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General Introduction

Motivation

A country's social policy comprises various political measures that aim at improving the social and economic situation of its citizens. Due to financial constraints efficiency plays a key role in social policy. This is closely interconnected with individual behavior because individuals react to changes in their socio-political environment by adjusting their labor market behavior. Policy-makers take this into account by implementing policies that aim at steering individuals towards more efficient behavior but individual reactions to these policies can also lead to sub-optimal outcomes. For example, an increase in financial student aid affects university enrollment and subsequent degree attainment (Dynarski, 2003) but the effect on degree attainment can be more or less efficient depending on the design of the program (Scott-Clayton, 2011); recent retirement policies are meant to encourage potential early retirees to increase their labor supply but spillover effects towards individuals at already high levels of labor supply might undermine the goals of such policies (Huber et al., 2016). Policy reforms change the incentive structure underlying individual decision making. What was optimal from an individual perspective before a reform does not need to be optimal after reform. This is what lies at the heart of the famous Lucas-critique (Lucas, 1976) which was an important driver of the paradigm shift in economic theory in the 1970s. It is thus imperative to the efficiency of public policy[1] to understand how individuals react to policy changes.

Two strands of social policy are the focus of this dissertation: (1) education, and (2) pension politics. Both play a major role in state budgets and in 2013 public spending in these sectors amounted to 8.0 % and 8.2% of GDP in OECD countries. Chapter one analyses the role of time preferences in how an increase in financial student aid -as a grant and as loan- affects schooling attendance and degree attainment. Chapters two and three focus on the effect of partial retirement on labor supply, fiscal balances and the income distribution.

There is no doubt that education is a key driver of economic growth (Barro, 1998; Lindahl and Krueger, 2001). Returns to one additional year of education range between 6 and 16% (Card, 1999) which in turn raises public funds through income taxation and social security contributions. It is therefore not surprising that all OECD countries provide public financial aid -either through lower study fees or student loans/grants- with the aim of increasing access and overall degree attainment in education (see OECD, 2016). In Germany financing education has since the 1990s undergone several fundamental reforms that included changing the student loan system to a partial loan-grant system (1990), extending the eligibility and the amount of financial student aid (2001), or introducing (2007) and abolishing (from 2008) study fees. Thus, in many countries with Germany being a noteworthy example, public involvement in student decisions is high. Understanding underlying mechanisms in the success of these policies in steering individuals towards more education is crucial to the success of educational policy. Therefore,

[1] Although social policy is a subset of public policy both terms are used interchangeably in this dissertation.

Chapter one sheds light on the relevance of time-inconsistent behavior for the effectiveness of financial student aid on schooling take-up and degree attainment. Population aging is increasing the financial burden on pay-as-you go funded public pension systems in many countries. The sustainability of such pension systems has become subject to intense political debate as demographic change leads to an increase in recipients relative to contributors. From 1970 to 2013 the share of the elderly population (people aged 65 and older) has risen from 11.46% to 18.37% in the European Union. With a rise from 13.18% to 21.45% in the same time interval, Germany has one of the steepest increases in the elderly population, globally. Moreover, public spending in pensions amounted to 10.1% of GDP in Germany in 2013 which is above the OECD average of 8.2%. Hence, population aging is a pressing problem for many countries and for Germany in particular. Therefore, most OECD countries introduced pension reforms that aim at increasing the labor supply among the elderly and at alleviating the decline of the working population. Reforms include tighter qualifying conditions or even the closing of early retirement routes as well as increases in the early or normal retirement age[2], the introduction of actuarial deductions for early retirement, or a combination of these policies. Most of these reforms, in fact, generate positive employment effects among the elderly population (see e.g. Staubli, 2011; Staubli and Zweimüller, 2013; Manoli and Weber, 2016, for some studies on each policy) but at the expense of restricting individual choice and potential program substitution effects in retirement (see e.g. Atalay and Barrett, 2015) that alleviate the fiscal gains from increased retirement age. In contrast, more recent policies try to reconcile the expansion of individual retirement choice with incentives for later retirement entry by enabling more

[2]This is the age at which people can first draw full benefits without actuarial deductions. It corresponds to the OECD defintion of *"pensionable age"*

flexible transitions into retirement. Partial retirement schemes allow for a gradual reduction of work hours in the last years before entering full retirement. In some schemes, income in partial retirement is a combination of part-time labor earnings and partial pension receipt. Several countries have already introduced partial retirement programs into their public pension systems (Eurofound, 2016) and, as a response to an increased normal retirement age, Germany is in the process of making retirement transitions more flexible.

There are many arguments for the implementation of partial retirement. First, there is a high demand for partial retirement as stated in various employee surveys: 45% of employees above age 50 in the EU and 49% of employees above age 55 in Germany would like to enter retirement gradually by reducing working hours (Eurofound, 2014; DGB, 2014). Meeting this demand could increase work satisfaction which in turn motivates people to work longer (Reday-Mulvey, 2000). Stated preference analysis indicates that people can be motivated to work past the normal retirement age if they were offered the option to combine part-time work with pensions (Van Soest et al., 2007). Second, it can help employees avoid a shock due to a sudden change in living conditions by allowing for a transition phase instead of an early full employment exit (Reday-Mulvey and Delsen, 1996). Third, people in poor health could have the opportunity to reduce working hours but still remain in the labor force (Pagán, 2009) which may curtail cognitive decline in higher ages (Rohwedder and Willis, 2010; Bonsang et al., 2012). Finally, employers could use partial retirement to maintain their human capital by keeping experienced workers with hard to replace skills in order to teach newly hired workers and reduce adjustment costs (Latulippe and Turner, 2000; Munzenmaier and Paciero, 2002).

Nevertheless, employment effects that arise from such partial retirement policies are ambiguous because, as per construction, partial retirement substitutes alternative retirement paths with inherently more labor supply (if it crowds out full-time employment) or less labor supply (if it substitutes early retirement or non-employment). The sign and the size of employment effects strongly depend on the design of partial retirement policies. Therefore, it is important to understand the mechanisms of partial retirement on the labor market. Hence, Chapters two and three analyze how different margins in partial retirement policies affect the take-up of partial retirement as well as the take-up of alternative employment states.

Methodological approach

All chapters of this dissertation apply dynamic structural life-cycle approaches to model individual decisions in a modern welfare state. In this line of modeling, researchers study particular margins in each context and analyze the underlying channels that drive the observable outcomes to a specific policy. This is done by explicitly modeling both individual behavior and the policy. From this perspective policy outcomes are the result of forward-looking individuals that maximize their present discounted utility by making decisions between options that are offered in a specific policy environment. Decisions are made in a dynamic context, i.e. at multiple periods and are subject to frequent information updates.

In a dynamic structural model, individual behavior comprises beliefs about and preferences for each potential choice in the policy environment. Preferences are usually divided into consumption-related and other factors and beliefs contain an individual's expectations about future outcomes that can also be subject to uncertainty. Assumptions need to be made about an individual's risk aversion and discounting of future utility. In addition, modeling the policy environment means specifying the sources of uncertainty, like labor market or health frictions as well as the sources of consumption and other utility components for each potential option in every period. This further requires the explicit implementation of the institutional background and the tax and transfer system. Thus, the endogeneity problem that usually arises when trying to measure policy outcomes is addressed by explicitly modeling the factors of individual behavior that lead to that outcome. The dynamic perspective is a particular strength of this research approach. Both education and retirement are life-cycle stages and as such exhibit a dynamic nature. It is a key feature of the life-cycle hypothesis that individuals in their life-cycle decisions face an intertemporal consumption trade-off (Modigliani and Brumberg, 1954). In other words, present actions affect future outcomes. This translates into the economics of education through human capital theory (Becker, 1964) which states that investments in human capital (such as education) yield higher income in the future. That is, in education individuals face short-term costs -in the form of schooling efforts and opportunity costs of foregone earnings- for the benefit of higher income in the long run.

In Chapters two and three the dynamics in retirement behavior are governed by an underlying public pension system which -like many public pension systems- is a compulsory defined benefit system. Throughout their working lives individuals contribute a percentage of their income to pensions and pension annuities depend on amounts and years contributed to the system. Again, in the decision to retire the individual faces short-term costs of labor (i.e. foregone leisure) for the benefit of higher pension annuities in the long run due to increased pension contributions.

Modeling these dynamic incentives is relevant because individuals take their future pension benefits into consideration when making retirement decisions (Coile and Gruber, 2007).

Thus, in all chapters of this dissertation the research question is approached using the dynamic structural life-cycle method. This may give the impression that I have picked my side on the most heated debate in modern empirical microeconomics: the conflict between *(quasi-)experimental* and *structural* econometricians which even caught the attention of The Economist.[3] However, instead of restricting myself to one side, I see both approaches complementing each other. The experimental approach focuses on the credible identification of a causal effect, the structural approach on underlying mechanisms. Both are important contributions to policy evaluation but this dissertation focuses more on *'the role'* of potentially transmitting channels in an established relationship, i.e. on mechanisms. For this purpose, it takes advantage of the strengths of the structural method in answering the research questions at hand, such as the incorporation of dynamics (as mentioned above), the ability to disentangle different mechanisms of a policy impact or the ability to perform counterfactual policy simulations. At the same time, I remain aware of potential weaknesses of this approach. The strongest argument against the structural approach is that it relies heavily on (unverifiable) economic assumptions. I address this problem through proofs of in-sample fit, sensitivity checks and the embedding of the findings in the literature. For instance, Chapter one tests a standard assumption in the dynamic structural literature, and provides a sensitivity check on the specification of a key structural parameter. All chapters contain a discussion of the in-sample fit and whenever adequate, I compare

[3]see e.g. Angrist and Pischke (2010) and Wolpin (2013) for statements from some of the most prominent advocates for each side.

my findings to similar studies that use alternative methods. What follows is an overview of the dissertation.

Overview and contributions

Chapter one is inspired by the famous Stanford marshmallow experiment which first highlighted a link between patience and educational success (Mischel et al., 1989). It sheds light on the role of individual time preferences in educational decision making. This is in line with the literature that evolves around the implementation of behavioral biases in empirical analysis using revealed-preference approaches (e.g. DellaVigna and Paserman, 2005; Paserman, 2008; Fang and Silverman, 2009). Chapter one relates most to Belzil and Hansen (1999) and Oosterbeek and van Ophem (2000), who study the role of the discount factor in education based on a model with exponential discounting.

This chapter contributes to the literature by augmenting a dynamic structural model of educational choice by a behavioral bias in its time preferences: hyperbolic discounting (Laibson, 1997; O'Donoghue and Rabin, 1999). Then, it sheds light on how much the functional form of patience in an economic choice model matters for policy evaluation. This is done by comparing policy simulations of this model with a version of the same model with more restrictive exponential time preferences. The exponential model is nested as a corner solution within the same model with hyperbolic discounting in order to ensure comparability between both models. As opposed to exponential discounting, hyperbolic discounting is time-inconsistent. It yields that valuations drop rapidly for early delays but fall less markedly for delays between any two future points in time.

The estimation is based on the German Socioeconomic Panel (SOEP). The parameters of discounting are identified not only on the basis of the functional form assumptions but also, in the spirit of Fang and Wang (2015) and Haan et al. (2017), by imposing exclusion restrictions that affect educational choices indirectly through their impact on individual expectations on future educational success. This reveals information on the discounting behavior. Birth cohort groups as well as regions that were affected by different educational policy reforms are used as exclusion restrictions and their relevance on the time invested for the attainment of educational degrees is shown. Therefore, agents are assumed to face uncertainty over the success of schooling take-up. The estimation of the structural parameters of the choice model indicates time-inconsistent behavior and provides quantitative evidence for its relevance.

Another contribution refers to an evaluation of the relevance of time-inconsistent behavior for the effectiveness of education policies. For this purpose, two policies are simulated where time preferences may play an important role: (1) an increase in financial student aid as a grant for students as a way to affect short-term costs while at school; and (2) an increase in financial student aid as a loan which will have to be paid back after the end of the education. The findings show substantial differences in the effects of these policies when comparing educational outcomes based on a model specification with hyperbolic discounting with the ones based on a specification with exponential discounting. Quantitatively, these estimates are in line with the effect sizes found by Steiner and Wrohlich (2012) who use a discrete-time hazard rate model for Germany. Furthermore, the response to the two policies differs more for exponential than for hyperbolic discounters. Hence, the common assumption of exponential discounting in educational decisions may be too restrictive.

Chapters two and three focus on the effect of partial retirement on labor supply public balances and the income distribution in retirement. From an empirical research perspective partial retirement poses a particular challenge. Simulating other pension reforms, such as the tightening of restrictions, increasing retirement ages, implementing financial (dis-)incentives for (earlier) later retirement, or the closing of retirement paths usually requires the change of one policy parameter in a well defined policy environment. In contrast, partial retirement is a more complex policy package that requires the definition on several margins, such as entry age, timing of pension benefits, taxation or the amount of reduction in works hours. In this dissertation this problem is addressed by identifying partial retirement preferences based on an existing policy that allows for the reduction of work hours by 50% (without part-time wage penalties or early pension benefits) in the same job that is held in the last years prior to retirement. Chapter two develops the model and simulates the implementation of partial retirement as specified in the underlying policy. Chapter three implements an additional aspect to partial retirement: the combination of part-time labor earnings and partial pension receipt. In this chapter income in partial retirement is a combination of part-time labor earnings and a share of earlier pension benefits. This changes the dynamics in income dynamics in partial retirement with respect to the settings in Chapter two. This chapter analyzes two particularly important margins of partial retirement in more detail: entry age and the timing of pension benefits.

Chapter two focuses on the effect of partial retirement on employment and retirement behavior, fiscal balances and the pension income distribution. For this purpose it augments a dynamic structural retirement model (Rust, 1989) by the additional option of partial retirement. The basic model consists of an individual's annual choice to continue working or exit employment through one of three possible retirement paths: regular retirement, retirement via bridge unemployment, or retirement via partial retirement. The choice is subject to individual employment and mortality risks. In addition, the model incorporates a tax and transfer system as well as the specification of the pension system rules.

This chapter contributes to the literature by providing evidence on the consumption smoothing potential of partial retirement for retirees in lower income deciles in the context of a reform that increases the normal retirement age. Therefore, a dynamic structural model of retirement decisions is used to estimate structural parameters of individual employment behavior based on a a sample of West German men from an administrative dataset. Then, this is used to compare findings from simulations of partial retirement with the pre-reform normal retirement age of 65 to outcomes of the same simulation with the post-reform normal retirement age of 67. The results show that introducing the option to retire via partial retirement reduces the average retirement age but still extends working lives by about four to five months by reducing the number of individuals exiting employment early via unemployment. In terms of the effect direction, these outcomes relate to findings from Huber et al. (2016) on the policy evaluation of partial retirement among West German men.

However, overall employment volume decreases upon the introduction of partial retirement although less so at an increased normal retirement age. This finding

suggests that in the context of an increased normal retirement age more people bridge the time between the early retirement age and the normal retirement age with partial retirement. This behavior leads to an increase in individual pensions in lower income deciles and thus consumption smoothing in the transition to retirement upon the introduction of partial retirement.
The second contribution of this chapter refers to the role of compensating wage and pension accrual subsidies in partial retirement. For this purpose, the simulation of the scenario with a normal retirement age at 67 is repeated with subsidies for income and pension accrual in partial retirement. These subsidies have the same specifications as in the underlying policy.[4] The results show that subsidizing partial retirement leads to a greater reduction in employment volume due to partial retirement than the same policy without subsidies (A decrease by 10% compared to the previous 3.86%). In addition, due to the implementation of partial retirement net public balances reduce by an additional 13,500€ more per person when partial retirement is subsidized. Finally, this chapter shows that independent of the normal retirement age and subsidy payments, the implementation of partial retirement leads to a reduction in pension income inequality.

Chapter three sheds light on the role of two particularly important margins in partial retirement: (1) the entry age and (2) the timing of pension benefits and analyzes how variations in these two margins affect employment and fiscal balances. It uses the model developed in Chapter two and takes advantage of the structural approach by disentangling effects from different margins in the policy

[4] Labor earnings and pension accrual in partial retirement are reduced without part-time wage penalties. Subsidies increase wages in partial retirement by 20% of full-time wages pension accrual by 40% of full-time pension accrual.

in detail instead of evaluating one *'policy package'* as a whole. This study is motivated by the fact that partial retirement is implementated in many countries (see e.g. Eurofound, 2016) despite its ambiguous findings from the literature on labor market outcomes (see e.g. Ghent et al., 2001; Wadensjö, 2006; Huber et al., 2016). The sign and the size of employment effects strongly depend on the design of partial retirement policies. Thus, Chapter three addresses the question under which conditions on entry age and the timing of pension benefits in partial retirement can yield beneficial results from a policy-maker's perspective. This is the first study that disentangles the role of different policy margins in the effect of partial retirement on labor market outcomes.

The analysis yields that employment effects of partial retirement are negative when individuals can enter partial retirement more than two years before the early retirement, i.e. before the age of 61. In contrast, employment effects are positive when people have access to partial retirement from the age of 61; the employment volume increases by 0.05 to 2.4 percentage points while these effects are higher the later the entry age. Moreover, partial retirement improves public balances for policies that allow access at any age in seven years before the normal retirement age. The fiscal plus is higher the earlier the partial retirement entry age. Allowing for pension benefit receipt in partial retirement can incentivize its take-up but individual pensions are lower the higher the share of these early pension benefits. In contrast, individual pensions even improve when no pensions benefits are paid out in partial retirement. Thus, limits to pension benefits in partial retirement are necessary to prevent substantial reductions in individual pensions and increased risk for retirees with low income to become subject to social assistance.

Chapter 1

The Role of Time Preferences in Educational Decision Making[1]

1.1 Introduction

Economists have long understood the key role of education for economic growth (Barro, 1998; Lindahl and Krueger, 2001). The estimates of the returns to one additional year of education range between 6 and 16% (Card, 1999). As a consequence, many educational policies aim at increasing educational investments of students (e.g. student grants or loans). While the design of successful education policies requires a good understanding of the underlying mechanisms of educational choices, the inter-temporal preferences of students are not yet fully understood. In this study, we contribute to closing this gap in our knowledge by investigating

[1]This chapter is based on joint work with Daniel Kemptner. Valuable comments by Peter Haan, Jaap Abbring, and Ulrich Schneider as well as by participants at the EEA-ESEM Congress 2016, and the Applied Microeconomics Seminars at Tilburg University and the DIW Berlin are gratefully acknowledged. An earlier version of the paper has been published as a *DIW Discussion Paper* (Kemptner and Tolan, 2016).

the role of time discounting within a structural dynamic choice model.

The famous Stanford marshmallow experiment first highlighted the strong positive link between patience and educational attainment (Mischel et al., 1989). We extend this literature by analyzing how much the functional form of patience in an economic choice model matters for policy evaluation. We do this by deviating from the assumption of exponential discounting and allow for time-inconsistent preferences through hyperbolic discounting. In the spirit of Magnac and Thesmar (2002), Fang and Wang (2015) and Chan (2013), we estimate not only an exponential discount factor, but also an additional parameter that captures hyperbolic discounting.[2] Behavioral responses to education policies hinge on intertemporal preferences because individuals trade off short-term costs against potential future returns on the educational investments. Hence, the way people discount is likely to have an important impact on the effectiveness of policies that decrease the short-term cost of education or increase its long-term benefits.

In this paper, we make two important research contributions. First, we use the German Socioeconomic Panel (SOEP), to estimate a dynamic structural model of educational choices that allows for hyperbolic discounting. The estimation is based on a sample of West German students. In line with Magnac and Thesmar (2002), Chan (2013), Fang and Wang (2015), and Haan et al. (2017) we achieve identification not only on the basis of our functional form assumptions but also impose exclusion restrictions that affect educational choices indirectly through their

[2]The analysis of potential deviations from standard assumptions in economic models is receiving increasing interest in the empirical literature (Fang and Silverman, 2006). One formalization of time-inconsistent preferences is hyperbolic discounting (Laibson, 1997; O'Donoghue and Rabin, 1999; O'Donoghue and Rabin, 1999). While the hyperbolic discounter discounts exponentially between any two subsequent payoffs made in a distant future, she might change her preferences and put a higher weight on the more immediate payoff once she approximates the point in time when the first payoff is made.

impact on the transition probabilities of relevant state variables and reveal information on the discounting behavior. We use birth cohort groups as well as regions that were affected by different educational policy reforms as exclusion restrictions and show their relevance on the time invested for the attainment of educational degrees. Agents are assumed to face two kinds of uncertainty: (1) there is uncertainty over whether an additional year invested into education will, in fact, be successful and lead to a degree (affected by the policy reforms); and (2) there is uncertainty over the returns to the degree earned when exiting education. The estimation of the structural parameters of the choice model indicates time-inconsistent behavior and provides quantitative evidence for its relevance.

Our second contribution to the literature refers to an evaluation of the relevance of time-inconsistent behavior for the effectiveness of education policies. For this purpose, we simulate two policies where time preferences may play an important role: (1) an increase in the state grant for students as a way to affect short-term costs while at school; and (2) an increase in the state grant as a loan which will have to be paid back after the end of the education. We investigate whether present-biased preferences matter for educational decisions depending on whether financial support during the educational time is a grant or a loan. We find substantial differences in the effects of these policies when comparing educational outcomes based on a model specification with hyperbolic discounting with the ones based on a specification with exponential discounting. Furthermore, the response to the two policies differs more for exponential than for hyperbolic discounters.

Aiming at a better understanding of educational decisions, other studies analyze the role of socio-economic background (Cameron and Heckman, 2001), preferences and abilities (Eckstein and Wolpin, 1999), uncertainty and sequential information updates (Carneiro et al., 2003; Heckman et al., 2005), as well as individuals' risk aversion (Belzil and Leonardi, 2007).

Experimental results in behavioral economics indicate hyperbolic behavior in intertemporal decision making (see Giné et al. (2010) for a review and Cohen et al. (2016) for a discussion of the predictive power of such experiments). There are a number of studies implementing quasi-hyperbolic discounting in dynamic discrete choice models – an approximation to hyperbolic discounting in discrete time (Laibson, 1997). Magnac and Thesmar (2002) show that basic dynamic structural models are underidentified if the discount factor is estimated along with the other structural parameters. A large share of the literature addresses this identification problem and tries to estimate the discount factor in both exponential and hyperbolic settings. For instance, Fang and Silverman (2009) estimate the discount factor in a dynamic choice model of labor supply and welfare take-up of single mothers. Their results suggest a significant present bias factor and a better fit to the data when allowing for hyperbolic discounting. Similarly, Paserman (2008) rejects the hypothesis of exponential discounting for low-wage workers when implementing and estimating hyperbolic discounting in a job search model. Further literature on the implementation and/or estimation of hyperbolic discounting include Laibson et al. (2007), who estimate short and long term discount rates in a structural buffer-stock consumption model, DellaVigna and Paserman (2005), who study the role of time preferences in job search, Tobacman and Skiba (2005), who explain the behavior of payday loan borrowers with hyperbolic discounting, and Gustman and Steinmeier (2012), who looks at hyperbolic discounting in the context of retirement.

In our study, we exploit two advantages of structural models: (1) the possibility to investigate channels that may drive the schooling decision; and (2) the possibility to simulate counterfactual policy changes. For this purpose, we set up a life-cycle model in a dynamic discrete choice framework. In education economics, this approach is pioneered by Keane and Wolpin (1997) and discussed by Heckman et al. (2016). Keane and Wolpin (1997) use their parameter estimates to simulate the effect of a college fee subsidy on educational decisions while risk attitudes or time preferences remain unidentified. Our study relies on the basics of the model formulated by Belzil and Hansen (2002). It is an optimal stopping model in which the agents make annual decisions to remain in education or to exit to the labor market. Our work relates to Belzil and Hansen (1999) and Oosterbeek and van Ophem (2000), who study the role of the discount factor in education and its relation to the socioeconomic background based on a model with exponential discounting.

This paper is structured as follows. First, we present the model together with the institutional background. Model solution and estimation results are discussed in the subsequent sections. In section 1.5, we show the estimation results and model fit. Section 1.6 presents the policy simulations and section 1.7 concludes.

1.2 Model and Institutions

Our basic model setup is drawn from Belzil and Hansen (2002). Individuals have rational expectations and maximize their present discounted value of expected lifetime utility by making annual schooling choices. Each year, they decide between continuing to go to school and exiting. Exit from school is defined as an absorbing state (optimal stopping problem). We distinguish between actual years of schooling and successful years of schooling. That is, when an individual invests an additional year at school, she faces uncertainty regarding the success of this year. By assumption, individuals leave school at the latest after 26 actual years in education or after having earned a Master's degree at university (highest degree observed), corresponding to 18 successful years of schooling. In this model setup, a transition to an increase in successful years of schooling can be interpreted as degree attainment.

In Germany, compulsory elementary school typically starts at age 6 and lasts four years until the age of ten. Subsequently, students continue their education on one of three tracks: (1) lower secondary education (five years); (2) intermediate secondary education (six years; typically preparing for vocational training); or (3) higher secondary education (eight or nine years, leads to the *Abitur*, the university entrance degree). Hence, individuals only start making educational choices after having spent nine years in school. Sorting into education tracks is based on ability, teacher recommendations, and parental choices. However, it is a special aspect of the German educational system that individuals can switch between tracks. Students who start off on a non-academic track have more than one chance to switch to higher secondary education in order to pursue, ultimately, university education. Some students also switch from the academic track to the non-academic track. And it is not uncommon for students with a university entrance degree to opt for vocational training instead of a university education after earning their *Abitur*. Due to this switching behavior, we follow Belzil and Hansen (2002) and model educational choices as a choice about staying in school rather than the schooling track.

In our model, the individual's information set at the beginning of each period t consists of her age, cohort, successful years of schooling at time t, and region. There are two sources of uncertainty. On the one hand, the decision maker faces uncertainty over the success of one additional year of schooling. On the other hand, she faces uncertainty over her returns to schooling when she decides to exit education. The model accounts for both unobserved heterogeneity in schooling preferences and returns to schooling. We abstain from an explicit implementation of labor market processes. Instead, we exploit information on life cycle income profiles by successful years of schooling. Individuals form expectations over the distribution of these profiles according to their successful years. After exiting school, they receive a random draw from the respective distribution of lifetime income profiles.

1.2.1 Objective Function and Hyperbolic discounting

Individuals maximize their present discounted expected utility streams over the life-cycle. They are indexed by n and discrete time, the agent's age, is indexed by t. The decision period ranges from age 16 to 33, which corresponds to the interval of actual schooling years [9;26]. We model individual utility from age 16 to $T = 70$. The utility flow at age t, $U(S_{n,t}, d_{n,t})$, depends on a vector of state variables, $S_{n,t}$, that affects the flow utilities and the agent's choice to continue school ($d_{n,t} = 1$) or not ($d_{n,t} = 0$). The important distinctive feature of this model is hyperbolic discounting that is captured by the following objective function:

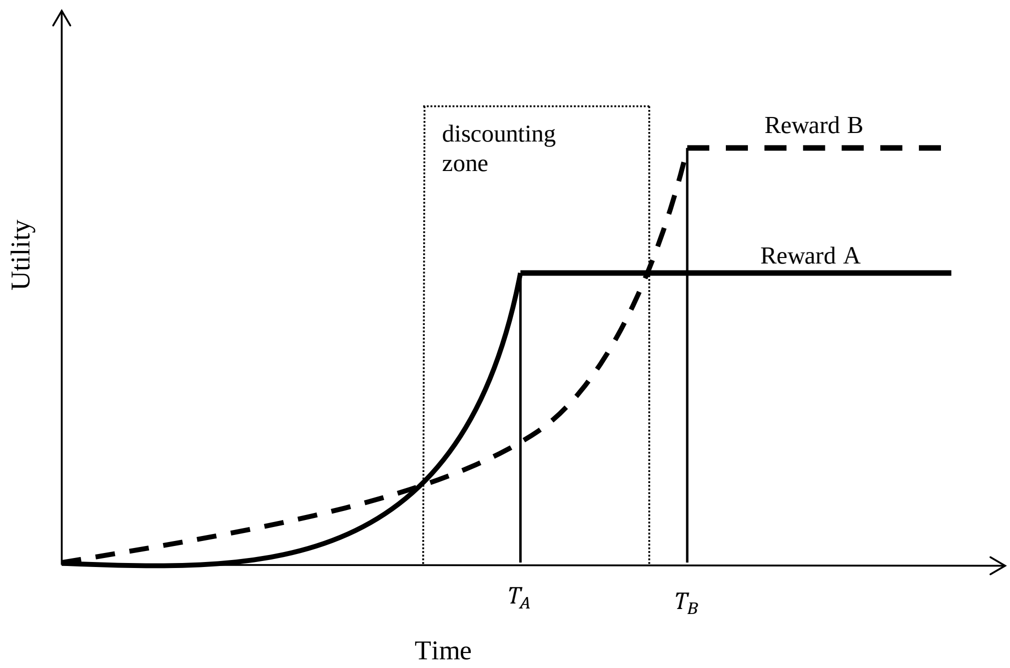
$$EU_t = U(S_{n,t}, d_{n,t}) + \beta E_t[\sum_{j=t+1}^{T} \delta^{j-t} U(S_{n,j}, d_{n,j})] \tag{1.1}$$

We distinguish between a short-term discount factor β, also known as the *present-bias factor*, and a long-term discount factor δ (O'Donoghue and Rabin, 1999). Between the current and the next period the individual discounts with $\beta\delta$, while

she discounts with δ between any two future adjacent periods. This is known in the literature as *β-δ-preferences* (Laibson, 1997). The standard model with exponential or time-consistent discounting is a special case of *β-δ-preferences* with $\beta = 1$ while the individual exhibits hyperbolic discounting if $\beta \in (0, 1)$.
Figure 1-1 illustrates the way a hyperbolic discounter evaluates rewards over time. We consider two rewards in the future, a sooner low reward A and a later high reward B. At an early point in time, the time delay between both rewards does not affect the utility derived from both rewards such that $B \succ A$. However, at a critical proximity to the reward A the discounter reverses the preference relationship. Since preferences for the same rewards change over time, hyperbolic discounting is a form of time-inconsistent preferences.

The literature on hyperbolic time preferences distinguishes between *naïve* and *sophisticated* decision makers, who differ in the perception of discounting behavior for future periods (Strotz, 1955; Pollak, 1968; O'Donoghue and Rabin, 1999; O'Donoghue and Rabin, 1999). The sophisticated discounter is aware of the fact that she will also have present-biased preferences in future periods while the naïve discounter remains ignorant of this fact. Unlike the sophisticated hyperbolic discounter, the naïve hyperbolic discounter is not aware of her future period self's self-control problem. Therefore, she has no intrinsic motivation to commit. In this case, only a binding commitment device imposed by a third party, e.g. the government, will provide incentives that make her behave in a way that is potentially more beneficial in the long term. In fact, student loans that are simulated in this study potentially represent such a commitment device since the prospect of having to repay loans in the future might motivate students to achieve higher degrees and therefore higher income after exiting education. Hence, a sophisticated hyperbolic

Figure 1-1: Illustration of Hyperbolic Discounting



solid: utility from reward A, dashed: utility from reward B

discounter is likely to react more strongly to the student loan policy than its naïve counterpart. The effects found for the naïve hyperbolic discounter can be seen as a lower bound to the effects observed for only partially naïve or sophisticated hyperbolic discounters and therefore give insights on what can be expected when studying these types. Within the scope of this study, we focus on naïve hyperbolic discounting.

1.2.2 Utility Function

Utility depends on consumption (C) and preferences for schooling (ϕ_{2g}), where schooling preferences are heterogeneous and follow a Heckman and Singer (1984) type mass-point distribution that comprises two mass-points κ_g with $g \in \{1, 2\}$ and $\kappa_1 + \kappa_2 = 1$. We allow for heterogeneity in and correlation between schooling preferences (ϕ_{2g}), the returns to successful years of schooling in the income equation (α_{1g}), and time preferences (β_g, δ_g). This is to account for the selection of individuals into schooling and to capture heterogeneity in time preferences between low and high productivity types. Note that schooling preferences and consumption are non-separable. That is, consumption affects utility through schooling-preferences as well as independently with a weight ϕ_1. We also allow schooling-preferences to change separately from consumption by ϕ_3 after 13 years of schooling, the usual time period, after which individuals enter university. The utility function exhibits constant relative risk aversion (CRRA) and is separable across time:

$$
\begin{aligned}
U_{n,t} = \exp(\phi_1 + \phi_{2g}\mathbf{1}[d_{n,t} = 1])\frac{C(S_{n,t}, d_{n,t})^{\rho} - 1}{\rho} \\
+ \phi_3\mathbf{1}[sc^{y}_{n,t} \geq 14] + \epsilon_{n,t}(d_{n,t})
\end{aligned}
\tag{1.2}
$$

where $\epsilon(d_{n,t})$ follows a type 1 extreme value distribution. In our model we set $\rho = -0.5$, which yields a coefficient of relative risk-aversion of 1.5. This is consistent with previous evidence (see e.g. Blundell et al. (1994) and Chetty (2006)) and our results are insensitive to changes in the value of ρ[3].

[3]See Table 1.6 in section 1.8.5 for sensitivity checks of time preference estimates in relation to different values of ρ

Consumption at School

Education in Germany is generally tuition free at all stages.[4] Students with low income parents receive an allowance from the state (Bafög), where the amount depends on the parents' income. A share of about 50% must be repaid. The Bafög defines a lower bound B for monthly consumption under the assumption that students do not save. We set $B = 585$ EUR which is the existential Bafög minimum in 2010.[5] Further, consumption at school is derived from household income, adjusted according to the OECD modified equivalence scale. For children below 18 we adjust the adult share by 0.6 which corresponds to the OECD equivalence scale-adjustments of household income for children. The corresponding function is denoted by $f(\cdot)$ such that consumption at school is given by

$$C(d_{n,t} = 1) = \begin{cases} f(HHinc_{n,t}) & \text{if } f(\cdot) \geq B \\ B & \text{if } f(\cdot) < B \end{cases} \tag{1.3}$$

Consumption after School

Instead of only considering earnings as returns to human capital, individual income is defined as a share of actual household income adjusted by the OECD modified equivalence scale.[6] This definition of income provides the advantage that individuals' expectations regarding future income are not exclusively formed about labor

[4] An exception is the period between 2005 and 2013 when universities in some states charged tuition fees of about 500 EUR per semester.

[5] The idea of Bafög is that each student should have enough net income to maintain an existential level, where this level is defined by the national government to a specific monthly amount that has been increased infrequently since its implementation.

