR was often used by firms seeking a personnel reduction. At any rate, the low use indicates that the subsidies were not the deciding factor to offer PR from the firms' point of view (Brussig et al. 2009).

[8] In 2012, a new retirement pathway for exceptional long-term employed was implemented. Since the birth cohorts of interest (1933-1944) in this paper are not affected by the introduction, the pathway is not discussed and presented in Table A.1.

the ERA, retirement is possible before reaching the NRA, but it is related to permanent deductions of 0.3 % of benefit amounts for every month of retiring before the NRA.[9]

Related to the AtG, workers in PR newly got access to the unemployment pathway. Workers were given the option to retire before the regular old-age retirement age of 65 if they were born before the first of January 1952, aged 60 and older, had contributed at least eight years within the last 10 years to the pension system, had at least 15 years of contribution or substitution (*Wartezeit*), and spend at least 24 months in PR.[10] Due to various reforms, the NRA and ERA of retirement due to unemployment differs by birth cohort (see column A of Table A.1 in the appendix). Individuals born before January 1, 1937 could enter retirement at age 60 with full benefits. Starting with birth cohort 1937, the NRA increased stepwise from age 60 to 65 and an ERA of 60 was introduced. Starting with birth cohort 1946, the ERA increased from 60 to 63.

Additional to these changes in the ERA and NRA of the pathway due to unemployment, it is important to consider further reforms of retirement pathways affecting the birth cohorts (1933-1944) and period of interest (1996-2003) in this paper. These reforms affected the NRA and ERA of the retirement for women, the retirement for severely handicapped, and the retirement for long term employed (see columns A, B, and E of Table A.1). Finally, also the disability pathway which allows retirement even before age 60 under certain conditions underwent relevant changes in 2001 (see column F of Table A.1).[11]

Since the eligibility for early retirement options can explain older workers' labor force participation (see e.g., Engels et al. 2017, Riphahn and Schrader 2021), I control for the individual earliest retirement age and the potential deductions for an early old-age or disability retirement.[12] For disability retirement, I also add a control for being eligible for the old regime before 2001.

[9] Related to this definition, early retirement strictly speaking means retirement prior to the NRA in the respective pathway. But in a broader sense and in this paper, early retirement is used as a general term for every retirement entry prior to the regular old-age retirement.

[10] The requirement of 24 months in PR was implemented as an alternative to the condition that individuals need to spend at least 52 weeks in unemployment after age 58.5.

[11] Individuals born 1937 and before were able to enter retirement without deductions as soon as they became disabled, independently of age. Starting with birth cohorts 1938, for retirement entries after 31.12.2000 and before the age of 63, benefit discounts of up to 10.8 percent were introduced. Furthermore, the reform in 2001 tightened the eligibility criteria for retirement entries after 2000.

[12] See Table A.2 in the appendix for an overview of the potential deductions by year and birth cohort.

2.3 Related institutions: Unemployment benefits

In Germany, employees paying social security contributions also pay contributions to the Unemployment Insurance (UI). After becoming unemployed, insured people receive unemployment benefits. The duration and amount of benefits depend on age and the duration of contribution payments. During my observation period, the institutional details governing UI remained unchanged. The maximum duration of unemployment benefit receipt for the age group 58 and older amounts to 24 months when the worker contributed to the UI for a minimum of 48 months prior to the unemployment entry. The unemployment benefits cover about 60 percent of previous net pay and the unemployment insurance pays pension contributions based on 80 percent of the previous gross pay.

Many studies confirm strong interactions between unemployment benefits and labor market participation of older workers (e.g., Dlugosz et al. 2014, Riphahn and Schrader 2020, Inderbitzin et al. 2016). Employees exploit the maximum duration of unemployment benefits to leave the labor market before entering retirement. This behavior is documented as *using unemployment as a bridge to retirement* (Inderbitzin et al. 2016).

2.4 Hypotheses on expected reform effects

From a theoretical point of view, individuals' decisions on labor supply are decisions between leisure and consumption. Following the life-cycle theory, individuals would steadily adapt working time over the life-cycle evaluating actual preferences for leisure and consumption. Since the preference for work gradually decreases and preference for leisure gradually increases with age due to for instance health issues, individuals prefer to end their working life by partially reducing working hours (Hurd 1996). Due to, e.g., fixed costs of restructuring workplaces within firms, older workers who want to reduce working hours would often have to accept substantial pay losses that forces them to exit full-time employment into early retirement or unemployment (Hurd 1996).

As a consequence, the option to reduce working hours with fixed wage rates in form of the part-time model of PR should ceteris paribus lead to an increase in older workers' employment duration. Thereby, I expect to see longer employment for older employees

having access to the part-time model of PR (H1). For workers who would have used unemployment to bridge the gap between the labor market exit and retirement entry in the situation without PR, employment in the part-time model of PR should decrease entries into unemployment (H2). Equally, also for those people who would have left the labor market by early retirement, PR in form of the part-time model should ceteris paribus lead to a decrease in early retirement.

However, to hypothesize the effect on retirement, I have to consider that related to the new AtG in 1996, employees in PR have received access to the unemployment pathway and thereby to early retirement with full or reduced benefits, depending on age and birth cohort. This would clearly influence the retirement behavior since early retirement can be more attractive than unemployment depending on age, birth cohort, and employment history. In the event unemployment is substituted by early retirement via the unemployment pathway, the decrease in unemployment will further be intensified and the probability for early retirement increases. It is not straightforward to derive which of the effects on early retirement dominate for the part-time model of PR, but if we observe an overall increase in early retirement, the effect should be lowest for those employees who only have access to the part-time model since employment in PR substitutes periods of unemployment and early retirement (H3).

For employees in the block model of PR, potential periods of unemployment should be substituted by early retirement or by the release phase of the block model since the wage and pension compensation are more generous for the two latter options and leisure would be the same for all three options. Therefore, I expect to see an increase in the probability for early retirement including entries into the release phase (H4) and a decrease in the probability for unemployment for the block model (H5).

Following the life-cycle theory, I do not expect to observe longer employment of older workers due to the block model of PR (H6).[13] Instead, it depends on the employee's preference for leisure and consumption if employment in the situation without PR is fully

[13] Employment within the block model is measured as employment in the work phase. Employment within the release phase is not coded as an employment stay but as an entry into early retirement (see section 3.2). Consequently, increases in the probability for employment stays can only be induced by workers who work longer in the work phase compared to employment in the situation without PR.

substituted by employment in the work phase. The release phase of PR gives workers the option to end their working lives earlier with relatively low costs since they are still paid within the release phase. This could incentivize employees with a high preference for leisure to decide for an earlier employment exit than they would have decided for without PR.[14]

3 Data and identification strategy

3.1 Data

This study uses the Linked-Employer-Employee Data (LIAB) from the Institute for Employment Research (IAB) of the Federal Employment Agency in Germany. The data set links information on firms surveyed in the IAB Establishment panel (EP) with employment biographies of employees of the interviewed firms. The EP surveys firms yearly for a fixed reference date (30th June). Employment biographies cover personal characteristics and information on employment and unemployment receipt at the daily level. Information on employment is given by the employers at least once a year. The employers inform inter alia about start and end of employment, changes in the employment status, birth year, gender, nation, residence of work, and the employers' industry. Additionally, employment biographies report times in unemployment provided that individuals receive UI benefits. For these times, the data set includes information on start and end of benefit receipt, amount of benefits, occupation, and reasons for the end of benefit receipts.

The LIAB longitudinal model 1 1990-2007 (LIAB LM1 9007) I use in this study contains information on firms surveyed in the IAB Establishment panel between 1999 and 2001. In 1999, the firms were asked about their partial retirement (PR) arrangements. In detail, firms report if there is an agreement on partial retirement in the firm in 1999 and what kind of PR model the firms offer to their employees. Additionally, they are asked if

[14] Given that PR is offered to the employees, I assume that firms' interest of offering PR do not play any further role for the employees' decision-making. But even if firms' interests can influence the decision on using PR, these interests would not be opposed to the expected employment effects. Firms offering the part-time model likely have an interest in enabling their employees longer employment. Firms using the block model are obviously not interested in longer employment but often in a socially acceptable workforce reduction (Wanger 2009).

employees applied for PR in 1998. The survey data is linked to employment biographies of all employees who worked at least for one day between 1996 and 2002 in the surveyed firms. For those workers, employment biographies are available for the period 1990 to 2007 (1991 to 2007 for workers in East Germany). For more information about the EP and the LIAB models, see Fischer et al. (2009) and Jacobebbinghaus (2008).

In this paper, I identify the causal effect of PR on the employees' labor force participation by comparing differences in the outcomes of workers employed in firms introducing PR in the year 1999 (treatment group) to outcomes of workers being employed in firms not introducing PR during the entire observation period 1996 to 2004 (control group). From all firms in the sample, I exclude those not answering to the question about PR. Also, I exclude those firms that have at least one employee in PR in the years 1996 to 1998 according to the employment biographies of the firms' employees.[15] Treatment is based on the introduction of PR in firms in 1999 according to the EP of 1999. Thereby, I can use the information on PR collected by the survey in 1999.[16] Consequently, firms that do not offer PR in 1999 according to the EP, but in 2000 or later according to the employment biographies are not considered.[17] Also firms that report to have no PR arrangements, but have at least one employee in PR in 1999 according to the employment biographies are excluded. Employees of the remaining firms that do not offer PR in 1999 according to the EP constitute the control group. The treatment group includes employees of those firms answering to offer PR in 1999 whereby I exclude firms that report in the EP of 1999 to have employees in PR in 1998.[18]

Additionally, I include only those firms that are established at least on January 1, 1996 since I use information on the workforce in 1996. I also omit firms belonging to

[15] This concerns 10 percent of all firms in the survey.

[16] I could also have based treatment on the availability of PR in 1998 and responding to the question about PR in the EP of 1999. I decided to use 1999 to include as many as firms possible in the treatment group on the one hand and to have a sufficient number of pre-treatment years on the other hand.

[17] This concerns 15 percent of all firms in the survey.

