

Geyer, Johannes; Haan, Peter; Lorenz, Svenja; Zwick, Thomas; Bruns, Mona

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ORIGINAL ARTICLE

Role of labor demand in the labor market effects of a pension reform

Johannes Geyer¹ | Peter Haan² | Svenja Lorenz³ | Thomas Zwick⁴ |
Mona Bruns³

¹DIW Berlin, Berlin, Germany

²DIW Berlin, Free University of Berlin, Berlin, Germany

³University of Würzburg, Würzburg, Germany

⁴ZEW Mannheim, ROA Maastricht, University of Würzburg, Würzburg, Germany

Correspondence

Thomas Zwick, ZEW Mannheim, ROA Maastricht, University of Würzburg, Würzburg, Germany.
Email: thomas.zwick@uni-wuerzburg.de

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Abstract

This paper shows that labor demand plays an important role in the labor market reactions to a pension reform in Germany. Employers with a high share of older worker inflow compared with their younger worker inflow, employers in sectors with few investments in research and development, and employers in sectors with a high share of collective bargaining agreements allow their employees to stay employed longer after the reform. These employers offer their older employees partial retirement instead of forcing them into unemployment before early retirement because the older employees incur low substitution costs and high dismissal costs.

JEL CLASSIFICATION

J14; J18; J22; J26; H31

INTRODUCTION

Since the 1990s, most OECD countries have reversed their retirement policies and started to encourage longer working lives to alleviate the decline in the working age population (see, e.g., the overview in Börsch-Supan and Coile, 2018). In addition to tighter qualifying conditions and increases in the retirement age, policymakers have introduced actuarial deductions for early retirement. These reforms increase the financial incentives for older employees to work longer and to postpone retirement. Consequently, employers with employees affected by these pension reforms face a labor supply shock because these older employees want to work longer than unaffected employees.

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Most pension reforms target labor supply and do not directly stimulate labor demand. Thus, almost all existing empirical studies on the labor market effects of these reforms concentrate on the labor supply effects. However, large labor supply shocks force employers to deviate from their optimal workforce structure. In the present study, we distinguish the following two cost sources resulting from the supply shock. The first is keeping older workers longer in employment, even though their replacements would be more efficient. The second is stopping the employment contracts of older employees, even though this is associated with dismissal, severance, and other compensation payments for these employees. We argue that these cost sources differ between employers. Thus, some employers may not be able or willing to react as flexibly to the changes in labor supply as others. We provide empirical evidence confirming our hypothesis that employers with higher adaptation costs related to the age structure and employers with lower dismissal costs react less flexibly to an increase in the labor supply of their older employees. These findings demonstrate that labor demand reactions are an important driver of the labor market effects of pension reforms.

In the empirical analysis, we focus on the 1992 pension reform in Germany that increased the normal retirement age (NRA) for women gradually from age 60 to 65 for the pension for women and introduced deductions in pension entitlements for early retirement for women born after December 1939. The pension eligibility age for early retirement options remained constant at age 60 (early retirement age; ERA). Therefore, the reform introduced financial incentives to postpone retirement entry between the ERA and NRA. The exogenous variation in the NRA by birth cohort allows us to identify the effects of the reform on the labor market outcomes of affected women (Engels et al. 2017).

Our analysis is based on large administrative social security data from the Institute for Employment Research (Sample of Integrated Labor Market Biographies; SIAB), a representative 2% sample of employees in Germany. These data include daily information on the full working history of individuals. Thus, we can calculate pension entitlements and eligibilities for different retirement pathways including partial retirement (*Altersteilzeit*), which is a special working time model for employees who are close to retirement. Most importantly for our analysis, SIAB provides employer-specific information that enables us to analyze differences in the labor market outcomes among employers.

Employers usually cannot prolong the employment of their older employees without increasing their labor costs. If employers keep older employees longer than planned, they incur costs for substituting older employees for younger employees, and the costs usually cannot be compensated by wage reductions for the older employees. Furthermore, terminating the employment of older employees before their preferred retirement age is also often costly because most older employees are protected against dismissals. Thus, we argue that employers with relatively low substitution costs allow their older workers to stay longer in employment and offer them partial retirement between the ERA and NRA. We measure the substitution costs by using the share of older employees hired compared with young employees hired and the investment intensity in research and development (R&D) in the economic sector of the employer. Additionally, we argue that employers with low dismissal costs prefer the dismissal of their older employees. Dismissal costs are measured by the share of collective bargaining agreements in the sector and the applicability of the dismissal protection law to the employer.

Our study is related to the sizable literature analyzing the labor market effects of pension reforms. Almost all of these studies focus on the supply side determinants of individual behavioral changes induced by pension reforms (Atalay and Barrett, 2015; Brinch et al. 2015; Coe and Haverstick, 2010; Duggan et al. 2007; Hanel and Riphahn, 2012; Hernæs et al. 2016; Krueger and Pischke, 1992; Lalive and Staubli, 2015; Manoli and Weber, 2016; Martins, et al. 2009; Mastrobuoni, 2009; Staubli and Zweimüller, 2013; Vestad, 2013). The role of employers in the labor market effects is largely neglected in these studies (Rabaté, 2019). Thus, the literature on individual labor market consequences of pension reforms assumes the autonomy of older employees

on how and when to exit employment as well as a perfectly elastic labor demand reaction to labor supply shocks (Peichl and Sieglöcher, 2012). There is other literature that examines the reaction of employers to pension reforms and their associated supply shocks. These studies concentrate on firm-level outcomes, including total employment, wages, hiring of younger workers, the offer of early retirement schemes, and value added (Bellmann and Janik, 2007; Bello and Galasso, 2020; Boeri et al. 2021; Bovini and Paradisi, 2019; Hakola and Uusitalo, 2005; Hallberg, 2011; Kondo, 2016; Martins et al. 2009; Rabaté, 2019; Vigtel, 2018). However, these papers do not consider individual differences in retirement behavior within a workforce or examine the labor market effects of pension reforms on the individual employees of affected firms.

Our paper combines both strands of the literature, considering that the labor market decisions of older employees are jointly made by employers and employees. Previous studies on the 1992 pension reforms concentrate on its effects on employment and unemployment and do not include any employer indicators (Engels et al. 2017; Riphahn and Schrader, 2020b). We also analyze partial retirement¹ as a central employer option and show that reactions of employers to the labor supply shock are not perfectly elastic. Based on labor demand theory, we explain which groups of employers use partial retirement and dismissals to influence the labor supply decisions of affected older employees.

The paper is organized as follows. In Section ‘Institutional Background’, we provide information about the German pension system and the 1992 pension reform. In Section ‘Employers’ impact on old-age labor market outcomes: Theoretical background’, we discuss the role of the employer in the labor market effects of the pension reform and derive testable hypotheses on how employer characteristics may affect the labor market results of older employees. In Section ‘Data’, we introduce the data and present descriptive evidence. Our identification method is explained in Section ‘Estimation Method’. The labor market effects of the pension reform and the impact of labor demand on these effects are presented in Section ‘Pension Reform Effects’. Section ‘Conclusions’ concludes the paper.

INSTITUTIONAL BACKGROUND

The 1992 pension reform in Germany was the first attempt to increase employment of older employees (Schmähl, 2003; Börsch-Supan and Coile, 2018, Figure 3). Its implementation phase started in 2000 and ended in 2009 for women in the birth cohorts 1940–1944. Males in the birth cohorts 1937–1941 were slightly earlier affected by similar reforms (Riphahn and Schrader, 2020b). Therefore, the implementation period 1997–2006 for males and females partly overlaps, and thus, we cannot exclude that, for example, the behavior of affected older male employees influenced the employer reaction toward older female employees. However, we are not aware of additional labor market reforms during the implementation period that affected older employees.

Engels et al. (2017) showed that the 1992 pension reform had sizeable labor market effects. Based on data from the pension insurance, they found a large negative effect on retirement rates and an increase of employment and unemployment of affected women after the ERA. However, they could not distinguish employment and partial retirement because partial retirement is treated as active employment in the pension data. Moreover, the data do not include firm information. In this section, we describe the important characteristics of the German pension system, the 1992 pension reform, and the institutional features of the two important bridge options, unemployment and partial retirement, which bridge the time between active employment and take-up of retirement benefits. We also discuss the role and incentives of the employer in these decisions.

¹Huber et al. (2016) and Berg et al. (2020) concentrated on the employment effects of the introduction of partial retirement, which was part of the 1992 pension reform. They also did not differentiate between employer types.

The German pension system

Statutory public pension insurance is compulsory for all private and public sector employees and certain groups of the self-employed. Public pension benefits are the most important income source for the elderly, accounting for about two-thirds of their gross household income, on average (Pfister et al. 2018). Depending on their career length and other conditions, the pensionable age varied between 60 and 65 for the cohorts analyzed in our study (1937–1944). There were four different options to retire before reaching the statutory retirement age: the pension for women, the pension for the severely disabled, the pension for people with long service records, and the pension after unemployment or following old-age part-time employment. Moreover, the pension system provides disability benefits before age 60 for people who are not able to work because their health is impaired.² Engels et al. (2017, Appendix A) discussed these options and their differences in detail. They showed that the pension for women, which accounted for around 80% for those who retired early, was by far the most important pathway for entering early retirement benefits for the cohorts in our study. Therefore, we do not consider the disability pension as a substitution option for the pension for women.

The pension for women allowed women who qualified for this pension to retire at the age of 60.³ To be eligible, 15 years of contributions were required, of which at least 10 years must have been after the age of 40. According to our data and consistent with Engels et al. (2017), about 60% of all employed women were eligible for this pension at the age of 55.

Pension benefits before and after the 1992 pension reform

Pension benefits are calculated based on a points system. A pension point is calculated annually by dividing the contributor's earnings by average earnings subject to social security contributions. In addition, pension entitlements may be acquired during other periods, such as unemployment, childcare, and informal care.

Before the introduction of actuarial deductions in 1992, pension benefits were calculated as the product of the sum of pension points at retirement and the pension point value in year t by

$$\text{Pension}_t^{\text{pre92}} = \left(\sum_{a=\text{age}}^{\text{ret.age}} \text{pension point}_a \right) \times \text{pension point value}_t. \quad (1)$$

The pension point value is indexed to earnings growth and adjusted annually. Full pension benefits could be claimed before reaching the statutory retirement age of 65 years without actuarial deductions for early retirement. That is, the system featured strong incentives to retire as early as possible. Adjustment of pensions with respect to the retirement age occurred only implicitly through the reduced number of contribution years (Börsch-Supan and Schnabel, 1999).

²The disability pension scheme was reformed in 2001. It abolished occupational disability benefits, and changed the health assessment and benefit calculation. It generally reduced the generosity of disability pensions. For more details, see Hanel (2012) who used the reform of 2001 to estimate incentive effects of disability benefits and did not find a behavioral response to this reform. We follow Engels et al. (2017) and control for this reform in the empirical analyses using a shift dummy that accounts for decreased generosity of disability pensions.

³In principle, it was possible to continue working after early retirement. However, for those in early retirement who continued working, pension benefits were withdrawn at relatively high rates. Consequently, only a negligible fraction of women worked while receiving a pension.

Beginning with cohort 1940, the 1992 pension reform introduced actuarial deductions.⁴ The NRA of the pension for women was raised in monthly steps from age 60 to 65, depending on the month and year of birth of the individual. The reform introduced an access factor, D (*Zugangsfaktor*), which accounts for deductions and permanently reduces pension benefits by 0.3% per month a person is retired before reaching the NRA.

$$\text{Pension}_t^{\text{pre92}} = \left(\sum_{a=\text{age}}^{\text{ret.age}} \text{pension point}_a \right) \times \text{pension point value}_t \times (1 - D_{c,\text{ret.age}}) . \quad (2)$$

The factor D depends on the month of birth, c , and retirement age. The NRA for the pension for women varied across cohorts born between January 1940 and December 1944. The variation across month-of-birth cohorts and age is exploited in the empirical analysis.⁵

Unemployment

Almost all women in our sample were eligible for early retirement at age 60 given they had been unemployed for at least 12 months before retirement (Pfister et al. 2018). Unemployment benefits replace about 60% of previous net earnings and people acquire pension entitlements as if they earned 80% of their previous gross earnings. The entitlement period depends on age and previous working history. The maximum entitlement period for individuals older than 57 years was up to 32 months until January 2006. Between February 2006 and December 2007, it was reduced to 18 months, and then it was increased to 24 months in 2008.⁶

Old employees are well protected against dismissals in Germany (Schmähl, 2003).⁷ Some collective bargaining agreements forbid the dismissal of employees who are older than 55 years. A dismissal frequently causes older employees a more problematic financial situation, higher potential pension losses, and longer spells out of the labor market than most of their younger colleagues. These disadvantages have led to higher specific dismissal protection for older employees, and employers must explain in writing why the dismissal of an older employee is unavoidable. Almost all older employees have permanent contracts that end by reaching the NRA. Therefore, the employer must buy out the right of the employee

⁴In addition to the introduction of deductions for the pension of women, actuarial deductions were introduced for other types of pensions. Potentially, this could threaten our identification strategy. However, women born between 1937 and 1945 were only marginally affected by these reforms. The introduction of deductions for pensions for unemployed/old-age part-time employed starting with cohort 1937 mainly affected men. As shown by Engels et al. (2017), only 2% of women enter retirement through this pension type and this fraction remains constant across cohorts.

