Online Appendix:
Extended Unemployment Benefits and Early Retirement: Program Complementarity and Program Substitution

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A Additional Tables

Table A.1: Exit to early retirement with DI for age group 50-54

	DI-entry at age 50-54	DI-entry at age 55+
During REBP	-0.014**	0.117***
($D \times TR$)	(0.006)	(0.017)
Mean TRs pre-REBP	0.084	0.133
R^2	0.057	0.172
No. of observations	58,343	58,343

Notes: The Table reports coefficients from a linear probability model. Standard errors adjusted for clustering within labor market districts. Control variables: log previous wage, dummies for marital status, dummies for education, dummies for weeks of UI eligibility (20, 30, 39, 52 weeks), blue-collar status at last job, work experience in last 13 years, years of service in last job, number of days receiving sick leave benefits prior to UI entry, dummies for previous industry, age-in-year dummies, dummies for year-month of unemployment entry, dummy for spells that start within 30 weeks before REBP introduction, and dummies for labor market districts. Significance levels: *** = 1%, ** = 5%, * = 10%.

Table A.2: Heterogeneous effects on unemployment exit by generosity of DI pensions and health status for unemployed men

	Age 50-54			Age 55-57		
	Early retirement	Early retirement with DI	Early retirement without DI	Early retirement	Early retirement with DI	Early retirement without DI
A. Low versus high DI pension						
During REBP	0.110***	0.068***	0.042***	0.126***	-0.130***	0.256***
	(0.013)	(0.014)	(0.010)	(0.020)	(0.019)	(0.022)
During REBP× (DI pension>median)	0.070***	0.064***	0.006	-0.003	0.046**	-0.050**
	(0.023)	(0.023)	(0.009)	(0.022)	(0.019)	(0.020)
Mean TRs pre-REBP	0.252	0.217	0.035	0.505	0.315	0.190
R^2	0.205	0.177	0.091	0.258	0.140	0.321
No. of observations	58,343	58,343	58,343	23,294	23,294	23,294
B. Healthy versus sick						
During REBP	0.151***	0.101***	0.049***	0.146***	-0.092***	0.238***
	(0.016)	(0.019)	(0.012)	(0.018)	(0.019)	(0.025)
During REBP× (sick leave days>0)	-0.002	0.011	-0.013	-0.048**	-0.021	-0.027
	(0.016)	(0.016)	(0.009)	(0.021)	(0.020)	(0.019)
Mean TRs pre-REBP	0.252	0.217	0.035	0.505	0.315	0.190
R^2	0.205	0.180	0.091	0.260	0.146	0.322
No. of observations	58,343	58,343	58,343	23,294	23,294	23,294

Notes: The Table reports coefficients from a linear probability model. Standard errors adjusted for clustering within labor market districts. "DI pension>0" is equal to one if the expected DI pension is above the median and zero otherwise. "Sick leave days>0" is equal to one if the number of sick leave days in the year before UI entry is positive and zero otherwise. Controls: log previous wage, dummies for marital status, dummies for education, dummies for weeks of UI eligibility (20, 30, 39, 52 weeks), blue-collar status at last job, work experience in last 13 years, years of service in last job, number of days receiving sick leave benefits prior to UI entry, dummies for previous industry, age-in-year dummies, dummies for year-month of unemployment entry, dummy for spells that start within 30 weeks before REBP introduction, and dummies for labor market districts. Significance levels: *** = 1%, ** = 5%, * = 10%.

Table A.3: Effects on other labor supply measures of unemployed men in the age groups 50-54 and 55-57

	Pr(claim UA)	Years working	Earnings	Claiming age DI or old age pension
A. Age 50-54				
During REBP	-0.084***	-0.723***	-15,728***	0.293***
$(D \times TR)$	(0.018)	(0.099)	(2,723)	(0.083)
Mean TRs pre-REBP	0.253	2.871	56,857	57.640
R^2	0.220	0.222	0.215	0.174
No. of observations	58,343	42,899	42,899	42,899
B. Age 55-57				
During REBP	-0.195***	-0.363***	-8,570***	0.590***
$(D \times TR)$	(0.028)	(0.066)	(1,463)	(0.087)
Mean TRs pre-REBP	0.236	0.949	21,205	58.839
R^2	0.254	0.203	0.185	0.212
No. of observations	23,294	15,175	15,175	15,175

Notes: The Table reports the impact of the REBP on different measures of labor supply. "Pr(claim UA)" is an indicator for whether an individual receives UA benefits during the unemployment spell, "years working" is the number of years spent working until age 65, and "earnings" measures the total earnings until age 65 in 2014 Euros. Future earnings are discounted using an interest rate of 2.5%. Standard errors adjusted for clustering within labor market districts. Controls: log previous wage, dummies for marital status, dummies for education, dummies for weeks of UI eligibility (20, 30, 39, 52 weeks), blue-collar status at last job, work experience in last 13 years, years of service in last job, number of days receiving sick leave benefits prior to UI entry, dummies for previous industry, age-in-year dummies, dummies for year-month of unemployment entry, dummy for spells that start within 30 weeks before REBP introduction, and dummies for labor market districts. Significance levels: *** = 1%, ** = 5%, * = 10%.

Table A.4: Effects on pathway costs for unemployed men in the age groups 50-54 and 55-57

	Age 50-54			Age 55-57		
	Return to work	Early retirement with DI	Early retirement without DI	Return to work	Early retirement with DI	Early retirement without DI
During REBP	-22,106***	27,538***	7,541***	-21,766***	-19,278***	50,435***
($D \times TR$)	(2,230)	(4,812)	(2,493)	(3,248)	(5,614)	(7,513)
Mean TRs pre-REBP	90,105	31,653	7,141	66,314	54,962	42,666
R^2	0.137	0.207	0.105	0.223	0.144	0.350
No. of observations	42,899	42,899	42,899	15,175	15,175	15,175

Notes: Return to work, early retirement with DI, and early retirement without DI measure the total government net expenditures for an unemployed men until age 78 if he returns to work after the UI spell, retires early with DI, and retires early without DI, respectively. All amounts are in 2014 Euros. Future benefits and taxes are discounted using an interest rate of 2.5%. Standard errors adjusted for clustering within labor market districts. Controls: log previous wage, dummies for marital status, dummies for education, dummies for weeks of UI eligibility (20, 30, 39, 52 weeks), blue-collar status at last job, work experience in last 13 years, years of service in last job, number of days receiving sick leave benefits prior to UI entry, dummies for previous industry, age-in-year dummies, dummies for year-month of unemployment entry, dummy for spells that start within 30 weeks before REBP introduction, and dummies for labor market districts. Significance levels: *** = 1%, ** = 5%, * = 10%.