[18] Otherwise, with my outcome definition (see next section), I would measure treatment effects already in the pre-reform period by observing transitions in 1997.

the mining sector because they face special retirement regulations I cannot control for.[19] Finally, I discard firms that have had no employee over age 55 in the year 1996.

3.2 Outcome variables and sample

For my analysis, I construct three outcomes related to the hypotheses derived in section 2.4. First, I observe if a worker who was employed in year t (starting year of transition) stays employed during the next year $t + 1$ (*employment*). Second, I estimate if a worker was employed in year t becomes unemployed within the next year $t + 1$ (*unemployment*). Third and last, I observe if a worker who was employed in year t leaves employment for early retirement within the next year $t + 1$ (*retirement*). *Retirement* is defined to be an absorbing state and observations are censored thereafter. Since I observe employment transitions on a yearly basis, I convert the spell data on the individuals to a panel of person-year observations. I limit the sample to those employees being 59 to 63 years old in the starting year of the employment transition. Thereby, I focus on employees in those ages where the expected effects on employment, unemployment and early retirement should be directly observable.

Employment includes all employees paying mandatory social security contributions.[20] *Unemployment* includes all individuals who receive unemployment benefits (*Arbeitslosengeld I*).[21]

Retirement is not directly coded in the data. I assume that employees enter early retirement if the firm reports an end of employment and the employment spell is not followed by another spell in (un)employment for a certain time period. Since I observe employees being 59 to 63 years old in the starting year of transition and for all individuals in my sample, early retirement was possible by at least age 60 (see Table A.1), employees fulfill

[19] Miners who fulfill certain requirements were excluded from the increase in the NRA for the unemployment and women pathway beginning with cohorts 1937 (for details on the pension reforms, see section 2.2).

[20] For multiple employment spell during a year, I follow Berg et al. (2020) and keep only the longest spell.

[21] In some cases, parallel spells of employment and unemployment exists. Following the recommendations by Jaenichen et al. (2005), I code these spells as employment. Furthermore, gaps between employment and unemployment can occur, for example due to sanctions by the unemployment insurance for late unemployment report. I follow Riphahn and Schrader (2020) and fill gaps of up to 12 weeks as direct transitions and gaps of more than 12 weeks as exits from the labor market. For details see Riphahn and Schrader (2020).

the age requirements to enter early retirement at any point within the observation period. Additionally, last employment spells of individuals who return to the labor market as employed retirees and employees who start to receipt an occupational pension are assumed to be labor market exits into early retirement.

I do not want to code transitions from the work phase into the release phase of the block model as employment stays since employment within the release phase likely serves as an alternative way to leave the labor market into leisure and substitutes for periods in unemployment (see section 2.4). Employees that would have exited employment into unemployment without PR and instead use the release phase of PR to stop working do not prolong employment. Equally, employment stays within the release phase do not result in longer employment. Therefore, entries into the release phase of PR are coded as retirement entries and consequently employment stays within the release phase are censored.[22]

There are further employment transitions not included in the outcomes and thereby not part of my analysis. Inter alia, this includes transitions from or into marginal employment, receipt of income support, employment of trainees, civil servants, individuals in military service, or interns. Exits of the labor market by death are not considered in any of the states. I drop such spells from the data.

Since my observation period is limited, I have to find a rule to define when I can claim to observe no returns to the labor market. I argue that if for a minimum of three years after the last employment spell, there is no further spell observable in the data, there will be no return to the labor market at any later point since the individuals are already aged 59 and older. Consequently, employment spells that end in 2004 (or earlier), are reported as employment exits by the employer, and have no spells followed for a minimum of three years (until 31.12.2007) are defined as employment exits into early retirement. Consequently, employment spells that end within the period 01.01.2005 to

[22] In the data, I can identify employees in PR, but not the kind of PR model that is used. To detect workers in the release phase, I use the firm's information on PR and assume the following: First, employees in PR whose employer declared in the Establishment panel in 1999 to offer only the part-time model use the part-time model, and second, the remaining workers use the block model. For this group, I divide the entire employment period in PR in two periods of the same size and code the second one as "release phase".

31.12.2007 cannot be defined as early retirement entries and thereby, for employment transitions starting in 2004, I cannot observe exits into early retirement. Thus, I omit employment transitions starting in 2004 and later from the sample.[23]

Additionally, outcomes measured in 1990 to 1995 do also not enter the sample. The data include information about employees who worked in the sampled firms at least for one day between 1996 and 2002. Thus, for the years 1990 to 1995, I can observe just those workers in the sampled firms who have survived in employment until 1996 or later. Mechanically, in the years 1990 to 1995, I would not observe final retirement or unemployment entries. Therefore, I exclude employment transitions in the respective years. Furthermore, I also exclude outcomes measured in 1998 from the sample. Employment transitions starting in 1998 measure employment stays and exits within the year 1999 and thereby within the year of the introduction of PR. It is very likely that these outcomes already reflect treatment effects. My final sample includes 1,803 firms, 39,253 individuals and 77,616 person-year observations.

3.3 Descriptive statistics

Table 1 provides some descriptive statistics. From 17,379 workers in the control group, the share of those workers staying employed within the next year amounts to 65 percent and the share of workers who exit employment into unemployment accounts to 14 percent. 18 percent of the 59 to 63 years old employees in the firms not introducing PR leave the labor market into retirement in the next year. The treatment group has a similar employment rate, but a lower tendency to use unemployment as a bridge to retirement and a higher tendency for early retirement. The control group workers are employed by 1,232 firms and workers in the treatment group by 571 firms.

Figures 1-3 provide more detail on the development of the outcome variables for the treated and control group workers within the observation period. The outcomes measure the share of employment stays, employment exits into unemployment, and employment exits into early retirement from year t to year $t + 1$. This means the employment rate

[23] In section 4.4, I show that my results are robust to the exclusion of one further year.

in 1999 reflects the share of all employees in 1999 that stayed employed until the end of 2000. The employment, unemployment and retirement rate are depicted for treatment and control group for the pre-treatment years 1996 and 1997 and the post-treatment years 1999 to 2003.[24]

In Figure 1, I depict the development of the employment rate for treatment and control group workers from 1996 to 2003. For the control group employees, the course of the employment rate is not stable, but consistent with the general labor market development in Germany and the pension reforms described in section 2.2 that show the highest impacts starting in 1999 (see Table A.2).[25]

Comparing the rate of treated workers to that of the control group workers, I can observe an increase in the probability for employment stays for the treated workers in 1997 and thereby before treatment took place. It seems that in anticipation of the PR introduction, individuals adjusted their behavior in 1997 and stayed more often in employment.[26] In 1999, there is a clear jump in the probability for employment stays for the treatment group employees compared to the control group employees. In the following years, the rate for the treated workers steadily decreased until 2003, but remained on a higher level than employment for the control group except for 2003. Overall, the difference in the development of the employment rate between treatment and control group workers suggests an increase in the older workers' employment stays due to the introduction of PR.

Figure 2 presents the development of the unemployment rate for control and treatment group workers. For workers without access to PR, the development of the unemployment rate again can be explained by periods of high unemployment in Germany and pension reforms of unemployment, women, and disability pathways. By comparing the rate of treated workers to that of the control group workers, I can observe again anticipation behavior related to the introduction of PR. With the introduction of the PR, the decrease in the unemployment rate of the treatment group workers compared to the control group

[24] Employment transitions starting in 1998 are not included in the sample (see section 3.2). However, in order to provide completeness, Figures 1-3 include the rates also for 1998.

[25] During the years 1996 to 1999, the number of unemployed and the unemployment rate reached a historically high level from over 4 million unemployed persons which corresponds to 11 percent of the labor force (BA 2020a).

[26] In section 3.6, I discuss how I deal with these anticipation effects.

workers further increased indicating an overall decrease in older workers' probability to leave the labor market by using unemployment caused by the introduction of PR.

Figure 3 presents the share of 59 to 63 years old employees in a year exiting employment into early retirement within the next year. For workers in firms not introducing PR, the early retirement rate also reflects high unemployment in Germany in the end of the 90s and the pension reforms outlined in section 2.2. The early retirement rate for the treated workers increases from 1996 to 1997 as for the control group. However, comparing the gradients of both slopes, I can observe a slight decrease in the early retirement rate like for the unemployment rate. Again, this indicates that employees stayed in employment instead of exiting into early retirement in anticipation of the introduction of PR. In 1999, the early retirement rate significantly decreases before it increases again in 2000 reaching almost its pre-treatment level in 2003. Comparing the retirement behavior of treatment and control group before and after the introduction of PR points to more employment exits into early retirement exits of older workers due to the introduction of PR.

For each outcome, I graphically observe the expected treatment effects of PR. The next sections reveal if these observations can be causally attributed to the introduction of PR and how the effects differ by the kind of PR model offered by the firms.

3.4 Estimation model

I estimate the causal effect of partial retirement (PR) by using the following difference-in-differences regression models:

$$Y_{i,t} = \alpha\, treat_i + \beta\, year_t + \delta\,(treat_i * post_t) + \theta X_{i,t} + \epsilon_i, \tag{1}$$

$$\begin{aligned} Y_{i,t} =& \alpha\, treat_i + \beta\, year_t + \gamma\,(treat_i * post_t * part_i) + \tau\,(treat_i * post_t * block_i) \\ &+ \lambda\,(treat_i * post_t * block\_part_i) + \theta X_{i,t} + \epsilon_i. \end{aligned} \tag{2}$$

Let $treat$ indicate whether a worker is employed in a firm introducing PR in 1999 and belongs to the treatment group ($treat = 1$) or is employed in a firm not introducing PR in 1996-2004 and belongs to the control group ($treat = 0$). $Year$ is a vector of year fixed effects indicating the base year of the employment stay respectively employment

exit. $Post$ shows if the outcome is measured in the pre-treatment period 1996 to 1997 ($post = 0$) or in the post-treatment period 1999-2004 ($post = 1$).

