# Retirement Decisions in Germany: Micro-Modelling

Axel Börsch-Supan, Irene Ferrari, Nicolas Goll, Johannes Rausch

International Social Security Project Phase 10

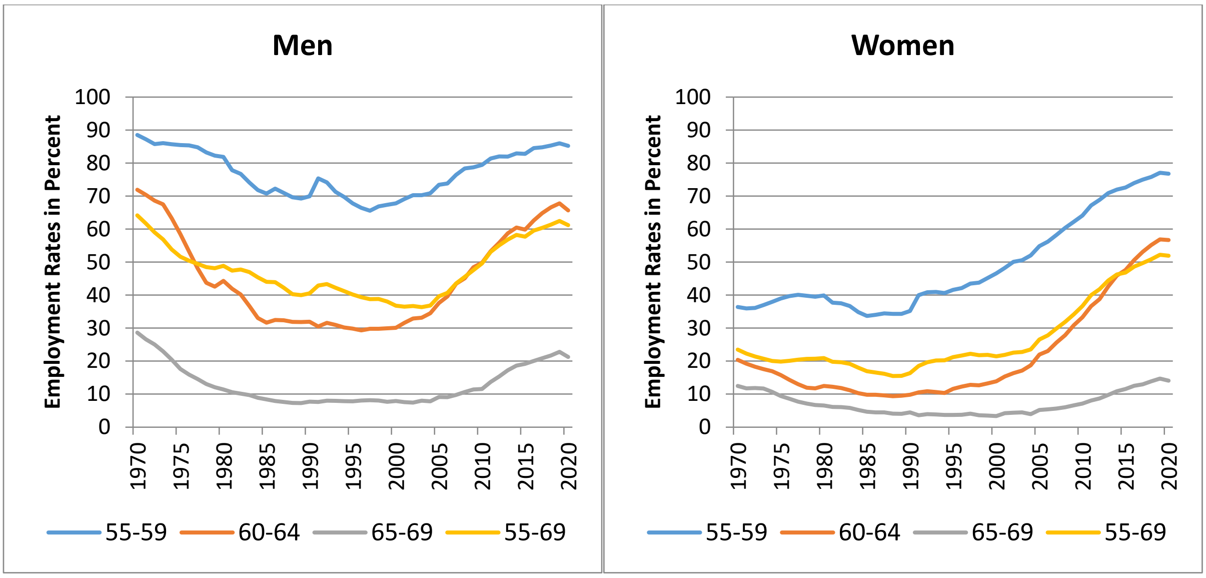
**This version: 5 December 2022**

**CONTENT**

## 1. INTRODUCTION

Employment in older ages has declined for a long time in Germany, even for women, reaching a level of only 36.8/21.5 percent (men/women) in 2000 for the 55-69 age group (Figure 1). Since about 2000, however, working later in life has been making a stark comeback. Among the countries represented in this book, West Germany has actually experienced the largest increase in the employment rate of the 55-69 age group. In 2019, the year before the Corona pandemic broke out, the employment rate reached a level of 62.5/52.2 percent (Eurostat 2022). The trend reversal is particularly pronounced among men, while the picture is a bit more complex for women who experienced a rather constant increase for the 55-59 age group and a mild reversal for the other age groups.

**Figure 1: West German employment rate by age group and gender**




Source: Authors' own calculations based on Eurostat 2022 and German Federal Statistical Office (2022).

Understanding the causes for this recent increase in employment is important if one wants to assess whether the current rising trend will continue, thus reducing the negative consequences of ageing on fiscal sustainability. If the reversal is mainly caused by transitory or one-off events, old-age labor force participation may slow down again in the near future. However, if it is indeed caused by a structural change, we may expect a lasting impact on fiscal sustainability.

Explaining the causes for this reversal with micro-econometric methods is the aim of the current phase of the International Social Security Project (ISSP). This long-term international research program under the auspices of the National Bureau of Economic Research (NBER), based in Cambridge, Massachusetts, founded by Jonathan Gruber and David Wise and now led by Axel Börsch-Supan and Courtney Coile, explores the interactions between social security schemes and retirement behavior. It involves 12 western industrialized countries (nine EU countries, United States, Canada and Japan). This paper is the West German country study of this collaborative research project. It refers to West Germany in order to avoid confounding pension policy effects with the strong unification effects in East Germany after 1989.

The evidence in our earlier paper (Börsch-Supan, Rausch and Goll 2020) suggested that much of the trend reversal of older men's labor force participation could be explained by changes in Germany's public pension rules, in particular by the phasing in of actuarial adjustments for early retirement. Regarding women's LFP, the picture was more complex. This suggests that the secular change of women's role in society was the main driver of the steadily increasing LFP among the younger West

German women while there was a policy-related trend reversal among older women. However, these conclusions were based on aggregate data and stylized model households. The bivariate correlations do not control for the many other potential explanatory factors and the heterogeneity in the population. This requires a much more elaborate multivariate analysis. This is the aim of the current paper. We use microdata and structural policy changes since 1980 as instruments to draw causal inference on the effect of public pension rules on retirement and labor force participation choices at older ages.

In addition to public pension rules, other causes for the trend reversal in employment could be historical trends. Younger cohorts are healthier and have been better educated, permitting longer working lives. Moreover, the role of women in society has dramatically changed, affecting LFP of both genders. While a previous phase of the ISSP has shown that these secular developments have contributed astonishingly little to the trend reversal (Börsch-Supan and Coile 2020 for an overview; Börsch-Supan and Ferrari 2019 for Germany), we use a set of covariates to account for these changes.

The paper is organized as follows. Section 2 provides a summary of the institutional changes and pension reforms in Germany that might be the causes for the observed trend reversal. Sections 3 and 4 are the main methodological parts of the paper and describe our data (Section 3) and our main explanatory variable, the "implicit tax on working longer" (Section 4). Section 5 presents our regression results. We then use these results to counterfactually predict what would have happened to labor force participation if the pension rules underlying the implicit tax on working longer had not changed since the 1980s (Section 6). Indeed, old-age labor force participation would have been substantially lower than it is today. Section 7 therefore concludes, that the negative correlation between the employment rate and the incentives to claim benefits early found in our earlier paper has a causal interpretation: as the implicit tax on working longer decreased, employment at older ages increased.

## 2. GERMAN PUBLIC PENSION SYSTEM

In this section, we outline the German public pension system (*Gesetzliche Rentenversicherung (GRV)*) and its general aspects. We primarily focus on the properties and the main mechanics we need for the analysis in this paper. As this study is part of a multistage research project, a comprehensive analysis of the institutional details, the reforms process in the past decades and the resulting financial incentives for typical individuals has been carried out in the first step of this research project (see Börsch-Supan et al. 2020).

The German public pension system was the first formal pension system in the world. It goes back to German Chancellor Otto von Bismarck, originally conceived as a funded disability insurance scheme in 1889. The system was quickly broadened into a general old-age security system with both disability pensions and old-age pensions. After two world wars and a period of hyperinflation, about half of the capital stock was lost and the system was transformed into a pay-as-you-go (PAYG) system in 1957, where the pensions of current retirees are financed by the contributions of current workers.

The public pension system features a very broad coverage of workers. About 85% of the German workforce are part of the system. For most of the insurants, pension entitlements from the public pension system is the most important income source in old age. For the majority of the insurants, public pension benefits were even the only source of income in old age until the end of the 1990s. For this reason, the German public pension system was considered a monolithic pension system. Caused by the decline in birth rates since the 1970s and a parallel increase in life expectancy, demographic change has led to a paradigm shift at the end of the 1990s. With the 2001 pension reform the public old-age provision in Germany was transformed into a three-pillar system. In the three-pillar system, public pension benefits are still regarded as main source of income in old age (first pillar). However, in order to maintain their previous living standard, retirees are supposed to top up public pension benefits with occupational pension benefits (second pillar) and benefits from private pensions (third pillar). Until today, first-pillar public pension benefits still shape the current retirees' income in old age. Second- and third-pillar benefits do play a minor role in providing old-age income. For that reason, we focus on the public pension system in our analysis.

**Coverage and contributions.** The scheme is mandatory for all private and public employees and covers about 85% of the German workforce. Civil servants, about 5%, are not part of the public pension scheme and have their own old-age provision scheme. With the exception of certain groups, the self-employed (roughly 10% of the workforce) also have their own pension systems.

Roughly 77% of the budget of the public pension scheme is financed by contributions of the insurants. The contributions are administrated like a payroll tax, levied equally on employees and employers. In 2018, the contribution rate was 18.6% on the first 78,000€ of yearly gross income. The latter is the upper-earnings threshold (*Beitragsbemessungsgrenze)* and represents about the double of the average yearly gross income of all insured individuals in the public pension system.[1] Technically, contributions are split evenly between employees and employers. The remaining approximately 23% of the public pension system budget are financed by governmental subsidies (*Bundeszuschüsse)*.

[1] The values refer to West Germany only (see Deutsche Rentenversicherung 2018).

**Table 1: Pathways to retirement: Eligibility criteria**

| Pathway | Earliest eligibility age (EEA) | Years of service | Actuarial deductions* | Earnings Tests | Other |
|---|---|---|---|---|---|
| (1) Regular OAP | Until 2012: 65 (i.e. SEA)<br>After 2029: 67 (i.e. SEA) | Until 1984: 15<br>Since 1984: 5 | None | None | |
| (2) OAP for long-term insured | 63 | 35 | Yes | Yes | |
| (3) OAP for especially long-term insured | Increase from 63 to 65 until 2029 | 45 | None | Yes | |
| (4) OAP for invalids | Until 2011: 60<br>After 2025: 62 | 35 | Yes | (Yes) | At least 50% disabled |
| (5) OAP after unemploym. | Until 1996: 60<br>After 2002: 63 | 15 (8 in last 10 years) | Yes | Yes | At least 52 weeks unemployed;<br>Born before 1952 |
| (6) OAP after part-time employ. | Until 1996: 60<br>After 2002: 63 | 15 (8 in last 10 years) | Yes | (Yes) | Two years part-time;<br>Born before 1952 |
| (7) OAP for Women | 60 | 15 (10 after age 40) | Yes | Yes | Born before 1952 |
| (8) Disability pension | -- | Until 1984: 5<br>Since 1984: 5 (3 in last 5) | Yes | Yes | Medical exams |

(*) Actuarial deductions for early retirement were introduced between 1992 and 2004.

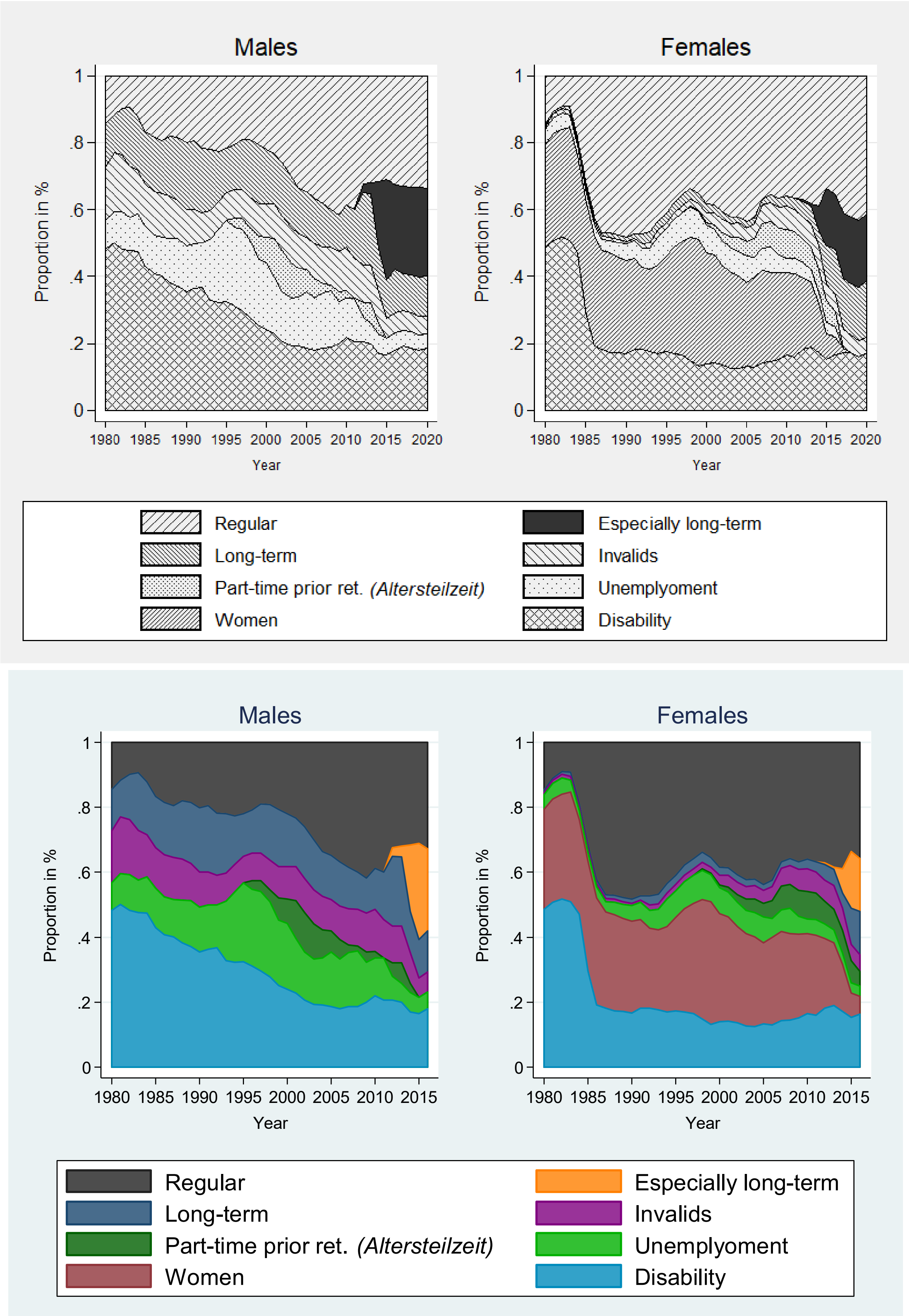
Source: Börsch-Supan et al. (2020).

**Eligibility and pathways to retirement.** The German public pension scheme provides old-age pensions, disability pensions, and survivor pensions. In 2018, the German public pension system distinguishes seven major types of old-age pensions (OAP) and disability pensions. Primarily, these are: (1) regular OAP, (2) OAP for long-term insured, (3) OAP for especially long-term insured, (4) OAP for invalids, (5) OAP after unemployment, (6) OAP after part-time employment prior to retirement *(Altersteilzeit)*, (7) OAP for women, and (8) disability pensions.[2] Survivor pensions are not a separate pension pathway. Survivor pensions grant old-age pension or disability pension entitlements to a certain quota to eligible individuals after the death of an insurant. The pension types differ in eligibility criteria individuals have to fulfill to get access to their pension entitlements (Table 1). Regular old-age pension benefits can be drawn after individuals have reached the statutory eligibility age. The earliest eligibility age of the other pension types is lower than the statutory eligibility age and consequently offers early retirement. The old-age pension for invalids and the disability pension are slightly different from the other pension types since eligibility for those pension types additionally depend on the health status of an insurant.

[2] The public pension system offers other very specific pension types like a separate old-age pension for miners. Measured against the total number of insurants, the number of individuals choosing one of the specific pension types is very low, so we do not consider these retirement pathways in our analysis.

Figure 1 shows the uptake of the various pension types in West Germany over nearly the past 40 years. For each year the graph shows – separately for men and women – the proportion of each pension type on all newly claimed pensions in that particular year. For example, in 1980, about 15 percent of all new pension claims chose a regular old-age pension and, almost half of the new retirees claimed a disability pension. Figure 1 depicts how the different retirement pathways evolved over time, mostly in response to reforms, benefit adjustment, and institutional rule changes (e.g. tightening of the disability screening process, for details see Börsch-Supan et al. 2020). The figure shows the multitude of possible retirement pathways. A major undertaking of this paper is to take account of this diversity.

**Figure 1: Pathways to retirement, West Germany.**




Source: Deutsche Rentenversicherung Bund (2022).

