Unemployment Insurance, Disability Insurance, and the Early-Retirement Decision

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Abstract

We explore how more generous unemployment insurance (UI) rules affect the early-retirement decision of older unemployed workers. In Austria, workers aged 55+ enjoy relaxed access to disability insurance (DI) and take-up of a disability pension essentially allows workers to withdraw permanently from the labor market. To identify the causal impact of more generous UI benefits on early retirement we exploit a policy change that increased the maximum duration of UI benefits from initially 30 weeks to 209 (!) weeks. Since the UI benefit extension was confined to a sub-set of Austrian regions, this policy change allows us to compare residents in eligible regions to residents in non-eligible regions. We find that workers in the age group 50-54 exploit the more generous unemployment benefits as a channel that allows them to retire early by taking advantage of longer UI benefits followed by relaxed access to DI benefits. We also find a very large increase in early retirement rates for individuals closer to the retirement age (age group 55-57). These individuals do not only strongly reduce their labor supply, they also substitute UI for DI in order to bridge the gap to eligibility for regular public pensions.

Keywords: Early retirement, policy reform, disability, unemployment

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1 Introduction

Understanding the decision that lets workers prematurely retire from work, is of crucial importance for economic policy. Increasing life expectancy and low fertility rates have been creating increasing pressure for reform to pay-as-you-go pension systems. Most importantly, most of these reforms aim at increasing the early retirement age. To be successful, these reforms also require a thorough understanding of the process that induces older workers to leave the labor market prematurely. There are mainly two reasons why the early retirement decision of older unemployed individuals face a different situation than other workers. First, once hit by unemployment, it is harder for older workers than for prime-age workers to find a new job. Second, older workers have potentially access to a multitude of welfare state programs: in particular, they often get preferential treatment in unemployment insurance (UI) and disability insurance (DI) resulting on substantially lower transition rates from unemployment back to regular jobs. Understanding the incentive and liquidity effects of the entire set of welfare state programmed on the job search behavior is crucial for policy reform.

The aim of our study is to estimate the impact of generosity of the UI system on the incidence of early retirement and the particular pathways of early retirement. To identify such an effect we study the Regional Extended Benefits Program (REBP) which allowed workers above age 50 to draw regular unemployment benefits for as long as four (!) years. Because this policy was restricted to certain regions of the country, our identification strategy involves difference-in-differences comparisons of individuals in eligible regions to individuals in non–eligible regions, before, during, and after the reform. We find that individuals with access to the REBP had a huge effect on the incidence of early retirement. We estimate that unemployment entrants aged 50 to 54 who ultimately ended up as early retirees was 17 percentage points higher among individuals eligible to the REBP. Among workers who became unemployed between ages 55 and 57 the incidence of early retirees increased by 10.8 percentage points for REBP-eligible individuals.

Our analysis allow us to go one step further by looking at the alternative pathways to early retirement that was created through access to the REBP. We find that, among unemployment entrants aged 50 to 54, excess early retirement is almost entirely driven by individuals who used the REBP to bridge the gap until the age of relaxed access to DI benefits. Our estimated 17 percentage points excess retirement were due 12.6 percentage points excess DI take-up, 3.9 percentage point due to transitions to old-age pensions, and the remaining difference due to other sources (such as benefits for those in need, sickness benefits, and inactivity). Our results are even more striking in the case of individuals aged 55 to 57. Individuals who entered unemployment in this age bracket, remained unemployed until age 60 when they could draw a regular old-age pension. In fact, our estimated 10.8 percentage points of excess retirement in this age group, comprises of an increase in 23.1 percentage points of individuals who stay on UI benefits and a reduction of 12.7 percentage points in DI benefits. In other words, there is a large program substitution effect, that lets individuals use the long duration of UI benefits before applying to a regular old-age pension rather than entering the lengthy process of applying for DI benefits.

The focus of our empirical analysis is of unemployed workers. Focusing on unemployed workers is particularly interesting because the typically labor market history of an early retiree starts with losing his or her job, becoming unemployment benefit recipient and, after a unsuccessful search for appropriate new job, applying for disability insurance benefits and withdrawing from work permanently. In our empirical analysis we also briefly consider transitions from employment to early retirement in the age groups 50-54 and 55-57, respectively. We find that, while transition from employment to disability are non-negligible, they are much less driven by incentives created by DI or UI regulations. This suggests that policies that directly affect transitions out of unemployment to disability are more likely to be driven by economic incentives. Hence policy reforms that target the unemployment-disability margin are more likely to affect the incidence of early retirement.

We think that Austria is a particularly interesting case for studying the early retirement decision. First, policy makers in Austria have used early retirement schemes disproportionately to mitigate labor market problems of older workers over the past decades. As a result, the effective retirement age of Austria has decreased to somewhat less than 59, well below the OECD average.[1] Second, while early retirement schemes created larger incentives for older workers to leave the work force than in many other countries, the Austrian early retirement system works qualitatively similar to most other countries. Hence understanding the Austrian situation is of more general interest.

Like in most other OECD countries, the Austrian early retirement system is a mix of preferential treatment of older workers both in unemployment, disability insurance, as well as specific early retirement schemes. In this paper we focus on the effects for preferential treatment in access to unemployment and disability insurance to understand the labor supply decisions of older workers. In particular, it is important to understand how unemployment insurance rules and disability insurance rules allow older workers to withdraw from the labor market before the statutory minimum age and bridge until eligibility to regular old-age pensions by drawing income transfer from those welfare programs. In Austria, workers aged 50+ are granted a maximum duration of unemployment benefits for 52 weeks (as opposed to 39 weeks for workers aged 40-49 and 30 weeks for workers below 40). Moreover, workers above age 55 had relaxed access to disability insurance during the period under study.[2] The minimum age when regular public pensions can be drawn is age 60 (age 55) for male (female) workers with a continuous work history and hence a continuous history of contributions to the old-age social security system.

Our paper is related to a small literature studying how the broader set of welfare state programs impact on the labor supply decisions of older workers. This is different from the larger literature that studies the isolated effect of (or reforms to) a single programs on labor supply and/or early retirement. Papers that study the interaction/spillover effects of the unemployment insurance and disability insurance systems for the early retirement decision include Karlström et al. (2008),

[1]According to OECD (2006), in 2004 the average effective retirement age among males ranged from 58 years in Hungary to 74 years in Mexico. The effective retirement ages in US, UK, Switzerland, Germany and France the effective retirement ages were 63, 62, 66, 61, and 59.

[2]Access to disability insurance became more restrictive in 1996, when the minimum age of relaxed access to disability insurance was increased from 55 to 57. For an analysis of this policy change see Staubli (2011).

Kyyrä (2010), Bloemen et al. (2011), and Staubli (2011). Karlström et al. (2008) study how a DI reform in Sweden affected labor supply of older workers. It turns out that stricter DI rules increased take-up of unemployment and sickness benefits, but did not increase employment rates. Kyyrä (2010) provide more favorable evidence from Finland where a series of reforms that changed the age-thresholds for UI and partial retirement and tightened medical criteria for DI eligibility. As a result of these reforms, the effective retirement age increased by almost 4 months. Staubli (2011) studies the effect of a reform Austria that increased the age at which older individuals have relaxed access to DI from age 55 to age 57. The results of suggest a significant decline in disability enrollment and a somewhat weaker increase in employment. The Austrian DI reform also produced non-negligible spillover effects to UI and sickness insurance benefits. Our study differs from the above ones by its focus on the impact of an UI rather than DI reform; and by its focus on unemployed workers. A recent paper by Bloemen et al. (2011) is closest to our paper. They look at how a reform to UI in the Netherlands that increased search requirements for the older unemployed affected their transition rates to employment, early retirement and sickness/disability benefits. It turns out that stricter search requirements increased not only employment rates but also DI take up. In contrast to Bloemen et al. (2011) our papers focuses on the impact of changes to the maximum duration of UI benefits rather than on search requirements. Moreover, since the Austrian REBP treated the various labor market regions differentially, our empirical strategy is based not only on contrasts before and after the policy change but also on a cross-regional comparisons of eligible and non-eligible individuals.

A further related literature has studies the interaction between DI and UI programs. Autor and Duggan (2003, 2006) document the rise in disability payrolls in the U.S. that happened despite improving health conditions in the population. Autor and Duggan (2003) show that less strict screening, declining demand for less skilled workers, and an increase in the earnings replacement rate are the most plausible candidates to explain the rise in DI take up. Petrongolo (2009) studies the impact of the UK JSA reform of 1996 that imposed stricter job search requirements and additional administrative hurdles for UI benefit claimants. It turns out that the fall in UI benefit recipients was associated with higher take-up of DI benefits. Furthermore, rather than increasing the transition to regular jobs, the reform temporarily decreased the outflow to employment.[3]

The paper is organized as follows. In the next section we review the institutional background of Austria. In particular, we discuss the various pathways to early retirement that the Austrian welfare state offers to older workers and the rules associated with the regional extended benefit program. In section 3 we develop a theoretical framework for optimal early retirement and develop various testable hypothesis concerning the impact of an UI reform. In section 4 we describe our

[3]Related to this paper is the work on UI benefits duration extensions of older workers by Kyyrä and Wilke (2007), Kyyrä and Ollikainen (2008), and Lalive (2008). Winter-Ebmer (2003), Lalive and Zweimüller (2004a, 2004b), and Lalive (2008) analyzed the labor market effects of the REBP change and discussed potential endogeneity issues. Chen and van der Klaauw (2008), Staubli (2011), de Jong et al. (2011) (DI screening and eligibility) and Gruber (2000) and Autor and Duggan (2003) (DI benefits) investigated labor supply effects of DI parameters. Finally, spillover effect in other social programs were analyzed by Garrett and Glied (2000), Schmidt and Sevak (2004), Bound et al. (2004), and Duggan et al. (2007).

data and provide some preliminary descriptive evidence of the impact of the REBP. Section 5 lays out our identification strategy. In section 6 we discuss our main results. Section 7 summarizes our main results and draws some policy conclusions.

2 Institutional Background

2.1 Pathways to Retirement

Austria's public pension system provides the most important income source for retired individuals. The pension system, that expenditures in 2005 were equal to 13% of national income, is very generous (OECD, 2009a) compared to OECD countries that spent on average 7% of GDP on public pensions. The resulting labor supply effects for older workers are substantial: In 2007, Austria's male employment rate of 55 and older was around 39 percent. This implies, compared to the OECD country average of 54% (OECD, 2009b), a substantial labor market withdrawal. This is even more puzzling given the fact that the employment rate among prime aged (age group between 25 to 54) was 3% above the OECD level of 88%. This Chapter outlines the institutional settings of the old-age pensions and disability insurance as important pathways to retirement. Moreover, we show how the unemployment insurance provides a way to withdraw from labor market before claiming public pension benefits.

Old-age insurance. Austria's pension system covers all active labor market participants. Statutory pension benefits can be claimed at the age of 65 (60) for men (women). Workers are eligible to old-age pensions with either 15 contribution years (periods of employment, including sick leave, and maternity leave) or at least 15 insurance years (sum of contribution years and qualifying years that are periods of unemployment, military service, or secondary education) within the last 30 years. Experienced workers are allowed to retire early via old age pension at the age of 60 (men) or 55 (women), respectively. This option is provided to individuals with either i) at least 15 insurance years within the last 30 years or ii) 15 contribution years and 30 insurance years in total.

The amount of pension benefits, irrespective of the retirement age, are mainly determined by two components: First, the average wage of the 15 highest labor income years constitutes the so-called assessment basis. Second, the number of accumulated insurance years determines to what extend the assessment basis is converted into an old-age pension. Postponing the retirement age by one year, or having an additional insurance year, increases the replacement rate by roughly 2 percent. A typical male worker with complete curriculum, that corresponds to a statutory retirement with 45 insurance years, is eligible to a net replacement rate of 91 percent. This is very generous given the average replacement rate of 82% in OECD countries (OECD, 2009b). Individuals that receive old-age pension benefits are subject to income tax and health insurance contributions.

Unemployment insurance. The unemployment insurance provides an important pathway to withdraw from labor market because almost 40% of new enrolled unemployed transition directly to the disability or old-age pension. Unemployment benefits replace around 55 % of the last wage and are neither taxed nor means-tested. Workers above the age of 50 that have at least (less than) 9 contribution years within the last 15 years can claim unemployment benefits up to 52 (30) weeks.[4] After the exhaustion of unemployment benefits, the unemployed can apply for "transfer payments for those in need" ("Notstandshilfe"). Those transfers are means-tested and can be at maximum 97% of the unemployment benefits.[5]

The access to early retirement at 60 (55, females) via old age pension is considerably eased for the long term unemployed. Individuals are required to have been unemployed for at least 12 month within the last 15 months. No further restrictions are imposed on the work history such as insurance or contribution years. The old-age pension benefits are calculated in the same way as early retirement due to long insurance duration.

The use of the special income support program ("Sonderunterstützung") provides a very attractive way to withdraw from labor market one year before early retirement age. The SIS lasts one year and provides benefits that are 25% higher than unemployment benefits. Eligibility is based on having at least 15 contribution years out of the last 25 years. Most important, the receipt of SIS is treated as an unemployment spell, therefore, by combining the SIS program and early retirement, many older male (female) unemployed are able to withdraw form labor market at the age of 59 (54).

Disability insurance. The importance of Austria's disability insurance is mainly due to its financial generosity and relaxed eligibility criteria for workers close to retirement. Disability benefits are determined in the same way as old age pension benefits. Hence, the average gross replacement rate is around around 80 percent of the last wage that is very high by intergenerational standards. The second feature of the DI is the considerable relaxation of the eligibility criteria at the age threshold of 55. In general, disability benefits are awarded to individuals with an impairment that reduces the ability to work by more than 50% relative to a comparable healthy person if i) it does not entail a loss of social status and ii) there exist at least 100 jobs in the field (vacant and occupied) in Austria (Wörister, 1999). Above the age of 55, criterion ii) is relaxed to a broader interpretation of a similar occupation. We refer to the less restricted access at the age of 55 as the "relaxed disability".

2.2 The Regional Extended Benefit Program

The Regional Extended Benefit Program (REBP) is rooted in the strong protectionism of Austria's heavy industry. After World War II, the nationalization of Austria's iron, steel, and oil industries, and related heavy industries was supposed to preclude the Soviets from appropriating private firms. After the mid-1970, the state-run company Österreichische Industrie AG, in charge

[4]Before August 1989, the potential unemployment duration was 30 for all individuals above 50. See Lalive et al. (2006) for a detailed description of the policy change and how it affected younger workers.

[5]The median unemployment assistance benefits level corresponds to an equivalent 70% of the median unemployment benefits Lalive (2008).

of administrating the nationalized firms, faced shrinking markets due to the international oil and steel crisis, low productivity, and out-dated smokestack industries. The resulting financial losses were covered by governmental subsidies - manly to protect jobs in these industries. In 1986, a speculation scandal in the steel industry triggered the abolishment of the protectionism, introduced privatization, and the implementation of a though restructuring plan. This process caused mass layoffs and downsizing of production plants, especially in the steel sector.

The REBP, enacted in June 1988, aimed to protect older workers against bad labor market conditions in the steel industry. The Austrian government reduced this exposure extending the potential unemployment duration from 52 weeks to 209 weeks for workers older than 50. The REBP was implemented until December 1991 in 28 regions. However, at the end of 1991, the Austrian parliament decided to prolong the program until August 1993 for a sub-group of six regions (extended duration). Figure 1 plots the REBP regions with normal and extended duration.

Figure 1

The program eligibility based on the following criteria: i) age 50 or older, ii) continuous work history, iii) location of residence in one of the 28 selected labor market districts since at least 6 months prior to the claim, and iv) start of new unemployment spell after June 1988 or spell in progress in June 1988.

This policy change provides a a quasi-experimental design by comparing REBP regions (treatment) with non-REBP regions (control). Hence, we can investigate how extended unemployment benefits affect retirement behavior. Figure 2 visualizes how the REBP financially eased the access to disability insurance and early retirement for male unemployed.

Figure 2

Figure 2 clearly shows that eligible individuals can withdraw from labor market at 51 with a non interrupted use of unemployment benefits up to the age of 55, when the disability benefits eligibility is relaxed. After 55, the use of the REBP, in combination with special income support, allowed individuals to withdraw from labor market without having a financial gap.

3 Modeling the Early Retirement Decision

This section provides a theoretical framework that captures, in a stylized way, how combined incentives of UI and DI systems on the one hand, and regular retirement rules on the other hand, affect the decision of *older unemployed individuals* to withdraw permanently from labor market. Our approach sheds light on how individuals retire early by making use of multiple social programs and replace programs when UI policies change. To introduce our terminology, we define *program substitution* as the individual's switching behavior from one early retirement pathway to another induced by more generous benefits in one program. In contrast, *program complementarity* characterizes a situation when more generous benefits in one program strengthens the sequential take-up of multiple programs, such as unemployment insurance and disability insurance for example. Moreover, our framework will also allow us to draw social welfare conclusions concerning the entire program. The welfare effects induced by substitution versus complementarity behavior are, of course, conceptually different.

We introduce a discrete-time retirement model to capture the notion of substitution versus complementarity effects. Suppose unemployed individuals, who are at the center of interest, differ along two dimensions: First, unemployed agents face heterogeneous additive disutility to return to employment θ. One may think of fixed "search costs" to get a job for certain.[6] Second, individuals are entitled to different levels of social security benefits accumulated throughout their previous work life. For consistency with later modeling, assume that pension benefits entitlement can be represented by d. This set-up implies that heterogeneity in θ matters *whether* individuals return to work while financial incentives d are crucial for *which* pathway they choose given the retirement decision.[7] At each point of time t, unemployed individuals do retire if the value of retirement R_t is larger than the value of work W_t reduced by the job search disutility θ, or

$$U_t\left(d,\theta_t\right) = \max_{\text{retire, work}} \left\{R_t(d), W_t(d) - \theta_t\right\}. \tag{1}$$

Two important points should be stressed. First, unemployment benefits b may (or may not) be part of R_t. Second, note that early retirement R_t is an absorbing state and individuals face no unemployment shocks anymore (but they give up the option to retire later). Going back to work is not absorbing in a sense that individuals may become unemployed one period later. Equation (1) pins formally down the notion of program substitution and program complementarity effects:

- The term R_t comprises potential substitution effects. Suppose that there are two competing pathways to retire with values R_t^1 and R_t^2 such that

  $$R_t = \max\left\{R_t^1, R_t^2\right\}.$$

  A marginal change in a policy parameter, such as unemployment benefits duration, may increase the relative value R_t^1 in comparison to R_t^2. This change is likely to induce switching behavior among some sub-groups of individuals that retire ($R_t > W_t - \theta_t$). Hence, program substitution captures the interplay of competing pathways to early retirement.