With $part$, I measure if an employee works for a firm introducing solely the part-time model of PR ($part = 1$) or for a firm introducing also or only the block model ($part = 0$). With $block$, I measure if an employee works for a firm introducing solely the block model of PR ($block = 1$) or for a firm introducing also or only the part-time model ($block = 0$). With $block\_part$, I measure if an employee works in a firm introducing the block and part-time model ($block\_part = 1$) or in a firm introducing either solely the block model or solely the part-time model ($block\_part = 0$).[27] In the basic specification modeled in equation 7, δ is the general treatment effect of PR. In the main specification modeled in equation 8, I insert the three triple interaction terms $treat_i * post_t * part_i$, $treat_i * post_t * block_i$ and $treat_i * post_t * block\_part_i$ to identify potential differences in the causal effect by the PR model offered by firms. Here, γ is the treatment effect of PR when solely the part-time model is introduced, τ represents the effect of introducing PR when solely the block model is offered and λ is the treatment effect of PR when both models are offered. For all estimations of equation 8, I further present the results of F-tests on the significance of the difference in the treatment effects of the part-time and block model (F-Test on the hypothesis $\gamma - \tau = 0$). For all estimations, I follow suggestions by Cameron and Miller (2015) and cluster standard errors at the firm level.

For Y, I insert the three outcomes defined in section 3.2. With X, I include a constant and a vector of control variables at the individual level which have the potential to determine labor market performances. Hereby, I increase precision of the estimations (see Angrist and Pischke (2009)). First, I include controls on individuals' socio-demographic characteristics as age, gender, and education.[28] Second, I add firm level controls for the

[27] From 60,237 treated workers in my sample, for 3,554 observations, PR is offered only in form of the part-time model. Only the block model is available for 21,945 observations. 34,411 observations have the choice between the block and the part-time model. For 327 observations, the information on the PR model is missing. They are coded as $block\_part = 1$.

[28] My data do not contain information about birth month, but only birth year. To give an approximation of the age in the starting year of employment transitions, I assume that all workers were born on 30th of June. The education variable suffers from inconsistencies and missing values. I improve the variable by using an imputation procedure suggested by Fitzenberger et al. (2006). I assume that educational degrees cannot be lost and extrapolate education degrees from an individual's past to future observations to fill missing values.

firms' residence state, the unemployment rate on district level, number of employees, industry, and the employees' employment status subdivided into full-time and part-time work. All variables are measured in June 1996 to ensure exogeneity. Equally, I insert controls for tenure, and earnings measured from 1991 until the end of 1995.

Studies by e.g., Engels et al. (2017) and Riphahn and Schrader (2021) show that differences in eligibility and costs for early retirement also explain labor market preferences. Therefore, I take into account various pension reforms (see section 2.1) and control for the individual eligibility and potential deductions for old-age retirement related to gender, age, and birth cohort. Since all workers are at least 59 years old in the starting year of the employment transition I observe and all birth cohorts in my sample (1933-1944) have at least the option to retire at age 60 (see columns A and B of Table A.1), eligibility is given for all observations. For all observations, I insert a control for the highest deduction a worker has to anticipate for a retirement entry within the next year.[29] Besides gender, age, and birth cohort, eligibility for the old-age retirement pathways is determined by further conditions like for example a certain amount of insurance and contribution years or times in unemployment. Due to data limitation and to ensure exogeneity, I can only control for the number of days an individual has spent in unemployment from 1991 to 1995. Finally, I also control for the deductions workers have to anticipate if they would enter disability retirement in the next year as this regime also underwent relevant changes for my sample and period of interest (see column F of Table A.1). For details and descriptive statistics on all controls, please see Tables A.3 and A.4 in the appendix.

3.5 Selection into partial retirement

An employee's decision for employment in PR takes place on two levels. First, the firm has to offer PR either as the result of individual agreements between employee and employer, firm level agreements, or branch collective agreements. Second, the employee has to decide for an employment in PR. Thereby, the decision is influenced by the employee's

[29] I take into account that due to to protect the 'legitimate expectation' male (female) workers born before February (May) 1941 and being unemployed in February (May) 1996 were not affected by the reform of the unemployment (women) pathway and can still retire at age 60 without deductions.

characteristics but also by firms' characteristics if the firm is not bound to a branch collective agreement (Brussig et al. 2009). In my analysis, I avoid problems related to the selection of workers into PR in two ways. First, I do not condition treatment on using PR but on being in a firm introducing PR. This means that the results shown in the next section need to be interpreted as intention to treat effects (ITT). These are the effects of introducing PR for employees who could use PR in principle.[30] Second, I limit the sample to those workers being employed by their employer in the treatment year 1999 for a minimum of 3 years, i.e., I exclude workers with entries into the sampled firms after January 1, 1996.[31]

By using a difference-in-difference design, I deal with the selection of firms into PR related to time-constant firm level characteristics. By calculating differences in outcome changes for control and treatment group workers, I can control for differences in outcomes that are systematically influenced by time-constant differences in firm level characteristics that are related to the firms' decision on PR. The selection of firms in PR should not be an issue as long as there are no time-varying differences between the firms introducing PR and firms not introducing PR that systematically influence the employees' outcomes. In section 4.4, I show that my results are robust to limit the sample to firms bound to branch collective agreements. These firms do not decide on offering PR by themselves and thereby exogeneity of treatment is given.

3.6 Common trends assumption

The difference-in-differences approach fails to provide causal effects if labor market behavior of employees in firms introducing PR and in firms not introducing PR would not have followed the same trend in absence of the introduction of PR. Evidence for the plausibility of this so-called common trends assumption can be provided by showing parallel

[30] Some of the branch collective agreements define a limit for the share of employees in PR a firm has to accept. If the limit is reached, firms can deny further claims to PR (Brussig et al. 2009). The data do not provide information on limits for PR and denied applications for PR within firms that would bias my results toward zero. Therefore, the results on the ITTs should be interpreted as lower bound results.

[31] I provide a robustness test in section 4.4 where I change the limitation to 4 years.

trends in the developments of outcomes in the pre-treatment period for control and treatment group.

Figures 1-3 describe the development of the outcome variables for the entire observation period. For each of the three outcomes, I observe a slightly different trend in the rate's development from 1996 to 1997 for employees in firms with PR and firms without PR. It seems that employees adopted their employment behavior in 1997 in expectation of the introduction of PR in 1999. This is not very surprising because by measuring employment transitions in 1997, I observe if employees being employed in 1997 stay employed or exit employment into unemployment or early retirement until the end of 1998 and thereby very near to the introduction of partial retirement. Employees who expect to be able to reduce working hours by a partial retirement employment in form of the part-time model in 1999 likely stay employed instead of leaving into unemployment and early retirement. This explains the observed increase in the employment rate and the decrease in the unemployment and retirement rate of the treated group employees compared to the control group in 1997. As a consequence of the anticipation effects, I limit the pre-treatment period for all outcomes to 1996 and define year 1997 as 'anticipation period'. [32]

In order to provide evidence for the common trends assumption that workers of the treatment group firms and workers of the control group firms follow the same trend in employment transitions measured in 1996, which include transitions from employment in 1996 to employment, unemployment, and early retirement in 1997, I convert the spell data to a panel of person-month observations. Thereby, I am able to observe potential trends within 1996 and 1997. I observe if an individual who is employed in month t either stays employed, exits employment into unemployment, or exits employment into early retirement in month $t+1$ for both years.[33] For this sample, I test on differences in time trends

[32] Formally, in equation 7, I insert an interaction between the treatment group indicator $treat$ and an indicator for outcomes measured in the anticipation period $anticip$. In equation 8, I insert the interaction terms $treat_i * anticip_t * part_i$, $treat_i * anticip_t * block_i$, and $treat_i * anticip_t * block\_part_i$ to control for PR model-specific anticipation effects.

[33] Within the panel of person-month observations, I observe workers aged 60 to 64 in order to ensure comparability to the panel of person-year observations. In the sample with yearly transitions, I observe employees being 59 to 63 years old in the starting year of transitions. Thereby, they are 60 to 64 years old in the year where the decide to stay employed, to leave employment into unemployment, or to leave employment into early retirement. See Tables A.5 and A.6 for details on the sample.

in the monthly outcomes between control and treatment group workers in 1996 and 1997 by adding linear treatment-specific time trends (tt and $tt * treat$) to equation 7 and linear PR model-specific time trends (tt, $tt * part$, $tt * block$, and $tt * block\_part$) to equation 8. To find supportive evidence for the common trends assumption, the coefficients on the time trends for the treatment groups should be insignificant. The results on the pooled treatment-specific time trend (columns 1, 3, and 5) and for the PR model-specific time trends (columns 2, 4, and 6) in Table 2 provide evidence for parallel trends in outcomes of control and treatment group workers for all outcomes and thereby for the validity of my identification strategy.

4 Results and robustness

4.1 Main results

Table 3 presents the OLS estimates of the treatment effects of PR as modeled in equation 7 and 8 in the previous section on the outcomes for employment (columns 1-3), unemployment (columns 4-6), and retirement (columns 7-9).[34] The outcome variables are measured as rates from 0 to 1. To interpret the effects in percentage points, the coefficients have to be multiplied by 100. For each of the three outcomes, I estimate three different specifications. First, I estimate two specifications of equation 7 by which I estimate treatment effects of PR pooled for the the different PR models. In equation 7, I regress the outcome variables on the reform indicators $treat$ and $treat * post$ as well as year fixed effects and all X variables presented in Table A.3. In the first specification, I do not control for anticipation effects in the outcomes in 1997 and 1998 (columns 1, 4, and 7). For the second specification (columns 2, 5, and 8), I add the indicator $anticipXtreat$ to control for treatment-specific anticipation effects. Finally, I estimate equation 8 where I add the triple interaction terms $treat * post * part$, $treat * post * block$ and $treat * post * block\_part$

[34] It is important to note that the effects on employment, unemployment, and retirement do not add up to one. On the one hand, employment exits into the state “other" is not analyzed, on the other hand for employees in the block model transitions from work phase to release phase are not coded as employment stays but as retirement entries. For details see section 3.2.