⁵The reform also changed the adjustment of benefits for people retiring after reaching the statutory retirement age. Before the 1992 pension reform, benefits were permanently increased by 0.6% per month or by 7.2% per year when people retired between 65 and 67. The 1992 pension reform changed the monthly adjustment factor to 0.5%. Moreover, there is no longer an age limit for retirement. However, only a negligible number of workers used this option before and after this reform.

⁶Riphahn and Schrader (2020a) studied the labor market effects of this reform and found that it has positive employment effects and contributes to the general trend of increasing old-age employment. In the empirical analysis, we account for the time-specific changes in the unemployment system.

⁷There are no official seniority rules in the German labor market, compare for example Böckerman et al. (2018, p. 50). Our sample only includes women who work for their employer at least since 1997, or in other words all women included in our sample work for their last career employer at least four years before the start of the reform. We therefore can be sure that all women included in our sample are not affected differently in case an employer applies an unofficial seniority rule.

to work until the NRA if they want to dismiss the employee. The first option is to reach a mutual agreement on a dismissal by offering severance pay and, in some cases, additional voluntary compensation (Jahn, 2009). However, the compensation offered by the employer might not be enough to compensate for the income loss and the social stigma of a perceived undignified exit from work associated with a dismissal (Hetschko et al. 2014). Thus, the second option is that the employer unilaterally dismisses the employee. In these cases, the employee can sue the employer at a labor court if the employer was subject to dismissal protection law. Usually the employee obtains a (higher) severance payment *ex post*, but almost never re-employment (Jahn, 2009). Consequently, the absence of a mutual dismissal agreement increases dismissal costs but does not reverse the dismissal. Besides reaching a mutual agreement and social criteria protecting the employee from dismissal, severance pay is mainly determined by the size of the employer, applicability of a collective bargaining agreement, the fairness of the dismissal, and the tenure of the dismissed (Jahn, 2009; Schmähl, 2003).

Partial retirement

Almost all women affected by the pension reform in our sample were also eligible for partial retirement (Pfister et al. 2018). Partial retirement was introduced in 1996 and also offered early retirement at age 60. Employees and employers were given the choice between two models: the continuity model with reduced working hours during the entire period of partial retirement, or the block model with full-time work in the first half (active period) and a leave of absence in the second half of the period (passive period) (Huber et al. 2016; Kirchner and Mittelhamm, 2010).

The employer must increase the current salary by at least 20% during partial retirement and wage earnings in excess of 50% of prior earnings are exempt from income taxes. Employers also must pay additional pension contributions of at least 70% of the pre-partial retirement earnings. As a consequence, average earnings during partial retirement are about three-quarters of the previous gross salary (Klammer and Weber, 2001) and pension entitlements accrue at a minimum of 90% of the rate obtained under full-time work (Berg et al. 2020).

An important advantage of partial retirement compared with the pension for women is the option to exit employment before reaching the ERA with generous compensation. With a standard partial retirement arrangement spanning 5 years (Kaldybajewa and Kruse, 2007), employees can exit employment 2.5 years before they turn 60. On average, about 90% of older employees choose the block model.⁸ Therefore, we assume that all women in our sample chose the block model (we do not observe the two types of partial retirement in our data) because all women in our sample had the option to combine partial retirement and the pension for women. Partial retirement in the block model was attractive for women in our sample because it allows an exit from employment before the ERA (Brussig et al. 2009; Wanger, 2009).

The relatively generous financial compensation for partial retirement compared with unemployment is deliberate. In contrast to a dismissal, employers cannot force employees into partial retirement. If an employer wanted an older woman from our sample to enter partial retirement, it would have had to offer a partial retirement package that was at least as attractive as retiring early via the pension for women.

In summary, the 1992 pension reform induces older women eligible for the pension for women and the bridge options to stay longer in the labor market after the ERA to avoid pension deductions. Employers have the option to dismiss their older employees or to offer them

⁸The shares of the block model were lower during the first years after the introduction of partial retirement (Berg et al. 2020).

partial retirement to terminate employment before the ERA. Both bridge options give the employer a stronger influence on the time when the employee leaves employment.

EMPLOYERS' IMPACT ON OLD-AGE LABOR MARKET OUTCOMES: THEORETICAL BACKGROUND

In a frictionless labor market, employers can completely accommodate increases in the labor supply of older workers by reducing their wages or by costless dismissal of workers. However, in Germany, wages are rigid in continuing jobs (Dustmann and Schönberg, 2009; Hirsch and Zwick, 2015) and dismissal costs are especially high for older employees (Jahn, 2009). Thus, employers cannot freely optimize the age structure of their workforce and must weigh the costs and benefits of prolonging contracts with an older employee. The first cost source is substitution costs if older employees substitute younger employees. The second cost source is dismissal, severance, or other compensation costs of terminating employment of older employees.

In our empirical analysis, we explain how the pension reform affects the period of time employees remain in employment, partial retirement, or unemployment after the ERA. We assume that employers with relatively low substitution costs allow their older employees to stay longer in employment or in partial retirement. Employers may offer partial retirement as a substitute for the early retirement options their employees have (Huber et al. 2016). However, employers with relatively low dismissal costs will instead dismiss their employees, causing unemployment spells after the ERA. Dismissals of older employees may be a strategic labor supply measure instead of a reaction to the business cycle (Baguelin and Remillon, 2014; Grogger and Wunsch, 2013; Inderbitzin et al. 2016).

Employers are heterogeneous and their reaction to the desire of their older employees to stay longer in employment can vary for numerous reasons. Our data include a selection of important employer characteristics. These characteristics allow us to identify differences in the following cost sources:

- substitution costs, which are related to the age structure of the newly hired workforce, namely the employer-specific complementarity between old employees and the employees they replace;
- substitution costs, which are also related to the value of employer-specific human capital of older employees in the production process and their replacement costs; and
- employment termination costs, which are related to the employer-specific dismissal costs of older employees.

Related to the employer characteristics, we derive testable hypotheses and explain how specific groups of employers are expected to react to the exogenous increase in labor supply of older women. We distinguish the following options: allowing employees to stay longer in employment after the ERA (the default); dismissing older employees; and offering partial retirement.

Hypothesis 1: Older worker inflow relative to younger worker inflow

The substitution of older with prime-aged employees is less expensive than that of older with young employees (Boeri et al. 2021; Hebbink, 1993). Thus, an older employee who stays longer in employment than expected causes higher adaptation costs if their potential substitute is a young employee instead of a prime-aged or old employee. We can use a high share of old employees hired relative to young employees hired as an indicator of young

substitutes for retiring employees. A high share of old employees relative to young employees in all hires also may indicate the absence of an internal labor market characterized by entry points reserved for young inexperienced employees who are offered career ladders within the hierarchies of their employers (Gibbons and Waldman, 2006). An internal labor market makes the unexpected substitution of a younger employee with an older employee more expensive because this may reduce the motivation of young employees who are waiting for senior positions to become vacant (Backes-Gellner and Veen, 2013). Consequently, employers that have a high share of old employees relative to young employees may have low substitution costs. Accordingly, Hypothesis 1 states that the labor supply shock has a stronger positive effect on employment and partial retirement after the ERA for employees who work for employers with a high share of newly hired older employees in relation to newly hired young employees.

Hypothesis 2: R&D expenses

High R&D expenses are an indicator of the strong innovation orientation of employers (Cassiman and Veugelers, 2006). Thus, employers with high R&D expenses may have higher substitution costs if they keep their older employees longer because they need the human capital of their younger employees to keep up their innovation capacity. However, the human capital of their older employees is less valuable and may not need to be replaced if an older employee leaves the employer (Wasmer, 2006). The age structure of the workforce is negatively related to firm-level innovativeness in Germany (Schneider, 2008). The negative relation between workforce age and innovativeness may be a consequence of older employees working with outdated technological knowledge, having less cognitive flexibility and openness to absorbing new topics, and a general decline in creativity with age (Schmähel, 2003; Simonton, 2007). Ilmakunnas and Maliranta (2007) show that in innovative sectors the dismissal of employees who are older than 49 years increases innovation success. Schubert and Andersson (2015) find that firms with older employees can partially compensate for the decrease in innovations by increased substitution of older employees with younger employees. Thus, Hypothesis 2 states that the labor supply shock has a higher positive effect on employment and partial retirement after the ERA for employees who work for employers with low R&D expenses.

Hypothesis 3: Dismissal protection

Dismissal protection legislation increases costs to terminate the employment of older employees. Employees working for employers with more than five employees are subject to dismissal protection and have the legal right to obtain compensation for a dismissal depending on the length of tenure and the employer's economic situation. Grund (2006) and Jahn (2009) reported an average severance pay of around 25,000 EUR in the years 2000–2006. However, severance payments are higher for older employees because they increase with age and tenure.⁹ In some cases, severance payments can total 400,000 EUR. Thus, Hypothesis 3 states that the labor supply shock has a larger positive effect on unemployment after the ERA for employees who work for employers that are not subject to dismissal protection.

⁹Considering that older women in our sample had 16.6 years of tenure before they were dismissed, the tenure effect on severance pay alone would be between about 80% and 100% of an annual salary. This sum is the lower bound of dismissal costs given that age has a separate positive effect on severance pay in addition to tenure (Grund, 2006; Jahn, 2009).

Hypothesis 4: Collective bargaining agreements

Many collective bargaining agreements include additional rules providing employment protection for older employees. These rules differ among sectors and collective bargaining agreements, but they increase dismissal costs and they can make the dismissal of older employees virtually impossible. In addition, unions favor partial retirement as an alternative to unemployment before retirement (Berg et al. 2020). Unions also support older employees in their bargaining efforts with their employers to prolong employment or obtain a partial retirement contract. They also help employers to organize the frictionless implementation of the complicated partial retirement legislation (Wanger, 2009). Thus, Hypothesis 4 states that the labor supply shock has a stronger positive effect on employment and partial retirement for employees who work for employers subject to collective bargaining. It also states that the supply shock has a smaller positive effect on unemployment for employees who work for employers subject to collective bargaining.¹⁰

Hypothesis 5: Group-specific reform effects and bridge option usage

Employers have a stronger impact on the exit age of an employee who uses partial retirement or unemployment as bridge option than on that of employees who stay in regular employment until retirement age. Older employees have a legal right to work until they reach the NRA and they can decide autonomously if and when to quit earlier. We assume that older women do not differ in their propensity to exit from employment with respect to the employer groups defined in Hypotheses 1–4. This means that, without interference from the employers, we should observe the same labor market pattern in the respective employer groups. Thus, Hypothesis 5 states that differences in labor market states after the ERA among employees who work for different employer groups are only present for those who use the bridge options of partial retirement and unemployment. However, employment exit age should not differ for those older employees who do not use bridge options.

DATA

Our study is based on a large, high-quality administrative data set provided by the Federal Employment Agency in Germany (*Bundesagentur für Arbeit*). The publicly available data comprise a 2% sample of employees in Germany from 1975 to 2014 (SIAB7514)¹¹ and contain daily information about employment and receipt of social benefits for about 2 million individuals, for example, unemployment benefits, as specified in the German Social Books II and III. We add the daily date of birth to the data set because the exact calculation of pension entitlements requires the birth date.¹² Moreover, we link a rich set of establishment information from the IAB Establishment History Panel (BHP) to the individual employment history. Finally, we

¹⁰We assume that the choice of remaining in the employers' association, and thus being subject to collective bargaining agreements, is not driven by the potential extra costs and inflexibilities for the employment of older employees implied by the membership. Given that only 5.6% of our sample are employees aged 60–65, differences in their labor market behavior constitute secondary effects compared with the overall effects of employer association membership. In addition, it is rare that employers cancel their membership of employer associations (Schmähl, 2003).

¹¹Onsite data access and subsequently remote data access was provided by the Research Data Centre (FDZ) of the German Federal Employment Agency (BA) at the Institute for Employment Research (IAB). A detailed description of the SIAB can be found in Antoni et al. (2016).

¹²We are grateful to Philip vom Berge and Dana Müller from the FDZ at the IAB for merging this information as part of the Custom Shaped Administrative Data for the Analysis of Labor Market (CADAL) project.

match the monthly regional unemployment rates for the 50 functional labor market regions as defined by Kropp and Schwengler (2011) from the Federal Employment Agency to the place of work. We calculate the average annual regional unemployment rates between 1991 and 2014 for each labor market region.

The data allow us to distinguish partial retirement from regular employment. Previous studies are based on pension insurance data, which do not distinguish partial retirement from employment (Engels et al. 2017; Riphahn and Schrader, 2020b).¹³ The SIAB data set does not include direct information about pension entitlements or pension eligibility. However, based on the detailed biographical information, we can determine individual pension entitlements and identify eligibility criteria for old-age pensions and the corresponding statutory retirement dates (NRA and ERA) with negligible errors; see Pfister et al. (2018) and Lorenz et al. (2018).¹⁴

Estimation sample

For the empirical analysis, we consider the individual monthly employment biographies of women born between 1937 and 1944 who were between 55 and 65 years old. We only include women who fulfill the requirements for the pension for women at the age of 55 (see Section ‘Institutional background’) to restrict our sample to those treated by the pension reform. In addition, we restrict our sample to West German¹⁵ women with a high labor market attachment. All women in our sample were active in the labor market at the age of 59 (i.e., employed or registered unemployed), can be observed at least once before age 42,¹⁶ and have no gaps in their labor market histories that are longer than 5 years.¹⁷ Moreover, we only include women with reported employer characteristics in their last employment spell. These restrictions have the advantages that we exclude all women with relevant options for substitution into other early retirement pathways and that all women in our sample were eligible for early retirement after partial retirement and unemployment (Pfister et al. 2018).¹⁸ Finally, we restrict our sample to employees who did not change their employer after the pension reform was introduced

¹³To the best of our knowledge, partial retirement spells can be identified only in the SIAB. In other data sets that are used to study the labor market effects of pension reforms, such as the VSKT (*Versichertenkontenstichprobe der deutschen Rentenversicherung, Mikrozensus*) or the SOEP (*Sozio-oekonomisches Panel*), partial retirement cannot be separated from regular employment.