[6] http://www.oecd.org/eco/growth/OECD-Note-EquivalenceScales.pdf.

market returns but also account for the sociological effect of educational choices. For instance, studies show that individuals are more likely to match with a partner with the same educational level (Mare, 1991). That is, even in the case of a highly educated person being unemployed, the higher education could still generate a higher income through the increased probability of being in a relationship with an equally well educated person who earns a higher income for both.
Individuals' beliefs on income after school are based on potential lifetime income profiles conditional on the number of successful years of schooling (sc_n^d). In line with the heterogeneity in schooling preferences, the returns to successful years of schooling (α_{1g}) follow a mass-point distribution with two mass-points. After exiting school, individuals receive a draw from the distribution of lifetime income profiles that are derived from the following equation:

$$\log(inc_{n,t}) = \alpha_0 + \alpha_{1g} sc_n^d + \alpha_2 age_{n,t} + \alpha_3 age_{n,t}^2 + \eta_{n,t} \tag{1.4}$$

where $\eta_{n,t}$ is a normally distributed random error. α_0 is a constant, α_{1g} represents the returns to successful years of schooling and α_2 and α_3 describe the income-age profile. We set the existential minimum of $inc_{n,t}$ to the average social security minimum of the year 2010 because all monetary values are price-adjusted to the year 2010.

1.2.3 Schooling Transitions and Identification

The number of actual years of schooling increases by one for every decision $d_{n,t} = 1$. Whether or not an additional year spent in education translates into a degree is subject to uncertainty. The probability to attain a degree and, thus, a higher value of successful years of schooling is derived from the latent variable $sc^{d*}_{n,t+1}$, which is given by the following equation:

$$\begin{aligned} sc^{d*}_{n,t+1} =&\gamma_0(sc^{y}_{n,t} - sc^{d}_{n,t}) + \gamma_1(sc^{y}_{n,t} - sc^{d}_{n,t})^2 + \gamma_2 cohort2_n + \gamma_3 cohort3_n \\ &+\gamma_4 South_n + \gamma_5 South_n * cohort2_n + \gamma_6 South_n * cohort3_n + \zeta_{n,t} \end{aligned} \tag{1.5}$$

where $sc^{d}_{n,t}$ represents the number of successful years of schooling and $sc^{y}_{n,t}$ represents the number of actual years of schooling. The difference between actual and successful years of schooling enters the transition equation in linear and quadratic form. In line with Magnac and Thesmar (2002), Chan (2013), Fang and Wang (2015), and Haan et al. (2017) we achieve identification not only on the basis of our functional form assumptions but also impose exclusion restrictions that affect educational choices indirectly through their impact on the transition probabilities of relevant state variables and reveal information on the discounting behavior. For this purpose, we exploit inter-cohort and regional variation in the transition probabilities that is stemming from two reform phases that affected the German educational system (see Appendix 1.8.2 for details). The rationale behind this identification strategy is as follows: if two individuals with the same current utility flow exhibit different value functions and, therefore, make different choices, this must be due to differences in their expectations about future outcomes. $cohort2_n$ indicates individuals from birth cohorts 1964 to 1984 (affected by reform phase I) and $cohort3_n$ indicates individuals born from 1985 to 1992 (affected by reform phase II). $South_n$ is a regional indicator and is equal to one if individual n lives in the south and 0 otherwise. We include interactions between $South_n$ and the cohort dummy variables to account for regional variation in the implementation of educational reforms. We summarize the variables entering the transition equation (1.5) with S^{Π} as the set of state variables relevant for the transition probabilities. Given that $sc^d_{n,t}$ has $M = 11$ distinct values, we estimate $K = 10$ corresponding cut-off points: $m_1, \ldots, m_K$. Thus,

$$sc^d_{n,t+1} = \begin{cases} 1 & \text{if } sc^{d*}_{n,t+1} < m_1 \\ k & \text{if } m_{k-1} \leq sc^{d*}_{n,t+1} < m_k \\ 11 & \text{if } sc^{d*}_{n,t+1} > m_K \end{cases}$$

From this we can compute Π_m as a vector describing the discrete probability distribution for $sc^d_{n,t+1}$ that results from equation (1.5). The parameters of equation (1.5) are summarized in the vector γ and we compute this probability in an ordered logit model as follows:

$$Pr(sc^d_{n,t+1} > sc^d_j) = \frac{exp(X\gamma - m_j)}{1 + exp(X\gamma - m_j)}, j = 1, 2, \cdots, M-1, \tag{1.6}$$

such that

$$\begin{aligned} Pr(sc^d_{n,t+1} > sc^d_1) =& 1 - \frac{exp(X\gamma - m_1)}{1 + exp(X\gamma - m_1)} \\ Pr(sc^d_{n,t+1} = sc^d_j) =& \frac{exp(X\gamma - m_{j-1})}{1 + exp(X\gamma - m_{j-1})} \\ &- \frac{exp(X\gamma - m_j)}{1 + exp(X\gamma - m_j)}, j = 2, \cdots, M-1 \\ Pr(sc^d_{n,t+1} = sc^d_M) =& \frac{exp(X\gamma - m_{M-1})}{1 + exp(X\gamma - m_{M-1})} \end{aligned} \tag{1.7}$$

When constructing Π, we need to account for the fact that the value of sc^d cannot decrease, such that $sc^d_{n,t+1} \geq sc^d_{n,t}$, $\forall$ n, t.[7]

1.2.4 Value Functions: Hyperbolic Discounting

In this section, we discuss the construction of the expected value functions. For readability, we suppress the transition array in this section and use a uniform matrix of state variables, S. We assume that state transitions follow a Markov process that allows us to break down the value function to a two-period decision problem between the current and the present discounted value of future expected utility. In the basic exponential case the value function exhibits the form

$$V_t(S_{n,t}, d_{n,t}) = U(S_{n,t}, d_{n,t}) + \delta_g E_t[max\{V^1_{t+1}, V^0_{t+1}\}] \tag{1.8}$$

where

$$\begin{aligned} V^1_{t+1} &= V(S_{n,t+1}, d_{n,t+1} | S_{n,t} = s_{n,t}, d_{n,t} = 1) \\ V^0_{t+1} &= V(S_{n,t+1}, d_{n,t+1} | S_{n,t} = s^-_{n,t}, d_{n,t} = 0) \end{aligned} \tag{1.9}$$

Following the terminology of Fang and Wang (2015), we call equation (1.8) the *perceived long-term value function.* Since the discount factor is constant over time in the exponential discounting case, there is no difference between the decision maker's perception of her discounting behavior in the future and how she discounts in the present. Hence, expected payoffs over the short- and long-term are

[7] We adjust the array accordingly, such that the remaining probabilities over the potential outcomes for $sc^d_{n,t+1}$ still sum up to one. This is accomplished by taking the sum over all probabilities for values with $sc^d_{n,t+1} < sc^d_{n,t+1}$ and adding equal shares of this sum to all remaining probabilities.

discounted equally. This leads to one value function covering all aspects of forward looking behavior.

For hyperbolic discounting, we distinguish between two aspects of forward looking behavior: (1) The individual's *actual* discounting behavior for the short- and long-term. (2) The individual's *perceived* discounting behavior for the short- and long-term.

Therefore, we introduce a second value function that describes the discounting behavior of the hyperbolic discounter for the short-term:

$$W_t(S_{nt}, d_{nt}) = U(S_{n,t}, d_{n,t}) + \beta_g \delta_g E_t[max\{V^S_{t+1}, V^W_{t+1}\}] \tag{1.10}$$

We call this function the *current value function.* If $0 < \beta < 1$, all non-immediate periods are discounted more heavily than in the exponential discounting case. Therefore, this type of discounting is also referred to as *present bias.* The case of exponential discounting is embedded in this model as a corner solution.

With hyperbolic discounting, the decision problem expands from a two-period to a three-period problem because we also consider how the current period self perceives the next period self to discount subsequent utility flows.

1.3 Solving the Model and Estimation

Given the finite horizon of the choice problem, the solution can be computed by backwards induction starting from the utility flow in the last decision period. After exit from schooling, the final value is defined through the distribution of lifetime income profiles. This yields the expected choice specific exit value of

$$E_t[W^0_{n,t}] = \beta_g \sum_{j=t+1}^{T} \delta_g^{j-(t+1)} U^0_{n,j}(S_{n,t} = \bar{s}_{n,t}, d_{n,t} = 0) \tag{1.11}$$

$E_t[W^0_{n,t}]$ represents the present discounted sum of future utility streams that evolve deterministically with age up to age $T = 70$. It follows from the type I extreme value distribution of $\epsilon(d_{n,t})$ that we can derive a closed form solution for the expected maximum of future choice specific value functions (Rust, 1987):

$$\begin{aligned} E_t[W^1_{n,t}] =& U(S_{n,t}, d_{n,t}) + \Pi(S^{\Pi}_{n,t})\beta_g\delta_g \\ & \times \log\{\exp(E_t[V^1_{t+1}]) + \exp(E_t[V^0_{t+1}])\} \end{aligned} \tag{1.12}$$

where,

$$\begin{aligned} E_t[V^1_{n,t+1}] =& U(S_{n,t+1}, d_{n,t+1}) + \Pi(S^{\Pi}_{n,t})\delta_g \\ & \times log\{\exp(E_{t+1}[V^1_{t+2}]) + \exp(E_{t+1}[V^0_{t+2}])\} \end{aligned} \tag{1.13}$$

For the backward induction with naïve hyperbolic discounting, we compute the value functions recursively until $t+1$ using the perceived long-term value function and compute the last step from $t+1$ to t using the current value function.
Rust (1987) shows that with the assumption of additive separability in utility over time and conditional independence, the probability of a continuation of schooling in period t takes on the following logit-type form:

$$Pr(d_{n,t} = 1) = \frac{exp(E[W^1_{n,t}])}{\exp(E[W^0_{n,t}]) + exp(E[W^1_{n,t}])} \tag{1.14}$$

The probability to remain in school for $\bar{t}$ years (after grade 9) for individual n is:

$$L_{1n} = \sum_g \kappa_g \{\prod_{t=1}^{\bar{t}} Pr(d_{n,t} = 1) \times Pr(d_{n,\bar{t}+1} = 0)\} \tag{1.15}$$

The full log-likelihood of the model is obtained by multiplying the likelihood contribution from (1.15) with the income density that follows from equation (1.4) (L_{2n}):

$$\sum_{n=1}^{N} \{log(\sum_g \kappa_g \{L_{1n} \times L_{2n}\})\} \tag{1.16}$$

We compute the transition probabilities presented in equation (1.5) (L_{3n}) in a first step and take them as given in the main estimation procedure. The parameters of our model are estimated by the method of maximum likelihood.

1.4 Data

This study is based on the German Socio-Economic Panel (SOEP), an annual survey that, since 1984, collects individual- and household-level information from about 12,000 households (Wagner et al., 2007). We confine our analysis to the 1992-

2013 waves (collected after the German reunification) and focus on West German students with a West German school degree. This allows us to abstract from institutional differences in former East German regions. Furthermore, we exclude disabled individuals and individuals who remained in education for more than 26 years (outliers that account for less than 2% of the sample). Since missing income information must be imputed, we further reduce the sample to individuals with a minimum of two observed periods of household income during the educational period. The final sample is a balanced panel consisting of 2305 individuals.

Table 1.1: Summary Statistics

	Cohort group 1		Cohort group 2		Cohort group 3	
	Mean	Std.	Mean	Std.	Mean	Std.
successful years of school	15.80	2.52	13.65	2.57	13.38	2.50
actual years at school	18.65	2.86	15.70	3.50	15.87	2.20
$sc^y - sc^d$	2.93	2.22	2.08	2.23	2.01	1.68
equivalent individual income(10,000 e)	1.60	0.57	1.77	0.94	2.30	1.39
net HH income(10,000 e)	2.39	0.97	3.11	2.07	4.66	3.35
south	0.56	0.50	0.57	0.50	0.60	0.49
N	95		1,799		411	

Note: Authors' calculations based on SOEP.

Table 1.1 shows summary statistics of the relevant variables by cohort group. It displays average values for successful and actual years of schooling as well as the average difference between both values. We use the following variables in the estimation of our model:

Actual years of schooling Actual years of schooling are defined as the last age that the individual is observed in any educational institution minus seven (the age most students reach during their first year at school). The variable ranges from

9 to 26 years (9 years is the minimum number of years required by compulsory schooling laws and 26 years is the highest number of school years that we observe, covernig more than 98% of our sample). We drop a 2%-share of individuals who need more than six years longer at school than the regular years for a certain degree.

Successful years of schooling Successful years of schooling are derived from information on obtained degrees. Although we do not observe the assigned schooling variable in each period, the supplemental biographical data set *BIOEDU* (Lohmann and Witzke, 2011) provides information on educational participation and transitions of the individuals in the SOEP. We use this to reconstruct educational paths. We then assign years of schooling to the respective degrees. The method used to assign years of schooling to a degree follows mostly Anger et al. (2014) for the generation of the "years of schooling" variable in the SOEP. That is, we assign 9 years to a lower secondary degree, 10 years to an intermediary school degree and 12 years to a degree for a professional college or high school degree. Then, we do not assign half years and summarize degrees for an apprenticeship by assigning 2 years and other vocational degrees with additional schooling by assigning 3 years. Finally, we assign 5 years to a degree from a university of applied sciences and 6 years to a degree from a university.

Income Individual income is computed by adjusting total net income (also covering government transfers) of all household members according to the OECD modified equivalence scale.[8] We set the minimum annual income of an individual to the average social security minimum in 2010 in order to avoid any bias due to unobserved transfers in the income variable. All monetary values in this study

[8]http://www.oecd.org/eco/growth/OECD-Note-EquivalenceScales.pdf.

are price adjusted to 2010. Figure 1-7 in the appendix shows the average annual income by different levels of education. Similarly to labor market earnings profiles, these income profiles are hump-shaped and differ by levels by education.

Cohort groups The cohorts range from 1946 to 1992. We define three cohort groups as follows: group 1 consists of all born before 1964, group 2 consists of all born between 1964 and 1984, while group 3 consists of everyone born after 1984. It is not easy to specify cohort groups that were clearly affected by one or the other educational reform phase. This is due to the differences in years of schooling invested for specific degrees but also due to the fact that the duration of both reform phases spans several years. Nevertheless, we chose this categorization for the following reasons: the oldest cohorts of group 2 were nine years old and, thus, mostly in the fourth grade when the implementation of the integrated comprehensive schools started. This is the age when the decision for the secondary schooling track is made. The oldest cohorts of group 3 were 20 years old when the implementation of the Bologna process started. This is the age when most students enter university.

South This variable is equal to 1 if the individual lives in a Southern state and 0 otherwise. The southern states are Hesse, Rhineland-palatinate, Baden-Wurttemberg, Bavaria and Saarland. The remaining states are Schleswig-Holstein, Hamburg, Lower-Saxony, Bremen and North-Rhine-Westphalia.

1.5 Estimation Results

In the following, we estimate two versions of our model: one with hyperbolic and one with exponential discounting. Under hyperbolic discounting, there are two parameters to explain observed discounting behavior. And under exponential discounting, there is one parameter to explain the same economic feature. When $\beta < 1$, we expect δ to be lower in the exponential version than the hyperbolic version of the model because the model is used to rationalize the same degree of myopia. Note that the exponential model is nested within the hyperbolic model. Therefore, we can compare both models in their ability to explain the data in the framework of a likelihood-ratio test.

1.5.1 Transition Probabilities

The estimation results of the transition equation are reported in Table 1.2. A likelihood-ratio test against the hypothesis of zero impact of the exclusion restrictions yields a p-value of 0. All covariates in the logit regression significantly affect the transition in successful years of schooling. The higher the difference between actual and successful years of schooling, the more like the probability to increase successful schooling years.

Table 1.2: Ordered Logit Results of Transition Probabilities

	Value	**Std.Err**	**T-Value**	**P-Value**
$l.sc^y - l.sc^d$	0.4528***	0.0058	77.7482	0.0000
$(l.sc^y - l.sc^d)^2$	0.0081**	0.0040	2.0551	0.0483
$cohort2$	-0.0310***	0.0073	-4.2253	0.0001
$cohort3$	0.0669***	0.0142	4.7035	0.0000
$south$	0.0335***	0.0078	4.3181	0.0000
$south * cohort2$	-0.0598***	0.0123	-4.8824	0.0000
$south * cohort3$	-0.1381***	0.0135	-10.2237	0.0000
No. of Cutpoints	10			
N	2,305			
ll	29,425.98			

*,** and *** denote significance level of 10%, 5% and 1%, respectively.

The negative coefficient for the *cohort*2 dummy suggests that the second reform phase generally decreased transitions in successful schooling years for both northern and southern states. Southern states generally have a higher probability to increase successful years of schooling. The last reform phase seems to affect the two regions differently; the effects are positive in the North and negative in the South. Figure 1-8 in the appendix depicts the probability to reach 12, 14, 15, or 18 successful schooling years by the difference between actual and successful years of schooling for all groups.[9] The transition probabilities shown in figure 1-8 are averaged over individuals with different lagged levels of successful years of schooling. This allows focusing on the functional relationship between the probabilities

[9]Note that transition probabilities are adjusted to the fact that *successful years of schooling* can only remain equal or increase for every add. That is, $pr(sc^d_{t+1} = k | sc^d_t < k)$.

and the difference between actual and successful years of schooling. A comparison with a non-parametric estimation of transition probabilities confirmed the good fit of our more efficient parametric model specification.

1.5.2 Flow Utility and Income

The estimation results for the parameters of the utility function are reported in Table 1.3. As mentioned before, we set $\rho = -0.5$, which corresponds to a coefficient of relative risk aversion of 1.5.

Table 1.3: Schooling and Utility Parameters

	Hyperbolic		Exponential	
	Value	**Std.Err**	**Value**	**Std.Err**
β_1(type 1: short run)	0.5601***	0.0744	1	-
β_2(type 2: long run)	0.6378***	0.0582	1	-
δ_1(type 1: short run)	0.9708***	0.0127	0.8926***	0.0101
δ_2(type 2: long run)	0.9877***	0.0074	0.9298***	0.0107
ρ	-0.5	-	-0.5	-
ϕ_1(C-weight$=exp(\phi_1)$)	-1.0846***	0.1295	-0.6037***	0.1234
$\phi_3(sc^y >= 14)$	-0.7857	0.0345	-0.8082***	0.0422
prob(type1)	0.4817***	-	0.4815***	-
prob(type2)	0.5183***	-	0.5183***	-
ϕ_{21}(type 1:school disut.)	-1.1633***	0.1898	-1.6901***	0.4308
ϕ_{22}(type 1:school disut.)	-0.2939***	0.1017	-0.9465***	0.2357
N	2305	1	2305	1
ll	-57672.4714	-	-57690.3122	-
LR-Test Exp vs. Hyp	0.0000	-	-	-

*,** and *** denote significance level of 10%, 5% and 1%, respectively.

For both models we estimate parameters of two types. For the hyperbolic model, we estimate a short-term discount factor of 0.56 for the low type and 0.64 for the high type and a long-term discount factor of 0.97 for the low type and 0.99 for the high type. For the exponential model, we estimate a discount factor of 0.89 for the low type and 0.93 for the high type. Correspondingly, we find heterogeneity in the disutility of schooling. In both specifications schooling disutility is higher for the low discounting type than for the high discounting type. More specifically, in the hyperbolic model we find a schooling disutility of -1.16 for the low discounting type and -0.29 for the high discounting type. In the exponential model, schooling disutility for the low type is at -1.69 and for the high type it is at -0.95. This corresponds to the idea that more impatient types have lower preferences for schooling and tend to leave school earlier than more patient types. The parameter for the change in schooling preferences after 13 years of schooling is negative and similar in both cases (in the hyperbolic case: -0.79; in the exponential case: -0.81). That is, individuals exhibit lower schooling preferences after having spent 13 years at school.

Since the exponential model is nested within the hyperbolic model, we can test the exponential model against the hyperbolic model using a likelihood-ratio test. With a p-value of 0, we reject the null of the exponential model in favor of the hyperbolic model. Hence, this is strong empirical evidence of hyperbolic discounting in educational decisions.

Finally, the results for the income equation are presented in Table 1.4. We report strong heterogeneity in the returns to successful years of schooling, namely 11.25 % for type 1 and 6.96 % for type 2. These effects are at the lower bound of what is usually found in the empirical literature (Card, 1999), but it compares favorably to the effects found in the structural model of Belzil and Hansen (2002). This may be due to the choice of using net household-equivalent income instead of gross labor earnings as our income measure. Hence, the returns to education are lower because of the redistributive effects of the tax and transfer system.

Table 1.4: Income Equation

	Hyperbolic		Exponential	
	Value	**Std.Err**	**Value**	**Std.Err**
α_{11}	0.1125***	0.0008	0.1125***	0.0008
α_{12}	0.0696***	0.0008	0.0696***	0.0007
age	0.0536***	0.0009	0.0534***	0.0009
age^2	-0.0004***	0.0000	-0.0004***	0.0000
$\alpha_0(const.)$	7.3378***	0.0185	7.3404***	0.0194
σ_η	0.3369***	0.0007	0.3369***	0.0007

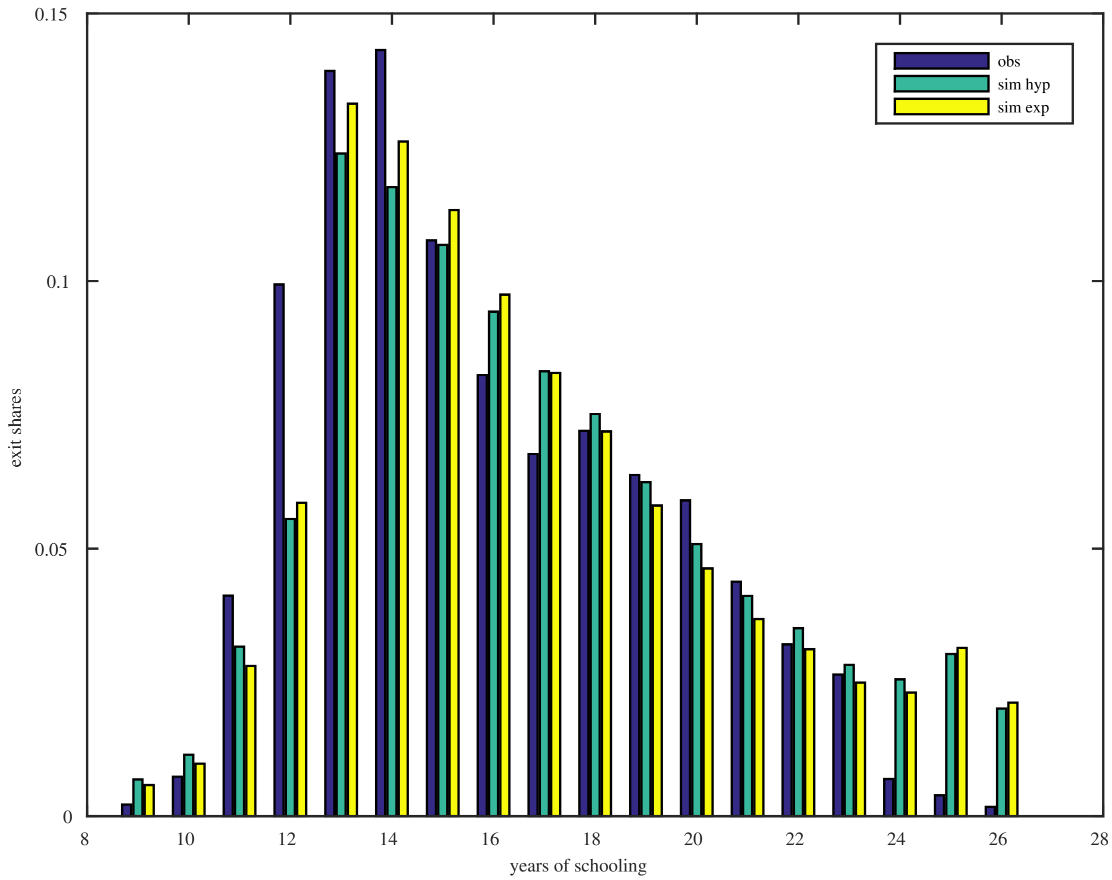
*,** and *** denote significance level of 10%, 5% and 1%, respectively.

Our estimates of the coefficients on age and age^2 indicate a concave relationship between log(inc) and age, as well established in the literature. Overall, our estimates of the income equation show reasonable results that fit well into the model and the existing literature.

1.5.3 Model Fit

We check the internal validity of not only our preferred model specification with hyperbolic discounting, but also the specification with exponential discounting. For this purpose, we compare simulated exit shares with the respective shares from the estimation sample. Figure 1-2 depicts the comparison. We simulate synthetic samples with $N = 50,000$ individuals based on the point estimates of the parameters of the respective model specifications. For the cohort groups and the south indicator, we rely on the distribution observed in the estimation sample. Choices and transitions are simulated taking draws from the uniform distribution.

Figure 1-2: Educational Decisions: Observed and Simulated



Choice probabilities are non-parametrically estimated based on simulated samples.

The model fits the overall shape of the observed distribution reasonably well. We somewhat underpredict the exit shares at the lower end of the distribution and overpredict them at the upper end. However, we refrain from improving the in-sample fit artificially by including more years of schooling dummies because it is ultimately our goal to rationalize choices based on a model of economic reasoning. The focus of this study lies on the comparison of behavioral responses to policy changes. Therefore, small deviations in the levels between the predicted and observed exit shares are very unlikely to affect these results.

1.6 Policy Analysis

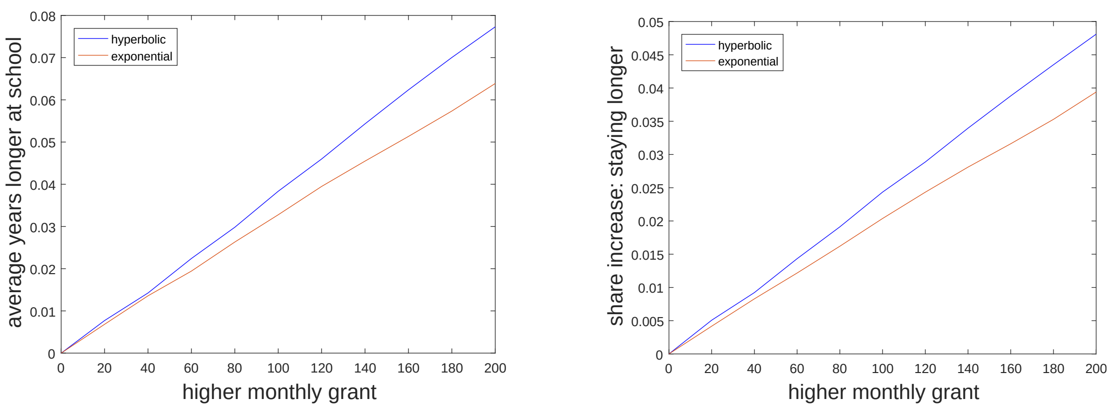
We investigate the relevance of individuals' discounting behavior for policy evaluations by considering policies that affect individual utility streams at different points in time. In particular, we analyze the effects of an increase in the state-supplied student loans (BaföG). Generally, student loans are an internationally widespread policy measure to encourage take-up of higher education. They affect the inter-temporal substitution of consumption and, therefore, represent an excellent setting for the analysis of time discounting. The regulatory structure of payback laws differ between countries. We simulate two different variants of this policy: (1) an increase in the state grant for students as a way to affect short-term costs while at school; and (2) an increase in the state grant as a loan that will have to be paid back after the end of the education. The increase of the student loan is implemented through an increase of the lower bound B in equation (1.3). Since income during the schooling period is a function of household income, not everyone is affected by this policy. Only individuals from lower income groups with an initial income below the threshold receive this loan.

In our analysis, we consider both the short-term effects in terms of changes in the educational choices and the long-term effects in terms of changes in the life-cycle income. The policy measures affect educational choices through the relative utility costs of schooling and through an increase in the financial means available to the individuals. If the increase in the state grant is provided as a loan, the payback scheme affects the relative utility costs of schooling differently depending on how individuals discount future repayments. Returns to education are expected to differentially affect individuals under hyperbolic or exponential discounting.

1.6.1 Student Grant

In this policy variant, the short-term gain does not correspond to long-term costs. We simulate the increase in student loans by gradually raising the minimum threshold of income at school (B) by 20€ per month.

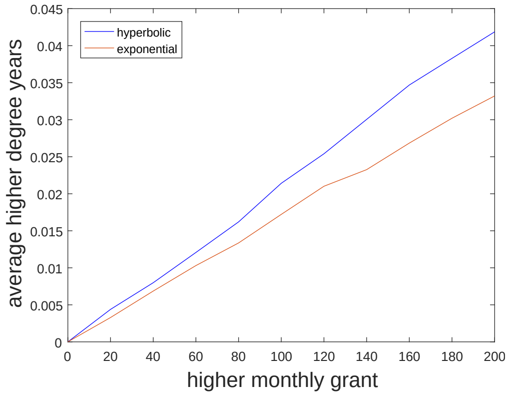
Figure 1-3: Effect of a higher grant on actual years of schooling

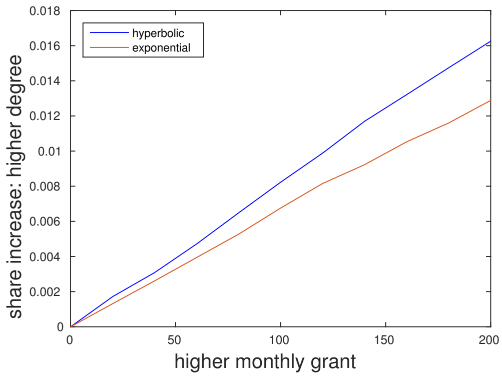


We run all simulations for a synthetic sample of 70,000 simulated individuals.[10] Figure 1-3 shows the effect of a 20 to 200 € increase in the monthly grant on actual years of schooling. The left part presents the average increase in years spent at school as a response to a higher monthly grant of 20 to 200€. The right

[10] This is the maximum number of simulations we could run at maximum memory capacity of our computer system.

Figure 1-4: Effect of a higher grant on successful years of schooling





part presents the share of individuals who stay longer at school as a response to the policy changes. The actual years spent at school increase under both model specifications. These results show that under hyperbolic discounting individuals react slightly stronger to the policy and stay longer at school. With respect to effect sizes, it can be said that a 100€ increase in the monthly grant leads to an average increase in actual years of schooling of about 0.035 years (or about 1/3 of a month) for the hyperbolic discounter and about 0.03 years for the exponential discounter. In case of exponential discounting, a share of about 2% of the population stays longer in education while this is about 2.25% under hyperbolic discounting. In terms of magnitude these estimates are in line with the effect sizes found by Steiner and Wrohlich (2012) using a discrete-time hazard rate model for Germany.

We observe stronger differences between exponential and hyperbolic discounting when we consider the effects of the policy on successful years of schooling as it is displayed in Figure 1-4. The effects are larger under hyperbolic discounting. This reflects the fact that the hyperbolic discounter behaves less efficiently and can realize higher gains by staying one year longer at school. For example, an individual is more likely to be at the margin of obtaining a degree when dropping out before the reform under hyperbolic discounting. Within the framework of our model, only additional successful years of schooling yield a higher income after school exit while actual years of schooling only translate into a higher probability of achieving additional successful years. The exponential discounter puts more weight on the specific transition probabilities of actual to successful years of schooling when making the choice (e.g. tends not to drop out shortly before obtaining a degree before the reform). This is in line with the behavioral specifications of the two types of discounting.

Figure 1-9 in the appendix shows the effect of a 100€ increase in the monthly grant on the exit shares by actual years of schooling. Under exponential discounting, the changes in actual years of schooling do not strongly affect the overall distribution of actual years of schooling with small changes at the tails of the distribution and larger changes in the middle of the distribution. Overall, this leads to a more equal distribution of actual years of schooling. Under hyperbolic discounting, individuals generally exhibit a similar behavior, however with a particularly strong decrease in the exit share for individuals with eleven or twelve years of schooling that corresponds to a large spike at 16 years of schooling. The probability to obtain a degree after eleven years of schooling is relatively small while it is comparatively larger after 16 years of schooling. This further explains the stronger effect on successful years of schooling under hyperbolic discounting.

1.6.2 Student Loan

Unlike the grant, the student loan needs to be repaid once the individual exits school. Individuals start repaying their loan after school exit in equal annuities over five years. Again, we run all simulations for a synthetic sample of 70,000 simulated individuals and gradually increase the provided loan from 20 to 200€. In this policy variant, the short-term gains correspond to long-term losses in consumption when the repayments start.

Figure 1-5 shows the effect of a 20 to 200€ increase in the monthly loan on actual years spent at school. For the purpose of comparison, we also add the results from the grant simulation in dashed lines to the plot. These results show that the response to the two policies differs more for exponential than for hyperbolic discounters.

Figure 1-6 shows the effect of the policy on successful years of schooling. Again, we also plot the effects of the grant policy in dashed lines. Similar to the grant policy, we see larger effects on the successful years of schooling for the hyperbolic discounter. This can also be explained by the more efficient behavior of the exponential discounter as opposed to the more impulsive behavior of the hyperbolic discounter before the reform. In both cases, the response to the loan policy is stronger than for the grant. It appears that individuals try to offset the negative effects on consumption in the long-term by earning higher degrees. The payback mechanism triggers a further positive effect on school participation. This is less the case for the hyperbolic discounters.