- Program complementarity on the other hand relies on the the comparison between R_t and $W_t - \theta_t$. Again, take for example a marginal extension of the unemployment duration. Suppose R_t^1 denotes the value of using the UI as a bridge to retirement and this pathway is the best option to withdraw ($R_t = R_t^1$). Then R_t is likely to increase as UI duration increases, less

[6] Alternatively, the variable θ represents disutility to adapt to a new job's requirements (learning new skills, etc.). Introducing uncertainty does complicate the present framework without changing the predictions.

[7] This set-up is largely consistent with the retirement literature that emphasizes finical incentives (Gustman and Steinmeier (1986), Stock and Wise (1990), and Gruber and Wise (1999,2004)) as well as health-related issues (Autor and Duggan (2003) and Bound et al. (2010)) are key in understanding early-retirement behavior.

individuals will return to work, and the use of early retirement increases.

Of course, any policy change may have both complementarity and substitution effects.

Next, using Austria as an interesting case study, we investigate in more detail how changes in the unemployment benefits scheme lead to complementarity and substitution effects for different age groups. We restrict on three time periods, $t = 0, 1, 2$. In case of Austria, we may think of "period 0" as the age range 50-54; "period 1" as ages 55-59; and "period 2" as ages above 60. The first two periods comprise the early retirement decisions. At these stages, individuals may either collect disability benefits d, unemployment benefits b, or earn an after-tax wage ω. In the normal retirement period $t = 2$, retirees get regular old age pension benefits p. Indeed, Austria´s pension and unemployment system creates a large heterogeneity among the financial incentives to use different exit pathways. Table 1 reports the quantiles of UI and DI replacement rates.

Table 1

We find a large dispersion among all UI (respectively DI) replacement rate quantiles indicating that complementarity and substitution effects are potentially important for a large size of the population. The model is solved backwards as rational unemployed individuals at $t = 0$ incorporate available pathways in $t = 1$. All proofs are provided in the Appendix

Early retirement at $t = 1$**.** To formalize consumption values of different pathways, let be $u(c_t)$ the utility that agents derive from consumption c_t, with $u'(c_t) > 0$ and $u''(c_t) < 0$. Individuals becoming unemployed after 55 face two different pathways to early retirement. *First*, due to the relaxed disability in period 1 (at age 55), there is the possibility to retire directly via disability benefits. We assume that claiming disability benefits involves disutility κ.[8] This option yields disability benefits d in $t = 1$ that are converted to pension benefits p^D after normal retirement age. Hence, the lifetime utility of this pathway is given by $u(d) + Tu(p^D) - \kappa$. *Second,* as a competing pathway, individuals may withdraw from labor market at the beginning of period 1 drawing unemployment benefits b before they retire "regularly" in period 2 with p^U.[9] Hence, the value of early retirement R_1 is given by the maximum life time value of both pathways

$$R_1 = \max\left\{u(d) + Tu\left(p^D\right) - \kappa, u(b) + Tu\left(p^U\right)\right\}.$$

According to the Austrian rules outlined in Chapter 2.1, there is a close relation between old age benefits and disability benefits:[10] Workers entering regular retirement directly from disability insurance get an old-age pension equal to the previous DI benefits in period 1, or $p^D = d$. Moreover,

[8] This may represent discomfort caused by the medical evaluation, stigma costs, or simply forgone time needed to become tested. Manoli et al. (2011) use a similar specification for Austria (but introducing financial claiming costs instead).

[9] We denote by b the average transfer that an individual gets when staying unemployed throughout one period. This benefit may either be "regular" unemployment benefits b^u or unemployment assistance b^a where $b^a << b^u$. The average benefit $b = \tau b^u + (1 - \tau) b^a$, where we think of τ as the "maximum duration" of regular UI benefits b^u.

[10] No such direct relation exists between disability benefits and unemployment benefits.

unemployed and employed worker's old age pension equals the (potential) disability benefits in $t = 1$ augmented by some factor $\alpha > 1$, or $p^W = p^U = \alpha d$.[11] This set-up allows to capture heterogeneity in disability benefits and old-age pension benefits by the parameter d only. The threshold $\hat{d}$ separates individuals that take up disability rather than unemployment benefits

$$d \geq \hat{d}, \qquad \text{where } \hat{d} \text{ satisfies} \qquad u(b) = u(\hat{d}) - T\left(u(\alpha\hat{d}) - u(\hat{d})\right) - \kappa.$$

Third, individuals can go back to work in period 1 and retire in period 2. The value of this pathway W_1 is given by the utility of the consumption stream

$$W_1(d) \;\;=\;\; u(\omega) + Tu\left(p^W\right).$$

Again, using the relationship $p^W = \alpha d$ and the decision problem characterized in equation (1), we derive the early retirement threshold

$$\hat{\theta}_1 \;\;=\;\; \begin{cases} u(\omega) - u(b) & \text{if } d < \hat{d} \\ u(\omega) - u(d) + T\left(u(\alpha d) - u(d)\right) & \text{if } d \geq \hat{d} \end{cases}. \tag{2}$$

The threshold is decreasing in d given $\left(p^W - p^D\right)T \leq d$ holds true:[12] Individuals that are eligible to more generous pension benefits d are more likely to retire early. Figure 3 shows how individuals decide, given their location in the (θ_1, d) space, on the optimal pathway.

Figure 3

We are interested in how an increase in b affects the the critical values $\hat{\theta}_1$. This can be done in a straightforward way by taking derivatives with respect to b

$$\frac{\partial\hat{\theta}_1}{\partial b} = \begin{cases} -u'(b) & \text{if } d < \hat{d} \\ 0 & \text{if } d \geq \hat{d} \end{cases} \tag{3}$$

According to our terminology we refer to the increased behavior as a program complementarity effect because individuals below $\hat{d}$ stop working and make sequentiatl use of UI and DI benefits. Note that we have program substitution effects as well. This effect measures, conditional on early retirement, how an increase in b reduces the critical value of d at which the individual is indifferent

[11] As outlined in Chapter 2.1, the pension p_{t+1} is given by the average of best wages, the so-called assessment base, $\hat{\omega}_{t+1}$ times the pension coefficient a_{t+1}. Assuming that the average of best wages remains stable, or $\hat{\omega}_{t+1} = \hat{\omega}_t$, we obtain $p_{t+1} = p_t\alpha$ with $\alpha = a_{t+1}/a_t$. We will calibrate α such that empirical moments are matched.

[12] Assuming that the inequality $\left(p^W - p^D\right)T \leq d$ holds true is a sufficient, but not a necessary, condition to make sure that the retirement indifference curve $\hat{\theta}_1$ is weakly decreasing in pension generosity d. This condition states that the net gains from postponing retirement by one period $(p^W - p^D)T$ are lower or equal than the (immediate) gains from the disability take up d. In practice, this condition is satisfied because Austrian's pension system is not "fair" with respect to postponing the retirement by one year (Hofer and Koman, 2006).

between early retirement via DI and early retirement via UI. Implicit differentiation yields

$$\frac{\partial \hat{d}}{\partial b} = \frac{u'(b)}{(1+T)u'(\hat{d}) - T\alpha u'(\alpha \hat{d})} > 0. \tag{4}$$

The numerator and denominator are positive which is again implied by assuming $\left(p^W - p^D\right) T \leq d$. These results are visualized in Figure 3 on the right panel and are summarized in the following proposition.

Proposition 1. *Early retirement in $t = 1$: More generous unemployment benefits increase overall early retirement due to program complementarity effects. At the same time, disability benefit take up decreases because agents substitute DI and UI (program substitution effects).*

Proof. Assume heterogeneity is sufficient, or that the density $f(d, \theta_1)$ is strictly positive over the relevant domain and $\left(p^W - p^D\right) T \leq d$ holds true for all individuals. Then equation (3) and (4) are sufficient to establish program complementarity and substitution effects. See Proposition 3 and 4 in the Appendix for technical proofs. □

Early retirement at $t = 0$. Early retirement means leaving permanently labor work force by drawing UI benefits b during $t = 0$, DI benefits d during $t = 1$, and regular retirement benefits $p^D = d$ during $t = 2$.[13] For those retirees lifetime utility is given by

$$R_0(d) = u(b) + (1+T)u(d) - \kappa.$$

The alternative is to take up a job at the beginning of $t = 0$. This involves search disutility θ_0 but earning an after-tax wage ω. At the beginning of period $t = 1$, workers face an exogenous layoff probability q and, contingent on job loss, draw a new job search disutility θ_1. We allow the distribution of θ_1 to depend on θ_0, or $F(\theta_1 \mid \theta_0) \neq F(\theta_1)$ but assume that $F(\theta_1 \mid \theta_0)$ decreases weakly in θ_0. This means that higher disutility types in $t = 0$ have a higher probability to draw a high θ in $t = 1$ again. The expected utility of unemployment is given by $\mathbb{E}\left(U_1(\theta_1, d) \mid \theta_0\right)$ whereas employment is valued by W_1. Therefore, the expected value of work W_0 is given by

$$W_0(d, \theta_0) \quad = \quad u(\omega) + q\mathbb{E}\left(U_1(\theta_1, d) \mid \theta_0\right) + (1-q)W_1(d).$$

We are now able to calculate the critical values of θ that makes a worker indifferent between retiring early and continuing to work at $t = 0$. Denote by $\hat{\theta}_0$ the critical level of search effort that makes a worker indifferent between early retirement and work

$$\hat{\theta}_0 \quad = \quad W_0(d, \hat{\theta}_0) - R_0(d). \tag{5}$$

One can show that $\hat{\theta}_0$ is uniquely defined and decreasing in d. Hence, more generous retirement

[13] We implicitly neglect the pathway "disability in $t = 0, 1$" as screening in $t = 0$ is rather tight and empirically of minor importance.

benefits lead to a higher rate of labor force exit. Figure 4 shows the early retirement threshold in the (d, θ_0)-space.

Figure: 4

Interestingly, increasing b has two countervailing effects on the threshold $\hat{\theta}_0$: First, more generous unemployment benefits increase the incentive to make joint use of DI and UI. Hence, the program complementarity effect increases the value of early retirement R_0. But, at the same time, the value of going back to work increases as becoming unemployed in $t = 1$ harms less (or U_1 increases). This inter-temporal insurance effect decreases the likelihood to retire early by increasing the value of working W_0. This countervailing forces can be best seen by deriving $\hat{\theta}_0$ with respect to b

$$\frac{\partial \hat{\theta}_0}{\partial b} = \left[\underbrace{q \frac{d\mathbb{E}\left(U_1(\theta_1, d) \middle| \theta_0 \right)}{db}}_{\text{intertemporal insurance}} - \underbrace{u'(b)}_{\text{complementarity in } t=0} \right] \cdot \frac{1}{1 - q \cdot d\mathbb{E}\left(U_1(\theta_1, d) \middle| \hat{\theta}_0 \right) / d\hat{\theta}_0} \tag{6}$$

for any d. However, our framework predicts that the early retirement effect in $t = 0$ dominates, or program complementarity is stronger (see Proposition 2 in the Appendix).

Proposition 2. *Early retirement in $t = 0$: More generous b increase the probability to retire early by inducing people to jointly use unemployment and disability insurance (program complementarity).*

Proof. Implicite differentiation of $\hat{\theta}_0 = W_0(d, \hat{\theta}_0) - R_0(d)$ with respect to b yields Equation (6). Intuition here only, we we refer to the technical proofs (Lemma 5 and Proposition 5) provided in the Appendix for further details. One has to distinguish between two cases. Case 1: $(d < \hat{d})$ Due to the Envelope theorem we can ignore swiching behavior and the additional utility is simply given by $u'(b)$ times the conditional probability to retire early $F_1(\hat{\theta}_1(d) \mid \hat{\theta}_0)$. Case 2 :$(d > \hat{d})$ Individuals do never choose the UI pathway therefore its value is not affected. Hence, we obtain

$$\frac{d\mathbb{E}\left(U_1(\theta_1, d) \middle| \hat{\theta}_0 \right)}{db} = \begin{cases} F_1(\hat{\theta}_1(d) \mid \hat{\theta}_0) \cdot u'(b) & \text{if } d < \hat{d} \\ 0 & \text{if } d > \hat{d} \end{cases}$$

Finally, we conclude that $\partial \hat{\theta}_0 / \partial b < 0$ because $0 < q < 1$, $0 \leq F_1(\hat{\theta}_1 \mid \hat{\theta}_0) \leq 1$ and $d\mathbb{E}\left(U_1(\theta_1, d) \middle| \hat{\theta}_0 \right) / d\hat{\theta}_0 < 0$. □

4 Data and Descriptive Evidence

4.1 Data

To examine the impact of extended unemployment benefits on transitions out of unemployment, we combine register data from two different sources. The Austrian Social Security Database (ASSD) provides very detailed longitudinal information dating back to 1972 on the labor market history and earnings for the universe of private sector workers in Austria (Zweimüller et al., 2009). The second source is the Austrian unemployment register, which contains information on socio-economic characteristics including the place of residence.

Our main sample consists of all male job losers aged 50-57 at the beginning of the unemployment spell who enter unemployment from a job in the non-steel sector in the time period 1/1985 until 12/1987 and in the time period 6/1988 until 12/1995. These spells are followed up until end of 2006. We focus on men because women are already eligible for an old age pension at age 55 (as opposed to age 60 for men), which is also the age for relaxed access to a disability pension. Hence, for women the REBP affects the transition to retirement only through program complementarity but not program substitution. We exclude unemployment spells starting between 1/1988 and 5/1988 because ongoing spells were also eligible for the REBP. Excluding these spells guarantees that the before-period is not affected by the REBP. In our observation period 196,364 unemployment spells were started by men in the age group 50-57. From these, we drop 41,130 unemployed men with less than 15 employment years in the past 25 years. Only job seekers who satisfy this criteria are eligible for the REBP. Because the Austrian labor market is characterized by large seasonal employment fluctuations (Del Bono and Weber, 2008), we also exclude 87,920 men who were recalled by their previous employers to eliminate job seekers on temporary layoffs who are not searching for a job. The final sample comprises 67,314 unemployment spells.

Table 2 presents summary statistics on job seekers entering unemployment before (1/1985–12/1987), during (6/1988–7/1993), and after the REBP (7/1993–12/1995) by region of residence. A comparison of exit destinations before, during, and after the REBP illustrates the impact of the program on early retirement behavior of unemployed men. Specifically, before the REBP the probability to retire early is 7.8 percentage points higher in treated regions (41.5%) relative to control regions (33.7%) because job losers in treated regions are more likely to exit unemployment by claiming a disability pension. The difference in the probability to retire early increases to 31.3 percentage points during the REBP, providing first evidence on the impact of the policy change. The increase in the incidence of early retirement during the REBP is driven by more unemployed men claiming disability and old-age pensions. After the abolishment of the program, the difference in the incidence of early retirement between treated and non-treated regions decreases again to the pre-REBP level. Note also the upward trend in the incidence of early retirement and disability over the whole period, suggesting that labor market conditions over the observation period deteriorated in treated and non-treated regions.

A comparison of background characteristics shows that job losers in treated regions are more likely to work in blue-collar occupations and tend to be less educated than job losers in control regions. These differences partially explain the higher probability to claim a disability pension in the treated regions before and after the REBP. Table 2 also illustrates that during the REBP the unemployment inflow increases in treated regions relative to control regions. Specifically, the ratio of unemployment spells in treated regions versus non-treated regions is roughly 1 to 4 before the REBP. This ratio increases to approximately 1 to 2.5 during the REBP. Winter-Ebmer (2003) finds that this increase occurs because firms used the REBP to get rid of high-tenured and expensive older workers. This result is consistent with the statistics in Table 2 given that during the REBP job losers in the treated regions earn higher wages and have more tenure compared to job losers in non-treated regions.

Table 2

4.2 Descriptive Evidence

To assess the impact of the change in unemployment benefit duration graphically, Figures 5-7 plot the transition rate from unemployment into difference exit states by age of UI entry and region of residence before, during, and after the REBP.

Figure 5 illustrates that the REBP had a strong effect on the incidence of early retirement among eligible unemployed. More specifically, there is a drastic increase in transitions to early retirement at ages 50-57 in treated regions during the program was in effect. The regional difference in transitions to early retirement during the REBP amounts to almost 30 percentage points for the age group 50-55 and is somewhat smaller for the age group 56-57. For the age group 58-59 there are only small regional differences during the REBP because unemployed men in this age group do not need the REBP to retire early. Also for the age group 45-50 there are almost no regional differences in transitions to early retirement, as these individuals were not eligible for the REBP.

Figure 5

Figure 6 shows the corresponding picture for transitions from unemployment into disability pensions. As the middle panel of Figure illustrates, the higher incidence of early retirement for the age group 50-54 is driven by an increase in transitions to disability pensions. For this age group the regional difference in transitions to disability pensions during the REBP amounts to around 20 percentage points. This is an example of program complementarity. That is, the increased generosity of unemployment insurance during the REBP strengthens the sequential take-up of multiple programs. For the age group 55-57, there is also clear evidence for a program substitution effect. Specifically, There is a decline in transitions to disability pensions during the REBP in treated regions relative to control regions and a significant increase in transitions to old-age pensions, as illustrated in Figure 7.

Figure 6

Figures 5 and 6 also show that transitions to early retirement and disability pensions tend to be slightly higher in the treated regions after age 50 before the implementation of the program and after its abolishement. These differences are likely to reflect underlying differences in the structure of the workforce between treated and non-treated regions. In particular, Table 2 shows that job losers in treated regions work more often in blue-collar occupations and are less educated on average. Both factors are likely to increase the risk of experiencing a career ending disability.

Figure 7

Figure 8 illustrates how transitions into early retirement, disability pensions, and old-age pension for the age groups 50-54 and 55-57 developed over time in treated and non-treated regions. For both age groups there are only small regional differences in transitions to different exit states before the REBP started. In the second half of 1988, the period when the program started, transitions rates start to diverge. For the age group 50-54 transition rates to early retirement, disability pensions, and (to a smaller extent) old-age pensions increase in REBP-regions relative to non-REBP regions. For the age group 55-57, there is a decline in transitions to disability pensions and a disproportionate increase in transitions to old-age pensions so that overall transitions to early retirement increase. After the second half of 1993, when the program was abolished, the effects of the REBP are reversed and regional differences in transition rates are relatively small again.

In sum, these figures provide evidence that the REBP increased the incidence of early retirement among eligible unemployed. The observed changes in transition rates are consistent with our theoretical predictions: for the age group 50-54 there is program complementarity, as transitions to disability pensions and old-age pensions increase during the REBP. For the age group 55-57 there is both program substitution and program complementarity, as transitions to disability pensions decline and transitions to old-age pensions increase during the program.

Figure 8

5 Identification Strategy

Our identification strategy exploits the quasi-experimental variation in the duration of unemployment benefits across regions in Austria created by the REBP. This approach is a difference-in-difference (DD). The first difference is over time, since the program was in effect only from June 1988 to July 1993. The second difference is across geographic areas; only older job seekers living in one of the 28 selected regions were eligible for the benefit extension. Because the REBP was only in effect for a limited period of time, we are able to test whether the policy effects of introducing and abolishing the REBP were symmetric.