(columns 3, 6, and 9). Thereby, I allow for heterogeneous treatment effects by the kind of PR model. I further add indicators to control for PR model-specific anticipation effects.

For employment, the result of specification 1 shows a negative, but insignificant effect of PR (column 1). By adding the interaction between anticipation and treatment group indicator, the coefficient remains insignificant, but turns positive (column 2). This confirms my concern that without a control for anticipation the treatment effect of PR on employment would probably be underestimated. Estimating the PR model-specific treatment effect in specification 3 (column 3), I find the expected significant positive employment effect for the part-time model (H1). For those 59 to 63 year olds being in employment, the mean probability to stay employed within the next year rises by around 8 percentage points respectively 12 percent when PR is introduced in form of the part-time model. In contrast, the effect for the block model is negative and insignificant as expected (H6).

For the first specification of equation 7, I observe that the probability to exit employment into unemployment significantly decreases by about 8 percentage points for employees in firms introducing PR (column 4). Again, by adding the treatment group-specific anticipation effect (column 5), the absolute amount of the PR effect increases which again points to the importance to control for anticipation. Looking at the effects by the model of PR (column 6), I find evidence for hypotheses 2 and 5 where I assumed that the part-time model and also the block model of PR decrease older workers' probability to use unemployment as a bridge to retirement.

Estimating the pooled treatment effect on retirement, the result reveals a significant increase in early retirement due to PR (columns 7 and 8). Both effects are significant at the 1 percent level. However, the estimation of specification 3 reveals that this significant positive effect is solely driven by the block model of PR. As expected in hypothesis 3, the coefficient for the effect of the part-time model is significantly lower than for the block model and even insignificant. For the block model, I find the expected higher propensity for early retirement due to PR (H4) which is significant at the 1 percent level.

To sum up, when PR is used solely in form of the part-time model, I find the expected persistence in employment (H1) and a lower probability for unemployment (H2).

The results imply that PR leads to longer old-age employment due to the substitution of periods in unemployment by employment in PR.[35] For early retirement, I also observe the expected lower increase in the propensity for early retirement for the part-time model compared to the block model (H3). For the block model, besides the expected positive effect on early retirement that also includes entries into the release phase of the block model (H4), I also observe the expected lower propensity for unemployment (H5). Lastly, I observe no significant effect on employment (H6). Periods in unemployment seem to be substituted by employment stays within the release phase of PR where employees do not work anymore and by entries into early retirement via the unemployment pathway when PR in form of the block model is used. In all, the results suggest that PR in form of the block model cannot serve as an instrument to exploit older workers' employment potential since it does not motivate the extension of working lives but only substitutions between alternative ways to leave the labor market.

4.2 Estimations on full-time employment

So far, I find evidence that the part-time model of PR leads to an increase in the probability to stay employed for 59 to 63 years old workers. By looking at employment stays in general, I am not able to say anything about the employment volume. If PR in form of the part-time model leads to a crowding-out of full-time employment (years in full-time employment are substituted by part-time employment in PR), the effect on the employment volume could be negative if the reduction of full-time employment is not compensated by a sufficient time in PR.

In the following, I estimate the effects of PR on the probability for full-time employment stays and on the probability for employment transitions from full-time to part-time work. I define employment stays in full-time as the share of all employees working full-time in year t that stay in full-time employment within the next year $t + 1$ instead of

[35] The employment rate increases by more percentage points than the unemployment rate decreases. Since the effect on early retirement is small and insignificant, it is possible that PR motivated employees to stay employed who would have exit employment neither into unemployment nor early retirement but for example into marginal employment or receipt of income support.

working part-time or exiting employment. Employment transitions from full-time to part-time work measure the share of all employees working full-time in year t that change in part-time employment within the next year $t+1$ instead of exiting employment. For both outcomes, I present the results of the PR model-specific effects (equation 8) in Table 4. For the part-time model, I find no effect of PR on the probability for employment stays in full-time employment, but a positive effect on the probability for employment transitions from full-time to part-time work. Instead of leaving the labor market abruptly from a full-time employment, PR seems to enable older workers in full-time to stay employed by reducing working hours. Hereby, I find evidence that PR in form of the part-time model does not lead to a crowding out of full-time employment, but to an overall increase in the employment volume.

4.3 Effect heterogeneity by education

Next, I investigate whether the effects of the part-time model of partial retirement differ by education. Low educated workers are more likely to do hard physical work (ISSP 2015) which is related to a lower ability to work until the regular old-age retirement (Wanger 2009). Furthermore, the group of low educated workers is the group of older workers with the lowest average incomes and average pension entitlements (Steiner and Geyer 2010). Consequently, older workers with low education should have higher incentives to use the opportunity of the part-time model of PR to reduce working hours respectively workload in order to increase their own employability and extend working lives. This would lead in turn to higher income and pension entitlements. Thereby, I expect to see the highest effects of the part-time model on employment for low educated employees. Table 5 shows the results of the estimation of the PR model-specific treatment effects (equation 8) on employment, unemployment, and early retirement for three different education groups. The first education group (Panel A) consists of workers without university degree as well as vocational training. The second education group (Panel B) includes workers with vocational training, and the third group (Panel C) all workers having a university degree or a degree from a technical college. As expected, the results show the strongest response

to the part-time model of PR for the lowest education group compared to the pre-reform mean. Due to the introduction of PR, the probability for low educated employees to stay employed increases by almost 30 percent compared to 10 percent for the middle educated workers and no employment effect for the highest educated workers. For the block model, I find a small effect on employment for the low educated workers and no effects for the other two education groups as for the whole sample. To sum up, the part-time model offers especially low educated workers an effective option to ensure employability and thereby to stay employed. Due to the low average incomes and pension entitlements, the low educated workers have a higher risk for old-age poverty (Geyer et al. 2019). Thereby, PR may additionally contribute to decrease the risk for future income supports by the government.

4.4 Robustness

This section assesses the robustness of the PR model-specific effects of PR (columns 3, 6, and 9 of Table 3) with respect to sample selection and the choice of estimator. The estimation results for the sample variations are presented in columns 2 to 5 of Table 6 and compared to the main results of Table 3 presented again in column 1. Table 7 provide results for alternative estimators whereas the main results from Table 3 are presented again in columns 1, 4, and 7.

For the first test, I exclude workers who have been employed in 1999 by less than four years. To deal with the problem that workers could have self selected into firms with partial retirement (PR), I only include workers who have been employed by the sampled firms since January 1, 1996. To show robustness of my results, I limit my sample to workers whose employment relationship with the surveyed firm starts on first of January 2005 or even before. The results in column 2 of Table 6 confirm the robustness of my results with respect to this variation.

In a second test, I exclude outcomes observed in 2003. In the data, I cannot directly observe employment exits into early retirement. For employment spells that have no spells followed for a minimum of three years, I claim that these can be defined as employment

exits into early retirement. For the last three years of my observation period (2005-2007), following this definition, I cannot observe early retirement entries. Thereby, I exclude employment transitions that start in 2004 and later. I test robustness of my data and also exclude employment transitions starting in 2003. My results are robust to this check as shown in column 3 of Table 6.

For a third test, I limit the sample of firms to those bound by a branch collective agreement according to the Establishment panel in 1999. Firms self select into PR if they are not bound by collective agreements. By using a difference-in-differences model, I can control for differences in outcomes of control and treatment group workers due to time-constant firm characteristics that are related to firms' decision on PR. Thereby, the selection of firms in PR should not be an issue if there are no time-varying differences between the firms introducing PR and firms not introducing PR that systematically influence the employees' outcomes. To show robustness of my results, I estimate the effect of PR only for workers in firms that signed a branch collective agreement. Thereby, the decision on PR is not made on firm but on branch level and exogeneity of treatment is given. The results in column 5 of Table 6 show robustness of the main results on the PR model-specific effects against this sample limitation.

In the last and fourth test, I re-estimate equation 8 by using alternative estimators. In Table 7, I show the estimated PR model-specific treatment effects by using a logit (columns 2, 5, and 8) and probit (columns 3, 6, and 9) estimator. By comparing the sign and significance of the coefficients with the main results (columns 1, 4, and 7), I find that my results are robust with respect to alternative estimators.

5 Conclusions

Governments with pension systems suffering from population aging are seeking ways to incentivise longer old-age employment in order to ensure financial sustainability of the pension system and adequate pension benefits (OECD 2019). In this study, I investigate whether PR can serve as an instrument to exploit the old-age employment potential. For this purpose, I exploit the introduction of partial retirement (PR) options at the firm

level following the law on partial retirement of 1996 by using a difference-in-differences approach. I compare changes in employment, unemployment, and early retirement for employees aged 59 to 63 who work in firms introducing PR in 1999 and employees who work in firms not introducing PR. My analysis includes one major feature: I can distinguish if firms solely offer the part-time model of PR, solely the block model or both kinds of models and thus provide heterogeneous effects of PR with respect to the PR model. Thereby, I am able to provide differentiated policy implications especially for the German labor market policy where part-time and block model coexist.

I find that when PR is offered in form of the part-time model, employment in PR substitutes periods in unemployment yielding a higher persistence in employment. Furthermore, I show that older workers' probability to stay in full-time employment remains unchanged by the introduction of PR in form of the part-time model. This implies that the part-time model of PR results in a net labor supply gain of older workers. In contrast, when PR is offered in form of the block model, effects on the probability for continued employment are not observable. The release phase of the block model and the option to enter early retirement via the unemployment pathway serve as an alternative to leave the labor market and substitute periods in unemployment. My heterogeneity analysis further reveals that least educated workers respond to the introduction of PR the most strongly. This is especially meaningful from the governments' perspective since low educated workers are very likely to have the highest risk for old-age poverty.