¹⁴Selected sample descriptive statistics are given in Table A1 of Appendix A.

¹⁵Labor market careers can only be observed in East Germany from January 1, 1991. Therefore, we exclude East German women from our sample because we cannot calculate their eligibility for the pension for women.

¹⁶We only observe labor market careers after January 1, 1975, and we cannot calculate the waiting period of 15 years for all women, especially those with long employment gaps after 1975. Thus, we assume that women who completed more than 10 years of compulsory contribution periods after age 40 also fulfilled the waiting period of 15 years, which is the case for almost all women in our sample (Lorenz et al. 2018).

¹⁷In the full sample of eligible women ($N = 26,137$), we exclude about 29% of the observations for not being active in the labor market at the age of 59, about 6.7% for completing the last employment subject to social security contributions before reaching the age of 55, 11.3% for no observable labor market status until the age of 41, 0.5% for no compulsory contribution in the last 10 years before leaving the labor market, and 11.5% for labor market gaps longer than 5 years. Finally, we lose 33.2% of our sample by restricting it to women who did not change their employer after the reform was introduced.

¹⁸The main channel to avoid pension deductions in Germany when retiring before the ERA was the pension for those with reduced earnings capacities. This pension allowed employees to retire immediately when they were no longer able to work in their occupation (*Berufsunfähigkeit/Erwerbsunfähigkeit*). Average retirement age for those with reduced earnings capacity was around 53 years for women born in the cohorts we focus on (Deutsche Rentenversicherung Bund, 2018). Therefore, almost all women who used the pension with reduced earnings capacity left the labor market before age 59 (Lorenz et al. 2018). Thus, these women are not included in our sample. There are only two alternative channels for early retirement: the pension for the severely disabled and special pension schemes (miners and seamen). We can rule out that older women obtained disability status or became miners or seamen to avoid pension deductions.

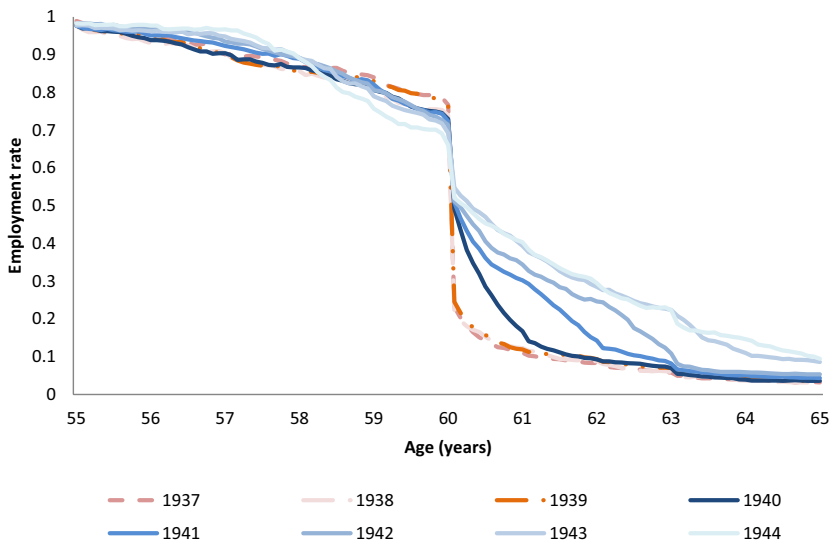


FIGURE 1 Employment rates (employment subject to social security contributions with active phase of partial retirement divided by all women included in sample) by age (monthly data) and cohort. Source: SIAB7514, own calculations [Colour figure can be viewed at [wileyonlinelibrary.com](https://onlinelibrary.com)]

to avoid selection and sorting effects induced by the pension reform. The 1992 pension reform was introduced in 1997¹⁹ when the affected birth cohorts (1940–1944) were between 53 and 57 years old.²⁰

After introducing the sample restrictions, we are left with 9034 women and 551,074 person-month observations.

Descriptive evidence

In the empirical analysis, we focus on employment, unemployment, and partial retirement, showing how these labor market states vary between ages 55 and 65 for each of the birth cohorts 1937–1944. The different age patterns provide the first evidence of employees' labor market behavior in response to the pension reform before and after the ERA. Figure 1 shows age-specific employment rates without partial retirement for the different cohorts.²¹ Before women turn 60, employment rates are similar for all birth cohorts and only slightly higher for 58- and 59-year-old women in the pre-reform cohorts 1937–1939 than in the treated cohorts 1940–1944.²² The absence of reform effects on employment before women

¹⁹During the discussion of the pension reform since 1992, there have been several surprising changes in the design of the reform and the group of affected employees. Therefore, we can assume that there are no anticipation effects before 1997 (Riphahn and Schrader, 2020a).

²⁰In a robustness test, we drop the restriction on women without employer changes after 1997. The results are robust with respect to this restriction.

²¹We only consider employment that is subject to social security contributions and partial retirement. In the data, marginal employment has only been recorded since April 1999 (Antoni et al. 2016).

²²The reduction in regular social security employment in the younger cohorts is almost completely compensated by employment during the active phase in partial retirement, compare Figure B1 in Appendix B.

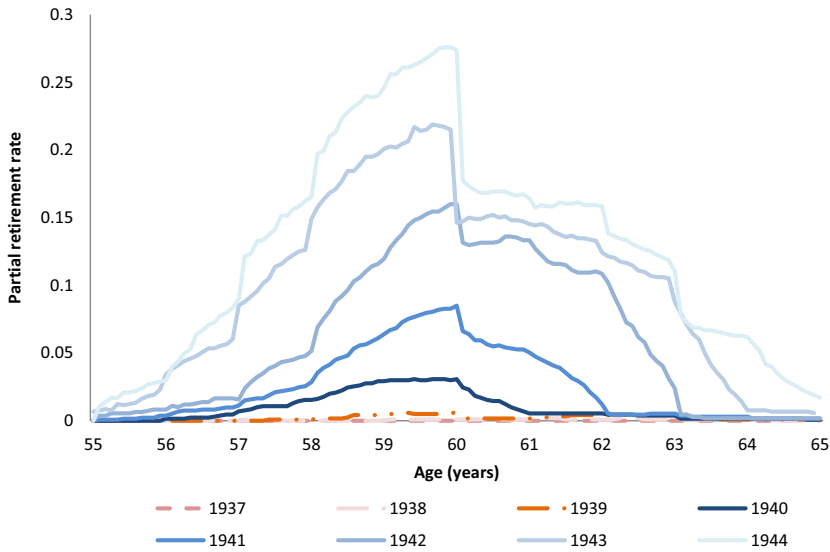


FIGURE 2 Partial retirement rates by age (monthly data) and cohort. Source: SIAB7514, own calculations [Colour figure can be viewed at wileyonlinelibrary.com]

reach the ERA suggests that there were no anticipation effects of the reform in our sample (see also Riphahn and Schrader, 2020b). However, we find a sharper drop in the employment rate for the pre-reform cohorts at age 60 than for the reform cohorts. About 50% of all women left employment at the ERA in the cohorts not affected by the pension reform. From age 60 to 65, the gradual introduction of pension deductions for those who retired earlier than the NRA for the pension for women increased employment after the ERA by birth cohort in line with the financial incentives. The employment increase decelerated for the younger cohorts, suggesting that the pension deductions had a decreasing effect on employment rather than a linear effect. In addition, the reform seems to have had almost no positive effect on employment beyond the NRA for those who did not exit via partial retirement or unemployment. For cohorts 1940–1942, employment rates after the NRA are similar to those of the cohorts not affected by the reform. For example, employment after age 62 for cohort 1941 is the same as for cohorts 1937–1939. Therefore, the positive employment effect induced by the pension reform is only found for the period between the ERA and NRA. Only cohort 1943 has higher employment after the group-specific NRA at age 64 than cohorts 1937–1939.

The cohort-specific patterns of partial retirement rates, including the passive (retirement) phase, are shown in Figure 2. The Partial Retirement Act gave employers the option to offer partial retirement as a bridge to retirement from 1996 onward. During the initial years following the introduction of partial retirement, employers could only offer the bridge option if they were subject to collective agreements that included partial retirement (Berg et al. 2020). Accordingly, partial retirement incidence increased with the number of employers entitled to offer partial retirement²³ from less than 3% in cohort 1940 to almost 28% in cohort 1944 combined with a strong extension in the duration of partial retirement from about 32 months in cohort 1940 to about 48 months in cohort 1944. After finishing partial retirement, most women applied for the pension for women because the ERA and NRA, and thus deductions for early

²³Before the reform, only the chemical industry had a specific partial retirement option in its collective bargaining agreement. Therefore, there are few cases of partial retirement reported for the cohorts 1937–1939. After 1998, the number of employees working in firms covered by collective agreements including partial retirement options dramatically increased (Berg et al. 2020).

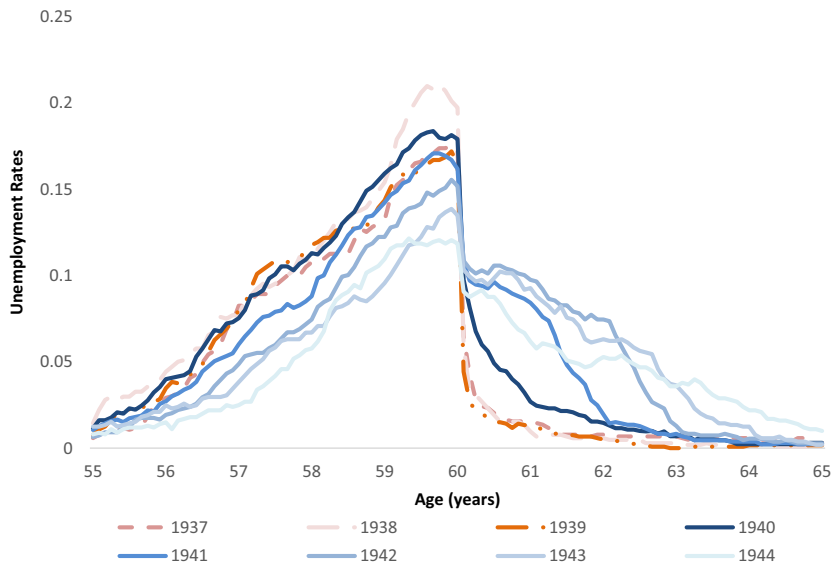


FIGURE 3 Unemployment rates by age (monthly data) and cohort. Source: SIAB7514, own calculations [Colour figure can be viewed at wileyonlinelibrary.com]

retirement, were higher for the pension after partial retirement. Consequently, partial retirement ending after the NRA for the pension for women was not attractive. Accordingly, we do not observe partial retirement after, for example, age 61 for cohort 1941 or age 62 for cohort 1942.

Figure 3 displays unemployment rates by birth cohort and age. The unemployment rates of the control group (cohorts 1937–1939) strongly increased before the age of 60 in line with the general increase in unemployment from 7% to 13% in West Germany between 1991 and 1997 (Bundesagentur für Arbeit, 2019). Many employers used dismissals of their older employees to meet their reorganization requirements externally during the recession (Schmähl, 2003). After 1998, the business cycle picked up and the pressure to reduce the workforce eased. Thus, the observed unemployment pattern is mainly a consequence of the correlation between unemployment incidence and the business cycle. A share of 21% used unemployment as a bridge into retirement in birth cohort 1937. This share increases to 25% in cohort 1941, and then decreases again to less than 23% in cohort 1944. In the observed birth cohorts, the unemployment duration oscillates slightly between 27 and 29.4 months. There are few unemployment spells after age 60 in the control cohorts because all unemployed older women in our sample had the right to enter the pension for women at age 60 without deductions. To avoid pension deductions, unemployment incidence increases for treated birth cohorts between the ERA and NRA. Unemployment is not attractive after the NRA for the pension for women, whereas the ERA and NRA are higher for the pension after unemployment. Therefore, the ERA and NRA for the pension for women are relevant for the women in our sample and there is little unemployment after, for example, age 61 for cohort 1941 and age 62 for cohort 1942.

Examining the average employment exit age demonstrates that women who did not use bridge options show a stronger increase in employment with pension deductions after the reform. Among this group, women born in 1944 left employment at age 62.4 on average, about 15 months later than women born in 1940 and almost two years later than women not affected by the pension reform. Employment exit age is stable at around 60 years for women in birth cohorts 1940–1944 who used partial retirement. Average employment exit age at dismissal is

always below 60 years for all birth cohorts in our sample. It increases by 1 year between birth cohorts 1940 and 1944. This pattern suggests that employers successfully limited the increase in employment exit age induced by the pension reform when the employee accepts partial retirement or dismissal.