A third difference would be age because only unemployed aged 50 or older were eligible for the REBP. However, as Figures 5-7 illustrated, few unemployed workers below age 50 enter early retirement by claiming a disability pension or an old-age pension. A comparison between job losers below and above age 50 will therefore not be very informative to identify the effect of extended UI benefits on transitions from unemployment into early retirement.

The difference-in-difference comparison is implemented by estimating regressions of the following type:

$$y_{it} = \alpha + \beta TR1_i + \gamma TR2_i + \delta D_t + \eta A_t + \pi(D_t \times TR_i) + \tau(A_t \times TR_i) + \lambda_t + X'_{it}\theta + \varepsilon_{it}, \qquad (7)$$

where i denotes individual and t is the start date of the unemployment spell. The outcome variable y_{it} is a dummy, which is equal to 1 if an individual leaves unemployment into the exit state of interest and 0 otherwise. We distinguish between three different types of exits: early retirement, disability pension, and old-age pension. The variables $TR1$ and $TR2$ are dummy variables that indicate whether or not an individual lives in treated region 1 or treated region 2 to control for region-specific trends; TR is an indicator taking the value 1 if an individual lives in a treated region; D is an indicator taking the value 1 if the unemployment spell started after the REBP was in effect (June 1988); A is an indicator taking the value 1 if the unemployment spell started after the REBP was abolished (January 1992 in TR1s and August 1993 in TR2s); λ_t is a vector of year fixed effects to control for changes in macroeconomic conditions; and X_{it} is a vector of background characteristics to control for observable differences that might confound the analysis (age fixed effects, marital status, blue-collar status, education, work experience, years of service, sick leave history, last wage, previous industry, and quarter of inflow).

The coefficients of interest are π and τ which measure the effect of the REBP on older job losers in treated regions relative to control regions in the years when the program was in effect relative to before its implementation (π) and in the years after which the program was abolished relative to during the program (τ). Clearly, if the introduction and abolishment of the REBP have symmetric effects on the outcome variable of interest we have $\pi = -\tau$.

Equation (7) is estimated separately for the age groups 50-54 and 55-57 because our model predicts that the impact of the REBP on transitions out of unemployment to be very different for both groups. In particular, job losers in the age group 50-54 may use the REBP to bridge the gap until age 55 at which conditions for disability classification are relaxed. Job losers in the age group 55-57, on the other hand, can directly apply for DI benefits under the relaxed eligibility criteria, but may use the REBP instead to bridge the gap until age 60 when they become eligible for an old-age pension.

To explore the impact of the policy reform for each age separately, we generalize this identification strategy to an interaction term analysis:

$$
\begin{aligned}
y_{it} &= \alpha + \sum_{j=50}^{59} \beta_j (d_{ijt} \times TR_i) + \sum_{j=50}^{59} \gamma_j (d_{ijt} \times D_t) + \sum_{j=50}^{59} \delta_j (d_{ijt} \times A_t) \\
&\quad + \sum_{j=50}^{59} \pi_j (d_{ijt} \times D_t \times TR_i) + \sum_{j=50}^{59} \tau_j (d_{ijt} \times A_t \times TR_i) + \lambda_t + X_{it}'\theta + \varepsilon_{it}, \qquad (8)
\end{aligned}
$$

where d_{ijt} is a dummy that indicates whether individual i is age j at the start date of the unemployment spell t. Each coefficient π_j and τ_j captures all variation in the outcome variable specific to individuals of age j in the treated region (relative to the control regions) when the program was in effect (π_j) and after the program was abolished (τ_j), using variation in the duration of unemployment benefits over time.

The central identifying assumption is that there are no omitted time-varying and region-specific effects correlated with the program. Lalive and Zweimüller (2004b) show that entitled regions were characterized by a strong concentration of employment in the steel sector, which casts doubts on the assumption that the REBP is an exogenous policy. Therefore, we focus on job losers not previously employed in the steel sector. However, this strategy will still yield biased results if treated and non-treated regions have different trends even in the absence of the REBP.

The graphical analysis from the previous section suggests that labor market trends in treated and non-treated regions are similar given that there are no substantial differences in transition rates from unemployment into other states prior to the inception of the REBP and after its abolishment. To examine the existence of differential trends across regions in more detail, equation (7) is generalized by replacing $(D_t \times TR_i)$ and $(A_t \times TR_i)$ with a full set of treatment times half-year interaction terms:

$$y_{it} = \alpha + \beta TR1_i + \gamma TR2_i + \delta D_t + \eta A_t + \sum_{j=1985h1}^{1995h2} \pi_j (d_j \times TR_i) + \lambda_t + X_{it}' \theta + \varepsilon_{it}, \tag{9}$$

in which d_j is a dummy that equals 1 in half-year j and 0 otherwise and λ_t is a vector of half-year fixed effects. Here, we set TR equal to 0 in $TR1s$ after December 1991. Each coefficient π_t can be interpreted as an estimate of the impact of the policy change in a given half-year on the treatment group relative to the comparison group. The interaction terms prior to 1988 and after the first half of 1993 provide tests for anticipatory behavior and differential trends.

Another concern is that there were idiosyncratic shocks to the labor market prospects of non-steel workers in treated regions during the period the REBP was in effect. We perform three robustness tests to examine the presence of region-specific labor market shocks. First, we estimate equation (7) for job losers in the age groups 45-49 and 58-59. Because theses individuals were not eligible for the REBP (age group 45-49) or did not need the REBP to retire early (age group 58-59), the estimated coefficients should be zero. In the second approach we estimate equation (7) for a sample of job losers who previously worked in the tradable-goods sector. The idea behind this approach is that labor demand prospects in this sector are less influenced by local economic conditions. Hence, potential spillovers effects from the steel sector should be less important. In the third approach we restrict attention in the estimation to unemployed men who live no father than a 30 minutes car drive from the border between treated and control regions. The idea is that job losers living close to the border are likely to operate in the same local labor market. Hence, labor market shocks should affect treated and non-treated job losers in the same way. These robustness tests will yield unbiased estimates if the extension of UI benefits in treated regions does not feed back to the labor demand for non-treated individuals.

A final concern is differences in the characteristics of job losers in treated and non-treated regions. On the one hand, Table 2 shows that unemployed men in treated regions tend to be less educated and are more likely to work in blue-collar occupations. If the impact of the policy is heterogeneous with respect to observable characteristics, it is important to control for relevant observable characteristics in a very flexible way. The linear specification proposed in equation (7) may not be sufficient to capture the influence of covariates. To allow for more flexibility, we follow Blundell et al. (2004) and use propensity score matching adapted for the case of difference-in-difference.

On the other hand, Table 2 also illustrates that there was an increase in unemployment inflow in REBP-regions while the program was in effect. Winter-Ebmer (2003) suggests that this increase occurs because firms used the REBP to get rid of high-tenured and expensive older workers. This finding is consistent with the fact that during the REBP job losers in the treated regions earn higher wages and have more tenure that job losers in the control regions. To ascertain that selective inflow does not affect our results, we estimate equation (7) excluding job losers with high tenure from the sample.

6 Results

6.1 Main Results

The first set of results is summarized in Table 3, with columns 1 through 3 providing the results from equation 7 for the age group 50-54 and the next three columns displaying the analogous results for the age group 45-49. The dependent variable is an indicator, which is equal to 1 if an individual exits unemployment through the state in question and 0 otherwise.

The first row shows that the REBP increases the probability of entering early retirement among 50-54 year old job losers in treated regions by 17 percentage points, or 50% of the baseline transition rate into early retirement in the pre-REBP period. This decline is mostly driven by an increase in transitions to disability pensions of 12.6 percentage points (column 2) and – to a lesser extent – by an increase in transitions to old-age pensions by 3.9 percentage points (column 3). The third row shows that the effects on transitions from unemployment into different exit states are reversed after the program is abolished. The effect on transitions to early retirement is somewhat larger in absolute value, but the difference is statistically not significant.

The next three columns present analogues estimates for the age group 45-49 who were not eligible for the REBP. The point estimates are always small and insignificant. This finding suggests that the REBP had no substantial spillover effects to the labor demand for the age group 45-49 via general equilibrium effects and that labor market prospects of job losers in treated regions and non-treated regions followed similar trends. Table 3 also illustrates that over the period under consideration there is an upward trend in the incidence of early retirement for the age group 50-54 both in treated and non-treated regions. More specifically, among 50-54 year old job losers there is 14.2 percentage point increase in the probability to enter early retirement. The rise in early retirement is due to an increase in transitions to disability pensions. No such increase can be observed for the age group 45-49. This pattern may indicate a general decline in labor market conditions for older workers.

Table 3

Table 4 presents analogous estimates for the age group 55-57 (columns 1 to 3) and the age group 58-59 (columns 4 to 6). The first row indicates that the introduction of the REBP led to an increase in transitions from unemployment to early retirement of 10.8 percentage points among the treated individuals aged 55-57. Consistent with the predictions from the theoretical model, there is also clear evidence for a program substitution effect. In the years the program was in effect older job seekers are significantly less likely to enter the DI program and more likely to use the REBP as a bridge to an old-age pension. More specifically, during the REBP there is a decline in transitions to disability pensions of 12.7 percentage points and an increase in transitions to old-age pensions of 23.1 percentage points. Similar to unemployed men in the age group 50-54, there is a clear reversal in the effects on early retirement behavior after the program was abolished, as shown in the third row. Columns 4 to 6 present analogous estimates for the age group 58-59. The point estimates are mostly insignificant, which is consistent with the proposition that for this age group the REBP had no impact on the set of available pathways to early retirement.

Table 4

In the estimates presented in Tables 3 to 4, the variables to correct for differences in observable characteristics between treated and non-treated regions enter in a linear way. This approach is quite restrictive as it imposes common support on the distribution of covariates across regions before, during, and after the REBP. To allow for more flexibility, we follow Blundell et al. (2004) and match on two propensity scores to estimate the effects of the introduction of the REBP. These propensity scores balance the distribution of observable characteristics in the treated and non-treated regions before and during the REBP. A similar matching method can be applied to estimate the effects of the abolishment of the REBP. We estimate the propensity score with a probit model and use radius matching with a radius of 0.02. Estimates of the matching difference-in-difference approach are reported in Table 5. The first three columns show that tor the age group 50-54 the estimates are very similar as the OLS estimates reported in Table 3. For the age group 55-57 we find similar effects for the abolishment of the REBP as in Table 4 and a somewhat larger program substitution effect during the REBP. Overall, these results suggest that the linear model corrects well for regional differences in observable characteristics.

Table 5

To further explore the impact of the introduction and abolishment of the REBP, Figure 9 plots the estimated coefficients of the interaction terms from equation (8) for each age l separately. Each dot on the solid lines is an indicator for living in a treated region and being a given age during the REBP (red line) and after the REBP (black line). A 95-percent confidence interval is shown by dotted lines.

As shown in the first panel, coefficients for entering early retirement are positive for all ages during the REBP is in effect. The point estimate at age 50 amounts to approximately 10 percentage points and increases to around 20 percentage points for the ages 51 to 55. The effect is not so strong for 50 year olds because in addition to the REBP these individuals need to draw one year of unemployment assistance, which is lower than regular unemployment benefits, to bridge the gap until the age for relaxed access to a disability pension. The point estimates decline at ages 56 and 57 because these job losers are relatively close to age 59 when they become eligible for special income support. Hence, many of these job losers permanently retire even without the REBP. As the black line illustrates, the impact of extended unemployment benefits on the incidence of early retirement are reversed after the program is abolished.

The red line in the middle panel shows that for job losers below age 54 in treated regions there is a significant increase in transitions from unemployment to disability pension of almost 20 percentage points. The point estimate for age 54 is insignificant because 54 year old old job losers in non-treated regions can also bridge the time until age 55 with the regular duration of UI benefits of one year. With the abolishment of the REBP excess DI take-up in the age group 50-53 is reversed, as shown by the black line.

For unemployed workers in the age group 55-57, estimated coefficients for entering disability are negative, providing evidence for the program substitution effect. More specifically, with the introduction of the REBP, the exit channel into an old-age pension became financially more attractive relative to claiming a disability pension. The estimated decline during the REBP is large and amounts from 12 to 20 percentage points. Consistent with this view, for unemployed men above age 55 transitions to old-age pensions increase by almost 30 percentage points during the REBP is in effect, as illustrated in the third panel. There is also a significant increase in transitions to old-age pensions for 54 year old job losers, even though these individuals need to rely on one year of unemployment assistance to bridge the time until age 60 when they become eligible for an old-age pension. Finally, the black line in the third subfigure highlights that after the abolishment of the REBP the effects on transitions to old-age pensions are reversed for all ages.

Figure 9

Our model assumes that for the age group 50-54 there is no program substitution effect because eligibility criteria for disability pensions are very strict before age 55. Our data allow us to examine this conjecture since we know the exact age at which job losers start to claim disability benefits. More specifically, we estimate two versions of 7. In the first version the dependent variable is an indicator taking the value 1 if a 50-54 year old job loser claims a disability pension before age 55. In the second version the dependent variable is an indicator taking the value 1 if a 50-54 year old job loser claims a disability pension after age 55. If there is a program substitution effect, we would expect to see less DI entry at ages 50-54 because during the REBP job losers are more likely to stay unemployed until age 55 when access to a disability pension is relaxed. The first column of Table 6 shows that the program substitution effect for the age group 50-54 is small. The probability to claim a disability pension before age 55 declines by 2.5 percentage points during the REBP and increases by 1.3 percentage points after the REBP. On the other hand, the probability to enter DI after age 55 increases by 15.1 percentage points during the REBP and decreases by 13.6 percentage points after the REBP.

Table 6

6.2 Sensitivity Analysis

The key assumption of our identification strategy is that trends in transitions from unemployment into different exit states would be the same in treated and non-treated regions in the absence of the REBP. This assumption rules out differential trends that existed already prior to the REBP as well as idiosyncratic shocks to treated and non-treated regions.

The availability of several years of data before and after the REBP allows us to investigate to what extent trends differ across regions. More specifically, Figure 10 plots the estimated coefficients of the interaction terms (equation (9)) for the age groups 50-54 and 55-57 over the full sample period 1985 to 1995. Each dot on the solid line is the coefficient of the interaction between an indicator variable for half-year and living in a treated region (a 95-percent confidence interval is shown by dotted lines). In all six panels the estimated coefficients fluctuate around 0 before the REBP (June 1988) and after its complete abolishment (July 1993), providing evidence that the empirical strategy is not simply picking up long-run trends in differences between treated and non-treated regions. As shown in the top left and bottom left panels, coefficients for early retirement turn significantly positive during the REBP. For the age group 50-54 the effect increases over time, except for a sharp drop after the REBP was abolished in TR1s (January 1992). For the age group 55-57 the estimated increase declines over time. The raise in early retirement in the age group 50-54 is driven by a large increase in transitions to disability pensions and, to a lesser extent, transitions to old-age pensions (top right panel). The bottom middle and the bottom right panel indicate that for the age group 55-57 there is a decline in transitions to disability pensions and a large increase in transitions to old-age pensions during the REBP.

Figure 10

Table 7 presents OLS estimates of equation (7) for job losers who live no father than a 30 minutes car drive from the border between treated and control regions.

Table 7

Effects for unemployed whose last job was in the tradable goods sector

Table 8

Effects for unemployed with low-tenure (see Winter-Ebmer (2003))

Table 9

7 Social Welfare Analysis

This section quantifies social welfare effects based on the early-retirement model outlined in Chapter 3. Optimal unemployment benefits level are approximated when individuals face one early retirement pathway in $t = 0$ (age group 50 to 54) and two competing pathways $t = 1$ (age group 55 to 59).

Set-up. We extend the model to a life-cycle framework by adding a work period prior to the early retirement decisions in $t = 0, 1$. This period lasts φ and is not subject to any long-term unemployment risk. This particular modeling choice implies that we restrict on the design of unemployment benefits for the elderly while program costs are shared among the entire population/life-cycle. The mass of individuals is normalized to one. The probability to become unemployed is given by q. However, we account for the fact that the unemployed in $t = 0$ may have a higher probability ($q^u > q$) to become again unemployed in $t = 1$. Denote Π_t^i the mass of unemployed that retire early in t using either the unemployment pathway ($i = U$) or disability pathway ($i = D$). In the same spirit, π_t^i measures these outflows conditional on unemployment at the beginning of t.[14] Finally, define the mass of workers at t by Π_t^W and the conditional probability to return to work by π_t^W. (Note that we have $\pi_0^W = 1 - \pi_0^U$ and $\pi_1^W = 1 - \pi_1^U - \pi_1^D$.) Workers contribute pay roll taxes τ and earn before tax wage ω such that gross wage is given by $w = \omega + \tau$.

Social planner. The government faces an important trade-off: Increasing unemployment benefit generosity b provides insurance against long-term unemployment and the resulting disutiltiy to reenter into the labor market but affects labor supply adversely. The major difference to standard theory/models is that both complimentarity as well as substitution effects are incorporated. We show that program substitution effects, which provide the main extension over the standard labor supply in the literature, mitigate program expenditures and thereby work in the opposite direction than the "standard" complementarity channel.

Suppose the government maximizes the ex-ante utilitarian social welfare function

$$\mathcal{W} = \varphi u\left(w - \tau\right) + q \int U_0 dF_0 + (1-q)\left(u\left(w-\tau\right) + \int qU_1 + (1-q)W_1 dF_1\right)$$

subject to the budget constraint

$$b \cdot (\Pi_0^U + \Pi_1^U) + N = \tau \cdot (\varphi + \Pi_0^W + \Pi_1^W)$$

where N denotes the corresponding pension (disability and old-age) expenditures triggered by pathway choices in $t = 0, 1$. N is defined in the Appendix.

[14] An simple example of how these measures are related: $\Pi_0^U = q\pi_0^U$ whereas q denotes the probability to become unemployed.