**Benefits and taxation.** Pension benefits of the PAYG public pension system are related to the individual earnings and contributions history. Pension benefits are computed according to the pension benefit formula as the product of two individual components (1, 2) and two universal components (3, 4): the individual components are (1) the sum of earnings points an individual has accumulated over her working career (*Entgeltpunkte)* and (2) an access factor which captures actuarial adjustments for early or late retirement *(Zugangsfator).* The universal components are (3) the current pension value *(aktueller Rentenwert)* and a (4) pension type factor (*Rentenartfaktor).*

(1) The sum of earnings points represents the individual earnings history. The earnings points ensure a relation between earnings and benefits (exceptions for care, unemployment, disability etc.). Earnings points are calculated by dividing the individual gross income by the average income of all insurants in the public pension system. If the individual's earnings are exactly the average gross earnings of all insurants, then this individual receives one earnings point. Half the average gross income entails 0.5 earnings points, etc. The official government computations, such as the official replacement rate (*Rentenniveau)*, are based on a pensioner with forty-five contributions years and average earnings in each year. This standardized pensioner *(Eckrentner)* accumulates exactly forty-five earnings points. (2) The access factor *(Zugangsfator)* captures actuarial adjustments for early or late retirement. Actuarial deductions apply if individuals claim pension benefits before the statutory eligibility age. For each year of early retirement, pension benefits are reduced by 3.6%. With the 1992 pension reform, actuarial supplements for late retirement were adjusted. Late retirement is the practice of postponing benefit claiming beyond the SEA. For each year of late retirement actuarial supplements of 6% percent are granted for postponing the pension claiming beyond the statutory eligibility age.[3] The factor equals one if individuals claim pension benefits at the statutory eligibility age or a pension-type-specific full rate age where no adjustments apply (e.g. age 63 for individuals born until 1952 with forty-five service years). (3) The current pension value indicates the relationship between average earnings and pension benefits. The current pension value is the amount of monthly pension benefits related to one earnings point.[4] Each year, the current pension value is replaced with a new value by law. (4) The pension type factor (*Rentenartfaktor)* reflects the type of pension and the percentage of pension entitlements. The pension type factor is for example one for old-age pensions and full disability pension benefits, and 0.55 (0.6 until 2001) for full survivor benefits (*große Witwen-/Witwerrente)*.

Until 2004, pension benefits were only taxed if benefits surpassed a quite large allowance. This affected only relatively few cases. With the 2004 pension reform coming into effect in 2005, deferred taxation of pension was introduced. Thus, contributions to the public pension system got tax exempted and the pension benefits taxable. To prevent a double taxation the reform included a generous transition period until 2040.

## 3. DATA AND VARIABLE SPECIFICATION

In the following sections, we will introduce our main data source, the German Socio-Economic Panel (GSOEP), and we will describe our strategy for constructing the income profiles using the panel data. We will then explain how we define retirement status – our outcome variable – and how we handle the choice of multiple retirement pathways. Finally, we will check our pension calculations against the actual pension received by individuals, as reported in GSOEP.

[3] Actuarial supplements were already introduced in 1972. Until the 1992 reform, however, only for two years of late retirement actuarial supplements in the amount of 7.2% applied (i.e. until age 66 and 67).

[4] Note that the pension benefit calculation is the base in the computation of social security wealth in Section 4.

### 3.1. The German Socio-Economic Panel

The German Socio-Economic Panel (GSOEP) is a representative longitudinal study of private households. Interviews take place annually and the sample size has currently reached around 30,000 respondents in around 15,000 households. GSOEP was started in 1984 and we use waves up to 2019 included, therefore we can count on 36 consecutive years of data. This is particularly convenient for the current analysis, as this time span includes the reversal of older men's labor force participation since around the late 1990s. Furthermore, several pension reforms were implemented during these years, which provide variation in pension incentives necessary for the identification of our retirement model.

GSOEP includes several subsamples, each with different sampling probabilities that were chosen to ensure that the number of cases are large enough for separate analyses of each sample.[5] We draw our sample from the sample of West German citizens, as retirement patterns in East Germany are affected by the transition to a market economy and slightly different pension rules.

The data provide information on all household members and contain a stable set of core demographic and economic questions, including labor market status, gross and net income, hours worked, education and marital status. Since each member in the household is interviewed, we have the same information for both spouses.

A further advantage of the dataset is the possibility of constructing individuals' labor history since the age of 15. Individuals are asked once to provide information on their activity status over their entire life course up to the time of the interview. The information provided is in the form of spells of activities and distinguishes between time spent in education, doing apprenticeship or training, in the military force or community service, in full-time employment, in part-time employment, unemployed, out of the labor force or pensioner.

This retrospective occupation history can be integrated with information on the activity status during the sample period, as GSOEP also collects detailed information on occupation in the form of a calendar, with monthly information on labor market status.

On the other hand, while information on labor income is available for the sample period, no retrospective information is available. Furthermore, the dataset includes little or irregular information on health - especially objective measures of heath – and on household wealth.

Our sample selection is mostly based on two criteria. The first one is age: we keep individuals aged 55 or above until retirement, or until age 70 if they are not yet retired by this age. Second, we only keep employees of the private and public sector, therefore excluding civil servants and self-employed workers, as participation in the public pension system is not mandatory for these two latter categories of workers. This leaves us with around 5,500 individuals and 24,300 panel-year observations, with an average and median observation time equal to 4.4 and 4 years, respectively. In Table 2, we show some descriptive statistics of the main variables in our sample.

[5] The subsamples consist, among others, of West German citizens, East German citizens, immigrants, high income individuals, as well as several refreshment samples.

**Table 2: Descriptive statistics of main variables.**

| Variable | Valid observations | Mean | Standard Deviation |
|---|---|---|---|
| **Age** | 24,334 | 58.61 | 2.79 |
| **Male** | 24,334 | 0.52 | 0.50 |
| **Married** | 24,154 | 0.76 | 0.43 |
| **Medium education** | 24,281 | 0.67 | 0.47 |
| **High education** | 24,281 | 0.14 | 0.35 |
| **Number of children** | 24,334 | 1.88 | 1.32 |
| **Home owner** | 24,327 | 0.59 | 0.49 |
| **Health satisfaction** | 24,117 | 6.31 | 2.15 |
| **Experience** | 24,334 | 33.46 | 8.84 |
| **Full-time** | 24,136 | 0.59 | 0.49 |

Source: Own calculations.

### 3.2. Income profiles

As explained above, GSOEP allows constructing the whole employment history of individuals. Information on labor income, however, is only available for the sample period. Since the pension benefit formula depends on earnings points (EP) - computed from the relative income position of the individuals with respect to the "average" earner - we need to predict each individual's history of earnings points, rather than incomes.

In order to do so, we calculate the earnings points position of all individuals in the sample who are working full- or part-time and earn a positive wage. Then, we estimate a fixed-effects earnings points model on the same sample of individuals:[6]

$$EP_{it} = \alpha + \beta_1 age_{it} + \beta_2 age_{it}^2 + \beta_3 exper_{it} + \beta_4 exper_{it}^2 + \beta_5 exper_{it} * educ_i + \beta_6 parttime_{it} + a_i + u_{it}$$

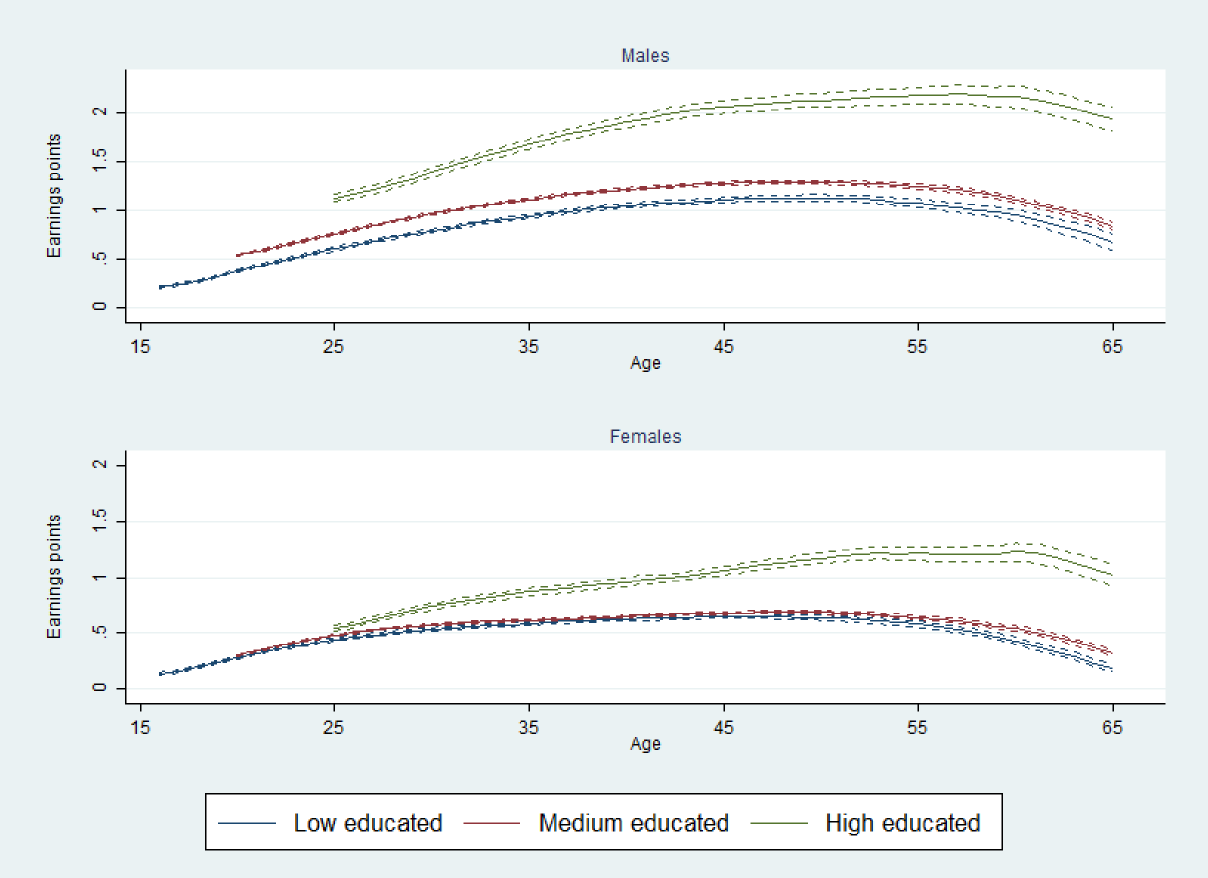
We include quadratics in age and experience, an interaction effect between experience and education, and a dummy indicating part-time status. The fixed effects absorb all individual constant characteristics. Finally, using the estimated model, we predict EP for the pre-survey years.

In Figure 2 we show our predicted profiles for three education levels, separately by gender. A decreasing EP profile in the last part of the working life clearly emerges from this graph. This is quite surprising, since it is shown in the literature that hourly wages do not decline at later ages (see Myck (2010) for evidence on Germany, Charni and Bazen (2017) for evidence on the UK). At the same time, hours of work do not dramatically decrease for men. In our sample the proportion of men working part-time increases from 2-3% to almost 8% at 63 with a peak of 10.76% at 64. For women, the proportion working part-time is around 50% at earlier ages, and it reaches 65% by age 65. Unlike men, for women this steep increase is mostly due to a selection effect, whereby women working full-time leave the labor market earlier. In any case, we observe the same EP pattern even when we restrict the analysis to only full- and only part-time workers.

[6] The sample size used in this exercise amounts to 215,000 individual-year observations and 32,300 individuals.

A possible reason for the pattern of our predicted profiles is that we observe a too short period of a panel, which does not allow fully controlling for cohort effects. Indeed, the average and median observation periods of the EP estimation sample are only 6.6 and 4 years, respectively. At the same time, there might be a reduction in hours that are not accounted for by a simple part-time dummy. Finally, there might be selection into retirement of higher income individuals.

**Figure 2: Earnings points profiles, by gender and education.**

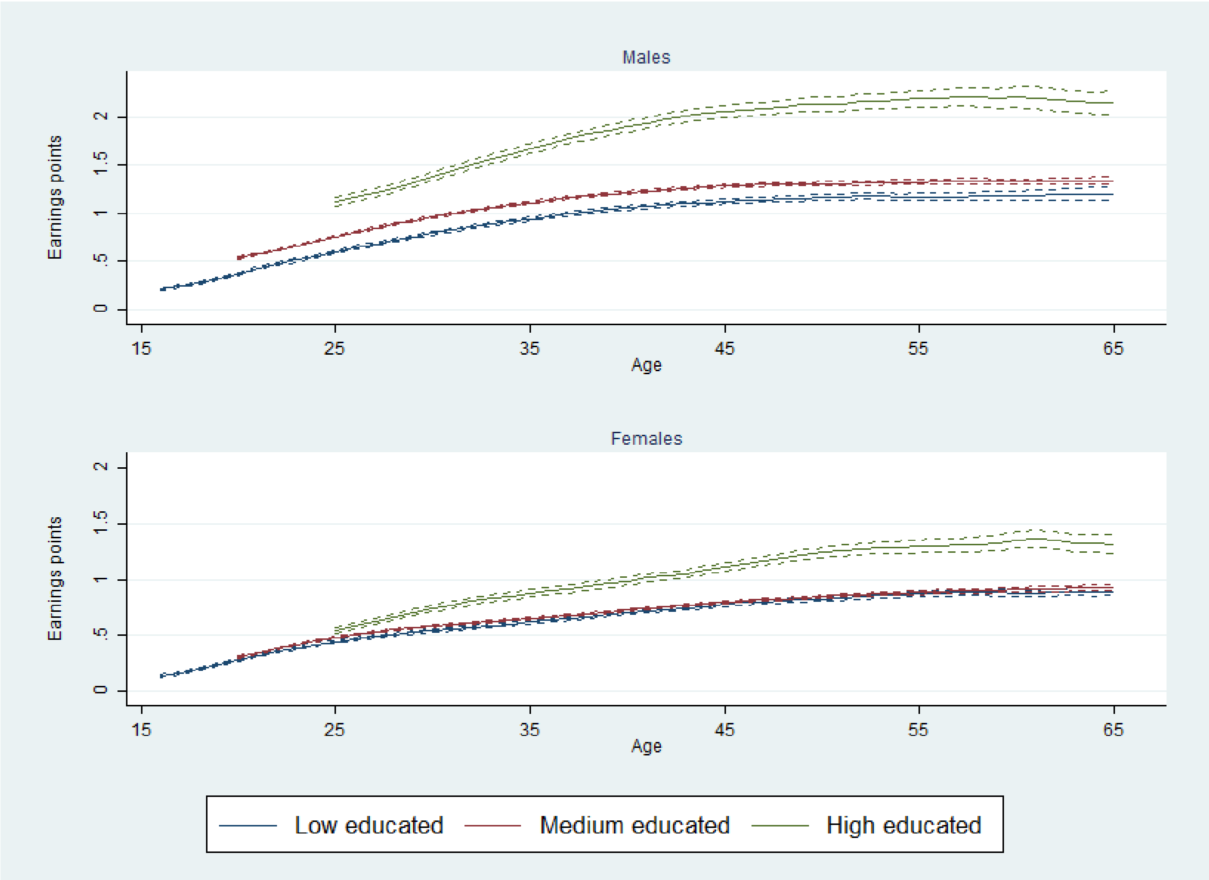



Source: Own calculations.

As the evidence seems to point to rather flat income profiles at the end of the working life, we will assume flat profiles after each individual's income peak, and proceed with the analysis under this assumption. Figure 3 displays the EP profiles we obtained under this assumption for three different education levels and separately by males and females.[7] We will, however, also run robustness checks where we use the unadjusted profiles.

[7] We assume different ages of entry into the labor market depending on the level of education: 16 for the low-educated, 20 for the medium-educated and 25 for the high-educated.