I use rich administrative and survey data on a large sample of employers and employees. Nevertheless, the analysis reveals some data limitations which leave room for improvements and potentially future research. The first and probably most critical limitation arises from missing data on part of the workforce of the sampled firms for the years 1990 to 1995 (for details see section 3.2). Extended information on the workforce from 1995 and before for the surveyed firms would allow further tests on the validity of the identification strategy. Furthermore, it would allow to exploit the introduction of PR before 1999 and thereby to include also those surveyed firms which introduced PR in the years 1996 to 1998. The second limitation is missing information on birth months in the personal

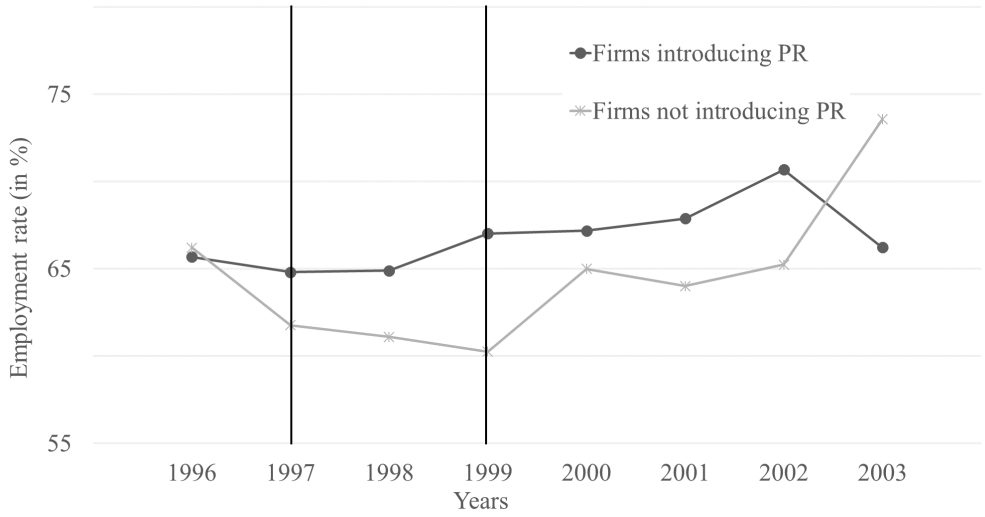
data set. Knowledge of the birth months would allow to code retirement entries and the control for the pension reforms taking place during my observation period more precisely. Thereby, precision of the estimation result would potentially increase. The third limitation arises from missing information on the exact working hours of employment spells in the personal data. Knowing the exact working hours would allow quantifying changes in the employment volume that would be needed to provide detailed cost-benefit analyses. The fourth limitation is missing information on the process behind the take-up of PR. Some branch collective agreements define an upper limit for the share of employees in PR a firm has to accept. If the limit is reached, firms can deny further claims to PR (Brussig et al. 2009). The data do not provide information on denied applications for PR within firms that would bias my results towards zero. Therefore, the results have to be interpreted as lower bound results.

Despite these data limitations, I am able to provide causal evidence that PR can be used as an instrument to prolong older workers' employment and thus to meet the challenge of an aging society concerning the financial sustainability of the pension system. For policy makers, the results of this study imply the recommendation to foster the availability of PR in form of the part-time model and thereby of 'real' PR for all employees. Given the lack of interest at the firm level to offer the part-time model of PR (see 2.1), German policy makers should consider to implement a legal claim to 'real' PR in form of the part-time model within the AtG. By a legal claim of employees to work in part-time, firms would be forced to restructure workplaces so that also qualified jobs could be performed in part-time. By that, working part-time could lose its stigma of being simple work which could make it more attractive for more employees (see 2.1). Related to the legal claim, it would be necessary to review the arrangement of PR within the AtG. First of all, the option to choose the block model or at least the exemption for workers using the block model should be abolished. My findings confirm that the block model of PR is solely used as an alternative to leave the labor market which clearly stands in contrast to the labor market and pension policy's need to prolong working lives. The use of the block model as a kind of early retirement should not be financed by the tax payers and

and social security contributors who compensate the losses due to the exemption of the additional premium to the pay and pension contributions from taxes and social security contributions (compare Wanger 2009). Additionally, further research should investigate if and how the exemption from tax and social security contributions should remain for the part-time model to compensate employees for the losses in income and pension contributions on the one hand and to be in a balanced ratio to the benefits of PR on the other hand. Equally, future research needs to discuss if the premium to the pay and pension contribution paid by the employer should be subsidized for certain firms like small ones that could likely not afford them (compare Haan and Tolan 2017). Finally, employees should get the option to reduce working hours individually and not only by 50 percent (compare Brussig et al. 2009). This would maintain older workers' employability in the best possible way PR is able to do since workers are in the best position to decide which workload they are able and willing to provide.

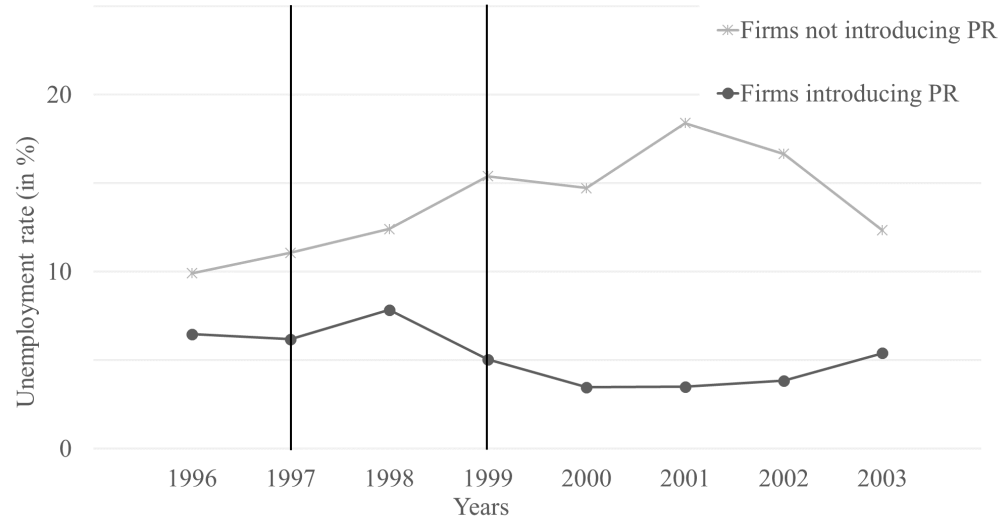
Figures and tables

Figure 1: Employment rate by treatment status over time



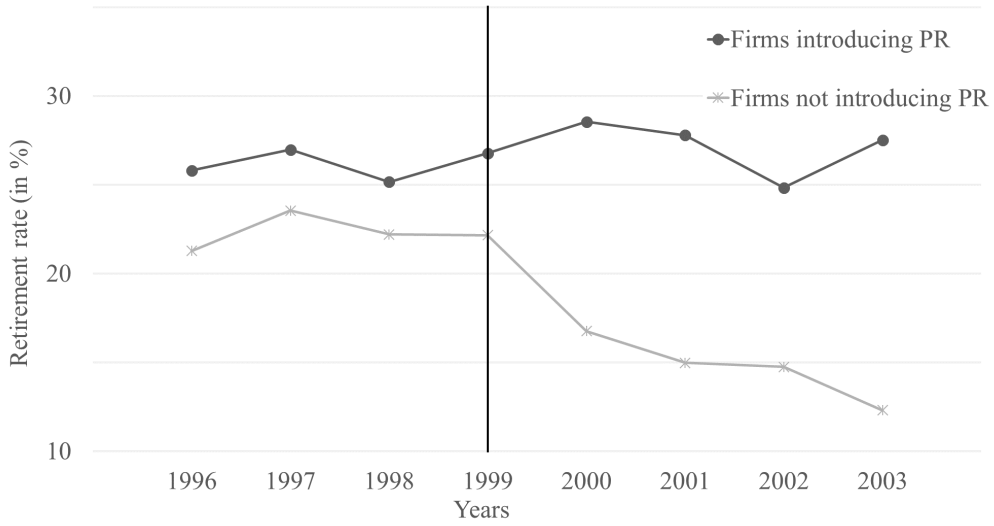
Notes: The employment rate measures the share of individuals being employed in the base year which stay in employment in the next year relative to all employees in the respective base year. The first vertical line in each figure marks the last pre-treatment year, the second vertical line tags the first post-treatment year. Outcomes measured in year 1998 are dropped from the sample.
Source: LIAB LM1 9007, own calculations.

Figure 2: Unemployment rate by treatment status over time



Notes: The unemployment rate measures the share of individuals being employed in the base year which exit employment in unemployment in the next year relative to all employees in the respective base year. The first vertical line in each figure marks the last pre-treatment year, the second vertical line tags the first post-treatment year. Outcomes measured in year 1998 are dropped from the sample.
Source: LIAB LM1 9007, own calculations.

Figure 3: Retirement rate by treatment status over time



Notes: The retirement rate measures the share of individuals being employed in the base year which exit employment into early retirement in the next year relative to all employees in the respective base year. The first vertical line in each figure marks the last pre-treatment year, the second vertical line tags the first post-treatment year. Outcomes measured in year 1998 are dropped from the sample.
Source: LIAB LM1 9007, own calculations.

Table 1: Mean of outcome variables by treatment group

	Control group	Treatment group	Total sample
Employment	0.6504	0.6724	0.6675
Unemployment	0.1435	0.0468	0.0685
Retirement	0.1778	0.2694	0.2489
Observations	17,379	60,237	77,616
Firms	1,232	571	1,803

Source: LIAB LM1 9007, own calculations.

Table 2: Estimation results of differences in time trends

	Employment		Unemployment		Retirement	
	(1)	(2)	(3)	(4)	(5)	(6)
Treat * time trend	-0.0002		0.0000		0.0002	
	(0.0002)		(0.0001)		(0.0001)	
Treat * part * time trend		-0.0002		0.0001		0.0000
		(0.0003)		(0.0001)		(0.0003)
Treat * block * time trend		-0.0003		0.0002		0.0001
		(0.0002)		(0.0001)		(0.0002)
Treat * block_part * time trend		-0.0002		-0.0000		0.0002
		(0.0002)		(0.0001)		(0.0002)
Controls:						
PR model	No	Yes	No	Yes	No	Yes
Anticipation effect	No	No	No	No	No	No
X Variables	Yes	Yes	Yes	Yes	Yes	Yes
Observations	148,365		148,365		148,365	

Notes: The table shows OLS estimates of the coefficient on “treat * tt" of equation 7 (columns 1, 3, and 5) and on “treat * tt * part", “treat * tt * block" and “treat * tt * block_part" of equation 8 (columns 2, 4, and 6). Outcome variables are measured as monthly transitions and the observation period is limited to 1996-1997. In addition to the reported variables, all regressions include a constant, an indicator for treatment, monthly fixed effects, and a linear time trend tt. Post is equal to 1 for outcomes measured in month 7 to 12 in 1996. “F-Test diff. part and block" provides p-values of an F-test for significance of the differences between the treatment effect for the group of workers having solely access to the part-time model and for the group of workers having solely access to the block model. Standard errors in parentheses are clustered at firm level. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.
Source: LIAB LM1 9007, BA (2005), own calculations.