B Additional Figures

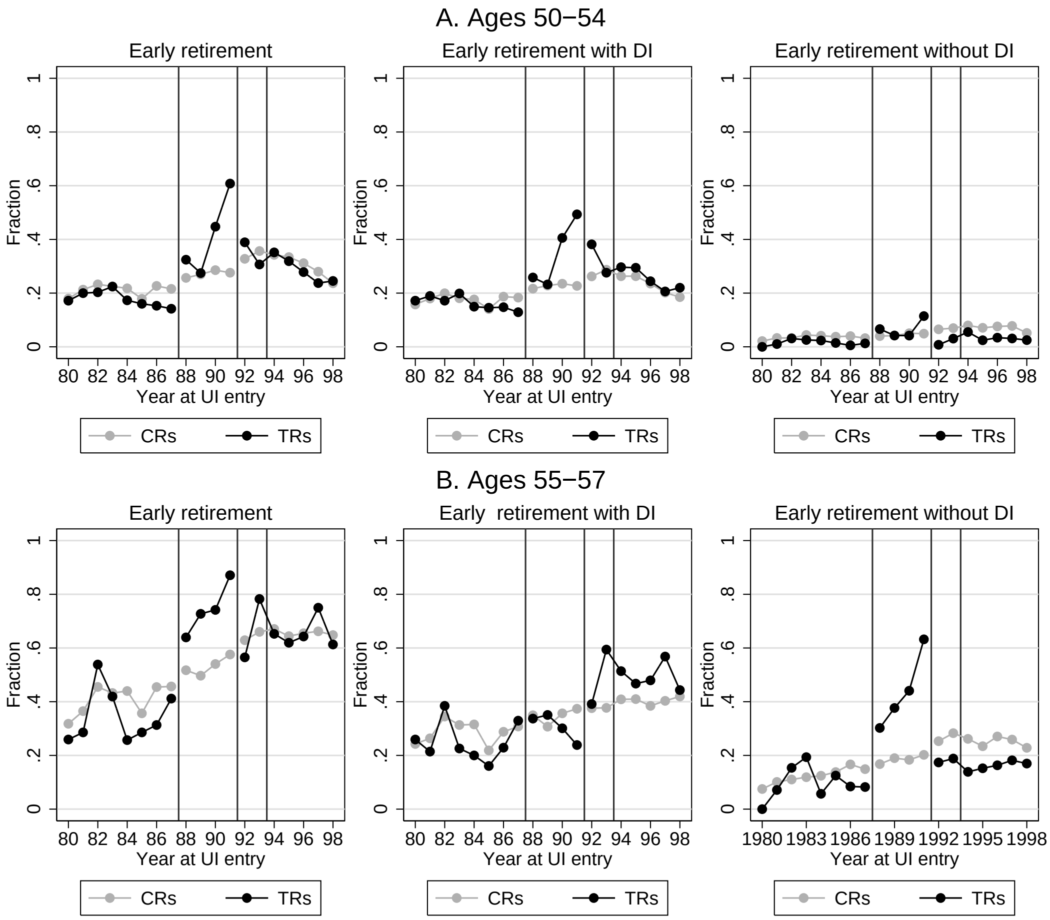


Figure B.1: Trends in transitions into early retirement, early retirement with DI, and early retirement without DI in TR1s and CRs by year and age group

Notes: First vertical line denotes the date when the REBP was implemented. The second and the third vertical line denote the dates when the REBP was abolished in TR1s and TR2s, respectively.

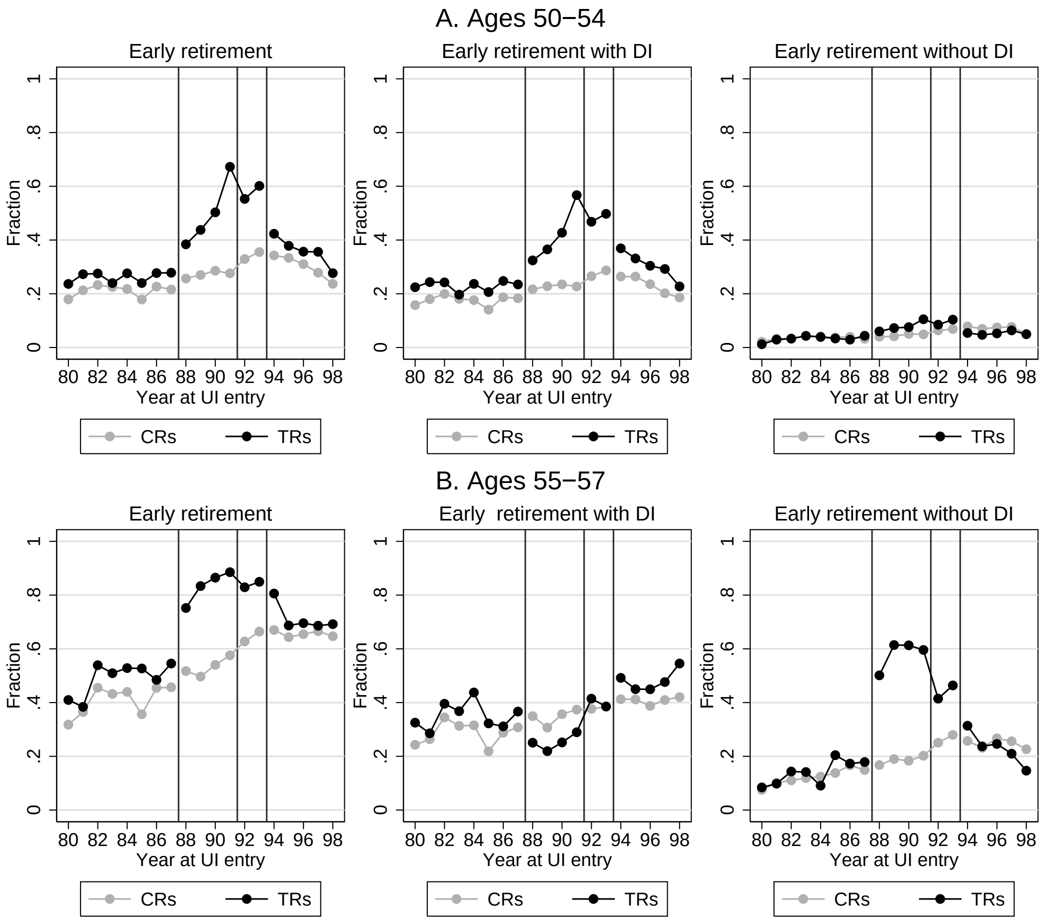


Figure B.2: Trends in transitions into early retirement, early retirement with DI, and early retirement without DI in TR2s and CRs by year and age group

Notes: First vertical line denotes the date when the REBP was implemented. The second and the third vertical line denote the dates when the REBP was abolished in TR1s and TR2s, respectively.