**Figure 3: Earnings points flat profiles, by gender and education.**



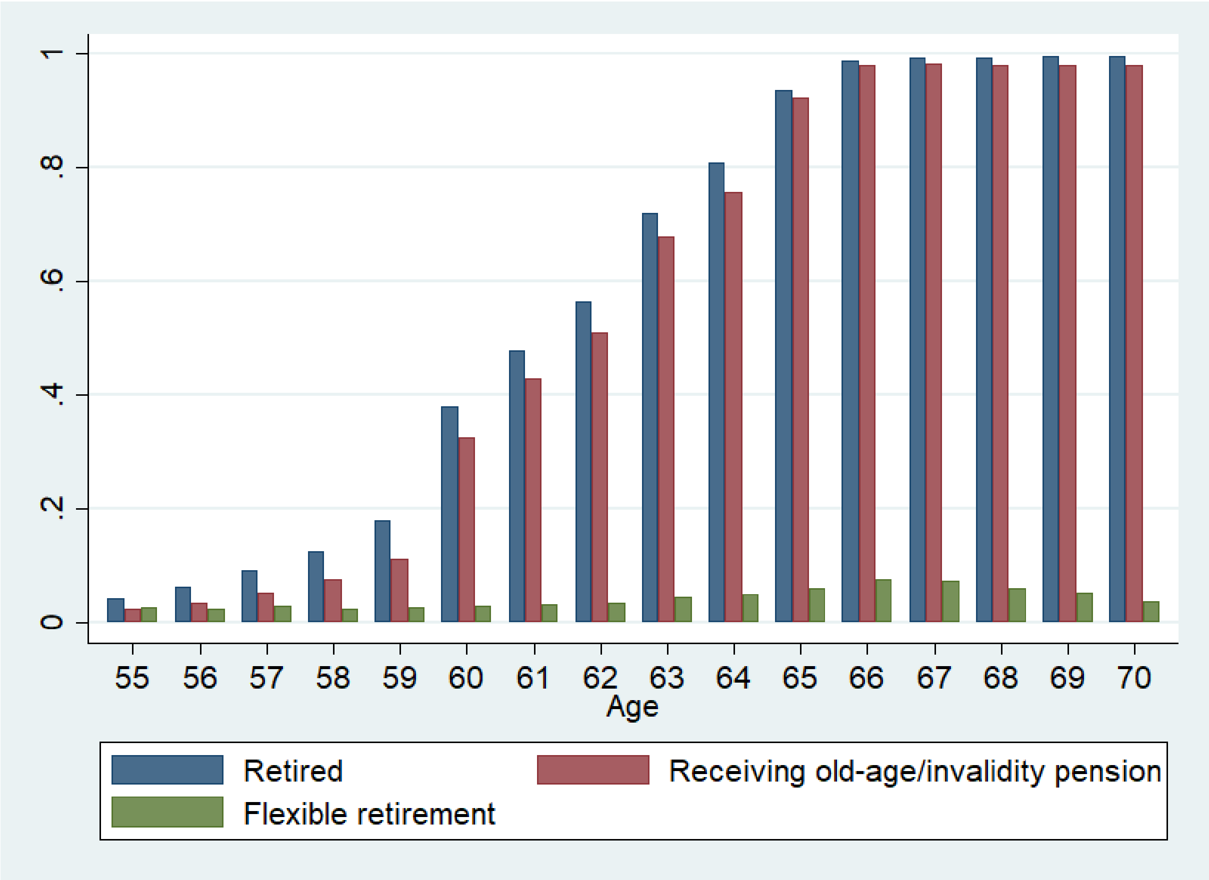

Source: Own calculations.

### 3.3. Definition of retirement status

The definition of our outcome variable – retirement status - is not trivial. There are at least two possible interpretations of it: one coincides with exit from the labor force, the second with the start of pension benefits claiming. Furthermore, the distinction between these two definitions is often not clear-cut. Indeed, individuals could receive pension benefits and simultaneously continue working or go back to work; alternatively, they could claim they are retired when receiving sources of income other than pension benefits, like severance payments or unemployment benefits. Understanding the relative importance of these potential definitions in Germany is crucial to model the retirement decision meaningfully.

In Figure 4, we show the percentage of workers who retire at each age, conditional on having worked until that age. We distinguish between three possible definition of retirement. The first definition, that we label "Retired", is simply based on the individuals' self-reported labor market status. The second definition, "Receiving old-age/invalidity benefits", is based on a question asking individuals what sources of income, if any, they received in the previous year. Finally, "Flexible retirement" is defined as claiming to be retired and simultaneously in full- or part-time work for at least two consecutive months, when asked about labor market status.

**Figure 4: Retiring, benefit claiming and flexible retirement.**




Source: Own calculations.

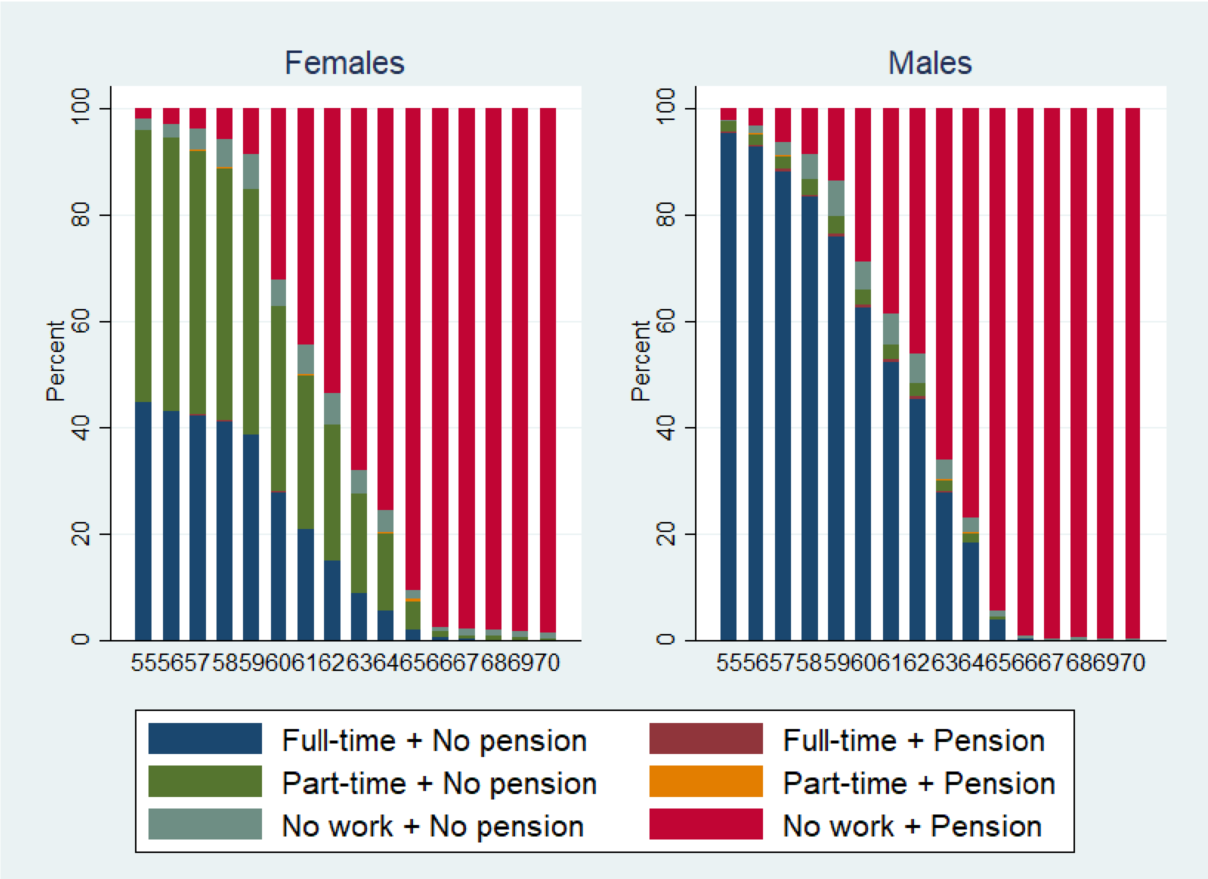
From this graph, we can learn first of all that the majority of individuals in Germany identify retirement with pension benefit claiming. However, the self-assessed notion of retirement is more general than this, as a significant portion of retired individuals at earlier ages do not receive pension benefits. Other individuals, on the other hand, claim they are simultaneously working and in retirement. Most likely, these individuals receive other types of income sources (e.g. severance pay), or are employed within the „block model" of the gradual retirement scheme for employees over 55.[8] Anyhow, flexible retirement is a rather marginal occurrence, therefore we do not deem it necessary to model it formally. From now on, our definition of retirement will be based on the self-reported labor market status of respondents.

In Figure 5, the evolution by age of all the possible work and pension receipt combinations is shown, separately for males and females. Notice that "work + pension" is a different concept than flexible retirement, as with the latter we refer to individuals who consider themselves retired while working at the same time, irrespective of receiving or not receiving a pension. It emerges clearly from this graph

[8] The block model is one form the part-time scheme prior to retirement can be claimed as. The part-time scheme prior to retirement *(Altersteilzeit)* is the by far most widely used model of work reduction before retirement, which entered into force in 1996. With this scheme, the German legislator tried to implement flexible retirement. The minimum eligibility age is 55 and the scheme is based on a bilateral agreement between the employee and the employer. The scheme requires a reduction of working hours by half and lasts over a period of five years. Working time can be distributed in two distinctly different ways: Either the employee reduces his working hours for the whole period of five years by half or the so-called block model option can be chosen. In this option the employee continues working without any reduction in working hours for the first two and a half years (first block), while for the second two and a half years (second block), the employee stops working completely. About 90% opt for the block model option (Wanger 2010, Ellguth and Koller 2000). Therefore, in most of the cases the scheme is not used for a real gradual transition, but rather for an early exit from the labor force.

that the occurrence of work (full- or part-time) together with pension benefits receipt is nearly non-existent.

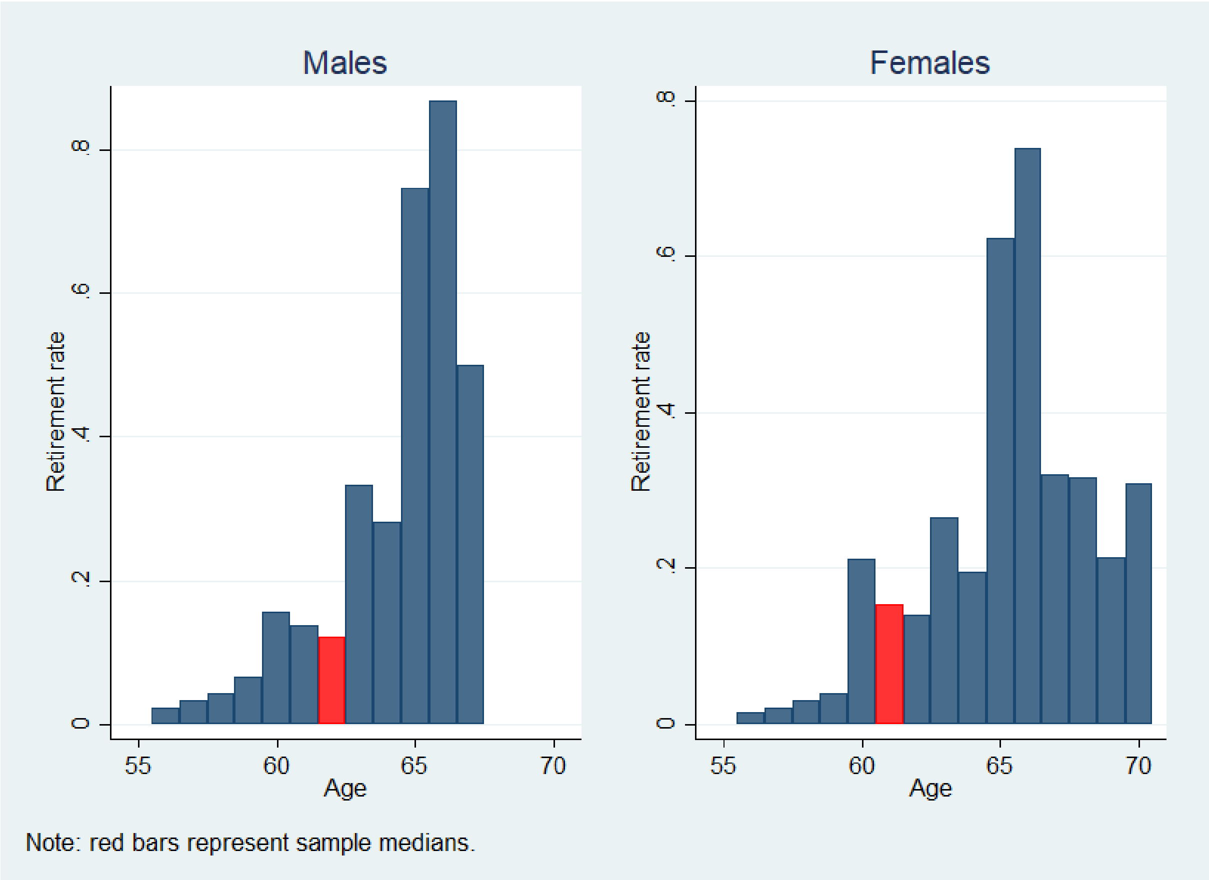
**Figure 5: Working status and benefit claiming, by age and gender.**




Source: Own calculations.

Figure 6 shows the retirement hazard, defined as the flow into retirement on the stock of workers at each age between 55 and 70, separately by men and women. The graph clearly shows spikes in retirement at the early and statutory eligibility ages (60, 63 and 65). The red bars indicate the median age of retirement, which amounts to 62 years for men and 61 for women.

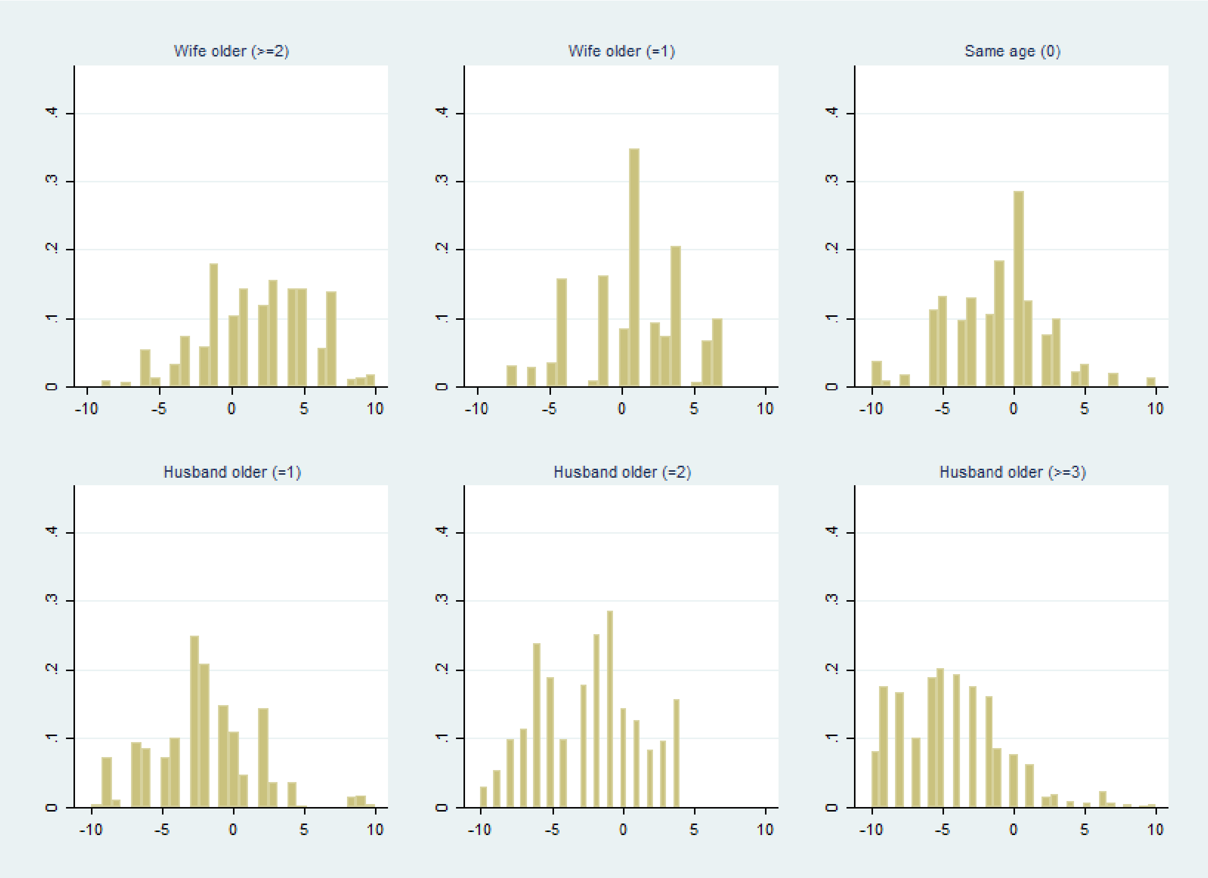
**Figure 6: Retirement hazard, by gender.**




Source: Own calculations.