Table 3: Main estimation results of treatment effects on employment transitions

	Employment			Unemployment			Retirement		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Treat * post	-0.0059	0.0122		-0.0725***	-0.0799***		0.0853***	0.0798***	
	(0.0152)	(0.0172)		(0.0100)	(0.0125)		(0.0117)	(0.0141)	
Treat * post * part			0.0800***			-0.0658***			0.0012
			(0.0215)			(0.0145)			(0.0182)
Treat * post * block			-0.0044			-0.0885***			0.1050***
			(0.0181)			(0.0127)			(0.0164)
Treat * post * block_part			0.0155			-0.0760***			0.0722***
			(0.0184)			(0.0137)			(0.0142)
F-Test diff. part and block			0.0000***			0.0294**			0.0000***
Controls:									
PR model	No	No	Yes	No	No	Yes	No	No	Yes
Anticipation effect	No	Yes	Yes	No	Yes	Yes	No	Yes	Yes
X Variables	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Pre-treatment mean	0.6580			0.0727			0.2474		
Observations	77,616			77,616			77,616		

Notes: The table shows OLS estimates of the coefficient on “treat * post" of equation 7 (columns 1, 2, 4, 5, 7, and 8) and on “treat * post * part", “treat * post * block" and “treat * post * block_ part" of equation 8 (columns 3, 6, and 9). In addition to the reported variables, all regressions include a constant, an indicator for treatment, and year fixed effects. “F-Test diff. part and block" provides p-values of an F-test for significance of the differences between the treatment effect for the group of workers having solely access to the part-time model and for the group of workers having solely access to the block model. Standard errors in parentheses are clustered at firm level. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.
Source: LIAB LM1 9007, BA (2005), own calculations.

Table 4: Estimation results of treatment effects on full-time employment

	Employment stays in full-time employment
	(1)
Treat * post * part	0.0340
	(0.0248)
Treat * post * block	-0.0014
	(0.0189)
Treat * post * block_part	0.0131
	(0.0197)
F-Test diff. part and block	0.0772*
Controls:	
PR model	Yes
Anticipation effect	Yes
X Variables	Yes
Observations	64,104

Notes: The table shows OLS estimates of the coefficients on “treat * post * part", “treat * post * block" and “treat * post * block_ part" of equation 8. The outcome variables is defined as the share of employees which exit full-time employment within the next year related to all full-time employees in the starting year. In addition to the reported variables, all regressions include a constant, an indicator for treatment, and year fixed effects. “F-Test diff. part and block" provides p-values of an F-test for significance of the differences between the treatment effect for the group of workers having solely access to the part-time model and for the group of workers having solely access to the block model. Standard errors in parentheses are clustered at firm level. * p < 0.1, ** p < 0.05, *** p < 0.01.
Source: LIAB LM1 9007, BA (2005), own calculations.

Table 5: Estimation results of treatment effects by workers' education

	Employment	Unemployment	Retirement
	(1)	(2)	(3)
Panel A: Low educated (N=11,601)			
Treat * post * part	0.1737***	-0.0450	-0.0993**
	(0.0432)	(0.0281)	(0.0404)
Treat * post * block	0.0650*	-0.0726***	0.0247
	(0.0348)	(0.0250)	(0.0321)
Treat * post * block_part	0.0744**	-0.0697***	0.0140
	(0.0344)	(0.0255)	(0.0300)
F-Test diff. part and block	0.0013***	0.1366	0.0008***
Pre-reform mean	0.5847	0.0748	0.3195
Panel B: Middle educated workers (N=48,652)			
Treat * post * part	0.0678***	-0.0728***	0.0141
	(0.0240)	(0.0162)	(0.0212)
Treat * post * block	-0.0216	-0.0974***	0.1270***
	(0.0207)	(0.0148)	(0.0193)
Treat * post * block_part	-0.0063	-0.0816***	0.0946***
	(0.0211)	(0.0154)	(0.0175)
F-Test diff. part and block	0.0000***	0.0265**	0.0000***
Pre-reform mean	0.6396	0.0777	0.2581
Panel C: High educated workers (N=12,009)			
Treat * post * part	0.0321	-0.0684**	0.0661*
	(0.0481)	(0.0293)	(0.0354)
Treat * post * block	-0.0047	-0.0830***	0.1092***
	(0.0389)	(0.0237)	(0.0259)
Treat * post * block_part	0.0225	-0.0744***	0.0731***
	(0.0383)	(0.0252)	(0.0245)
F-Test diff. part and block	0.2622	0.4351	0.1212
Pre-reform mean	0.8168	0.0657	0.1018
Controls:			
PR model	Yes	Yes	Yes
Anticipation effect	Yes	Yes	Yes
X Variables	Yes	Yes	Yes

Notes: The table shows OLS estimates of the coefficients on "treat * post * part", "treat * post * block" and "treat * post * block_ part" of equation 8 for three different samples (Panel A-C). Panel A includes workers without university degree and vocational training, Panel B includes workers with vocational training, and Panel C includes all workers having an university degree or a degree from a technical college. In addition to the reported variables, all regressions include a constant, an indicator for treatment, and year fixed effects. "F-Test diff. part and block" provides p-values of an F-test for significance of the differences between the treatment effect for the group of workers having solely access to the part-time model and for the group of workers having solely access to the block model. Standard errors in parentheses are clustered at firm level. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.
Source: LIAB LM1 9007, BA (2005), own calculations.

Table 6: Robustness tests of treatment effects: sample variation

	Main estimation	Workers with firm entries on January, 1 1995 or before	Outcomes measured in 1996 to 2002	Only firms with branch collective agreement
	(1)	(2)	(3)	(4)
Dependent variable: Employment				
Treat * post * part	0.0800***	0.0791***	0.0955***	0.1045***
	(0.0215)	(0.0216)	(0.0215)	(0.0253)
Treat * post * block	-0.0044	-0.0073	0.0106	0.0289
	(0.0181)	(0.0182)	(0.0184)	(0.0219)
Treat * post * block_part	0.0155	0.0122	0.0375**	0.0411*
	(0.0184)	(0.0184)	(0.0170)	(0.0229)
F-Test diff. part and block	0.0000***	0.0000***	0.0000***	0.0000***
Dependent variable: Unemployment				
Treat * post * part	-0.0658***	-0.0630***	-0.0741***	-0.0865***
	(0.0145)	(0.0145)	(0.0148)	(0.0178)
Treat * post * block	-0.0885***	-0.0837***	-0.0939***	-0.1070***
	(0.0127)	(0.0128)	(0.0130)	(0.0164)
Treat * post * block_part	-0.0760***	-0.0717***	-0.0879***	-0.0937***
	(0.0137)	(0.0138)	(0.0129)	(0.0170)
F-Test diff. part and block	0.0294**	0.0434**	0.0653*	0.0667*
Dependent variable: Retirement				
Treat * post * part	0.0012	-0.0006	-0.0042	0.0065
	(0.0182)	(0.0183)	(0.0186)	(0.0218)
Treat * post * block	0.1050***	0.1032***	0.0962***	0.0998***
	(0.0164)	(0.0164)	(0.0167)	(0.0192)
Treat * post * block_part	0.0722***	0.0718***	0.0645***	0.0724***
	(0.0142)	(0.0143)	(0.0146)	(0.0179)
F-Test diff. part and block	0.0000***	0.0000***	0.0000***	0.0000***
Controls:				
PR model	Yes	Yes	Yes	Yes
Anticipation effect	Yes	Yes	Yes	Yes
X Variables	Yes	Yes	Yes	Yes
Observations	77,616	75,443	65,776	60,060

Notes: The table shows OLS estimates of the coefficient on “treat * post * part", “treat * post * block" and “treat * post * block_ part" of equation 8 for different samples. In addition to the reported variables, all regressions include a constant, an indicator for treatment, and year fixed effects. “F-Test diff. part and block" provides p-values of an F-test for significance of the differences between the treatment effect for the group of workers having solely access to the part-time model and for the group of workers having solely access to the block model. Standard errors in parentheses are clustered at firm level. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.
Source: LIAB LM1 9007, BA (2005), own calculations.