In Appendix D, Figures D1-D10 provide descriptive evidence that the patterns of labor market status for the different employer groups, according to our hypotheses, are comparable to the overall age pattern (Figures 1–3). Most importantly, employment patterns before age 60 are similar for all birth cohorts and differ only by employer group. We find an employment increase between the ERA and NRA for the birth cohorts affected by the pension reform for each employer sub-group analogous to that observed in Figure 1. The partial retirement incidence also increases for the younger birth cohorts for each employer sub-group and exhibits the same pattern by birth cohort between the ERA and NRA, as in Figure 2. Finally, we observe an increase in unemployment incidence between the ERA and NRA analogous to Figure 3 for each employer sub-group. Thus, the impact of the pension reform on the labor market of older employees is mainly driven by changes in labor market behavior between the ERA and NRA that are observed for all employer sub-groups.

ESTIMATION METHOD

In the regression analysis, we test the hypotheses derived above by studying if and how reform effects vary across different groups of employers. We estimate the impact of the monthly increases in pension deductions for early retirement by the 1992 pension reform on labor market outcomes between the ERA and NRA (age 60 and 65) with the following model:

$$y_{it} = \alpha + \theta_{it} + \lambda_c + \gamma D_{it} + \delta (D_{it} \times G) + \beta_x' X_{it} + \beta_y' Y_j + v_j + e_{it}. \quad (3)$$

Here, individual i is employed at employer j . Outcome variable y denotes the individual labor market states employment, partial employment, and unemployment at age t . The main variable of interest, D_{it} , measures the deductions from pension entitlements for those who enter early retirement with the pension for women (i.e., the difference between employment exit and birth-cohort-specific NRA in months). Vector δ captures differences in individual reactions to deductions between treated and non-treated women working at different employer groups G . If the coefficients in this vector are significant, the employer group influences the labor market outcomes of older women affected by the pension reform, conditional on individual characteristics X_i and employer characteristics Y_j . In matrix X_p , we include the individual pension wealth at age 55 to capture the individual employment and earnings history,²⁴ job exposure of the occupation in the last job,²⁵ level of requirement in the last job, changes in the legislation for disability pensions, and changes in the entitlement rules for unemployment insurance. Establishment-level controls are measured at age 55 and include the employer group dummy, G , the mean imputed wage of all full-time employees, establishment size, share of full-time and part-time female employees, share of full-time regular workers, share of trainees, share of full-time unskilled employees, share of full-time qualified employees, share of full-time highly qualified employees, share of employees aged 55–59, share of employees aged 60–64, mean age of

²⁴We measure pension wealth at age 55 according to the method proposed by Stock and Wise (1990), also see Hanappi and Nagl (2019) or Pfister et al. (2018), p. 10. Therefore, pension wealth is not affected by the pension reform and does not systematically vary among the different cohorts.

²⁵To measure the job exposure in occupations, we use the job exposure matrices (JEM) developed by Kroll (2011) and match the JEM via the classification of occupations 2010 (*Klassifikation der Berufe* KLDB-2010) to our data.

the total full-time employees, economic sector, and the regional unemployment rate.²⁶ To capture possible unobserved differences among employers in their treatment of older employees, we include establishment fixed effects v_j .²⁷ The identification of establishment-specific effects is possible because we observe individuals with different deduction levels at the same establishment. However, by definition, during unemployment spells, employees do not have an employer, and thus establishment fixed effects cannot be included for the unemployment regressions.

To account for age- and cohort-specific effects on the individual retirement decisions that are not directly related to the deductions, we also include monthly age fixed effects (θ_{it}) and monthly cohort fixed effects (λ_c). As discussed in detail in Engels et al. (2017), the age and cohort-specific effect can be identified separately from the pension deductions because the 1992 pension reform affects cohorts at different ages. To identify the causal effect of deductions, we need to assume that the age-specific effects on employment do not change among the cohorts after controlling for individual and firm-specific characteristics. This assumption is weaker than assuming that there are no general labor market differences between the cohorts.²⁸

In general, it is difficult to separate labor supply and labor demand effects on labor market outcomes because employers and employees take joint decisions (Rabaté, 2019). However, the longitudinal structure of the data combined with the exogenous variation induced by the pension reform allows us to identify the labor market effects separately for different groups of employers. Specifically, the deductions of pension entitlements for those who entered early retirement at the age of 60 or later do not differ among employers; thus, the overall effect of deductions captures the labor supply incentives of the pension reform. In addition, we include employer characteristics and establishment fixed effects, which account for the heterogeneous composition of workers and sorting into different establishments. Importantly, all employer characteristics are measured before women were affected by the pension reform, and all women in our sample selected the last employer of their career before the pension reform was introduced in 1997. The women in our sample were, on average, 41 years old when they entered their last employer before retirement. Stock and Wise (1990) showed that retirement issues are of little interest for young and prime age employees. Thus, we can safely assume that the expected behavior of the employer with respect to the pension reform was not important in the choice of employer. In summary, there seems to be little scope for time-variant unobserved employer characteristics related to individual labor market outcomes after age 60 and self-selection of employees for employers based on the employers' reaction to the pension reform. Consequently, we are confident that we can identify the causal impact of employer characteristics on the reform effects.

PENSION REFORM EFFECTS

Overall effects

Before we discuss the heterogeneous effects related to employer characteristics, we present the estimated effects of the monthly changes in pension deductions on labor market outcomes for

²⁶Detailed descriptive statistics about the individual and employer characteristics are given in Appendix A.

²⁷Unfortunately, our data do not provide a firm indicator. Theoretically, the firm-level could also be relevant for hiring decisions assuming that firms have a common set of rules and policies that are applied to all units of the firm. However, many firms (especially large conglomerates) set different rules for hiring, dismissal and remuneration for different establishments that may be active in different sectors. These divisions have different business goals and they are very flexible in their human resource management measure to pursue these goals. Therefore, the establishment level may capture these differences better than using the firm level.

²⁸Engels et al. (2017) present descriptive evidence that the labor market behavior of the adjacent cohorts is similar, in the absence of the changes induced by the pension reform.

the entire sample (Table 1). The main variables of interest are the cohort-specific pension deductions that are categorized in intervals to capture potential non-linear effects of deductions. In Column I, we display the effects of deduction without further employer characteristics;²⁹ in Column II, we add employer characteristics and the regional unemployment rate, and in Column III, we add establishment fixed effects.

We find that a small pension deduction has sizeable effects on employment. On average, an increase in deductions by 0.3 to 3.6 percentage points (PP) increases employment between age 60 and 65, including the active phase of partial retirement, by 12.6 PP (Column I). The employment effect almost doubles for the group with maximum deductions (25.1 PP). The results do not change significantly when controlling for individual and firm-specific characteristics (Column II), or for establishment fixed effects (Column III). Overall, we find a stronger positive effect of the pension reform on employment than Engels et al. (2017; Table 1). The larger effects are consistent with our sample selection of women who are either employed or registered as unemployed at age 59. Therefore, the probability of working beyond age 60 is higher in our sample than for all women eligible for the pension for women.

The overall effects on partial retirement and unemployment are also positive, but smaller. This result holds across the different specifications. Pension deductions of 0.3 to 3.6 PP increase partial retirement by 5.9 PP (Column III) and unemployment by 4.4 PP (Column II). Maximum deductions increase partial retirement by 12.5 PP and unemployment by 6.5 PP.³⁰

Hypothesis testing

We examine how employer characteristics correlate with the reaction of employees induced by the pension reform.³¹

Hypothesis 1: Older worker inflow relative to younger worker inflow

In Table 2, we report the reform effects on labor market outcomes separately for employees in establishments with high and low average shares of older versus young worker inflow. More specifically, we calculate the average share of newly hired employees older than 55 with respect to new hires younger than 30 over the period in which we observe the last employer before retirement up to the year 1999. Employers with an average share above the 75th percentile of older worker inflow to young worker inflow are defined as “high” and employers with an average share below the 25th percentile are defined as “low.” According to Hypothesis 1, the labor supply shock has a higher effect on partial retirement for employers with a high number of newly hired older employees in relation to all newly hired young employees. The analogous effect on unemployment is lower for this group of employers, although the effects on employment are not significantly different.

²⁹Individual and employer-specific effects are presented in Table C1 in Appendix C.

³⁰As a robustness test, we estimate a placebo regression comparing labor market behavior of two unaffected birth cohorts (1938 and 1939). We do not find any “reform effect.” Results are available upon request.

³¹Our results are mainly driven by the employers in the non-manufacturing sectors. If we reduce the sample to non-manufacturing establishments, the results are qualitatively and quantitatively the same. For manufacturing firms, most coefficients are insignificant because the number of observations is too low.

TABLE 1 Direct effects on labor market outcomes

	Employment			Partial retirement			Unemployment			
	I	II	III	I	II	III	I	II	III	
	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	
No deductions										
0.3–3.6	0.126** (0.005)	0.126** (0.005)	0.163** (0.006)	0.046** (0.003)	0.046** (0.003)	0.059** (0.004)	0.043** (0.003)	0.044** (0.003)	0.044** (0.003)	
3.9–7.2	0.149** (0.006)	0.149** (0.006)	0.189** (0.007)	0.074** (0.004)	0.074** (0.004)	0.095** (0.005)	0.056** (0.004)	0.056** (0.004)	0.056** (0.004)	
7.5–10.8	0.195** (0.007)	0.195** (0.007)	0.232** (0.009)	0.101** (0.005)	0.101** (0.005)	0.127** (0.007)	0.052** (0.004)	0.052** (0.004)	0.052** (0.004)	
11.1–14.4	0.228** (0.010)	0.228** (0.010)	0.261** (0.011)	0.114** (0.007)	0.114** (0.007)	0.142** (0.009)	0.057** (0.006)	0.057** (0.006)	0.057** (0.006)	
14.7–18.0	0.243** (0.015)	0.243** (0.015)	0.266** (0.017)	0.121** (0.011)	0.121** (0.011)	0.150** (0.013)	0.010** (0.010)	0.061** (0.010)	0.061** (0.010)	
Cohort effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	
Legislative changes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	
X variables	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	
Y variables	No	Yes	Yes	No	Yes	Yes	No	Yes	Yes	
Establishment fixed effects	No	No	Yes	No	No	Yes	No	No	No	
N	544,791	544,791	429,378	544,791	544,791	429,378	544,791	544,791	544,791	
Pre-reform mean for 60–65 year olds	0.092			0.001			0.010			
R ²	0.170	0.224	0.666	0.097	0.115	0.519	0.05	0.064	0.064	

Notes: Employment includes the active phase of partial retirement. In specification I, we control for individual characteristics. In column II, we additionally control for employer characteristics, and, in column III, we estimate establishment fixed effects. Standard errors in parentheses are clustered on the individual level. Significance levels: * $p < 0.05$, ** $p < 0.01$. The pre-reform mean refers to the control group (cohorts 1937–1939). Source: SIAB7514, own calculations.

TABLE 2 Inflow of older employees

	Employment with working phase of partial retirement	Partial retirement	Unemployment
No penalties	Reference	Reference	Reference
0.3–3.6	0.143** (0.010)	0.032** (0.005)	0.048** (0.006)
3.9–7.2	0.169** (0.012)	0.050** (0.007)	0.064** (0.008)
7.5–10.8	0.204** (0.015)	0.070** (0.010)	0.069** (0.009)
11.1–14.4	0.245** (0.019)	0.073** (0.013)	0.082** (0.012)
14.7–18.0	0.295** (0.030)	0.050** (0.018)	0.083** (0.021)
High inflow of older employees	–0.040** (0.010)	–0.013** (0.003)	0.005 (0.003)
0.3–3.6 * High inflow of older employees	–0.010 (0.016)	0.024** (0.009)	–0.010 (0.008)
3.9–7.2 * High inflow of older employees	–0.021 (0.019)	0.037** (0.013)	–0.016 (0.011)
7.5–10.8 * High inflow of older employees	–0.003 (0.025)	0.050* (0.018)	–0.031** (0.013)
11.1–14.4 * High inflow of older employees	–0.009 (0.032)	0.073** (0.024)	–0.042** (0.017)
14.7–18.0 * High inflow of older employees	–0.082 (0.049)	0.135** (0.038)	–0.040 (0.027)
<i>N</i>	252,174	252,174	252,174
Pre-reform mean for 60–65 year olds (Low inflow of older employees)	0.093	/	0.011
Pre-reform mean for 60–65 year olds (High inflow of older employees)	0.098	/	0.006
<i>R</i> ²	0.239	0.120	0.071

Notes: High inflow of older employees is defined as last employer in career with above the 75th percentile of inflow share of employees older than 55 years compared with employees younger than 30 years. Low inflow is defined as last employer has less than the 25th percentile of inflow share of older employees. We control for changes in the legislation for disability pensions and in the entitlement rules for unemployment insurance. Moreover, we consider pension wealth with a planning age of 55, job exposure, the level of job requirements and education, regional unemployment rates, and employer characteristics. Standard errors in parentheses are clustered on the individual level. We do not show pre-reform means for partial retirement for data protection reasons because the numbers of observations are too low. Significance levels: * $p < 0.05$, ** $p < 0.01$. The pre-reform mean is calculated for the cohorts 1937 to 1939. Source: SIAB7514, own calculations.