Figure 1-10 in Appendix 1.8.4 presents the effect of a 100€ increase in the monthly loan on the shares of students exiting school by actual years of schooling. Under hyperbolic discounting, we observe a strong decrease at twelve years of schooling that corresponds to a large spike at 16 years. This also explains the strong effects on successful years of schooling under hyperbolic discounting. Under exponential discounting, we also observe a large drop at 13 actual years (usually about the time spent to achieve the university access degree) and somewhat larger spikes at

Figure 1-5: Effect of a higher loan on actual years of schooling

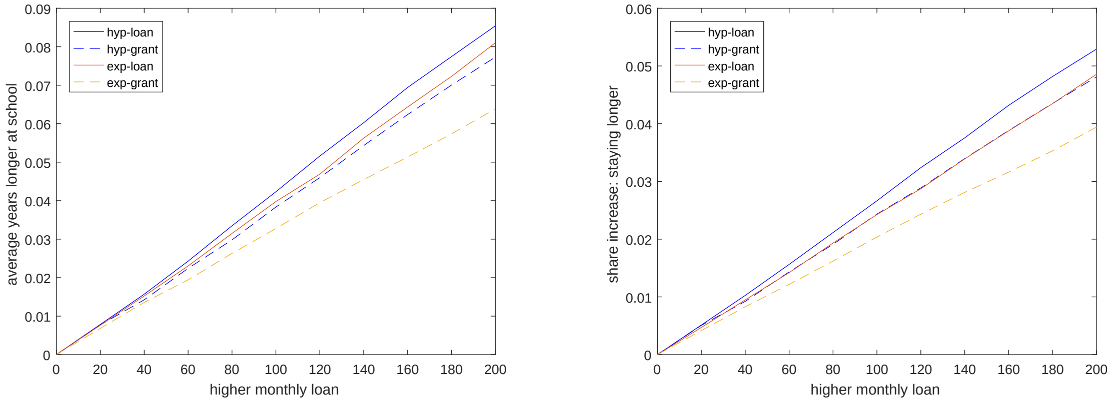
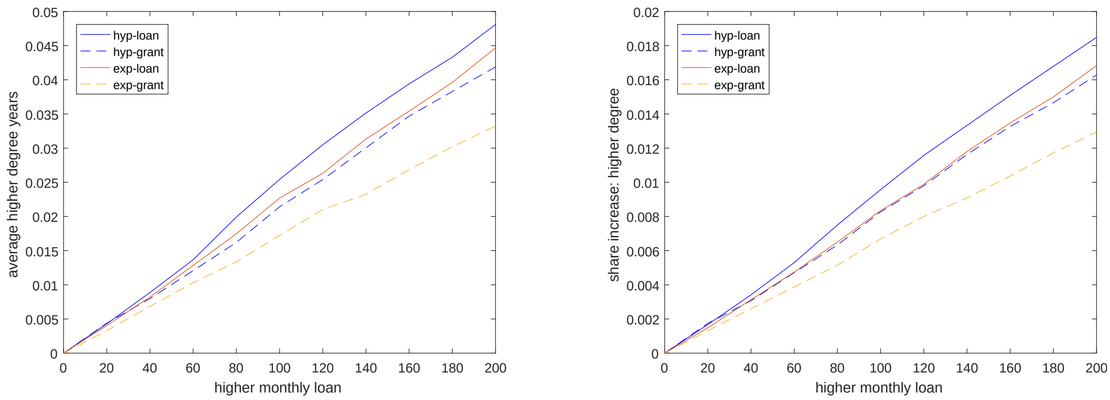


Figure 1-6: Effect of a higher loan on successful years of schooling



16, 17 and 18 years (corresponding to the usual amount of years spent to achieve a bachelor's or a masters degree). This again supports the hypothesis that hyperbolic discounters are more often at the margin of obtaining a degree when leaving education, while exponential discounters more often just obtained a degree when they leave education.

1.6.3 Sensitivity Analysis

In our model, we set $\rho = -0.5$, which yields a coefficient of relative risk aversion (CRRA) of 1.5. We check the sensitivity of this assumption by estimating the same model with different values of ρ that correspond to a CRRA range of $[1, 2]$ (see Chetty (2006) for a discussion of the possible range). The results are summarized in Table 1.6. In the hyperbolic model, the short-term discount factors β_1 and β_2 decrease for both unobserved types (from 0.590 to 0.512 and from 0.659 to 0.607) with rising degrees of risk aversion, while the long-term discount factors either increase (δ_1 from 0.964 to 0.985) or remain practically unchanged (δ_2 from 0.991 to 0.987). Similarly, in the exponential model δ_1 remains practically unchanged (from 0.892-0.898) while δ_2 decreases (from 0.945 to 0.915) with rising degrees of risk aversion. That is, we observe a decrease in the long-term discount factor as risk aversion rises.

Despite the interdependence of these parameters, the overall pattern and, therefore, our main results are very robust to the whole range of levels of relative risk aversion. In all cases, we see that the short-term discount factor is substantially smaller than the long-term discount factor in the hyperbolic model and that the long-term discount factor in the exponential model is smaller than in the hyperbolic model (offsetting the restriction of $\beta = 1$ in the exponential model).

1.7 Conclusion

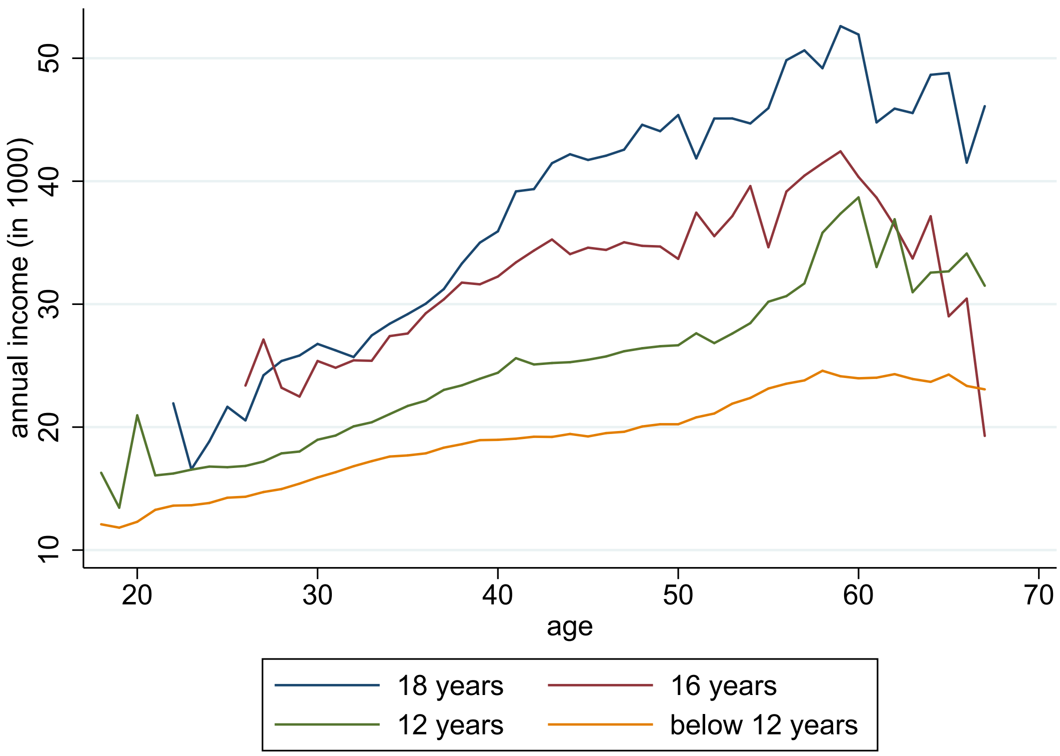
We investigate time-inconsistent preferences in educational decision making and corresponding policies using a structural dynamic choice model. Based on a novel identification approach, we exploit the variation in average years invested in degree attainment through various educational reforms to identify the discount factor of hyperbolic time preferences. We achieve identification by imposing exclusion restrictions that affect educational choices indirectly through their impact on the transition probabilities of relevant state variables but have no impact on current utility flows. The estimates indicate time-inconsistent behavior and provide quantitative evidence for its relevance. Failure to account for this behavioral feature in a structural model may lead to misleading results in subsequent policy simulations.

In our study, this is demonstrated for two different policy scenarios: (1) an increase in the state grant for students as a way to affect short-term costs while at school; and (2) an increase in the state grant as a loan that will have to be paid back after completing education. We find substantial differences in the effects of these policies when comparing educational outcomes based on a model specification with hyperbolic discounting with the ones based on a specification with exponential discounting. In particular, the effects on successful years of schooling are much stronger for hyperbolic discounters. This reflects the fact that the hyperbolic discounter behaves less efficiently and can realize higher gains by staying one year longer at school. Moreover, the response to the two policies differs more for exponential than for hyperbolic discounters.

1.8 Appendix

1.8.1 Supplemental Descriptive Statistics

Figure 1-7: Annual average of income by different levels of education



1.8.2 Educational reforms

The cohorts analyzed in our study were affected by two major educational reform phases, summarized in Table 1.5 that are crucial to our identification strategy. The first phase (1960s and 1970s) was devoted to the objective of equal opportunities for children from different socioeconomic backgrounds. It started with an expansion of universities in 1965 and the creation and introduction of universities of applied sciences in 1968. It continued with the introduction of Bafög in 1971 and the introduction of integrated comprehensive schools parallel to the standard three-tier school system in 1973.[11] Overall, this phase led to an expansion of the academic track. The second reform phase started in 2005 with the implementation of the Bologna process. Before this reform, the usual university academic degree was the *Diplom*, corresponding to about ten semesters of university education. The Bologna process introduced the Bachelor's degree as an intermediate academic degree and the Master's degree, which replaced the *Diplom*. The second phase continued with a decrease in the years of higher secondary education from nine to eight.

[11] Instead of opting for one of the tracks in the three-tier system, students of any ability can enroll in an integrated comprehensive school that combines all three options in one school without strictly separating students into education tracks.

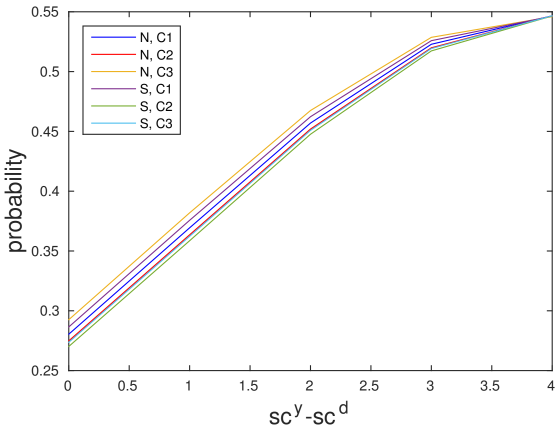
Table 1.5: Summary of Educational Reforms

reform introduction	reform content
Phase 1: Academic track expansion	
1968	Implementation of advanced technical colleges
1972	Reorganization of the upper secondary level
1973	Implementation of integrated comprehensive schools parallel to the three-tier school system
Phase 2: Adapting to European schooling standards	
1999	Signing of Bologna Declaration marks transition from former 5-year university programmes to 3+2 years
2005	Implementation of Bologna Declaration structures
2007	Shortening of upper secondary level education by one year

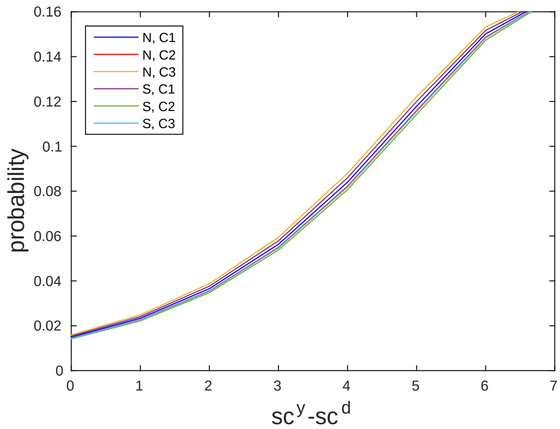
In our analysis, we exploit the effects of the two reform phases on transition probabilities from actual to successful years of schooling. While the actual years merely reflect time spent in an educational institution, the successful years reflect completion of school, university, or professional degrees (see below for additional information). The expansion of higher education in reform phase I lead to crowding effects and is likely to have reduced the transition probabilities from actual to successful years. Reform phase II was specifically targeted at the reduction of schooling time. The effect on transition probabilities is nevertheless unclear because the reform may have increased students' work load and, as a consequence, dropout rates.

1.8.3 Depiction of Transition Probabilities

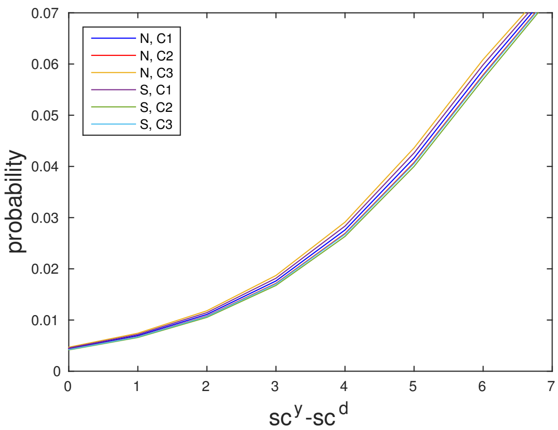
Figure 1-8: Probability to achieve levels of successful years of schooling by difference between actual and successful years for different groups



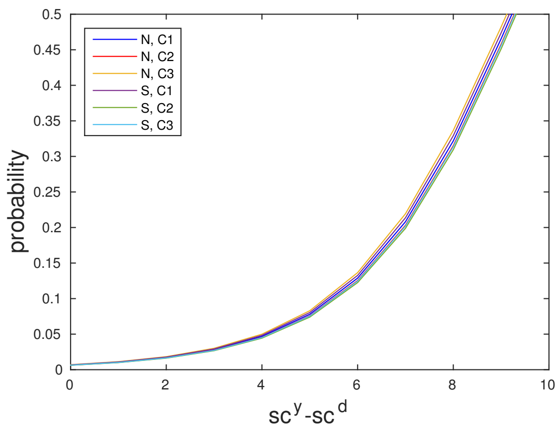
(a) 12 years



(b) 14 years



(c) 15 years



(d) 18 years

Source: Own calculations based on SOEP. The transition probabilities are averaged over individuals with different lagged levels of successful years of schooling. N: North, S: South, C1: Cohort group 1, C2: Cohort group 2, C3: Cohort group 3.

1.8.4 Further Policy Analysis

Figure 1-9: Difference in exit shares by actual years of schooling for 100€ increase in a monthly grant

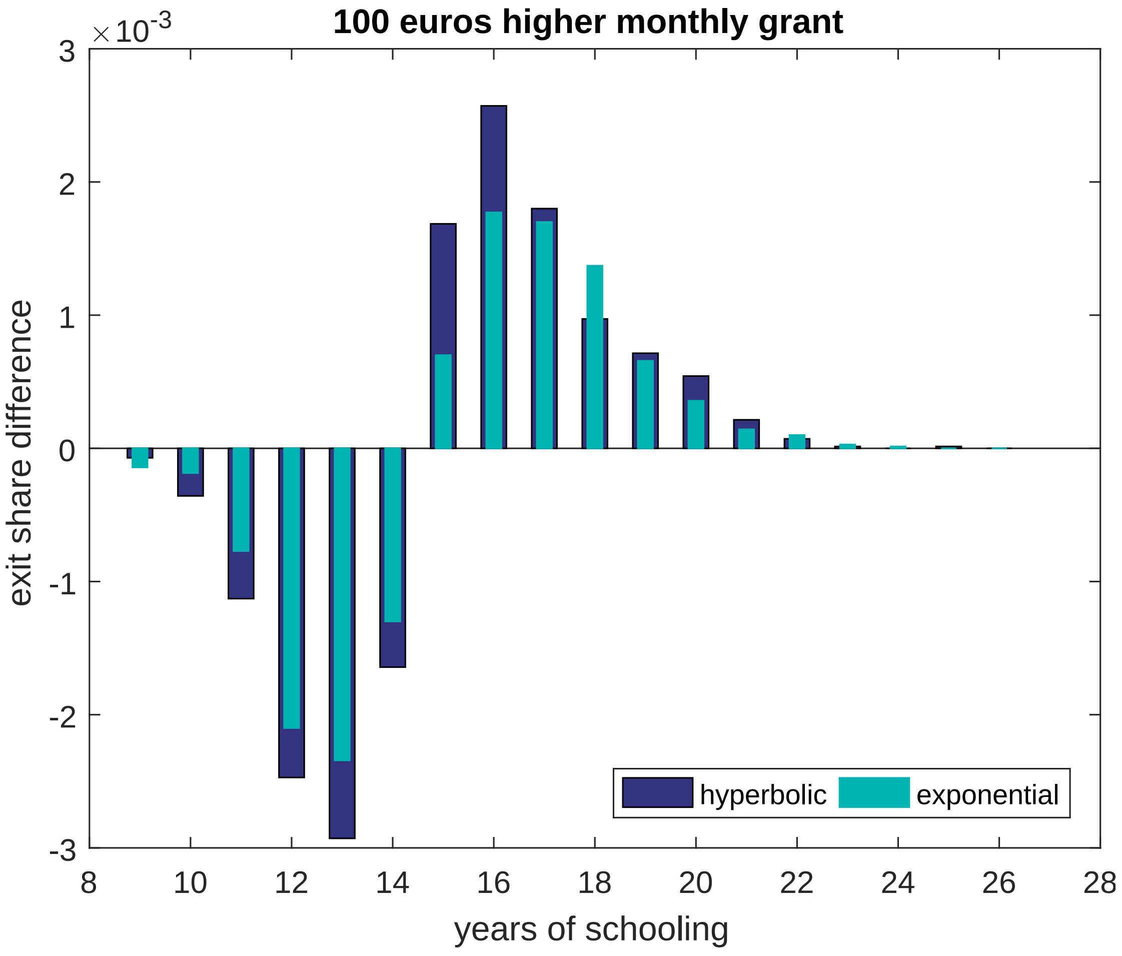
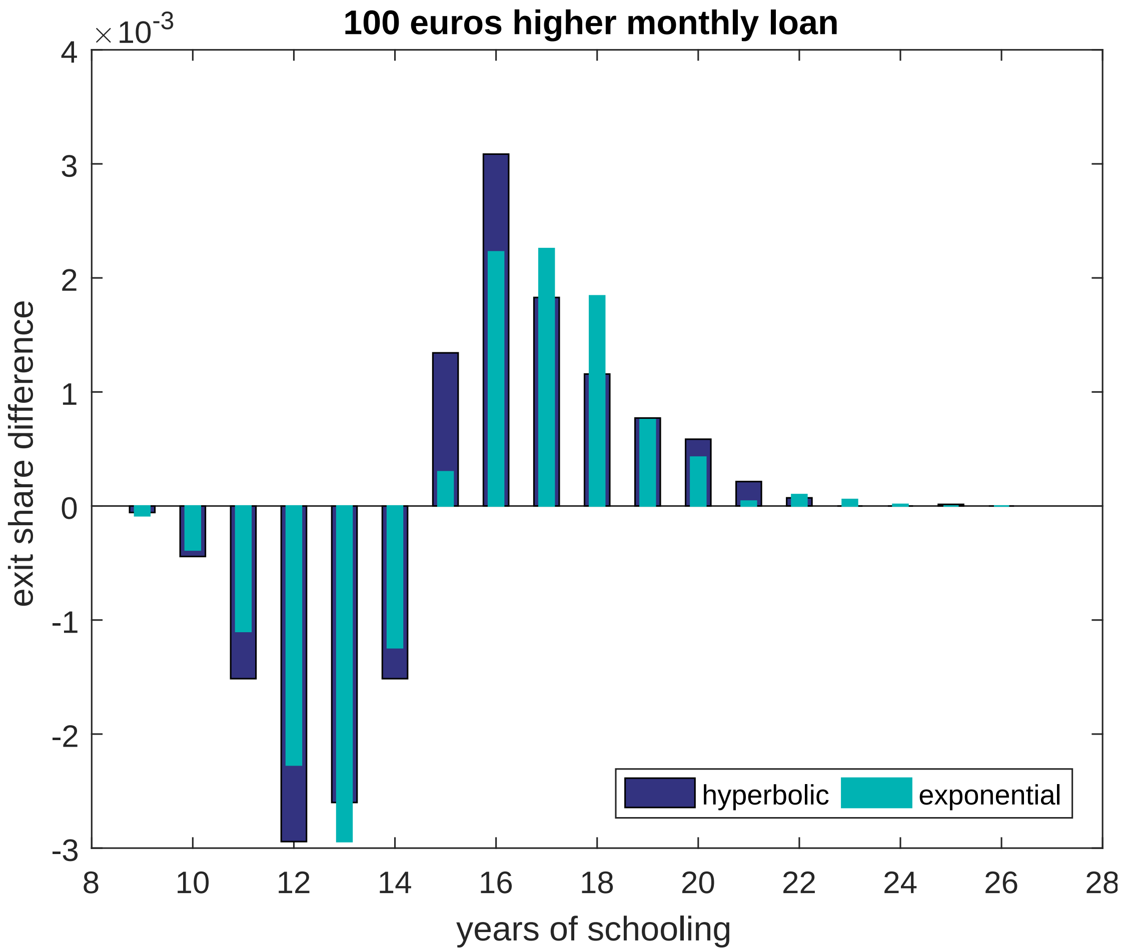


Figure 1-10: Difference in exit shares by actual years of schooling for 100€ increase in a monthly loan



1.8.5 Sensitivity Check

Table 1.6: Sensitivity of β and δ with respect to ρ

	Hyperbolic				Exponential	
$1-\rho$	β_1	δ_1	β_2	δ_2	δ_1	δ_2
1.000	0.590	0.964	0.659	0.991	0.892	0.945
1.100	0.590	0.964	0.659	0.991	0.892	0.942
1.200	0.584	0.965	0.654	0.990	0.891	0.937
1.300	0.550	0.971	0.634	0.991	0.891	0.935
1.400	0.569	0.968	0.643	0.988	0.892	0.933
1.500	0.560	0.971	0.638	0.988	0.893	0.930
1.600	0.552	0.973	0.632	0.987	0.893	0.927
1.700	0.543	0.976	0.626	0.987	0.894	0.924
1.800	0.541	0.976	0.613	0.986	0.895	0.921
1.900	0.523	0.982	0.613	0.987	0.896	0.918
2.000	0.512	0.985	0.607	0.987	0.898	0.915

Source: Own calculations. Estimation results of time preference parameters β_1,β_2,δ_1, and δ_2 for different values of the coefficient of relative risk aversion $(1-\rho)$.

Chapter 2

The Effect of Partial Retirement on Labor Supply, Public Balances and the Income Distribution -Evidence from a Structural Analysis[1]

2.1 Introduction

Population aging is increasing the financial burden on pay-as-you go funded public pension systems in many countries. The sustainability of such pension systems is challenged as the group of elderly recipients increases relative to the number

[1]Valuable comments by Peter Haan, Arthur van Soest, Johannes Geyer, Tunga Kantarci and participants at the Netspar International Pension Workshop 2017 as well as internal seminars at the DIW and the CPB in The Hague are gratefully acknowledged. I thank the Forschungsnetzwerk Alterssicherung (FNA) for financial support through a Ph.D. scholarship. In addition, I thank Netspar for financial support through the Medium Vision Grant (Project name: Flexible combinations of work and retirement).

of contributors. A promising way to counteract this imbalance is to increase the labor force participation of the elderly by extending working lives (Maestas and Zissimopoulos, 2010). Consequently, increasing attention is being paid to measures that motivate elderly employees to remain in the workforce longer in order to extend their time on the contributing side of the social security equation.

Most recently, many European countries introduced partial retirement programs into their pension systems and, in the face of population aging, practically every partial retirement program aims to motivate elderly employees to stay longer in employment (Eurofound, 2016). Partial retirement schemes allow for a reduction of working hours in the last years before entering full retirement. The idea behind increasing labor supply through partial retirement is that a gradual phasing out of work instead of abrupt full retirement encourages workers to stay longer in employment. However, the employment effects of partial retirement programs are ambiguous. Partial retirement may increase labor supply if people opt for partial retirement instead of full early retirement or unemployment. On the other hand, partial retirement might also generate negative employment effects if it crowds out years that would have been spent in full-time employment. The direction of the employment effect also depends on the design of the partial retirement scheme and evidence on underlying mechanisms that drive the effects of partial retirement is still scarce.

In this paper I develop a structural dynamic retirement model to investigate the effects of partial retirement on employment and retirement behavior, fiscal balances as well as the pension income distribution. The biggest challenge to the empirical literature that measures the effects of partial retirement is that it cannot be observed what partial retirees would have done had it not been possible to enter the partial retirement path. Instead of exploiting an exogenous variation to the retirement decision (e.g. through a reform) this study approaches the identification problem by explicitly modeling the drivers (financial and non-financial) of individual retirement decisions. The basic model consists of an individual's annual choice to continue working or exit employment through one of three possible retirement paths: 1) regular retirement, 2) retirement via bridge unemployment, or 3) retirement via partial retirement. The choice is subject to employment and mortality risks. Finally, the model incorporates a tax and transfer system as well as the rules of the underlying pension system. Besides controlling for the endogeneity of the retirement decision as well as the dynamic nature of the problem, the structural approach further enables the explicit modeling of program margins, such as financial subsidies, and counterfactual policy simulations. In addition, the revealed preference approach also allows identifying partial retirement preferences directly at the relevant decision margin.

Based on the estimation of structural parameters of individual employment behavior, I perform policy simulations that investigate the effect of different aspects of a partial retirement policy. First, in order to understand the effect of just introducing partial retirement in the present system, I simulate an unrestricted access to partial retirement. Secondly, I investigate the effect of partial retirement in the context of an increased normal retirement age (NRA) from 65 to 67 because the role of partial retirement as an option to extend working lives through a lower immediate amount of work may be increasing in the face of increasing retirement ages (Eurofound, 2016). Finally, I investigate the role of compensating wage and pension accrual subsidies for partial retirees.

I make use of a unique administrative dataset, the Biographical Data of Social

Insurance Agencies in Germany (BASiD), which combines information on employment history, wages, and partial retirement take-up with the information on corresponding public pension accrual. The combination of the date of partial retirement take-up with pension point accrual is unique since this information is collected by two different government agencies and essential to the present research question as this study not only looks at the ad-hoc effects of retirement decisions but also considers a trade-off between current and future income streams of forward-looking individuals. In addition, compared to survey data, this dataset contains personal information, e.g. on wages or education, that does not suffer from non-response or reporting bias. The focus of this study lies on West German men, which constitutes the largest group of workers in partial retirement.

Determining the sign of the labor supply effect of partial retirement is difficult because the additional retirement path competes with the take-up of alternative employment states that would yield higher (e.g. full-time employment) or lower (e.g. unemployment or early retirement) labor supply. Which of these counteracting substitutions dominates the other depends on the way partial retirement is used. It may yield a positive effect, e.g. if employers use partial retirement to maintain their human capital by keeping experienced employees longer in their firms in order to teach newly hired workers (see e.g. Ghent et al., 2001; Munzenmaier and Paciero, 2002). It can also yield negative effects if partial retirement is used as a tool to renew the working force in firms by reducing work hours of elderly employees and practically sending them off to retirement earlier. For employees partial retirement may be seen as a way to remain in the labor force longer and keep social relations at work even if full-time employment is not wanted or not possible due to health reasons. In addition, staying employed longer, even in part-time, could curtail cognitive decline in higher ages (Rohwedder and Willis, 2010; Bonsang et al., 2012), which could motivate employees to extend their working lives in partial retirement. However, if partial retirement only signals preferences for early retirement (Machado and Portela, 2012) the employment effects may be negative. Financial incentives for partial retirement could also limit positive labor supply effects if it increases its attractiveness relative to full-time employment (Börsch-Supan et al., 2015).

Empirical findings on the effect of partial retirement on labor supply are sparse and ambiguous. For instance, in a pre-post analysis of a phased retirement program at the University of North Carolina Ghent et al. (2001) find suggestive evidence that the program lead to a crowd out from full-time employment and thus negative employment effects and Albanese et al. (2016) use a competing risks model to show that the Belgian partial retirement program leads to an increased take-up of early retirement leading to an overall reduction in labor supply. In contrast, Wadensjö (2006) find that the Swedish partial retirement program lead to a stronger substitution of potential early exiters relative to the substitution of potential full-time employees. Graf et al. (2011) analyze the Austrian old age part-time scheme that is institutionally very similar to the German partial retirement policy *'Altersteilzeit'* (ATZ) and find a cumulative negative effect on employment over the five year duration of the program. The effects of the German ATZ policy are studied by Berg et al. (2015) and Huber et al. (2016). Both studies distinguish between labor market exit and retirement entry since factual retirement can start earlier in Germany if individuals bridge the transition to retirement with unemployment insurance take-up. While Berg et al. (2015) find an overall positive effect of ATZ on the average labor market exit age, the results by Huber et al. (2016)

are more modest. Moreover, Huber et al. (2016) only find a significant positive effect for East Germany and no effect for West Germany, which they attribute to differences in labor market conditions between the regions. Stated-preference approaches identify partial retirement preferences by individual ranking of hypothetical retirement schemes (Van Soest et al., 2007; Elsayed et al., 2015) and find that elderly workers can be motivated to work beyond the NRA in part-time if compensated adequately.

This paper is in line with the literature that uses structural research approaches to model retirement behavior (e.g. Rust, 1989; Stock and Wise, 1990; Rust and Phelan, 1997; Benitez-Silva, 2000; Heyma, 2004; Karlstrom et al., 2004; French, 2005; Blau, 2008; Van der Klaauw and Wolpin, 2008). Although some of these studies implement part-time labor, all of them model retirement as a binary decision. Gustman and Steinmeier (2008) present a noteworthy difference. They analyze the effect of partial retirement on the employment behavior of married men in the context of a dynamic structural retirement model using data form the US Health and Retirement Study. They find that removing restrictions for partial retirement generates an overall positive effect of partial retirement on total labor supply.

Finally, given the simulated policies this paper contributes to the literature on alternative paths into retirement (e.g. Staubli, 2011; Inderbitzin et al., 2016) and to studies that analyze the effect of an increase in early retirement age (ERA) or NRA on actual retirement age (e.g. Duggan et al., 2007; Li and Maestas, 2008; Staubli and Zweimüller, 2013; Atalay and Barrett, 2015; Geyer and Welteke, 2017). The increase of the NRA from 65 to 67 is still in a transitional process in Germany and was only studied in a structural context with an *ex-ante* analysis by Etgeton

(2017).
I find that introducing the option to retire via partial retirement extends working lives by about four to five months by reducing the number of individuals exiting employment early via unemployment. However, overall employment volume still decreases by on average 4.71% if the NRA is at 65 and by on average 3.86% if the NRA is at 67 due to a large share of individuals that substitute full-time employment with partial retirement. With a reduction in employment volume by about 10% this effect is stronger when wages and pensions are subsidized in partial retirement. Subsidizing partial retirement also leads to a reduction in net balances by an additional 9,500 to 13,500€ per person. More importantly, I find that income inequality in pensions is reduced with the introduction of partial retirement. However, not compensating pension accumulation in partial retirement leads to a decrease in pensions across almost all income deciles but these reductions are less pronounced when the NRA is 67 since more people bridge the time between ERA and NRA with partial retirement. Especially for lower income deciles partial retirement provides a way to smooth consumption when transitioning into retirement in the context of an increased NRA.
The rest of this paper is structured as follows. Section 2.2 introduces the dynamic decision model and the estimation strategy, section 2.3 presents the data and descriptive analysis, section 2.4 presents the estimation results, section 2.5 discusses counterfactual policy simulations, and section 2.6 concludes.

2.2 Model

This section introduces a dynamic structural life-cycle model of individuals' retirement decisions at pensionable age. The institutional background is incorporated

in this model as closely as necessary.[2] The core of this model is based on the standard dynamic retirement model by Rust (1989). A forward-looking individual i derives utility at time t from consumption (C_{it}) and has leisure preferences that vary over employment states Γ_{it}^{k}. He[3] maximizes his expected remaining lifetime utility through annual decisions between continuing to work or employment exit via regular retirement, retirement via bridge unemployment, or partial retirement. The individual's horizon ranges from age 55 to $T = 100$ but decisions can only be made from age 55 to age 65, where everyone is in retirement at age 65. Moreover, there are two sources of uncertainty: job loss and mortality.
Figure 2-1 illustrates the structure of the decision problem. The model is conditioned on being employed at age 54.[4]

Every period, the individual faces the risk of job loss with probability Φ_{it}^{u}. Individuals that lose their jobs cannot return to the labor market. This assumption is supported by the data as only a very small fractions returns to the labor market after unemployment in the observed age range. The expected value of job loss is divided into three different phases: before age 58, between 58 and 62, and between 63 and 65. Individuals that loose their job before age 58 receive at least one year of unemployment insurance, then social assistance until they enter regular retirement.[5] Individuals that lose their job at age 58 -with at least two years of unemployment insurance eligibility- will enter retirement after at least two years

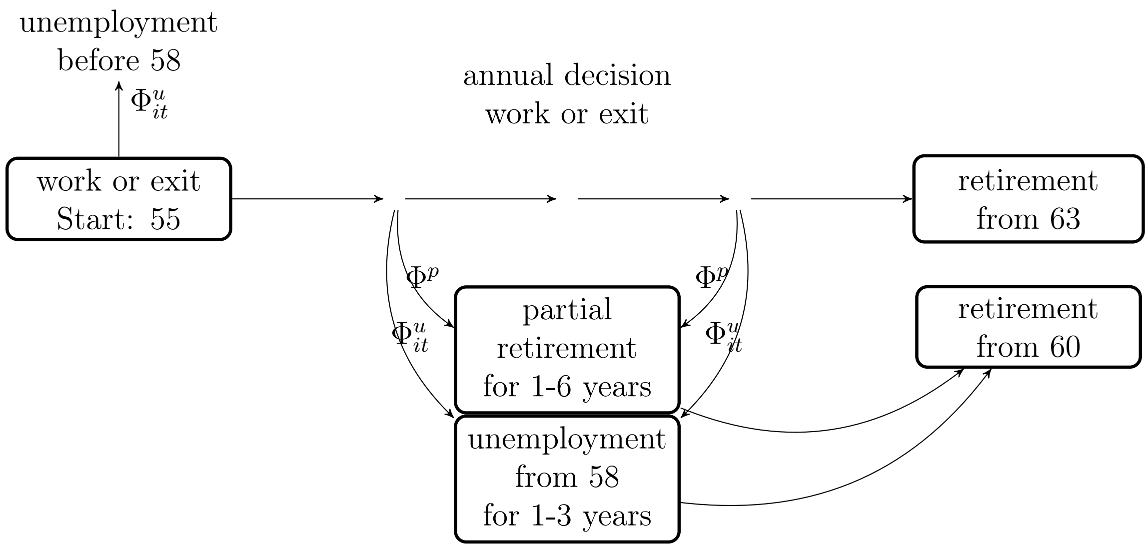
[2]The institutional background is described in a bit more detail in Appendix 2.7.1

[3]I use the male form for the decision maker because the present study focuses on retirement decisions of West German men.

[4]This assumption introduces favorable selection in terms of labor market history and income. However, it also conditions on the eligibility criteria for partial retirement. The decisions of individuals not eligible for partial retirement yield no information on the preferences for partial retirement.

[5]I include this group in the model due to their eligibility for partial retirement prior to job loss.

Figure 2-1: Structure of the decision problem



Own illustration

of unemployment insurance receipt.[6] If job loss occurs after age 63, the individual can either decide between immediate regular old-age pension or retirement after unemployment.

If job loss does not occur, with probability Φ^p_i the individual can decide between the following options:

1. continue to work in full-time (f)

2. exit work through 1 to 6 years of partial retirement and eventual full retirement (p_a), where $a \in \{1, \cdots, 6\}$[7]

[6]I assume that individuals use the full duration of their unemployment insurance eligibility. Due to sample restrictions discussed in Section 2.3, every individual is eligible to at least one year of unemployment insurance.

[7]Note that opting for partial retirement has the additional value of job security. This is due to the fact that take-up and duration of partial retirement is predefined in an employer-employee arrangement. Thus, partial retirement take-up inherits the additional decision over the duration in partial retirement.

