APPENDIX FOR ONLINE PUBLICATION

Appendix A: A Dynamic Model of Retirement Decisions

The concept of the reduced-form participation semi-elasticity can be motivated within a dynamic framework that has been used extensively in the literature on retirement decisions. In particular, we refer to dynamic models by Stock and Wise (1990) and Berkovec and Stern (1991), as well as on the reduced form models by Coile and Gruber (2007) and Gruber and Wise (1999, 2004). In this framework a forward looking individual decides each period whether to continue working or to exit the labor market permanently and retire, based on an evaluation of the current and future benefits of continued work relative to the benefits of retirement. If tenure-based severance pay is introduced into this setting, the individual faces a sharp increase in the incentive to retire once she reaches a tenure threshold, since the benefits from retiring have jumped to a higher level. Intuitively, our reduced-form semi-elasticity measures the effects on retirement decisions from the increase in the financial incentive at the tenure threshold.

To formalize the role financial incentives on retirement decisions, we develop a simple optimal stopping time model, which contrasts retirement decisions in a scenario without severance pay to a scenario where individuals become eligible for severance pay once they reach a tenure threshold.[3] The model is designed to highlight the impacts of severance pay and therefore, following the graphical evidence, we simplify the model by abstracting from incentives to retire at certain ages. This simple model allows us to focus on two factors to explain the patterns in the graphical evidence: (1) the changes in benefits at the tenure thresholds and (2) the option value from continuing to work (see Stock and Wise, 1990 for a similar option value model).

We start with an employed individual at age 55 who decides whether to retire or continue to work based on the discounted flow of lifetime income under both options. Retirement is an irreversible decision, such that a retired individual does not have the choice to return to work and decisions are only possible as long as the individual stays employed. Considering first the scenario without severance pay, the decision in each period t, with $t = 0$ at age 55, is based on a set of state variables:

$$\Omega_t = \begin{cases} t & \text{age} \\ b_t & \text{annual social security benefits if retiring at age } t \\ y & \text{annual earnings if working} \\ \alpha_t & \text{(disutility) costs of working at age } t \end{cases}$$

The state variables evolve according to the following laws of motion. We assume that age increases by 1 each period and that earnings from employment y are fixed over time, while the level of benefits b_t rises deterministically with each year of delay in retirement such

[3] In the comparison of both scenarios we assume that severance pay only affects the retirement decisions of workers, but not any decisions at the employer's side such as wage setting policy or hiring decisions.

that $b_{t+1} > b_t$. The uncertainty in the model comes from α_t, the cost of working, which evolves according to a stochastic process with $\alpha_{t+1} = \rho\alpha_t + \epsilon_{t+1}$, where $\epsilon_{t+1} \sim F_t(\eta_t)$.

At each age t the individual bases her decision on the set of value functions: The value for retirement is given by

$$V^R(t, b_t) = u(b_t) + \beta_t V^R(t+1, b_t),$$

and the value of employment is

$$V^W(\Omega_t) = u(y) - \alpha_t + \beta_t E_t[V(\Omega_{t+1})].$$

We assume that consumption equals income in each period with per period utility given by u and there is no saving.[4] The series of discount factors β_t of future utility is assumed to also capture the probability of survival. $E_t[V(\Omega_{t+1})]$ captures the expected value of next period's decision

$$V(\Omega_{t+1}) = max\left\{V^R(t+1, b_{t+1}), V^W(\Omega_{t+1})\right\}.$$

The optimal strategy can be described by a reservation disutility value $\bar{\alpha}_t(\Omega_t)$, which determines the retirement decision: the individual retires if $\alpha_t \geq \bar{\alpha}_t(\Omega_t)$. $\bar{\alpha}_t$ is implicitly given by the indifference condition

$$V^R(t, b_t) = V^W(t, b_t, y, \bar{\alpha}_t)$$

Using a first order Taylor expansion of u around y, we can express the reservation disutility as

$$\bar{\alpha}_t = \lambda(y - b_t) + \beta_t OV_t \quad (7)$$

where λ denotes the marginal utility of consumption $\lambda = u'(y)$. This expression highlights the dependence of the reservation disutility on two components: the gain from working $y - b_t$ in period t and the option value OV_t of retiring at a later age which is given by $OV_t = E_t[V^W(\Omega_{t+1})] - V^R(t+1, b_t)$ and incorporates future earnings and benefits as well as expectations of future realizations of α_t. Equation (7) defines $\bar{\alpha}_t$ dynamically and in order obtain a solution for $\bar{\alpha}_t$ we solve the equation recursively starting at a fixed maximum lifetime T. For details see the next section. Let us call the gain from working $\tilde{y}_t$ and re-write it in terms of the implicit tax rate τ_t defined as[5]

$$\tilde{y}_t = y(1 - \tau_t) = y - b_t. \quad (8)$$

[4]This is potentially a very crude approximation, as it also implies that individuals have to consume severance pay in a single period in the model scenario with severance pay. It does not affect the main model properties, however. Importantly, the option value always takes the potential receipt of future severance pay into account. We make this simplifying assumption for two reasons. First, we have no data on consumption or savings and hence we cannot identify savings decisions. Second, this assumption allows us to write net wages and implicit tax rates in terms of income differences (i.e. earnings net of taxes and benefits) rather than consumption differences. See the next footnote for more information.