Approximate optimal unemployment benefits. We present a sufficient statistic to check for local optimality.[15] Deriving $\mathcal{W}$ with respect to b is substantially simplified by the fact that welfare effects due program switchers are second-order (Envelope Theorem). Hence, one has to consider only direct welfare effects on the various states (unemployed, disabled, working). A marginal increase in unemployment benefits yields

$$\frac{d\mathcal{W}}{db} = u'(b) \cdot (\Pi_0^U + \Pi_1^U) - u'(w - \tau) \cdot (\varphi + \Pi_0^W + \Pi_1^W) \cdot \frac{d\tau}{db}. \tag{10}$$

Higher unemployment benefit increase the insurance value which is given by the expected duration to draw UI benefits, or $\Pi_0^U + \Pi_1^U$, times the marginal utility gain $u'(b)$. At the same time, higher taxes are necessary to cover the additional expenditures ($d\tau/db$) which reduces the marginal utility of ex-ante workers $u'(w-\tau)$ weighted by the expected duration in this state, or $\varphi + \Pi_0^W + \Pi_1^W$. We impose two key assumptions in order to obtain an implementable characterization of $d\tau/db$. First, marginal sorting effects induced by $db > 0$ at $t = 0$ on unemployment inflow in $t = 1$ are neglected. This assumption allows to ignore path-dependent sorting effects induced by a marginal policy change which is a reasonable approximation if the inflow of unemployment in $t = 1$ is not strongly driven by previously unemployed individuals ($t = 0$). Second, the required tax increase to fund this policy is "sufficiently small" such that the margin work-disabiliy is not affected due to higher taxation. This is manly justified by the fact that the policy targets at a relatively small group while costs are shared among the entire population. Nevertheless, this approximation underestimates the true program costs and, hence, does not alter our policy conclusions derived in the calibration part. A more formal discussion can be found in the Appendix. Under these assumptions, we are able to approximate the "true" marginal expenditures ($\mathcal{E}$) by

$$\mathcal{E} \approx \Pi_0^U \left(1 + \frac{\pi_0^{U,c}}{\pi_0^U} \Delta_0^c\right) + \Pi_1^U \left(1 + \frac{\pi_1^{U,c}}{\pi_1^U} \Delta_1^c + \frac{\pi_1^{U,s}}{\pi_1^U} \Delta_1^s\right) \tag{11}$$

where $\pi_t^{U,c}$ ($\pi_t^{U,s}$) denotes the the mass of unemployed that are subject to complementarity (substitution) effects and Δ_t^i captures the financial net gains/losses of program switcher in t imposed on government resources. For example, Δ_1^c equals $b + \tau$ as individuals that become unemployed draw b and do not pay taxes τ anymore (while old-age pensions are ignored because the individual retires in $t = 2$ irrespective of pathway choice). All Δ´s are derived in the Appendix and estimated in the calibration part. Equation (11) may be subdivided into two effects:

1. Mechanical effect ($\Pi_0^U + \Pi_1^U$) arises due to the fact that unemployment benefits are higher ignoring any adjustment effects.

2. Behavioral effects: Complementarity and substitution correspond to the mass of program switchers $\Pi_t^U \cdot (\pi_t^{U,i}/\pi_t^U)$ weighted by their respective financial impact Δ_t^i.

[15] See Chetty (2009) for a comprehensive review on the use of the sufficient statistics approach contextual to income taxation, social insurance, and behavioral models.

A balanced budget requires marginal expenditures to be equal to marginal tax revenues, or $\mathcal{E} = (\varphi + \Pi_0^W + \Pi_1^W) \cdot \frac{d\tau}{db}$. Finally, set $d\mathcal{W}/db = 0$ and combine equations (10) and (11) to obtain the approximate optimal level of unemployment benefits

$$\frac{u'(b) - u'(w-\tau)}{u'(w-\tau)} \approx \rho_0 \cdot \varepsilon_0^c \frac{\Delta_0^c}{b} + \rho_1 \cdot \left(\varepsilon_1^c \frac{\Delta_1^c}{b} + \varepsilon_1^s \frac{\Delta_1^s}{b} \right) \tag{12}$$

with time-related weighting factors $\rho_t = \Pi_t^U/(\Pi_0^U + \Pi_1^U)$ and program substitution (complementarity) elasticity $\varepsilon_t^s = \pi_t^{U,s}/(b/\pi_t^U)$ $(\varepsilon_t^c = \pi_t^{U,c}/(b/\pi_t^U))$. The left hand side of formula (12) captures the value of consumption smoothing while the right hand side quantifies the distortion costs induced by labor supply adjustments. Some further comments: First, ρ_t captures the probability to use UI benefits during t conditional on drawing UI benefits at any time of work life ($t = 0, 1$). Second, given the Austrian institutional setting, we may ignore substitution effects in $t = 0$ which would enter similar to the $t = 1$ counterpart ε_1^s. Finally, one might wonder why φ and θ (or $F(\theta)$) do not appear in the formula: i) The work phase prior to early retirement (φ) appears only indirectly in Equation (12). Lower pay roll taxes τ help to relax the overall tax burden that carry over to the older individuals. Therefore, longer work duration φ implies lower taxes τ and thereby higher UI benefit generosity for older individuals. ii) The return to job disutility (θ) does also not appear in formula (12). This is due to the assumed additive separability of consumption and disutility in the utility function, or θ has no impact on marginal consumption values.

Calibration. This section implements formula (12) empirically. Suppose the utility function over consumption features constant relative risk aversion (CRRA), or $u(c) = c^{1-\gamma}/(1-\gamma)$ with the corresponding risk aversion parameter γ. Then the left hand side of equation (12) becomes

$$\frac{u'(b) - u'(w-\tau)}{u'(w-\tau)} \quad = \quad RR(b)^{-\gamma} - 1$$

where $RR(b)$ denotes the replacement rate of unemployment benefits measured in terms of after tax income $(w - \tau)$. Note that $RR(b)$ captures the replacement rate of long-term unemployment and is normalized to a five year average. To obtain $RR(b)$ note that regular unemployment benefits are paid one year (1/5) with net replacement rate $RR(b^r) = 55\%$ while the remaining time (4/5) unemployment assistance benefits are paid with around 70% of $RR(b^r)$. Hence, we get time-weighted $RR(b) = 0.42$ before/after REBP and $RR(b) = 0.52$ during the policy change (4/5 regular unemployment benefits).

Next, we implement the right hand side of formula (12) and the respective pathway elasticities ε in Table 10. The interpretation is straightforward: For example, the elasticity ε_0^c quantifies the percentage increase of early retirement due to complementarity effects in $t = 0$ triggered by a one percentage increase of long-term UI benefits.[16]

[16]The complementarity elasticities ε_t^c required in formula (12) include the effect of the change in τ as well. The REBP however was only introduced in several regions for older individuals while costs were shared among the entire working population. Therefore, we think that the gap between the REBP estimates and the one that includes the

Table 10

The financial impact of pathway switchers (Δ) is mostly about calculating factual and counter factual pensions. Program switcher have an after tax DI replacement rate of around 80%. This holds true for both pathways into disability from $t = 0, 1$. In our sample, the average pension increases by around 1.9 percentage points per annum, or $\alpha = 1.1$ using a five years interval. Finally, payroll taxes τ are set equal 12.25 percentage point of gross wage.[17] Table 11 lists the estimated program switching costs. All values in Table 11 are provided in after tax replacement rates in order to have a simpler interpretation.[18]

Table 11

Summing up all terms, the right hand side of equation (12) becomes

$$\frac{0.068}{0.142} \cdot 2.02 \cdot \frac{0.98}{0.42} + \frac{0.074}{0.142} \cdot \left(1.68 \cdot \frac{0.56}{0.42} - 1.48 \cdot \frac{0.11}{0.42}\right) = 2.26 + (1.17 - 0.2) \quad = \quad 3.23. \quad (13)$$

A short discussion on result (13) which captures program costs induced by complementarity and substitution effects. Looking at the relative shares provides the following insights: First, complementarity effects in $t = 0$ are very expensive because both the individuals react very strongly to financial work incentives and early retirement in $t = 0$ is very expensive. Second, complementarity effects in $t = 1$ are less expensive than its $t = 0$ counterpart. This is mainly due to the substantially lower financial impact as early retirement is triggered five years later. Third, program substitution effects mitigate program costs. Economically, this feature stems from the application disutility κ to become eligible for disability benefits. Therefore, individuals, who switch from DI to UI, are willing to accept lower benefits without first-order utility effects. In sum, this channel relaxes the budget due to lower expenditures without adversely affecting labor supply. Finally, given the calibration stated above, we are able to calculate a hypothetical risk aversion level γ^h that satisfies the local optimality condition. If the "true" relative risk aversion γ is above (below) the threshold value γ^h then UI benefits are too low (high). The hypothetical risk aversion is given by

$$\gamma^h = -\frac{\ln(1 + \text{RHS of equation 12})}{\ln RR(b)} = -\frac{\ln(1 + 3.23)}{\ln 0.42} \quad = \quad 1.66.$$

Unfortunately, we do not know the relative risk aversion (γ) of the population considered and it is well known that risk preferences vary among different contexts and types of risk. This particular setting involves substantial labor supply choices (or risks) because of a complete withdrawal from labor market many years before normal retirement age. Therefore, it seems indeed appropriate to focus on the literature that elicit γ from larger income risks. The work by Manoli et al. (2011)

channel τ as well do not substantially differ. Nevertheless, one would expect the treatment effects to be even larger, inducing more program costs, and thereby not altering the conclusion.

[17] By using the historical pay roll tax rate τ we implicitly assume budget neutrality before the reform was enacted.

[18] To obtain a financial interpretation one has just to revert the normalization, or multiply $\hat{\Delta}$ by 5 years and the annual average after tax wage.

comes in particular close to our preferred setting. They estimate γ by comparing retirement adjustment of elderly households induced by various pension reforms in Austria. The relative risk preference is found to be around 0.71. As our hypothetical value (1.66) is fairly above, we conclude that UI benefits should be rather reduced than extended as in the REBP. This finding seems to be plausible given that UI benefits serve as an important bridge (complementarity effects) for the unemployed to a very generous pension system. Of course, this statement is contingent on the very generous pension system in place, and restricting eligibility or increasing age thresholds may be other valid policies to lower program costs.

Robustness. The model does not allow individuals to save and thereby rules out private insurance against long-term unemployment. We suppose that incorporation of savings would not alter the policy conclusions derived previously. First, Manoli et al. (2011) report, based on year 2003 SHARE survey data, that the median finical asset for Austrian households with age 50 to 54 was around EUR 25'000. Hence, assuming that individuals do not save seems to be a rather good approximation given the low accumulated wealth compared to the financial gap due to long-term unemployment (5 years). Second, private savings lower the insurance value of unemployment benefits and increase the required relative risk aversion γ^I further. In other words, the model might be seen as a benchmark where government UI policies are valuated most favorably. If one believes that UI benefits are too high, or equivalently γ^I too high as we argue, then this policy recommendation is even stronger supported in a model with endogenous savings.

8 Conclusion

In this paper, we study the labor supply effect of UI and DI insurance programs for the incidence of early retirement in Austria. We think that Austria is a particularly interesting case for studying the early retirement decision. Over the past decades, Austrian policy makers have used early retirement schemes disproportionately to mitigate labor market problems of older workers. As a result, the incidence of early retirement is much higher in Austria compared to other OECD countries. However, while early retirement schemes created larger incentives for older workers to leave the work force than in many other countries, the Austrian early retirement system works qualitatively similar to most other countries. Hence understanding the Austrian situation is of more general interest.

We focus on the impact of one particular policy parameter that is of crucial importance for transitions from UI to early retirement: the maximum duration of UI benefits. This parameter is of particular interest, because long unemployment benefits in connection with disability transfers are a very (perhaps the most) important pathway to early retirement in many countries. To identify the impact of the maximum duration of UI benefits for the early retirement decision, we exploit the introduction of the Regional Extended Benefits Program (REBP). This policy allowed workers above age 50 to draw regular UI benefits for as long as 4 (!) years (up from originally 0.6 years).

Because this policy was restricted to certain regions of the country, our identification strategy involves difference-in-differences comparisons of individuals in eligible regions to individuals in non–eligible regions, before, during, and after the reform.

We find that the REBP was essentially an early retirement program. The percentage early retirees among unemployment entrants aged 50 to 54 was 7.1 percentage points higher among individuals eligible to the REBP. The percentage early retirees among unemployment entrants between ages 55 and 57 even increased by 13.5 percentage points for REBP-eligible individuals. Among unemployment entrants aged 50 to 54 the REBP helped to bridge the gap until the age of relaxed access to DI benefits. Among unemployment entrants aged 55 to 57 the REBP was used to bridge the gap until the age of public pensions. There is a large program-substitution effect, that lets individuals use the long duration of UI benefits instead of bridging the gap to regular pension by the lengthy process of applying for DI benefits.

From a policy perspective, our study suggests that policy reforms aiming at increasing the effective retirement age should take particular care to carefully consider the entire set of welfare programs that impact on the early retirement decision. A policy mix that allow for simultaneous and coordinated reforms in UI and DI systems to tackle the unemployment disability margin, together with complementary measures that induce firms to hire older workers and that make older individuals better employable, are the most promising route for policy reforms.

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Appendix

All assumptions are stated and discussed in the paper (on a less formal level though).

Assumption 1. *Utility over consumption $u(c)$ is twice differentiable with $u'(c) > 0$ and $u''(c) < 0$.*

Define $\lim_{c\to\infty} u(c) = \bar{u} \in [-\infty, +\infty]$. Utility functions with CRRA property have $\bar{u} = 0$ ($\bar{u} = \infty$) for $\gamma > 1$ ($\gamma = 1$).

Assumption 2. *Insurance is (intertemporally) unfair, or $(\alpha d - d)T < d$;*

Assumption 2 is often stated as $1 - (\alpha - 1)T > 0$.

Assumption 3. *The application disutility for disability benefits is sufficiently small, or b and κ satisfy $\kappa < \bar{u} - u(b)$.*

Assumption 3 makes sure that disability take up is not prohibitively expensive.

Assumption 4. We assume that $F(\theta_1 \mid \theta_0) \leq F(\theta_1 \mid \theta_0')$ for all for all $\theta_0 \leq \theta_0'$. Moreover, $F(\theta_1 \mid \theta_0)$ is continuous in θ_0 with positive conditional density function over the range $[0, \infty]$.

Parametric example that satisfies Assumption 4: The unemployed draw first $\theta_0 \sim Exp(\beta)$ and, conditional on a second unemployment shock, according to $\theta_1 \sim Exp(1/\theta_0)$. This procedure yields a persistent shock in expected terms, or $\theta_0 = \mathbb{E}(\theta_1 \mid \theta_0)$. Importantly, Assumption 4 assures that the expected value of unemployment is continuously deceasing in θ_0, or $d\mathbb{E}\left(U_1(\theta_1, d)|\, \theta_0\right)/d\theta_0 \leq 0$.

Assumption 5. *Heterogeneity in $t = 1$ is captured by $F_1(\theta_1, d)$ and defined over the domain $[0, \infty] \times [\underline{d}, \overline{d}]$ with $\underline{d} < b$ and $\overline{d} > \hat{d}$. Moreover, the probability density function $f_1(d, \theta_1)$ is strictly positive over the entire domain.*

Assumption 5 imposes to have "sufficient heterogeneity" in the sample such that a UI policy change triggers program as well as complementarity effects in $t = 1$. Assumption 6 reflects the same reasoning in $t = 0$.

Assumption 6. *Heterogeneity in $t = 0$ is captured by $F_0(\theta_0, d)$ and defined over the domain $[0, \infty] \times [\underline{d}, \overline{d}]$ with $\underline{d} < b$ and $\overline{d} > \hat{d}$. Moreover, the probability density function $f_0(d, \theta_1)$ is strictly positive over the entire domain.*

Assumption 7. *Marginal sorting effects induced by $db > 0$ at $t = 0$ on unemployment inflow in $t = 1$ are neglected, e.g. $d\hat{F}_1/db = 0$ holds true.*

Assumption 8. *Marginal program expenditures at the work-disability threshold induced by $d\tau(b) > 0$ (or $db > 0$ indirectly) are neglected.*

Chapter 3: Retirement Model in $t = 1$

Lemma 1. *Under Assumption 1 to 3, there exists a unique threshold level* $\hat{d} \in (b, \infty)$.

Proof. We use the Intermediate Value Theorem to proof existence and exploit the monotonically increasing property of $\hat{d}$ to establish uniqueness. First, restate the threshold by

$$u(b) + \kappa = u(\hat{d}) - \left(u(\alpha\hat{d}) - u(\hat{d})\right) T.$$

We show that the RHS $\varphi(x) := u(x) - T\left(u(\alpha x) - u(x)\right)$ intersects only once with the LHS $(u(b)+\kappa)$. Three steps: i) For $x = b$ the LHS is strictly larger than the RHS because

$$\begin{array}{rccc} & u(b) + \kappa & > & u(b) - (u(\alpha b) - u(b))\, T \\ \Leftrightarrow & \kappa & > & -\,(u(\alpha b) - u(b))\, T \end{array}$$

which is true because $u(\alpha b) > u(b)$ and $\kappa > 0$. ii) Assume that $u(\infty) = \bar{u} < \infty$ then the RHS is larger than the LHS for $\hat{d} = \infty$ if $u(b) + \kappa = u(\infty)$. A similar procedure follows if $\bar{u} = \infty$ [to do]. Combining i) and ii) we know that $\varphi(b) < u(b) + \kappa < \varphi(\infty)$. iii) Derive $\varphi(\cdot)$ with respect to x

$$\frac{d\varphi(x)}{dx} = u'(x) - \left(\alpha u'(\alpha x) - u'(x)\right) T > u'(x)\left(1 - (\alpha - 1)\, T\right) > 0$$

due to Assumption 2. □

Lemma 2. *Under Assumption 1 to 3 and* $\omega > b$*, there exists a unique threshold level* $\hat{\theta}_1$ *for each* d*. Moreover,* $\hat{\theta}_1$ is constant (decreasing) in d below (above) $\hat{d}$.

Proof. Lemma 1 establishes the existence and uniqueness of $\hat{d}$. Two cases: i) For all values $d < \hat{d}$, we obtain the threshold $\hat{\theta}_1 = u(\omega) - u(b)$ which is positive $(\omega > b)$ and independent of d. ii) Given that $d > \hat{d}$, one gets the threshold $\hat{\theta}_1 = u(\omega) - u(d) + (u(\alpha d) - u(d))\, T$. Differentiation with respect to d yields

$$\frac{d\hat{\theta}_1}{dd} = -u'(d) + (\alpha u'(\alpha d) - u'(d))T < -u'(d)\left(1 - (\alpha - 1)T\right) < 0.$$

The last step follows from Assumption 2. Uniqueness and existence of $\hat{d}$ induce uniqueness and existence of $\hat{\theta}_1$. □

Proposition 3. *Under Assumptions 1 to 3* $\hat{d}$ *increases in* b.

Proof. Lemma 1 establishes the existence and uniqueness of $\hat{d}$ implicitly defined by $0 = u(\hat{d}) - \left(u(\alpha\hat{d}) - u(\hat{d})\right) T - u(b) - \kappa$. Implicit differentiation with respect to b yields

$$\frac{\partial\hat{d}}{\partial b} = \frac{u'(b)}{u'(\hat{d}) - \left(\alpha u'(\alpha\hat{d}) - u'(\hat{d})\right) T} > \frac{u'(b)}{u'(\hat{d})\left(1 - (\alpha - 1)\, T\right)} > 0.$$

□

Equation (3) is not proofed as it follows directly from the paper and requires the same assumption as Proposition 3. Finally, we state the technical version of Proposition 1.