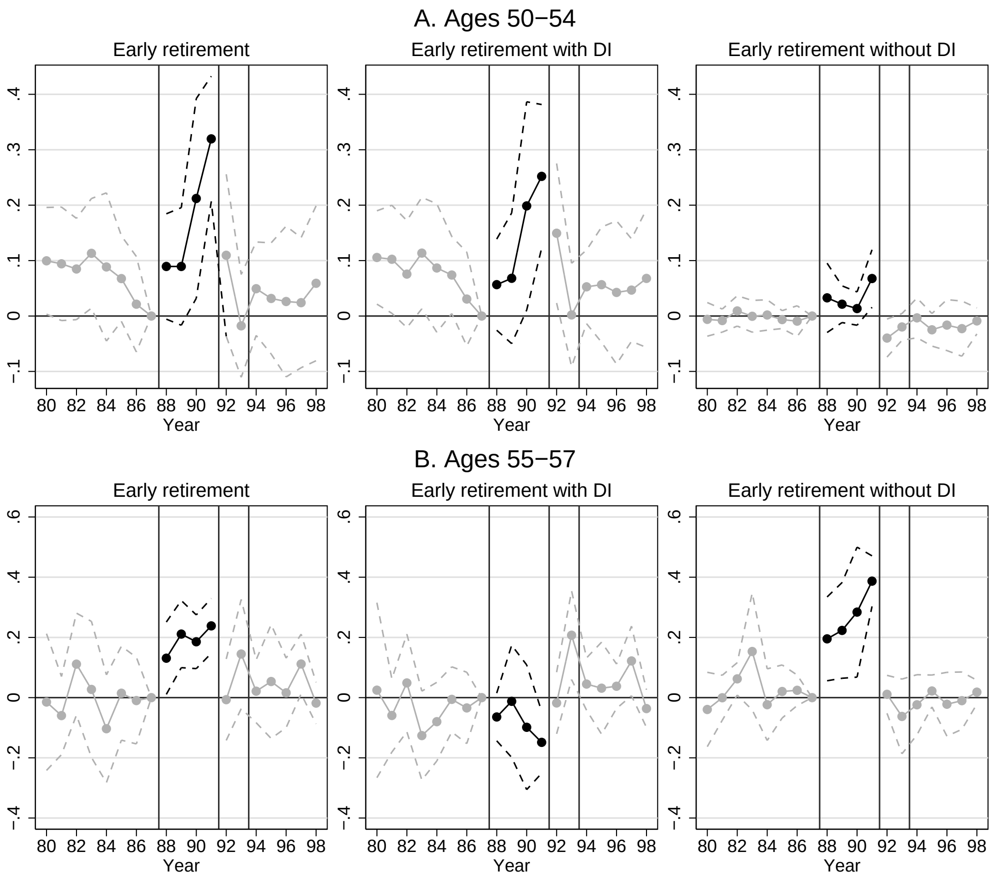


Figure B.3: Coefficients of the interactions $(d_{jt} \times TR_i)$ in equation (2) by age group, TR1s.

Notes: The dashed lines represent a 95% confidence interval. First vertical line denotes the date when the REBP was implemented. The second and the third vertical line denote the dates when the REBP was abolished in TR1s and TR2s, respectively.

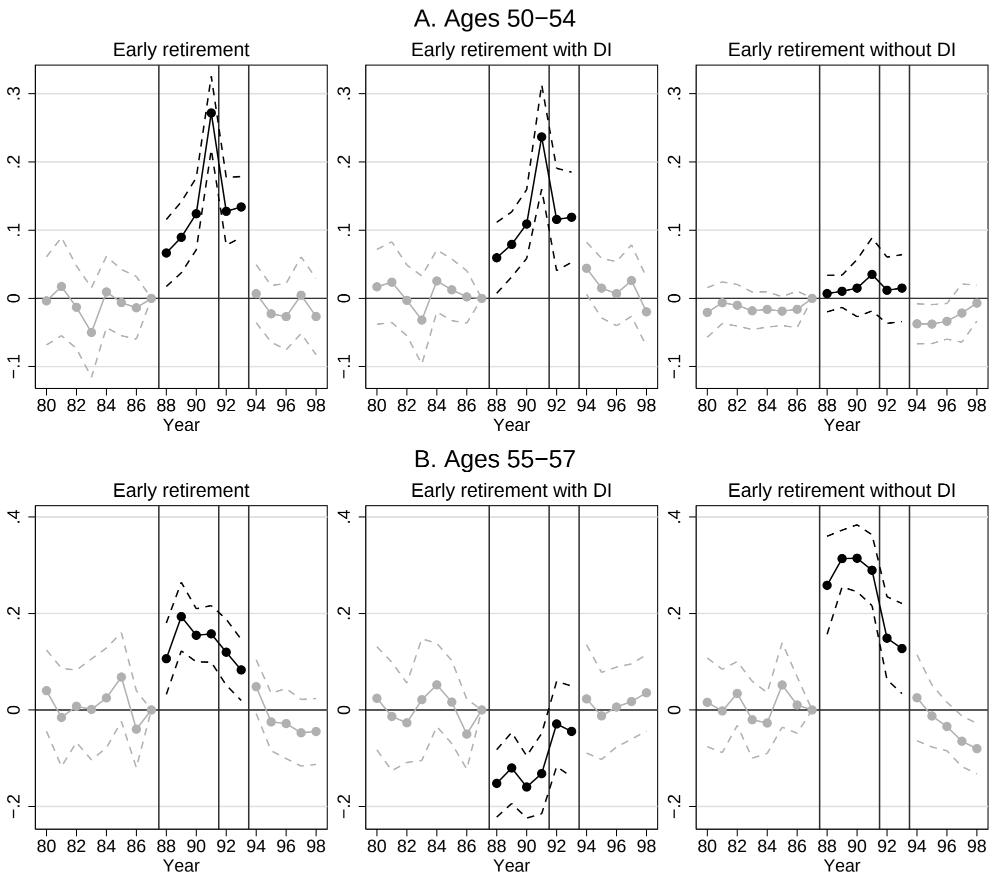


Figure B.4: Coefficients of the interactions ($d_{jt} \times TR_i$) in equation (2) by age group, TR2s

Notes: The dashed lines represent a 95% confidence interval. First vertical line denotes the date when the REBP was implemented. The second and the third vertical line denote the dates when the REBP was abolished in TR1s and TR2s, respectively.