3. exit work through bridge unemployment insurance or social assistance and eventual retirement (ru)

4. from age 63: exit work either through regular old-age retirement (re) or the other two retirement paths

However, due to the fact that partial retirement is not a legal right but based on an employer-employee agreement, there is a probability $(1 - \Phi_i^p)$ that the individual has no access to partial retirement. This produces two potential choice sets sets $D^p = \{f, p_a, ru, re\}$ and $D^{np} = \{f, ru, re\}$. To continue working is the only option with a continuation value. All other options are exit paths into retirement. Thus, the basic structure is a classic optimal stopping problem but with three instead of one exit option.

Assuming additive separability of utility over time, the decision problem can be written as

$$\max_{d_{it}} E_{t_0}[\sum_{t=t_0}^{\tilde{t}} \pi_t \delta^{t-t_0} U(C_{it}, \Gamma_{it}^k | d_{it}) + \sum_{t=\tilde{t}+1}^{T} \pi_t \delta^{t-t_0} U(C_{it}, \Gamma_{it}^k | d_{i\tilde{t}})] \tag{2.1}$$

where π_t[8] denotes the probability of living until age t conditioned on being alive at age $t-1$, δ denotes the discount factor and the maximum attainable age is denoted T which is set to 100.

In the individual's decision horizon, we distinguish between two phases: the decision phase (the first term of Equation 2.1) and the retirement phase (the second term of Equation 2.1). The decision phase ranges from $t = 55$ until $\tilde{t}$, where $\tilde{t}$ is

[8] Survival probabilities are obtained from the mortality database of the German Statistical Office and conditioned on gender and cohort (Statistisches Bundesamt).

either age 65 or the age at which one of the exit options was chosen. After $\tilde{t}$ utility evolves deterministically and choices can no longer be made.

The individual controls his consumption (C_{it}) and employment-state-specific utility (Γ_{it}^k) through decisions that affect his employment status (k), where k can either be full time employment (f), partial retirement (p), unemployment (u) or full retirement (r). In this study consumption equals income ($C_{it} = y_{i,t}^k$) which is explained in more detail in Section 2.2.4.

In the following chapters I subsequently describe (i) the utility function (ii) partial retirement (iii) pension accumulation (iv) the budget constraint (v) the tax and transfer system (vi) job loss probabilities and finally combine these components in the dynamic programming framework.

2.2.1 Utility Function

With regard to consumption, all individuals exhibit constant relative risk aversion (*CRRA*) in their within-period utility flows. Furthermore, individuals have preferences for each employment state k. The within-period utility function for individual i at period t in employment state k can be written as

$$U_{it}^k = \frac{(C_{it}^k)^{(1-\rho)} - 1}{1-\rho} + \Gamma_{it}^k + \epsilon_{it}(d_{it}) \tag{2.2}$$

where ρ denotes the coefficient of relative risk aversion and ϵ_{it} is a choice-specific random shock which follows a type-one extreme value distribution. C_{it}^k denotes consumption of individual i in period t in employment state k and is elaborated in detail in Section 2.2.4. Similar to Heyma (2004), individuals exhibit leisure preferences relative to their employment state k, Γ_{it}^{k} which is defined as follows.

$$\Gamma_{it} = \begin{cases} 0 & \text{if } k = f \\ \lambda_0 + \lambda_1 \cdot (age_{it} - 59) & \text{if } k = r \\ \theta_0 + \theta_1 \cdot \mathbf{1}[age_{it} >= 60] & \text{if } k = p \\ \upsilon_0 + \upsilon_1 \cdot \mathbf{1}[age_{it} >= 60] & \text{if } k = u \end{cases} \tag{2.3}$$

Thus, the baseline employment state is full-time employment and individuals experience the additional leisure time in the other employment states differently. Note that individuals can only enter retirement at the earliest from the age of 60. Therefore, preferences for leisure in retirement ($\lambda_0 + \lambda_1 \cdot (age_{it} - 59)$) can only be realized from the age of 60. Moreover, I include an age trend for retirement preferences (λ_1) which is expected to be positive in order to account for increasing leisure preferences as people age, e.g. due to deteriorating health (see e.g. Gustman and Steinmeier, 2005). In addition, θ and υ represent preferences for time spent in partial retirement and unemployment, respectively. Note that I let these differ for the periods before and after the earliest possible retirement age (60). The individual's choice set changes as the option for full retirement becomes available at age 60. Therefore, preferences for each employment state are allowed to differ between these two choice sets. The rationale behind this is as follows. Individuals have increasing utility for leisure. Before retirement entry is possible, υ_0 mainly represents preferences for leisure, since this is the only option for full leisure prior to retirement. However, it can be expected that unemployment insurance receipt is accompanied by a stigmatizing effect which yields disutility (Moffitt, 1983). At the same time, partial retirement is the only option to decrease labor without a stigmatizing effect. Full retirement opens up an additional option to increase leisure without social stigma. Thus, in both states partial retirement and unemployment, the non-financial preferences relative to full-time employment should be lower than the preference for full retirement; in unemployment due to the stigma effect, and in partial retirement due to the lower leisure level. The preferences for these employment states in relation to full retirement are only realized once full retirement is in the choice set.

2.2.2 Partial Retirement

I identify preferences for partial retirement through take-up of *part-time work for elderly employees* (known in Germany as *Altersteilzeit*).[9] Employees can take up partial retirement from the age of 55 by reducing their work hours prior to retirement by 50%. Wage and pension accumulation losses during the partial retirement period are compensated either by the respective employers or the Federal Employment Agency where the law sets a minimum for both compensations. I model subsidies for partial retirement according to these settings. That is, wage compensations in partial retirement amount to 20% of equivalent full-time employment wages ($sub^w = 0.2$) and pension accrual compensations amount to 40% ($sub^r = 0.4$).

Moreover, the model has to account for the fact that access to partial retirement is not a legally binding right but an agreement between employer and employees. Therefore, as mentioned above, with a probability $(1 - \Phi^p)$, the individual's choice set does not contain the option to enter partial retirement. Whether or not an

[9] Details on introduction, conditions and take-up of the policy are described in Appendix 2.7.1

individual has access to partial retirement, cannot be observed in the data. Since the model is estimated by Maximum Likelihood, I construct a likelihood that is adjusted by Φ^p depending on actual partial retirement-take-up. I set $\Phi^p = 35\%$ which is based on information obtained from Wanger (2009).[10]

2.2.3 Pension Accumulation

The German Statutory Pension Insurance, is a pay-as-you-go funded system. Contributions to the system are collected in a payroll tax throughout the working life in the form of annual pension points (pp_{it}) which are based on a ratio of the individual gross wage (w_{it}) to the annual specific average wage of all insured ($\bar{w}_t$), i.e. $pp_{it} = w_{it}/\bar{w}_t$. Annual contributions are capped by a ceiling which varies at around two pension points.
The model incorporates the fact that the individual's pension points are changing throughout the decision process according to the respective employment state as follows

$$P_{it} = \begin{cases} P_{it-1} + pp_{it}(w_{it}) & \text{if } k_t = f \\ P_{it-1} + (\frac{1}{2} + sub^r) \cdot pp_{it}(w_{it}) & \text{if } k_t = p \\ P_{it-1} + 0.8 \cdot pp_{it}(w_{it}) & \text{if } k_t = u \end{cases} \tag{2.4}$$

Thus, regular pension points from full-time employment are adjusted in partial retirement or unemployment. Here, I follow the institutional settings closely and set $sub^r = 0.4$, which denotes the pension points replacements provided by

[10] In particular, Wanger (2009) states that 15% of employees in small firms, where 40 % of the age-wise eligible for partial retirement work, take up partial retirement. The partial retirement take-up rate in the remaining firms is 36% to 44%. Due to its financial incentives, partial retirement is taken up by most employees who have access to it.

the partial retirement program. Pension points during unemployment insurance receipt equal the pension points from full-time wages adjusted by 0.8.

2.2.4 Budget Constraint

In this model consumption equals net income, i.e. $C_{it}^k = y_{i,t}^k$.[11] This is in line with Rust and Phelan (1997) who mainly motivate this with problems of imputing missing wealth information. Dynamic consumption choice in a life cycle model that starts relatively late in working life would require information on the initial distribution on wealth. However, the BASiD dataset does not provide information on wealth and matching a wealth distribution from another dataset is not very useful due to lack of good explanatory covariates. Clearly, I cannot assume that variation in individual retirement decisions is not driven by differences in wealth. However, I assume that most of this source of variation is already captured by income differences which is consistent with a strong correlation between income and wealth (Piketty and Zucman, 2014).

Despite the lack of a savings process the model still features decisions that affect intertemporal income. Given the underlying institutional settings, a pensioner's pension level is determined by his entire earnings and employment history. More specifically, an additional year of labor increases the individual's pension in the future. Furthermore, the system incorporates financial penalties and rewards on pension annuities for earlier or later retirement, respectively. The institutional

[11] While this may sound like a fairly restrictive assumption, it is not in the context of the German public pension system. Workers in Germany rely as main source of income during retirement on the pensions from the Statutory Pension Insurance. Other sources of income, such as returns to capital only play a role of distant second order. For instance, Frick et al. (2010) show that the majority of all German households store the largest share of their wealth in pension entitlements.

background is described in more detail in Appendix 2.7.1. In the following, I will elaborate on the income differences across employment states.
An individual's net-income at period t in employment state k ($y^k_{i,t}$) depends on his gross wages for his last observed state in full employment up to period t[12] and is subject to taxes as well as social security contributions.[13]

Income in full-time employment The administrative dataset provides information about gross daily wages for working individuals. The net annual income for a working individual (y^f_{it}) equals gross annual labor market earnings minus social security contributions and income tax. Similar to Manoli et al. (2014), who estimate a structural retirement model using Austrian data, the data shows little intertemporal variation in wages for elderly working individuals. Therefore, I apply the same approach to modeling future earnings by assuming that earnings w^f_{it} increase linearly by a growth rate g, such that

$$y^f_{it+1} = G((1+g)w^f_{it}) \tag{2.5}$$

where $G(.)$ denotes the model of the tax and transfer system and social security contributions which is explained in more detail in Section 2.2.5.

Income in partial retirement According to the institutional setting[14], income in partial retirement includes a compensation of full-time employment wages of at least 20% which is paid as a wage subsidy $sub^w = 0.2$. Furthermore, the

[12]The sample is conditioned on individuals in full-time employment at age 54. Therefore, I observe gross labor earnings from full-time employment in at least one period per individual.
[13]All monetary values in this analysis are price adjusted to 2005.
[14]See Appendix 2.7.1 For details on the institutional setting of partial retirement.

institutional background ensures that part-time wage penalties are not an issue. This yields the following specification for income in partial retirement.

$$y_{it}^{p} = G((\frac{1}{2} + sub^{w})w_{it}^{f}) \tag{2.6}$$

The individual obtains partial retirement income for the number of years that he has chosen to remain in partial retirement. The time in partial retirement is automatically followed by retirement.

Income in unemployment On average, unemployment insurance amounts to 60% of the net-income that the individual received in the employment period prior to unemployment (Haan and Prowse, 2015). Thus, income in unemployment is specified as follows.

$$y_{it}^{u} = 0.6 \cdot (G(w_{it}^{f})) \tag{2.7}$$

Individuals receive unemployment insurance according to their entitlement between one and three years. I assume that the decision maker takes up the maximum of his entitlement at unemployment insurance receipt. After that, the individual either receives social assistance or his pension depending on the respective employment status.

Income in retirement An individual in retirement receives an annual pension in period t (y_{it}^{r}) that is fixed from the moment of retirement entry up to the final period T. At retirement entry in period $\tilde{t}$, annual pension income is calculated as follows.

$$y_{it}^r = 12 \cdot P_{i\tilde{t}} \cdot Z(ra, rp, cohort) \cdot pv_t \tag{2.8}$$

where y_{it}^r represents the annual pension income of individual i at period t, $P_{i\tilde{t}}$ equals the individuals total sum of pension points collected up to period $\tilde{t}$, Z represents the retirement access factor and $pv_{\tilde{t}}$ represents the institutional pension value in year $\tilde{t}$. Z is equal to one if the individual opts for regular retirement at the NRA. Then, there are deductions of 3.6 % for every year that the individual enters retirement below the normal retirement age.[15] In addition, there is further variation in Z through cohort-based reforms for different retirement paths rp which are illustrated in Table 2.11 in Appendix 2.7.2. This introduces a cohort-based exogenous variation in pension levels that supports the identification of structural parameters.

2.2.5 Tax and Transfer System

Taxes as well as social security contributions (SSC) differ substantially across employment states. They therefore affect retirement decisions through their effect on income. To control for this, I include a model of the tax and transfer system that incorporates the key differences across employment states. The base year for these institutional settings is 2005. This includes the legislative settings for taxation in different employment states and price adjustments.

[15]When the NRA is 65, the pensions of someone who retires at age 60 are deducted by $5 \cdot 3.6\% = 18\%$

Due to lack of demographic information, I model taxes and transfers for a single earner household. The model considers a progressive income tax and differences in SSC across employment states. The wage compensations for partial retirees are not taxed but are still subject to the progression clause. This implicitly provides further financial incentives for partial retirement. Pensions are only taxed by 50% and exempt from pension contributions. Net income in unemployment insurance roughly equals 60% of previous net labor earnings. Furthermore, the model considers compensations in earnings and pension point accumulation for partial retirement and unemployment insurance receipt. Finally, all income is bounded from below by social assistance. Overall, this model incorporates the key differences in financial incentives across employment states.

2.2.6 Job Loss Risk

The individual's employment decision is subject to labor demand frictions. Similar to Haan and Prowse (2014) and Merkurieva (2016), the risk of involuntary job loss (Φ_{it}^{u}) is estimated in a first stage random effects logit regression based on the German Socio-Economic Panel (SOEP)[16]. The dataset contains information on employment status and self-reported reasons for job termination. Job loss is defined as involuntary if the respondent has one of the following reasons for job termination: 1) Company shut down, 2) Dismissal, and 3) Temporary contract expired. I let the risk of job loss depend on personal characteristics that are contained in both datasets to be able to match the computed risk to the sample that is used for the structural analysis. The associated risk of job loss depends on age, education, past year's log years of tenure and log monthly wages. Thus,

[16] This is an annual survey that, since 1984, collects individual- and household-level information from about 12,000 households (Wagner et al., 2007).

the probability of job loss Φ_{it}^u follows a logistic distribution $\Lambda(.)$ with the following specification.

$$\begin{aligned}\Phi_{it}^u = \Lambda(\alpha_i + \phi_0 + \phi_1 age_{it} + \phi_2 \mathbf{1}[educ_i = 2] + \phi_3 \mathbf{1}[educ_i = 3] \\ + \phi_4 log(tenure_{it-1}) + \phi_5 ln(wage_{it-1}))\end{aligned} \tag{2.9}$$

where $\alpha_i \sim N(0, \sigma_\alpha^2)$ is an individual-specific random error. The variable *educ* is defined as 1 if years of education are lower than 12, 2 if years of education are 12 or more and lower than 16 years and 3 if years of education are 16 or more. That is, the baseline is low education.

2.2.7 Value Functions

The maximization of the decision problem in Equation 2.1 requires the choice of an optimal sequence of d_t from t to T. Drawing on dynamic programming techniques (Bellman, 1957), the dynamic optimization problem can be broken down to a two-period problem by recursively defining it as a function of state-specific conditional value functions $V_{it}(C_{it}, \Gamma_{it}|d_{it}, \Omega_{it})$ which define the maximum present discounted value of the individual's future life-cycle utility, conditioned on the individual's choice (d_{it}) and state variables (Ω_{it}). For the purpose of readability, I define: $V_{it}^d(k) = V_{it}(C_{it}, \Gamma_{it}|d_{it} = d, \Omega_{it} = \Omega)$ as the value function with choice d in employment state k (since one choice can inherit different employment states) conditioned on other state variables. Furthermore, the method to condition on access to partial retirement produces two sets of value functions with different choice sets D^p and D^{np}. The choice-specific value functions are written as follows.

$$V_{it}^{f}(d_{it} \in D^{p}) = U_{it}^{f}(f) + \delta\pi_{t+1}[\Phi_{it}^{u}\,\mathrm{E}\max\{V_{it+1}^{re}, V_{it+1}^{ru}\} + (1-\Phi_{it}^{u})$$
$$\mathrm{E}\max\{\mathrm{E}\max\{V_{it+1}^{re}, V_{it+1}^{ru}\}, \mathrm{E}\max\{V_{it+1}^{p_1}, \cdots, V_{it+1}^{p_6}\}, V_{it+1}^{f}\}] \quad (2.10)$$

$$V_{it}^{p_a} = \sum_{j=t}^{t+a} \delta^{j-t}\pi_j^{\mathbf{1}(j\neq t)} U_{ij}^{p_a}(p) + \sum_{j=t+a+1}^{T} \delta^{j-t}\pi_j U_{ij}^{p_a}(r), \text{where } a \in \{1, \cdots, 6\} \quad (2.11)$$

$$V_{it}^{ru} = \sum_{j=t}^{t+a} \delta^{j-t}\pi_j^{\mathbf{1}(j\neq t)} U_{ij}^{ru_a}(u) + \sum_{j=t+a+1}^{T} \delta^{j-t}\pi_j U_{ij}^{ru_a}(r),$$
$$\text{where } a \in \{1, \cdots, 3\} \quad (2.12)$$

$$V_{it}^{re} = \sum_{j=t}^{T} \delta^{j-t}\pi_j^{\mathbf{1}(j\neq t)} U_{ij}^{re_a}(r) \quad (2.13)$$

The value function for full-time employment when there is no access to partial retirement is written as:

$$V_{it}^{f}(d_{it} \in D^{np}) = U_{it}^{f}(f) + \delta\pi_{t+1}[\Phi_{it}^{u}\,\mathrm{E}\max\{V_{it+1}^{re}, V_{it+1}^{ru}\} + (1-\Phi_{it}^{u})$$
$$\mathrm{E}\max\{\mathrm{E}\max\{V_{it+1}^{re}, V_{it+1}^{ru}\}, V_{it+1}^{f}\}] \quad (2.14)$$

Furthermore, there is no value function for the partial retirement choice when there is no access to partial retirement and the remaining value functions do not differ under both choice sets.

2.2.8 Solution and Estimation

Due to the finite horizon of the choice problem, the solution can be derived by backwards induction starting from the utility flow in the final decision period. Within the model's framework, the individual will eventually have to retire. After choosing one of the potential exit options, the individual receives (depending on the choice either immediately, after a period of partial retirement or after a period of unemployment insurance claiming) an annual pension according to Equation 2.8 up to the final period.
It follows from the type I extreme value distribution of $\epsilon_{it}(d_{it})$ in the utility function that we can derive a closed form solution for the expected maximum of choice-specific value functions (Rust, 1987) such that for any value function specific to the choices $l \neq m$

$$E \max\{V^l, V^m\} = ln(\exp(V^l) + \exp(V^m)) + \gamma \tag{2.15}$$

where γ represents the Euler-Mascharoni constant with $\gamma \approx 0.5772$. Moreover, with the assumption of additive separability over time and conditional independence (Rust, 1987), the model produces choice probabilities equal to

$$P(max(V_{it}^{d}) = V_{it}^{\bar{d}}) = \frac{exp(V_{it}^{\bar{d}})}{\sum_{j \in D^{p}} exp(V_{it}^{j})} \quad \text{for } d \in D^{p} \tag{2.16}$$

and

$$P(max(V_{it}^{d}) = V_{it}^{\bar{d}}) = \frac{exp(V_{it}^{\bar{d}})}{\sum_{j \in D^{np}} exp(V_{it}^{j})} \quad \text{for } d \in D^{np} \tag{2.17}$$

The probability to observe a choice needs to be adjusted by the unemployment probability Φ_{it}^{u} which yields

$$P(d_{it} = f) = (1 - \Phi_{it}^{u}) \cdot P(V^{f} > V^{r} \wedge V^{f} > V^{p}) \tag{2.18}$$

$$P(d_{it} = p_{\bar{a}}) = (1 - \Phi_{it}^{u}) \cdot P(V^{p} > V^{r} \wedge V^{p} > V^{f}) \cdot P(max(V_{it}^{p_{a}}) = V_{it}^{p_{\bar{a}}}) \tag{2.19}$$

$$P(d_{it} = ru) = (\Phi_{it}^{u} + (1 - \Phi_{it}^{u}) \cdot P(V^{r} > V^{p} \wedge V^{r} > V^{f})) \cdot P(V^{ru} > V^{re}) \tag{2.20}$$

$$P(d_{it} = re) = (\Phi_{it}^{u} + (1 - \Phi_{it}^{u}) \cdot P(V^{r} > V^{p} \wedge V^{r} > V^{f})) \cdot P(V^{re} > V^{ru}) \tag{2.21}$$

where $V^{r} = E \max\{V^{ru}, V^{re}\}$. The choice probabilities with the choice set D^{np} are computed analogously. Taking the product of the model's choice probabilities over observed choices produces the conditional individual likelihoods $L_{i}(D^{p}) = \prod_{t=1}^{\tilde{t}-1} P(d_{it} = f) \cdot P(d_{i\tilde{t}} \neq f)$ and $L_{i}(D^{np})$, analogously, where $\tilde{t}$ represents the period in which the exit decision is made. The final log-likelihood is written as

$$LL = \sum_{i=1}^{N^p} \log(L_i(D^p)) + \sum_{i=1}^{N^{np}} \log(\Phi_i^p \cdot L_i(D^p) + (1 - \Phi_{it}^p) \cdot L_{it}(D^{np}) \tag{2.22}$$

where N^p and N^{np} represent the number of individuals where the partial retirement decision is observed and where it is not observed, respectively. Parameters $(sub^w, sub^r, \pi_t, \delta, g, \Phi_i^p)$ are set in advance, Φ_{it}^u is estimated in a first step using a logit model, and the parameters $(\rho, \gamma, \lambda, \theta, \upsilon)$ are estimated with the structural model using maximum-likelihood estimation.

2.3 Data and descriptive analysis

This paper relies on the administrative Biographical Data of Social Insurance Agencies in Germany (BASiD). The data is a combination of two administrative datasets from the Statutory Pension Insurance and the Federal Employment Agency through the identical social security number that serves as the unique individual identifier (Hochfellner et al., 2012). The basis of this dataset is a random selection from the Sample of Insured Persons and their Insurance Accounts (VSKT) of the Statutory Pension Insurance, which was enriched with individual information from the Federal Employment Agency. The joint dataset provides spell information about the employment history for each individual on a daily level from first entry through 2007. The sample covers the cohorts 1940-1947. In addition, BASiD contains information about education as well as several individual and work-related characteristics. To avoid dropping much of the sample due to a high degree of missings in the education variable, I impute lacking educational information using the method suggested by Fitzenberger et al. (2005).

The administrative reporting of all contributors earnings biographies ensures a high reliability on earnings information. This constitutes a clear advantage over survey data since reported data on earnings and employment histories or education usually suffers from non-response or reporting bias.

Earnings information in German administrative records are top-coded since contributions to social security and pension are deducted as a share of earnings up to an annually specified wage ceiling. Since earnings beyond that wage ceiling are recorded as exactly equal to that limit, wage information in the present dataset are right-censored. In order to obtain a better approximation of the true distribution of earnings, individual earnings that are affected by top-coding are imputed based on a Pareto rule for each year with the censoring limit set to the respective annual wage ceiling as suggested by (Bönke et al., 2015). A more detailed description of the imputation is given in Appendix 2.7.3.

I focus on West German men, who constitute the largest group of workers in partial retirement. The number of women in the studied cohorts eligible to partial retirement take-up is comparatively small, with earnings- and employment histories considerably different between East and West Germans in the studied time interval (Huber et al., 2016). Furthermore, I set the panel level of the dataset to annual observations. However, the loss in information compared to the drastic reduction in the computational burden, as we move from daily to annual intervals, is small, since most individuals implement retirement decisions exactly on their birthdays, as shown in Figure 2-2, and partial retirement take-up mostly occurs in full years, as seen in Figure 2-7 in Appendix 2.7.4. Moreover, due to lacking information on health, I exempt individuals who are eligible for either of the two disability pensions types. The missing health information makes it difficult to account for the effect of health shocks on the studied retirement decisions, which is why individuals subject to particularly strong health shocks are excluded. Furthermore, I restrict to a minimum of five contribution years to the pension fund due to the institutional restriction on pension eligibility. Finally, individuals need to be in full-time employment subject to social security contributions at age 54 with at least two years of tenure. This is done in order to correct for workers selecting into firms with partial retirement only because they are able to enter partial retirement shortly after joining the firm. Refraining from this restriction could potentially yield an over-representation of individuals with strong partial retirement preferences, which could result in an upwards biased estimation of partial retirement preferences (Huber et al., 2016). Further, this restriction ensures eligibility for unemployment insurance receipt prior to retirement, such that the retirement path via unemployment is a viable alternative to partial retirement. Thus, these restrictions produce a homogeneous group of people who all fulfill the eligibility criteria for the studied retirement options.

The final sample consists of 3,188 individuals with observed retirement entries. Of those, about 39 % (1,246) enter old-age retirement directly after work, 29 % (910) after unemployment, and 32% (1032) after partial retirement. Since the estimation strategy allows the inclusion of right-censored observations in a panel data setting, the sample on which the analysis is based further includes employment decisions of 2,238 additional individuals for whom the retirement decision is not observed.

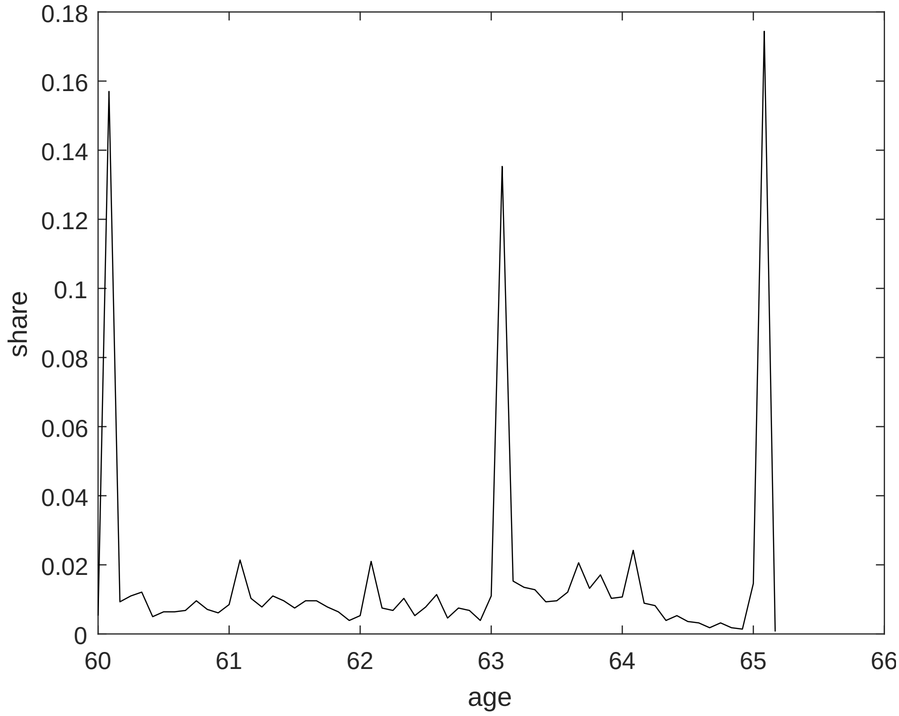
Table 2.1: Descriptive statistics by retirement path

	Regular		Unemployment		Partial	
	Mean	**Std.Dev.**	**Mean**	**Std.Dev.**	**Mean**	**Std.Dev**
Retirement age	64.123	0.872	60.995	1.228	61.316	1.308
Pension (mon)	1365.597	363.975	1128.939	265.997	1254.981	247.331
Pension points	54.426	14.431	51.851	11.302	56.315	10.083
Contribution years	44.791	6.759	43.533	4.980	44.281	4.197
German	0.812	0.391	0.843	0.364	0.872	0.334
Education low	0.091	0.288	0.108	0.310	0.078	0.269
Education interm.	0.697	0.516	0.760	0.480	0.775	0.473
Education high	0.211	0.434	0.132	0.351	0.146	0.368
$\mathbf{U}_p r$	0.009	0.015	0.022	0.033	0.015	0.024
N	1246		910		1032	

Source: Own calculations based on BASiD. "Partial" stands for partial retirement.

Table 2.1 shows the group means and standard deviations for relevant variables by retirement paths. It can be seen that institutional retirement age thresholds are binding since regular retirees enter retirement much later than those who retire via unemployment or partial retirement given the early retirement option for non-regular retirement paths. Despite this earlier retirement age for partial retirees, they collect, on average, more pension points than the other two groups suggesting that the share of partial retirement retirees is higher in higher paying jobs. This is in line with Chen and Scott (2006), who show that individuals with the option for partial retirement generally have a higher socio-economic background. This is further supported by the slightly higher education, share of German citizenship, pensions, and contribution years for partial retirement retirees compared to unemployment retirees. However, despite the higher average pension points for partial retirement retirees, regular retirees receive a slightly higher monthly pension on average. This can be explained by the lower retirement age of partial retirees and the corresponding deductions to pensions.

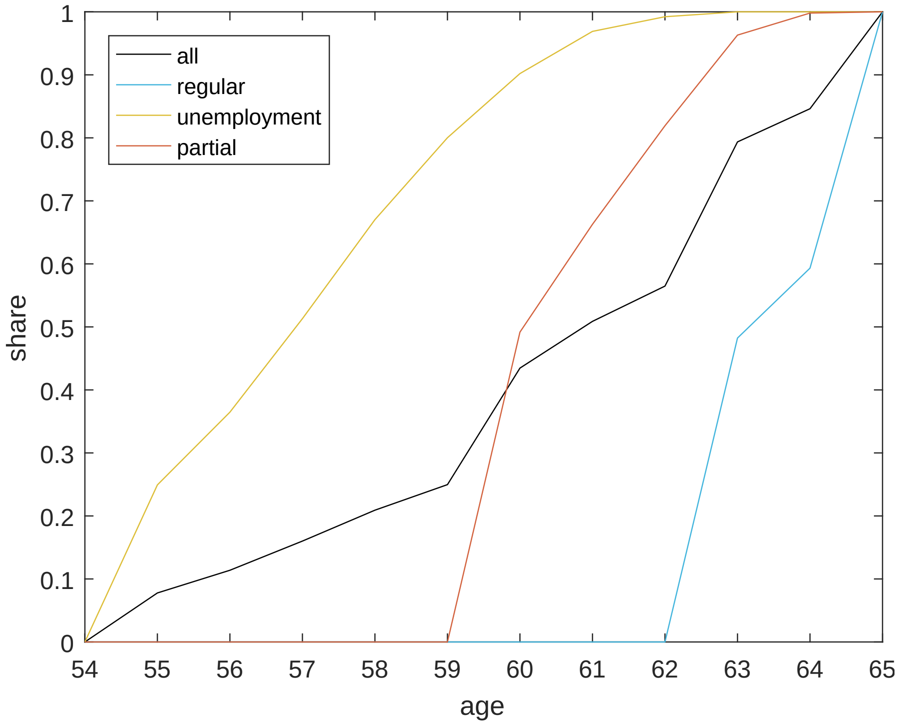
Figure 2-2: Retirement entry by age



Source: Own calculations based on BASiD sample with monthly observations. Sample restrictions: Only validated accounts, no disability insurance receipt, at least five pension contribution years, at least two years tenure at age 54.

The fact that retirement decisions are -to a large extent- driven by institutional age thresholds is supported by Figure 2-2 since the peak values for retirement entry occur at ages 60, the earliest possible retirement age for partial or unemployment retirees, 63, the early retirement age for regular retirees, and 65, the normal retirement age.

Figure 2-3: Relative shares in non-employment by age and retirement path



Source: Own calculations based on BASiD. Shares are relative to the retirement path group size.

Finally, Figure 2-3 shows the share of individuals in non-employment relative to the number of people in the respective retirement paths. Generally, the status *"non-employed"* is defined as being unemployed or in retirement. The figure shows that partial retirees leave the employment status earlier than regular retirees but later than unemployment retirees. Thus, this suggests that a shift from regular retirement to partial retirement would generate negative employment effects while a shift from retirement via unemployment to retirement via partial retirement would generate positive employment effects.

2.4 Results

In this section I subsequently discuss the results from the estimation of the job loss risk, the structural estimation and the goodness of fit of the structural model.

2.4.1 Job Loss Risk

Table 2.2 shows the marginal effects on the probability of becoming involuntarily unemployed from the logit model that is described in Equation 2.9.

Table 2.2: Logit, marginal effects, job loss risk

	Value	Std.Err
ϕ_1 (*age*)	-0.0146***	0.0017
ϕ_2 (*educ=2*)	-0.4375***	0.0487
ϕ_3 (*educ=3*)	-0.3337***	0.0758
ϕ_4 (*log(tenure)*)	-0.3268***	0.0126
ϕ_5 (*log(wage)*)	-0.0914**	0.0395
ϕ_0 (*constant*)	-1.7658***	0.2852
σ_α	0.9951	
N	90,723	
log-likelihood	-16,636	

*,** and *** denote significance level of 10%, 5% and 1%, respectively.

The estimation is based on a sample of all West German men in the SOEP excluding civil servants, self-employed and pensioners and the results are matched to the equivalent sample in BASiD. As expected, the risk of involuntary job-loss decreases with age. One reason for this could be that higher job-protection for people with higher tenure reduces the probability of job-loss due to the expiration of a temporary contract or firing as people get older. As expected, the job-loss risk also decreases with wage, education and tenure since better educated individuals in higher paid jobs with more tenure are less likely to risk involuntary job loss. Overall, the unemployment risk ranges between virtually 0 and 10%.

2.4.2 Model Estimates

Table 2.3 shows the results from the structural estimation of the model. Due to the separate identification problem between time and risk preferences (Rust, 1994), I set the discount factor δ to 0.96, as identified by Gourinchas and Parker (2002) in a consumption life-cycle model. Overall, I find reasonable and precise estimates of the structural parameters that are consistent with the present literature. I obtain an estimate of 2.9988 for ρ, the coefficient of relative risk aversion. This is above the 1.81 as found in the retirement model by Blau and Gilleskie (2006) but far below 5 as estimated in the model by French and Jones (2011). Given that the baseline employment status is full-time employment, the preferences for the other employment states, which yield more leisure, are positive.

Table 2.3: Structural parameters

	Value	**Std.Err**
Utility function		
β	0.96	-
ρ	2.9988***	0.1729
Retirement		
λ_0	0.8532***	0.0280
λ_1	0.0087**	0.0037
Partial retirement		
θ_0	1.2616***	0.0234
θ_1	-0.5856***	0.0318
Unemployment		
υ_0	1.2226***	0.0320
υ_1	-0.8413***	0.0599
ll	-14,861	

*,** and *** denote significance level of 10%, 5% and 1%, respectively.