Proposition 4 (Technical version of Proposition 1)**.** *Suppose that unemployment benefits increase from b^{old} to b^{new}. Under Assumptions 1 to 5 the mass of early retirees via UI strictly increases ($\Delta M_1^U > 0$). Moreover, the total early retirement effect $\Delta M_1^U > 0$ can be decomposed into strictly positive complementarity effects (C_1) and substitution effects (S_1); or $\Delta M_1^E = C_1 + S_1$ and $C_1, S_1 > 0$.*

Proof. Lemma 1 and 2 establish existence and uniqueness of $\hat{d}$ and $\hat{\theta}_1$. Define the mass of UI early retirees by

$$M_1^U(b) = \int_{\underline{d}}^{\hat{d}(b)} \int_{\hat{\theta}_1(b)}^{\infty} f_1(d, \theta_1) d\theta_1 dd.$$

with slightly abusing the notation by $\hat{\theta}_1(b) := \hat{\theta}_1(\underline{d}; b)$. The additional UI pathway take up triggered by the UI increase from b^{old} to b^{new} is given by

$$\begin{aligned}
\Delta M_1^U &= \int_{b^{old}}^{b^{new}} \left\{ \frac{dM_1^U(b)}{db} \right\} db \\
&= \int_{b^{old}}^{b^{new}} \left\{ \frac{\partial \hat{d}(b)}{\partial b} \int_{\hat{\theta}_1(b)}^{\infty} f(\hat{d}(b), \theta_1) d\theta_1 + \int_{\underline{d}}^{\hat{d}(b)} -\frac{\partial \hat{\theta}_1(b)}{\partial b} f(d, \hat{\theta}_1(b)) dd \right\} db \\
&= \underbrace{\int_{b^{old}}^{b^{new}} \left\{ \frac{\partial \hat{d}(b)}{\partial b} \int_{\hat{\theta}_1(b)}^{\infty} f(\hat{d}(b), \theta_1) d\theta_1 \right\} db}_{=S_1} + \underbrace{\int_{b^{old}}^{b^{new}} \left\{ -\frac{\partial \hat{\theta}_1(b)}{\partial b} \int_{\underline{d}}^{\hat{d}(b)} f(d, \hat{\theta}_1(b)) dd \right\} db}_{=C_1}
\end{aligned}$$

using subsequently Leibniz's rule for differentiation under the integral sign with variable limits. First, note that $C_1(S_1)$ contains only complementarity (substitution) effects $\partial \hat{\theta}_1(b)/\partial b$ ($\partial \hat{d}(b)/\partial b$). Both effects are strictly positive because i) $\partial \hat{d}(b)/\partial b > 0 > \partial \hat{\theta}_1(b)/\partial b$ due to Proposition 3 and equation (3) and ii) $f_1(d, \theta_1) > 0$ over the entire support under Assumption 5. Hence, ΔM_1^U is strictly positive, too. □

Chapter 3: Retirement Model in $t = 0$

Lemma 3. *Under Assumption 1* to 4, $d\mathbb{E}\left(U_1(\theta_1, d) | \theta_0\right) / d\theta_0 \leq 0$ holds true for all (d, θ_0).

Proof. Two cases: Case 1 ($d < \hat{d}$): Subset of individuals who strictly prefer to retire via UI instead of DI in $t = 1$. Hence, the expected value of unemployment in $t = 1$ is given by

$$\mathbb{E}\left(U_1(\theta_1, d) | \theta_0, d < \hat{d}\right) = \int_0^{\hat{\theta}_1(d)} W_1(d) - \theta_1 dF_1(\theta_1 \mid \theta_0) + \int_{\hat{\theta}_1(d)}^{\infty} R_1^U(d) dF_1(\theta_1 \mid \theta_0) \tag{14}$$

with $R_1^U = u(b) + Tu(p^U)$. Case 2 ($d > \hat{d}$): Subset of individuals who strictly prefer to retire via

DI instead of UI in $t = 1$. The expected value of unemployment in $t = 1$ is given by

$$\mathbb{E}\left(U_1(\theta_1, d) | \, \theta_0, d > \hat{d}\right) = \int\limits_0^{\hat{\theta}_1(d)} W_1(d) - \theta_1 dF_1(\theta_1 \mid \theta_0) + \int\limits_{\hat{\theta}_1(d)}^{\infty} R_1^D(d) dF_1(\theta_1 \mid \theta_0) \qquad (15)$$

with $R_1^D(d) = (1+T)u(d)$. By assumption we know that $F_1(\theta_1 \mid \theta_0)$ stochastically dominates $F_1(\theta_1 \mid \theta_0')$ for $\theta_0' > \theta_0$ then $\mathbb{E}\left(U_1(\theta_1, d) | \, \theta_0\right) \geq \mathbb{E}\left(U_1(\theta_1, d) | \, \theta_0'\right)$ because θ_1 enters strictly negative (giving more weight to the high θ_1). Differentiability then comes from the assumption that $F_1(\theta_1 \mid \theta_0)$ is differentiable with respect to θ_0. □

Lemma 4. *Under Assumptions 1* to 4*, there exists a unique $\hat{\theta}_0$ for each d that separates early retirement ($\theta_0 < \hat{\theta}_0$) and work ($\theta_0 > \hat{\theta}_0$).*

Proof. Similar to Lemma 1: Expand and rewrite equation (5) by

$$\hat{\theta}_0 - q\mathbb{E}\left(U_1(\theta_1, d) | \, \hat{\theta}_0\right) = u(\omega) + (1-q)W_1(d) - u(b) - (1+T)u(d) + \kappa.$$

Denote the RHS by β which is independent of θ_0. LHS will be denoted by the function $\varphi(x) = x - q\mathbb{E}\left(U_1(\theta_1, d) | \, x\right)$. The proof works again in three steps: i) The function $\varphi(x)$ is strictly increasing in x

$$\frac{d\varphi(x)}{dx} = 1 - q\frac{d\mathbb{E}\left(U_1(\theta_1, d) | \, x\right)}{dx} > 0$$

because $d\mathbb{E}\left(U_1(\theta_1, d) | \, x\right)/dx \leq 0$ (Lemma 3). ii) $\lim_{x\to\infty} \varphi(x) = \infty > \beta$ because $\mathbb{E}\left(U_1(\theta_1, d) | \, \hat{\theta}_0\right)$ is bounded above by $W_1(d)$. iii) Go back to equation (5) and note that $W_1(d) > \mathbb{E}\left(U_1(\theta_1, d) | \, x\right) > (1+T)u(d)$ for all x and $d < \omega$. Therefore, given $\theta_0 = 0$ it must hold

$$\begin{aligned} -\mathbb{E}\left(U_1(\theta_1, d) | \, \hat{\theta}_0 = 0\right) &< 0 \\ &< u(\omega) - u(b) \\ &< u(\omega) + (1-q)W_1(d) + q\mathbb{E}\left(U_1(\theta_1, d) | \, 0\right) - u(b) - (1+T)u(d) + \kappa. \end{aligned}$$

□

Lemma 5. *Under Assumptions 1* to 4*, $\hat{\theta}_0(d)$ decreases in d.*

Proof. Implicit differentiation of $\hat{\theta}_0$ (see equation (5)) with respect to d yields

$$\frac{\partial \hat{\theta}_0}{\partial d} = -\frac{(1+T)u'(d) - q\frac{\partial \mathbb{E}\left(U_1(\theta_1, d) | \hat{\theta}_0\right)}{\partial d} - (1-q)\alpha T u'(\alpha d)}{1 - q \cdot \partial \mathbb{E}\left(U_1(\theta_1, d) | \, \hat{\theta}_0\right)/\partial \hat{\theta}_0}.$$

The denominator is always positive because $d\mathbb{E}\left(U_1(\theta_1, d) | \, x\right)/dx \leq 0$ (Lemma 3). Hence, we have to figure out the sign of the nominator. Because $\mathbb{E}\left(U_1(\theta_1, d) | \, \hat{\theta}_0\right)$ varies with d we have to distinguish between two cases (two early retirement pathways, see Lemma 3). Case 1 ($d < \hat{d}$): The expected value of unemployment in $t = 1$ is given by equation (14) with $R_1^U = u(b) + Tu(p^U)$. All previously derived properties for $\hat{\theta}_1$ carry over. Hence, we know that $d\hat{\theta}_1/dd = 0$ over the range considered $d < \hat{d}$. We treat therefore $\hat{\theta}_1$ as "fixed" and differentiate directly within the integral (no change of boundary values have to be considered). This procedure yields

$$\begin{aligned}
\frac{d\mathbb{E}\left(U_1(\theta_1,d)|\hat{\theta}_0,d<\hat{d}\right)}{dd} &= \int_0^{\hat{\theta}_1} \frac{dW_1(d)}{dd} dF_1(\theta_1 \mid \hat{\theta}_0) + \int_{\hat{\theta}_1}^{\infty} \frac{dR_1^U(d)}{dd} dF_1(\theta_1 \mid \hat{\theta}_0) \\
&= \int_0^{\infty} \alpha T u'(\alpha d) dF_1\left(\theta_1 \middle| \hat{\theta}_0\right) = \alpha T u'(\alpha d)
\end{aligned}$$

because $\frac{dW_1(d)}{dd} = \frac{dR_1^U(d)}{dd} = \alpha T u'(\alpha d)$. Collecting all terms leads to a strictly positive nominator over $d < \hat{d}$ because

$$(1+T)u'(d) - \alpha T u'(\alpha d) > u'(d)\left(1 - (\alpha - 1)T\right) > 0.$$

Case 2: $d > \hat{d}$. Subset of individuals that strictly prefer to retire via DI instead of UI in $t = 1$. The expected value of unemployment in $t = 1$ is given by equation (15) with $R_1^D(d) = (1+T)u(d)$. Differentiation yields (Leibniz integral rule with variable limits)

$$\begin{aligned}
\frac{d\mathbb{E}\left(U_1(\theta_1,d)|\hat{\theta}_0,d>\hat{d}\right)}{dd} &= \frac{d\hat{\theta}_1(d)}{dd} \cdot f_1\left(\hat{\theta}_1(d) \middle| \hat{\theta}_0\right) \cdot \left(W_1(d) - \hat{\theta}_1(d) - R_1^D(d)\right) \\
&\quad + \int_0^{\hat{\theta}_1(d)} \alpha T u'(\alpha d) dF_1(\theta_1 \mid \hat{\theta}_0) + \int_{\hat{\theta}_1(d)}^{\infty} (1+T)u'(d) dF_1(\theta_1 \mid \hat{\theta}_0) \\
&= \alpha T u'(\alpha d) F_1(\hat{\theta}_1 \mid \hat{\theta}_0) + (1+T)u'(d)\left(1 - F_1(\hat{\theta}_1 \mid \hat{\theta}_0)\right)
\end{aligned}$$

The second step follows from equation (2) which imposes $\hat{\theta}_1(d) = W_1(d) - R_1^D(d)$ over the range $d > \hat{d}$. Collect all terms of the nominator (NOM) and use the abbreviation $\pi = F_1(\hat{\theta}_1 \mid \hat{\theta}_0)$

$$\begin{aligned}
NOM &= u'(d)(1+T)(1 - q(1-\pi)) - \alpha T u'(\alpha d)(1 - q(1-\pi)) \\
&> (1 - q(1-\pi))u'(d)\left(1 - (\alpha - 1)T\right) > 0
\end{aligned}.$$

Finally, note that the nominator is strictly positive for each case. □

The technical version of Proposition 2 is derived in two steps: First, we establish that $\hat{\theta}_0(d)$ decreases in b.

Lemma 6. *Under Assumptions 1* to 4, *$\hat{\theta}_0(d)$ decreases in b for each d.*

Proof. Differentiate $\hat{\theta}_0 = W_0(d, \hat{\theta}_0) - R_0(d)$ with respect to b to obtain equation (6). The proof works the same way as Lemma 5. Case 1 ($d < \hat{d}$) implicit differentiation of equation (14) yields

$$\frac{d\mathbb{E}\left(U_1(\theta_1,d)|\hat{\theta}_0\right)}{db} = \int_{\hat{\theta}_1(d)}^{\infty} u'(b) dF_1(\theta_1 \mid \hat{\theta}_0) = \left(1 - F_1(\theta_1 \mid \hat{\theta}_0)\right) \cdot u'(b).$$

Again, welfare effects due to switching behavior can be ignored because individuals optimize in $t = 1$ (or use Leibniz's integration rule with $\hat{\theta}_1(d) = W_1(d) - R_1^U(d)$ over the range $d > \hat{d}$). Case 2 ($d > \hat{d}$): does not depend on b because the UI pathway is never chosen. Hence, $d\mathbb{E}\left(U_1(\theta_1, d) | \hat{\theta}_0, d < \hat{d}\right)/dd = 0$. In sum we obtain

$$\frac{d\mathbb{E}\left(U_1(\theta_1, d) | \hat{\theta}_0\right)}{db} = \begin{cases} F_1(\hat{\theta}_1(d) \mid \hat{\theta}_0) \cdot u'(b) & \text{if } d < \hat{d} \\ 0 & \text{if } d > \hat{d} \end{cases}$$

which directly implies that $\hat{\theta}_0(d)$ decreases in b because $0 < q < 1$ and $0 \leq F_1(\hat{\theta}_1 \mid \hat{\theta}_0) \leq 1$. □

In a second step we tackle the technical version of Proposition 2.

Proposition 5 (Technical version of Proposition 2)**.** *Suppose that unemployment benefits increase from b^{old} to b^{new}. Under Assumptions 1* to *5, the mass of early retirees via UI strictly increases ($\Delta M_0^U > 0$). There are only complementarity effects, or $\Delta M_0^U = C_0$*

Proof. To be added later (similar to proof of Proposition 4). □

Chapter 7: Social Welfare Analysis

To simplify the notation we introduce the following distribution functions (see chapter 3)

- $F_0 = F_0(\theta_0, d)$ denotes the (unconditional) distribution of UI inflow in $t = 0$.
- $\hat{F}_1 = \hat{F}_1(\theta_1, d)$ denotes the (unconditional) distribution of UI inflow in $t = 1$ (includes the job returners in $t = 0$ as well)
- $F_1 = F_1(\theta_1, d)$ denotes the distribution of UI inflow in $t = 1$ conditional on individuals without unemployment spell in $t = 0$.
- $F_{1|0} = F_1(\theta_1 \mid \theta_0)$ denotes the conditional distribution function θ_1 given a previously drawn θ_0.

Note that $\hat{F}_1(\theta_1, d)$ depends on pathway choices in $t = 0$ while $F_1(\theta_1, d)$ is by construction independent of $t = 0$ behavior. Next, we introduce the pathway choices in terms of UI exit probabilities (definitions see paper, note that the values are based on F_0 and $\hat{F}_1$ as measured in the empirical model)

$$\begin{array}{lllll} \pi_0^W := \int_{W_0} dF_0 := \int_{\underline{d}}^{\overline{d}} \int_0^{\hat{\theta}_0(d)} f_0(\theta_0, d) d\theta_0 dd & , & \pi_1^W := \int_{W_1} d\hat{F}_1 := \int_{\underline{d}}^{\overline{d}} \int_0^{\hat{\theta}_1(d)} \hat{f}_1(\theta_1, d) d\theta_1 dd \\ \pi_0^U := \int_{U_0} dF_0 := \int_{\underline{d}}^{\overline{d}} \int_{\hat{\theta}_0(d)}^{\infty} f_0(\theta_0, d) d\theta_0 dd & , & \pi_1^U := \int_{U_1} d\hat{F}_1 := \int_{\underline{d}}^{\hat{d}} \int_{\hat{\theta}_1(d)}^{\infty} \hat{f}_1(\theta_1, d) d\theta_1 dd \\ & & \pi_1^D := \int_{D_1} d\hat{F}_1 := \int_{\hat{d}}^{\overline{d}} \int_0^{\hat{\theta}_1(d)} \hat{f}_1(\theta_1, d) d\theta_1 dd \end{array}$$

with $\pi_0^U = 1 - \pi_0^W$ and $\pi_1^W + \pi_1^U + \pi_1^D = 1$. The distribution functions F_0 and $\hat{F}_1$ are related by

$$\hat{F}_1(\theta_1, d) = \frac{(1-q)F_1(\theta_1, d) + q^u \int_{W_0} F_1(\theta_1|\theta_0) dF_0}{(1-q) + \pi_0^W q^u} \ . \tag{16}$$

Hence, whenever "selection effects" are small, or $\pi_0^W q^u \ll (1-q)$, then $F_1(\theta_1, d) \approx \hat{F}_1(\theta_1, d)$. The previous definitions allow to derive the unconditional measures (definitions see paper)

$$\begin{array}{rclcrcl} \Pi_0^W & = & 1-q(1-\pi_0^W) & , & \Pi_1^U & = & \Phi_1 \cdot \pi_1^U \\ \Pi_0^U & = & q\pi_0^U & , & \Pi_1^D & = & \Phi_1 \cdot \pi_1^D \\ & & & & \Pi_1^W & = & \Phi_1 \cdot \pi_1^W + (1-q)^2 \end{array}$$

whereas $0 \leq \Phi_1 \leq 1$ captures the mass of individual that become unemployed (inflow) at the beginning of $t = 1$, or

$$\Phi_1 = (1-q)q + q\pi_0^W q^u = (1-q)q\left(1 + \frac{\pi_0^W q^u}{1-q}\right).$$

Finally, we define the pension expenditures N as the sum of

$$\begin{array}{rcl} N_0 & = & q\int_{U_0} d(1+T)dF_0 \\ N_1 & = & \Phi_1\left(\int_{D_1} d(1+T)d\hat{F}_1 + \int_{U_1} \alpha dTd\hat{F}_1\right) \\ N_2 & = & \Phi_1\int_{W_1} \alpha dTd\hat{F}_1 + (1-q)^2\int \alpha dTd\hat{F}_1 \end{array}$$

Lemma 7. *Under Assumptions 1* to 6, *the marginal social welfare change induced by db is given by*

$$\frac{d\mathcal{W}}{db} = u'(b)\cdot(\Pi_0^U + \Pi_1^U) - u'(w-\tau)\cdot(\varphi + \Pi_0^W + \Pi_1^W)\cdot\frac{d\tau}{db}.$$

Proof. We take into account that the budged constraint has to be met, or for every b there is a corresponding τ implicitly defined by the budget constraint. Hence, we use $\tau(b)$. To simplify the derivation write down

$$\mathcal{W} = \varphi u\left(w-\tau\right) + q\underbrace{\int U_0 dF_0}_{\Xi_C:=} + (1-q)(u\left(w-\tau\right) + q\underbrace{\int U_1 dF_1}_{\Xi_C:=} + (1-q)\underbrace{\int W_1 dF_1}_{\Xi_A:=}).$$