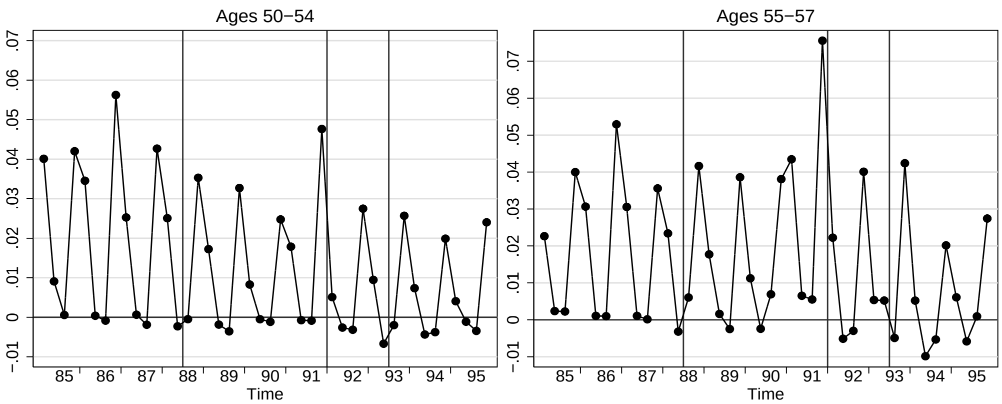


Figure B.5: Regional difference in quarterly unemployment inflow rate (% of employment) by age group, TR1s.

Notes: First vertical line denotes the date when the REBP was implemented. The second and the third vertical line denote the dates when the REBP was abolished in TR1s and TR2s, respectively.

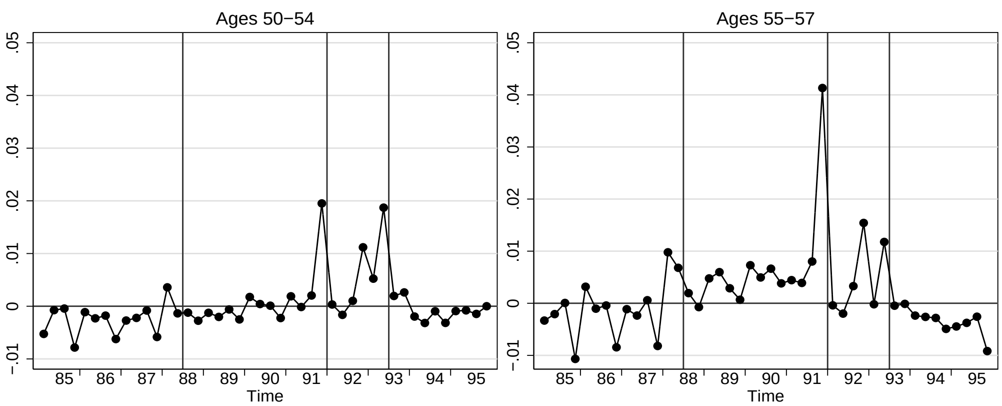


Figure B.6: Regional difference in quarterly unemployment inflow rate (% of employment) by age group, TR2s.

Notes: First vertical line denotes the date when the REBP was implemented. The second and the third vertical line denote the dates when the REBP was abolished in TR1s and TR2s, respectively.

C Retirement Model and Welfare Analysis

The following sections outline the retirement model and welfare analysis discussed in Section V.We proceed in three steps. In Section C.1 we derive a simple retirement model and discuss substitution and complementarity effects triggered by the REBP. Second, we discuss the social planner's optimization problem and derive the sufficient statistic (3) in Section C.2.[1]

C.1 The Retirement Decision

Suppose the worker's remaining lifetime consists of two working periods, $t = 0$ and $t = 1$, and a retirement period, $t = 2$.[2] Periods 0 and 1 have length 1 and period 2 has length T. When losing the job at the beginning $t = 0, 1$, the individual either goes back to work immediately or retires early. During both periods, the worker can be in only one of three states: UI, DI, or working during each period. At the beginning of $t = 2$, all remaining workers retire and draw an old-age pension.

Displacement at $t = 1$. Consider a worker who gets displaced at the beginning of $t = 1$. If the worker goes back to work he earns income w. In order to find a job, a search cost $\theta_1 \sim F(\theta)$ has to be incurred. Alternatively, the worker may retire early at $t = 1$. Early retirement through the DI system yields a benefit d. Claiming a disability pension is associated with disutility κ. Early retirement through the UI system yields a benefit b (any costs associated with claiming UI benefits are normalized to zero).[3]

In $t = 2$ the worker draws an old-age pension p^W if entering from employment, p^D if entering from the DI system, and p^U if entering from the UI system. Ignoring time discounting, the lifetime utilities from going back to work, $W_1 - \theta_1$, retiring early by claiming a disability pension, D_1, and retiring early by claiming UI benefits, U_1, are given by:

$$W_1 - \theta_1 = u(w) - \theta_1 + Tu(p^W), \quad D_1 = u(d) - \kappa + Tu(p^D), \quad U_1 = u(b) + Tu(p^U).$$

[1] A more detailed derivation of the key reults is available upon request from the authors.

[2] Period $t = 0$ can be associated with ages 50-54, period $t = 1$ with ages 55-59, and period $t = 2$ with ages 60+. This captures the early retirement incentives of the Austrian system: extended UI benefits of the REBP become available at age 50; relaxed access to disability pensions at age 55, and regular old-age pensions at age 60.

[3] We think of the UI benefit b as the UI transfer when staying unemployed throughout one period; b is a weighted average of UI benefits b^u and UA benefits b^a with $b = \tau b^u + (1 - \tau)b^a$, where τ is the maximum duration of regular UI benefits b^u. Eligibility to the REBP is associated with an increase in τ from 0.2 (1 year of the 5-year period) to 0.8 (4 years of a 5-year period).