Before people can enter retirement at age 60, leisure in unemployment and partial retirement is valued more positively than retirement. The preference for partial retirement before age 60 is strongly positive with a value of 1.26 but it decreases by 0.59 once people can enter retirement. This suggests that individuals are likely to forego higher earnings in full-time employment for the benefits of part-time employment in the given partial retirement program. At the same time, this also shows that people tend to opt for full retirement once the option occurs. Similarly, people experience leisure in unemployment positively (with a parameter value of 1.22) before they can enter retirement since this is the only option to fully reduce employment efforts for individuals younger than 60. At age 60 these preferences reduce by a value of 0.84 which is a more substantial drop than the reduction of partial retirement preferences. This is in line with the stigma in unemployment insurance receipt as mentioned in the model section. As expected, the preference for retirement is positive with a value of 0.85 and slightly increasing by a value of about 0.01 per year.[17]

2.4.3 Model Fit

Based on the estimation of structural parameters and random draws from the income distribution within the data, I simulate a dataset with 100,000 observations. Figure 2-4 shows how well the simulated dataset fits the real dataset by comparing the shares in each employment state by age in the present and the simulated dataset.[18]

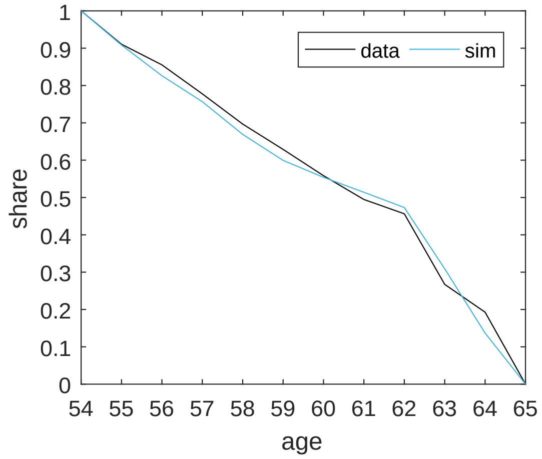
The overall pattern of individuals in each employment state is fitted reasonably well. The model slightly overpredicts the decrease in full-time employment at age 64 and correspondingly slightly overpredicts the increase in retirement or non-employment at age 64. This is because the model does account for the institutionally driven increase in retirement rates from age 63 but not for the observed differences in retirement entries between age 63 and 64 as seen in Figure 2-2. One

[17]Deteriorating health with age is a main reason to allow for increasing retirement preferences. The sample is restricted to more healthy individuals without disability benefits eligibility which explains why the positive trend in the retirement preference is relatively small.

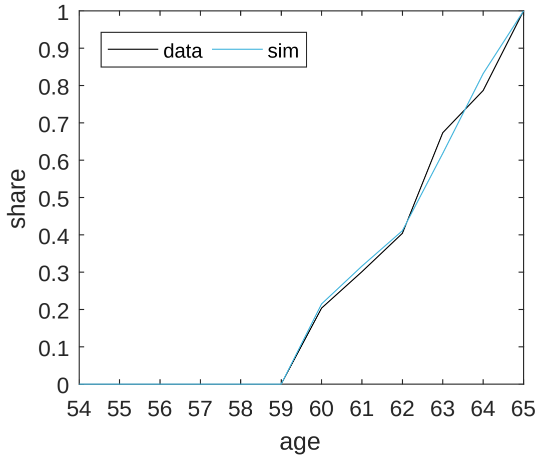
[18]For full-time employment it is equal to one at age 54 and for retirement it is equal to one at age 65 because of the model conditions on everyone being in full-time employment at the beginning of the decision period and everyone being retired at age 65. Therefore, the share of full-time employees is always decreasing while the share of individuals in retirement or non-employment is always increasing.

easy way to account for this, would be to incorporate a dummy variable for age 63 for leisure-preferences in retirement in the utility function. However, I refrain from this due to an economically difficult justification for this method and subsequently difficult interpretation of the corresponding parameter. Similarly, the decrease in partial retirement at ages 60-62 is a bit over-predicted. Again, this corresponds to the retirement entry behavior specifically for ages 63 that is not explicitly modeled. Instead, this is represented by a decrease in partial retirement preferences from age 60 which is seemingly estimated to fit partial retirement entry behavior from age 63. Finally, the model slightly overpredicts unemployment shares overall although the shape of the distribution across ages appears to be fitted relatively well. Overall, the simulated sample provides a reliable basis for further policy analysis.

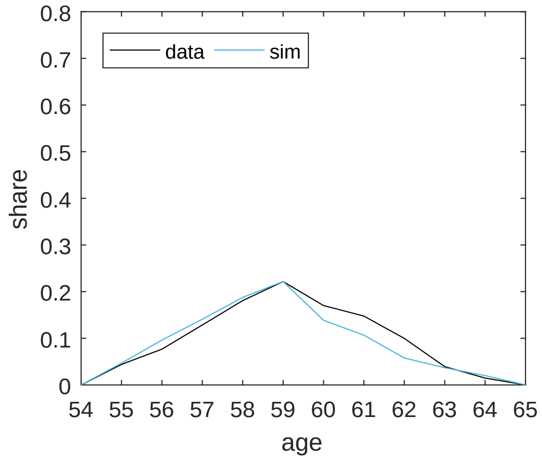
Figure 2-4: Model fit



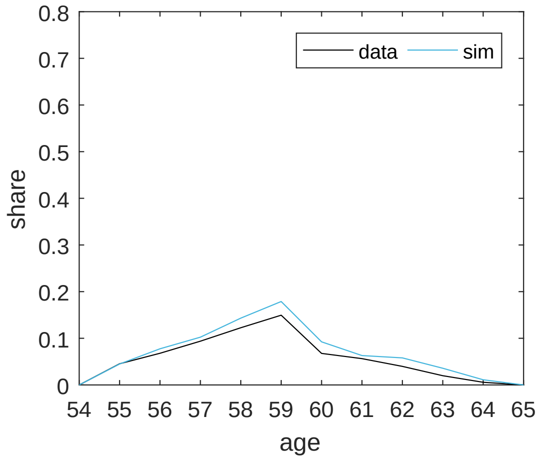
(a) Full-time



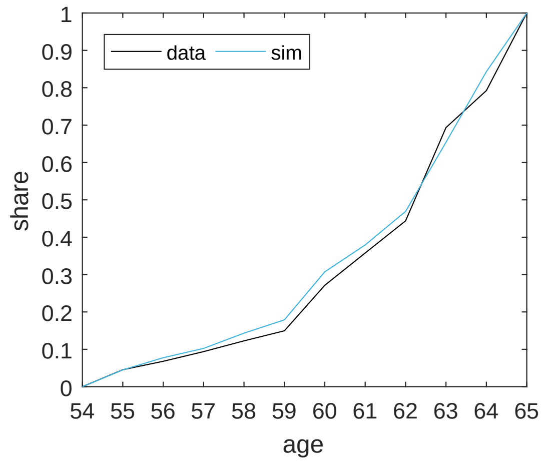
(b) Retirement



(c) Partial Retirement



(d) Unemployment



(e) Non-employment

Source: Own calculations based on BASiD. Based on 100,000 simulated observations. Figure depicts shares in each employment state by age. Sample is conditioned to 100% full-time employment at age 54 and 100% retirement at age 65.

2.5 Policy simulations

In this section, I present the results of counterfactual policy simulations that are performed based on the estimated parameters. Note that the institutional settings in the present data comprise different early retirement age thresholds for the studied retirement paths, an intermediate degree of access to partial retirement, and some specified financial incentives for partial retirement. For instance, in the underlying institutional setting, people become eligible for full retirement after partial retirement at the age of 60, while eligibility for regular retirement only starts at age 63. Using this as a benchmark in the planned policy simulations would make it difficult to reveal the effects that derive purely from partial retirement. Therefore, for the baseline scenario, I adjust the early retirement age threshold for retirees after unemployment and partial retirement (60) to the early retirement age threshold of regular retirees (63). Moreover, the baseline scenario has neither a partial retirement option nor subsidies for partial retirement. This is done in order to understand the isolated effect of each policy simulation. I then analyze the effects of the following policy scenarios: (1) full access to partial retirement, (2) an increase in the NRA from 65 to 67, and (3) subsidies for wages and pension accrual for partial retirement. Note that in order to understand the combined effects from these policies, some analysis also covers the interaction of these policies. In the following sections, I start with a discussion of the employment effects. This is followed by a discussion of the fiscal consequences and distributional effects of each policy simulation.

2.5.1 Employment Effects

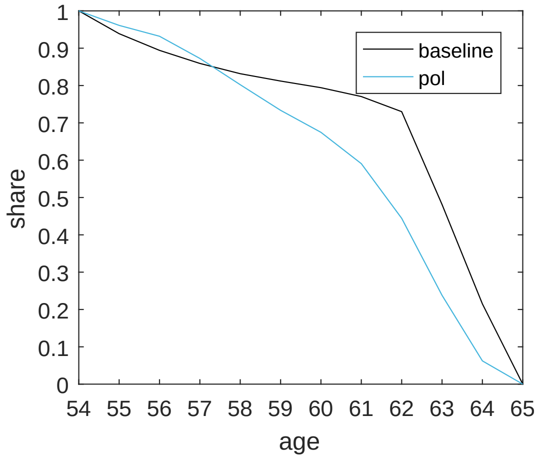
I compute the effect of partial retirement on working life duration as well as employment volume. For a better measurement of changes in working life duration, I distinguish between retirement entry (pension receipt) and employment exit (entry into unemployment or retirement). In order to measure the effects on employment volume, I compute the full-time equivalent (FTE) at every age where one year in partial retirement is counted as $\frac{1}{2} * FTE$.[19] In order to understand what drives these employment effects, I further depict changes in retirement path shares as well as changes in average shares of each employment state.

Introducing Partial Retirement

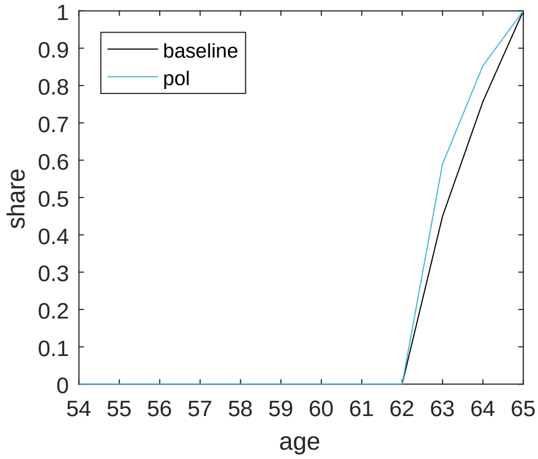
Figure 2-5 shows the effects on each employment status by age, from simulating full access to partial retirement compared to the baseline with no access to partial retirement. As expected, this leads to a significant increase in partial retirees at each age (2-5(c)), which corresponds to a decrease in unemployment shares (2-5(d)) as well as individuals in full-time employment (2-5(a)). Thus, upon the introduction of partial retirement we observe both a shift to partial retirement from full-time employment as well as unemployment in old age.

[19] This corresponds to the definition of FTE in Gustman and Steinmeier (2008)

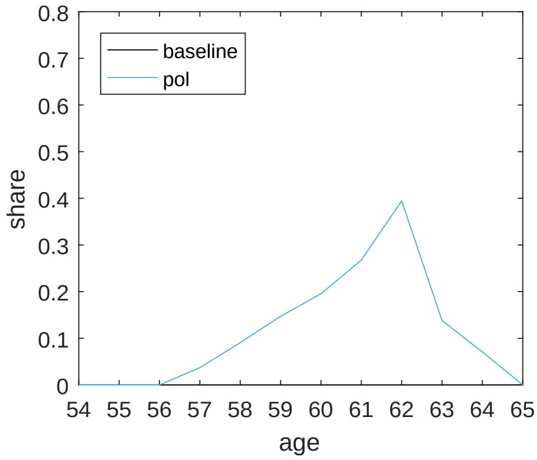
Figure 2-5: Policy Simulation: 100% access to partial retirement



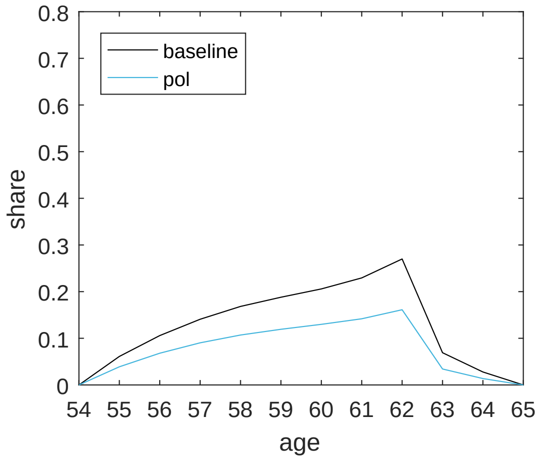
(a) Full-time



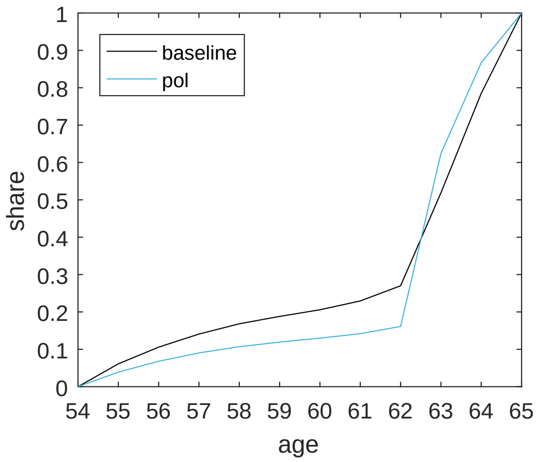
(b) Retirement



(c) Partial retirement



(d) Unemployment



(e) Non-employment

Source: Own calculations based on BASiD. Based on 100,000 simulated observations. Figure depicts shares in each employment state by age. Sample is conditioned to 100% full-time employment at age 54 and 100% retirement at age 65.

Furthermore, it can be seen in Figure 2-5(b) that people enter retirement slightly earlier under a regime with partial retirement. More precisely, with partial retirement, a higher share of individuals enter retirement at age 63 and 64 compared to the retirement entry behavior without partial retirement. Thus, the additional time spent in partial retirement does not seem to postpone the timing of full retirement.

However, the working life duration still increases upon the introduction of partial retirement. This is because fewer people exit employment at younger ages, which can be seen in Figure 2-5(d). Until age 63, when people become eligible for regular retirement, there is a substantially lower share of people exiting employment under a partial retirement regime. From age 63 onwards there are slightly more people leaving employment due to the increased share of retirees at these ages. This suggests that partial retirement reduces the number of people who exit the labor market at younger ages through unemployment before they become eligible for regular retirement.

Table 2.4: Employment effects, partial retirement

	No part. ret.	Part. ret.	Diff	Diff (%)
Avg. retirement age	63.79	63.56	-0.24	-0.37
Avg. employment exit age	62.33	62.65	0.33	0.52
FTE avg.	73.27	69.82	-3.45	-4.71
Retirement path shares				
Regular	73.00	29.63	-43.37	-59.41
Unemployment	27.00	16.12	-10.88	-40.30
Partial	0.00	54.25	54.25	-
Average share in employment state				
Full-time	73.27	63.11	-10.16	-13.86
Partial	0.00	13.41	13.41	-
Unemployment	14.66	9.04	-5.62	-38.32
Retirement	12.07	14.43	2.36	19.57

Source: Own calculations based on BASiD. Based on 100,000 simulated observations. FTE represents Full-time employment equivalent. Shares are represented in percent. Column 3 depicts absolute changes. Column 4 depicts relative changes.

Whether or not this policy yields a positive employment effect depends on the size of each movement from unemployment/early retirement to partial retirement or full-time employment to partial retirement. Table 2.4 shows a summary of average statistics describing the employment effects of the present policy simulation.

Differences in statistics between the policies are reported in both absolute and relative changes. The lowest panel of Table 2.4 supports the findings from above. The share of full-time employees and the unemployed falls by about 14% and 38%, respectively. The middle panel shows that this is driven by a partial retirement take-up rate of about 54%. While the increase in the partial retirement path seems drastic, it is reasonable when considering that partial retirement take-up with 35% access, as in the policy scenario underlying the original data, is more than 30%. Moreover, the upper panel shows that, while average retirement age reduces by 0.24 years (about 2.8 months), the average age at labor market exit increases by about 4 months from 62.33 to 62.65, which is mostly driven by fewer people leaving the labor market earlier through unemployment. That is, partial retirement leads to an extension of working lives. However, Table 2.4 shows that FTE employment decreases on average by 4.71%. Thus, although partial retirement leads to an extension of working lives, the overall effect of partial retirement on employment volume is negative, because the additional time spent in partial retirement instead of non-employment does not compensate the crowd out from full-time employment.

Increasing Normal Retirement Age to 67

Table 2.5: Employment effects, partial retirement, NRA: 67

	No part. ret.	Part. ret.	Diff	Diff (%)
Avg. retirement age	64.65	64.63	-0.02	-0.03
Avg. employment exit age	63.62	64.04	0.41	0.65
FTE avg.	71.85	69.08	-2.77	-3.86
Retirement path shares				
Regular	76.96	38.77	-38.19	-49.62
Unemployment	23.04	12.55	-10.49	-45.53
Partial	0.00	48.68	48.68	-
Average share in employment state				
Full-time	71.85	62.84	-9.01	-12.54
Partial	0.00	12.47	12.47	-
Unemployment	8.60	4.97	-3.63	-42.19
Retirement	19.55	19.73	0.18	0.92

Source: Own calculations based on BASiD. Based on 100,000 simulated observations. FTE represents Full-time employment equivalent. Shares are represented in percent.

Here I analyze the role of partial retirement with an NRA at 67. As before, the ERA is at 63 but pension receipt at 63 now yields four (instead of before two) years worth of deductions to pension annuities, i.e. $(4 \cdot 3.6\% = 14.4\%)$, because the NRA is increased by two years. As in the previous simulations, a large spike in partial retirement corresponds to reductions in unemployment and full-time employment. However, Figure 2-10(c) in Appendix 2.7.4 shows that at an NRA of 67 the take-up of partial retirement is lower at age 62 but higher between the ages 63 and 67. This indicates that at an increased NRA partial retirement take-up is higher particularly in the years between the ERA and NRA. It explains why the average retirement age virtually does not change when partial retirement is introduced as is shown in Table 2.5. Naturally, the average retirement age without partial retirement (64.65) and with partial retirement (64.63) is higher than in the previous policy simulation, which is due to the simulated increase in the NRA. More importantly, the findings indicate that people bridge the longer time between ERA and NRA with partial retirement in order to enter retirement at the same time as in the counterfactual scenario without partial retirement and prevent higher deductions to their individual pensions.

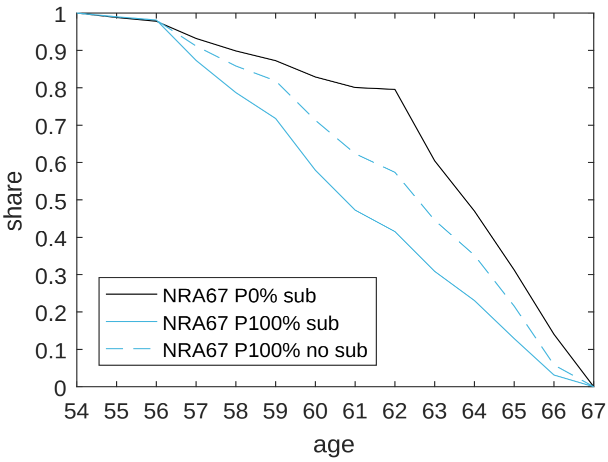
Similar to before, the average age at employment exit increases by almost 5 months from 63.62 to 64.04 due to the substitution of unemployment by partial retirement. The change in FTE employment when introducing partial retirement is still negative, but not as pronounced as under the NRA at 65 regime. This can be explained using the average full-time employment shares depicted in the lowest panel. When the NRA is at 67, average full-time shares decrease by 12.54%, compared to a 13.86% reduction when the NRA is at 65. This is enforced by the longer take-up of partial retirement as mentioned above.

Financial Subsidies for Partial Retirement

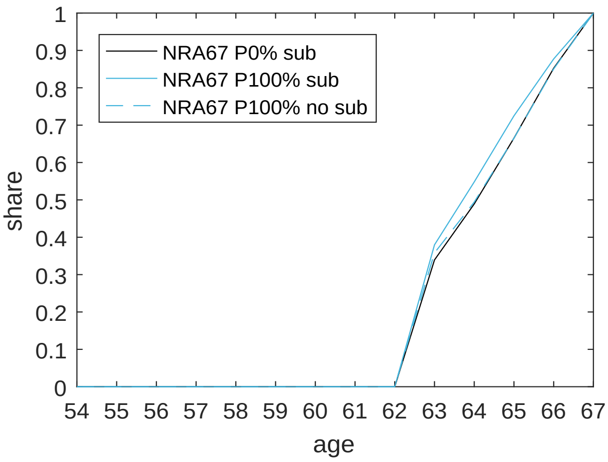
Since the model incorporates the tax and transfer system while distinguishing between financial and non-financial preferences, I am able to isolate the effect of

subsidies in a partial retirement program. The simulation considers changes in immediate income in partial retirement through a wage subsidy as well as changes in long-run income through changes in the pension point accrual during partial retirement. The long-run differences in income affect the decision makers utility through the model's forward-looking perspective. I employ the wage and pension accrual subsidies that are used in the underlying German partial retirement policy (20% for wages and 40% for pension point accrual). Moreover, note that the model further incorporates tax exemptions for the wage subsidy in partial retirement.
Figure 2-6 compares the policy with financial subsidies to the corresponding policy without financial subsidies. As expected, Figure 2-6(c) shows that subsidizing partial retirement clearly leads to a higher take-up of partial retirement at almost all ages. Further, Figures 2-6(a) and 2-6(d) show that the drops in both full-time employment and unemployment are correspondingly larger. In addition, the difference between subsidized and unsubsidized partial retirement is visibly higher for full-time employment shares than unemployment shares. In terms of employment effects, this suggests that subsidized partial retirement compared to unsubsidized partial retirement has a stronger negative effect due to its reduction in full-time employment than a positive effect due to its reduction in unemployment.

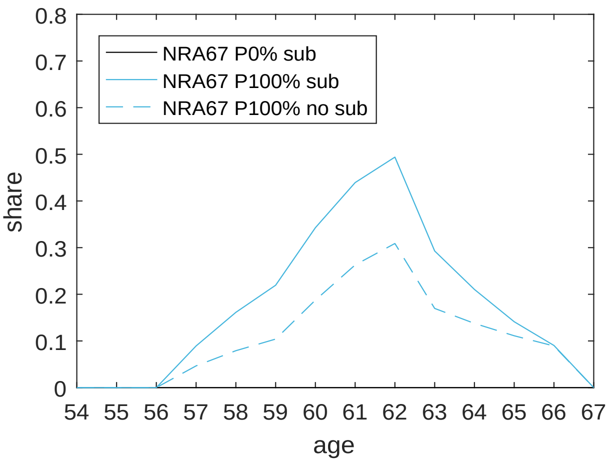
Figure 2-6: Policy Simulation: Subsidies for partial retirement. NRA set to 67



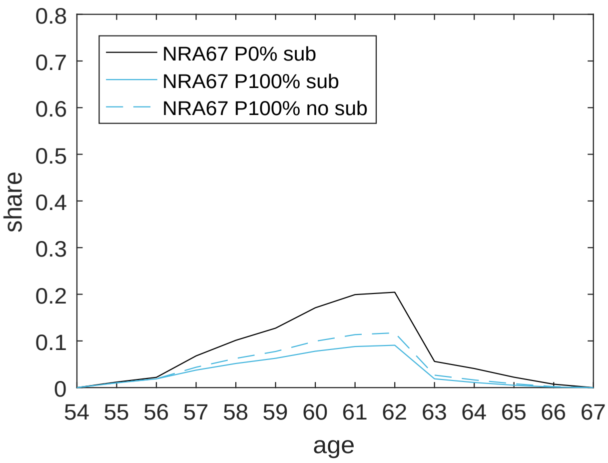
(a) Full-time



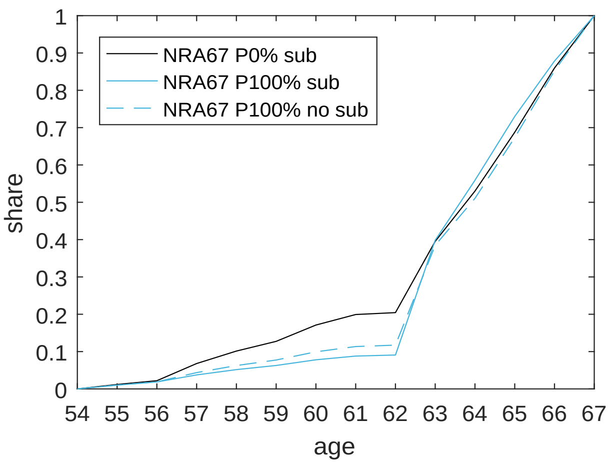
(b) Retirement



(c) Partial retirement



(d) Unemployment



(e) Non-employment

Source: Own calculations based on BASiD. Based on 100,000 simulated observations. Figure depicts shares in each employment state by age. Sample is conditioned to 100% full-time employment at age 54 and 100% retirement at age 67.

Table 2.6, which compares summary statistics between scenarios with and without subsidized partial retirement, supports this finding. It can be seen that wage and pension compensations incentivize partial retirement since the share of people retiring via partial retirement increases by 66.37% compared to the 48.68% change in the scenario without subsidies (Table 2.5). Similarly the average share in the partial retirement state (20.67%) is higher than the previous 12.47%.
Furthermore, with subsidized partial retirement, the average age at employment exit increases by 4.4 months compared to 4.9 months in the case without subsidies. The corresponding reduction of the average retirement age from 64.65 to 64.47 (about two months) suggests that the additional people who substitute full-time employment by partial retirement due to the subsidies end up retiring earlier in partial retirement. Consequently, I find that the drop in employment volume due to partial retirement is larger when it is subsidized: the FTE employment drops in this case by about 10% compared to the 4% drop in the scenario without subsidies. This is because the additional share in partial retirement and the reduction in unemployment due to the subsidies does not make up for the additional reduction in full-time employment. Thus, compared to the scenario with unsubsidized partial retirement, I find overall more negative employment effects due to partial retirement.

Table 2.6: Employment effects partial retirement, NRA: 67, subsidies for partial retirement

	No part. ret.	Part. ret.	Diff	Diff (%)
Avg. retirement age	64.65	64.47	-0.18	-0.28
Avg. employment exit age	63.62	64.00	0.37	0.59
FTE avg.	71.85	64.63	-7.21	-10.04
Retirement path shares				
Regular	76.96	24.06	-52.90	-68.74
Unemployment	23.04	9.57	-13.47	-58.46
Partial	0.00	66.37	66.37	-
Average share in employment state				
Full-time	71.85	54.30	-17.55	-24.43
Partial	0.00	20.67	20.67	-
Unemployment	8.60	3.95	-4.65	-54.10
Retirement	19.55	21.08	1.53	7.83

Source: Own calculations based on BASiD. Based on 100,000 simulated observations. FTE represents Full-time employment equivalent. Shares are represented in percent.

To sum up, I find that partial retirement leads to an extension of working lives by about four to five months. However, the effect of partial retirement on labor supply is still negative although less so at a higher NRA because then individuals stay longer in partial retirement to avoid higher pension deductions. Subsidizing partial retirement yields even more negative employment effects.

2.5.2 Fiscal Consequences

With the consideration of the underlying tax and transfer system as well as the simulation of counterfactual income streams for every policy simulation, I am able to analyze the fiscal consequences of each policy scenario. In this analysis, costs comprise unemployment insurance (UI) benefits, subsidies for partial retirement (P sub) as well as pension benefits (Pension). On the other side, public revenues comprise income tax (IT) and SSC. Since these costs and revenues from each individual vary across the respective employment states, the public budget varies with changes of the employment state distribution across different policy regimes. That is, each individual in the sample produces public costs and revenues in every period. Since it cannot be observed whose partial retirement compensations are subsidized by the federal employment agency, I assume an average subsidy rate of 18.5% of all partial retirement subsidies based on descriptive findings by Wanger (2009). All other changes in costs and revenues due to changes in employment states following a policy simulation are recorded within the model.

Table 2.12 in Appendix 2.7.2 summarizes the effects of a change in the employment state for each cost and revenue unit. The previous section shows that introducing partial retirement mostly induces a change in the employment state shares from full-time employment or unemployment to partial retirement while retirement entry behavior remains practically unchanged. Clearly, the change from full-time employment to partial retirement yields negative fiscal effects since an individual in full-time employment produces its potentially highest revenues and no public costs. The movement from unemployment to partial retirement produces a slightly more ambiguous public effect. On the one hand, the partial retirement state produces higher public revenues due to taxes and contributions that are gained from part-time wages. Clearly, it also reduces costs of UI. However, if partial retirement is publicly subsidized, this switch would produce public costs due to paid subsidies. Thus, the sign of the fiscal effect depends on the amount of paid subsidies as well as the size of the change in shares from full-time employment relative to the change from unemployment.

To illustrate the substantial difference in fiscal consequences for partial retirement with and without subsidies, I first start with an analysis of the effects with subsidies and then move to analyzing scenarios without subsidies. I collect costs and revenues in each period for each individual during its respective decision horizon. After labor market exit occurs, I take the present discounted sum of all future projected income streams that depend on the respective labor market exit and retirement age, chosen retirement paths, income levels, and collected pension points until the final period $T = 100$. Survival probabilities apply as before. Since this analysis considers the government's perspective, I replace the individual discount factor with the interest rate $r = 0.02$, which yields a government's discount factor of $\frac{1}{1+r} \approx 0.98$. This produces a lifetime balance for each individual for the simulated policy. Note that the decision period, as well as cost-revenue calculations, start at age 54 for every individual.

Table 2.7: Fiscal consequences of partial retirement with partial retirement subsidies

	acc. Costs			acc. Revenues		
	Pension	**UI**	**P sub**	**SSC**	**IT**	**Net balance**
			ERA 63, NRA 65			
No part. ret.	364,840	12,882	0	106,210	56,584	-214,928
Part. ret.	366,560	6,220	2,418	99,148	50,529	-225,521
Diff	1,720	-6,662	2,418	-7,062	-6,055	-10,593
			ERA 63, NRA 67			
No Part. ret.	350,170	9,148	0	115,200	64,299	-179,819
Part.ret.	352,840	4,146	2,781	106,090	56,705	-196,972
Diff	2,670	-5,002	2,781	-9,110	-7,594	-17,153

Average cost and revenue units per person. Based on 100,000 simulated observations. Costs and revenues are accumulated for every individual over the age interval [55,100] and adjusted by an interest rate of 2% and individual survival probabilities.

Table 2.7 compares the average costs and revenues per unit per person between policy regimes without partial retirement access and regimes with full access to partial retirement. This is done for the cases with the NRA set to 65 and to 67. In addition, partial retirement is subsidized in this case according to the underlying institutional settings. That is, wages in partial retirement are subsidized by 20% and pension point accrual during partial retirement by 40%. Clearly, partial retirement with subsidies leads to a large reduction in net public balances.

In both scenarios, partial retirement largely reduces revenues from SSC and IT, which is mostly driven by the reduction in full-time employment when allowing for partial retirement, as shown above. Moreover, subsidies in wages during partial retirement lead to an average increase in partial retirement costs by about 2,600

€ in both cases. In contrast, the introduction of partial retirement leads to a decrease in average UI payments per person, by about 6,700 € per person when the NRA is at 65 and 5,000 € per person when the NRA is at 67 because partial retirement substitutes unemployment.

Overall, introducing partial retirement in case of the NRA at 65 reduces net public balances on average per person by 10,593€ while public balances reduce largely more (by 17,153€ on average per person) in case of the NRA at 67. This is mostly driven by a larger substitution of full-time employment by partial retirement and correspondingly more pronounced reductions in SSC and IT. In addition, as shown above, the average retirement age drops less due to partial retirement when the NRA is at 67 which prevents high deductions to individual pensions. Therefore, pension payments increase more due to partial retirement when the NRA is at 67 (by 2,670€ per person) than when the NRA is at 65 (by 1,720€ per person).

Table 2.8: Fiscal consequences of partial retirement, no subsidies for partial retirement

	acc. Costs			acc. Revenues		
	Pension	**UI**	**ATZ sub**	**SSC**	**IT**	**Net balance**
ERA 63, NRA 65						
No part. ret.	364,840	12,882	0	106,210	56,584	-214,928
Part. ret.	361,140	7,856	0	101,410	51,637	-215,949
Diff	-3,700	-5,026	0	-4,800	-4,947	-1,021
ERA 63, NRA 67						
No Part. ret.	350,170	9,148	0	115,200	64,299	-179,819
Part. ret.	348,250	5,190	0	110,590	59,380	-183,470
Diff	-1,920	-3,958	0	-4,610	-4,919	-3,651

Average cost and revenue units per person. Based on 100,000 simulated observations. Costs and revenues are accumulated for every individual over the age interval [55,100] and adjusted by an interest rate of 2% and individual survival probabilities.

Table 2.8 shows the same analysis of fiscal consequences as before but without subsidies for partial retirement. Without subsidies, the negative effect on net balances from allowing for partial retirement reduces substantially to 1,021€ in case of the NRA at 65 and 3,651€ on average per person in case of the NRA at 67.

As before, the introduction of partial retirement leads to an average decrease per person in SSC and IT by 9,747€ (4,800+4,947) on average per person in case of the NRA at 65 and 9,529€ (4,610+4,919) in case of the NRA at 67 which are smaller effects than in the case with subsidies. At the same time, UI payments decrease by 5,026 € when the NRA is at 65 and 3,958€ on average per person when the NRA is at 67. Thus, not paying subsidies reduces the drop in SSC and

IT payments but also the drop in UI payments due to a lower substitution of full-time employment and unemployment.

Finally, it naturally cancels out any costs for wage subsidies and reverts the effect of partial retirement on pensions. That is, pensions reduce on average per person by 3,700€ when the NRA is at 65 and by 1,920€ when the NRA is at 67. As before, the smaller reduction in pensions due to partial retirement when the NRA is at 67 is driven by the fact that the average retirement age changes less at an increased NRA which implies lower deductions to individual pensions and the collection of more pension points in the additional time until full retirement. Thus, individual pensions are less affected by partial retirement when the NRA is at 67 because people have more time to *'make up'* for the loss in supplied work hours when switching to partial retirement.

To sum up, partial retirement has a negative effect on public balances due to reductions in IT and SSC. However, without subsidies, these negative effects reduce substantially by about 9,500€ to 13,500€ on average per person.