A final point to be discussed is the potential presence of joint retirement. If there are leisure complementarities, the marginal utility of retirement increases when the partner is also retired. Furthermore, spouses might have correlated tastes for leisure. In order to assess whether this is an issue that needs to be addressed in our retirement model, we show in Figure 7 the distance in years between the retirement dates of the two spouses, conditional on their age difference. It emerges clearly from these graphs that spouses do not, in general, retire at the same time. Rather, they retire depending on their own age and irrespective of their partner's retirement status.

**Figure 7: Distance between husband and wife's retirement dates, by age difference.**




Source: Own calculations.

## 4. THE IMPLICIT TAX ON WORKING LONGER

The German retirement insurance system creates strong incentives to claim a pension and exit the labor force relatively early in life through a variety of mechanisms. These mechanisms can be summarized compactly in terms of a loss in social security wealth when pension benefit claiming and the labor force exit is postponed. Since Germany applies a relatively strict earnings test for ages below the statutory eligibility age, claiming pension benefits invariable implies leaving the labor force when individuals are eligible for an early pension.

*Social security wealth* is the expected net present value of social security benefits minus contributions to the public pension and unemployment insurance during the retirement window, here defined as the age range from 55 through 69. Contributions before age 55 are considered sunk. Future contributions and benefits depend on the legal situation $l$ at the planning age $S$ and the used pathway to retirement $k$ (e.g. via unemployment or disability pension). Seen from the perspective of a worker who is $S$ years old and plans to claim pension benefits at age $R$ *social security wealth* is given by:

$$SSW_{S,k,l}(R,i) = \sum_{t=R}^{T} B_{t,k,l}(R,i) \cdot \sigma(i)_{S,t} \cdot \beta^{t-S} - \sum_{t=S}^{R-1} c_{t,l} \cdot Y_t(i) \cdot \sigma(\mathrm{i})_{S,t} \cdot \beta^{t-S}$$

with

$SSW$: net present discounted value of retirement/unemployment benefits

$S$: planning age
$R$: benefit claiming age
$i$: gender and skill type
$k$: pathway to retirement
$l$: legal situation at planning age $S$
$Y_t(i)$: gross labor income at age $t$
$B_{t,k,l}(R,i)$: net benefits from pathway $k$ at age $t$ for benefit claiming age $R$ and legal situation $l$
$c_{t,l}$: contribution rate to pension and unemployment system at age $t$ for legal situation $l$
$\sigma(i)_{S,t}$: probability to survive at least until age $t$ given survival until age $S$
$\beta$: discount factor $\delta = 1/(1+r)$. We choose the usual discount rate $r$ of 3%.

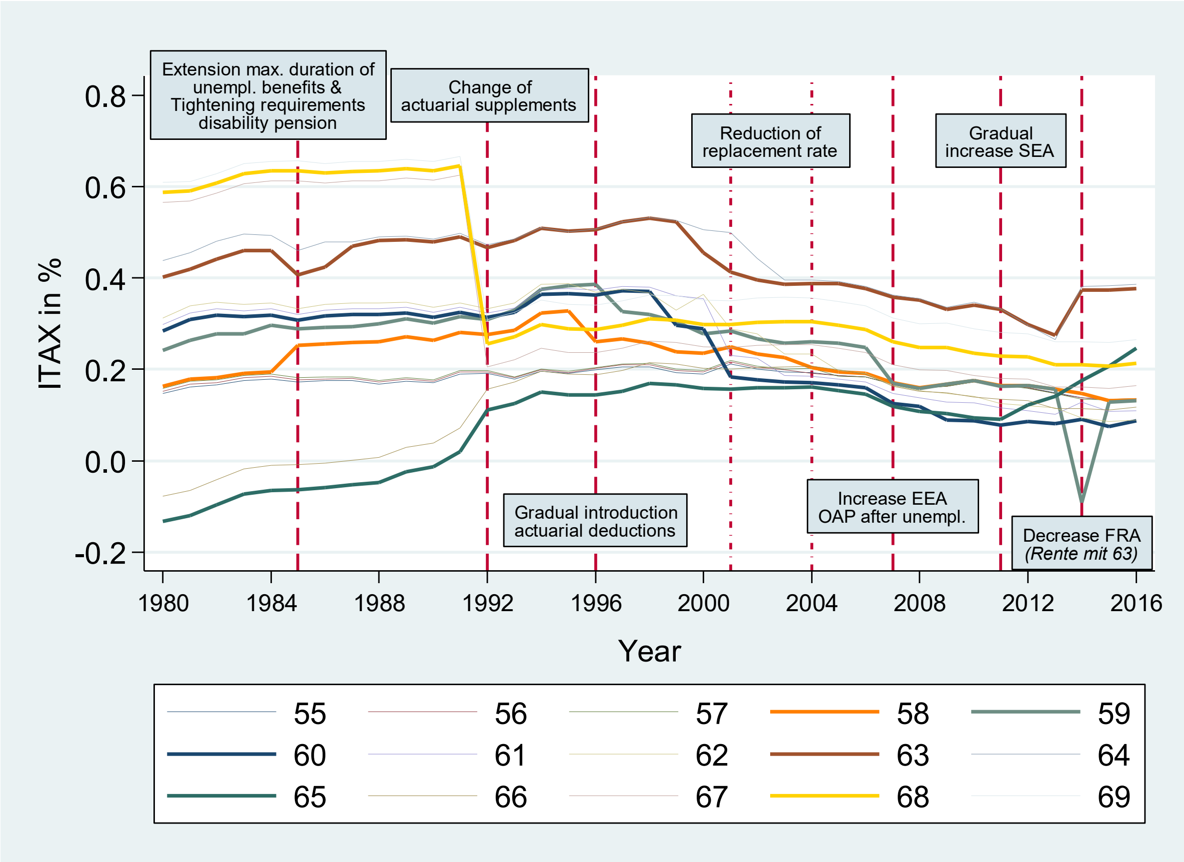
Postponing claiming social security benefits by one year has two effects on social security wealth. On the one hand, the individual receives one year less of benefits, which decreases social security wealth. On the other hand, annual benefits increase with later claiming in most countries due to additional contributions and actuarial adjustments. Additional contributions accrue because the individual now works a year longer, and having an extra year of earnings included in the benefit computation may result in an overall higher benefit amount. Moreover, in Germany as in almost all other countries, benefits are adjusted upwardly if benefits are taken later than the statutory eligibility age through the actuarial supplements. The balance between these mechanisms determines whether social security wealth increases or decreases with earlier or later retirement.

The incentives to leave the labor market and claim pension benefits can be expressed by the *implicit tax on working longer* which is based on the *accrual of social security wealth*. The *accrual* is defined as the numerical increase or decrease of social security wealth by postponing the labor market exit by one year. The implicit tax *($ITAX$)* is the negative accrual of social security wealth ($ACC$) divided by the after tax earnings ($Y^{Net}$) during the additional year of work:

$$ITAX = -\frac{ACC}{Y^{Net}}.$$

As long as the implicit tax is negative, it is rational to postpone the withdrawal from the labor market unless labor/leisure preferences or similar considerations dominate the expected gain in social security wealth. Negative implicit taxes from a certain age on are sufficient (although not necessary) for leaving the labor market and claiming a pension at that age. A positive value of $ITAX$, on the other hand, means a tax on working longer and with that an incentive to claim pension benefits early.

**Figure 8: ITAX in Germany over time, by single years of age, men, median-educated.**

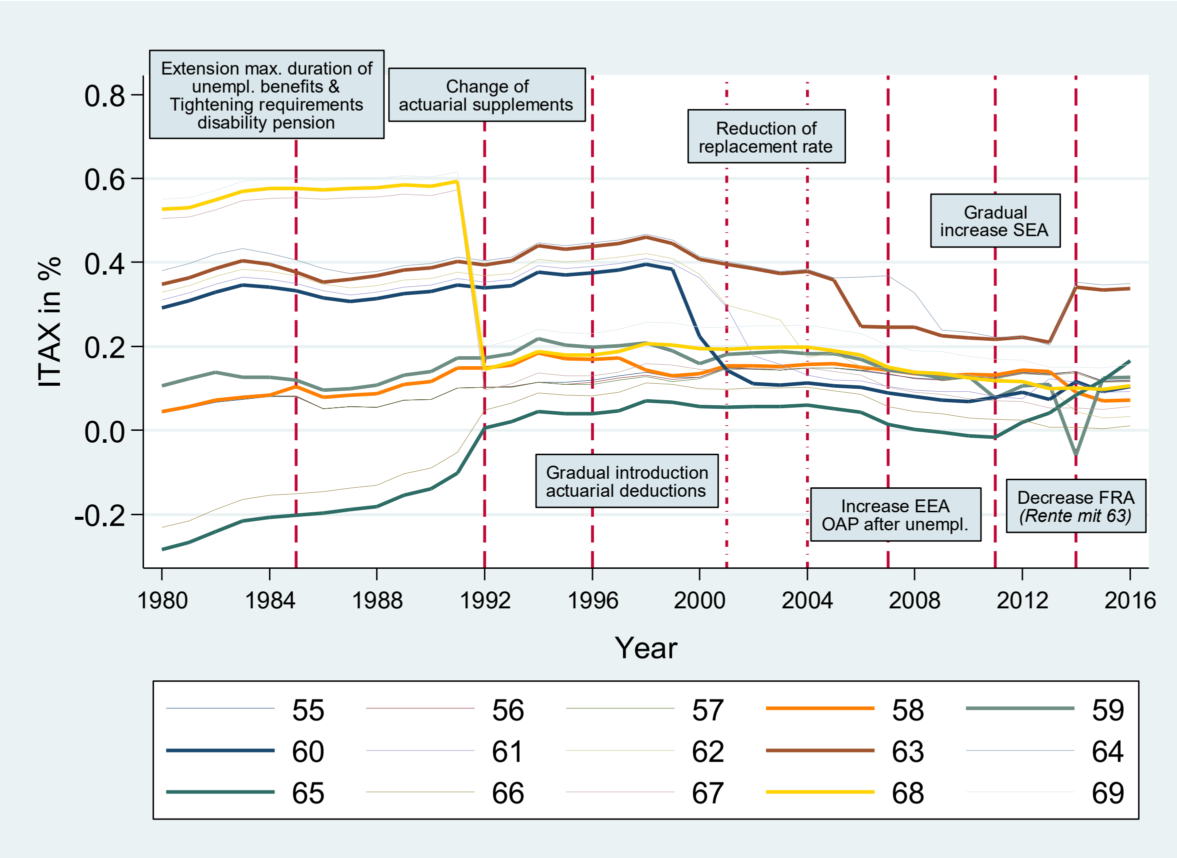



Source: Börsch-Supan et al. (2020).

Börsch-Supan et al. (2020) have calculated ITAX-time series for a few typical benefits recipients in the first phase of this multistage research project. The typical individuals differ by basic socio-economic characteristics (sex, marital status, and education). Figures 8 and 9 show the development of implicit tax rates for median-educated males and females from 1980 to 2016 in Germany. The authors show that there has been a positive ITAX for almost all ages in the retirement window throughout almost the whole observation period with only very few exceptions. Overall, this means that there has been an incentive to claim pension benefits early in nearly all periods. Additionally, the figure shows that ITAX captures reforms quite clearly. The introduction of actuarial adjustments for early or late retirement had a large influence on the incentives to work longer. This especially applies for the introduction of actuarial deductions for early retirement in 1997. We consider the reforms marked in the graph as main identifying reforms in the empirical analysis. Moreover, we consider the legal status throughout the entire observation period until 2019.[9]

[9] For a comprehensive description of the time series taking reform details into account see Börsch-Supan et al. (2020).

**Figure 9: ITAX In Germany over time, by single years of age, women, median-educated.**




Source: Börsch-Supan et al. (2020).

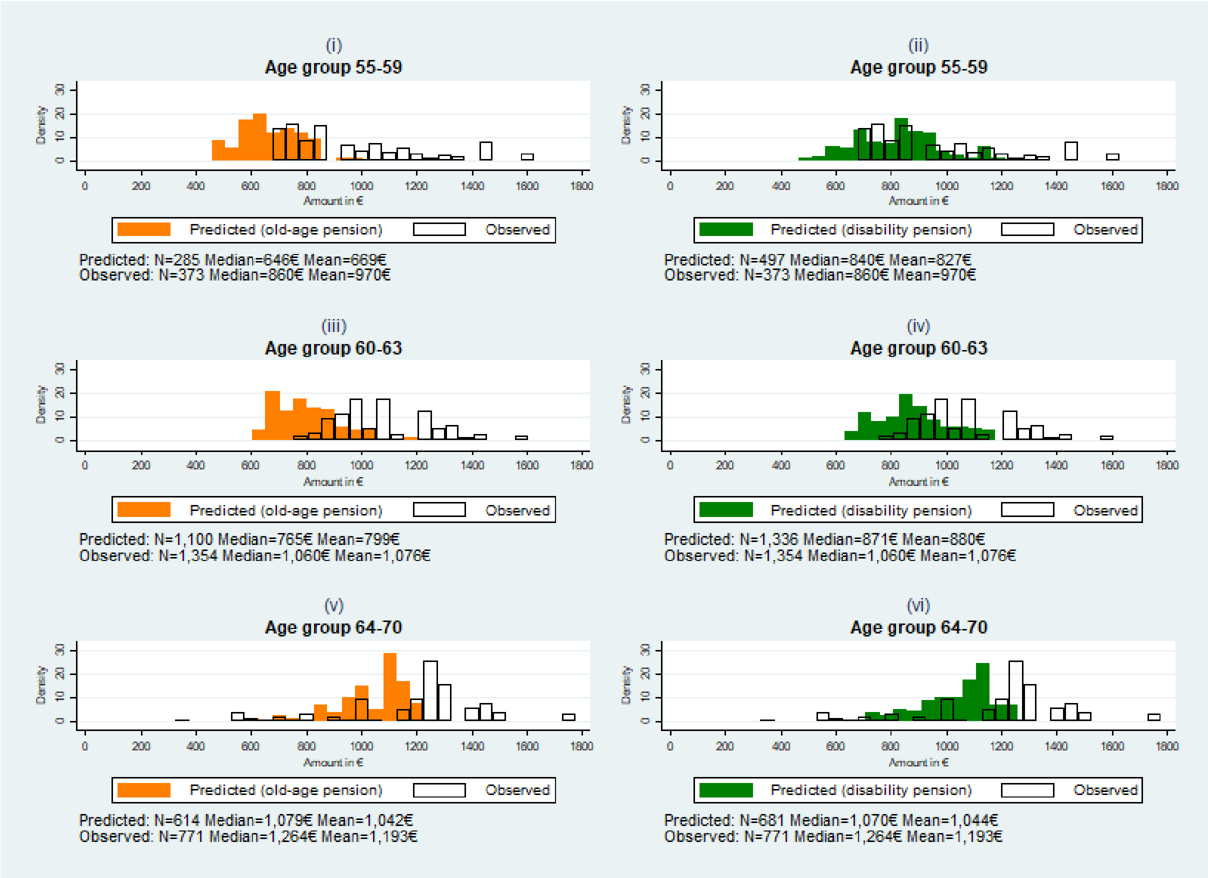
## 5. VALIDATION OF PENSION CALCULATOR

While Börsch-Supan et al. (2020) computed pension benefits and implicit taxes for synthetic individuals, this study aims at calculating individual pension benefits and implicit taxes for a representative sample of people from the GSOEP survey. Consequently, we have to determine their pension benefits under different assumptions, e.g. assumptions regarding the actual pension claiming age. In this section, we want to validate our pension calculator, which we use for this purpose. To do so, we compare observed pension benefit information that individuals report in the GSOEP survey with our generated predicted pension benefits. For the validation of the pension calculator, we predict old-age pensions and disability pensions based on the *actual* first pension claiming year which we observe in the survey data. For the construction of social security wealth and incentive variables of our main analysis, we will need, however, expected pension benefits for *all* labor market exit ages in the window of retirement (age 55-69). In Section 6, we show the two-step procedure on how we handle expected pension benefits for all labor market exit ages.