Assume that benefits d, p^D, p^U and p^W are related to each other in ways that capture the rules of the Austrian social security system. Hence, workers entering regular retirement directly from DI get an old-age pension equal to the previous disability pension in period 1, $p^D = d$. In contrast, unemployed and employed workers' old-age pension equals the (potential) disability pension in $t = 1$, augmented by some factor $\alpha > 1$, or $p^W = p^U = \alpha d$. Given these rules, heterogeneity in disability pensions and old-age pensions is captured by the parameter d. The following lemma describes optimal behavior given individual's location in (θ_1, d).

Lemma 1. *The worker will claim a disability pension rather than UI benefits, if the pension d is above the threshold $\hat{d}$. The worker will retire early rather than go back to work, if $\theta_1 \geq \hat{\theta}_1$, where $\hat{\theta}_1 = u(\omega) - u(b)$ if $d < \hat{d}$ and $\hat{\theta}_1(d) = W_1(d) - D_1(d)$ otherwise. Moreover, $\partial\hat{\theta}_1/\partial d \leq 0$ if $1 - (\alpha - 1)T \geq 0$.*

Proof. We proceed in two steps to derive the thresholds. First, we compute $\hat{d}$ as the implicit threshold value between claiming a DI pension (D_1) and claiming unemployment benefits (U_1), i.e. $u(b)+\kappa = u(\hat{d})-(u(\alpha\hat{d})-u(\hat{d}))T$. Next, we compare the value of working ($W_1 - \theta_1$) conditional on the best early retirement option, e.g. UI benefits if $d < \hat{d}$ and DI pension otherwise. This yields the $\hat{\theta}_1$-threshold:

$$\hat{\theta}_1 = \begin{cases} u(\omega) - u(b) & \text{if } d < \hat{d} \\ u(\omega) - u(d) + (u(\alpha d) - u(d))T + \kappa & \text{if } d \geq \hat{d} \end{cases}. \tag{1}$$

This function is constant over d for values $d < \hat{d}$ and decreasing in d for $d \geq \hat{d}$ because the implicit differentiation yields

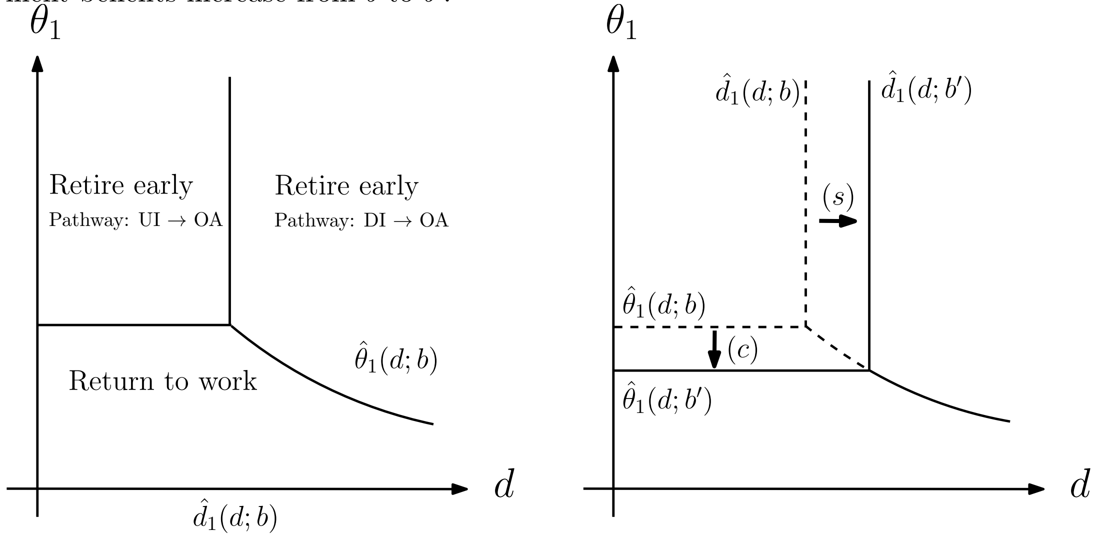
$$d\hat{\theta}_1/dd = -u'(d) + (\alpha u'(\alpha d) - u'(d))T < -u'(d)(1 - (\alpha - 1)T) < 0$$

if we assume $1 - (\alpha - 1)T \geq 0$. □

Figure C.1 illustrates individuals' optimal choices in $t = 1$ given their location in space. The critical value $\hat{d}$ simply represents the minimal pension d above which D_1 becomes larger than U_1. Notice that the threshold $\hat{\theta}_1$ is flat for $d < \hat{d}$, and decreases in d for $d \geq \hat{d}$. At low values of d, early retirement occurs through the UI system rather than the DI system, hence the level of the disability pension is irrelevant for the early retirement decision. However, at high values of d, early retirement occurs via the DI system and individuals with a higher disability pension are more likely to retire early.[4]

[4] A sufficient condition for a negative slope is $1-(\alpha-1)T \geq 0$ or, equivalently, $(p^W - p^D)T \leq d$.

Figure C.1: Left panel: early retirement thresholds in $t = 1$. Right panel: program complementarity effects (c) and program substitution effects (s) when unemployment benefits increase from b to b'.



How do incentives change when UI benefits become more generous? It is straightforward to see from the above Lemma that the $\hat{d}$-threshold shifts to the right. This reflects the program substitution effect: early retirees use the DI system under less generous UI rules but take up UI benefits under more generous UI rules. Moreover, the $\hat{\theta}_1$-threshold shifts down. This reflects the program complementarity effect of higher UI benefits: individuals go back to work under the less generous UI system, but use UI benefits as a bridge to an old-age pension under more generous UI benefits. This leads to the following proposition.

Proposition 1 (Period $t = 1$)**.** *More generous UI benefits increase early retirement due to the program complementarity effect. More generous UI benefits increase the UI rather than the DI pathway due to the program substitution effect.*

Proof. Implicit differentiation of the $\hat{d}$ threshold, given by $u(\hat{d}) - (u(\alpha\hat{d}) - u(\hat{d}))T - u(b) - \kappa = 0$, yields

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

under $1 - (\alpha - 1)\,T \geq 0$. The threshold (1) becomes $\partial\hat{\theta}_1/\partial b = -u'(b) < 0$ for $d < \hat{d}$

Future gains from postponing retirement $(p^W - p^D)T$ are lower than current gains from DI take-up d. This is the relevant case under Austrian disability and old-age pension rules (Hofer and Koman, 2006).

and $\partial\hat{\theta}_1/\partial b = 0$ otherwise. $\square$

Displacement at $t = 0$. Now consider a worker who gets displaced at the beginning of period $t = 0$. For such an individual, there are two options. *First,* the worker may retire early. We assume that this requires a sequential take-up of different welfare programs: UI benefits b in $t = 0$ and a disability pension d in $t = 1$.[5] In $t = 2$ the workers gets an old-age pension $p^D = d$.