Hypothesis 2: R&D expenses

We use the economic sector as an indicator for employers' R&D intensity to test Hypothesis 2. We categorize all employers in the three sectors with the highest R&D expenses into the "high R&D expenses" group and all employers in the three sectors with the lowest R&D expenses

TABLE 3 R&D expenditures

	Employment with working phase of partial retirement	Partial retirement	Unemployment
No penalties	Reference	Reference	Reference
0.3–3.6	0.145** (0.008)	0.074** (0.006)	0.022** (0.003)
3.9–7.2	0.166** (0.010)	0.113** (0.008)	0.027** (0.004)
7.5–10.8	0.216** (0.012)	0.144** (0.010)	0.020** (0.005)
11.1–14.4	0.255** (0.016)	0.155** (0.013)	0.015** (0.006)
14.7–18.0	0.271** (0.024)	0.170** (0.019)	0.020** (0.010)
High R&D expenditure	–0.013 (0.063)	0.011 (0.030)	0.008 (0.013)
0.3–3.6 * High R&D expenditure	–0.036** (0.012)	–0.045** (0.008)	0.033** (0.007)
3.9–7.2 * High R&D expenditure	–0.029 (0.015)	–0.058** (0.011)	0.047** (0.009)
7.5–10.8 * High R&D expenditure	–0.023 (0.020)	–0.067** (0.015)	0.061** (0.010)
11.1–14.4 * High R&D expenditure	–0.030 (0.026)	–0.067** (0.020)	0.079** (0.014)
14.7–18.0 * High R&D expenditure	–0.038 (0.040)	–0.079** (0.031)	0.083** (0.023)
<i>N</i>	403,698	403,698	403,698
Pre-reform mean for 60–65 year olds (Low R&D expenditure)	0.113	0.001	0.005
Pre-reform mean for 60–65 year olds (High R&D expenditure)	0.066	0.002	0.018
<i>R</i> ²	0.229	0.130	0.064

Notes: High R&D expenditure is defined as last employer is in the three economic sectors of the economy with the highest R&D expenses in 2003; low R&D expenditure is defined as last employer is in the three sectors with the lowest R&D expenses in 2003. We control for changes in the legislation for disability pensions and in the entitlement rules for unemployment insurance. Moreover, we consider pension wealth with a planning age of 55, job exposure, the level of job requirements and education, regional unemployment rates, and employer characteristics. Standard errors in parentheses are clustered on the individual level. Significance levels: * $p < 0.05$, ** $p < 0.01$. The pre-reform mean is calculated for the cohorts 1937 to 1939. Source: SIAB7514, own calculations.

into the “low R&D expenses” group.³² We find, according to Hypothesis 2, that employees in sectors with high R&D expenses are less likely to stay in employment and to enter partial retirement. The effect of deductions on unemployment is, accordingly, always significantly larger for these women (Table 3). This pattern is consistent with Hypothesis 2.

³²The three sectors with the highest share of R&D are manufacturing of goods; transport, storage, and communication; and real estate, renting, and business activities. The three sectors with the lowest share of R&D are hotels and restaurants; public administration, services, and private households; and mining and quarrying (own calculations based on Eurostat Data Base, series business expenditure on R&D by NACE Rev. 2 the European classification of economic activities).

TABLE 4 Employers subject or not subject to dismissal protection

	Employment with working phase of partial retirement	Partial retirement	Unemployment
No penalties	Reference	Reference	Reference
0.3–3.6	0.085** (0.028)	0.005 (0.011)	0.106** (0.025)
3.9–7.2	0.134** (0.034)	0.012 (0.015)	0.105** (0.027)
7.5–10.8	0.198** (0.042)	0.005 (0.016)	0.070* (0.029)
11.1–14.4	0.242** (0.054)	–0.021 (0.013)	0.079 (0.041)
14.7–18.0	0.254** (0.080)	–0.021 (0.021)	0.092 (0.069)
Dismissal protection	–0.027 (0.024)	–0.018** (0.006)	0.006 (0.008)
0.3–3.6 * Dismissal protection	0.065 (0.037)	0.026 (0.014)	–0.061* (0.028)
3.9–7.2 * Dismissal protection	0.035 (0.044)	0.039 (0.021)	–0.050 (0.031)
7.5–10.8 * Dismissal protection	–0.014 (0.053)	0.056* (0.024)	–0.018 (0.031)
11.1–14.4 * Dismissal protection	0.003 (0.066)	0.063** (0.022)	0.013 (0.045)
14.7–18.0 * Dismissal protection	0.063 (0.096)	0.050 (0.045)	0.046 (0.084)
<i>N</i>	50,081	50,081	50,081
Pre-reform mean for 60–65 year olds (No Dismissal protection)	0.099	0	0.008
Pre-reform mean for 60–65 year olds (Dismissal protection)	0.097	0.002	0.012
<i>R</i> ²	0.343	0.158	0.119

Notes: Dismissal protection dummy equals one if the last employer has more than five employees; dummy equals zero if the employer has five or fewer employees. We control for changes in the legislation for disability pensions and in the entitlement rules for unemployment insurance. Moreover, we consider pension wealth with a planning age of 55, job exposure, the level job requirements and education, regional unemployment rates, and employer characteristics. Standard errors in parentheses are clustered on the individual level. Significance levels: * $p < 0.05$, ** $p < 0.01$. The pre-reform mean is calculated for the cohorts 1937 to 1939. Source: SIAB7514, own calculations.

Hypothesis 3: Dismissal protection

In Table 3, we compare the labor market effects of the pension reform for employers with fewer than five employees, who are exempt from the strict dismissal protection law,³³ with those for employers with five to 20 employees to test Hypothesis 3. According to Hypothesis 3, older

³³The threshold was raised to 10 employees in 2004. Thus, the increase affected few employees in our sample, with most still protected by legitimate expectation rules. Therefore, we use the five-employee threshold for the entire sample.

women working in establishments subject to dismissal protection have longer spell lengths in partial retirement and lower unemployment incidence (Table 4). However, there are no differences in employment.³⁴ Thus, dismissal protection does not appear to play an important role in employer behavior as hypothesized.

Hypothesis 4: Collective bargaining

We cannot directly observe whether an employer is subject to a collective bargaining agreement. Therefore, we split the employers into two groups according to their economic sector: employers in the three sectors with the highest collective bargaining coverage and those in sectors with the lowest collective bargaining coverage.³⁵ Consistent with Hypothesis 4, the effect of deductions on partial retirement in establishments in sectors with high collective bargaining coverage is significantly larger (Table 5). Effects on unemployment are always significantly lower, which is consistent with the hypothesis that employees with union coverage are less likely to be dismissed by employers before the ERA (Table 5). There are no significant differences in the employment rates between both employer groups.

Hypothesis 5: Group-specific reform effects and bridge option usage

According to Hypothesis 5, significant differences in labor market states among employer groups are observed mainly for older women using the bridge options of partial retirement or unemployment spells. The pension effects after the ERA do not differ among the four employer comparison groups for women who did not use a bridge option (Table 6).

The estimations in Tables 2–6 are without establishment fixed effects because the unemployed do not have an establishment identifier. In addition, the direct effect of the employer group on the dependent variables disappears when we include the establishment fixed effects. We include establishment fixed effects in the estimations reported in Tables E1–E5 (Appendix E) on employment and partial retirement spells to test the robustness of our results. The results of the establishment fixed effect estimations are generally in line with the results presented above. However, the differences among employer groups in Hypothesis 1 are almost non-significant for partial retirement. Table 7 summarizes the empirical evidence of our hypotheses tests.

CONCLUSIONS

Employers do not have unlimited flexibility in their reaction to labor supply shocks because the unplanned prolonging of the employment of older employees incurs substitution costs.

³⁴If we cut off the employer sample at the 75th and 25th percentiles of establishment size or extend the group with dismissal protection to all employers with more than five employees instead of firms with 6–20 employees, we obtain higher and stronger significant differences for unemployment and partial retirement spells. However, it is probable that, for the less homogenous employer group, unobservable factors play a role in the pension reform effects in addition to dismissal protection.

³⁵The three sectors with the highest collective bargaining coverage in the year 2014 are energy provision; public services, defense, and social security; and education. The three sectors with the lowest collective bargaining coverage are agriculture and forestry; trade, maintenance, and repair of motor vehicles; and other professional, scientific and technical services (own calculation, based on German Statistical Office, series earnings structure (*Verdienststrukturhebung*)). Figures on collective bargaining coverage are not available for the years analyzed in this study. We assume that the rank order of collective bargaining strength is stable over the years.

TABLE 5 Collective bargaining agreements

	Employment with working phase of partial retirement	Partial retirement	Unemployment
No penalties	Reference	Reference	Reference
0.3–3.6	0.129** (0.010)	0.01* (0.005)	0.072** (0.007)
3.9–7.2	0.158** (0.012)	0.015* (0.006)	0.084** (0.009)
7.5–10.8	0.193** (0.016)	0.024** (0.009)	0.078** (0.010)
11.1–14.4	0.232** (0.021)	0.026* (0.012)	0.101** (0.014)
14.7–18.0	0.266** (0.032)	0.030 (0.021)	0.085** (0.022)
High Coverage	0.015 (0.094)	–0.026 (0.019)	0.036 (0.035)
0.3–3.6 * High Coverage	0.018 (0.016)	0.097** (0.011)	–0.062** (0.008)
3.9–7.2 * High Coverage	0.011 (0.020)	0.140** (0.015)	–0.077** (0.010)
7.5–10.8 * High Coverage	0.019 (0.025)	0.165** (0.019)	–0.077** (0.011)
11.1–14.4 * High Coverage	0.013 (0.032)	0.173** (0.026)	–0.103** (0.016)
14.7–18.0 * High Coverage	–0.012 (0.051)	0.200** (0.041)	–0.078** (0.025)
<i>N</i>	234,972	234,972	234,972
Pre-reform mean for 60–65 year olds (Low Coverage)	0.087	/	0.008
Pre-reform mean for 60–65 year olds (High Coverage)	0.107	0.0008	0.002
<i>R</i> ²	0.245	0.156	0.082

Notes: High coverage has a value of 1 for employers in the three economic sectors with the highest coverage of collective bargaining agreements in 2014; low coverage has a value of 1 for employers in the three economic sectors with the lowest collective agreement coverage in 2014. We control for changes in the legislation for disability pensions and in the entitlement rules for unemployment insurance. Moreover, we consider pension wealth with a planning age of 55, job exposure, the level of job requirements and education, regional unemployment rates, and employer characteristics. Standard errors in parentheses are clustered on the individual level. Significance levels: * $p < 0.05$, ** $p < 0.01$. The pre-reform mean is calculated for the cohorts 1937 to 1939.

However, if employers dismiss their older employees, this incurs dismissal, severance pay, and other costs. Substitution and dismissal costs should affect labor market outcomes after a labor supply shock. Pension reforms have been a regular trigger of labor supply shocks for clearly defined sub-groups of the labor force in most developed countries since the 1990s. Nevertheless, the empirical literature on the effects of pension reforms on individual labor market outcomes mainly focuses on the labor supply reaction, and thus indirectly assumes a perfectly flexible employer reaction.

TABLE 6 Employment effects for women without bridge paths by employer groups

Employment		Reference	No penalties	Reference	No penalties	Reference	No penalties	Reference	No penalties	Reference
No penalties										
0.3–3.6		0.208** (0.014)	0.3–3.6	0.195** (0.011)	0.3–3.6	0.136** (0.040)	0.3–3.6	0.200** (0.015)		
3.9–7.2		0.242** (0.016)	3.9–7.2	0.211** (0.013)	3.9–7.2	0.175** (0.046)	3.9–7.2	0.238** (0.018)		
7.5–10.8		0.266** (0.020)	7.5–10.8	0.243** (0.017)	7.5–10.8	0.230** (0.050)	7.5–10.8	0.272** (0.023)		
11.1–14.4		0.291** (0.026)	11.1–14.4	0.285** (0.022)	11.1–14.4	0.291** (0.061)	11.1–14.4	0.302** (0.030)		
14.7–18.0		0.391** (0.040)	14.7–18.0	0.310** (0.032)	14.7–18.0	0.235* (0.100)	14.7–18.0	0.346** (0.042)		
High inflow of older employees		-0.044** (0.013)	High R&D expenditure	-0.112 (0.097)	Dismissal protection	-0.032 (0.032)	High Coverage	0.107 (0.134)		
0.3–3.6 * High inflow of older employees		-0.005 (0.023)	0.3–3.6 * High R&D expenditure	0.006 (0.019)	0.3–3.6 * Dismissal protection	0.095 (0.051)	0.3–3.6 * High Coverage	0.008 (0.023)		
3.9–7.2 * High inflow of older employees		-0.020 (0.028)	3.9–7.2 * High R&D expenditure	0.028 (0.023)	3.9–7.2 * Dismissal protection	0.059 (0.059)	3.9–7.2 * High Coverage	-0.007 (0.028)		
7.5–10.8 * High inflow of older employees		-0.008 (0.035)	7.5–10.8 * High R&D expenditure	0.042 (0.029)	7.5–10.8 * Dismissal protection	-0.013 (0.064)	7.5–10.8 * High Coverage	-0.015 (0.036)		
11.1–14.4 * High inflow of older employees		-0.007 (0.044)	11.1–14.4 * High R&D expenditure	0.026 (0.037)	11.1–14.4 * Dismissal protection	-0.030 (0.069)	11.1–14.4 * High Coverage	-0.015 (0.045)		
14.7–18.0 * High inflow of older employees		/	14.7–18.0 * High R&D expenditure	0.020 (0.053)	14.7–18.0 * Dismissal protection	/	14.7–18.0 * High Coverage	-0.040 (0.066)		
N		171,081	N	267,180	N	34,343	N	162,504		

(Continues)

TABLE 6 (Continued)

Employment							
Pre-reform mean for 60–65 year olds (Low inflow of older employees)	0.117	Pre-reform mean for 60–65 year olds (Low R&D expenditure)	0.124	Pre-reform mean for 60–65 year olds (No Dismissal protection)	0.128	Pre-reform mean for 60–65 year olds (Low Coverage)	0.110
Pre-reform mean for 60–65 year olds (High inflow of older employees)	0.116	Pre-reform mean for 60–65 year olds (High R&D expenditure)	0.097	Pre-reform mean for 60–65 year olds (Dismissal protection)	0.112	Pre-reform mean for 60–65 year olds (High Coverage)	0.113
R^2	0.317	R^2	0.300	R^2	0.434	R^2	0.326

Notes: Employment without active part of partial retirement. Employer groups are defined as in Tables 2–5. We control for changes in the legislation for disability pensions and in the entitlement rules for unemployment insurance. Moreover, we consider pension wealth with planning age of 55, job exposure and education, regional unemployment rates, and employer characteristics. Standard errors in parentheses are clustered on the individual level. Significance levels: * $p < 0.05$, ** $p < 0.01$. The pre-reform mean is calculated for the cohorts 1937 to 1939. Source: SIA/B7514, own calculations.