First, the term Ξ_A simply yields $d\Xi_A/db = -u'\left(w-\tau\right)d\tau/db$. Second, write down Ξ_B by suppressing all d's to obtain

$$\Xi_B = \int_{\underline{d}}^{\overline{d}}\int_0^{\hat{\theta}_1}\left(W_1-\theta_1\right)f_1(\theta_1,d)d\theta_1 dd + \int_{\underline{d}}^{\hat{d}}\int_{\hat{\theta}_1}^{\infty} R_1^U f_1(\theta_1,d)d\theta_1 dd + \int_{\hat{d}}^{\overline{d}}\int_{\hat{\theta}_1}^{\infty} R_1^D f_1(\theta_1,d)d\theta_1 dd.$$

Deriving this function with respect to b yields three terms - each term represents one line below (subsequent use of Leibniz's integration rule)

$$\begin{array}{rcl} \frac{d\Xi_B}{db} & = & \int_{\underline{d}}^{\overline{d}}\left(\frac{d\hat{\theta}_1}{db}f_1(\hat{\theta}_1,d)\left(W_1-\hat{\theta}_1\right) - \int_0^{\hat{\theta}_1} u'\left(w-\tau\right)\frac{d\tau}{db}f_1(\theta_1,d)d\theta_1\right)dd \\ & & +\frac{d\hat{d}}{db}\cdot\int_{\hat{\theta}_1}^{\infty} R_1^U(\hat{d})f_1(\theta_1,\hat{d})d\theta_1 + \int_{\underline{d}}^{\hat{d}}\left(-\frac{d\hat{\theta}_1}{db}R_1^U f_1(\hat{\theta}_1,d) + \int_{\hat{\theta}_1}^{\infty} u'(b)f_1(\theta_1,d)d\theta_1\right)dd \\ & & -\frac{d\hat{d}}{db}\cdot\int_{\hat{\theta}_1}^{\infty} R_1^D(\hat{d})f_1(\theta_1,\hat{d})d\theta_1 + \int_{\hat{d}}^{\overline{d}}\left(-\frac{d\hat{\theta}_1}{db}R_1^D f_1(\hat{\theta}_1,d)\right)dd \\ & = & u'\left(b\right)\int_{U_1} dF_1 - u'\left(w-\tau\right)\frac{d\tau}{db}\int_{W_1} dF_1 \end{array}$$

Many terms cancel in the second step because individuals optimize with respect to the pathway choice, or mathematically it holds that $R_1^D(\hat{d}) = R_1^U(\hat{d})$ for all $\theta_1 > \hat{\theta}_1$, $W_1(d) - \hat{\theta}_1 = R_1^U(d)$ for all $d < \hat{d}$, and $W_1(d) - \hat{\theta}_1 = R_1^D(d)$ for all $d > \hat{d}$. Finally, write down Ξ_C (again ignoring d where appropriate)

$$\Xi_C = \int_{\underline{d}}^{\overline{d}} \int_0^{\hat{\theta}_0} R_0 f(\theta_0, d) d\theta_0 dd + \int_{\underline{d}}^{\overline{d}} \int_{\hat{\theta}_0}^{\infty} \left(u(w-\tau) - \theta_0 + q^u \mathbb{E}\left(U_1 | \, \theta_0\right) + (1-q^u) W_1\right) f(\theta_0, d) d\theta_0 dd.$$

Differentiation of Ξ_C with respect to b yields

$$\begin{aligned}
\frac{d\Xi_C}{db} &= \int_{\underline{d}}^{\overline{d}} \left(\frac{d\hat{\theta}_0}{db} R_0 f(d, \hat{\theta}_0) + \int_0^{\hat{\theta}_0} u'(b) f(\theta_0, d) d\theta_0 \right) dd \\
&\quad + \int_{\underline{d}}^{\overline{d}} -\frac{d\hat{\theta}_0}{db} \left(u(w-\tau) + q^u \mathbb{E}\left(U_1 | \, \hat{\theta}_0 \right) + (1-q^u) W_1 - \hat{\theta}_0 \right) f(\hat{\theta}_0, d) dd \\
&\quad + \int_{\underline{d}}^{\overline{d}} \int_{\hat{\theta}_0}^{\infty} \left(-u'(w-\tau)\frac{d\tau}{db} + q^u \frac{d\mathbb{E}(U_1|\theta_0)}{db} - (1-q^u) u'(w-\tau) \frac{d\tau}{db} \right) f(\theta_0, d) d\theta_0 dd \\
&= \pi_0^U u'(b) + \int_{W_0} \left(-u'(w-\tau)\frac{d\tau}{db} + q^u \frac{d\mathbb{E}(U_1|\theta_0)}{db} - (1-q^u) u'(w-\tau)\frac{d\tau}{db} \right) dF_0
\end{aligned}$$

again exploiting the fact that individuals optimize, or $R_0 = u(w-\tau) + q^u \mathbb{E}\left(U_1 | \, \hat{\theta}_0 \right) + (1-q^u) W_1 - \hat{\theta}_0$ for all d. $d\mathbb{E}\left(U_1 | \, \theta_0\right)/db$ works similar to $d\Xi_B/db$ but conditional on θ_0. Therefore, we obtain

$$\frac{d\mathbb{E}\left(U_1 | \, \theta_0\right)}{db} = u'(b) \int_{U_1} dF_{1|0} - u'(w-\tau) \frac{d\tau}{db} \int_{W_1} dF_{1|0}$$

and get

$$\frac{d\Xi_C}{db} = u'(b) \left(\pi_0^U + q^u \int_{W_0} \int_{U_1} dF_{1|0} dF_0 \right) - u'(w-\tau) \frac{d\tau}{db} \left((2-q^u) \int_{W_0} dF_0 + q^u \int_{W_0} \int_{W_1} dF_{1|0} dF_0 \right).$$

Finally, add up all terms

$$\begin{aligned}
\frac{d\mathcal{W}}{db} &= -\varphi \cdot u'(w-\tau) \frac{d\tau}{db} + \Pi_0^U \cdot u'(b) - \underbrace{(q\pi_0^W + (1-q))}_{=\Pi_0^W} \cdot u'(w-\tau) \frac{d\tau}{db} \\
&\quad + u'(b) \underbrace{q(q^u \int_{W_0} \int_{U_1} dF_{1|0} dF_0 + (1-q) \int_{U_1} dF_1)}_{=q((1-q)+\pi_0^W q^u) \int_{U_1} d\hat{F}_1 = \Pi_1^U} \\
&\quad - u'(w-\tau) \frac{d\tau}{db} (\underbrace{q(q^u \int_{W_0} \int_{W_1} dF_{1|0} dF_0 + (1-q) \int_{W_1} dF_1)}_{=q((1-q)+\pi_0^W q^u) \int_{W_1} d\hat{F}_1} + (1-q)^2) \\
&= u'(b) \cdot (\Pi_0^U + \Pi_1^U) - u'(w-\tau) \cdot (\varphi + \Pi_0^W + \Pi_1^W) \cdot \frac{d\tau}{db}
\end{aligned}$$

The steps in sub brackets follow from equation (16). □

While it is easier to work with F in Lemma 7, we change to $\hat{F}$ in Lemma 8.

Lemma 8. *Under Assumptions 1 to 8, the implicit marginal tax increase $d\tau/db$ satisfies the fol-*

lowing approximation

$$(\varphi + \Pi_0^W + \Pi_1^W)\frac{d\tau}{db} \approx \Pi_0^U\left(1 + \frac{\pi_0^{U,c}}{\pi_0^U}\Delta_0^c\right) + \Pi_1^U\left(1 + \frac{\pi_0^{U,c}}{\pi_1^U}\Delta_1^c + \frac{\pi_1^{U,s}}{\pi_1^U}\Delta_1^s\right) \tag{17}$$

with

$$\begin{array}{rclcrcl} \Delta_0^c &=& b + \tau + \overline{d}_0^U + \overline{p}_0^U - q^u \mathbb{E}\Upsilon_1 & , & \Delta_1^c &=& b + \tau \\ &&&& \Delta_1^s &=& \overline{d}_1^D + \overline{p}_1^D - b - \overline{p}_1^U \end{array}$$

and the expected $t = 1$ *transfers* $\mathbb{E}\Upsilon_1 = \int_{D_1} d(1+T)d\hat{F}_1 + \int_{U_1} b + \alpha dTd\hat{F}_1 + \int_{W_1} d\alpha T - \tau d\hat{F}_1$.

Proof. First, differentiate $\tau \cdot (\varphi + \Pi_0^W + \Pi_1^W) = b \cdot (\Pi_0^U + \Pi_1^U) + N$ with respect to b to obtain (again keep in mind that taxes depend on UI benefits $\tau(b)$)

$$(\varphi + \Pi_0^W + \Pi_1^W)\frac{d\tau}{db} + \tau\frac{d(\Pi_0^W + \Pi_1^W)}{db} = \Pi_0^U + \Pi_1^U + b\frac{d(\Pi_0^U + \Pi_1^U)}{db} + \frac{dN}{db}.$$

Next, we derive the pension expenditures N with respect to b. The first component N_0 yields

$$\frac{dN_0}{db} = q\int_{\underline{d}}^{\overline{d}}(1+T)d\frac{d\hat{\theta}_0}{db}f(\hat{\theta}_0, d)dd = q\pi_0^{U,c}(1+T)\overline{d}_0^U \quad = \quad \Pi_0^U\frac{\pi_0^{U,c}}{\pi_0^U}(1+T)\overline{d}_0^U.$$

whereas the second step exploits the following decomposition:

1) Marginal change of UI pathway take up in $t = 0$, or complementarity effects, defined as $\pi_0^{U,c} := \int_{\underline{d}}^{\overline{d}} \frac{d\hat{\theta}_0}{db} f(\hat{\theta}_0, d)dd$.

2) Average pension expenditures triggered in $t = 0$ due individuals who switch to early retirement of complementary effects, or $\overline{d}_0^U := \int_{\underline{d}}^{\overline{d}} d\frac{d\hat{\theta}_0}{db} f(\hat{\theta}_0, d)\left(\int_{\underline{d}}^{\overline{d}} \frac{d\hat{\theta}_0}{db} f(\hat{\theta}_0, d)dd\right)^{-1} dd$.

A similar decomposition is subsequently used in $t = 1$. To simplify the computation of the remaining pension expenditures define the quantity $\hat{N} = N_1 + N_2$, or

$$\hat{N} \quad = \quad \Phi_1\left(\int \alpha dTd\hat{F}_1 - \int_{D_1} d(1+T-\alpha T)d\hat{F}_1\right) + (1-q)^2\int \alpha dTdF_1$$

Note that $\hat{F}_1$ is not policy invariant as sorting effect in $t = 0$ have an impact on $t = 1$. Under Assumption 7, or ignoring sorting effects, $\hat{F}_1$ (distribution/composition of inflow) does not change with respect to db. Deriving $\hat{N}$ with respect to b yields

$$\frac{d\hat{N}}{db} \quad \approx \quad \Pi_1^U\frac{\pi_1^{U,s}}{\pi_1^U}(1+T-\alpha T)\overline{d}_1^D + \frac{d\Phi_1}{db}\left(\int \alpha dTd\hat{F}_1 - \int_{D_1} d(1+T-\alpha T)d\hat{F}_1\right)$$

It is important to note that Assumption 8 allows us to ignore additional pension costs along the DI-Work margin which would otherwise appear above. Next, because $\pi_0^W + \pi_0^U = 1$ holds true in $t = 1$, all behavioral effects can be attributed to the complementarity effect, or formally

$\frac{d\pi_0^U}{db} = -\frac{d\pi_0^W}{db} = \pi_0^{U,c}$. We conclude

$$\frac{d\Phi_1}{db} = q\frac{d\pi_0^W}{db}q^u \quad = - \quad \frac{\pi_0^{U,c}}{\pi_0^U}q^u.$$

A similar decomposition yields

$$\begin{aligned}
\frac{d(\Pi_0^W + \Pi_1^W)}{db} &= q\frac{d\pi_0^W}{db} + \Phi_1\frac{d\pi_1^W}{db} - \frac{d\Phi_1}{db}\pi_1^W = -\Pi_0^U\frac{\pi_0^{U,c}}{\pi_0^U}(1+q^u\pi_1^W) - \Pi_1^U\frac{\pi_1^{U,c}}{\pi_1^U} \\
\frac{d(\Pi_0^U + \Pi_1^U)}{db} &= q\frac{d\pi_0^U}{db} + \Phi_1\frac{d\pi_1^U}{db} + \frac{d\Phi_1}{db}\pi_1^U = \Pi_0^U\frac{\pi_0^{U,c}}{\pi_0^U}(1-q^u\pi_1^U) + \Pi_1^U\frac{\pi_1^{U,c} - \pi_1^{U,s}}{\pi_1^U}
\end{aligned}$$

because $-\frac{d\pi_1^W}{db} = \pi_1^{U,c}$ (change on the employment margins are due to complementarity effects) and $\frac{d\pi_1^U}{db} = \pi_1^{U,c} - \pi_1^{U,s}$ (UI pathway take up may be due to complementarity and substitution effects; we choose $\pi_1^{U,s}$ such that it enters negative to be in line with the empirical approach). Collecting all terms yields equation (17) with

$$\begin{aligned}
\Delta_0^c &= b + \tau + \overline{d}_0^U + \overline{p}_0^U - q^u\mathbb{E}\Upsilon_1 \quad , \quad & \Delta_1^c &= b + \tau \\
& & \Delta_1^s &= \overline{d}_1^D + \overline{p}_1^D - b - \overline{p}_1^U
\end{aligned}$$

and the expected $t = 1$ transfers $\mathbb{E}\Upsilon_1 = \int_{D_1} d(1+T)d\hat{F}_1 + \int_{U_1} b + \alpha dTd\hat{F}_1 + \int_{W_1} d\alpha T - \tau d\hat{F}_1$. $\square$

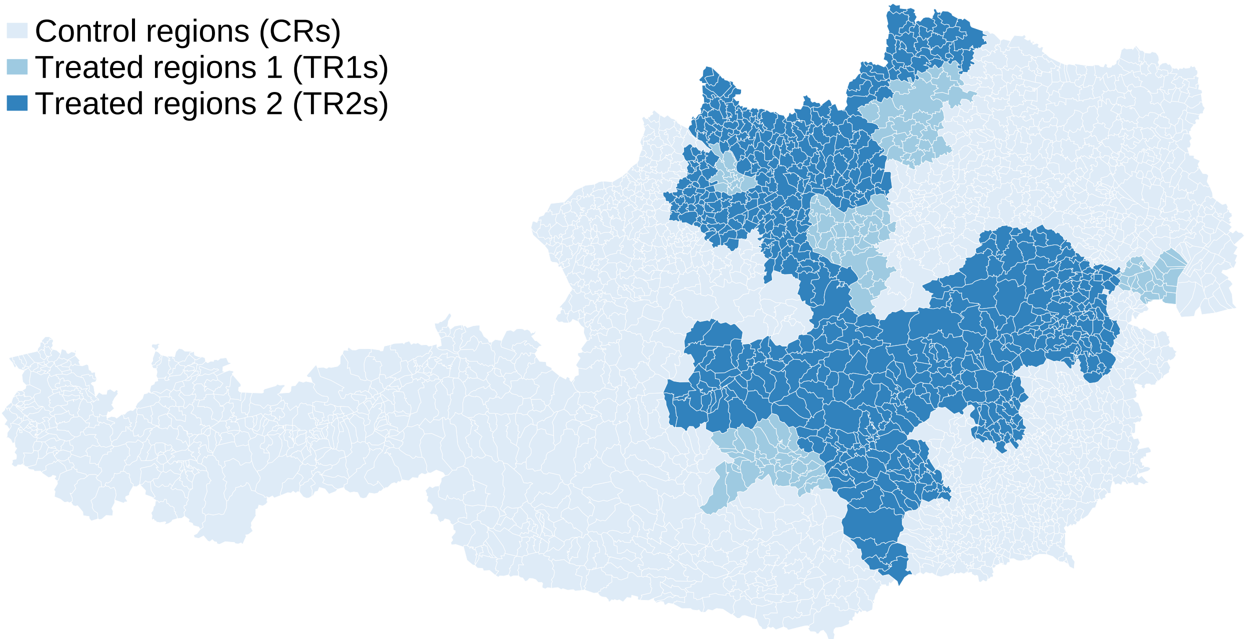

Figure 1: The Regional Extended Benefits Program (REBP)

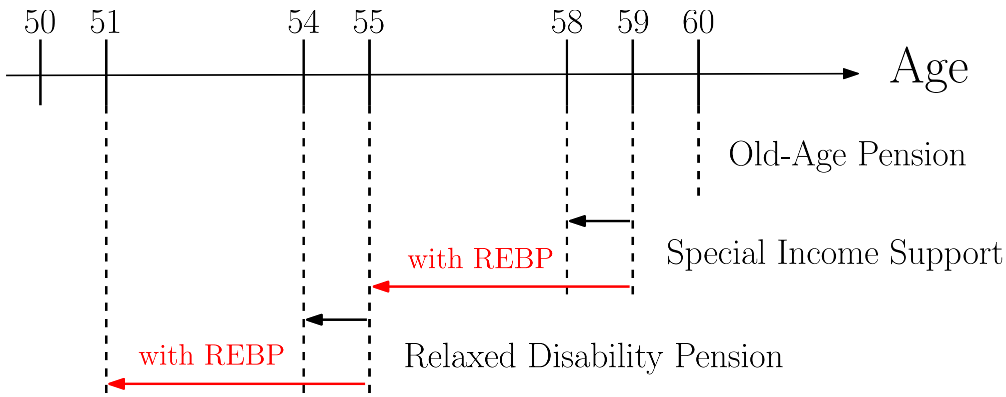

Figure 2: Pathways to retirement with/without REBP-eligibility

Table 1: Heterogeneity in UI and DI replacement rates

	DI repl. rate age 50-54				DI repl. rate age 55-57			
	1st quartile	2nd quartile	3rd quartile	4th quartile	1st quartile	2nd quartile	3rd quartile	4th quartile
UI repl. rate								
1st quartile								
No. of Obs.	6,841	6,216	5,720	2,572	1,383	1,541	1,648	925
Median DI repl. rate	48.0	62.5	72.1	90.5	47.5	64.0	74.2	84.8
Median UI repl. rate	55.3	54.3	53.5	54.8	55.0	53.7	52.2	54.5
2nd quartile								
No. of Obs.	5,326	6,001	5,921	4,103	1,360	1,780	1,376	980
Median DI repl. rate	49.6	62.4	72.7	88.6	49.5	63.8	73.7	85.5
Median UI repl. rate	58.6	59.2	59.9	60.0	57.9	58.3	58.6	59.4
3rd quartile								
No. of Obs.	4,594	5,205	5,680	5,871	1,131	1,216	1,579	1,572
Median DI repl. rate	49.1	62.6	72.8	91.6	49.1	64.7	74.2	89.2
Median UI repl. rate	61.4	61.4	61.4	61.5	61.2	61.1	61.1	61.1
4th quartile								
No. of Obs.	4,590	3,928	4,029	8,804	1,623	960	894	2,019
Median DI repl. rate	48.3	62.5	72.8	104.6	47.7	63.8	74.0	97.0
Median UI repl. rate	62.7	62.5	62.5	62.9	62.0	62.0	61.9	62.0

Notes: All replacement rates are after taxes. Sample includes unemployment spells starting in January 1985 to December 1995 (except spell starting between January 1988 and June 1988) by men aged 50-57. See section **??** for details on the construction of the sample.