The *second* option for the worker is returning to work in $t = 0$. Going back to work yields utility $u(w)$ but is associated with a search cost θ_0. Like before, we assume that θ_0 is a random draw from the distribution function $F(\theta)$. Provided θ_0 is low enough, the worker will go back to work. In $t = 1$ the workers keeps his job with probability $1 - q$ and is fired with probability q. We abstract from selective firing, hence q is the same for all workers. If the worker keeps his job, he earns a wage w also in $t = 1$ without having to bear search costs. If fired, the worker faces exactly the same decision problem as described in "Displacement at $t = 1$". We assume that the search costs after displacement at the beginning of $t = 1$ are independently drawn from the same distribution $F(\theta)$ as the search costs after displacement at the beginning of $t = 0$.[6] In $t = 2$ the worker draws an old-age pension that depends on employment or benefit status in $t = 1$ with $p^D = d$ and $p^W = p^U = \alpha d$.

In sum, the lifetime utilities at $t = 0$ from going back to work, $W_0 - \theta_0$, and from retiring early, R_0, can be written as:

$$W_0 - \theta_0 = u(w) - \theta_0 + q\mathrm{E}_\theta V_1 + (1-q)W_1, \quad R_0 = u(b) + (1+T)u(d) - \kappa,$$

whereas $\mathrm{E}_\theta V_1 \equiv \int \max(W_1 - \theta, D_1, U_1)dF(\theta)$ denotes the expected utility when losing the job in $t = 1$. Next, let us consider the worker's optimal choice in $t = 0$. We denote by $\hat{\theta}_0$ the critical level of search costs θ that keeps the worker indifferent between retiring early and going back to work.

[5] This set-up rules out three pathways. First, we neglect drawing a disability pension in both $t = 0, 1$ because the DI program as an early-retirement scheme is only available at $t = 1$ but not at $t = 0$. Second, we rule out drawing UI benefits in both periods because UI benefits have limited duration. While UA benefits are unlimited, benefits are lower and means-tested, and hence dominated by drawing a disability pension in the second period. Third, we assume a worker's human capital fully depreciates if not working in $t = 0$. Hence careers where individuals fully exhaust UI in $t = 0$ and then go back to work in $t = 1$ are ruled out.

[6] This implies that average search costs for worker fired in $t = 1$ are higher than the average search costs when fired in $t = 0$. Workers fired in $t = 1$ must have been re-employed after being fired in $t = 0$ meaning their draw θ_0 must have been sufficiently low to induce them going back to work. Average search costs conditional on re-employment are $\mathrm{E}_\theta(\theta \mid \theta \leq \theta_0)$. In contrast, θ_1 is a new independent draw from the same distribution $F(\theta)$ that is not conditional on re-employment. Hence average search costs of workers fired in $t = 1$ are $\mathrm{E}_\theta(\theta) > \mathrm{E}_\theta(\theta \mid \theta \leq \theta_0)$.

Lemma 2. *The worker will retire early if* $\theta_0 \geq \hat{\theta}_0(d)$*, and will go back to work otherwise. When* $1-(\alpha-1)\,T \geq 0$*, we have* $\partial\hat{\theta}_0/\partial d \leq 0$.

Proof. Set the value of working $(W_0 - \theta_0)$ equal to the value of early retirement (R_0) to obtain the threshold value $\hat{\theta}_0$. Differentiation of $\hat{\theta}_0$ with respect to d yields

$$\partial\hat{\theta}_0/\partial d = q(\partial \mathrm{E}_\theta V_1/\partial d) + (1-q)\alpha T u'(\alpha d) - (1+T)u'(d).$$

To calculate $\mathrm{E}_\theta V_1$, we need to distinguish two cases (see Lemma 1).

Case 1 ($d < \hat{d}$): This is the subset of job losers who strictly prefer to retire through UI rather than DI in $t = 1$. The back-to-work probability equals to $F(\hat{\theta}_1)$ while early retirement occurs with probability $1 - F(\hat{\theta}_1)$. The expected marginal utility corresponds to the sum of the marginal utility of continuing work and the marginal utility of retiring through UI, weighted by their respective take-up probabilities

$$\partial \mathrm{E}_\theta V_1/\partial d = F(\hat{\theta}_1)(\partial W_1/\partial d) + (1 - F(\hat{\theta}_1))(\partial U_1/\partial d),$$

with $\partial W_1/\partial d = \partial U_1/\partial d = \alpha T u'(\alpha d)$. Collecting $\partial\hat{\theta}_0/\partial d$-terms, and noting that $u'(\alpha d) < u'(d)$ and $1-(\alpha-1)T \geq 0$, we get $\partial\hat{\theta}_0/\partial d < -u'(d)(1-(\alpha-1)T) < 0$.

Case 2 ($d > \hat{d}$): This is the subset of job losers who strictly prefer to retire through DI rather than UI in $t = 1$. The same reasoning as above yields[7]

$$\partial \mathrm{E}_\theta V_1/\partial d = F(\hat{\theta}_1)(\partial W_1/\partial d) + (1 - F(\hat{\theta}_1))(\partial D_1/\partial d),$$