TABLE 7 Summary of the empirical evidence for our hypotheses

Group comparison	Effect on ...					
	Employment		Partial retirement		Unemployment	
	Expected	Estimated	Expected	Estimated	Expected	Estimated
Firms with no internal labor market and low substitution costs vs. firms with lower substitution costs	+	x	+	✓	-	(✓)
Firms with high R&D expenses vs. low R&D expenses	-	✓	-	✓	+	✓
Firms subject to dismissal protection vs. firms not subject to dismissal protection	+	x	+	(✓)	-	x
Firms subject to collective bargaining vs. firms without collective bargaining	+	x	+	✓	-	✓
Differences found among employer groups	No	✓	Yes	✓	Yes	✓

Notes: + positive correlation, - negative correlation, X hypothesis not supported, ✓ hypothesis supported, (✓) hypothesis weakly supported.

We focus on the role of labor demand in the labor market effects of the 1992 pension reform in Germany. The reform introduced yearly deductions of 3.6% from pension entitlements for women for retirement before the NRA and a stepwise increase in the NRA from 60 to 65 years, keeping the ERA constant at age 60. We showed that the reform had the expected positive effects on employment and, to a lesser extent, unemployment, and partial retirement between the ERA and NRA. Our results were comparable to previous results (Engels et al. 2017). For the first time, we also calculated the effects of the pension reform on partial retirement after the ERA, an early retirement bridge introduced with the pension reform. We carefully controlled for the usual drivers of individual labor supply reactions to show the additional labor demand effects in the next step.

Based on labor demand theory, we argued that employers with low substitution costs for their older employees, that value employer-specific knowledge of older employees, and with high dismissal costs allow longer employment and offer their older women partial retirement instead of dismissal. According to these hypotheses, we showed that older women who work for employers with a high share of older employees hired versus young employees hired, for employers in sectors with little investment in R&D, and for employers in sectors with a high share of collective bargaining agreements allow their older women to stay substantially longer in partial retirement and do not dismiss them into unemployment after the ERA. We did not find any differences in the reform effects on employment across employer groups. This finding may be explained by the smaller influence of the employer on the employment exit age of those who do not use the bridge options of partial retirement or unemployment.

Thus, we demonstrated that employers influence when and how an older employee leaves the labor market and employers do not react perfectly elastically to labor supply shocks. To understand the treatment effects of pension reforms on labor market outcomes of older employees, we included the labor demand reactions of their employers. For example, it is important whether an employee affected by the pension reform works for an employer that is subject

to collective bargaining, invests heavily in R&D, or is interested in rejuvenating the workforce when hiring new staff.

Our results suggested that after demand shocks affecting older employees, employers use instruments that allow them to influence the timing of retirement, despite the cost. Examples are the bridge options of partial retirement and early retirement after unemployment. These instruments specifically allow employers with high substitution costs and a low human capital value for their older employees to buy off the autonomy to decide when to enter retirement. The decision of which bridge options to choose is influenced by industrial relations institutions, such as works councils or unions, and dismissal costs. Therefore, these institutions seem to be effective in protecting older employees from unemployment before retirement.

We used a large administrative labor market history data set that covers a representative sample of all employees in Germany. The data set allowed us to control for the relevant individual financial retirement incentives. However, the establishment information in the data set is limited. For example, we could not directly analyze the labor supply influence of the presence of a works council or collective bargaining coverage; instead, we used sector proxies. In addition, training efforts, the inclusion of older employees in training, and establishment R&D expenditure may be better indicators for the value of human capital of older employees than our sector proxies on R&D intensity. Future research could use linked employer-employee data sets that include some of this establishment information. In addition, the influence of the pension reform on labor market outcomes besides employment, partial retirement, or unemployment, such as the earnings of older employees, substitution of younger by older employees, or employment after retirement, are interesting topics for future research. It would also be desirable to extend the analysis by modeling the general equilibrium effects of the pension reform. Finally, it would be interesting to examine whether there are differences among employer types for later pension reforms that increased the ERA, such as the German 1999 pension reform that increased the ERA for women by 3 years. The reform led on average to a substantial employment increase of older women, compare Geyer and Welteke (2021).

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APPENDIX A

TABLE A1 Descriptive statistics of individual and employer characteristics

Variable	Mean	Standard Deviation
Employer characteristics by last employment		
Total number of employees	801.318	2808.329
Imputed gross daily earnings of full-time employees	91.393	30.244
Employee age	42.181	5.019
Age full-time employees	42.091	5.330
Share women employees	0.592	0.257
Share full-time employees	0.659	0.231
Share part-time employees	0.217	0.195
Share regular employees	0.873	0.139
Share apprentices	0.039	0.059
Share women full-time employees	0.311	0.197
Share women part-time employees	0.199	0.184
Share regular full-time employees	0.657	0.232
Share low-skilled employees	0.156	0.135
Share medium-skilled employees	0.718	0.176
Share high-skilled employees	0.114	0.152
Share low-skilled full-time employees	0.070	0.108
Share medium-skilled full-time employees	0.500	0.214
Share high-skilled full-time employees	0.085	0.114
Share employees 55–59 years old	0.126	0.122
Share employees 60–64 years old	0.057	0.095
Regional unemployment rate	9.972	3.569
Individual characteristics		
Job exposure index: Overall job index	4.723	3.036
Job exposure index: Overall physical exposure index	4.494	2.892
Job exposure index: Overall psycho-social exposure index	4.943	3.147
Job exposure index: Carcinogenic agent index	4.513	2.882
Job exposure index: Heavy work index	4.744	2.968
Pension wealth at age 55	188,734	53,993
Number of observations	1,093,114	

Source: SIAB7514, own calculations.

APPENDIX B

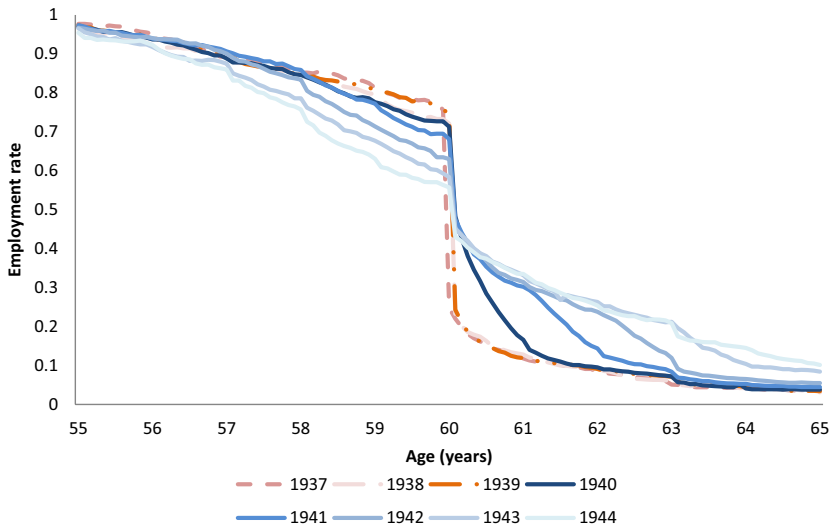


FIGURE B1 Employment rates (employment subject to social security contributions without active phase of partial retirement) by age (monthly data) and cohort. Source: SIAB7514, own calculations [Colour figure can be viewed at wileyonlinelibrary.com]

APPENDIX C

TABLE C1 Direct effects on labor market outcomes

	Employment	Partial retirement	Unemployment
No deductions	Reference	Reference	Reference
0.3–3.6	0.126** (0.005)	0.046** (0.003)	0.044** (0.003)
3.9–7.2	0.150** (0.006)	0.074** (0.004)	0.056** (0.004)
7.5–10.8	0.197** (0.007)	0.11** (0.005)	0.053** (0.005)
11.1–14.4	0.235** (0.010)	0.115** (0.007)	0.058** (0.006)
14.7–18.0	0.258** (0.015)	0.125** (0.010)	0.063** (0.010)
Pension wealth at age 55	0.06** (0.006)	0.01** (0.003)	–0.01** (0.002)
Overall job index	0.007 (0.009)	0.007 (0.005)	0.004 (0.004)
Overall physical exposure index	–0.007 (0.008)	–0.004 (0.004)	0.0001 (0.003)
Overall psycho-social exposure index	0.004 (0.004)	–0.003 (0.002)	–0.002 (0.001)
Carcinogenic agent index	–0.0001 (0.003)	0.0002 (0.001)	–0.001 (0.001)

TABLE C1 (Continued)

	Employment	Partial retirement	Unemployment
Heavy work index	-0.009 (0.003)	-0.0006 (0.001)	-0.001 (0.001)
Total number of employees	-3.64e-06** (9.07e-07)	-3.30e-07 (4.89e-07)	-8.44e-07** (2.23e-07)
Imputed gross daily earnings of full-time employees	0.001** (0.0002)	0.0006** (0.0008)	-0.0003 (0.0001)
Employee age	0.008** (0.001)	0.002** (0.0006)	-0.0009 (0.0006)
Age full-time employees	0.004** (0.001)	-0.002** (0.0004)	0.0006 (0.0004)
Share women employees	-0.282** (0.075)	-0.052 (0.029)	0.037 (0.028)
Share full-time employees	0.665* (0.277)	-0.075** (0.070)	0.153 (0.115)
Share part-time employees	0.125 (0.145)	-0.064 (0.062)	0.006 (0.045)
Share regular employees	-0.554** (0.113)	-0.007 (0.047)	0.044 (0.034)
Share apprentices	0.020 (0.069)	0.031 (0.027)	-0.041 (0.024)
Share women full-time employees	0.376** (0.079)	0.044 (0.030)	-0.034 (0.030)
Share women part-time employees	0.196 (0.117)	0.040 (0.053)	-0.049 (0.046)
Share regular full-time employees	-0.284 (0.231)	0.086 (0.062)	-0.078 (0.078)
Share low-skilled employees	0.106 (0.107)	0.126** (0.034)	-0.016 (0.047)
Share medium-skilled employees	0.208* (0.104)	0.152** (0.032)	-0.015 (0.045)
Share high-skilled employees	0.268* (0.115)	0.193** (0.045)	-0.039 (0.046)
Share low-skilled full-time employees	-0.262 (0.190)	-0.044 (0.051)	-0.089 (0.094)
Share medium-skilled full-time employees	-0.350 (0.186)	-0.095 (0.050)	-0.058 (0.092)
Share high-skilled full-time employees	-0.444* (0.199)	-0.165* (0.064)	-0.014 (0.093)
Share employees 55–59 years old	-0.417** (0.032)	-0.009 (0.012)	0.026 (0.015)
Share employees 60–64 years old	0.158** (0.050)	-0.021 (0.016)	0.008 (0.018)
Regional unemployment rate	-0.002** (0.0007)	0.0002 (0.0003)	0.0006** (0.0003)
<i>N</i>	551,074	551,074	551,074
<i>R</i> ²	0.224	0.114	0.064

Notes: Employment includes the active phase of partial retirement. Pension wealth is calculated with the planning age of 55 at the age of 59 and is multiplied by 1,000,000. We control for monthly age and cohort fixed effects, education, and changes in the legislation for disability pensions and in the entitlement rules for unemployment insurance, the level of job requirements and the economic sector. Standard errors in parentheses are clustered on the individual level. Significance levels: * $p < 0.05$, ** $p < 0.01$. Source: SIAB7514, own calculation.

APPENDIX D

We cannot show the figures on partial retirement rate and unemployment rate for women in establishments with and without dismissal protection to ensure data protection because the number of observations is too low.