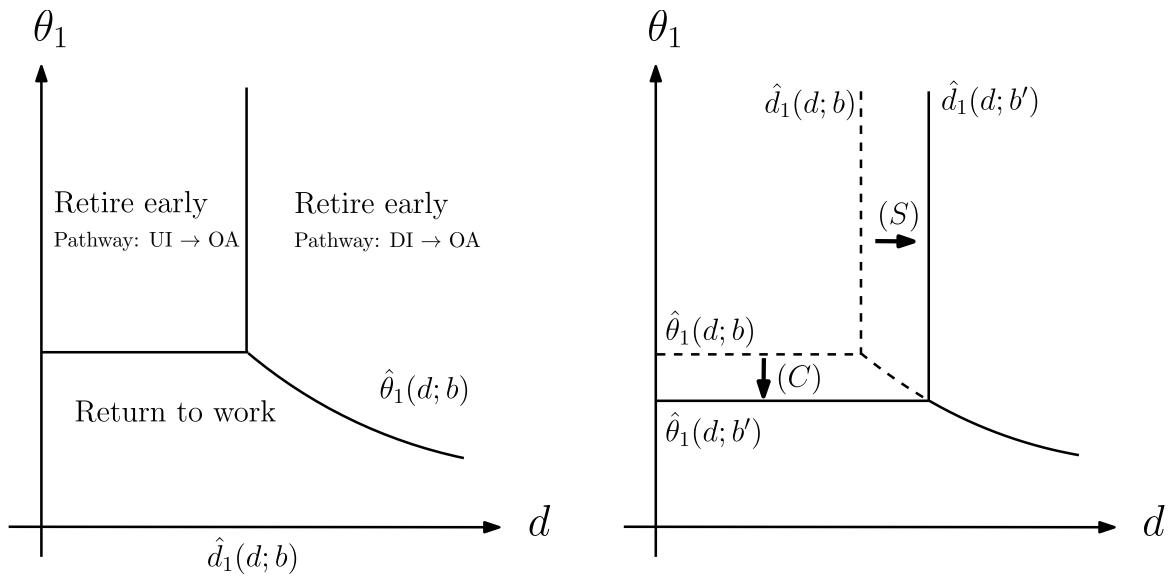

Figure 3: Left panel: Early retirement thresholds in $t = 1$. Right panel: Program complementarity effects (C) as well as program substitution effects (S) when unemployment benefits increase from b to b'.

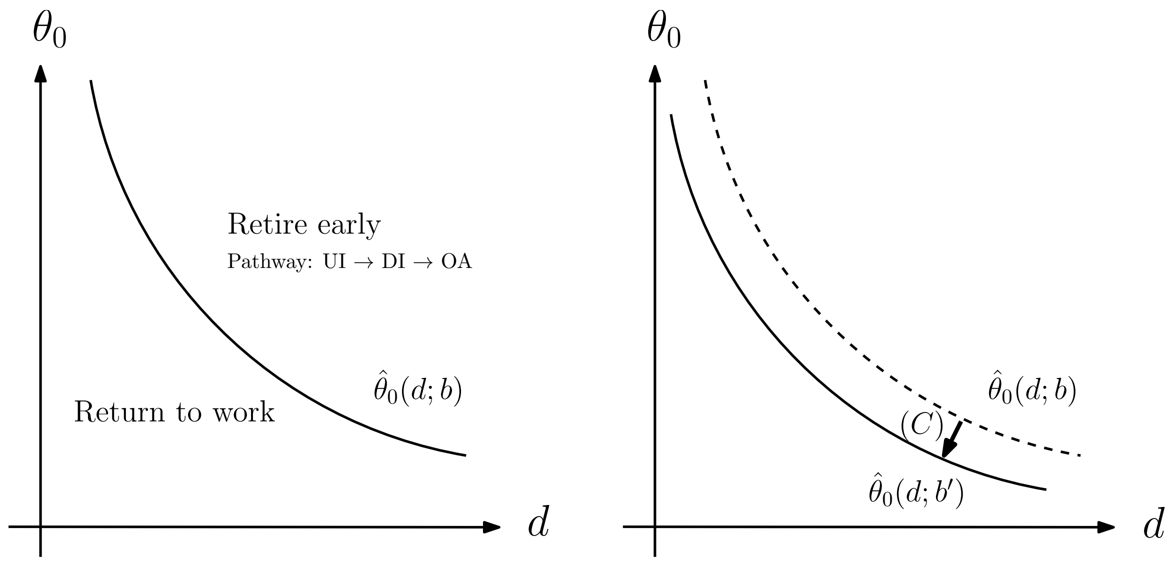

Figure 4: Left panel: Early retirement threshold $\hat{\theta}_0(d;b)$ in $t = 0$. Right panel: Program complementarity effects (C) when unemployment benefits increase from b to b'.

Table 2: Sample statistics in TRs and CRs before, during, and after REBP

	Before REBP		During REBP		After REBP	
	CRs	TRs	CRs	TRs	CRs	TRs
Exit destinations (%)						
Early retirement	33.7	41.5	44.1	75.4	47.9	56.8
Disability pension	22.4	29.7	30.2	45.7	33.0	42.1
Old-age pension	9.8	9.8	11.5	26.6	11.7	11.4
Censored	1.5	2.0	2.4	3.2	3.2	3.3
Background characteristics						
Age at UI entry	53.5	53.4	53.3	53.6	53.5	53.5
Sick days	113	117	112	93	97	101
Married	0.752	0.777	0.753	0.807	0.759	0.770
Education						
Low	0.575	0.621	0.495	0.485	0.429	0.455
Medium	0.356	0.336	0.404	0.436	0.443	0.444
High	0.070	0.043	0.101	0.079	0.128	0.101
Daily wage	56.6	54.5	63.7	69.4	68.9	68.2
Blue collar	0.802	0.837	0.726	0.745	0.664	0.719
Experience (years)	11.3	11.3	11.1	11.8	11.2	11.2
Tenure (years)	3.1	3.1	3.6	5.1	4.1	4.3
Number of observations	10,677	2,578	24,287	9,049	16,669	4,054

Notes: "Before" denotes unemployment spells starting in January 1985 to December 1987. "During" denotes unemployment spells starting in June 1988 to July 1993 (December 1991 in TR1s). "After" denotes unemployment spells starting in August 1993 (January 1992 in TR1s) to December 1995. "Sick days" is the sum of days spent in sick leave prior to unemployment entry, "experience" denotes work experience in the last 13 years, and "tenure" refers to tenure in last job. Daily wage is adjusted for inflation.

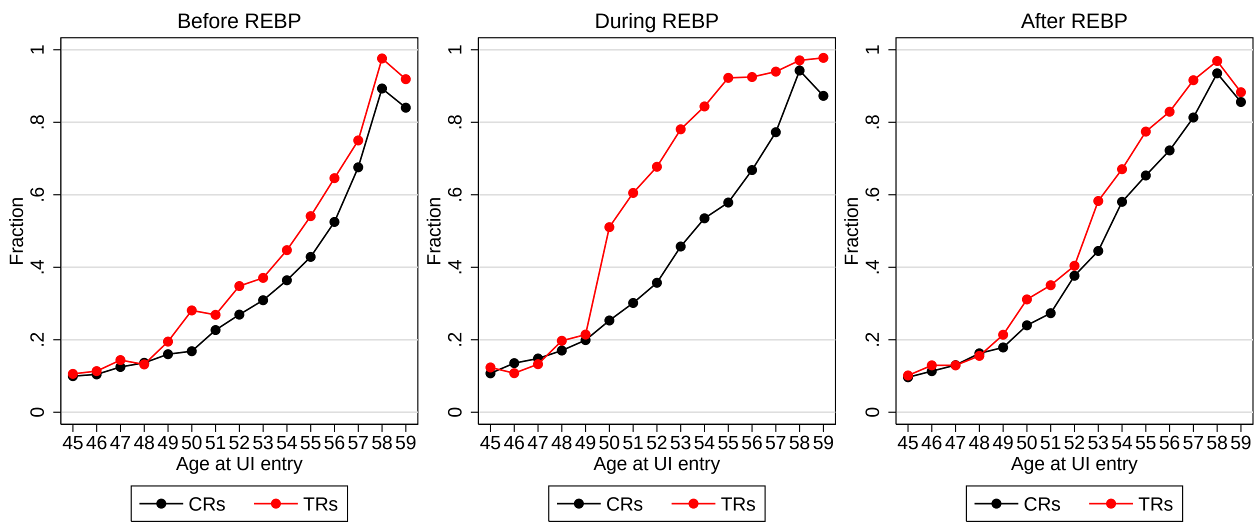

Figure 5: Transitions to early retirement by age in CRs and TRs before, during, and after REBP
Source: Own calculations, based on Austrian Social Security Data.

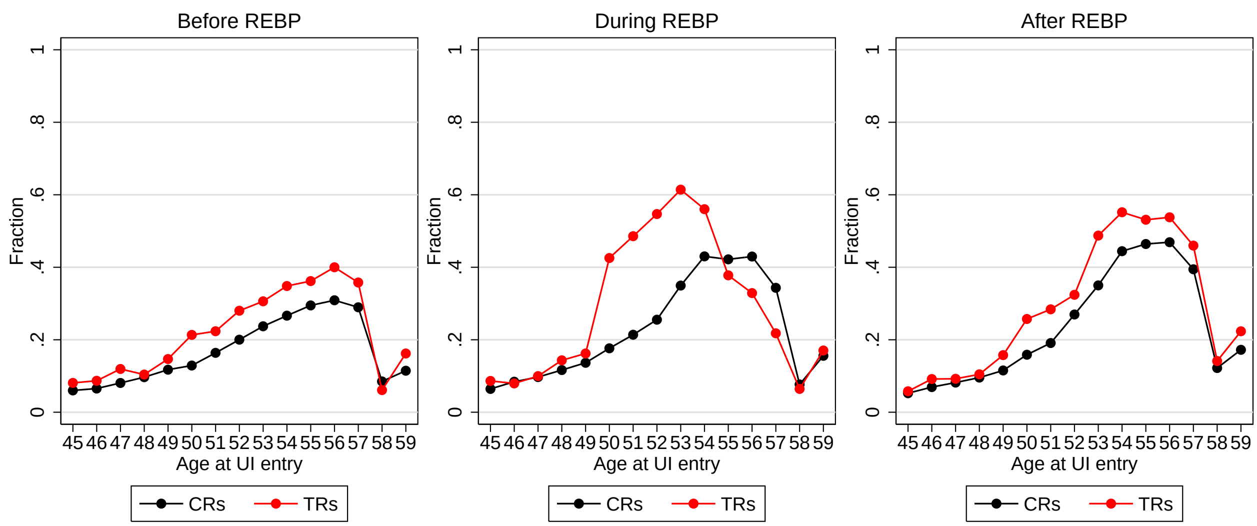

Figure 6: Transitions to disability pensions by age in CRs and TRs before, during, and after REBP

Source: Own calculations, based on Austrian Social Security Data.

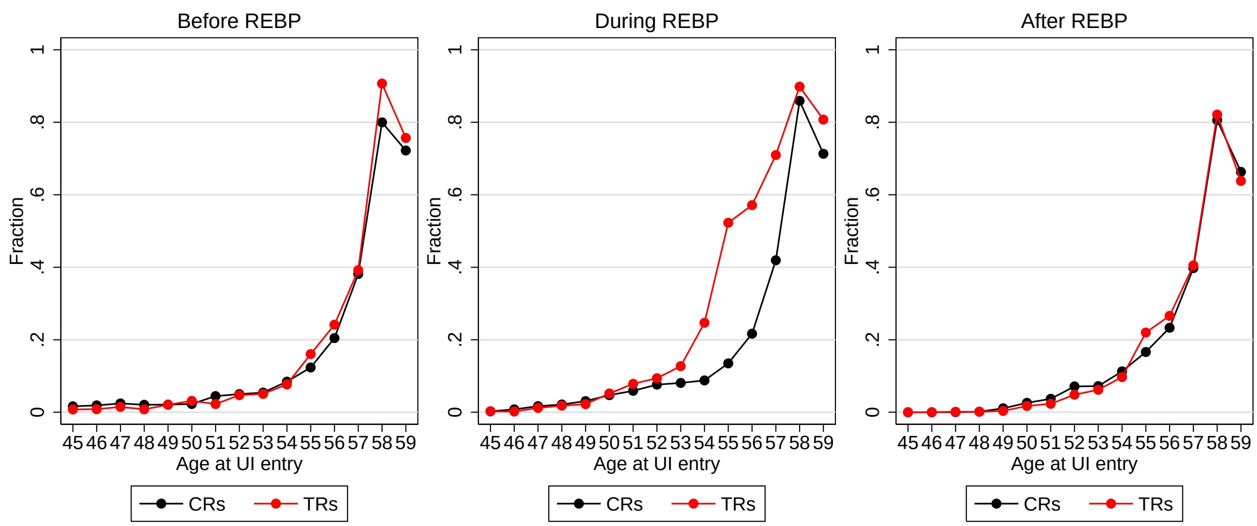

Figure 7: Transitions to old-age pensions by age in CRs and TRs before, during, and after REBP
Source: Own calculations, based on Austrian Social Security Data.

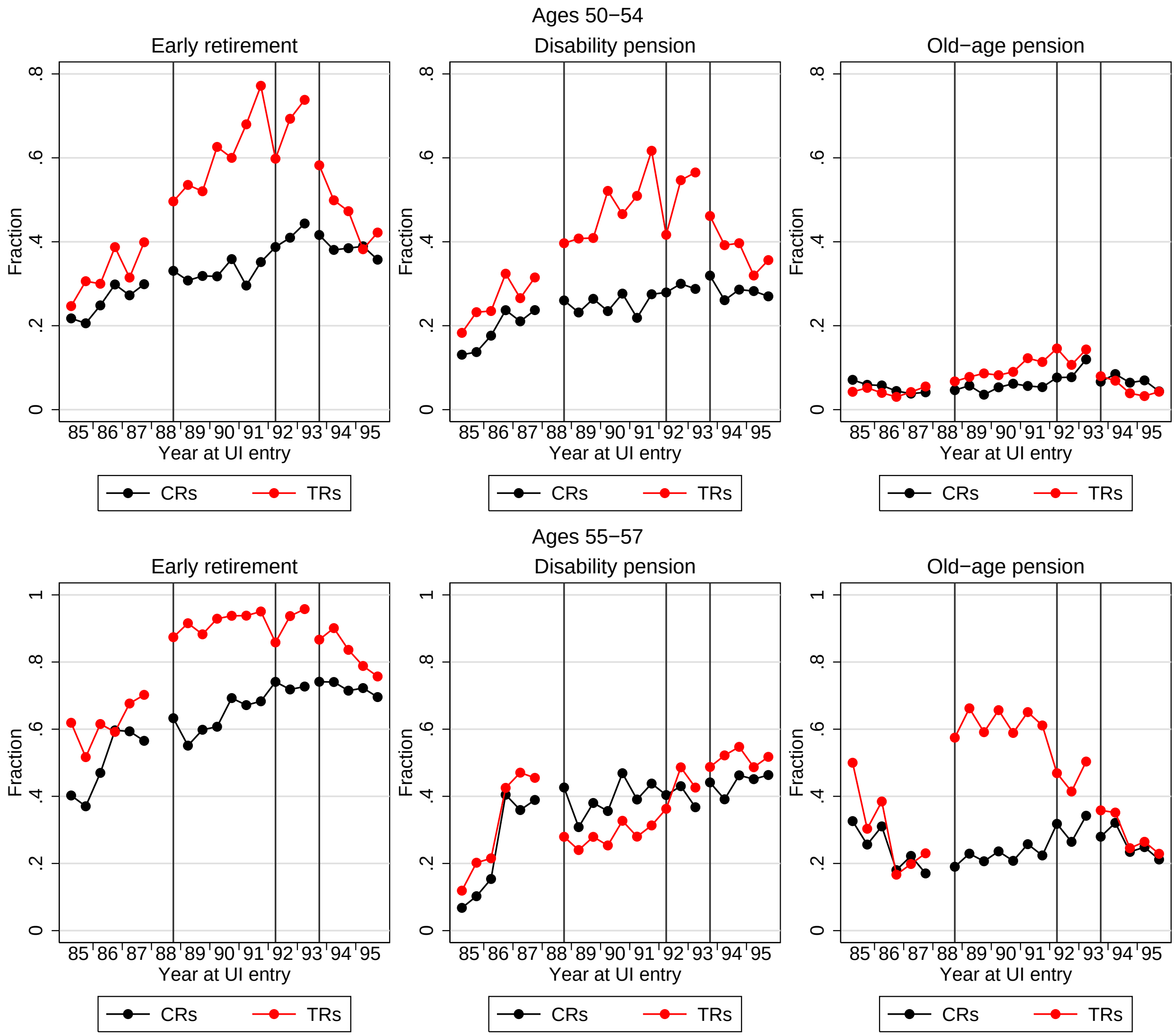

Figure 8: Trends in transitions to early retirement, disability pensions, and old-age pensions in CRs and TRs by year and age group

Source: Own calculations, based on Austrian Social Security Data.

Table 3: Average effect on unemployment exit of age groups 50-54 and 45-49

	Age 50-54			Age 45-49		
	Early retirement	Disability pension	Old-age pension	Early retirement	Disability pension	Old-age pension
REBP introduced	0.170***	0.126***	0.039*	-0.007	-0.008	0.004
($D \times TR$)	(0.022)	(0.028)	(0.022)	(0.012)	(0.011)	(0.004)
REBP abolished	-0.187***	-0.123***	-0.048***	0.006	0.002	0.003
($A \times TR$)	(0.017)	(0.022)	(0.013)	(0.010)	(0.008)	(0.003)
During	0.142***	0.127***	-0.008	0.024**	0.005	-0.022***
(D)	(0.019)	(0.014)	(0.014)	(0.012)	(0.008)	(0.005)
After	-0.008	0.005	-0.017*	-0.008	-0.004	-0.001
(A)	(0.012)	(0.013)	(0.010)	(0.008)	(0.007)	(0.002)
TRs 1	0.014	0.025	-0.014	-0.009	0.010	-0.010**
($TR1$)	(0.037)	(0.036)	(0.014)	(0.014)	(0.014)	(0.004)
TRs 2	0.081***	0.080***	-0.006	0.003	0.016	-0.008*
($TR2$)	(0.019)	(0.022)	(0.013)	(0.012)	(0.012)	(0.005)
R^2	0.194	0.144	0.084	0.133	0.103	0.011
Mean in TRs pre-REBP	0.336	0.269	0.044	0.079	0.061	0.017
No. of Obs.	48,666	48,666	48,666	63,689	63,689	63,689

Notes: The Table reports coefficients from a linear probability model. Standard errors adjusted for clustering within labor market regions. Controls: marital status, education, last annual wage, unemployment, blue collar status, employment history, tenure in last job, previous industry, age, year and quarter of inflow. Significance levels: *** = 1%, ** = 5%, * = 10%.