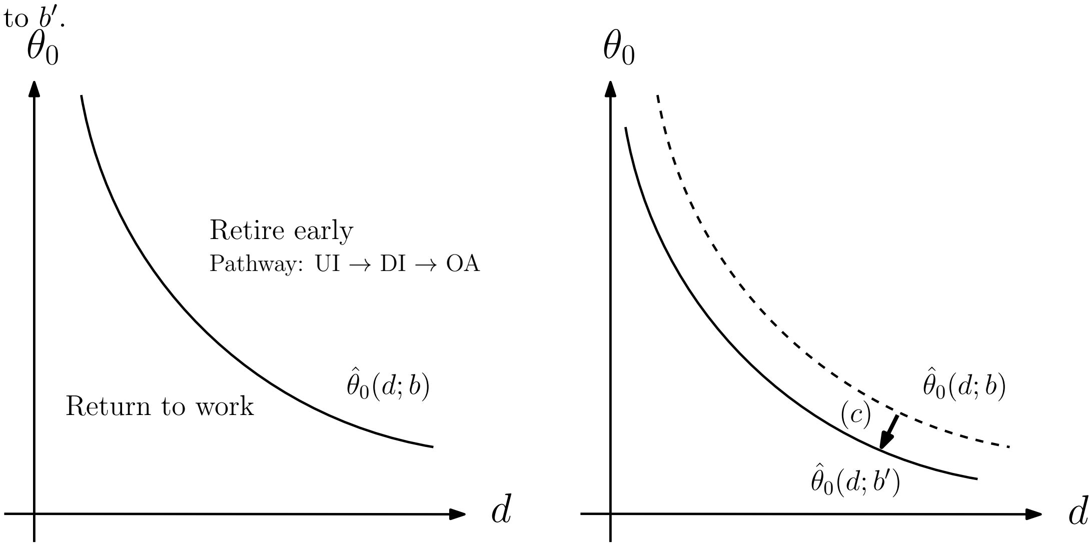
with $\partial W_1/\partial d = \alpha T u'(\alpha d)$ and $\partial D_1/\partial d = (1+T)u'(d)$. Collecting $\partial\hat{\theta}_0/\partial d$-terms and again using $1-(\alpha-1)T \geq 0$ yields $\partial\hat{\theta}_0/\partial d < -(1-q(1-F_1(\hat{\theta}_1)))u'(d)(1-(\alpha-1)T) < 0$. □

Figure C.2 illustrates individuals' optimal choices in $t = 0$ given the location in (θ_0, d) space. The threshold $\hat{\theta}_0$ is downward sloping in d. The flat segment that shows up in the early retirement choice at $t = 1$ (see Figure C.1 above), does not exist for the early retirement choice at $t = 0$. The reason is that, under our assumptions, the only feasible early retirement path is drawing UI benefits at $t = 0$ and a disability pension at $t = 1$. Since early retirees have to rely on a disability pension, early retirement is discouraged at very low values of d.

We are now able to explore how more generous UI benefits affects early retirement incentives in $t = 0$. A higher b has two countervailing effects on the threshold $\hat{\theta}_0$. On the one hand, a higher b increase the incentive to use UI and DI sequentially:

[7] There is one subtle difference to Case 1: the threshold $\hat{\theta}_1$ becomes a function of d over the domain $d > \hat{d}$. However, utility effects due to changes in the threshold $\hat{\theta}_1$ are second-order because individuals optimize over pathway choices (Envelope Theorem).

Figure C.2: 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'.



program complementarity increases the value of early retirement R_0. One the other hand, higher benefits also increase the value of going back to work. This entitlement effect (Mortensen, 1977) increases the value of going back to work at $t = 0$ because becoming unemployed in $t = 1$ is less harmful. We summarize our discussion in the following proposition.

Proposition 2 (Period $t = 0$)**.** *More generous UI benefits lead to a program complementarity effect and an entitlement effect. The former increases and the latter decreases the probability to retire early at* $t = 0$*. The program complementarity effect dominates.*

Proof. Differentiation of $\hat{\theta}_0$ with respect to b yields $\partial\hat{\theta}_0/\partial b = q \cdot (\partial \mathrm{E}_\theta V_1/\partial b) - u'(b)$. As in Lemma 2, there are two cases. *Case 1* ($d < \hat{d}$) we obtain $\partial \mathrm{E}_\theta V_1/\partial b = (1 - F(\hat{\theta}_1))(\partial U_1/\partial b)$ which represents the marginal utility gains of retirement weighted by the probability to retire early. Welfare effects due to switching behavior are second order because individuals optimize in $t = 1$ (Envelope Theorem). Hence, $\hat{\theta}_0(d)$ decreases in b because $0 < q < 1$ and $0 \leq F(\hat{\theta}_1) \leq 1$. *Case 2* ($d > \hat{d}$) yields $\partial \mathrm{E}_\theta V_1/\partial b = 0$ as the UI pathway is never chosen and therefore $\partial\hat{\theta}_0/\partial b = -u'(b)$. □

C.2 Welfare Analysis

We proceed by describing the social planner's problem. The social planner has to take into account how older workers' behavioral responses. Moreover, the social planner also has to take into account that younger individuals are affected since the additional tax burden is shared among the entire population. We therefore extend the above model by one additional period, $t = -1$, during which the worker is not yet eligible for the more generous UI benefits. For simplicity, we assume that period $t = -1$ has length φ and that individuals are fully employed during that period. Employed workers contribute payroll taxes τ, so the gross wage w equals $w = \omega + \tau$. We normalize the size of a cohort to unity. Heterogeneity in pension benefits among individuals is captured by the distribution $G(d)$ over the domain $[\underline{d}, \overline{d}]$. The utilitarian social welfare equals

$$\mathcal{W} = \int_{\underline{d}}^{\overline{d}} \left(\varphi u\left(w-\tau\right) + q \int_0^\infty V_0(d,\theta) dF(\theta) + (1-q) W_0(d) \right) dG(d) \tag{2}$$

and represents the average expected lifetime utility among all individuals. The expected value over the periods $t = 0$ to $t = 2$ is recursively defined: at the beginning of $t = 0$ individuals either (i) become unemployed with probability q, draw job search disutility θ, and choose pathways according to $V_0 = \max(W_0 - \theta, R_0)$ or (ii) stay employed with probability $(1-q)$ and obtain utility W_0.[8] As outlined in Section C.1, the pathway utilities W_0 and R_0 then comprise the subsequent periods as well.

The social planner maximizes the above welfare function subject to government's budget constraint, which takes into account that expenditures on UI, DI and old-age pensions have to be financed by taxes paid by the working population. This can be written as

$$(\Pi_0^U + \Pi_1^U) b + N = (\varphi + \Pi_0^W + \Pi_1^W)\tau, \tag{3}$$

where N denotes government expenditures on disability and old-age pensions and Π_t^i the *mass* of workers in state $i = U, D, W$ at date t.[9] N can be subdivided into three components $\{N_t\}_{t=0,1,2}$, where N_t denotes total expenditures in period t or later,

[8] We assume that the layoff probability$q$ is exogenous and does not depend on the generosity of UI benefits. In the Online Appendix D we show that if the layoff probability is increasing in the generosity of UI benefits then the optimal level of UI benefits is lower.