2.5.3 Distributional Effects

I base the analysis of distributional effects on pension payments since the underlying institutional settings yield pensions that reflect lifetime income better than employment earnings at any one point in time. Thus, I present distributional effects through deciles of realized annual pension payments and corresponding Gini coefficients for each policy simulation. As before, I start with analyzing the effects for policies with partial retirement subsidies and then move to policy scenarios without subsidies for partial retirement.

Table 2.9: Distributional effects in pensions, with subsidies for partial retirement

	Decile							
	1	**2**	**3**	**5**	**7**	**8**	**9**	**Gini coefficient**
ERA 63, NRA 65								
No part. ret.	10,406	12,077	13,196	15,188	17,119	18,107	19,240	25.46
Part. ret.	10,796	12,243	13,185	15,031	17,005	17,969	19,007	24.18
Diff	390	166	-11	-157	-114	-138	-233	-1.28
ERA 63, NRA 67								
No Part. ret.	10,290	11,962	13,014	14,782	16,562	17,499	18,666	24.90
Part.ret.	10,695	12,166	12,970	14,709	16,556	17,502	18,643	24.12
Diff	405	204	-44	-73	-6	3	-23	-0.78

Annual pension deciles. Based on 100,000 simulated observations. Gini coefficient is represented in percent.

Table 2.9 shows the distributional effects of partial retirement with the NRA at 65 in the upper panel and the NRA at 67 in the lower panel. The reduction in the Gini coefficient, by 1.28 percentage points with the NRA at 65 and by 0.78 percentage points with the NRA at 67 shows that introducing partial retirement reduces inequality in pension incomes. This result is independent of the NRA. Furthermore, we can see that partial retirement with subsidies leads to an increase in annual pensions for low deciles but a decrease in annual pensions for high deciles. When the NRA is set to 65, the effect is highest for the first decile where it increases annual pensions by 390€ per year and lower for higher deciles. For the ninth decile annual pensions decrease by 233€ .

These differences are more positive when the NRA is at 67. Again, the policy yields a positive effect on annual pensions for the lowest deciles but increasingly negative effects on annual pensions for higher deciles. While annual pensions increase for the first decile by 405€, they decrease by 23€ for the ninth decile.

Table 2.10: Distributional effects in pensions, no subsidies for partial retirement

	Decile							
	1	**2**	**3**	**5**	**7**	**8**	**9**	**Gini coefficient**
				ERA 63, NRA 65				
No part. ret.	10,406	12,077	13,196	15,188	17,119	18,107	19,240	25.46
Part. ret.	10,433	11,927	12,998	14,869	16,803	17,764	18,845	24.88
Diff	27	-150	-198	-319	-316	-343	-395	-0.58
				ERA 65, NRA 67				
No Part. ret.	10,290	11,962	13,014	14,782	16,562	17,499	18,666	24.90
Part. ret.	10,423	11,853	12,836	14,651	16,430	17,373	18,587	24.80
Diff	133	-109	-178	-131	-132	-126	-79	-0.10

Annual pension deciles. Based on 100,000 simulated observations. Gini coefficient if presented in percent.

Table 2.10 shows the distributional effects for the simulated policies without subsidies for partial retirement. The Gini coefficient reduces by 0.58 percentage points when the NRA is 65 and by 0.34 percentage points when the NRA is 67. Thus, the result that unrestricted access to partial retirement leads to a reduction in pension inequality is robust to retirement entry age thresholds and financial subsidies for partial retirement.

Without subsidies for partial retirement, annual pensions decrease across almost all deciles with the introduction of partial retirement. With the NRA at 65, annual pensions still increase for the first decile by 27€ but these effects are substantially different for the ninth deciles. Here, annual pensions reduce by 395€ . Except for the lowest income decile, these differences are markedly lower across deciles for the case with the NRA at 67. In this case annual pensions for the lowest decile increase by 133€ while they decrease by 79€ for the ninth decile. Thus pension accrual compensations are less important to make up for losses in individual pensions due to partial retirement as the NRA increases to 67 since in this scenario individuals spend more time in partial retirement to prevent higher deductions to pensions and thus smooth consumption.

To conclude, partial retirement clearly reduces income inequality in pensions. This finding is robust to different retirement entry age thresholds as well as financial incentives for partial retirement. Not subsidizing pension accrual leads to reductions in individual pensions across almost all income deciles which could potentially push retirees with low income into social assistance. However subsidies are less needed as a compensation for pension losses when the NRA is at 67.

2.6 Conclusion

In this paper, I develop a dynamic retirement model in order to analyze the effect of partial retirement on labor supply, public balances, and the pension income distribution. The basic model consists of an individual's annual choice to continue working or exit employment through one of three possible retirement paths: 1) regular retirement, 2) retirement via unemployment, or 3) retirement via partial retirement. The choice is subject to individual employment and mortality risks. Access to partial retirement is restricted. Based on the model, I investigate three different counterfactual scenarios that explore different aspects in the effect of partial retirement on employment behavior, public balances, and pension income distributions: (1) introducing partial retirement as a potential retirement path, (2) partial retirement in the context of an increased normal retirement age from 65 to 67, and (3) financial subsidies for partial retirement.

I distinguish between retirement entry (pension receipt) and employment exit behavior. I find that partial retirement reduces the average retirement age but this reduction is much smaller when the NRA is increased. It seems that people spend more time in partial retirement when the NRA is increased in order to avoid higher deductions to pensions. Especially for retirees in lower income deciles partial retirement provides a way to smooth consumption at an increased NRA.

Partial retirement yields an extension of working lives by about four to five months through a reduction of early employment exits via unemployment. However, in all cases partial retirement reduces the overall employment volume by 4.7% when the NRA is at 65 and 3.86% when the NRA is at 67. Hence, the employment effects of partial retirement are negative, but less so at a higher NRA. Financial incentives for partial retirement yield stronger negative employment effects (a reduction by about 10% when the NRA is at 67) because the additional number of people who switch from full-time employment to partial retirement due to its financial incentives is higher than the amount of people who switch from unemployment to partial retirement.

Not compensating pension accrual in partial retirement leads to a decrease in pensions across almost all income deciles but these reductions are less pronounced when the NRA is 67 since more people bridge the time between ERA and NRA with partial retirement. Especially for lower income deciles partial retirement provides a way to smooth consumption when transitioning into retirement in the context of an increased NRA. In addition, subsidizing partial retirement leads to a reduction of net public balances by about 10,500 (17,000)€ per person when the NRA is 65 (67), while this amount is far lower (1,000 to 3,600€) when no wage or pension compensations are paid for partial retirement. The differences in fiscal consequences are mostly driven by lower reductions in SSC and IT payments, which reduce by about 13,000 to 17,000€ per person when partial retirement is subsidized and by about 9,500€ per person when partial retirement is not subsidized. Finally, I find that partial retirement reduces pension income inequality in all policy scenarios. This also holds when financial subsidies for partial retirement are removed. From this analysis it can be concluded that partial retirement is more beneficial from a public perspective when it is not subsidized because subsidies lead to more crowding out from full-time employment causing stronger negative employment effects.

Whether or not potential costs for partial retirement are worth the benefit of less inequality in pensions and of providing an additional opportunity to smooth consumption in the transition to retirement for retirees with low income remains a normative question that is subject to public discussion. The discussion should also consider the fact that partial retirement differs characteristically from policies that raise statutory age thresholds. While statutory age thresholds impose specific barriers on individual choice, allowing for partial retirement extends individual choice. There are other positive effects that might be derived from an overall introduction of partial retirement, such as an additional alternative for an individual to smooth out health shocks or potential synergetic effects when employees remain in their firms longer to potentially train new workers. These points are subject to further research.

2.7 Appendix

2.7.1 Institutional Background

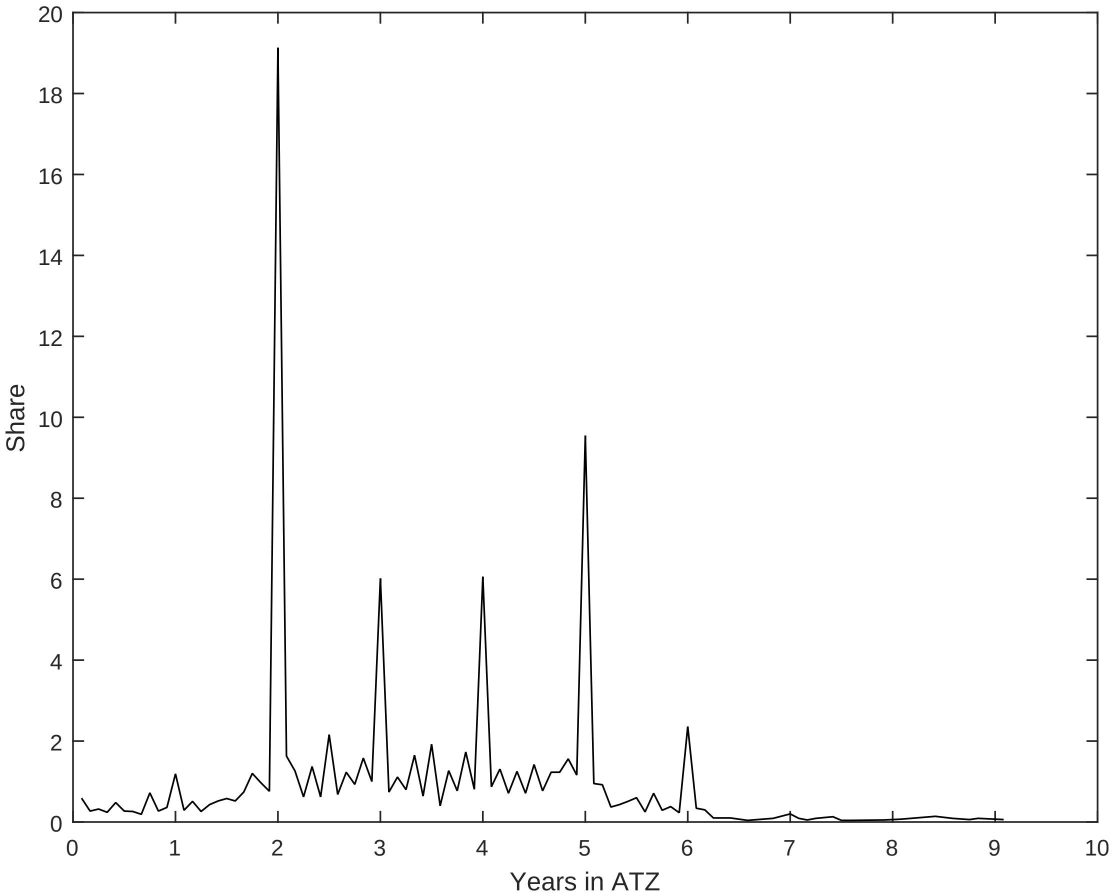
The German Statutory Pension Insurance, is a pay-as-you-go funded system. It covers the majority of the working population and is the main source of income after retirement entry. The Pension Fund is mainly financed by contributions through a payroll tax, evenly split between employee and employer.

The Altersteilzeit Policy

In 1996, Germany introduced the Altersteilzeit (ATZ) policy with the aim to provide elderly employees with the option to gradually transition from work to retirement.[20] It was also intended to extend working lives by offering an alternative to abrupt early retirement. This policy sets legal standards for requirements as well as compensation and pension contributions for gradual retirement options in firms. More precisely, every employee aged 55 or older who has worked at least 1080 days in the past five years can reduce their work hours by 50%. Furthermore, employees in ATZ have to be paid at least 50% of their previous full-time wages. Employers are not legally required to provide ATZ such that further standards were set in agreements within firms or collective wage agreements (Brussig et al., 2009). Among ATZ providing firms, these agreements contained compensation floors of at least 20% of previous wages and 40% of previous pension points. The average compensation for wages among ATZ firms was 23% (Wanger, 2009) while pension point compensations ranged from 30-45% (Berg et al., 2015).

[20] The law governing ATZ (Altersteilzeitgesetz): $https : //www.gesetze - im - internet.de/bundesrecht/alttzg_1996/gesamt.pdf$

Figure 2-7: Distribution of time spent in ATZ

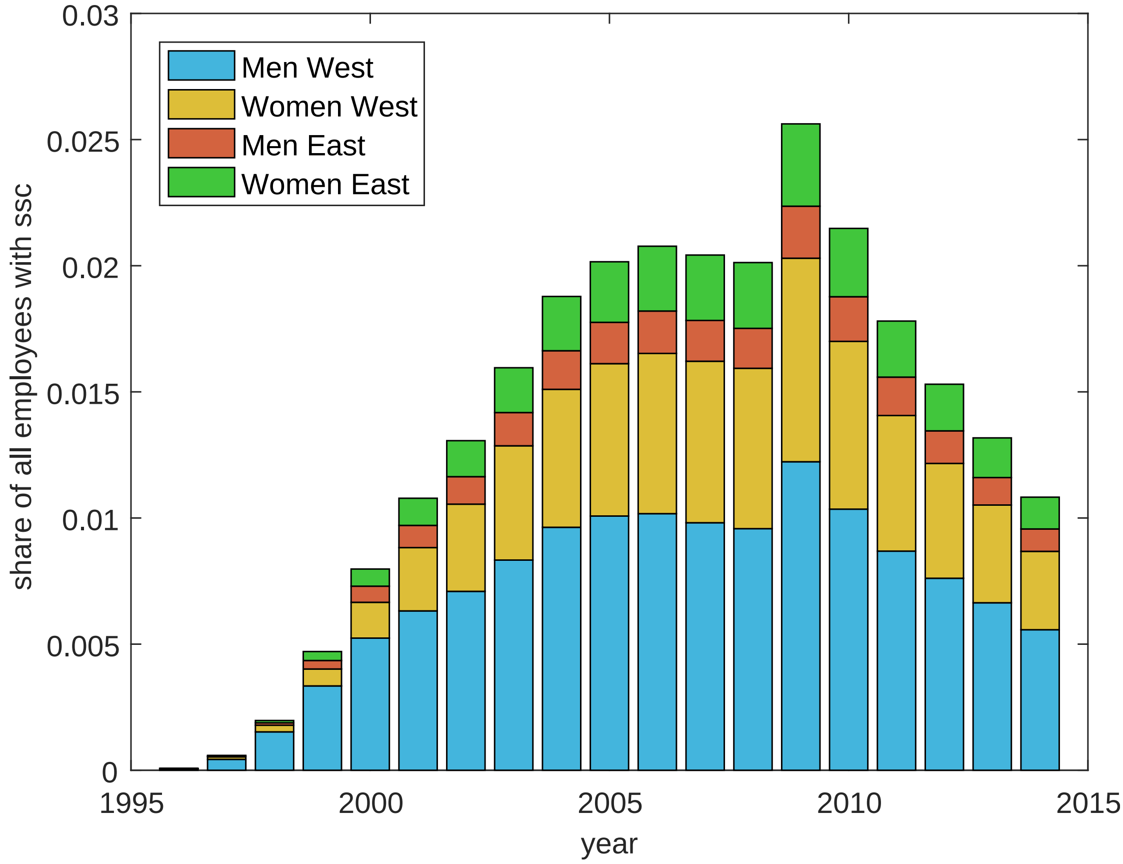


Source: Own calculations based on BASiD. Based on 258,296 monthly observations. Sample restrictions: Only validated accounts, all German men, no disability insurance receipt, at least five pension contribution years, at least two years tenure at age 54.

There are two options to realize the reduction in working time: The employee can either work part-time for the entire ATZ-period or opt for the so-called block model that consists of full-time work in the first half of the ATZ period and a leave of absence in the second half. With a take-up rate of 88 % in 2007 (Wanger, 2009), the block model is the more popular variant among ATZ-takers. While ATZ could be extended over a period of ten years, Figure 2-7 shows that virtually noone remains in ATZ for more than six years since this was the maximum number of years, the FEA would pay supplements to employers. These FEA subsidies stopped in 2009, while the minimum standards remained. Note that for the studied cohorts, workers in ATZ and unemployed can enter full retirement up to three years earlier than regular retirees.
Figure 2-8 shows that ATZ-take-up rose steadily since its introduction in 1996. From 2004 onwards ATZ-take-up reached about 18% of all employees subject to social security contributions aged 55 to 64 (Wanger, 2009), making it a relevant pathway into retirement.

We can also see that ATZ was significantly more relevant to West Germans. In addition, East Germans exhibited different employment effects than West Germans with the introduction of ATZ which could be contributed to differences in the respective economies (Huber et al., 2016). The extraordinary peek in ATZ-take-up in 2009 further indicates that employment effects due to ATZ are different in economic busts (Huber et al., 2016). 2009 marks the year of the European Economic Crisis. However, the periods in the present sample only extend to 2007. Although the share of women in ATZ seems non-negligible, it only rose when

Figure 2-8: Share of ATZ employees among all employees



Source: Own calculations based on Deutsche Rentenversicherung 2011, 2016

eligibility was extended to part-time employees (Brussig et al., 2009), making it an economically less relevant group of ATZ employees.

Retirement After Unemployment

Besides the presented retirement paths, workers from the studied cohorts have the additional option to retire at the early retirement age of 60 if they spent at least 12 months in UI receipt after turning 58.5. Depending on their previous employment history, workers are eligible to 18-32 months of unemployment insurance and they can use these months to bridge the time between labor market exit and official retirement entry three years prior to the normal old-age early retirement age of 63. This means that individuals that retire via unemployment are factually retired from the point they enter unemployment.

Retirees after ATZ have the same early retirement options and face the same pension deductions for early retirement (see Table 2.11). Periods spent in UI yield about 80% of the contributions from previous full-time employment. That is, relative to full-time employment, pension contribution replacements are higher in ATZ than in unemployment. Moreover, the replacement rate of labor earnings is lower in UI than in ATZ. To sum up the differences between these two retirement paths: Retirement via ATZ has higher financial incentives and ATZ employees have to work 50% of the bridge period while the unemployed have fully stopped working. Thus, when studying partial retirement-take-up through ATZ-take-up, retirement via unemployment should be considered as a voluntary alternative retirement option.

2.7.2 Auxiliary Tables

Table 2.11: Retirement access factors by cohorts and retirement type

	ATZ/Unemployment					Regular Retirement
age	**1940**	**1941**	**1942-1945**	**1946**	**1947**	**1940-1947**
60	0.892	0.856	0.820	0.000	0.000	0.000
61	0.928	0.892	0.856	0.856	0.000	0.000
62	0.964	0.928	0.892	0.892	0.892	0.000
63	1.000	0.964	0.928	0.928	0.928	0.928
64	1.000	1.000	0.964	0.964	0.964	0.964
65	1.000	1.000	1.000	1.000	1.000	1.000
66	1.060	1.060	1.060	1.060	1.060	1.060
67	1.120	1.120	1.120	1.120	1.120	1.120

Retirement access factors for retirement after ATZ/unemployment and regular retirement. Access factors of 0.000 indicate that access is not possible for that cohort-type combination Retirement entry for cohort 1946 can only be observed, if occurrence is at age 61. Retirement entry for cohort 1947 is outside the observed sample. Own Illustration

Table 2.12: Summary of changes in costs and revenues by state transitions

	Costs			Benefits
State change	**Pension**	**UI**	**ATZ sub**	**SSC/IT**
FT → **P**	0	0	+	-
FT → **U**	0	+	0	-
FT → **R**	+	0	0	-
P → **FT**	0	0	-	+
P → **U**	0	+	-	-
P → **R**	+	0	-	-
U → **FT**	0	-	0	+
U → **P**	0	-	+	+
U → **R**	+	-	0	0
R → **FT**	-	0	0	+
R → **P**	-	0	+	+
R → **U**	-	+	0	0

Own illustration. *ATZ sub* represents subsidies for partial retirement take-up. *UI* represents unemployment insurance payments. *SSC* represents employees' social security contributions. *IT* represents employees' payed income tax.

2.7.3 Imputation of Top-coded Earnings

Since wage information in German administrative dataset are right-censored, earnings reported as equal to the annual-specific contribution ceiling z_t are imputed. The imputation of top coded earnings is based on the assumption that earnings w_i^f exceeding a minimum earnings threshold $\tilde{w}$ are distributed according to the Pareto law. Then, the probability to observe an income $w_i^f \geq \tilde{w}$ is given by

$$1 - F(w_i) = (\frac{\tilde{w}}{w_i})^{\alpha}$$

where $F(w_i)$ denotes the cumulative distribution function (cdf) on the interval $[\tilde{w}, \inf]$ and α is the pareto-coefficient that will be estimated for the imputation. Moreover, let n be the number of earners with $w_i^f \geq \tilde{w}$. In addition, earners with observed wages are ranked in ascending order of their income and accordingly assigned a rank r_i. Zipf's law establishes a relation between the rank r_i and the cdf according to

$$\frac{r_i}{n} \cong (\frac{\tilde{w}}{w_i})^{\alpha}$$

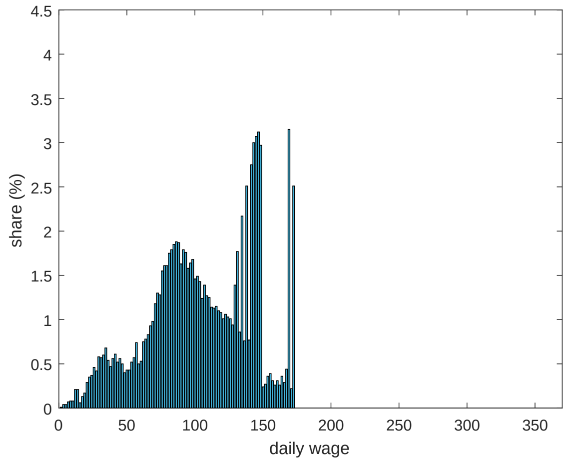
Taking the logarithm yields

$$ln(\frac{r_i}{n}) = -\alpha \quad ln(\frac{w_i}{\tilde{w}})$$

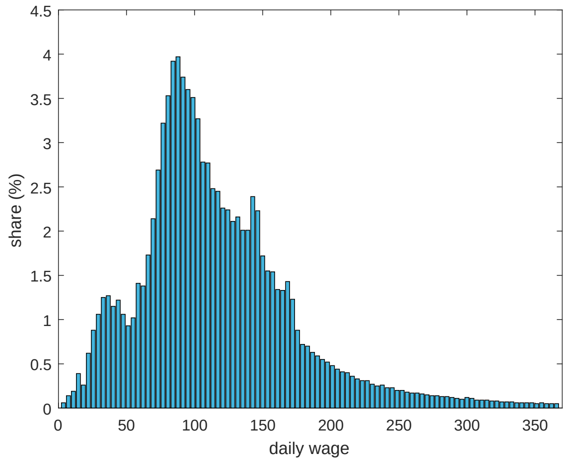
This equation enables the estimation of the pareto-coefficient α by OLS. After this, missing earnings $w_i \geq z_t$ are imputed by putting random draws into the inverse cdf. Since z_t is annual-specific, the estimation of α and the subsequent imputation is performed for each year separately. For each imputation, I set $\tilde{w}$ equal to the 90^{th} percentile of all observations below the respective contribution ceiling. Thus, I assume that at least 10 % of the top earnings on the interval $[0, z_t]$ follow a Pareto distribution.

Figure 2-9 shows the coarsened distribution of daily wages before and after the imputation. It can be seen that the imputation works well to smooth out the mass points at the wage-ceiling.

Figure 2-9: Distribution of daily wages before and after imputation of top-coded earnings



(a) Pre imputation

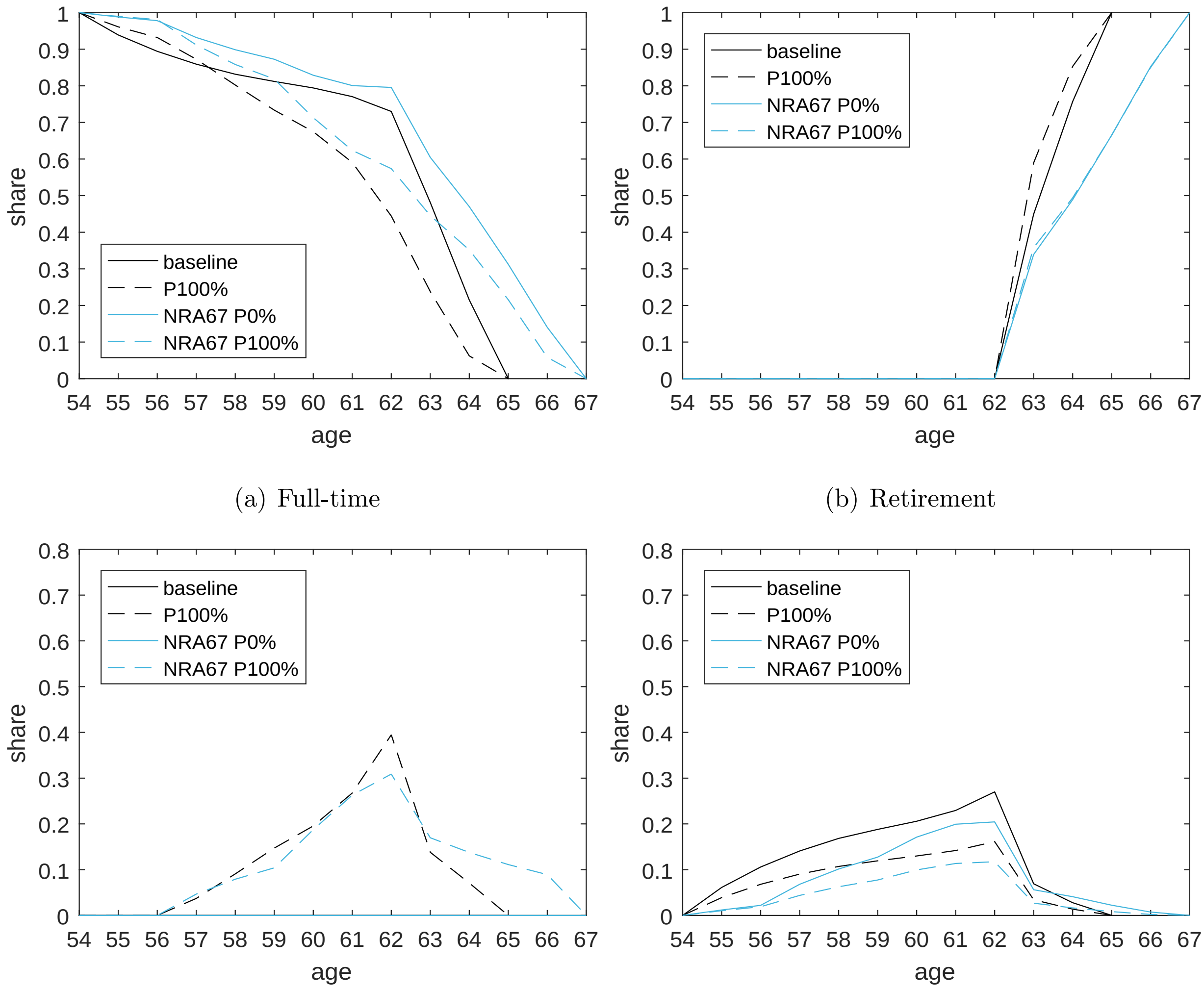


(b) Post imputation

Source: Own calculations based on BASiD. Due to confidentiality law, the distribution is coarsened to a minimum of 20 observations per X value and wages in the 99th percentile are cut off in the plot with imputed earnings. Differences between the figures in the distribution below the wage ceiling occur due to the coarsening. The true distribution does not have differences between right-censored and imputed wages in the distribution below the wage ceiling.

2.7.4 Further Results

Figure 2-10: Policy Simulation: Normal retirement age set to 67.



(a) Full-time (b) Retirement

(c) Partial retirement (d) Unemployment

Source: Own calculations based on BASiD. Based on 100,000 simulated observations. Figure depicts shares in each employment state by age. Sample is conditioned to 100% full-time employment at age 54 and 100% retirement at age 67.

Chapter 3

The Role of Entry Age and Timing of Pension Benefits in Partial Retirement[1]

3.1 Introduction

The demographic change challenges pension insurance systems around the world. In particular, the aging of the population increases the group of pension recipients relative to the number of contributors. Therefore, most OECD countries have reversed their retirement policies since the 1990s and introduced pension reforms to encourage longer working lives and to alleviate the decline of the working age population. Reforms include tighter qualifying conditions and increases in the early

[1]This project is joint work with Peter Haan. Valuable comments by Hermann Buslei are gratefully acknowledged. Songül Tolan would like to thank the Forschungsnetzwerk Alterssicherung (FNA) for financial support through a Ph.D. scholarship and Netspar for financial support through the Medium Vision Grant (Project name: Flexible combinations of work and retirement).

retirement age (ERA), the introduction of actuarial deductions for early retirement, increases in the normal retirement age (NRA), i.e. the age at which people first receive full benefits without actuarial deductions,[2] increases in the statutory retirement age or a combination of these policies. More recently, new policies aim to incentivize later retirement entry by enabling more flexible transitions into retirement through partial retirement or flexible retirement rules. Partial retirement schemes allow for a gradual reduction of work hours in the last years before entering full retirement. In some instances, income in partial retirement is a combination of part-time labor earnings and partial pension receipt. Several countries have already introduced partial retirement programs into their public pension systems (Eurofound, 2016) and other countries, including Germany, are in the process of making retirement more flexible.

The employment effects and the related fiscal effects of more flexibility in the pension system through partial retirement are ambiguous. On the one hand, partial retirement provides incentives to remain in the labor force for individuals who otherwise might exit employment through early retirement or through unemployment. On the other hand, partial retirement can also decrease employment if full-time working individuals who otherwise would work until the normal retirement age enter partial retirement and thus reduce their working hours. The sign and the size of employment effects strongly depend on the design of partial retirement regimes. Two margins are in particular important: (1) the entry age into partial retirement programs and (2) the timing of pension benefits. It is the aim of this paper to analyze how variations in these two margins affect employment and fiscal balances. This is the first study that disentangles the role of different policy margins in the

[2]This definition of the NRA is equal to the OECD definition of the “pensionable age”.

effect of partial retirement on labor market outcomes.

For our analysis, we use a dynamic structural retirement model developed in Tolan (2017) that incorporates the option for partial retirement. In the model, individuals maximize the present discounted utility of consumption and leisure by making annual decisions between continuing to work in a full-time position or leaving employment through one of three potential retirement paths: regular retirement, partial retirement, and retirement through unemployment. Individuals face uncertainty about mortality risk and labor market frictions through involuntary job loss. Moreover, the model includes a detailed description of the relevant aspects of the tax and transfer system and the pension rules. Using the estimated parameters from the model, we are able to perform counterfactual policy simulations in which we vary the entry age of partial retirement and the timing of pension benefits. In this paper the simulations of partial retirement differ from the partial retirement policy in the underlying institutional setting that is approximated in the model for estimation. In the simulations income in partial retirement is a combination of part-time labor earnings and a share of pension benefits.[3] This yields complicated income dynamics in partial retirement in which individuals face a problem of intertemporal substitution of consumption. We analyze the implications of partial retirement in the context of the German pension system and focus in the empirical analysis on West German men. For the estimation, we use high quality administrative data, the Biographical Data of Social Insurance Agencies in Germany (BASiD) which provides information on full employment histories, earnings, and pension accrual on the individual level.

[3] We identify partial retirement in the data through take-up of *part-time work for elderly employees* (known in Germany as *Altersteilzeit*. Under this policy partial retirees do not have the option to receive a share of their pension benefits.

Our results show that partial retirement can lead to positive employment effects. In more detail, we find that compared to a regime without partial retirement the employment volume measured as share in full-time equivalent (FTE) employment is 0.05 percentage points higher in a regime with partial retirement, when people can enter partial retirement at the age of 61, i.e. two years prior to the ERA. This effect is higher under partial retirement regimes with later entry ages. For example, the employment volume is 2.4 percentage points higher compared to a regime without partial retirement when the partial retirement entry age is at 63 (i.e. equal to the ERA). In addition, partial retirement yields positive fiscal effects. Public balances improve by about 6,300€ per person when people have access to partial retirement from the age of 61. This fiscal plus is lower the later the entry age to partial retirement. At an entry age of 63 the fiscal gain compared to a regime without partial retirement is at about 5,700€ per person. Allowing for pension benefit receipt in partial retirement can further incentivize partial retirement take-up but limits to these early pension benefits are necessary to prevent substantial reductions in individual pensions.

Previous empirical evidence on the employment effects of partial retirement is mixed. This heterogeneity is partly related to the specific context of the studies and the pension reforms that are analyzed. For instance, two cross European studies (Aranki and Macchiarelli, 2013; Been and van Vliet, 2014) find positive effects of partial retirement due to postponed retirement and even increased total work hours among men. Similarly, Wadensjö (2006) finds that the Swedish national partial retirement scheme increases overall labor supply because the potentially earlier exiters who move to partial retirement outweigh the number of potential full-time employees who move to partial retirement. Other studies on partial retirement in

Nordic countries, Ilmakunnas and Ilmakunnas (2006) for Finland and Hermansen (2015) for Norway, find no effect of partial retirement, neither on the probability of thinking about continuing working after the age of 63 nor on the probability that a 61- or 62-year-old withdraws from the labor market with an early pension in the next two years of their employment. In contrast, Graf et al. (2011) find a negative impact of the Austrian partial retirement scheme despite an increase in working life duration. Machado and Portela (2012) conclude that the negative employment effects of part-time work among elderly in Portugal means that partial retirement could be interpreted as a signal for a higher preference for early retirement and similarly Albanese et al. (2016) find overall negative effects of the Belgian partial retirement scheme on total labor supply. For the Netherlands, Elsayed et al. (2015) find in a stated preference analysis that partial retirement would extend working lives by about one year but still reduce the total employment volume of the elderly. For Germany, Berg et al. (2015) and Huber et al. (2016) evaluate the employment effect of a specific partial retirement scheme that was implemented in 1996. While both studies find a positive effect of partial retirement on the extension of working lives, Huber et al. (2016) find positive effects on total employment volume only for East Germany but not for West Germany.

Our analysis differs from the mentioned evaluations of specific partial retirement regimes. Instead our evaluation is closely linked to studies that use structural retirement models. (e.g. Rust, 1989; Stock and Wise, 1990; Rust and Phelan, 1997; Benitez-Silva, 2000; French, 2005; Van der Klaauw and Wolpin, 2008; Haan and Prowse, 2014). The studies by Gustman and Steinmeier (2008) and Tolan (2017) are particularly relevant for our analysis: they explicitly model partial retirement and simulate the employment effects of partial retirement schemes. We extend these studies and provide evidence on how the design of a partial retirement program, specifically the entry age and the timing of pension benefits affect employment and fiscal balances.

The paper is organized as follows. In Section 3.2 we provide and overview about the structural retirement model, the institutions and the data. Then, in Section 3.3 we perform policy simulations to analyze the employment, fiscal and distributional effects of partial retirement and show how these effects depend on the entry age into partial retirement and the timing of pension benefits in partial retirement prior to full retirement. Finally, Section 3.4 concludes.