Table 7: Robustness tests of treatment effects: logit and probit estimator

	Employment			Unemployment			Retirement		
	Main estimation	Logit estimation	Probit estimation	Main estimation	Logit estimation	Probit estimation	Main estimation	Logit estimation	Probit estimation
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Treat * post * part	0.0800***	0.3987***	0.2391***	-0.0658***	-0.5922**	-0.3398***	0.0012	0.0715	0.0428
	(0.0215)	(0.1048)	(0.0640)	(0.0145)	(0.2402)	(0.1151)	(0.0182)	(0.1121)	(0.0659)
Treat * post * block	-0.0044	-0.0241	-0.0161	-0.0885***	-1.1751***	-0.5862***	0.1050***	0.6728***	0.4024***
	(0.0181)	(0.0853)	(0.0523)	(0.0127)	(0.1913)	(0.0929)	(0.0164)	(0.0985)	(0.0576)
Treat * post * block_part	0.0155	0.0808	0.0467	-0.0760***	-0.9865***	-0.5055***	0.0722***	0.4870***	0.2915***
	(0.0184)	(0.0872)	(0.0533)	(0.0137)	(0.2392)	(0.1090)	(0.0142)	(0.0876)	(0.0514)
F-Test/chi2-test diff. part and block	0.0000***	0.0000***	0.0000***	0.0294**	0.0087***	0.0156**	0.0000***	0.0000***	0.0000***
Controls:									
PR model	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Anticipation effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
X Variables	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	77,616			77,616			77,616		

Notes: The table shows results of OLS (columns 1, 4, and 7), logit (columns 2, 5, and 8), and probit estimates (columns 3, 6, and 9) of the coefficients on “treat * post * part", “treat * post * block" and “treat * post * block_ part" of equation 8. In addition to the reported variables, all regressions include a constant, an indicator for treatment, and year fixed effects. “F-Test diff. part and block" provides p-values of an F-test for significance of the differences between the treatment effect for the group of workers having solely access to the part-time model and for the group of workers having solely access to the block model in columns 1, 4, and 7. “Chi2-Test diff. part and block" provides p-values of an chi-square-test for significance of the differences between the treatment effect for the group of workers having solely access to the part-time model and for the group of workers having solely access to the block model in columns 2, 3, 5, 6, 8, and 9. Standard errors in parentheses are clustered at firm level. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.
Source: LIAB LM1 9007, BA (2005), own calculations.

Appendix

Table A.1: Retirement age by retirement pathway and birth cohort

	A		B		C		D		E		F	
Birth Cohort	Retirement due to unemployment NRA (Yr.)	ERA (Yr.)	Retirement for women NRA (Yr.)	ERA (Yr.)	Ret. after long term employment NRA (Yr.)	ERA (Yr.)	Regular old age retirement NRA (Yr.)	ERA (Yr.)	Severely handicapped retirement NRA (Yr.)	ERA (Yr.)	Disability retirement NRA (Yr.)	ERA (Yr.)
1932	60 (1992)	n.a.	60 (1992)	n.a.	63 (1995)	n.a.	65 (1997)	n.a.	60 (1992)	n.a.	âdisability age	n.a.
1933	60 (1993)	n.a.	60 (1993)	n.a.	63 (1996)	n.a.	65 (1998)	n.a.	60 (1993)	n.a.	âdisability age	n.a.
1934	60 (1994)	n.a.	60 (1994)	n.a.	63 (1997)	n.a.	65 (1999)	n.a.	60 (1994)	n.a.	âdisability age	n.a.
1935	60 (1995)	n.a.	60 (1995)	n.a.	63 (1998)	n.a.	65 (2000)	n.a.	60 (1995)	n.a.	âdisability age	n.a.
1936	60 (1996)	n.a.	60 (1996)	n.a.	63 (1999)	n.a.	65 (2001)	n.a.	60 (1996)	n.a.	âdisability age	n.a.
1937	rising to 61 (1998)	60 (1997)	60 (1997)	n.a.	rising to 64 (2001)	63 (2000)	65 (2002)	n.a.	60 (1997)	n.a.	âdisability age	n.a.
1938	rising to 62 (2000)	60 (1998)	60 (1998)	n.a.	rising to 65 (2003)	63 (2001)	65 (2003)	n.a.	60 (1998)	n.a.	63 (2001)	< 63
1939	rising to 63 (2002)	60 (1999)	60 (1999)	n.a.	65 (2004)	63 (2002)	65 (2004)	n.a.	60 (1999)	n.a.	63 (2002)	< 63
1940	rising to 64 (2004)	60 (2000)	rising to 61 (2001)	60 (2000)	65 (2005)	63 (2003)	65 (2005)	n.a.	* rising to 61 (2001)	60 (2000)	63 (2003)	< 63
1941	rising to 65 (2006)	60 (2001)	rising to 62 (2003)	60 (2001)	65 (2006)	63 (2004)	65 (2006)	n.a.	* rising to 62 (2003)	60 (2001)	63 (2004)	< 63
1942	65 (2007)	60 (2002)	rising to 63 (2005)	60 (2002)	65 (2007)	63 (2005)	65 (2007)	n.a.	* rising to 63 (2005)	60 (2002)	63 (2005)	< 63
1943	65 (2008)	60 (2003)	rising to 64 (2007)	60 (2003)	65 (2008)	63 (2006)	65 (2008)	n.a.	* 63 (2006)	60 (2003)	63 (2006)	< 63
1944	65 (2009)	60 (2004)	rising to 65 (2009)	60 (2004)	65 (2009)	63 (2007)	65 (2009)	n.a.	* 63 (2007)	60 (2004)	63 (2007)	< 63
1945	65 (2010)	60 (2005)	65 (2010)	60 (2005)	65 (2010)	63 (2008)	65 (2010)	n.a.	* 63 (2008)	60 (2005)	63 (2008)	< 63
1946	65 (2011)	rising to 61 (2007)	65 (2011)	60 (2006)	65 (2011)	63 (2009)	65 (2011)	n.a.	* 63 (2009)	60 (2006)	63 (2009)	< 63
1947	65 (2012)	rising to 62 (2009)	65 (2012)	60 (2007)	65 (2012)	63 (2010)	rising to 65 1 m.	n.a.	* 63 (2010)	60 (2007)	63 (2010)	< 63
1948	65 (2013)	rising to 63 (2011)	65 (2013)	60 (2008)	65 (2013)	63 (2011)	rising to 65 2 m.	n.a.	* 63 (2011)	60 (2008)	63 (2011)	< 63
1949	65 (2014)	63 (2012)	65 (2014)	60 (2009)	rising to 65 3 m.	63 (2012)	rising to 65 3 m.	n.a.	* 63 (2012)	60 (2009)	rising to 63 7 m.	rising to < 63 7 m.
1950	65 (2015)	63 (2013)	65 (2015)	60 (2010)	rising to 65 4 m.	63 (2013)	rising to 65 4 m.	n.a.	* 63 (2013)	60 (2010)	rising to 63 8 m.	rising to < 63 8 m.
1951	65 (2016)	63 (2014)	65 (2016)	60 (2011)	rising to 65 5 m.	63 (2014)	rising to 65 5 m.	n.a.	63 (2014)	60 (2011)	rising to 63 9 m.	rising to < 63 9 m.
1952	retirement pathway terminated		retirement pathway terminated		rising to 65 6 m.	63 (2015)	rising to 65 6 m.	n.a.	rising to 63 1 m.	rising to 60 1 m.	rising to 63 10 m.	rising to < 63 10 m.
1953					rising to 65 7 m.	63 (2016)	rising to 65 7 m.	n.a.	rising to 63 2 m.	rising to 60 2 m.	rising to 63 11 m.	rising to < 63 11 m.
1954					rising to 65 8 m.	63 (2017)	rising to 65 8 m.	n.a.	rising to 63 3 m.	rising to 60 3 m.	rising to 64 (2008)	rising to < 64 0 m.
1955					rising to 65 9 m.	63 (2018)	rising to 65 9 m.	n.a.	rising to 63 4 m.	rising to 60 4 m.	rising to 64 4 m.	rising to < 64 4 m.
1956					rising to 65 10 m.	63 (2019)	rising to 65 10 m.	n.a.	rising to 63 5 m.	rising to 60 5 m.	rising to 64 6 m.	rising to < 64 6 m.
1957					rising to 65 11 m.	63 (2020)	rising to 65 11 m.	n.a.	rising to 63 6 m.	rising to 60 6 m.	rising to 64 8 m.	rising to < 64 8 m.
1958					rising to 66 (2024)	63 (2021)	rising to 66 (2024)	n.a.	rising to 63 7 m.	rising to 60 7 m.	rising to 64 10 m.	rising to < 64 10 m.

Notes: * Individuals born before Nov. 17, 1950 and who were severely handicapped on Nov. 16, 2000 can retire at age 60 without deductions. n.a., not available.
Ûntil 31.12.2000, the “old" disability retirement enabled eligible persons to enter the retirement independently of the age without deductions after the person became disabled.
< 63: Disability retirement prior to age 63 was charged with benefit discounts of up to 10.8 % if retirement entry occurred after 2001.
Source: Riphahn and Schrader (2021), BGBL.I (1989), and own calculations.

Table A.2: Deductions for a retirement entry within the next year by birth cohort and gender being employed in year…

	1996		1997		1999		2000		2001		2002		2003	
Birth cohort	OAR	DR	OAR	DR	OAR	DR	OAR	DR	OAR	DR	OAR	DR	OAR	DR
1933	0/0	0/0	/	/	/	/	/	/	/	/	/	/	/	/
1934	0/0	0/0	0/0	0/0	/	/	/	/	/	/	/	/	/	/
1935	0/0	0/0	0/0	0/0	/	/	/	/	/	/	/	/	/	/
1936	0/0	0/0	0/0	0/0	0/0	0/0	/	/	/	/	/	/	/	/
1937	1.8/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	/	/	/	/	/	/
1938	/	/	5.4/0	0/0	0/0	0/0	0/0	0/0	0/0	1.5/1.5	/	/	/	/
1939	/	/	/	/	5.4/0	0/0	1.8/0	5.1/5.1	0/0	1.5/1.5	0/0	1.5/1.5	/	/
1940	/	/	/	/	12.6/1.8	0/0	9/0	8.7/8.7	5.4/0	5.1/5.1	1.8/0	1.5/1.5	0/0	0/0
1941	/	/	/	/	/	/	16.2/5.4	10.8/10.8	12.6/1.8	8.7/8.7	9/0	5.1/5.1	5.4/0	1.5/1.5
1942	/	/	/	/	/	/	/	/	18/9	10.8/10.8	14.4/5.4	8.7/8.7	10.8/1.8	5.1/5.1
1943	/	/	/	/	/	/	/	/	/	/	18/12.6	10.8/10.8	14.4/9	8.7/8.7
1944	/	/	/	/	/	/	/	/	/	/	/	/	18/16.2	10.8/10.8

Notes: First number shows deductions for male employees and second number for female employees.
For the calculations of benefit deductions, I assume that all individuals were born on June, 30 of their respective birth year.
/ Employment transitions of the respective birth cohort are not observed in the respective year.
Source: BGBL.I (1989), Steffen (2018), and own calculations.