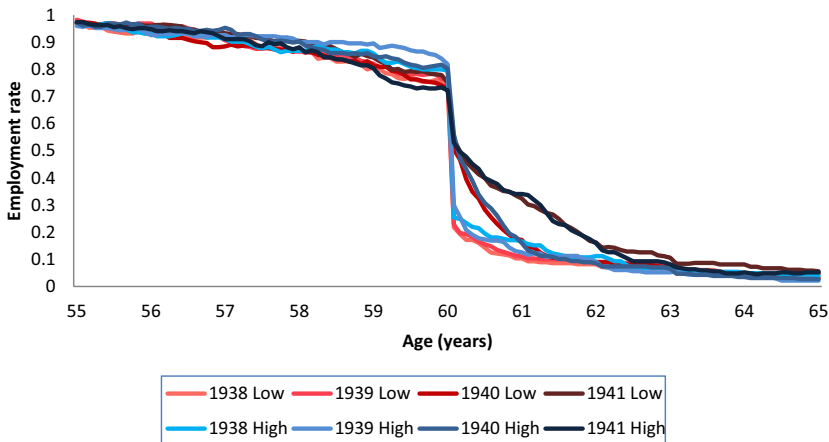


FIGURE D1 Employment rates for women in establishments with high and low average shares of older worker inflow compared with the share of young worker inflow by age and cohort. Notes: The rate is calculated as the share of employment subject to social security contributions including active phase of partial retirement in sample. High inflow of older employees is defined as last employer in career with inflow share above the 75th percentile of employees older than 55 years compared with employees younger than 30 years. Low inflow is defined as last employer with inflow share below the 25th percentile of older employees. Source: SIAB7514, own calculations [Colour figure can be viewed at wileyonlinelibrary.com]

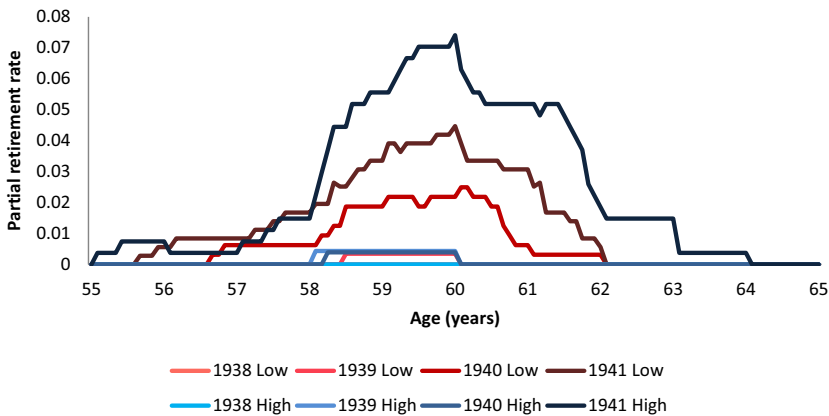


FIGURE D2 Partial retirement rates for women in establishments with high and low average shares of older worker inflow compared with the share of young worker inflow by age and cohort. Notes: High inflow of older employees is defined as last employer in career with inflow share above the 75th percentile of employees older than 55 years compared with employees younger than 30 years. Low inflow is defined as last employer with inflow share below the 25th percentile of older employees. Source: SIAB7514, own calculations [Colour figure can be viewed at wileyonlinelibrary.com]

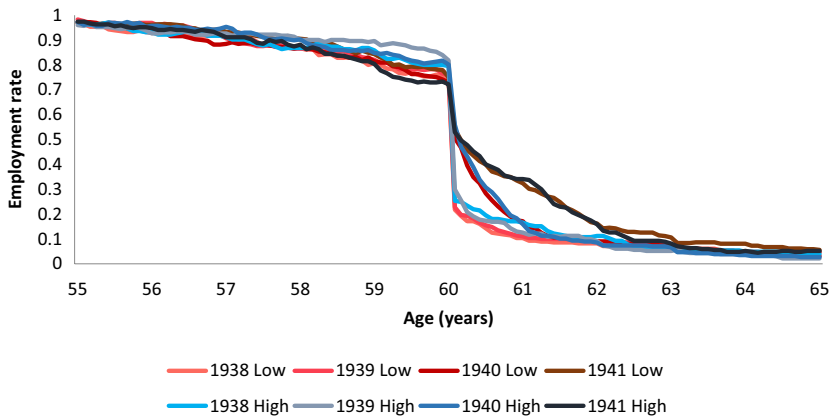


FIGURE D3 Unemployment rates for women in establishments with high and low average shares of older worker inflow compared with the share of young worker inflow by age and cohort. Notes: High inflow of older employees is defined as last employer in career with inflow share above the 75th percentile of employees older than 55 years compared with employees younger than 30 years. Low inflow is defined last employer with inflow share below the 25th percentile of older employees. Source: SIAB7514, own calculations [Colour figure can be viewed at wileyonlinelibrary.com]

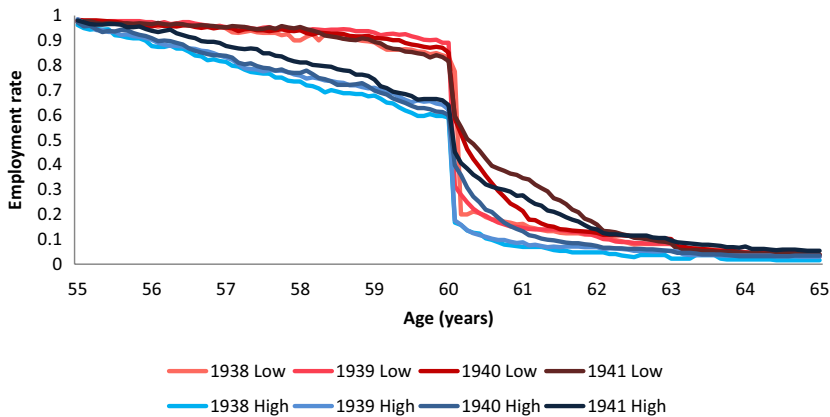


FIGURE D4 Employment rates for women in establishments with high and low R&D expenses by age and cohort. Notes: High R&D expenditure is defined as last employer being in the three economic sectors of the economy with the highest R&D expenses in 2003; low R&D expenditure is defined as last employer being in the three sectors with the lowest R&D expenses in 2003. Source: SIAB7514, own calculations [Colour figure can be viewed at wileyonlinelibrary.com]

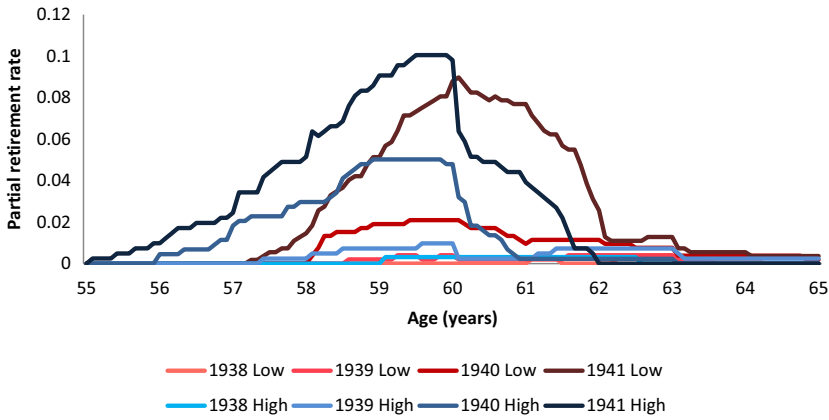


FIGURE D5 Partial retirement rates for women in establishments with high and low R&D expenses by age and cohort. Notes: High R&D expenditure is defined as last employer being in the three economic sectors of the economy with the highest R&D expenses in 2003; low R&D expenditure is defined as last employer being in the three sectors with the lowest R&D expenses in 2003. Source: SIAB7514, own calculations [Colour figure can be viewed at wileyonlinelibrary.com]

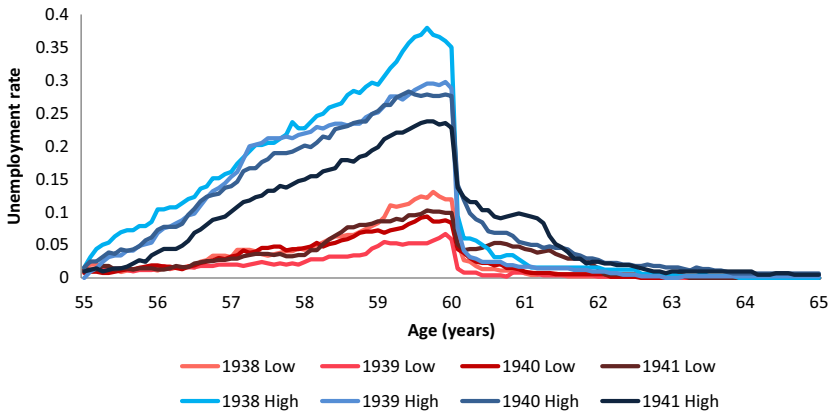


FIGURE D6 Unemployment rates for women in establishments with high and low R&D expenses by age and cohort. Notes: High R&D expenditure is defined as last employer being in the three economic sectors of the economy with the highest R&D expenses in 2003; low R&D expenditure is defined as last employer being in the three sectors with the lowest R&D expenses in 2003. Source: SIAB7514, own calculations [Colour figure can be viewed at wileyonlinelibrary.com]

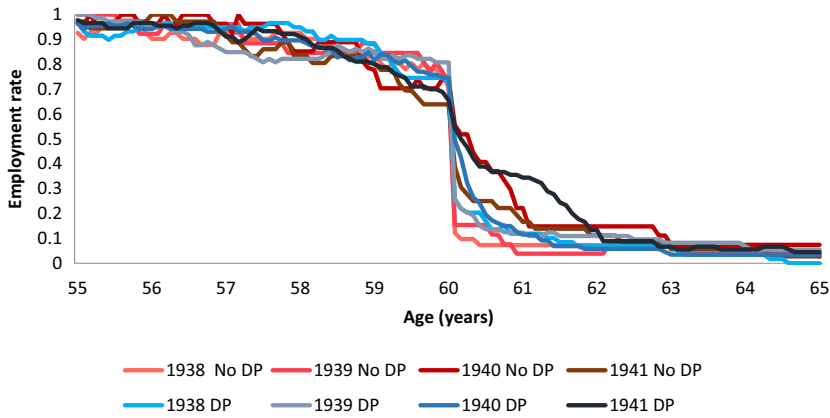


FIGURE D7 Employment rates for women in establishments with and without dismissal protection by age and cohort. Notes: DP means dismissal protection. Dismissal protection dummy is 1 if the last employer has more than five employees. Source: SIAB7514, own calculations [Colour figure can be viewed at wileyonlinelibrary.com]

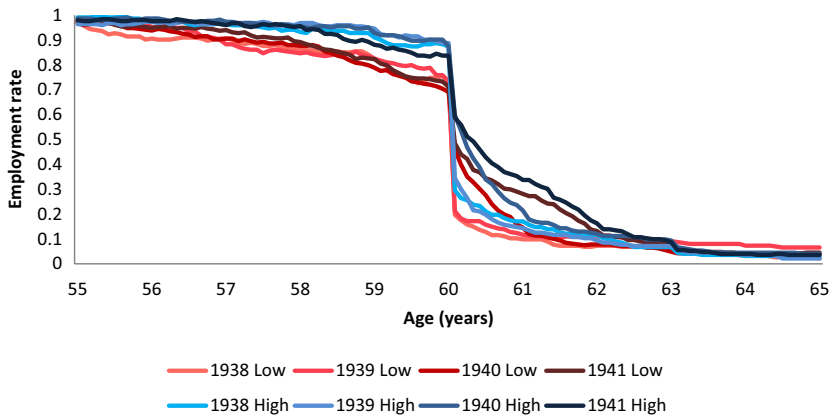


FIGURE D8 Employment rates for women in establishments with high and low collective bargaining agreements by age and cohort. Notes: High coverage has a value of 1 for employers in the three economic sectors with the highest coverage of collective bargaining agreements in 2014; low coverage has a value of 1 for employers in the three economic sectors with the lowest collective agreement coverage in 2014. Source: SIAB7514, own calculations [Colour figure can be viewed at wileyonlinelibrary.com]

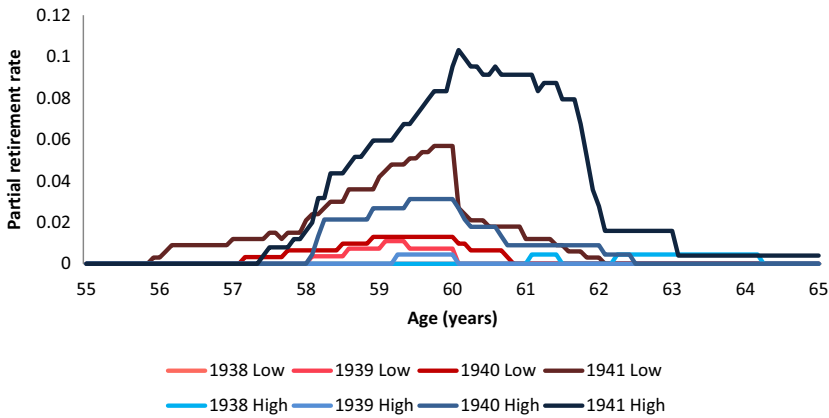


FIGURE D9 Partial retirement rates for women in establishments with high and low collective bargaining agreements by age and cohort. Notes: High coverage has a value of 1 for employers in the three economic sectors with the highest coverage of collective bargaining agreements in 2014; low coverage has a value of 1 for employers in the three economic sectors with the lowest collective agreement coverage in 2014. Source: SIAB7514, own calculations [Colour figure can be viewed at wileyonlinelibrary.com]