Unfortunately, the survey data do not contain a stable benchmark to which we can validate our pension calculator over the long observation period (1984-2019), which simultaneously differentiates between old-age pensions and disability pensions. In GSOEP, the best information is a variable which summarizes old-age pensions and disability pensions in one single variable. Until 2001, it is not even possible to distinguish occupational pension benefits. This is not an issue, however, for the predictions of our main analysis, since our pension benefit calculator depends on earnings points computed from relative-income positions (see Section 2 and 3.2.). Hence, our predictions rely on earnings information rather than on reported pension benefits.

Since we do not have a single benchmark to which we can validate our predictions, we compare the reported pension benefits, on the one hand, with generated old-age pensions (orange bars) and, on the other hand, with generated disability pensions (green bars) (see Figure 10). Moreover, we show the validation for different age groups, since claiming disability pension and/or old-age pension is not possible at any age. Indeed, in some cases it is possible to infer the type of received pension benefit from the pension claiming age.[10]

**Figure 10: Validation of pension benefit calculator – Distribution of predicted vs. observed pension benefits by age groups and pension type.**




Source: Own calculations.

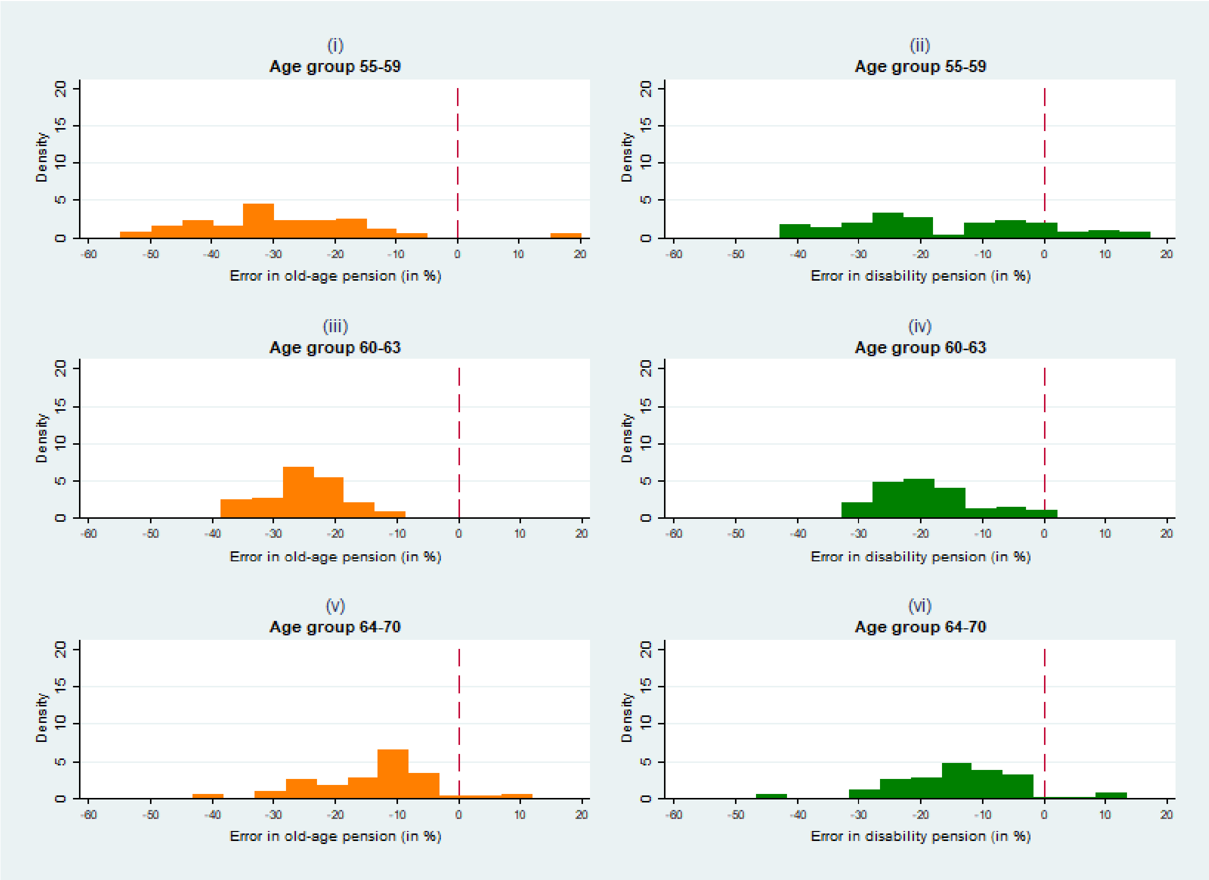
In the group of individuals aged 55-59 people most likely report disability pension benefits only. As we have shown in Table 1 (Section 2) old-age pension pathways are not available before age 60. For this age group it makes most sense to validate the quality of our pension calculator with subframe (ii) which displays our predicted disability pensions. With only few exceptions, the figure shows that our predicted disability pension benefits match the observed pension benefits well.

The subframes (iii) and (iv) suggest that our pension calculator systematically underestimates the observed values. In the age group 60-63, however, individuals might receive and report various income sources. First, individuals can report both old-age pensions and disability pensions. Moreover, people might get severance payments or other benefits from their employer. Especially in the 1990s,

[10] Note that within each age group the observe pension benefits (white bars) are the same for both sides.

severance payments were a widespread practice to discharge employees into early retirement and to rejuvenate the age structure of the workforce. Individuals might incorrectly report those payments as public pension benefits, which can explain part of the difference between the observed numbers and the predicted values. The difference might in addition arise from the fact that we cannot distinguish between public pension benefits (old-age pensions and disability pensions), and occupational pension benefits in the micro data for seventeen years (1984-2001) of the observation period. We do not capture these additional income sources individuals might incorrectly report as public pension benefits.

**Figure 11: Validation of pension benefit calculator – Difference between predicted and observed pensions by age group and pension type.**




Source: Own calculations.

In Figure 11, we show the percentage difference between predicted and observed benefits. A value of minus ten means that predicted pension benefits are ten percent lower than observed pension benefits. The figure graphically reflects the left-shifted distributions of predicted pension benefits displayed in Figure 10 and the lower mean values given in the notes to Figure 10. For the age group 55-59, receiving disability pension benefits is the only possibility. For part of the observations, our pension calculator matches the observed values. Subframe (ii) shows, however, that the distribution is broad. In the older age groups, the receiving of an old-age pension may coincide with receiving occupational pension benefits and other payments, which we do not include in our pension calculator (subframes iii and v).

Overall, our predicted pension benefits seem to underestimate the observed pensions. However, the differences can most likely be explained with the receipt of occupational pension benefits and other payments our pension calculator does not consider. However, since we focus on the evaluation of incentives from the public pension system, our pension calculator seems to work reasonably well.

## 6. EXPECTED PENSION BENEFITS ON MULTIPLE PATHWAYS TO RETIREMENT

So far, we validated our pension calculator for individuals at their actual first pension claiming year. For the construction of social security wealth and the incentive variables (see Section 4), we need expected pension benefits for all labor market exit ages of our retirement window. At least theoretically, there are several retirement pathways for a worker to exit the labor market and start drawing from his/her public pension. The most important ones are:

- Regular old-age pension (at the statutory eligibility age),
- Early pension claiming via old-age pension for (especially) long-term insured or for women,
- Leaving the labor market via unemployment,
- Part-time employment prior to retirement,
- Early pension claiming via old-age pension for the disabled, and
- Disability pension.

It is important to notice that all of these pathways pay the same benefit once a person is eligible. The main differences lie in the income between the labor market exit and first pension drawing. However, in practice there is no free choice, as all of these pathways are subject to eligibility criteria (see Table 1). Among those criteria, “strict” and “soft” eligibility rules can be distinguished. The first are tied to objective variables, such as age, gender, and previous contribution history while the second are subject to discretionary decisions, notably the determination of a workers’ disability status.

We compute the expected pension benefits, which depend on the choice of the specific pathway, in two steps. First, we compute the pension benefits for each pathway taking into account the “strict” eligibility criteria only. Once an individual fulfills the criteria of a pathway this individual is assumed to claim the pension as soon as possible. For example, a 60-year-old male worker with 35 service years can claim an old-age pension for long-term insured beginning from age 63. On the other hand, if this individual does not fulfill any additional criteria, he cannot draw a public pension earlier. A 60-year-old female worker with 35 service years fulfills, yet again, most likely also the eligibility criteria for an old-age pension for women and can consequently draw her pension immediately.

If an individual does not fulfill the criteria of the considered pathway, he may claim his pension at the statutory eligibility age.[11] In the worst case, when not even the five-year vesting period for a regular old age pension is met, we consider at least the basic old-age support.

As stated, the income between an individual’s actual age and first pension claiming depends on the considered pathway. For instance, there is no income in the case of normal early retirement while the pathway via unemployment considers unemployment benefit payments.

In the second step, we weight the benefits, or rather the SSW, of the different pathways by their observed frequency on all pension claims of the considered year (i.e. according to the number shown in Figure 1). For individuals with a disability status (handicap) of at least 50%, we weight only the pathway for the old-age pension for the disabled with the disability pension pathway. For individuals with no handicap or a handicap status below 50% we weight the disability pension with all other

[11] Consequently, the regular old-age pension is covered through all other pathways and must not be calculated separately.

retirement options. We make this distinction since the old-age pension for the disabled is more generous than the other retirement pathways.

Moreover, for couples we consider the possibility of survivor pensions. The survivor pensions are computed for each pathway and each possible death date of the spouse and are weighted with the probability that the spouse dies at the respective date.

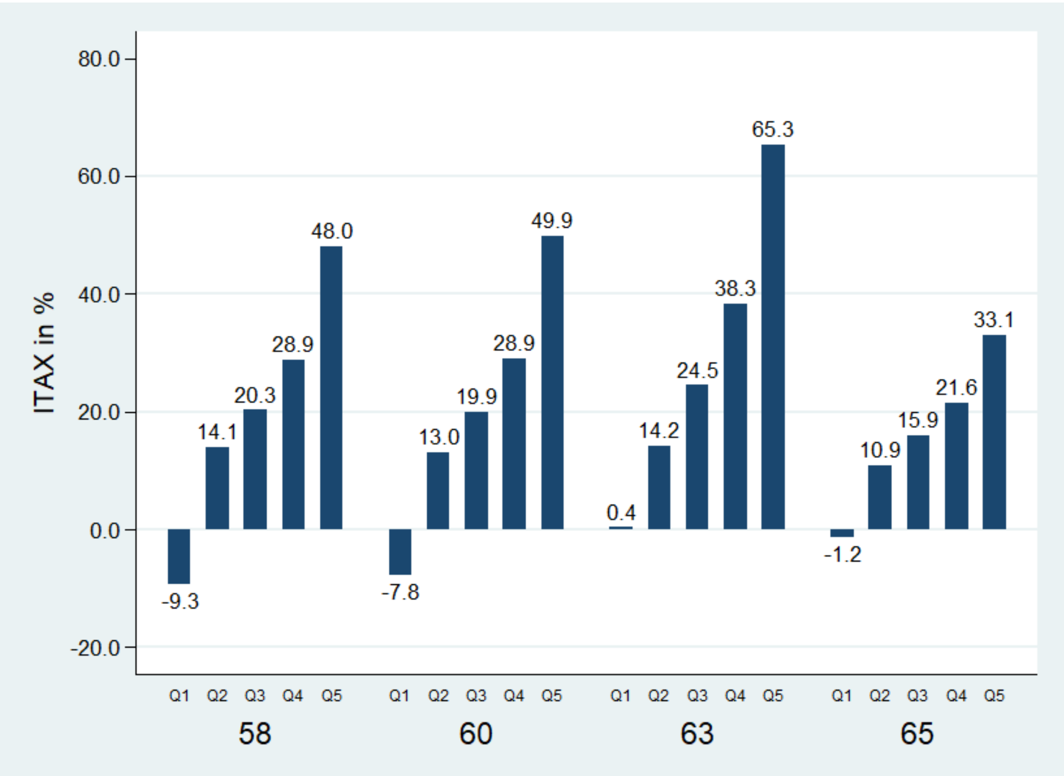
## 7. RESULTS

In this section, we present our results. In a first step, we present the implicit tax rates that we have calculated based on survey data from GSOEP. Subsequently, we present the results from our empirical estimation applying these ITAX rates.

### 7.1. ITAX based on micro data

Figure 12 gives an idea about how the distribution of ITAX computed from micro data looks like. The figure shows ITAX by age. For single years of age, we group ITAX in quintiles and depict the quintile-mean values of ITAX. We present the numbers for the most salient age steps (i.e. eligibility ages) in the German public pension scheme. The graph reflects the findings from the synthetic ITAX values from the first phase of this multistage research project (see Section 4 and Börsch-Supan et al. 2020). We observe a positive ITAX for almost each case, which provides a disincentive to postpone pension benefit claiming at each age.

**Figure 12: Distribution of ITAX by age.**




Source: Own calculations.

## 7.2. Empirical estimation

### 7.2.1. The retirement model

Our outcome variable is labor force status in old age. It takes the value 0 when the individual is in the labor force, and value 1 when she is retired. As explained above, we will simply model the transition from being in the labor force (full- or part-time) to being fully retired, as flexible retirement is relatively rare in Germany. We assume that retirement is an absorbing state; therefore, individuals are kept in the regression sample only until the first observation in retirement, and are dropped from the sample afterwards. Thus, we can interpret our dependent variable as the probability to retire in a given year, provided that the individual has been working in the previous year.

Our main explanatory variable will be one of the two incentive variables described in Section 4: accrual rate (the accrual divided by the level of social security wealth) and implicit tax rate. This reduced form model of retirement has been extensively used in the literature, and different incentive measures have been used as well, for example the option value and the peak value (see, among others, Coile and Gruber (2000) and Gruber and Wise (2004)). The main difference with respect to measures like accrual or ITAX is that the latter are one-year forward measures, whereas option value and peak value are forward-looking measures, where the individual looks forward to the optimal retirement year, rather than just to next year. However, as workers may be not completely forward-thinking or may be not willing to postpone retirement for too many years, the incentive measures we are using may be considered appropriate.

A crucial issue in the analysis of retirement "is identification - that is, determination of the separate effect of each variable on retirement, as distinct from each of the other variables" (Gruber and Wise (2004)). Indeed, in order to determine the effect of social security or pension incentives on retirement, one needs to be able to separate the pure effect of economic incentives from the other determinants of SSW, for example age and income. Controlling for these other determinants is important if they are also independently correlated with retirement choices. However, there might be a trade-off to take into account when introducing other control variables, as their estimated effect may capture part of the effect pertaining to financial incentives, rather than individual heterogeneity, thus leading to an underestimation of the incentives themselves. For this reason, exogenous variation of financial incentives is important for identification. In this respect, Germany represents a particularly well suited setting, given the various reforms and minor changes of the pension system that were presented in Section 2. Furthermore, as first observed by Hurd (1990) and then reiterated by Coile and Gruber (2001), "if there are significant non-linearities and interactions otherwise (likely) uncorrelated with retirement that primarily identify the impact of these incentive measures, one might feel more confident about retirement estimates" (Coile and Gruber, 2001).

In the following regressions, households are divided into single households, meaning either non-married individuals or single-earner households, and couple households, meaning households with two earners or one earner and one retired spouse.[12] Furthermore, we will show results separately for men and women. Besides the main incentive variables, we will run regressions with and without including a measure of individuals' position in the lifetime earnings distribution (calculated as the cumulative sum of earnings points, EP, divided by the length of the working life), as well as a number of control variables: number of children, dummies for low and medium educated, ISCO code (1-digit classification of occupation), health satisfaction (from 0-low to 10-high), a dummy for home

[12] We include couples with one retired spouse in the group of couple households because the pension of the retired spouse enters the calculation of the working spouse's ITAX through total household income.

ownership, and a dummy for working full-time. As displayed clearly in Figure 6, the retirement probability by age is characterized by peaks in correspondence of the pension eligibility ages. This may be due to liquidity constraints or social norms, the effects of which are not taken into account by our constructed incentives measure. In order to address this concern, we will include age dummies in all regressions.

Our main analysis is based on a random effects probit model. We will, however, also show the robustness of our results by the use of alternative models, in particular: linear probability model (LPM), random effects linear probability model (RE-LPM), fixed effects linear probability model (FE-LPM), and probit model. In all models, standard errors are clustered at the individual level.