3.2 Model

This section gives an overview about the dynamic structural retirement model which is described in detail in Tolan (2017). The model extends the standard dynamic retirement model by e.g. Rust (1989) and includes in addition to regular retirement the option of partial retirement. In more detail the model evolves around a forward-looking individual who maximizes his[4] expected remaining lifetime utility by making annual decisions between continuing to work or exiting employment through one of three potential retirement paths: regular retirement, partial retirement, and retirement through unemployment. The time horizon ranges from age 55 to 100 but decisions can only be made between age 55 and the NRA which is defined at the age of 65. After the age of 65 full retirement is the only feasible employment state. This assumption is supported by the data used for the estimation which shows virtually no individual who works beyond the NRA of 65.[5]

[4] We refer to the decision maker as male since the present study focuses on retirement decisions of men.

[5] In the present sample, less than 0.25% have a retirement age above 65.

Retirement is possible from the age of 60.[6]

The individual's annual choice is subject to mortality and job loss risks and access to partial retirement is restricted as a result of the institutional framework. We obtain survival probabilities from the mortality database of the German Statistical Office.[7] We estimate the annual job-loss risk for each individual in a first stage random effects logit model using data from the German Socio-Economic Panel (SOEP).[8] Job-loss risk depends on age, education and work experience. The sample for the estimation of job-loss risks is equivalent to the sample that is used for the structural estimation. We restrict access to partial retirement because it is not an employees legal right but depends on an employer-employee agreement. In line with empirical evidence from Wanger (2009) we assume that 35% of the population has access to partial retirement.

The decision maker's utility depends on consumption (C) (where in this model consumption is equal to net income)[9] and leisure preferences (Γ) that vary across four potential employment states: (1) full-time employment (f), (2) partial retirement (p), (3) unemployment (u), and (4) retirement (r). The individual's within-period utility is described by the following function:

$$U_{it}^{k} = \frac{(C_{it}^{k})^{(1-\rho)} - 1}{1-\rho} + \Gamma_{it}^{k} + \epsilon_{it}(d_{it}) \tag{3.1}$$

[6]More specifically, if the individual opts for retirement after partial retirement or unemployment, he can enter full retirement from the age of 60 whereas regular retirement can be entered from 63.

[7]https://www.destatis.de/DE/ZahlenFakten/GesellschaftStaat/Bevoelkerung/Sterbefaelle

[8]This is an annual survey that, since 1984, collects individual- and household-level information from about 12,000 households (Wagner et al., 2007).

[9]In line with Rust and Phelan (1997) this is approximation is motivated by lack of wealth information and feasible wealth imputation methods which is required due to considerate heterogeneity in wealth at late stages in the life cycle.

where U_{it}^{k} describes the utility of individual i in period t and employment state k. Individuals exhibit constant relative risk aversion ($CRRA$) with respect to consumption where the degree is determined by ρ, the coefficient of relative risk aversion. ϵ_{it} is a choice-specific random shock which follows a type-one extreme value distribution. Leisure preferences Γ_{it}^{k} are identified relative to the baseline of full-time employment and defined as follows:

$$\Gamma_{it} = \begin{cases} 0 & \text{if } k = f \\ \lambda_0 + \lambda_1 \cdot (age_{it} - 59) & \text{if } k = r \\ \theta_0 + \theta_1 \cdot \mathbf{1}[age_{it} >= 60] & \text{if } k = p \\ \upsilon_0 + \upsilon_1 \cdot \mathbf{1}[age_{it} >= 60] & \text{if } k = u \end{cases} \tag{3.2}$$

The model allows for changes in leisure preferences relative to full-time employment when the choice set changes and people become eligible for full retirement at the age of 60.

Pension Accumulation and Income

We now describe how pension accumulation and net income in each employment state is implemented in the model. Here, the model represents an approximation to the underlying institutional settings. Contributions to the pension system are collected as a payroll tax throughout the working life. According to the contributions individuals earn pension claims in the form of annual pension points (pp_{it}). Pension points are calculated as the ratio of the individual gross wage (w_{it}) to the annual specific average wage of all insured ($\tilde{w}_t$), i.e. $pp_{it} = w_{it}/\tilde{w}_t$. Annual pension points are capped by a ceiling which varies at around two pension points. Individuals can collect pension points in full-time employment, partial retirement and unemployment. In full-time employment, individual i collects pension points in period t according to his gross wage and the above mentioned pension formula. That is, $pp_{it} = pp_{it}(w_{it})$ if the employment state $k_{it} = f$. Following institutional rules in Germany during estimation, pension accumulation in partial retirement is subsidized by 40%. Therefore, an individual in partial retirement with 50% of full-time labor supply collects pension points according to 90% (50%+40% subsidies) of his full-time gross wage. Finally, an individual's pension points in unemployment can be approximated by 80% of the corresponding full-time employment pension points, i.e. $pp_{it} = 0.8 \cdot pp_{it}(w_{it}) \quad \text{if} \quad k_{it} = u$.

The individual's net income depends on his gross wage in employment. This is subject to income tax (IT) and social security contributions (SSC). Both gross wages as well as tax and transfer rules vary across employment states. Net income in any employment state is bounded from below by social assistance. We summarize the tax and transfer rules with function $G(\cdot)$ and denote an individual's income in period t and employment state k by y_{it}^k: Net income in full-time employment is defined as $y_{it}^f = G(w_{it})$. The specific institutional rules guarantee a subsidy in partial retirement by 20% of individual's full-time wages. Hence, an individual's net income in partial retirement is defined as $y_{it}^p = G(0.7 \cdot w_{it})$[10]. Individuals in unemployment receive unemployment insurance for one to three years, according to their eligibility, and then social assistance. Unemployment insurance can be approximated by 60% of an individual's net full-time employment income (Haan and Prowse, 2015). Thus, $y_{it}^u = 0.6 \cdot G(w_{it})$. Following pension system rules, a retiree

[10]The adjustment by 0.7 is 50% labor income plus 20% subsidies.

receives an annual pension that depends on his accumulated pension points, his retirement entry age, the chosen retirement path and his cohort. Compared to net full-time labor income, pensions are lower. Pension annuities are deducted by 3.6% for every year that the individual enters retirement before the NRA. For example, if an individual enters retirement at the age of 60 his pensions are deducted by $5 \cdot 3.6\% = 18\%$.[11]

Data

The estimation of the model is based on an administrative dataset, the Biographical Data of Social Insurance Agencies in Germany (BASiD) (Hochfellner et al., 2012). The main feature of this data is that it combines information on the timing of partial retirement take-up with information on pension accrual which are collected by two different public institutions. Moreover, the dataset provides spell information about the employment history (including daily wages[12]) for each individual on a daily level until 2007 as well as information on other work-related characteristics and education.[13] As mentioned above, we concentrate our analysis on West German men. The sample covers the cohorts 1940-1947 who enter full retirement in the years 2000 to 2007. The final sample consists of 3,188 individuals with observed retirement entries. Of those, about 39 % (1,246) enter old-age retirement directly after work, 29 % (910) after unemployment, and 32% (1032)

[11] Due to a reform that occurred during the studied period, pension annuities for some cohorts are penalized slightly less if they retire earlier via unemployment or partial retirement. We account for this in the model. For details see https://dejure.org/gesetze/SGB_VI/237.html

[12] Information on gross wages are top-coded due to a ceiling to social security contributions. Therefore, we impute top-coded wages according to the pareto-rule as suggested in Bönke et al. (2015).

[13] Lacking educational information is imputed using a method suggested by Fitzenberger et al. (2005).

after partial retirement. Furthermore, the sample further includes employment decisions of 2,238 additional individuals for whom the retirement decision is not observed.

Estimation Results

We summarize all model features in the dynamic programming framework, solve it by backwards induction using functional form assumption and set up a likelihood similar to Rust (1987) to estimate the structural parameters of the model by maximum-likelihood. We set the discount factor δ to 0.96 (as proposed by Gourinchas and Parker, 2002). Table 3.1 shows the results. Overall, we find estimates that are consistent with the present literature. The estimate of 2.9 for ρ, the coefficient of relative risk aversion is within the range of estimates in the literature (Blau and Gilleskie, 2006; French and Jones, 2011). On average individuals enjoy leisure time: therefore, the state specific effects for partial retirement, full retirement and unemployment are positive. Preferences for partial retirement and unemployment are lower than for full retirement, as represented by reductions of these preferences from age 60, i.e. the first time full retirement is possible (see θ_1 and υ_1). In comparison, preferences for full retirement are increasing with age (see λ_1).[14]

[14] This could be the result of age-related deteriorating health and consequently higher preferences for leisure.

Table 3.1: Structural parameters

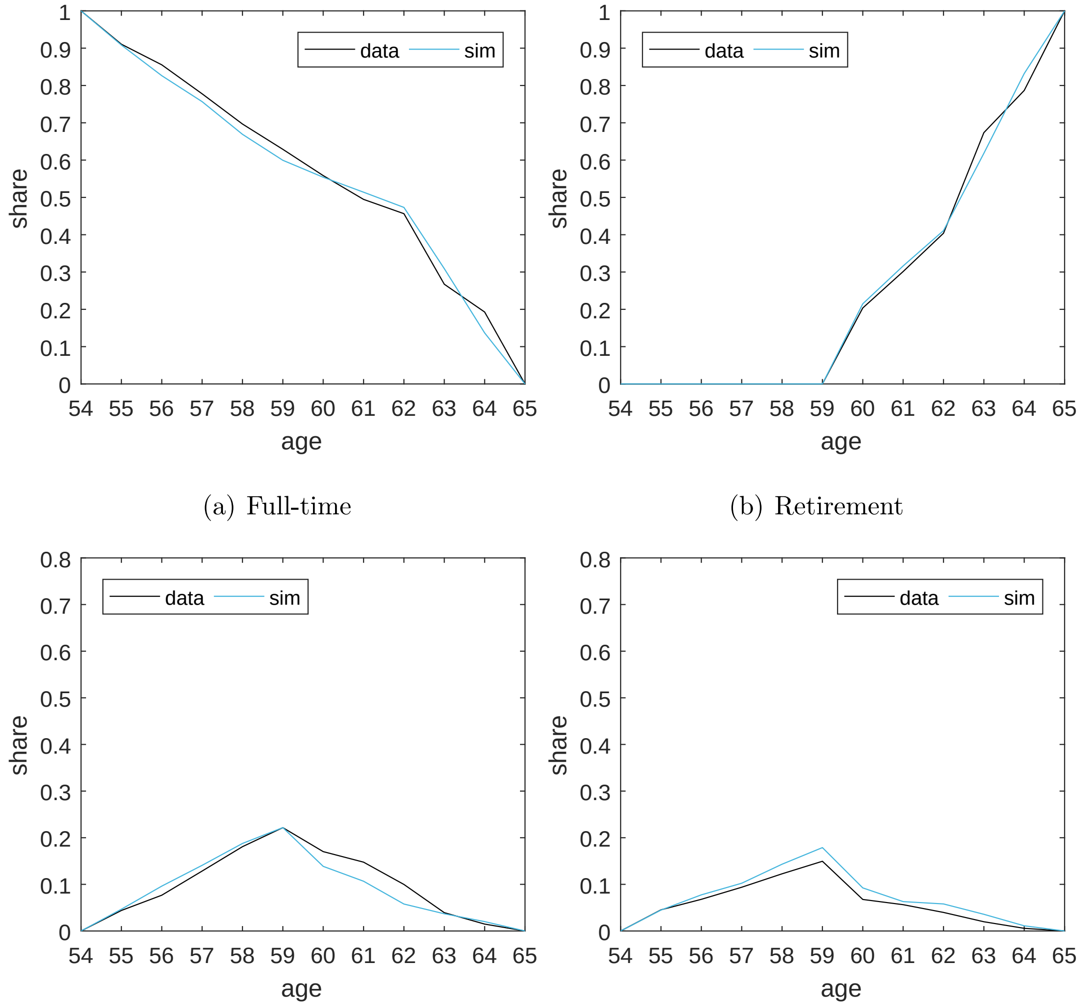
	Value	**Std.Err**
Utility function		
β	0.96	-
ρ	2.9988***	0.1729
Retirement		
λ_0	0.8532***	0.0280
λ_1	0.0087**	0.0037
Partial retirement		
θ_0	1.2616***	0.0234
θ_1	-0.5856***	0.0318
Unemployment		
υ_0	1.2226***	0.0320
υ_1	-0.8413***	0.0599
ll	-14,861	

*,** and *** denote significance level of 10%, 5% and 1%, respectively.

In addition to the estimation results we provide evidence about the in-sample fit of the model. Figure 3-1 shows that the simulated data[15] replicate the age pattern of the employment states observed in the estimation sample.

[15] Based on these results we simulate a dataset with 100,000 observations.

Figure 3-1: Model fit



(a) Full-time (b) Retirement

(c) Partial Retirement (d) Unemployment

Source: Own calculations based on BASiD. Based on 100,000 simulated observations. Figure depicts shares in each employment state by age. Sample is conditioned to 100% full-time employment at age 54 and 100% retirement at age 65.

3.3 Policy Simulation

For the policy analysis we simulate a sample of 100,000 individuals under different policy regimes. In particular, in the different policy regimes we vary the design of partial retirement rules with respect to entry age and timing of pension benefits and compare employment and fiscal effects to a baseline scenario without partial retirement. We do not focus on the effects of subsidies for partial retirement.[16] Therefore, in contrast to the legislation imposed in the estimated model, partial retirement is not subsidized in the policy simulations. Finally, in line with a recent pension reform in Germany, we set the NRA in all scenarios to 67 while the ERA remains at 63. Hence, we move the restriction that everybody has to be in full retirement from age 65 to 67.[17]

Baseline Scenario

For the baseline scenario we approximate a pension system without the option of partial retirement.[18] In the baseline individuals can exit employment either through unemployment or full retirement from the ERA onwards.

[16]For an analysis of subsidies see Tolan (2017)

[17]According to the increase of the NRA by two years, we increase the margin of the age effects in the utility function (there set to 60) also by two years and set it to 62.

[18]The pension rules in the baseline scenario differ from the German pension rules imposed for the estimation of the model. As mentioned above, we identify partial retirement in the data through take-up of *part-time work for elderly employees* (known in Germany as *Altersteilzeit.* This policy features subsidies for partial retirement. In addition, under this policy partial retirees do not have the option to receive a share of their pension benefits. Hence, the policy does not feature any early pensions or deductions to early pension benefits in partial retirement. Moreover, in this system access to partial retirement is restricted.

Simulating Partial Retirement

In the simulation of partial retirement we remove the restriction on partial retirement access and allow for 100% access to partial retirement. Moreover, in every simulated scenario with full access to partial retirement working hours in partial retirement are equal to 50% of equivalent full-time working hours[19] independent of the timing of pension benefits. In general, income in partial retirement consists of a pension part (y_{it}^{pp}) and a labor income part (y_{it}^{pl}). Part-time wages are not penalized, such that the labor income of partial retirement of individual i in period t is equal to half of the equivalent full-time earnings net the corresponding taxes and social security contributions. As described above, an individual's pension depends on the pension contributions during the full working life. Moreover, the timing of pension receipt is important because pensions are subject to deductions for every year that the individual retires prior to the NRA.[20] We use the pension formula (including deductions for earlier pension receipt) to compute the pension income part of partial retirement income. The amount of pension income that is associated with partial retirement depends on the respective pension benefit policy that we simulate. That is, if we simulate that individuals receive 100% of their pension benefits in partial retirement, income in partial retirement is equal to the sum of the part-time labor wages and the full pension amount that the individual receives at the respective entry age. Equivalently, if we simulate that individuals do not receive any pension benefit in partial retirement, income in partial retirement amounts to only the labor income part from part-time employment. For our main

[19] This is ensured by the legal conditions on working hours in partial retirement in the approximated underlying policy.

[20] For every year the individual retires prior to the NRA, pension annuities are deducted by 3.6%. For details see: https://dejure.org/gesetze/SGB_VI/77.html

specification we assume 50% pension benefits in partial retirement, i.e. individuals in partial retirement receive 50% of pension claims that are accumulated up to the point of entry into partial retirement, they receive the other 50% of pension claims when they enter full retirement. Since individuals enter partial retirement before the NRA these pension claims are subject to deductions for early retirement.

How Does Partial Retirement Affect Employment?

Employment effects of partial retirement are ambiguous because they are the net result of two counteracting effects: (1) The movement from unemployment or early retirement to partial retirement and (2) the transition from full-time employment to partial retirement. The entry age into partial retirement can play an important role for the sign and the size of the employment effect. The earlier individuals can enter partial retirement and the longer they can stay in partial retirement, the more individuals will be in partial retirement instead of full-time employment or non-employment. If entry age is too early, it might crowd out years that would have been spent in full-time employment. If it is too late, people might exit employment earlier through alternative retirement paths. That is, changing the entry age affects how partial retirement competes with employment paths with more or less labor supply. The overall effect on employment volume depends on the net effect of these two counteracting movements.

Similarly, the financial situation in partial retirement, i.e. the amount and timing of pension benefits in partial retirement, may determine employment effects since individual retirement behavior is affected by financial incentives (see e.g. Van Soest and Vonkova, 2014; Manoli and Weber, 2016). Clearly, more income in partial retirement will increase its attractiveness relative to alternative retirement paths.

However, pension benefits in partial retirement generate complex dynamics in an individual's income stream. An individual in partial retirement finances his higher income through a share of his pension. Due do deductions to early pension benefits, this share would have been higher had he opted to receive these pension benefits only at entry into full retirement. In more detail, partial retirees finance higher current income with loss in future income which is a form of intertemporal substitution. In this context, two behavioral factors play a role: (1) individuals discount future income, and (2) individuals enjoy additional earnings in times of low income more than in times of high income (due to risk aversion). As mentioned above, pension annuities are lower than labor income. This affects individual preferences in their decision between more current earnings (a high share of pension benefits in partial retirement) or more future earnings (a low share of pension benefits in partial retirement).

3.3.1 Partial Retirement Rntry Age

In the first set of policy simulations we focus on the role of the entry age of partial retirement. More precisely, we simulate partial retirement regimes with increasing entry ages for partial retirement. In all simulations the ERA is at the age of 63 and the NRA is fixed to the age of 67. This allows us to demonstrate how results change when the entry age to partial retirement equals the ERA and when entry to partial retirement is possible before the ERA.

We measure employment effects by looking at changes in employment duration defined by retirement entry (pension receipt) and employment exit (entry into unemployment or full retirement). Moreover, we focus on the effect of total employment volume by computing the average full-time equivalent (FTE) employment share under every regime; one year in full-time employment is counted as one FTE while one year in partial retirement is counted as $\frac{1}{2}\cdot$ FTE.[21]. Finally, in order to understand the dynamics of the employment effects, we present how employment states and the share of each retirement path changes over the age distribution. We compute the fiscal consequences of each scenario from the governments perspective for every individual from age 55 to the terminal age 100. The computations further take into account an interest rate of 2% and individual survival probabilities. Social assistance and unemployment insurance (UI) payments as well as pension payments (Pension) are considered costs while income tax (IT) and social security contributions (SSC) are considered revenues. Cost and revenue vary across different policy scenarios as the distribution across the employment states changes.

Employment Effects

Table 3.2 summarizes the employment effects of partial retirement with 50% of pensions in partial retirement for different entry ages which vary from 60 to 63. The top panel shows the shares of each chosen retirement path. The middle panel summarizes average retirement age (timing of full pension receipt), average employment exit age (timing of entry into unemployment or retirement) and average annual FTE and the lowest panel presents the average shares in each employment state between ages 55 to 67.

Overall, we find that the introduction of partial retirement changes the retirement behavior of individuals: more individuals retire via partial retirement the earlier they have access to it (about 44% when the entry age is 60 and about 27% when the entry age is 63) and correspondingly, the shares of individuals that retire reg-

[21] This corresponds to the definition of FTE in Gustman and Steinmeier (2008)

ularly or via unemployment drop with the introduction of partial retirement.

We now move to explain how partial retirement affects employment duration. We find a positive effect of partial retirement on the retirement age but the effects strongly vary by entry age. The average retirement age increases by about 0.4 months from 64.65 (without partial retirement) to 64.68 when the entry age is 60. When the entry age is equal to the ERA at age 63, retirement increases by even 4.4 months from 64.65 to 65.02. This finding is supported by Figure 3-2(b) in Appendix 3.5 which shows that fewer people enter retirement at the ERA the later the partial retirement entry age while the retirement entry behavior virtually does not change compared to the scenario without partial retirement when the entry age is 60. This suggests that people postpone earlier retirement for the benefit of spending some time at reduced working hours in partial retirement and contributing more towards their pensions.

Table 3.2: Employment effects of different partial retirement entry ages

	No part. ret.	**Pret60**	**Pret61**	**Pret62**	**Pret63**
Retirement path shares					
Regular	76.96	40.28	44.90	50.37	54.48
Unemployment	23.04	15.45	16.61	17.66	18.47
Partial	0.00	44.27	38.50	31.98	27.05
Employment duration and volume					
Avg. retirement age	64.65	64.68	64.81	64.96	65.02
Avg. employment exit age	63.62	63.95	64.03	64.14	64.16
FTE avg.	71.85	70.11	71.90	73.57	74.27
Average share in employment state					
Full-time	71.85	65.67	68.56	71.00	72.21
Partial	0.00	8.88	6.69	5.14	4.12
Unemployment	8.60	6.13	6.52	6.87	7.16
Retirement	19.55	19.32	18.23	16.99	16.51

Source: Own calculations based on BASiD. Based on 100,000 simulated observations. FTE represents Full-time employment equivalent. Shares are represented in percent.

The increase in the average employment exit age is more pronounced. More specifically, partial retirement leads to an extension of the working life by about 4 months (from 63.62 to 63.95) when the entry age is 60. This finding is strongly linked to the drop in unemployment shares which are depicted in the lowest panel of the table. Average shares in unemployment fall from 8.6% to 6.13% when partial retirement access is 60 and remain below the baseline level as the entry age increases. However, unemployment shares increase the later people can access partial retirement. This suggests that partial retirement extends working life by substituting years spent in unemployment by years in partial retirement. Despite higher unemployment shares as the partial retirement entry age increases, we find that the average exit age and FTE employment are higher the later people have access to partial retirement. The exit age increases by even 6.5 months (from 63.62 to 64.16) when the entry age is 63. This can be explained by analyzing changes in employment volume.

FTE employment is lower compared to the baseline when partial retirement is introduced at the age of 60. However, as we increase the entry age, FTE employment increases. From an entry age of 61 the effects of partial retirement on employment volume are positive. The average FTE employment increases from 71.85% in a regime without partial retirement by about 0.05 percentage points to 71.90%. If the entry age is equal to the ERA, the average FTE employment even increases by about 2.4 percentage points (from 71.85% to 74.27%). This effect is mostly driven by changes in full-time employment shares as depicted in the lowest panel. As mentioned above, partial retirement crowds out years in full-time employment. Still, the full-time employment share at an entry age of 61 combined with years in partial retirement that substitute years in unemployment dominate this negative effect and generate overall positive employment effects. In addition, the later people can enter partial retirement, the higher are full-time employment shares. The full-time employment share when partial retirement starts at the ERA (age 63) is even higher than in the baseline without partial retirement. Figure 3-2(a) in Appendix 3.5, which shows average full-time employment shares by age, visualizes why this is the case. The figure shows that full-time employment is higher than in the baseline up to the age where people can enter partial retirement. Then, the full-time employment share falls below the baseline share. This suggests that people anticipate partial retirement entry and remain in full-time employment until they can enter partial retirement. If they exited employment earlier, they would not be able to enter partial retirement. This also explains the higher exit age with increasing entry age.

Fiscal Effects

We now turn to the fiscal effects of partial retirement. Table 3.3 summarizes the fiscal consequences of partial retirement with different entry ages. For all entry ages we find positive fiscal effects. Specifically, the fiscal gains range from 5,692€ on average per person when the entry age is 63 to 6,276€ per person when the entry age is 61. Thus, we find that fiscal gains are generally higher the earlier people can enter partial retirement. This is because the change in the reduction of costs (UI and pension payments) is stronger than the corresponding decrease in SSC and IT revenue. The reduction in pensions ranges from 8,960€ when the entry age is 60 to 10€ (virtually nothing) when the entry age is 63. From the entry ages 60 to 63 changes in payments in UI range from -2,701€ to -1,554€ while changes in SSC and IT together range from -5,648€ (-2,280-3,368) to 4,128€ (2,810+1,318) when the entry age is 63.

Table 3.3: Fiscal consequences of different partial retirement entry ages

	acc. Costs		acc. Revenues		
	Pension	**UI**	**SSC**	**IT**	**Net balance**
	No partial retirement				
	350,170	9,148	115,200	64,299	-179,819
	Partial retirement entry ages 60-63				
60	341,210	6,447	112,920	60,931	-173,806
Diff	-8,960	-2,701	-2,280	-3,368	6,013
61	344,720	6,877	115,080	62,974	-173,543
Diff	-5,450	-2,271	-120	-1,325	6,276
62	348,250	7,273	117,130	64,781	-173,612
Diff	-1,920	-1,875	1,930	482	6,207
63	350,160	7,594	118,010	65,617	-174,137
Diff	-10	-1,554	2,810	1,318	5,692

Source: Own calculations based on BASiD. Based on 100,000 simulated observations. Amounts indicate averages per person. FTE represents Full-time employment equivalent. Shares are represented in percent. Costs and revenues are accumulated for every individual over the age interval [55,100] and adjusted by an interest rate of 2% and individual survival probabilities.

We have documented that the average retirement entry age increases when partial retirement is introduced. This implies, with partial retirement people receive pensions on average for a shorter duration than in the case without partial retirement. Therefore, the reduction in pensions due to partial retirement is driven by three factors: (1) people receive half of their pensions with deductions, (2) collect half of otherwise full-time pension points per period and (3) receive pensions for a shorter time span than in a scenario without partial retirement. Especially the effect of the deductions to pension annuities due to an early pension receipt can be substantial. For instance, individuals who enter partial retirement at age 60 receive seven years worth of deductions (i.e. $7 \cdot 3.6 = 25.2\%$) to half of their pension annuities.

The changes in UI, SSC and IT with respect to an increasing entry age can be explained by changes in unemployment and full-time employment shares as explained above. Reductions in UI payments decrease with an increasing entry age because unemployment is the higher the later people can enter partial retirement. Similarly, SSC and IT payments increase when the partial retirement entry age increases. This is because full-time employment increases as partial retirement starts later. We find, that changes in payments into SSC and IT start to become positive when the partial retirement entry age is at 62. If we disregard the effects on pensions, partial retirement has already positive effects from entry age 61 because the reductions in UI payments are higher than the reductions in SSC and IT.

Finally, note that the substantial reductions in pension payments translate into lower pension annuities for retirees. This means, the earlier people can enter partial retirement, the stronger the reduction in their pensions. Thus, the fiscal gains at very low entry ages for partial retirement imply reductions in individual pensions.

3.3.2 Pension Benefits in Partial Retirement

In the final section we perform policy simulations in which we vary the amount of pensions benefits that individuals receive while in partial retirement. We present results from two extreme scenarios: in the first case individuals receive in addition to their labor income their entire pensions already at entry into partial retirement, in the second case partial retirees receive no pensions until they enter full retirement and only receive labor income. Results from the intermediate pension benefit scheme with 50% of pensions in partial retirement are presented as a benchmark. The working hours in partial retirement remain the same in all three simulated scenarios: individuals in partial retirement reduce their working hours to 50% of their equivalent full-time working hours. Since the effect of different entry ages has been documented in the previous section, we focus only on the entry age of 62.[22]

Employment Effects

Table 3.4 presents the employment effects of different pension benefit timing policies with partial retirement entry age 62. The percentages in the top row indicate the share of pension benefits in partial retirement.

[22] Results with other partial retirement entry ages are comparable - they are available upon request.

Table 3.4: Employment effects, timing of pension benefits, entry age 62

	No part. ret.	**100%**	**50%**	**0%**
Retirement path shares				
Regular	76.96	53.60	50.37	52.25
Unemployment	23.04	18.11	17.66	17.90
Partial	0.00	28.29	31.98	29.85
Employment duration and volume				
Avg. retirement age	64.65	64.96	64.96	64.93
Avg. employment exit age	63.62	64.11	64.14	64.09
FTE avg.	71.85	73.67	73.57	73.43
Average share in employment state				
Full-time	71.85	71.41	71.00	71.08
Partial	0.00	4.53	5.14	4.69
Unemployment	8.60	7.02	6.87	6.96
Retirement	19.55	17.04	16.99	17.27

Source: Own calculations based on BASiD. Based on 100,000 simulated observations. FTE represents Full-time employment equivalent. Shares are represented in percent. Percentages in the top row indicate the share of pension benefits in partial retirement.

The top panel in the table indicates that partial retirement has the highest take-up rate in the scenario with an intermediate pension benefit timing scheme. 31.98% of the studied population enters retirement through partial retirement compared to 28.29% when people receive full pensions in partial retirement and 29.85%

when people do not receive any pension in partial retirement. This suggests that people prefer partial retirement in a regime where they can combine part-time labor earnings with partial pensions. Moreover, it indicates that there is some potential to incentivize partial retirement with earlier pension benefit receipt although a too high share of pensions in partial retirement discourages take-up.

The different pension benefit timing policies do not substantially affect the average duration in employment.[23] Neither the average retirement entry age, nor the average age at employment exit markedly differs across the pension benefit timing policies. The same is true for the employment volume and the employment shares. In particular, FTE employment is at 73.67% when people receive their full pensions in partial retirement, compared to 73.57% in the intermediate case and 73.43% when no pensions are paid in partial retirement. Hence, employment volume is at its lowest when no pensions are paid in partial retirement. Allowing for the receipt of pension benefits in partial retirement slightly improves the overall employment volume.

Fiscal Effects

Despite the similar employment effects, the timing of pension benefits has sizable implications for the fiscal effects (Table 3.5). Overall, net balances improve in all partial retirement regimes; however with a plus of 8,845€ the effect is largest when full pensions are paid in partial retirement. In contrast, the net balance has a plus of 2,523€ when no pensions are paid in partial retirement and 6,207 when 50% of pensions benefits are received. The differences are mainly driven by the different pension payments in the three scenarios while the differences in UI payments as

[23] This is supported by Figure 3-3 in Appendix 3.5 which shows the age effects of different pension benefit timing schemes on employment states

well as SSC and IT payments are not as pronounced. When full pensions are paid in partial retirement the reduction in pension payments are the largest (4,460€) since in this scenario almost 100% of pensions are subject to deductions. In the scenario where pensions are only paid after partial retirement, pensions even increase by 1,560€ because the average retirement entry age is higher in a regime with partial retirement. Thus, even if no pensions are paid in partial retirement, individuals take up partial retirement since it offers a way to increase pensions by postponing retirement at reduced working hours.

Hence, note again that these differences in average overall pensions translate into considerable differences for individual pensions across pension benefit timing schemes. However, despite the high reductions under a pension benefit timing scheme that pays full pensions in partial retirement, we show above that the take-up rate of partial retirement is not markedly affected by this. The underlying behavioral mechanisms for this is that individuals discount future income and face uncertainty regarding their mortality in the future. In this scenario individuals receive substantially higher income in the years they spend in partial retirement. This behavior suggests that the utility gains from the higher current income are not offset by the utility drop due to large reductions in future income. Thus, pension benefit receipt in partial retirement should be limited to prevent sizable reductions in pensions.

Table 3.5: Fiscal consequences, timing of pension benefits, entry age 62

	acc. Costs		acc. Revenues		
	Pension	**UI**	**SSC**	**IT**	**Net balance**
	No partial retirement				
	350,170	9,148	115,200	64,299	-179,819
	Full pensions in partial retirement				
	345,710	7,438	117,260	64,914	-170,974
Diff	-4,460	-1,710	2,060	615	8,845
	Partial pension in partial retirement				
	348,250	7,273	117,130	64,781	-173,612
Diff	-1,920	-1,875	1,930	482	6,207
	No pension in partial retirement				
	351,730	7,345	116,960	64,819	-177,296
Diff	1,560	-1,803	1,760	520	2,523

Source: Own calculations based on BASiD. Based on 100,000 simulated observations. Amounts indicate averages per person. FTE represents Full-time employment equivalent. Shares are represented in percent. Costs and revenues are accumulated for every individual over the age interval [55,100] and adjusted by an interest rate of 2% and individual survival probabilities.

3.4 Conclusion

In this paper we analyze the design of partial retirement programs. In particular we quantify the employment and fiscal effects of different entry ages and different pension benefit timing schemes in partial retirement programs. This is the first study that disentangles the role of different policy margins in the effect of partial retirement on labor market outcomes.

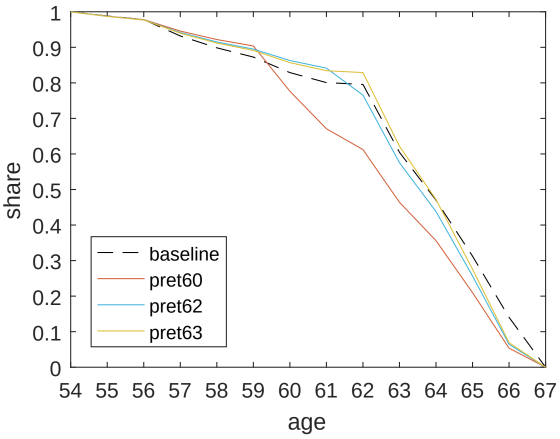
For this purpose we use a dynamic structural retirement model in which forward-looking individuals aged 55 and above maximize their present discounted utility by making annual decisions between continuing to work and exiting the labor market via one of three potential retirement paths: regular retirement, retirement after unemployment, and via partial retirement. The model accounts for the risk of job-loss and mortality. It also incorporates relevant institutional specifications of the underlying pension system, unemployment insurance, and tax and transfer rules. We use the model to simulate counterfactual policies of partial retirement with varying entry ages for partial retirement (prior and equal to the ERA) as well as pension benefit timing schemes.

The employment effects and the related fiscal effects of partial retirement are ambiguous. On the one hand, partial retirement provides incentives to remain in the labor force for individuals who otherwise might exit employment through early retirement or through unemployment. On the other hand, partial retirement can also decrease employment if full-time working individuals who otherwise would work until the normal retirement age enter partial retirement and thus reduce their working hours. We find that the sign and the size of employment effects depends on the distance between access to partial retirement and the ERA. In more detail, employment effects are negative when individuals can enter partial retirement more than two years before the ERA, i.e. before the age of 61. In contrast, we find positive employment effects when individuals have access to partial retirement at the age of 61; the employment volume increases by 0.05 percentage points when partial retirement is introduced at an entry age of 61. At an entry age which is equal to the ERA (63 in our simulation), the employment volume is even 2.4 percentage points higher than in a baseline scenario without partial retirement. We find that partial retirement improves public balances for policies that allow access at any age in seven years before the NRA. The fiscal plus is higher the earlier we allow for access to partial retirement. Depending on the entry age, we find improvements in fiscal balances from 5,700€ to 6,300€ per person. Hence, from a policy-makers perspective it can be beneficial to offer partial retirement before the ERA (at age 61 or 62), to generate both a high fiscal plus as well as positive employment effects.