Table 4: Average effect on unemployment exit of age groups 55-57 and 58-59

	Age 55-57			Age 58-59		
	Early retirement	Disability pension	Old-age pension	Early retirement	Disability pension	Old-age pension
REBP introduced	0.108***	-0.127***	0.231***	-0.017	0.001	-0.019
($D \times TR$)	(0.029)	(0.046)	(0.042)	(0.012)	(0.015)	(0.021)
REBP abolished	-0.101***	0.134***	-0.240***	-0.018	0.038*	-0.055**
($A \times TR$)	(0.019)	(0.022)	(0.023)	(0.013)	(0.023)	(0.028)
During	0.242***	0.377***	-0.146***	0.452***	0.199***	0.237***
(D)	(0.054)	(0.035)	(0.048)	(0.079)	(0.029)	(0.074)
After	0.025	0.000	0.020	-0.004	-0.010	0.008
(A)	(0.018)	(0.023)	(0.025)	(0.014)	(0.015)	(0.019)
TRs 1	0.071**	0.065	0.009	0.061***	-0.050*	0.112***
($TR1$)	(0.031)	(0.056)	(0.052)	(0.020)	(0.026)	(0.034)
TRs 2	0.094***	0.048	0.046	0.045***	-0.001	0.046
($TR2$)	(0.030)	(0.042)	(0.039)	(0.014)	(0.020)	(0.028)
R^2	0.204	0.079	0.250	0.141	0.087	0.169
Mean in TRs pre-REBP	0.632	0.374	0.249	0.971	0.070	0.893
No. of Obs.	18,648	18,648	18,648	11,501	11,501	11,501

Notes: The Table reports coefficients from a linear probability model. Standard errors adjusted for clustering within labor market regions. Controls: marital status, education, last annual wage, unemployment, blue collar status, employment history, tenure in last job, previous industry, age, year and quarter of inflow. Significance levels: *** = 1%, ** = 5%, * = 10%.

Table 5: Difference-in-difference matching

	Age 50-54			Age 55-57		
	Early retirement	Disability pension	Old-age pension	Early retirement	Disability pension	Old-age pension
REBP introduced	0.165***	0.128***	0.031**	0.113***	-0.186***	0.284***
	(0.021)	(0.020)	(0.013)	(0.023)	(0.038)	(0.038)
REBP abolished	-0.166***	-0.102***	-0.044***	-0.112***	0.115***	-0.233***
	(0.012)	(0.013)	(0.007)	(0.017)	(0.023)	(0.021)

Notes: Estimation based on the approach by Blundell et al. (2004). Radius matching with a radius of 0.02. Propensity score estimated with a probit model. Controls: marital status, education, last annual wage, unemployment, blue collar status, employment history, tenure in last job, previous industry, age, and quarter of inflow. Significance levels: *** = 1%, ** = 5%, * = 10%.

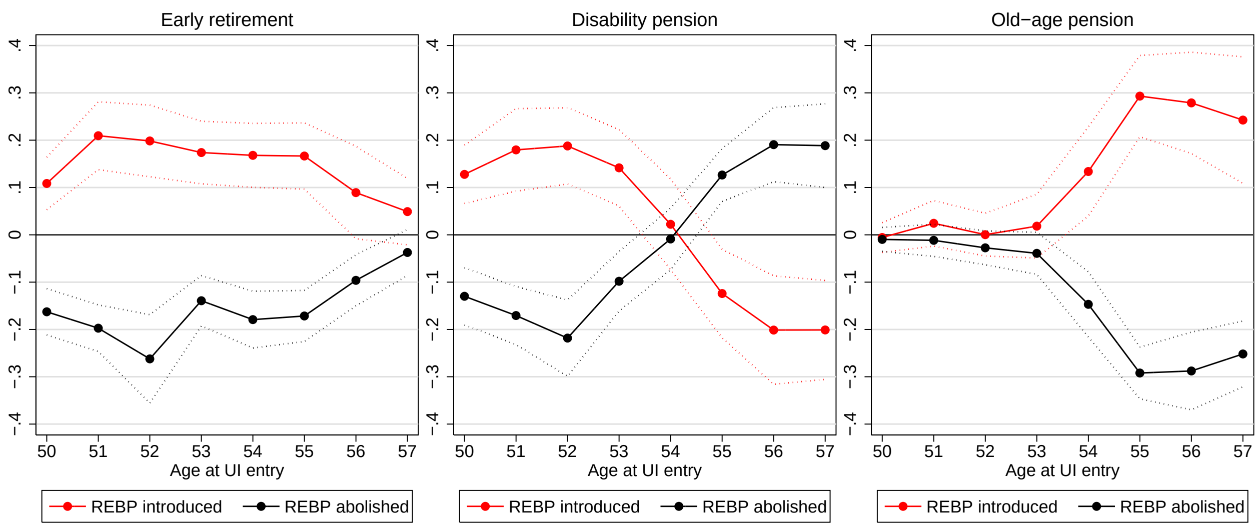

Figure 9: Coefficients of the interactions $(d_{ijt} \times D_t \times TR_i)$ and $(d_{ijt} \times A_t \times TR_i)$ in equation (8) for transitions to early retirement, disability pensions, and old-age pensions (dotted lines represent 95-percent confidence interval).

Source: Own calculations, based on Austrian Social Security Data.

Table 6: Exit to disability pensions for age group 50-54

	Exit age 50-54	Exit Age 55+
REBP introduced	-0.025**	0.151***
$(D \times TR)$	(0.011)	(0.026)
REBP abolished	0.013	-0.136***
$(A \times TR)$	(0.008)	(0.023)
During	0.038***	0.090***
(D)	(0.010)	(0.013)
After	-0.018**	0.023**
(A)	(0.009)	(0.011)
TRs 1	0.013	0.012
$(TR1)$	(0.017)	(0.024)
TRs 2	0.026**	0.054***
$(TR2)$	(0.013)	(0.017)
R^2	0.035	0.155
Mean in TRs pre-REBP	0.100	0.169
No. of Obs.	48,666	48,666

Notes: The Table reports coefficients from a linear probability model. Standard errors adjusted for clustering within labor market regions. Controls: marital status, education, last annual wage, unemployment, blue collar status, employment history, tenure in last job, previous industry, and quarter of inflow. Significance levels: *** = 1%, ** = 5%, * = 10%.

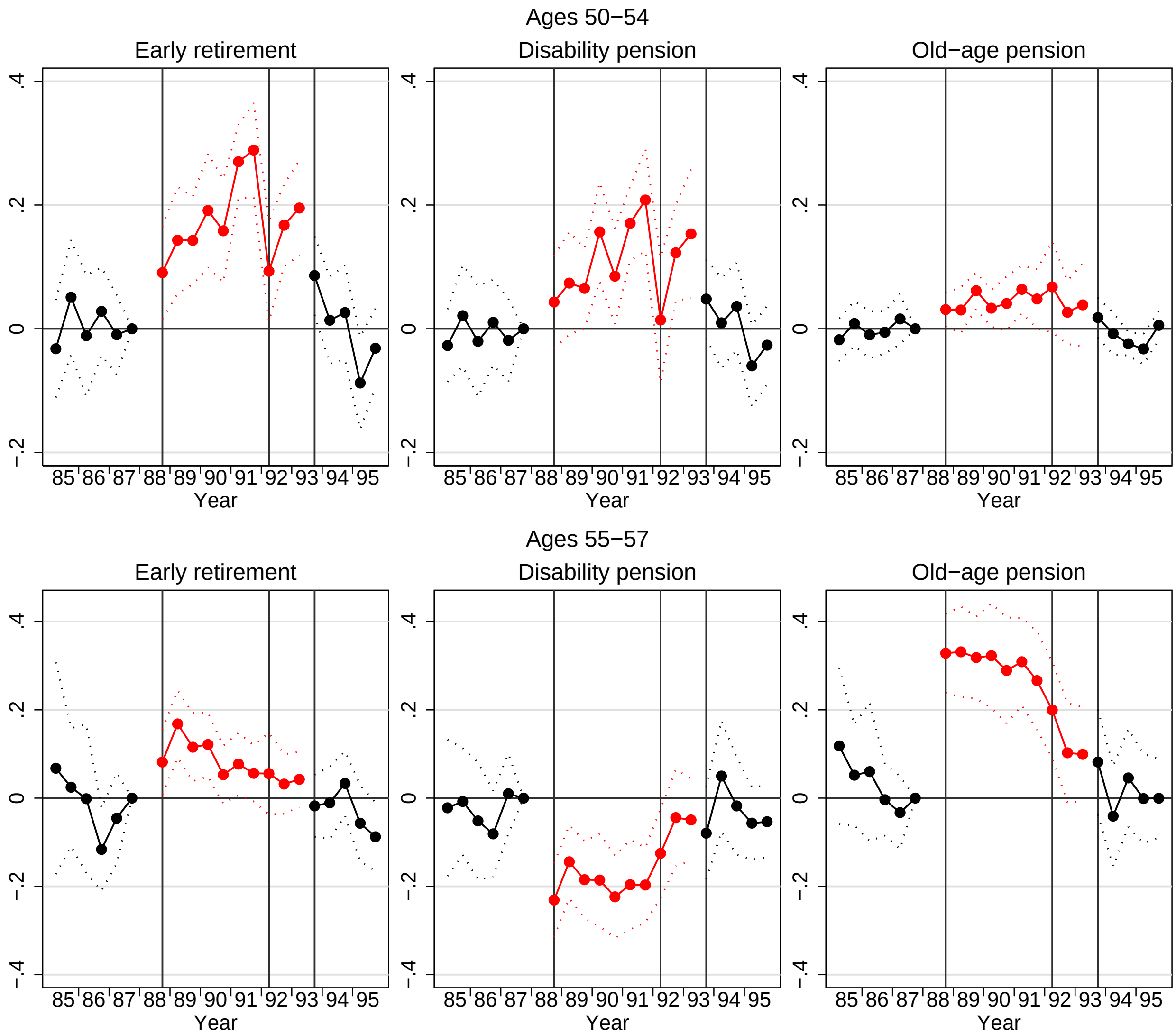

Figure 10: Coefficients of the interactions $(d_{ijt} \times D_t \times TR_i)$ and $(d_{ijt} \times A_t \times TR_i)$ in equation (9) for transitions to early retirement, disability pensions, and old-age pensions by age group (dotted lines represent 95-percent confidence interval).

Source: Own calculations, based on Austrian Social Security Data.

Table 7: Effects for unemployed who live within 30 minutes driving time to the border

	Age 50-54			Age 55-57		
	Early retirement	Disability pension	Old-age pension	Early retirement	Disability pension	Old-age pension
REBP introduced	0.167***	0.099**	0.066***	0.084**	-0.131**	0.203***
($D \times TR$)	(0.032)	(0.046)	(0.024)	(0.032)	(0.058)	(0.048)
REBP abolished	-0.176***	-0.116***	-0.058***	-0.082***	0.140***	-0.220***
($A \times TR$)	(0.026)	(0.032)	(0.014)	(0.022)	(0.030)	(0.026)
During	0.121***	0.114***	-0.015	0.333***	0.465***	-0.129
(D)	(0.035)	(0.037)	(0.019)	(0.047)	(0.083)	(0.079)
After	0.019	0.029	-0.010	0.029	0.000	0.019
(A)	(0.025)	(0.025)	(0.013)	(0.035)	(0.054)	(0.054)
TRs 1	-0.012	-0.007	-0.008	0.051	0.012	0.039
($TR1$)	(0.041)	(0.037)	(0.014)	(0.035)	(0.050)	(0.048)
TRs 2	0.056**	0.054	-0.006	0.092***	0.032	0.065
($TR2$)	(0.028)	(0.032)	(0.015)	(0.032)	(0.061)	(0.051)
R^2	0.215	0.142	0.088	0.230	0.095	0.269
Mean in TRs pre-REBP	0.317	0.253	0.039	0.599	0.347	0.242
No. of Obs.	12,057	12,057	12,057	4,953	4,953	4,953

Notes: The Table reports coefficients from a linear probability model. Standard errors adjusted for clustering within labor market regions. Controls: marital status, education, last annual wage, unemployment, blue collar status, employment history, tenure in last job, previous industry, age, year and quarter of inflow. Significance levels: *** = 1%, ** = 5%, * = 10%.

Table 8: Effects for unemployed whose last job was in the tradable goods sector

	Age 50-54			Age 55-57		
	Early retirement	Disability pension	Old-age pension	Early retirement	Disability pension	Old-age pension
REBP introduced	-0.183***	0.138***	0.037	-0.054	-0.171***	0.234***
($D \times TR$)	(0.033)	(0.038)	(0.030)	(0.035)	(0.052)	(0.057)
REBP abolished	0.212***	-0.150***	-0.040***	0.105***	0.134***	-0.239***
($A \times TR$)	(0.024)	(0.029)	(0.015)	(0.018)	(0.029)	(0.032)
During	-0.146***	0.128***	-0.010	-0.193***	0.374***	-0.198***
(D)	(0.036)	(0.024)	(0.026)	(0.054)	(0.053)	(0.071)
After	0.021	0.011	-0.032**	-0.019	0.009	0.007
(A)	(0.019)	(0.019)	(0.016)	(0.021)	(0.036)	(0.038)
TRs 1	-0.018	0.041	-0.018	-0.121***	0.094	0.022
($TR1$)	(0.063)	(0.057)	(0.022)	(0.039)	(0.081)	(0.079)
TRs 2	-0.092***	0.095***	-0.006	-0.120***	0.081*	0.029
($TR2$)	(0.030)	(0.031)	(0.021)	(0.036)	(0.045)	(0.047)
R^2	0.207	0.160	0.100	0.159	0.088	0.202
Mean in TRs pre-REBP	0.415	0.325	0.067	0.796	0.440	0.340
No. of Obs.	22,563	22,563	22,563	8,941	8,941	8,941

Notes: The Table reports coefficients from a linear probability model. Standard errors adjusted for clustering within labor market regions. Controls: marital status, education, last annual wage, unemployment, blue collar status, employment history, tenure in last job, previous industry, age, year and quarter of inflow. Significance levels: *** = 1%, ** = 5%, * = 10%.

Table 9: Effects for unemployed with low-tenure

	Age 50-54			Age 55-57		
	Early retirement	Disability pension	Old-age pension	Early retirement	Disability pension	Old-age pension
REBP introduced	-0.166***	0.129***	0.033*	-0.134***	-0.097**	0.229***
($D \times TR$)	(0.024)	(0.030)	(0.018)	(0.033)	(0.042)	(0.039)
REBP abolished	0.180***	-0.123***	-0.042***	0.111***	0.135***	-0.256***
($A \times TR$)	(0.020)	(0.025)	(0.012)	(0.023)	(0.025)	(0.023)
During	-0.134***	0.132***	-0.018*	-0.283***	0.407***	-0.129***
(D)	(0.018)	(0.016)	(0.010)	(0.055)	(0.040)	(0.042)
After	-0.001	-0.007	0.002	-0.035	-0.006	0.027
(A)	(0.012)	(0.013)	(0.007)	(0.024)	(0.030)	(0.025)
TRs 1	-0.009	0.015	-0.010	-0.071**	0.049	0.022
($TR1$)	(0.035)	(0.034)	(0.011)	(0.034)	(0.052)	(0.043)
TRs 2	-0.080***	0.072***	-0.001	-0.098***	0.029	0.068*
($TR2$)	(0.019)	(0.020)	(0.009)	(0.033)	(0.043)	(0.038)
R^2	0.165	0.131	0.048	0.180	0.079	0.226
Mean in TRs pre-REBP	0.415	0.325	0.067	0.550	0.335	0.207
No. of Obs.	36,485	36,485	36,485	13,983	13,983	13,983

Notes: The Table reports coefficients from a linear probability model. Standard errors adjusted for clustering within labor market regions. Controls: marital status, education, last annual wage, unemployment, blue collar status, employment history, tenure in last job, previous industry, age, year and quarter of inflow. Significance levels: *** = 1%, ** = 5%, * = 10%.

Table 10: Early-retirement elasticities

	Estimated elasticities
$\varepsilon_0^c = \pi_0^{U,c}/(b/\pi_0^U)$	$0.13/(0.52-0.42)/(0.42/0.27) = 2.02$
$\varepsilon_1^c = \pi_1^{U,c}/(b/\pi_1^U)$	$0.10/(0.52-0.42)/(0.42/0.25) = 1.68$
$\varepsilon_1^s = \pi_1^{U,s}/(b/\pi_1^U)$	$-0.13/(0.52-0.42)/(0.42/0.37) = -1.48$

Notes: Early-retirement treatment effects are taken from Table 3 (= 0) and Table 4 ($t = 1$). Note that in $t = 1$, the 55-57 estimates are taken (hence the SIS program at 59 is ignored) and, in line with Chapter 3, we elicit the complementarity effect (0.10) by subtracting disability pension exit (0.13) from old-age pension exit (0.23).

Table 11: Financial gains/losses of program switcher

	Estimated financial impacts
$\hat{\Delta}_0^c \approx RR(b) + \hat{\tau} + \mathbb{E}\mathcal{N}_1$	$0.42 + 0.14 + 0.42 = 0.98$
$\hat{\Delta}_1^c = RR(b) + \hat{\tau}$	$0.42 + 0.14 = 0.56$
$\hat{\Delta}_1^s = RR(\overline{d}_1^D + \overline{p}_1^D) - RR(b + \overline{p}_1^U)$	$(1 + 3.4) \times 0.8 - 0.42 - 3.4 \times 1.1 \times 0.8 = 0.11$

Notes: All pension benefits are stated in after tax replacement rates with $RR(x) = x/(w - \tau)$ denoting the corresponding operator. Similarly, after tax contribution rates are adjusted by $\hat{\tau} = \tau/(1 - \tau) = 0.14$. Finally, the required values in equation (12) can be obtained by the equivalence $\hat{\Delta}_t^i/RR(b) \equiv \Delta_t^i/b$. $\mathbb{E}\mathcal{N}_1$ denotes the expected net payments in $t = 1$ which is approximated by $\mathbb{E}\mathcal{N}_1 \approx \left(1 - q^u \pi_1^W\right)\left(d + p^D + \tau - p^W\right) = (1 - 0.6 \cdot 0.63)(0.8 + 3.4 \cdot 0.8 + 0.14 - 3.4 \cdot 0.8 \cdot 1.1) = 0.42$.