#### 7.2.2. Estimation results

Our main results are shown in Tables 3 to 6, where we report marginal effects for the explanatory variables of interest. As the accrual rate captures the substitution effect on retirement decision from foregone future labor income, we expect the sign of this incentive to be negative: the greater the foregone opportunities, the less likely workers are to retire. On the contrary, we expect the sign of ITAX to be positive, as ITAX is defined as the negative accrual of social security wealth divided by the after tax earnings during the additional year of work.

In almost all groups and specifications, we obtain the expected incentives signs. In all specifications where the sign goes in the wrong direction, the corresponding coefficient is not significant (accrual in the single-males specification, see Column (3), ITAX in two single-female specifications, see Columns (4) and (5)). In general, results for couples are more satisfactory than results for singles, as coefficients are more often found to be statistically significant and are more robust to the inclusion of average EP and other control variables. This might depend, among other things, on the larger sample sizes.

Overall, our results point to a generally statistically insignificant effect of accrual rate for single households), and a positive and statistically significant effect of ITAX for single households. If we concentrate on the full specification, a 10 percentage point increase in ITAX determines an increase in the probability of retirement of 1.01 percentage points (pps) for females and 0.39 pps for males (see Table 5). In regards to couples, a 10 pps increase in the accrual rate determines a 2.18 pps decrease in the probability of retirement for males, while the effect of this incentive is not statistically significant for females when control variables are included. A 10 pps increase in ITAX is instead found to increase males' probability of retirement by 1.07 pps, and females' probability by 0.64 pps.

In Tables 7 to 10, we check the robustness of these results using different models. For the sake of space, in these tables we concentrate on the full specification that includes all control variables. In general, results are rather robust. LPM and RE-LPM deliver almost exactly the same results, and both seem to underestimate the effect of the incentives that we find using the RE probit model. Similarly, probit and RE probit also deliver almost exactly the same results.

**Table 3: Regression estimates for single households (accrual rate)**

| | SINGLE MALES | | | SINGLE FEMALES | | |
|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) |
| | | | | | | |
| **Accrual rate** | -0.038 | -0.038 | 0.084 | -0.021 | -0.021 | -0.042 |
| ***p-value*** | *0.301* | *0.307* | *0.367* | *0.234* | *0.240* | *0.833* |
| **Average EP** | | -0.007 | -0.003 | | -0.006 | 0.024 |
| ***p-value*** | | *0.245* | *0.605* | | *0.669* | *0.493* |
| **Age dummies** | X | X | X | X | X | X |
| **Control variables** | | | X | | | X |
| **Observations** | 5,227 | 5,227 | 4,203 | 3,334 | 3,334 | 2,599 |

Source: Own calculations.

**Table 4: Regression estimates for couple households (accrual rate)**

| | COUPLE MALES | | | COUPLE FEMALES | | |
|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) |
| | | | | | | |
| **Accrual rate** | -0.298 | -0.311 | -0.218 | -0.141 | -0.139 | -0.101 |
| ***p-value*** | *0.003* | *0.002* | *0.044* | *0.001* | *0.001* | *0.162* |
| **Average EP** | | -0.030 | -0.015 | | 0.006 | -0.033 |
| ***p-value*** | | *0.000* | *0.026* | | *0.546* | *0.023* |
| **Age dummies** | X | X | X | X | X | X |
| **Control variables** | | | X | | | X |
| **Observations** | 7,491 | 7,491 | 5,983 | 8,270 | 8,270 | 5,932 |

Source: Own calculations.

**Table 5: Regression estimates for single households (ITAX)**

| | SINGLE MALES | | | SINGLE FEMALES | | |
|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) |
| | | | | | | |
| **ITAX** | 0.002 | 0.002 | 0.039 | -0.009 | -0.007 | 0.101 |
| ***p-value*** | *0.908* | *0.881* | *0.062* | *0.683* | *0.752* | *0.014* |
| **Average EP** | | -0.011 | -0.003 | | -0.006 | 0.013 |
| ***p-value*** | | *0.085* | *0.591* | | *0.619* | *0.409* |
| **Age dummies** | X | X | X | X | X | X |
| **Control variables** | | | X | | | X |
| **Observations** | 5,598 | 5,598 | 4,480 | 3,669 | 3,669 | 2,859 |

Source: Own calculations.

**Table 6: Regression estimates for couple households (ITAX)**

| | COUPLE MALES | | | COUPLE FEMALES | | |
|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) |
| | | | | | | |
| **ITAX** | 0.062 | 0.073 | 0.107 | 0.060 | 0.060 | 0.064 |
| ***p-value*** | *0.002* | *0.000* | *0.000* | *0.000* | *0.000* | *0.008* |
| **Average EP** | | -0.032 | -0.016 | | 0.003 | -0.030 |
| ***p-value*** | | *0.000* | *0.016* | | *0.704* | *0.017* |
| **Age dummies** | X | X | X | X | X | X |
| **Control variables** | | | X | | | X |
| **Observations** | 7,851 | 7,851 | 6,267 | 8,683 | 8,683 | 6,216 |

Source: Own calculations.

| | SINGLE MALES | | | | | SINGLE FEMALES | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | LPM | LPM with RE | LPM with FE | Probit | Probit with RE | LPM | LPM with RE | LPM with FE | Probit | Probit with RE |
| | | | | | | | | | | |
| **Accrual rate** | 0.053 | 0.053 | -0.173 | 0.084 | 0.084 | -0.014 | -0.011 | 0.014 | -0.042 | -0.042 |
| **p-value** | *0.014* | *0.014* | *0.334* | *0.334* | *0.367* | *0.721* | *0.781* | *0.684* | *0.579* | *0.833* |
| **Average EP** | -0.004 | -0.004 | -1.793 | -0.003 | -0.003 | 0.023 | 0.023 | 0.995 | 0.023 | 0.024 |
| ***p-value*** | *0.380* | *0.379* | *0.001* | *0.558* | *0.605* | *0.076* | *0.075* | *0.068* | *0.132* | *0.493* |
| **Age dummies** | X | X | X | X | X | X | X | X | X | X |
| **Control variables** | X | X | X | X | X | X | X | X | X | X |
| **Observations** | 4,823 | 4,823 | 4,823 | 4,203 | 4,203 | 2,996 | 2,996 | 2,996 | 2,599 | 2,599 |

**Table 7: Regression estimates for single households using alternative models (accrual rate)**

Source: Own calculations.

**Table 8: Regression estimates for couple households using alternative models (accrual rate)**

Source: Own calculations.

| | COUPLE MALES | | | | | COUPLE FEMALES | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | LPM | LPM with RE | LPM with FE | Probit | Probit with RE | LPM | LPM with RE | LPM with FE | Probit | Probit with RE |
| | | | | | | | | | | |
| **Accrual rate** | -0.242 | -0.242 | -0.328 | -0.218 | -0.218 | -0.036 | -0.036 | -0.044 | -0.101 | -0.101 |
| **p-value** | *0.086* | *0.086* | *0.142* | *0.040* | *0.044* | *0.233* | *0.233* | *0.464* | *0.067* | *0.162* |
| **Average EP** | -0.011 | -0.011 | -1.402 | -0.014 | -0.015 | -0.028 | -0.028 | 2.268 | -0.033 | -0.033 |
| ***p-value*** | *0.024* | *0.024* | *0.005* | *0.023* | *0.026* | *0.006* | *0.006* | *0.000* | *0.005* | *0.023* |
| **Age dummies** | X | X | X | X | X | X | X | X | X | X |
| **Control variables** | X | X | X | X | X | X | X | X | X | X |
| **Observations** | 6,973 | 6,973 | 6,973 | 5,983 | 5,983 | 6,827 | 6,827 | 6,827 | 5,932 | 5,932 |

**Table 9: Regression estimates for single households using alternative models (ITAX)**

| | SINGLE MALES | | | | | SINGLE FEMALES | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | LPM | LPM with RE | LPM with FE | Probit | Probit with RE | LPM | LPM with RE | LPM with FE | Probit | Probit with RE |
| | | | | | | | | | | |
| **ITAX** | 0.041 | 0.041 | 0.080 | 0.039 | 0.039 | 0.100 | 0.100 | 0.075 | 0.101 | 0.101 |
| ***p-value*** | *0.028* | *0.031* | *0.096* | *0.061* | *0.062* | *0.003* | *0.003* | *0.116* | *0.002* | *0.014* |
| **Average EP** | -0.003 | -0.004 | -1.894 | -0.003 | -0.003 | 0.015 | 0.015 | 0.439 | 0.013 | 0.013 |
| ***p-value*** | *0.425* | *0.399* | *0.000* | *0.584* | *0.591* | *0.235* | *0.235* | *0.379* | *0.409* | *0.409* |
| **Age dummies** | X | X | X | X | X | X | X | X | X | X |
| **Control variables** | X | X | X | X | X | X | X | X | X | X |
| **Observations** | 5,139 | 5,139 | 5,139 | 4,480 | 4,480 | 3,276 | 3,276 | 3,276 | 2,859 | 2,859 |

Source: Own calculations.

**Table 10: Regression estimates for couple households using alternative models (ITAX)**

| | COUPLE MALES | | | | | COUPLE FEMALES | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | LPM | LPM with RE | LPM with FE | Probit | Probit with RE | LPM | LPM with RE | LPM with FE | Probit | Probit with RE |
| | | | | | | | | | | |
| **ITAX** | 0.096 | 0.096 | 0.121 | 0.107 | 0.107 | 0.039 | 0.039 | 0.109 | 0.064 | 0.064 |
| ***p-value*** | *0.000* | *0.000* | *0.003* | *0.000* | *0.000* | *0.002* | *0.001* | *0.000* | *0.001* | *0.008* |
| **Average EP** | -0.012 | -0.012 | -1.492 | -0.016 | -0.016 | -0.026 | -0.026 | 2.159 | -0.030 | -0.030 |
| ***p-value*** | *0.023* | *0.023* | *0.002* | *0.014* | *0.016* | *0.008* | *0.008* | *0.000* | *0.008* | *0.017* |
| **Age dummies** | X | X | X | X | X | X | X | X | X | X |
| **Control variables** | X | X | X | X | X | X | X | X | X | X |
| **Observations** | 7,298 | 7,298 | 7,298 | 6,267 | 6,267 | 7,151 | 7,151 | 7,151 | 6,216 | 6,216 |

Source: Own calculations.

## 8. COUNTERFACTUAL SIMULATIONS

In this section, we exploit the estimated coefficients to perform counterfactual simulations. The key idea is to show the impact of the incentive variable in the metric of the outcome variable, e.g., the probability to be retired. Our aim is to show what the probability of retirement would have been, had there been no policy changes, or in other words, had the incentives to retire remained constant throughout our observation period. Our expectation is that, without interventions on the pension rules aimed at reducing the generosity of the pension system, the probability to retire would have been higher than what we actually observe.

In the following graphs, we show two lines. The first line ("pred") depicts the average individual retirement probabilities as predicted by our estimated model for the years 1984 to 2018. The model includes the explanatory variables as they have actually developed during those years. In contrast, the second line ("cfac") is based on the counterfactual retirement probabilities. These probabilities are obtained by the same model, but we substitute the observed time- and individual-varying incentive variable (ITAX) by the values that would have been obtained if the rules at time 0 (in our case: 1985) had been valid in all years between 1985 and 2018. All other covariates, including age, are kept at their actual and changing value, including the effect of age and other covariates in the incentive variables. This way, we remove the changes due to policy reforms but acknowledge all other changes. All calculations are based on our preferred specification which includes both age dummies and a set of control variables.

In mathematical terms, assume a labor force probability model:

$$LFP_{it} = f(ITAX_{it}(age_{it}, covariates_{it}), age_{it}, covariates_{it}) + \mu_{it}$$

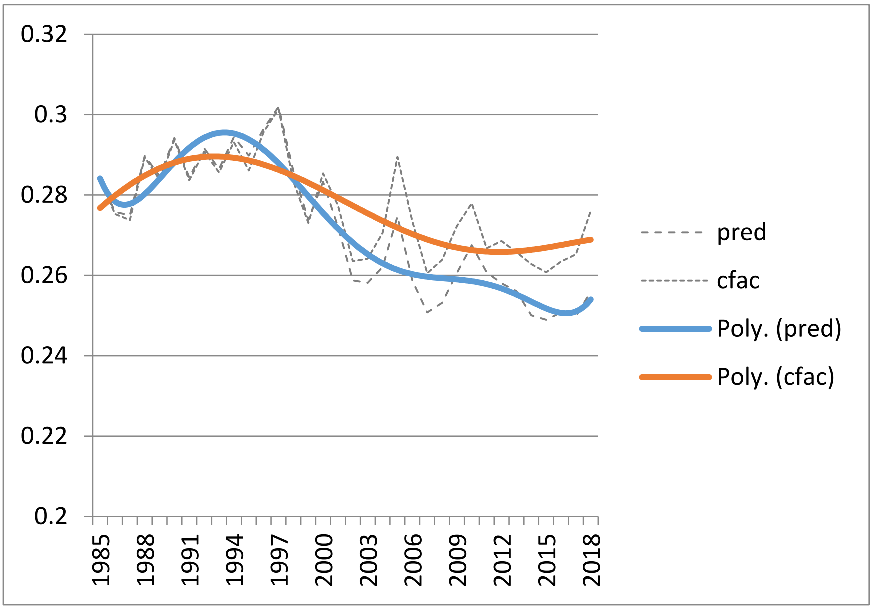
Here, $i$ and $t$ index individuals and years, respectively, $LFP_{it}$ stands for labor force participation and $\mu_{it}$ is the error term. Then the counterfactual predicted labor force probability for each individual is defined as:

$$LFP_{it}^{pred} = f(ITAX_{i0}(age_{it}, covariates_{it}), age_{it}, covariates_{it})$$

Figures 13-15 show the development of the average retirement probability, first across the entire age range from 55 to 65, then separately for the younger and the older age range. They refer to the evolution of the predicted and counterfactual statistics for the subsample of males in dual-earner households. The baseline model used is RE probit with ITAX as incentive variable.

Figure 13 shows that the 1992 reform, which gradually introduced actuarial adjustments and closed certain early-retirement pathways, kicked in after 2000. In 2007, the gradual shift of the normal retirement age was legislated; it took effect in 2011. The combined effect reduced the average probability of retiring in 2018 by about 2 percentage points, with respect to a counterfactual situation with no reforms. In other words, reforms explain around 72% of the observed reduction in retirement probability between 1985 and 2018.

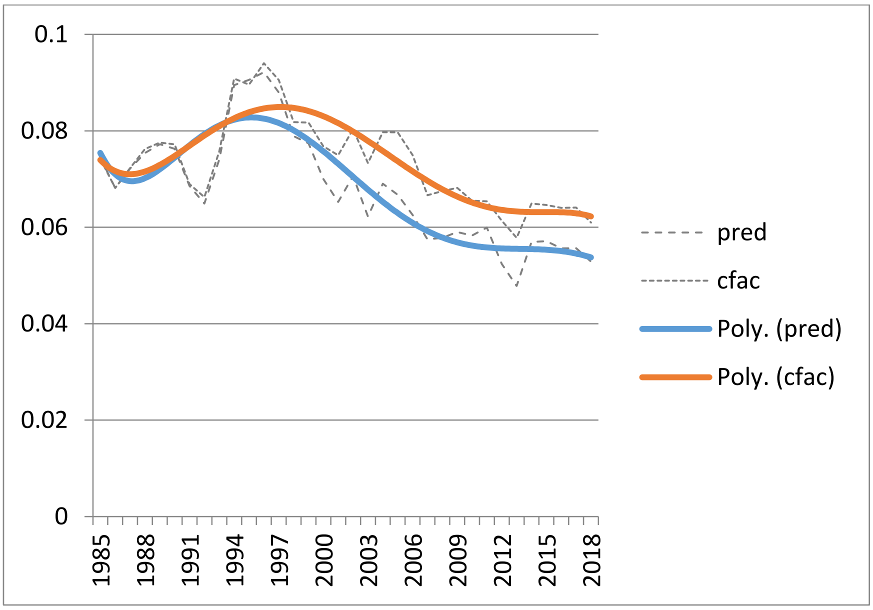
**Figure 13: Counterfactual simulations: average retirement probability for age 55-65.**




Source: Own calculations.