Table A.3: Description of variables

Variable	Description
Dependent variables	
Employment (0/1)	Employee in year t stays employed within next year t+1
Unemployment (0/1)	Employee in year t exits employment into unemployment within next year t+1
Retirement (0/1)	Employee in year t exits employment into early retirement within next year t+1
Independent variables	
1. Reform indicators	
Treat (0/1)	Employee works in firm introducing PR in 1999
Year1996-Year2003 (0/1)	Starting year of employment transition (ref. = 1999)
Treat * post (0/1)	Treatment indicator times indicator for outcomes measured in post-treatment years 1999 to 2003
Anticipation effect	
Treat * anticipation (0/1)	Treatment indicator times indicator for outcomes measured in anticipation year 1997
Treat * anticipation * part (0/1)	Treatment indicator times anticipation indicator times indicator for employee working in firm solely offering the part-time model of PR
Treat * anticipation * block (0/1)	Treatment indicator times anticipation indicator times indicator for employee working in firm solely offering the block model of PR
Treat * anticipation * block_part (0/1)	Treatment indicator times anticipation indicator times indicator for employee working in firm offering the part-time model and block model of PR
PR model	
Treat * post * part (0/1)	Treatment indicator times post-treatment indicator times part-time model indicator
Treat * post * block (0/1)	Treatment indicator times post-treatment indicator times block-model indicator
Treat * post * block_part (0/1)	Treatment indicator times post-treatment indicator times part-time and block model indicator

(continued on next page)

Table A.3 - continued

Variable	Description
2. X-Variables	
Socio-demographic characteristics	
Age59-Age63 (0/1)	Employee's age at time of observation measured in years (ref. = 59 years old)
Male (0/1)	Employee is male
No university degree and no vocational training, vocational training, university degree/ technical college, missing information (0/1)	Employee's education group (ref. = no univ. degree and no voc. train.)
Firm related characteristics	
Schleswig-Holstein, Hamburg, . . . , Thuringia (0/1)	Firm's residence state in 1996
0-49 workers, 50-499 workers, 500-999 workers , > 1,000 workers (0/1)	Firm's size based on numbers of workers in 1996 (ref. = 0-49 workers)
Agriculture/forestry, manufacturing, construction, trade, communication/news, financial intermediation, other services, non-industrial organizations, public administration (0/1)	Firm's industry in 1996 (ref. = manufacturing)
Unemployment rate	Unemployment rate in firm's district (Kreis) in 1996
Full-time, part-time, missing information (0/1)	Employee's employment status in 1996
Tenure	Employee's days in current establishment in period 1991-1995
Earnings	Employee's sum of daily wage in period 1991-1995
Unemployment days	Employee's days in unemployment in period 1991-1995
Institutions	
Deductions old-age retirement	Employee's (potential) deductions for old-age retirement within next year in percent (see Table A.2)
Deductions disability retirement	Employee's (potential) deductions for disability retirement within next year in percent (see Table A.2)
Disability regime (0/1)	Employee's eligibility for the old disability regime being valid before 2001 for disability retirement within next year

Table A.4: Descriptive statistics on variables of Table A.3

	Mean	SD	Min	Max	N
Dependent variables					
Employment	0.6675	0.4711	0	1	77,616
Unemployment	0.0685	0.2526	0	1	77,616
Retirement	0.2489	0.4324	0	1	77,616
Independent variables					
1. Reform indicators					
Treat	0.7761	0.4169	0	1	77,616
Year	2000.00	2.2494	1996	2003	77,616
Treat * post	0.6058	0.4887	0	1	77,616
Treat * anticipation	0.0895	0.2855	0	1	77,616
Treat * anticipation * part	0.0055	0.0737	0	1	77,616
Treat * anticipation * block	0.0321	0.1763	0	1	77,616
Treat * anticipation * block_part	0.0520	0.2220	0	1	77,616
Treat * post * part	0.0355	0.1850	0	1	77,616
Treat * post * block	0.2215	0.4153	0	1	77,616
Treat * post * block_part	0.3488	0.4766	0	1	77,616
2. X variables					
Socio-demographic characteristics					
Age	60.17	1.2338	59	63	77,616
Male	0.7284	0.4448	0	1	77,616
No university degree and no vocational training	0.1495	0.3566	0	1	77,616
Vocational training	0.6268	0.4836	0	1	77,616
University degree/technical college	0.1547	0.3616	0	1	77,616
Education missing	0.0690	0.2534	0	1	77,616
Firm related characteristics					
0-49 workers	0.0576	0.2330	0	1	77,616
50-499 workers	0.3957	0.4890	0	1	77,616
500-999 workers	0.1678	0.3737	0	1	77,616
> 1,000 workers	0.3789	0.4851	0	1	77,616
Unemployment rate	12.41	3.6844	4.1	21.9	77,616
Full-time	0.8883	0.3150	0	1	77,616
Part-time	0.0798	0.2710	0	1	77,616
Working status missing	0.0319	0.1756	0	1	77,616
Tenure	1,532.94	472.59	0	1,826	77,616
Earnings	121,664	61,661	0	245,956	77,616
Unemployment days	2.7730	30.77	0	1068	77,616
Institutions					
Deductions old-age retirement	6.9265	6.6527	0	18	77,616
Deductions disability retirement	4.6980	4.6252	0	10.8	77,616
Disability regime	0.3727	0.4835	0	1	77,616

Source: LIAB LM1 9007, BA (2005), own calculations.

Table A.5: Description of variables of person-month sample

Variable	Description
Dependent variables	
Employment (0/1)	Employee in month t stays employed within next month t+1
Unemployment (0/1)	Employee in month t exits employment into unemployment within next month t+1
Retirement (0/1)	Employee in month t exits employment into early retirement within next month t+1
Independent variables	
1. Reform indicators	
Treat (0/1)	Employee works in firm introducing PR in 1999
Month1-Month12 (0/1)	Starting month of employment transition (ref. = January)
tt	Linear time trend (January 1996 to December 1997)
Treat * tt (0/1)	Treatment indicator times indicator for linear time trend
PR model	
Treat * tt * part (0/1)	Treatment indicator times post-treatment indicator times part-time model indicator
Treat * tt * block (0/1)	Treatment indicator times post-treatment indicator times block-model indicator
Treat * tt * block_part (0/1)	Treatment indicator times post-treatment indicator times part-time and block model indicator
2. X-Variables	
Socio-demographic characteristics	
Age60-Age64 (0/1)	Employee's age at time of observation measured in years (ref. = 59 years old)
Male (0/1)	Employee is male
No university degree and no vocational training, vocational training, university degree/technical college, missing information (0/1)	Employee's education group (ref. = no univ. degree and no voc. train.)

(continued on next page)

Table A.5 - continued

Variable	Description
Firm level characteristics	
Schleswig-Holstein, Hamburg,. . . , Thuringia (0/1)	Firm's residence state in 1996
0-49 workers, 50-499 workers, 500-999 workers , >1,000 workers (0/1)	Firm's size based on numbers of workers in 1996 (ref. = 0-49 workers)
Agriculture/forestry, manufacturing, construction, trade, communication/news, financial intermediation, other services, non-industrial organizations, public administration (0/1)	Firm's industry in 1996 (ref. = manufacturing)
Unemployment rate	Unemployment rate in firm's district (Kreis) in 1996
Full-time, part-time, missing information (0/1)	Employee's employment status in 1996
Tenure	Employee's days in current establishment in period 1991-1995
Earnings	Employee's sum of daily wage in period 1991-1995
Unemployment days	Employee's days in unemployment in period 1991-1995
Institutions	
Deductions old-age retirement	Employee's (potential) deductions for old-age retirement within next month in percent (see Table A.2)
Deductions disability retirement	Employee's (potential) deductions for disability retirement within next month in percent (see Table A.2)
Disability regime (0/1)	Employee's eligibility for the old disability regime being valid before 2001 for disability retirement within next month

Table A.6: Descriptive statistics on variables of Table A.5

	Mean	SD	Min	Max	N
Dependent variables					
Employment	0.9650	0.1837	0	1	148,365
Unemployment	0.0073	0.0849	0	1	148,365
Retirement	0.0271	0.1623	0	1	148,365
Independent variables					
1. Reform indicators					
Treat	0.7647	0.4242	0	1	148,365
Month	6.0873	3.4281	1	12	148,365
tt	12.1611	7.9581	1	24	148,365
Treat * tt	9.3077	7.9581	0	24	148,365
Treat * tt * part	0.5451	2.9217	0	24	148,365
Treat * tt * block	3.3834	6.5551	0	24	148,365
Treat * tt * block_part	5.3791	7.6013	0	24	148,365
2. X variables					
Socio-demographic characteristics					
Age	61.1370	1.1916	60	64	148,365
Male	0.7741	0.4182	0	1	148,365
No university degree and no vocational training	0.1876	0.3904	0	1	148,365
Vocational training	0.6012	0.4896	0	1	148,365
University degree/technical college	0.1456	0.3527	0	1	148,365
Education missing	0.0656	0.2475	0	1	148,365
Firm related characteristics					
0-49 workers	0.0644	0.2455	0	1	148,365
50-499 workers	0.4162	0.4929	0	1	148,365
500-999 workers	0.1574	0.3642	0	1	148,365
> 1,000 workers	0.3620	0.4806	0	1	148,365
Unemployment rate	11.93	3.6213	4.1	21.9	148,365
Full-time	0.9061	0.2916	0	1	148,365
Part-time	0.0813	0.2734	0	1	148,365
Working status missing	0.0125	0.1112	0	1	148,365
Tenure	1,575.99	453.46	0	1,826	148,365
Earnings	124,621	58,614	0	249,267	148,365
Unemployment days	2.1322	27.11	0	1,284	148,365
Institutions					
Deductions old-age retirement	0.0000	0.0000	0	0	148,365
Deductions disability retirement	0.0000	0.0000	0	0	148,365
Disability regime	1.0000	0.0000	1	1	148,365

Source: LIAB LM1 9007, BA (2005), own calculations.

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