[9] The stocks Π_t^i, $i = U, D, W$ refer to the fraction of a cohort that chooses a particular retirement pathway. These stocks derive from the behavioral responses of workers as follows: Denote by π_t^i the probability that a worker displaced at the end of $t-1$ enters state $i = W, U, D$ during t, we have $\pi_0^W = 1 - \pi_0^U$ and $\pi_1^W = 1 - \pi_1^U - \pi_1^D$ (since, by assumption, workers can enter state D only in period $t = 1$ but not in period $t = 0$). In steady-state, $\Pi_0^U = q\pi_0^U$ workers choose early retirement in period $t = 0$; $\Pi_0^W = 1 - \Pi_0^U$ continue to work during $t = 0$; $\Pi_1^U = q(1 - q\pi_0^U)\pi_1^U$ choose early retirement in $t = 1$ by drawing UI benefits and $\Pi_1^D = q(1 - q\pi_0^U)\pi_1^D$ chooses early retirement by claiming DI-pensions; $\Pi_1^W = 1 - \Pi_0^U - \Pi_1^U - \Pi_1^D$ retire regularly at $t = 2$. In our quantitative exercise below, we make assumptions on q and use our empirical estimates to calculate the π_t^i's. This lets us infer steady-state value of the stocks Π_t^i, $i = U, D, W$.

that arises from a worker retiring in t. Let E_t be the expectation of d, conditional on retirement in t. There are Π_0^U individuals who retire in $t = 0$. They cause total pension expenditures:

$$N_0 = \Pi_0^U \mathrm{E}_0((1+T)d \mid \theta \geqslant \hat{\theta}_0(d))\cdot$$

There are $\Pi_1^D + \Pi_1^U$ individuals who retire in $t = 1$. They cause DI- and pension expenditures:

$$N_1 = \Pi_1^D \mathrm{E}_1((1+T)d \mid \theta \geqslant \hat{\theta}_1(d), d \geqslant \hat{d}) + \Pi_1^U \mathrm{E}_1(\alpha T d \mid \theta \geqslant \hat{\theta}_1(d), d < \hat{d}).$$

Finally, there are Π_1^W individuals who retire not before $t = 2$. These workers can be divided into three groups: (i) Π_1^{W1}, workers displaced at the beginning of $t = 1$ who return to work, (ii) Π_1^{W2}, workers displaced in $t = 0$ who return to work in $t = 0$ and continue to work in $t = 1$, and (iii) Π_1^{W3}, workers without displacement in $t = 0$ and $t = 1$. Workers in Π_1^{W1} and Π_1^{W2} tend to have a lower d because they self-selected themselves into work because of both low DI pensions d and low adjustment costs θ. The sum of old-age pensions that accrue to the government by all three subgroups is:

$$N_2 = \Pi_1^{W1} \mathrm{E}_1(\alpha T d \mid \theta < \hat{\theta}_1(d)) + \Pi_1^{W2} \mathrm{E}_0(\alpha T d \mid \theta < \hat{\theta}_0(d)) + \Pi_1^{W3} \mathrm{E}_0(\alpha T d).$$

Notice that workers without a previous displacement (third term) are not subject to previous self-selection. Hence, the mean E_0 is unconditional.

Deriving Equation (3). In a first step, we derive the first-order condition of (2) subject to the behavioral retirement responses. This procedure yields:

$$\frac{d\mathcal{W}}{db} = (\Pi_0^U + \Pi_1^U)u'(b) - (\varphi + \Pi_0^W + \Pi_1^W)u'(w - \tau)\frac{d\tau}{db}. \tag{4}$$

Equation (4) yields the familiar result that optimal UI balances the marginal social benefits of better insurance to the marginal social costs of higher taxes.

Next differentiate both sides of the budget constraint (3) with respect to b:

$$(\varphi + \Pi_0^W + \Pi_1^W)\frac{d\tau}{db} = \Pi_0^U + \Pi_1^U + b\frac{d(\Pi_0^U + \Pi_1^U)}{db} - \tau\frac{d(\Pi_0^W + \Pi_1^W)}{db} + \frac{dN}{db}. \tag{5}$$

The above equation can be decomposed into two parts:

1. The mechanical effect, $\mathcal{C}_M = \Pi_0^U + \Pi_1^U$, represents the additional program expenditures if the government increases the UI benefits marginally and workers

would not adjust their retirement choices to the new incentives.

2. The behavioral effect, $\mathcal{C}_B = b\frac{d(\Pi_0^U+\Pi_1^U)}{db} - \tau\frac{d(\Pi_0^W+\Pi_1^W)}{db} + \frac{dN}{db}$, captures the marginal program expenditures due to higher UI benefits which are caused by pathway switching. We distinguish two sub-categories:

   (a) Additional expenditures due to increase in unemployment and decrease in employment: $b\frac{d(\Pi_0^U+\Pi_1^U)}{db} - \tau\frac{d(\Pi_0^W+\Pi_1^W)}{db}$

   (b) Additional expenditures due to changes in pension behavior: dN/db

Using the above notation, we rewrite equation (5) as:

$$(\varphi + \Pi_0^W + \Pi_1^W)\frac{d\tau}{db} = \mathcal{C}_M + C_B.$$

Inserting the above equation into (4) yields:

$$\frac{d\mathcal{W}}{db} = \mathcal{C}_M \cdot u'(b) - u'(w-\tau)(\underbrace{\mathcal{C}_M + \mathcal{C}_B}_{\mathcal{C}_T}).$$

Note that mechanical and behavioral effects sum up (by definition) to the total effect, i.e. $\mathcal{C}_M + \mathcal{C}_B = \mathcal{C}_T$. Finally, impose optimality $d\mathcal{W}/db = 0$ and subtract 1 on both sides to obtain equation (3).

D Endogenous UI Inflow

Assume a standard Baily-Chetty framework with endogenous unemployment inflow as the only modification. The job separation rate q becomes endogenous with respect to the unemployment benefits b. The government maximizes:

$$\max_b \{q(b)\,[e \cdot u(w-t) + (1-e)\cdot u(b)] + (1-q(b))\cdot u(w-t)\}$$

subject to individual optimization behavior $\max_e \{e \cdot u(w-t) + (1-e)\cdot u(b) - \varphi(e)\}$ and the budget constraint $q(b)\,[e\cdot t - (1-e)\cdot b] + (1-q(b))\cdot t = 0$. Solving the optimization problem yields the sufficient statistic:

$$\frac{u'(b) - u'(w-t)}{u'(w-t)} = \varepsilon\frac{b+t}{b} + \underbrace{\frac{dq}{db}\frac{1}{q}\left\{\frac{u(w-t)-u(b)}{u'(w-t)} + (b+t)\right\}}_{\text{job separation externality}}.$$

To the extent that job separations react to benefit generosity ($dq/db > 0$), the r.h.s of the above equation becomes larger which reduces the optimal level of UI benefits even further.

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