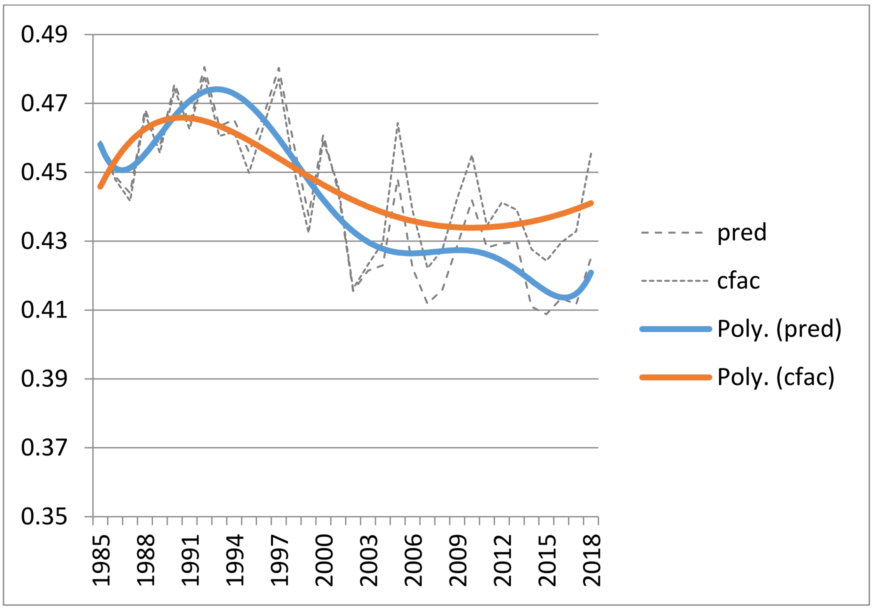
In Figures 14 and 15 we look at specific age subgroups, restricting the analysis to individuals of age 55 to 59 and 60 to 65, respectively. We conclude that the reforms explain around 38.5% of the observed reduction in retirement probability, and that the probability of retirement in 2018 would have been around 0.83 pps higher without the reforms for workers of age 55 to 59. For workers older than 59 years, the policy effect amounts to around 90%, and the probability of retirement in 2018 would have been around 3 pps higher without the reforms that changed ITAX. Therefore, in relative terms, we observe a distinct larger size of the effect of reforms for the older age group.

**Figure 14: Counterfactual simulation: average retirement probability for age 55-59.**




Source: Own calculations.

**Figure 15: Counterfactual simulation: average retirement probability for age 60-65.**



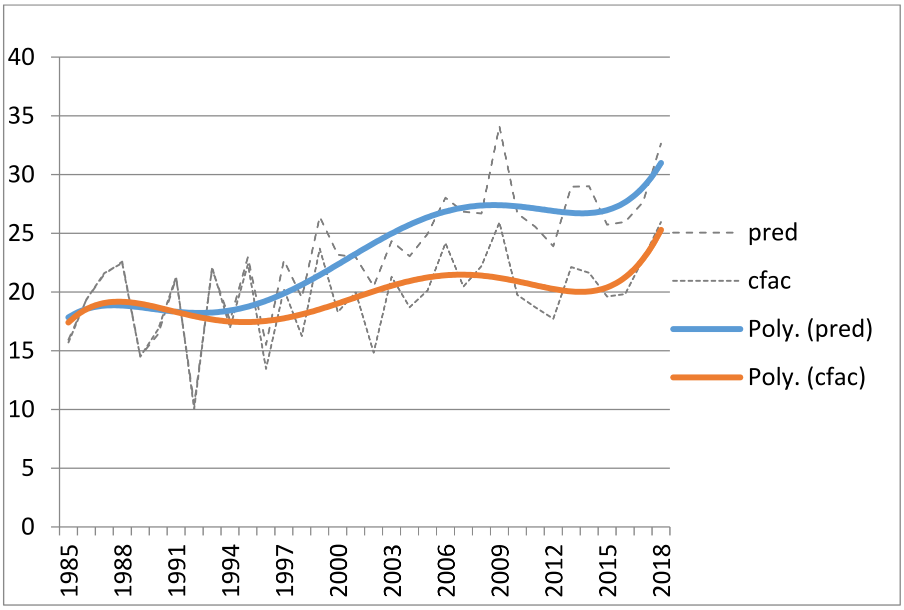

Source: Own calculations.

The retirement probabilities in Figures 13-15 can be used to construct a "worklife table" from which the equivalents of survival rates and conditional life expectancies for a cohort of workers can be derived. Survival corresponds to remaining in the labor force, and conditional life expectancy corresponds to the expected retirement age seen from the viewpoint of a worker at a given age.[13]

Figure 16 depicts the percentage of individuals still working at age 65, given that they were working at age 55. In the counterfactual scenario without reforms, this percentage would have been substantially lower than what was actually observed (26 rather than 33 percent). Reforms explain in this case about 38% of the overall increase. This corresponds closely to the actual development of labor force participation among men aged 55-69, displayed in Figure 17, which is slightly decreasing until the beginning of the 2000s, and then strictly increasing.[14]

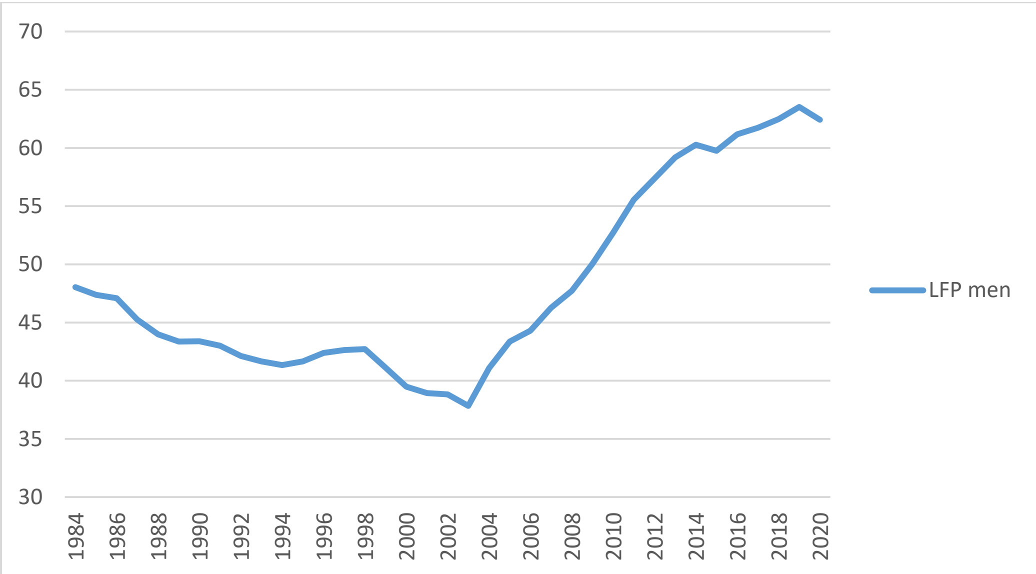
[13] To be precise: cohort life expectancies, not period life expectancies.
[14] Note that Figure 17 corresponds to the later part of the developments shown in Figure 1.

**Figure 16: Counterfactual simulation: percentage of individuals still working at age 65.**




Source: Own calculations.

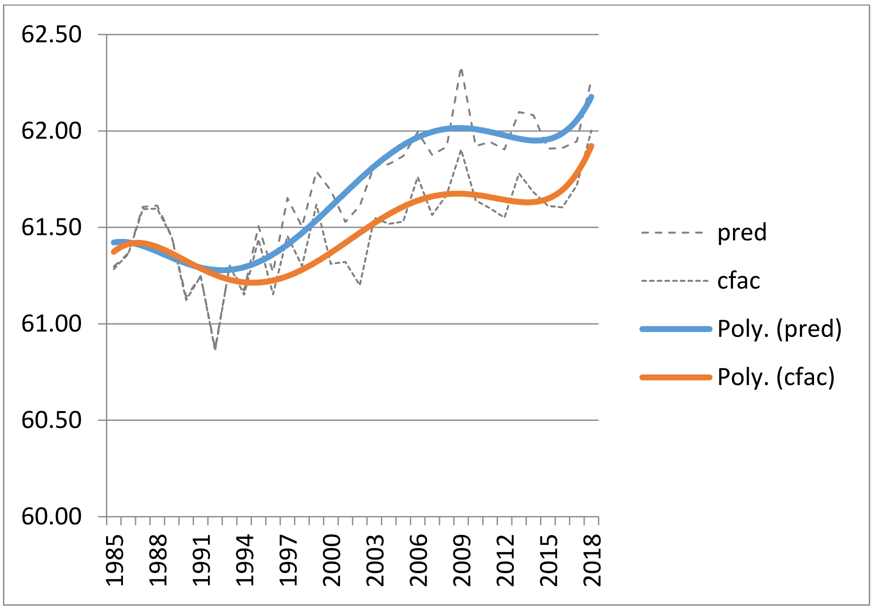
**Figure 17: Observed labor force participation of men, 1984-2020.**




Source: Own calculations.

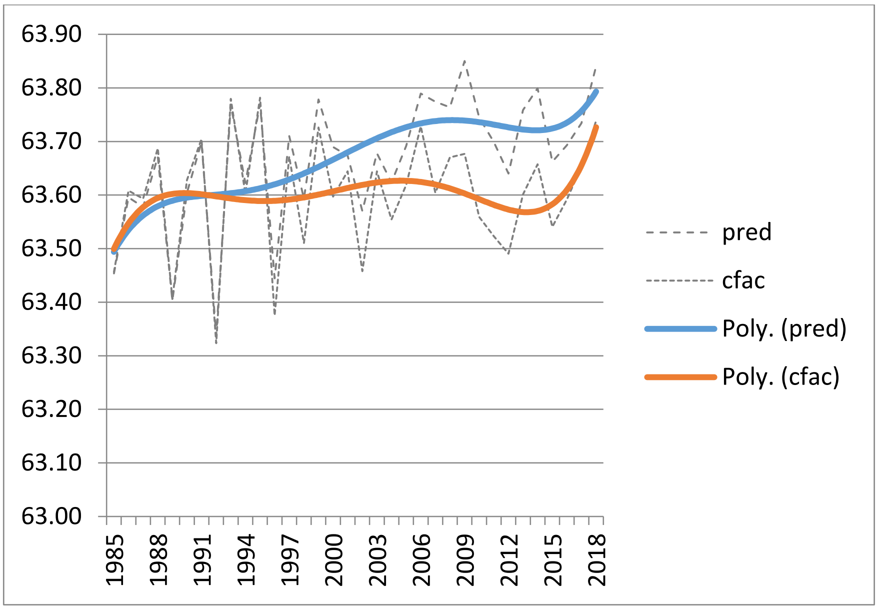
Finally, we calculate expected retirement ages seen from the perspective of workers at age 55 and 62, respectively. The shapes are very similar but the magnitudes differ. Expected retirement seen from the younger perspective (and thus closer corresponding to the actually observed retirement age) would have been 3.6 months lower in the counterfactual case of no reforms (62.0 rather than 62.3). Seen from the perspective of a 62-year-old worker, expected retirement age would have been 63.7 rather than 63.8. The reforms explain 26 and 27%, respectively, of the overall increase in expected retirement age observed between 1985 and 2018.

**Figure 18: Counterfactual simulation: expected retirement age at age 55.**




Source: Own calculations.

**Figure 19: Counterfactual simulation: expected retirement age at age 62.**




Source: Own calculations.

## 9. CONCLUSIONS

Employment of older individuals in Germany has experienced a remarkable reversal around the late 1990s. After a long declining trend that began in the early 1970s, the employment rate for older men has strongly increased again. This increase has lasted until today. This paper uses micro data from the German Socio-Economic Panel in order to link these labor market trends to changes in public pension policies, especially the change in the incentive variables ITAX, the implicit tax on working longer, using various regression models.

Our model produced predicted retirement probabilities for each sample person and how this has changed from 1985 to 2018. We also used this model to compute counterfactual retirement probabilities, i.e., estimates of how retirement probabilities would have changed if public pension policies in Germany had remained unchanged after 1985. The difference between the counterfactual retirement probabilities and the predicted baseline probabilities can be interpreted as the causal effect of the sequence of pension reforms that took place between 1985 and 2018 in Germany.

We find that for men in couple households the predicted and counterfactual retirement probabilities start to deviate from each other after about the year 2000. This coincides with the introduction of the actuarial deductions as legislated in the 1992 reform. Overall, we find that the reforms that have taken place between 1985 and 2018 explain almost three quarters (72%) of the observed reduction in retirement probability over this time span. We also find that our model relates an increase of about 0.3 years in the average retirement age to the reform-driven change of the implicit tax on working longer. In the analysis on the average retirement age, however, the reforms in our model can explain clearly less (26%) of the overall increase in expected retirement age observed between 1985 and 2018. Thus, the increase in our model is substantially less than the actual increase, which was around 1.5 years.[15] One reason may be that ITAX captures only part of the changed policy environment. Other parts of this environment include the general awareness of population aging and related or unrelated changes in the preference for work vs. leisure in the age range under consideration. Moreover, the closure of entire pathways such as the pathway for women and the pathway for unemployment may only partially be reflected in the construction of our main incentive variable ITAX.

This paper only observes labor supply reactions until 2019, the last year of our data. We therefore do not observe reactions to further changes that have already been legislated, especially the gradual increase of the retirement age which will last until 2030. Future research has to show whether this gradual change will increase the actual retirement age in Germany even further.

[15] Actual retirement age for men was 62.5 in 1980 and 64 in 2018.

**REFERENCES**

Börsch-Supan, A., and C. Coile (2020): 'Social Security Programs and Retirement around the World: Reforms and Retirement Incentives', University of Chicago Press, Chicago.

Börsch-Supan, A., and I. Ferrari (2019): 'Old-Age Labor Force Participation in Germany: What Explains the Trend Reversal among Older Men and the Steady Increase among Women?', in Coile, C., K. Milligan and D. Wise (eds.): *Social Security Programs and Retirement Around the World: Working Longer*, University of Chicago Press, Chicago, Chapter 5, pp. 117-145.

Börsch-Supan, A., J. Rausch, and N. Goll (2020): 'Social security reforms and the changing retirement behavior in Germany', in Börsch-Supan, A. and C. Coile (eds.): *Social Security Programs and Retirement around the World: Reforms and Retirement Incentives*, University of Chicago Press, Chicago, Chapter 5, pp. 175-226.

Charni, K., and S. Bazen (2017): 'Do earnings really decline for older workers?', *International Journal of Manpower*, 38(1), pp.4-24.

Coile, C., and J. Gruber (2001): 'Social security incentives for retirement. In Themes in the Economics of Aging', pp. 311–354. University of Chicago Press.

Deutsche Rentenversicherung Bund (2018): 'Rentenversicherung in Zahlen 2018', https://www.deutsche-rentenversicherung.de/cae/servlet/contentblob/238692/publicationFile/61815/01_rv_in_zahlen_2013.pdf.

Deutsche Rentenversicherung Bund (2022): *Statistikportal der Rentenversicherung,* [https://statistik-rente.de/drv/], 01.03.2022.

Ellguth, P., and B. Koller (2000): 'Frühverrentung: Arbeitsmarktentlastung durch Altersteilzeit', *IAB Materials* Nr. 1, pp. 4-5.

Eurostat (2022): 'Employment rates by sex, age and degree of urbanisation (%)', [https://ec.europa.eu/eurostat/de/web/main/data/database], 30.3.2022.

German Federal Statistical Office (2022): 'Bevölkerung, Erwerbstätige, Erwerbslose, Erwerbspersonen, Nichterwerbspersonen aus Hauptwohnsitzhaushalten: Deutschland, Jahre, Geschlecht, Altersgruppen', Table 12211-0001', [https://www.destatis.de/DE/Themen/Arbeit/Arbeitsmarkt/Erwerbstaetigkeit/datenbank-teaser.html], 30.03.2022.

Gruber, J., and D. A. Wise (2004): 'Social Security Programs and Retirement around the World: Micro-Estimation'. University of Chicago Press.

Hurd, M. (1990): 'Research on the elderly: Economic status, retirement, and consumption and saving'. Journal of Economic Literature 28(2), pp.565–637.