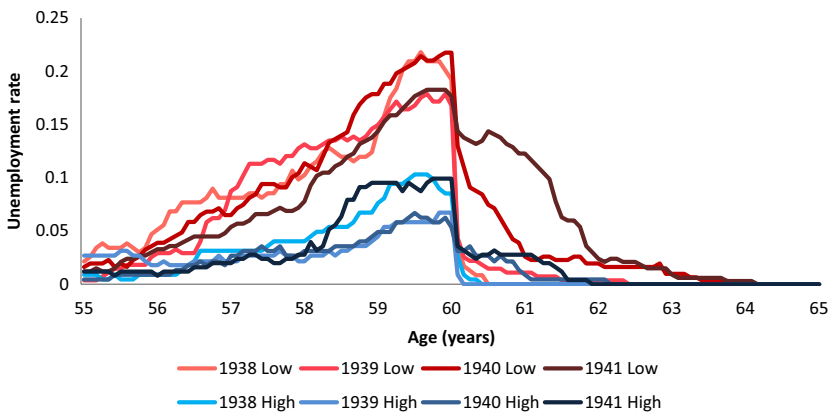


FIGURE D10 Unemployment rates for women in establishments with high and low collective bargaining agreements by age and cohort. Notes: High coverage has a value of 1 for employers in the three economic sectors with the highest coverage of collective bargaining agreements in 2014; low coverage has a value of 1 for employers in the three economic sectors with the lowest collective agreement coverage in 2014. Source: SIAB7514, own calculations [Colour figure can be viewed at wileyonlinelibrary.com]

APPENDIX E

TABLE E1 Inflow of older employees

	Employment with working phase of partial retirement	Partial retirement	Unemployment
No penalties	Reference	Reference	Reference
0.3–3.6	0.174** (0.012)	0.048** (0.007)	0.048** (0.006)
3.9–7.2	0.204** (0.014)	0.075** (0.009)	0.064** (0.008)
7.5–10.8	0.237** (0.016)	0.105** (0.012)	0.072** (0.009)
11.1–14.4	0.277** (0.021)	0.112** (0.014)	0.087** (0.013)
14.7–18.0	0.331** (0.032)	0.108** (0.020)	0.093** (0.021)
High inflow of older employees			0.005 (0.003)
0.3–3.6 * High inflow of older employees	0.008 (0.018)	0.012 (0.012)	–0.011 (0.008)
3.9–7.2 * High inflow of older employees	–0.0002 (0.021)	0.017 (0.015)	–0.017 (0.011)
7.5–10.8 * High inflow of older employees	0.026 (0.024)	0.016 (0.020)	–0.035** (0.012)
11.1–14.4 * High inflow of older employees	0.032 (0.030)	0.030 (0.024)	–0.049** (0.017)
14.7–18.0 * High inflow of older employees	–0.039 (0.046)	0.066* (0.032)	–0.049 (0.028)
Establishment fixed effects	Yes	Yes	No
<i>N</i>	203,715	203,715	255,041
Pre-reform mean (low inflow of older employees)	0.096	/	0.012
Pre-reform mean (high inflow of older employees)	0.098	/	0.006
<i>R</i> ²	0.678	0.560	0.072

Notes: High inflow of older employees is defined as last employer in career with inflow share above the 75th percentile of employees older than 55 years compared with employees younger than 30 years. Low inflow is defined as last employer with inflow share below the 25th percentile of older employees. We control for changes in the legislation for disability pensions and in the entitlement rules for unemployment insurance. Moreover, we consider pension wealth with a planning age of 55, job exposure, the level of job requirements and education, regional unemployment rates, employer characteristics, and establishment fixed effects. Standard errors in parentheses are clustered on the individual level. Values based on few observations, typically less than 20, that cannot be displayed for data protection reasons (indicated by “/” in the table) (FDZ, 2017). Significance levels: * $p < 0.05$, ** $p < 0.01$. The pre-reform mean is calculated for the cohorts 1937 to 1939. Source: SIAB7514, own calculations.

TABLE E2 R&D expenditure

	Employment with working phase of partial retirement	Partial retirement	Unemployment
No penalties	Reference	Reference	Reference
0.3–3.6	0.175** (0.009)	0.082** (0.007)	0.022** (0.003)
3.9–7.2	0.201** (0.010)	0.124** (0.009)	0.027** (0.004)
7.5–10.8	0.251** (0.013)	0.156** (0.010)	0.021** (0.005)
11.1–14.4	0.295** (0.016)	0.167** (0.012)	0.016** (0.006)
14.7–18.0	0.319** (0.024)	0.187** (0.018)	0.022** (0.010)
High R&D expenditure			0.006 (0.014)
0.3–3.6 * High R&D expenditure	-0.035** (0.014)	-0.036** (0.010)	0.033** (0.007)
3.9–7.2 * High R&D expenditure	-0.028 (0.016)	-0.041** (0.013)	0.047** (0.009)
7.5–10.8 * High R&D expenditure	-0.018 (0.020)	-0.046** (0.017)	0.060** (0.010)
11.1–14.4 * High R&D expenditure	-0.032 (0.025)	-0.050* (0.020)	0.078** (0.014)
14.7–18.0 * High R&D expenditure	-0.056 (0.037)	-0.063* (0.029)	0.086** (0.023)
Establishment fixed effects	Yes	Yes	No
<i>N</i>	326,125	326,125	408,151
Pre-reform mean (low R&D expenditure)	0.113	0.001	0.005
Pre-reform mean (high R&D expenditure)	0.065	0.002	0.019
<i>R</i> ²	0.661	0.528	0.064

Notes: High R&D expenditure is defined as last employer being in the three economic sectors of the economy with the highest R&D expenses in 2003; low R&D expenditure is defined as last employer being in the three sectors with the lowest R&D expenses in 2003. We control for changes in the legislation for disability pensions and in the entitlement rules for unemployment insurance. Moreover, we consider pension wealth with a planning age of 55, job exposure, the level of job requirements and education, regional unemployment rates, employer characteristics, and establishment fixed effects. Standard errors in parentheses are clustered on the individual level. Significance levels: * $p < 0.05$, ** $p < 0.01$. The pre-reform mean is calculated for the cohorts 1937 to 1939. Source: SIAB7514, own calculations.

TABLE E3 Employers subject or not subject to dismissal protection

	Employment with working phase of partial retirement	Partial retirement	Unemployment
No penalties	Reference	Reference	Reference
0.3–3.6	0.104** (0.033)	0.024 (0.016)	0.107** (0.025)
3.9–7.2	0.149** (0.041)	0.038 (0.023)	0.106** (0.027)
7.5–10.8	0.174** (0.047)	0.041 (0.023)	0.070* (0.029)
11.1–14.4	0.202** (0.063)	0.020 (0.015)	0.078 (0.040)
14.7–18.0	0.213** (0.089)	0.043 (0.025)	0.092 (0.066)
Dismissal protection			0.006 (0.008)
0.3–3.6 * Dismissal protection	0.107** (0.042)	0.011 (0.021)	–0.062* (0.028)
3.9–7.2 * Dismissal protection	0.088 (0.051)	0.019 (0.030)	–0.051 (0.030)
7.5–10.8 * Dismissal protection	0.083 (0.059)	0.021 (0.033)	–0.019 (0.030)
11.1–14.4 * Dismissal protection	0.122 (0.075)	0.008 (0.027)	0.006 (0.044)
14.7–18.0 * Dismissal protection	0.154 (0.110)	–0.052 (0.039)	0.026 (0.080)
Establishment fixed effects	Yes	Yes	No
<i>N</i>	38,774	38,774	50,569
Pre-reform mean (no dismissal protection)	0.098	0	0.008
Pre-reform mean (dismissal protection)	0.096	0.002	0.012
<i>R</i> ²	0.739	0.588	0.115

Notes: Dismissal protection dummy is 1 if the last employer has more than five employees; dummy is 0 if the employer has five or fewer employees. We control for changes in the legislation for disability pensions and in the entitlement rules for unemployment insurance. Moreover, we consider pension wealth with a planning age of 55, job exposure, the level job requirements and education, regional unemployment rates, employer characteristics, and establishment fixed effects. Standard errors in parentheses are clustered on the individual level. Significance levels: * $p < 0.05$, ** $p < 0.01$. The pre-reform mean is calculated for the cohorts 1937 to 1939. Source: SIAB7514, own calculations.

TABLE E4 Collective bargaining agreements

	Employment with working phase of partial retirement	Partial retirement	Unemployment
No penalties	Reference	Reference	Reference
0.3–3.6	0.174** (0.013)	0.024** (0.006)	0.071** (0.007)
3.9–7.2	0.207** (0.015)	0.036** (0.008)	0.083** (0.009)
7.5–10.8	0.232** (0.018)	0.050** (0.011)	0.078** (0.010)
11.1–14.4	0.273** (0.023)	0.052** (0.013)	0.099** (0.014)
14.7–18.0	0.283** (0.034)	0.051** (0.021)	0.085** (0.021)
High coverage			0.034 (0.035)
0.3–3.6 * High coverage	–0.007 (0.018)	0.085** (0.013)	–0.061** (0.008)
3.9–7.2 * High coverage	–0.013 (0.021)	0.119** (0.016)	–0.075** (0.010)
7.5–10.8 * High coverage	0.010 (0.024)	0.134** (0.019)	–0.076** (0.011)
11.1–14.4 * High coverage	0.014 (0.030)	0.140** (0.023)	–0.102** (0.016)
14.7–18.0 * High coverage	0.050 (0.047)	0.176** (0.034)	–0.080** (0.024)
Establishment fixed effects	Yes	Yes	No
<i>N</i>	195,853	195,853	237,900
Pre-reform mean (low coverage)	0.091	/	0.009
Pre-reform mean (high coverage)	0.106	0.0007	0.002
<i>R</i> ²	0.669	0.559	0.082

Notes: High coverage has a value of 1 for employers in the three economic sectors with the highest coverage of collective bargaining agreements in 2014; low coverage has a value of 1 for employers in the three economic sectors with the lowest collective agreement coverage in 2014. We control for changes in the legislation for disability pensions and in the entitlement rules for unemployment insurance. Moreover, we consider pension wealth with a planning age of 55, job exposure, the level of job requirements and education, regional unemployment rates, employer characteristics, and establishment fixed effects. Standard errors in parentheses are clustered on the individual level. Significance levels: * $p < 0.05$, ** $p < 0.01$. The pre-reform mean is calculated for the cohorts 1937 to 1939.

TABLE E5 Employment effects for women without bridge paths by employer groups

Employment		Reference	No penalties	Reference	No penalties	Reference	No penalties	Reference	No penalties
No penalties									
0.3–3.6		0.200** (0.014)	0.3–3.6	0.205** (0.011)	0.3–3.6	0.117** (0.037)	0.3–3.6	0.199** (0.015)	
3.9–7.2		0.234** (0.016)	3.9–7.2	0.226** (0.013)	3.9–7.2	0.146** (0.046)	3.9–7.2	0.236** (0.017)	
7.5–10.8		0.255** (0.019)	7.5–10.8	0.261** (0.016)	7.5–10.8	0.174** (0.052)	7.5–10.8	0.267** (0.021)	
11.1–14.4		0.282** (0.025)	11.1–14.4	0.310** (0.020)	11.1–14.4	0.234** (0.073)	11.1–14.4	0.304** (0.027)	
14.7–18.0		0.372** (0.041)	14.7–18.0	0.333** (0.030)	14.7–18.0	0.275** (0.108)	14.7–18.0	0.349** (0.041)	
High inflow of older employees									
			High R&D expenditure						
0.3–3.6 * High inflow of older employees		0.016 (0.022)	0.3–3.6 * High R&D expenditure	-0.022 (0.018)	Dismissal protection	0.121* (0.048)	High coverage	0.008 (0.022)	
3.9–7.2 * High inflow of older employees		0.003 (0.025)	3.9–7.2 * High R&D expenditure	-0.009 (0.020)	0.3–3.6 * Dismissal protection	0.102 (0.058)	0.3–3.6 * High coverage	-0.003 (0.025)	
7.5–10.8 * High inflow of older employees		0.028 (0.030)	7.5–10.8 * High R&D expenditure	0.001 (0.025)	7.5–10.8 * Dismissal protection	0.086 (0.066)	7.5–10.8 * High coverage	-0.005 (0.030)	
11.1–14.4 * High inflow of older employees		0.047 (0.038)	11.1–14.4 * High R&D expenditure	-0.009 (0.032)	11.1–14.4 * Dismissal protection	0.076 (0.086)	11.1–14.4 * High coverage	-0.0003 (0.038)	
14.7–18.0 * High inflow of older employees		/	14.7–18.0 * High R&D expenditure	0.002 (0.049)	14.7–18.0 * Dismissal protection	/	14.7–18.0 * High coverage	-0.008 (0.058)	
Establishment fixed effects	Yes	Yes	Establishment fixed effects	Yes	Establishment fixed effects	Yes	Establishment fixed effects	Yes	
<i>N</i>		172,622	<i>N</i>	268,824	<i>N</i>	34,349	<i>N</i>	163,974	
Pre-reform mean (low inflow of older employees)		0.12	Pre-reform mean (low R&D expenditure)	0.124	Pre-reform mean (no dismissal protection)	0.128	Pre-reform mean (low coverage)	0.114	
Pre-reform mean (high inflow of older employees)		0.116	Pre-reform mean (high R&D expenditure)	0.096	Pre-reform mean (dismissal protection)	0.111	Pre-reform mean (high coverage)	0.113	
<i>R</i> ²		0.702	<i>R</i> ²	0.692	<i>R</i> ²	0.744	<i>R</i> ²	0.697	

Notes: Employment without the active part of partial retirement. Employer groups are defined as in Tables 2–5. We control for changes in the legislation for disability pensions and in the entitlement rules for unemployment insurance. Moreover, we consider pension wealth with planning age of 55, the job exposure and education, regional unemployment rates, and firm characteristics. Standard errors in parentheses are clustered on the individual level. Significance levels: **p* < 0.05, ***p* < 0.01. The pre-reform mean is calculated for the cohorts 1937 to 1939. Source: SIAB7514, own calculations.