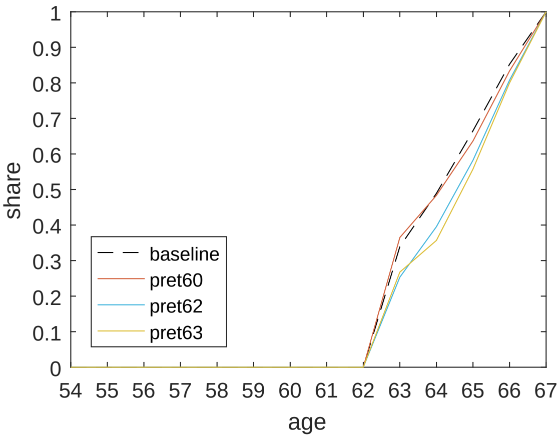
The take-up rate of partial retirement is at its highest under a regime in which individuals receive 50% of their pensions in partial retirement and the other 50% at entry into full retirement, i.e. when part-time labor is combined with partial pensions. Therefore, allowing for pension benefits in partial retirement can incentivize its take-up. However, we find only a marginal reduction in take-up when no pensions are paid in partial retirement (by about 2.13 percentage points) since it also offers an opportunity to improve individual pensions by postponing retirement entry at reduced working hours. Hence, pensions are the lower the higher the share of pensions that are received in partial retirement. Thus, limits to pension benefits in partial retirement are necessary to prevent substantial reductions in individual pensions and increased risk for retirees with low income to become subject to social assistance.

3.5 Appendix

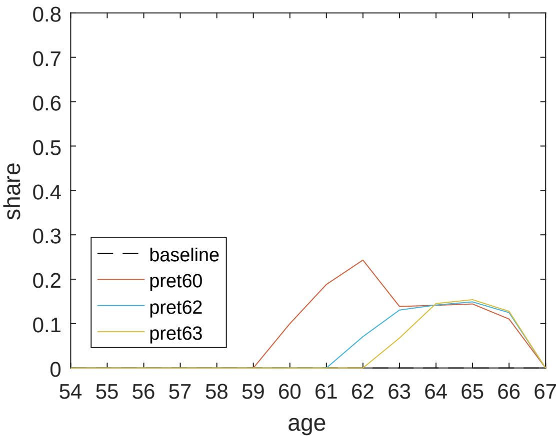
Figure 3-2: Employment state shares, partial retirement from 60, 63 and 65



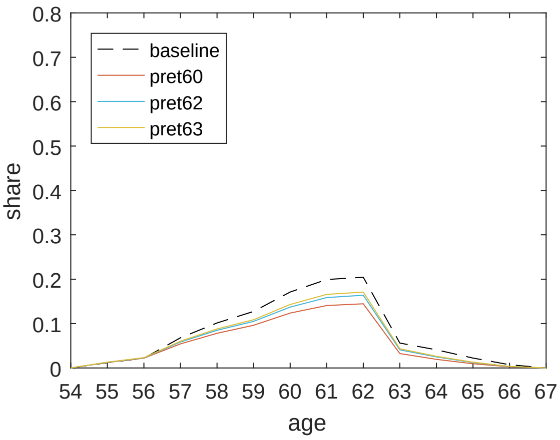
(a) Full-time



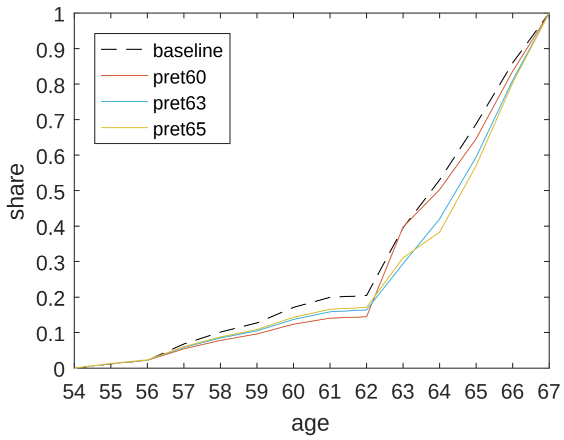
(b) Retirement



(c) Partial retirement



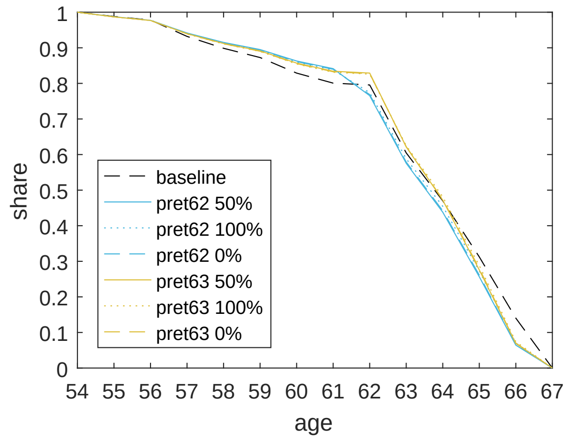
(d) Unemployment



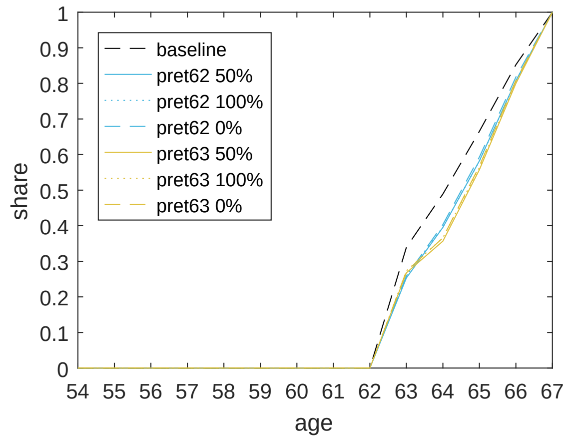
(e) Non-employment

Source: Own calculations based on BASiD. Based on 100,000 simulated observations. Figure depicts shares in each employment state by age.

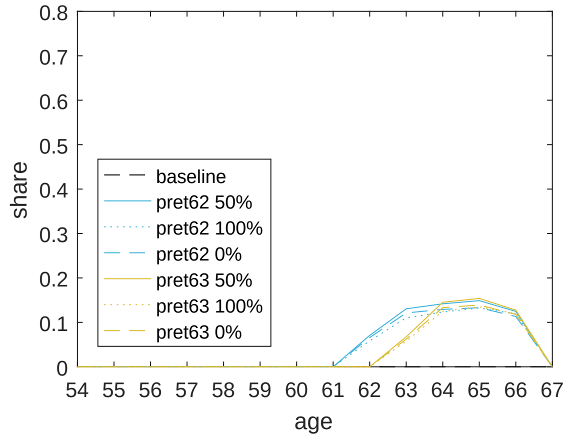
Figure 3-3: Employment state shares, partial retirement from 62 and 65, 0%, 50% and 100% pensions in partial retirement



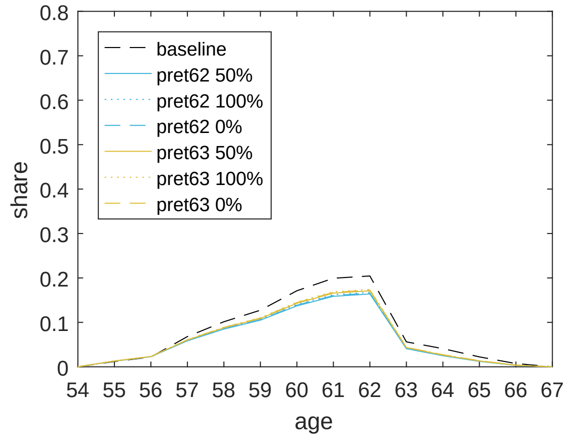
(a) Full-time



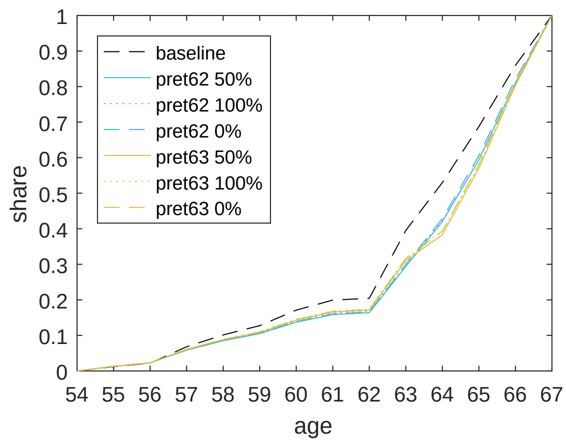
(b) Retirement



(c) Partial retirement



(d) Unemployment



(e) Non-employment

Source: Own calculations based on BASiD. Based on 100,000 simulated observations. Figure depicts shares in each employment state by age.

General Conclusion

This dissertation evaluates policies in two strands of social policy: education and pension politics. More precisely, it focuses on the analysis of underlying mechanisms in the impact of financial student aid (Chapter one) and partial retirement (Chapters two and three) on labor market outcomes. Due to the empirical nature of this analysis, the results of this dissertation must be interpreted in light of limitations that are discussed in the following. Since the methodological approach is basically the same in all three chapters, I will start with a discussion of the limitations in analyzing the research questions at hand using a dynamic structural life-cycle model.

As mentioned in the introduction, the strongest argument against the structural approach is that it relies heavily on (unverifiable) economic assumptions. This relates to the discussion on *'external'* vs. *'internal'* validity. The structural approach emancipates itself from the need of a (quasi-)experiment that provides an external variation to a specific group of *'treated'* individuals for the sake of identifying *'deep structural'* parameters of individual behavior that also hold for the population outside the sample. However, the claim of external validity does not come without the need to proof internal validity first. Therefore, every chapter of this dissertation provides evidence for the in-sample fit of the estimated model

before moving on to counterfactual policy simulations. This is done by comparing relevant moments of the data to the equivalent moments in the simulated sample that is used for policy analysis. Visible deviations are discussed in each chapter. Moreover, the estimation results of the structural model are compared to equivalent findings in the literature and the outcomes of counterfactual policy simulations are, if possible, compared to equivalent studies that use alternative methods. Finally, because the focus of Chapter one is the identification of time-prefenrences, i.e. structural parameters, this chapter also provides a sensitivity check on these parameters.
Another problem in structural analysis is the *'curse of dimensionality'* (Bellman, 1957). It refers to the problem of an exponential increase in the computational time needed to solve a dynamic programming model as the number of variables increases. It forces the structural econometrician to keep the models for estimation as simple as possible. This dissertation deals with this problem by keeping the focus of the models on the research question at hand and finding other ways to account for additional dimensions without going to much into detail. However, in some instances adding an additional dimension could have helped to add better targeted policy advice. This is explained in more detail further below.

Chapter one investigates whether present-biased preferences matter for educational decisions depending on whether financial support during the educational time is a grant or a loan. This chapter shows that the common assumption of exponential discounting in economic models of educational decisions may be too restrictive. This also has policy implications because the results of the policy analysis shows substantial differences in the educational outcomes between a model with hyperbolic and a model with exponential time preferences. In addition, Chapter one shows that individuals react more strongly to the loan than to the grant because the prospect of having to repay the loan serves as a commitment to higher educational attainment. Finally, the analysis shows that the response to the two policies differs more for exponential than for hyperbolic discounters.

In the context of hyperbolic discounting, it is important to note that there are two types of hyperbolic discounters: a *naïve* and a *sophisticated* type who differ in the perception of discounting behavior for future periods (Strotz, 1955; Pollak, 1968; O'Donoghue and Rabin, 1999; O'Donoghue and Rabin, 1999). Chapter one focuses on the naïve hyperbolic discounter. The sophisticated discounter is aware of the fact that she will also have present-biased preferences in future periods while the naïve discounter remains ignorant of this fact. Since the sophisticated discounter is aware of her future period self's self-control problem, she will react more strongly to policies that impose a commitment to education. Student loans that are simulated in Chapter one potentially represent such a commitment device since the prospect of having to repay loans in the future might motivate students to achieve higher degrees and therefore higher income after exiting education. Hence, a sophisticated hyperbolic discounter is likely to react more strongly to the student loan policy than its naïve counterpart. The effects found for the naïve hyperbolic discounter can be seen as a lower bound to the effects for sophisticated hyperbolic discounters and therefore give insights on what can be expected when studying this type.

A potential problem of reverse causality poses a threat to identification in Chapter one since the model relies on the assumption that these parameters do not change throughout the education period. On the one hand, hyperbolic discounting somewhat accounts for the fact that preferences change over time. On the other hand, the parameters estimated for present discounting and future discounting are assumed to remain constant over time. Perez-Arce (2017) presents some suggestive evidence for this reverse causality. However, other long-term studies point towards a strong persistence in time-preferences over time (see e.g. Golsteyn et al., 2014). The literature related to Mischel et al. (1989) on the effect of time preferences on later success in life supports this.

The model could be extended to relate the findings on discount rates to socio-economic background. The literature established a strong link between socio-economic status and educational attainment which is not exclusively linked to financial constraints (see e.g. Heckman, 2006). This is further supported by evidence on a strong link between academic family background and educational attainment in Germany (Middendorff et al., 2013), despite the fact that education is practically free in Germany. Another explanation for this strong relationship could be the link to the discount rate which is theoretically established in Willis and Rosen (1979). Moreover, Oosterbeek and van Ophem (2000) provide evidence on the relationship between family background, the discount rate and subsequent educational attainment. Thus, linking the heterogeneity found in the discount factors in Chapter one to socio-economic background could be a relevant extension to the model.

Chapter two studies the employment, fiscal and distributional effects that arise due to the implementation of partial retirement. the study shows that partial retirement extends working lives by substituting years that would have been spent in unemployment if partial retirement was not offered as a retirement option.

Moreover, in the context of an increased normal retirement age, partial retirement is potentially used for consumption smoothing by bridging time between the early retirement age and the normal retirement age with partial retirement. This accounts especially for retirees with low income. However, allowing for partial retirement from the age of 55 leads to a reduction in overall employment volume and the net fiscal balance which is enforced when wages and pension accrual in partial retirement are subsidized. Finally, allowing for unrestricted access to partial retirement leads to a reduction in pension income inequality among retirees.

Chapter three sheds light on the role of entry age and timing of pension benefits in partial retirement on labor supply and fiscal balances. As in Chapter two, this chapter shows that partial retirement extends working lives by substituting unemployment shares with partial retirement. In contrast to the previous chapter, this chapter shows that the introduction of partial retirement can also lead to an increase in the average retirement age and the overall employment volume if access to partial retirement is allowed only from the age of 61. This effect increases with an increasing entry age to partial retirement. In addition, fiscal balances improve when access to partial retirement is allowed from the age of 60, where this effect is lower the higher the entry age for partial retirement. Finally, this shows that allowing for pension benefit receipt in partial retirement can incentivize its take-up but pensions are lower the higher the share of pension benefits received in partial retirement.

The model that is used as a basis for the policy simulations lacks some features that are relevant in the context of retirement decisions. First, In this model consumption equals net income which means that this model does not account for the impact of private wealth on retirement decisions. The implications of this assumption are slightly mitigated by the fact that workers in Germany rely as main source of income during retirement on the pensions from the Statutory Pension Insurance. Other sources of income, such as returns to capital only play a role of distant second order and Frick et al. (2010) show that the majority of all German households store the largest share of their wealth in pension entitlements. Rust and Phelan (1997) motivate their modeling decision to not account for wealth by problems of imputing missing wealth information. Dynamic consumption choice in a life cycle model that starts relatively late in working life would require information on the initial distribution on wealth. Chapters two and three face the same data problems. A strong correlation between income and wealth (Piketty and Zucman, 2014) helps to capture variation in individual retirement decisions due to wealth through variations in income. Nevertheless, individuals with very high wealth may be less likely to react to incentives from the public pension system. Thus, in terms of effect size the outcomes of this model should be interpreted as an upper bound.

Another important driver of retirement decisions might be the partner's retirement behavior. The data this analysis is based on does not provide household information, i.e. information on martial status and partner's income and employment status which poses a particular challenge when trying to account for the partner's influence on retirement decisions. However, couples are often observed to exit work at about the same time which motivated the literature on couples' joint retirement decisions (see e.g. Hurd, 1990; Blau, 1998; Gustman and Steinmeier, 2014). The literature identifies three mechanisms that drive this effect: complementarity in leisure preferences, interrelated household budget constraints, and unobserved correlated shocks to leisure preferences (Gustman and Steinmeier, 2014). Depending on the underlying mechanism, not accounting for joint retirement decisions may over- or underpredict the changes in consumption due to retirement. However, Hospido and Zamarro (2014) do not find a significant effect of joint retirement preferences on husband's retirement decisions in a cross-country analysis. Moreover, even though Blau and Riphahn (1999) provide evidence for joint retirement in Germany, they also show, for cohorts similar to the cohorts these chapters are based on, that husbands are on average three years older than their wives. Thus, on average husbands reach respective retirement ages before their wives which would require more adjustments in terms of joint retirement from wives than from husbands. The fact that the present chapters are based on data of West German men might mitigate the presence of joint retirement preferences in the studied sample.

Thus, another interesting feature missing in the present model is an analysis of women's retirement decisions. This is mainly driven by data concerns. The number of women in the studied cohorts eligible to partial retirement take-up is comparatively small, with earnings- and employment histories considerably different from their male counterparts (Huber et al., 2016). However, as female labor force participation is increasing over time, future studies with younger cohorts will provide better information on female retirement decisions.

In July 2017 Germany implemented a new law on partial retirement that will simplify conditions to work beyond the normal retirement age, allow for combinations of labor income and pension benefits (with limits) and an entry age to partial retirement from the early retirement age onwards. Thus, partial retirement will become more relevant in the future. The analysis from these chapters shows that partial retirement can help to increase overall employment volume and postpone the average retirement age if access to partial retirement is already allowed one to two years before the early retirement age. Allowing for earlier access can also yield better fiscal effects from partial retirement since the fiscal plus due to partial retirement is higher at entry ages before the early retirement age. Finally, subsidizing partial retirement only leads to higher substitutions of full-time employment in favor of partial retirement and consequently lower labor supply as well as fiscal balances. In contrast, a combination of part-time labor and pension benefits can incentivize partial retirement by substituting years in early retirement/unemployment. However, limits to pension benefits in partial retirement are necessary to prevent substantial reductions in individual pensions and increased risk for retirees with low income to become subject to social assistance. An *'ex-post'* analysis of the new partial retirement policy in Germany will shed more light on this topic.

Summary

This dissertation evaluates policies in two strands of social policy: education and pension politics. Both play a major role in state budgets and in 2013 public spending in these sectors amounted to 8.0% and 8.2% of GDP in OECD countries. More precisely, this dissertation focuses on the analysis of underlying mechanisms in the impact of financial student aid (Chapter one) and partial retirement (Chapters two and three) on labor market outcomes using a dynamic structural life-cycle approach.

Chapter 1 investigates time-inconsistent preferences in educational decision making and corresponding policies using a structural dynamic choice model. For this purpose it augments a dynamic structural model by hyperbolic discounting, a behavioral bias that exhibits time-inconsistent preferences. Estimates of this model are compared to the same model but with classic exponential discounting. The estimation is based on a sample of West German students from the German Socio-Economic Panel (SOEP). In line with Chan (2013), Fang and Wang (2015), and Haan et al. (2017) identification is achieved not only on the basis of functional form assumptions but also by imposing exclusion restrictions that affect educational choices indirectly through their impact on the transition probabilities of relevant state variables and reveal information on the discounting behavior. Birth cohort

groups as well as regions that were affected by different educational policy reforms are used as exclusion restrictions. Their relevance on the time invested for the attainment of educational degrees is shown. Agents are assumed to face two kinds of uncertainty: (1) there is uncertainty over whether an additional year invested into education will, in fact, be successful and lead to a degree (affected by the policy reforms); and (2) there is uncertainty over the returns to the degree earned when exiting education. The estimation of the structural parameters of the choice model indicates time-inconsistent behavior and provides quantitative evidence for its relevance. The relevance of time-inconsistent behavior for the effectiveness of education policies is evaluated. For this purpose, two policies are simulated where time preferences may play an important role: (1) an increase in the state grant for students as a way to affect short-term costs while at school; and (2) an increase in the state grant as a loan which will have to be paid back after the end of the education.
Substantial differences are found in the effects of these policies when comparing educational outcomes based on a model specification with hyperbolic discounting with the ones based on a specification with exponential discounting. Furthermore, the response to the two policies differs more for exponential than for hyperbolic discounters.

Chapter 2 develops a structural dynamic retirement model to investigate the effects of partial retirement on employment and retirement behavior, fiscal balances as well as the pension income distribution. Partial retirement schemes allow for a gradual reduction of work hours in the last years before entering full retirement. The basic model consists of an individual's annual choice to continue working or exit employment through one of three possible retirement paths: regular retirement, retirement via bridge unemployment, or retirement via partial retirement. The choice is subject to employment and mortality risks. In addition, the model incorporates a tax and transfer system, and the rules and settings of the underlying pension system. The model is estimated based on a sample of West German men from the administrative dataset "Biographical Data of Social Insurance Agencies in Germany" (BASiD). The estimated structural parameters are used to simulate partial retirement under different conditions: 1) as in the data with the normal retirement age at 65, 2) with an increased normal retirement age at 67, and 3) with compensating subsidies for wages and pension accrual in partial retirement. The analysis yields the following results. Introducing the option to retire via partial retirement extends working lives by about four to five months by reducing the number of individuals exiting employment early via unemployment. However, overall employment volume still decreases by on average 4.71% if the normal retirement age is at 65 and by on average 3.86% if the normal retirement age is at 67 due to a large share of individuals that substitute full-time employment with partial retirement. With a reduction in employment volume by about 10% this effect is stronger when wages and pensions are subsidized in partial retirement. Subsidizing partial retirement also leads to a reduction in net balances by an additional 9,500 to 13,500€ per person. More importantly, income inequality in pensions is reduced with the introduction of partial retirement. However, not compensating pension accumulation in partial retirement leads to a decrease in pensions across almost all income deciles. Nevertheless, these reductions are less pronounced when the normal retirement age is 67 since more people bridge the time between early retirement age and normal retirement age with partial retirement. Especially for lower income deciles partial retirement provides a way to smooth consumption when transitioning into retirement in the context of an increased normal retirement age.

Chapter 3 analyzes how variations in two important margins of partial retirement, the entry age and limits to early pension benefits, affect employment and fiscal balances. This study is based on the dynamic structural retirement model developed in Chapter two. However, in this chapter income in partial retirement is a combination of part-time labor earnings and a share of earlier pension benefits. Using the estimated parameters from the model, counterfactual policies are simulated in which the entry age of partial retirement and the amount of pensions benefits received in partial retirement are varied. The implications of partial retirement are investigated in the context of the German pension system and a sample of West German men.
The results show that partial retirement can lead to positive employment effects. In more detail, compared to a regime without partial retirement the employment volume, measured as share in full-time equivalent (FTE) employment, is 0.05 percentage points higher in a regime with partial retirement, when people can enter partial retirement at the age of 61, i.e. two years prior to the early retirement age. This effect is higher under partial retirement regimes with later entry ages. For example, the employment volume is 2.4 percentage points higher compared to a regime without partial retirement when the partial retirement entry age is at 63 (i.e. equal to the early retirement age). In addition, partial retirement yields positive fiscal effects. Public balances improve by about 6,300€ per person when people have access to partial retirement from the age of 61. This fiscal plus is lower the later the entry age to partial retirement. At an entry age of 63 the fiscal gain compared to a regime without partial retirement is at about 5,700€ per

person. Allowing for pension benefits in partial retirement can further incentivize partial retirement take-up but limits to pension benefits are necessary to prevent substantial reductions in individual pensions.

German Summary (Zusammenfassung)

Diese Dissertation bewertet Politiken in zwei sozialpolitischen Bereichen: Bildungs- und Rentenpolitik. Beide spielen eine wichtige Rolle in Staatshaushalten. Im Jahr 2013 beliefen sich die öffentlichen Ausgaben in diesen Sektoren auf 8,0% und 8,2% des BIP in OECD-Ländern. Im Detail befasst sich diese Dissertation mit Hilfe des dynamischen strukturellen Lebenszyklusansatz mit der Analyse der zugrunde liegenden Mechanismen in den Auswirkungen der finanziellen Bildungsförderung (Kapitel eins) und des Teilruhestands (Kapitel zwei und drei) auf Arbeitsmarktergebnisse.

Kapitel 1 untersucht zeit-inkonsistente Präferenzen in Bildungsentscheidungen und zugehörigen Politiken mit Hilfe eines dynamischen strukturellen Entscheidungsmodells. Hierfür wird ein dynamisches strukturelles Modell um hyperbolische Diskontierung erweitert. Dies ist eine Verhaltensannahme bei der zeit-inkonsistente Präferenzen aufgewiesen werden. Die Ergebnisse dieses Modells werden mit demselben Model, aber unter der klassischen Annahme des exponentiellen Diskontierung, verglichen. Die Schätzung des Modells basiert auf einer Stichprobe westdeutscher Studenten des Sozio-ökonomischen Panels (SOEP). Gemäß Chan (2013), Fang and Wang (2015), und Haan et al. (2017) wird die Identifikation von Zeitpräferenzen nicht nur auf Basis von Annahmen zur funktionalen Form sondern auch mit Hilfe von Ausschließbarkeitsbedingungen erreicht. Diese Bedingungen beeinflussen Bildungsentscheidungen nur indirekt durch die Beeinflussung von Übergangswahrscheinlichkeiten relevanter Zustandsvariablen und offenbaren so Informationen zum Diskontierungsverhalten von Individuen. Geburtskohortengruppen und Regionen, die von unterschiedlichen Bildungsreformen betroffen waren, werden als Ausschließbarkeitsbedingungen verwendet. Die Relevanz dieser Bedingungen hinsichtlich der benötigten Zeit für einen Bildungsabschluss wird aufgezeigt. Es wird angenommen, dass Entscheidungsträger zwei Arten von Unsicherheiten ausgesetzt sind: (1) Es besteht Unsicherheit darüber, dass investierte Bildungsjahre zu einem Abschluss führen und (2) Es besteht Unsicherheit über die Höhe der Bildungsrenditen nach Beendigung der Bildungszeit. Die Schätzung der strukturellen Parameter des Entscheidungsmodells deutet auf zeit-inkonsistentes Verhalten hin was einen Hinweis für die quantitative Relevanz dieser Verhaltensannahme liefert. Die Bedeutung von zeit-inkonsistentem Verhalten für die Wirksamkeit der Bildungspolitik wird bewertet. Hierfür werden zwei kontrafaktische Politiken simuliert in denen Zeitpräferenzen eine wichtige Rolle spielen: (1) Eine Erhöhung finanzieller Bildungsförderung als Stipendium, um kurzfristige Kosten der Bildung zu beeinflussen und (2) Eine Erhöhung finanzieller Bildungsförderung als Darlehen, welches nach Beendigung der Bildungszeit zurückgezahlt werden muss.

Beim Vergleich dieser Politiksimulationen zwischen einem Modell mit klassischer exponentieller Diskontierung und einem Modell mit hyperbolischer Diskontierung können erhebliche Unterschiede hinsichtlich der Bildungsergebnisse festgestellt werden. Zudem ergibt sich, dass in einem Modell mit klassischer exponentieller Diskontierung ein größerer Unterschied zwischen der Stipendien- und Darlehenspolitik besteht als in einem Modell mit hyperbolischer Diskontierung.

In Kapitel 2 wird ein dynamisches strukturelles Rentenentscheidungsmodell entwickelt, um die Effekte eines Teilruhestands auf Arbeitsangebot, öffentlichen Haushalt und der Einkommensverteilung von Renten zu untersuchen. Der Teilruhestand ermöglicht eine allmähliche Reduzierung der Arbeitszeit in den letzten Jahren vor dem Eintritt in den Ruhestand. Das Grundmodell besteht aus einem Entscheidungsträger der jährlich zwischen der Weiterführung der Vollzeitarbeit und dem Arbeitsaustritt über drei verschiedene Rentenpfade wählt. Diese Rentenpfade sind: (1) Die reguläre Altersrente, (2) Rente über Arbeitslosigkeit und (3) Rente über einen Teilruhestand in dem die geleisteten Arbeitsstunden auf 50% reduziert werden. Die Entscheidung unterliegt Beschäftigungs- und Sterblichkeitsrisiken. Darüber hinaus enthält das Modell ein Steuer- und Transfersystem sowie die Regeln und Bedingungen des zugrunde liegenden Rentensystems. Das Modell wird auf der Grundlage einer Stichprobe von westdeutschen Männern aus dem administrativen Datensatz: „Biografiedaten ausgewählter Sozialversicherungsträger in Deutschland" (BASiD) geschätzt. Die geschätzten strukturellen Parameter werden verwendet, um vollen Zugang zum Teilruhestand unter verschiedenen Bedingungen zu simulieren: 1) Wie in den Daten mit dem regulären Rentenalter bei 65, 2) Mit einem erhöhten regulären Rentenalter bei 67 und 3) Mit finanziellen Ausgleichsbeihilfen für Löhne und Rentenrückstellungen.

Die Analyse liefert die folgenden Ergebnisse. Die Einführung der Option, den Ruhestand über einen Teilruhestand anzutreten, verlängert das durchschnittliche Arbeitsleben um etwa vier bis fünf Monate, indem die Zahl der Personen, die die

Beschäftigung frühzeitig über Arbeitslosigkeit verlassen, verringert wird. Allerdings sinkt das Gesamtarbeitsvolumen im Durchschnitt um 4,71%, wenn das reguläre Rentenalter bei 65 und um 3,86%, wenn das reguläre Rentenalter bei 67 liegt. Dies geschieht aufgrund eines großen Anteils an Personen, die bei diesen Simulationen von der Vollzeitbeschäftigung in den Teilruhestand wechseln . Mit einer Verringerung des Beschäftigungsvolumens um etwa 10% ist dieser Effekt stärker, wenn die Löhne und Renten im Teilruhestand subventioniert werden. Die Subventionierung des Teilruhestands führt auch zu einer Senkung des öffentlichen Haushalts um weitere 9.500 bis 13.500€ pro Person. Noch wichtiger ist, dass die Einkommensungleichheit in den Renten mit der Einführung des Teilruhestands reduziert wird. Allerdings führt ein nicht-subventionierter Teilruhestand zu einer Verringerung der Renten in fast allen Einkommensgruppen. Diese Kürzungen sind weniger ausgeprägt, wenn das reguläre Rentenalter bei 67 Jahren liegt, da dann mehr Menschen die Zeit zwischen dem Frührentenalter (63) und dem regulären Rentenalter mit einem Teilruhestand überbrücken. Vor allem für personen mit geringerem Einkommen bietet der Teilruhestand einen Weg, um den Einkommensverlust beim Übergang in den Ruhestand im Kontext eines erhöhten regulären Rentenalters zu verkleinern.

In Kapitel 3 wird analysiert, wie sich die Unterschiede in zwei besonders wichtigen Bedingungen des Teilruhestands, das Eintrittsalter und die Begrenzung des vorzeitigen Rentenbezugs im Teilruhestand, auf die Beschäftigung und den öffentlichen Haushalt auswirken. Diese Studie basiert auf dem in Kapitel zwei entwickelten dynamischen strukturellen Rentenmodell. Allerdings besteht in diesem Kapitel das Einkommen im Teilruhestand aus einer Kombination aus Teilzeitarbeitseinkommen und einem Anteil der Rente, der vorzeitig bezogen wird. Unter

Verwendung der geschätzten Parameter aus dem Modell werden kontrafaktische Politiken simuliert, in denen das Eintrittsalter des Teilruhestands und die Höhe des Rentenbezugs im Teilruhestand, variiert werden. Die Implikationen des Teilruhestands werden im Rahmen des deutschen Rentensystems und einer Stichprobe westdeutscher Männer untersucht.

Die Ergebnisse zeigen, dass der Teilruhestand zu positiven Beschäftigungseffekten führen kann. Im Einzelnen ist im Vergleich zu einem Regime ohne Teilruhestand das Beschäftigungsvolumen, gemessen als Anteil an vollzeitäquivalenter Beschäftigung, um 0,05 Prozentpunkte höher in einem Regime mit Teilruhestand, wenn die Menschen ab einem Alter von 61 Jahren (also zwei Jahre vor dem Frührentenalter von 63) in den Teilruhestand gehen können. Dieser Effekt ist bei Teilruhestandsregelungen mit späterem Eintrittsalter höher. Zum Beispiel ist das Beschäftigungsvolumen um 2,4 Prozentpunkte höher als bei einem Regime ohne Teilruhestand, wenn das Eintrittsalter bei 63 liegt. Darüber hinaus führt die Einführung des Teilruhestands zu positiven fiskalischen Effekten. Der öffentliche Haushalt verbessert sich um etwa 6.300€ pro Person, wenn die Menschen Zugang zum Teilruhestand ab dem Alter von 61 haben. Dieses fiskalische Plus ist niedriger je später Menschen in den Teilruhestand können. Bei einem Eintrittsalter von 63 liegt der fiskalische Gewinn im Vergleich zu einem Regime ohne Teilruhestand bei etwa 5.700€ pro Person. Die Zulassung frühzeitiger Rentenbezüge im Teilruhestand kann die Annahme des Teilruhestands weiter anregen, doch sollte die Höhe des frühzetigen Rentenbezugs begrenzt werden, um eine wesentliche Senkung individueller Renten zu verhindern.

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Declaration

Erklärung gem. §4 Abs. 2 der Promotionsordnung

Hiermit erkläre ich, dass ich mich noch keinem Promotionsverfahren unterzogen oder um Zulassung zu einem solchen beworben habe, und die Dissertation in der gleichen oder einer anderen Fassung bzw. Überarbeitung einer anderen Fakultät, einem Prüfungsausschuss oder einem Fachvertreter an einer anderen Hochschule nicht bereits zur Überprüfung vorgelegen hat.

Ich erkläre außerdem, dass ich meine Dissertation selbstständig verfasst habe.

Berlin
August 29, 2017

Songül Tolan

Erklärung gem. §10 Abs. 3 der Promotionsordnung

Hiermit erkläre ich, dass ich für die Dissertation folgende Hilfsmittel und Hilfen verwendet habe:

Die Datenauswertungsprogramme Stata und Matlab sowie MS Excel.

Auf dieser Grundlage habe ich die Arbeit selbstständig verfasst.

Berlin
August 29, 2017

Songül Tolan