Myck, M. (2010): ‘Wages and ageing: Is there evidence for the ‘Inverse-U’ profile?’, Oxford Bulletin of Economics and Statistics, 72(3), pp. 282-306.

Wanger, S. (2010): ‘Die Altersteilzeit im Zusammenspiel individueller und betrieblicher Einflussfaktoren’, *WSI Notifications*, Vol. 63, No. 8, pp. 395-403.

**APPENDIX**

**A.1.: Regression estimates including social security wealth (SSW).**

**Table A.1: Regression estimates for single households (accrual rate). Marginal effects of random effects probit model.**

| | SINGLE MALES | | | | SINGLE FEMALES | | | |
|---|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
| | | | | | | | | |
| **Accrual rate** | -0.038 | -0.038 | -0.051 | 0.040 | -0.021 | -0.020 | -0.019 | -0.129 |
| ***p-value*** | *0.301* | *0.307* | *0.226* | *0.571* | *0.234* | *0.240* | *0.270* | *0.899* |
| **Average EP** | | -0.006 | -0.015 | -0.023 | | -0.005 | 0.008 | -0.027 |
| ***p-value*** | | *0.245* | *0.123* | *0.151* | | *0.669* | *0.672* | *0.890* |
| **SSW/100000** | | | 0.010 | 0.025 | | | -0.009 | 0.035 |
| ***p-value*** | | | *0.086* | *0.123* | | | *0.346* | *0.920* |
| **Age dummies** | X | X | X | X | X | X | X | X |
| **Control variables** | | | | X | | | | X |
| **Observations** | 5,227 | 5,227 | 5,227 | 4,203 | 3,334 | 3,334 | 3,334 | 2,599 |

Source: Own calculations.

**Table A.2: Regression estimates for couple households (accrual rate). Marginal effects of random effects probit model.**

| | COUPLE MALES | | | | COUPLE FEMALES | | | |
|---|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
| | | | | | | | | |
| **Accrual rate** | -0.298 | -0.311 | -0.327 | -0.271 | -0.141 | -0.139 | -0.157 | -0.066 |
| ***p-value*** | *0.003* | *0.002* | *0.003* | *0.025* | *0.001* | *0.001* | *0.000* | *0.348* |
| **Average EP** | | -0.030 | -0.033 | -0.023 | | 0.006 | 0.001 | -0.027 |
| ***p-value*** | | *0.000* | *0.000* | *0.007* | | *0.546* | *0.895* | *0.049* |
| **SSW/100000** | | | 0.002 | 0.008 | | | 0.003 | -0.003 |
| ***p-value*** | | | *0.511* | *0.063* | | | *0.258* | *0.330* |
| **Age dummies** | X | X | X | X | X | X | X | X |
| **Control variables** | | | | X | | | | X |
| **Observations** | 7,491 | 7,491 | 7,491 | 5,983 | 8,270 | 8,270 | 8,270 | 5,932 |

Source: Own calculations.

**Table A.3: Regression estimates for single households (ITAX). Marginal effects of random effects probit model.**

| | SINGLE MALES | | | | SINGLE FEMALES | | | |
|---|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
| | | | | | | | | |
| **ITAX** | 0.002 | 0.002 | 0.036 | 0.046 | -0.009 | -0.007 | 0.001 | 0.120 |
| ***p-value*** | *0.908* | *0.881* | *0.065* | *0.043* | *0.683* | *0.752* | *0.960* | *0.010* |
| **Average EP** | | -0.011 | 0.001 | -0.001 | | -0.006 | 0.020 | 0.027 |
| ***p-value*** | | *0.085* | *0.781* | *0.927* | | *0.619* | *0.198* | *0.163* |
| **SSW/100000** | | | -0.015 | -0.003 | | | -0.019 | -0.012 |
| ***p-value*** | | | *0.001* | *0.490* | | | *0.010* | *0.237* |
| **Age dummies** | X | X | X | X | X | X | X | X |
| **Control variables** | | | | X | | | | X |
| **Observations** | 5,598 | 5,598 | 5,598 | 4,480 | 3,669 | 3,669 | 3,669 | 2,859 |

Source: Own calculations.

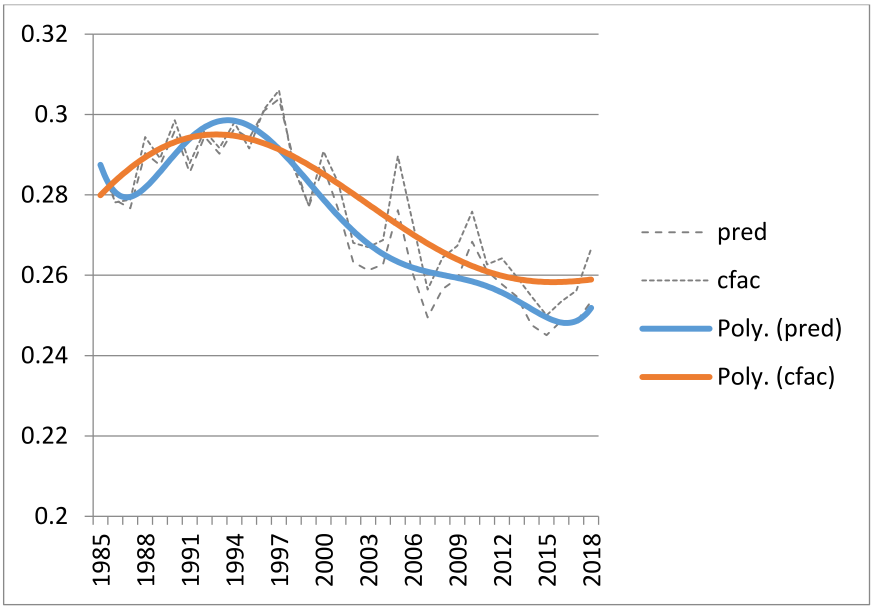
**Table A.4: Regression estimates for couple households (ITAX). Marginal effects of random effects probit model.**

| | COUPLE MALES | | | | COUPLE FEMALES | | | |
|---|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
| | | | | | | | | |
| **ITAX** | 0.062 | 0.072 | 0.104 | 0.122 | 0.060 | 0.060 | 0.057 | 0.057 |
| ***p-value*** | *0.002* | *0.000* | *0.000* | *0.000* | *0.000* | *0.000* | *0.001* | *0.017* |
| **Average EP** | | -0.032 | -0.014 | -0.009 | | 0.003 | 0.006 | -0.025 |
| ***p-value*** | | *0.000* | *0.019* | *0.214* | | *0.704* | *0.562* | *0.048* |
| **SSW/100000** | | | -0.017 | -0.008 | | | -0.001 | -0.003 |
| ***p-value*** | | | *0.000* | *0.023* | | | *0.477* | *0.261* |
| **Age dummies** | X | X | X | X | X | X | X | X |
| **Control variables** | | | | X | | | | X |
| **Observations** | 7,851 | 7,851 | 7,851 | 6,267 | 8,683 | 8,683 | 8,683 | 6,216 |

Source: Own calculations.

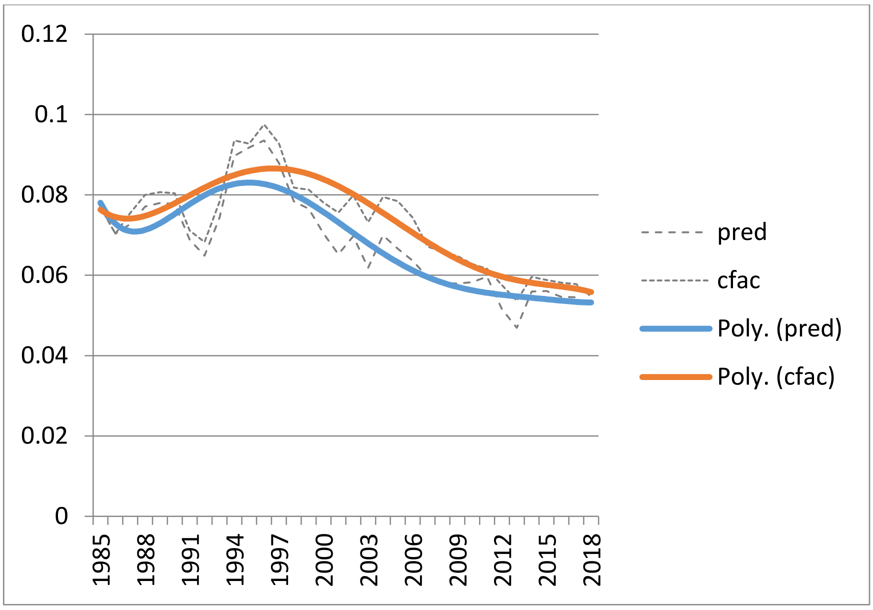
A.2.: Counterfactual simulations including social security wealth (SSW)

**Figure A.5: Counterfactual simulations including social security wealth (SSW): average retirement probability for age 55-65.**



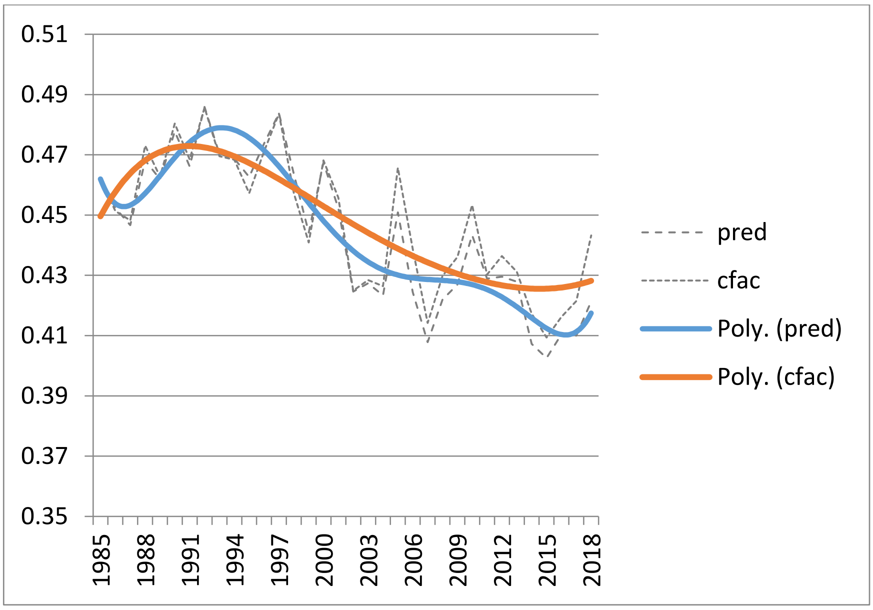

Source: Own calculations.

**Figure A.6: Counterfactual simulation including social security wealth (SSW): average retirement probability for age 55-59.**



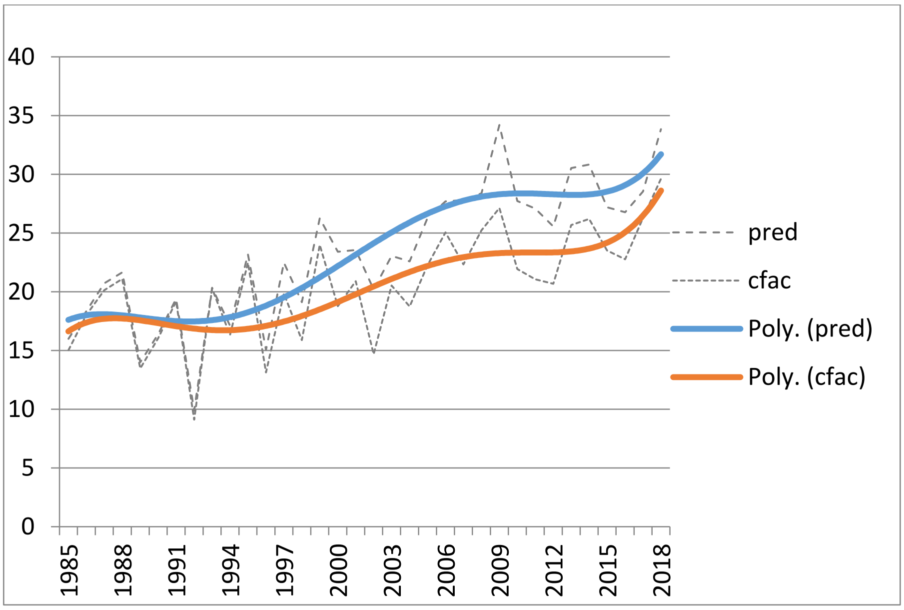

Source: Own calculations.

**Figure A.7: Counterfactual simulation including social security wealth (SSW): average retirement probability for age 60-65.**



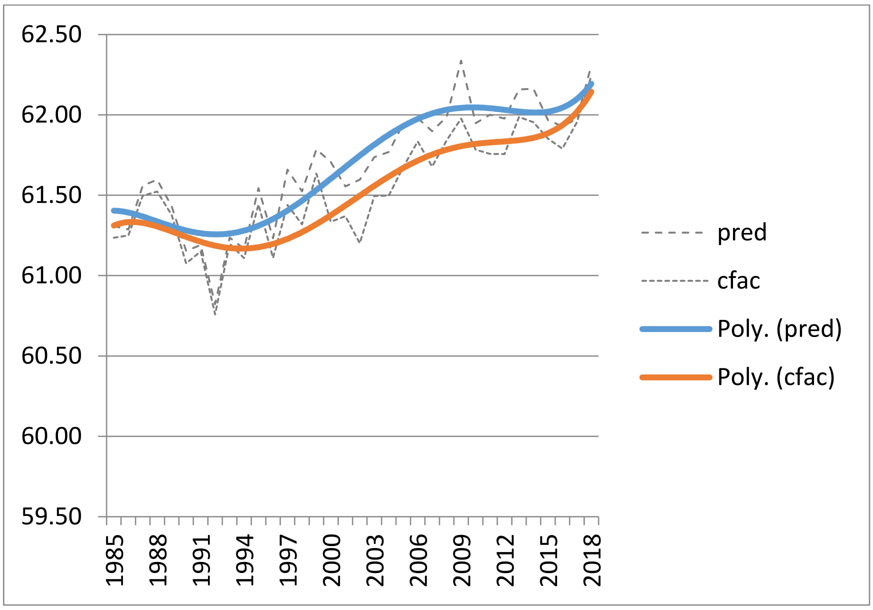

Source: Own calculations.

**Figure A.8: Counterfactual simulation including social security wealth (SSW): percentage of individuals still working at age 65.**



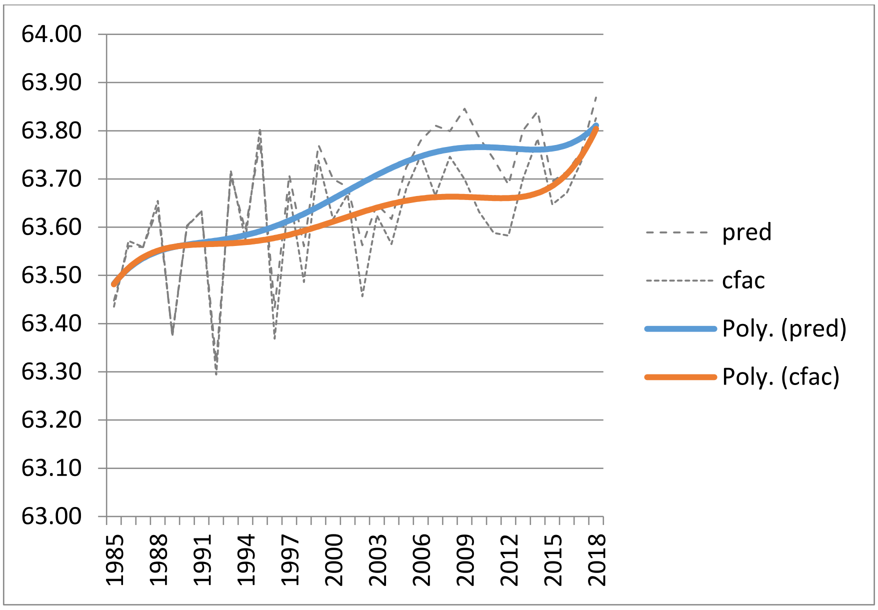

Source: Own calculations.

**Figure A.9: Counterfactual simulation: expected retirement age at age 55.**




Source: Own calculations.

**Figure A.10: Counterfactual simulation: expected retirement age at age 62.**




Source: Own calculations.