[5]In a more general model that allows for endogenous consumption decisions and hence consumption

Based on a solution for $\bar{\alpha}_t$ we can express the hazard rate of retirement at age t as

$$h_t = \Pr\{\alpha_t > \lambda y_t(1-\tau_t) + \beta_t OV_t\}.$$

Given the hazard rates, the distribution of retirements by age n_t is determined based on the initial population size N_0.

In terms of policy tools we interpret the implicit tax rate τ_t as the key parameter through which financial incentives can be manipulated by policy makers. Let us elaborate on this idea by introducing severance pay into the model. Severance pay enters the model through the assumption that in addition to b_t the individual receives a one time severance payment amount of SP if she retires with a level of tenure higher than the threshold s^*. Based on the empirical findings we make two simplifying assumptions. First, we model the severance pay policy with only one tenure threshold and second, we assume that tenure at age 55 is randomly assigned. This implies that the individual threshold dates are exogenous with respect to the other determinants of retirement and thresholds vary across the population. To include severance pay into the retirement decision we include tenure Ten_t as an additional state variable in Ω_t^{SP}. Tenure increases by one in each period as long as an individual remains employed and it is set equal to zero at retirement. Under this scenario the value functions change to

$$\begin{aligned} V^R(t, b_t) &= u(b_t + SP \times I(Ten_t \geq s^*)) + \beta_t V^R(t+1, b_t) \\ V^W(\Omega_t^{SP}) &= u(y) - \alpha_t + \beta_t E_t[V(\Omega_{t+1}^{SP})] \end{aligned}$$

The equation for the reservation disutility $\bar{\alpha}_t^{SP}$ is given by

$$\bar{\alpha}_t^{SP} = \begin{cases} \lambda(y - b_t) + \beta_t OV_t^{SP} & \text{if } Ten_t < s^* \\ \lambda(y - b_t - SP) + \beta_t OV_t^{SP} & \text{if } Ten_t \geq s^* \end{cases} \tag{9}$$

For tenure levels above the threshold we define the gain from working and the implicit tax rate to include severance pay

$$\tilde{y}_t^{SP} = y(1 - \tau_t^{SP}) = y - b_t - SP. \tag{10}$$

smoothing, the implicit tax rate could be defined in terms of consumption differences,

$$\begin{aligned} (1-\tau)c_t^W &= c_t^W - c_t^R \\ &\Rightarrow \tau = \frac{c_t^R}{c_t^W}. \end{aligned}$$

In this expression, c_t^W denotes endogenous consumption if the individual were to choose to continue working at time t and similarly c_t^R denotes endogenous consumption if the individual were to choose to retire at time t.

The corresponding hazard rate is given by

$$h_t^{SP} = \begin{cases} \Pr\{\alpha_t > \lambda y_t(1-\tau_t) + \beta_t OV_t^{SP}\} & \text{if } Ten_t < s^* \\ \Pr\{\alpha_t > \lambda y_t(1-\tau_t^{SP}) + \beta_t OV_t^{SP}\} & \text{if } Ten_t \geq s^*. \end{cases} \tag{11}$$

In this model scenario future decisions take the potential receipt of severance pay into account and the option value of retirement at a later age OV_t^{SP} includes the option of becoming eligible for severance pay. Note that individuals receive severance pay if they retire at any age after reaching the tenure threshold and the option value includes severance pay also at ages above the threshold. In other words, the option value of retiring at a later age changes permanently at the tenure threshold, while severance pay changes the gain from working only in a single period.

Equations (9) and (11) indicate that the option of severance pay will have different effects on the hazard rate depending on tenure. Prior to the tenure threshold severance pay increases the option value of delaying retirement and thus increases $\bar{\alpha}_t^{SP}$ and decreases h_t^{SP}. After the threshold severance pay increases the implicit tax rate and increases the hazard rate. The equations for $\bar{\alpha}_t^{SP}$ and h_t^{SP} also indicate that induced by the jump in the implicit tax rate at the tenure threshold, there will be a discrete drop in the reservation disutility of work at the tenure threshold s^* and a corresponding increase in the hazard rate. To investigate the shapes of the reservation disutility and hazard rates before and after the tenure threshold in both scenarios with and without severance pay we turn to model simulations.

Model Simulations

To show the retirement decisions implied by our model over age and by tenure we simulate model solutions for the two scenarios with and without severance pay. For specific details and assumptions of the model simulations are explained at the end of this section.

We start with retirement outcomes for a cohort of identical individuals, who all have the same level of tenure at age 55. We choose $Ten_0 = 2$, which implies that they reach the tenure threshold s^* at age 63. The following graphs trace the disutility of work and hazard rate into retirement for the cohort of individuals in both scenarios.

Appendix Figure 6 plots the simulated profiles of the reservation disutility of work $\bar{\alpha}_t$ and $\bar{\alpha}_t^{SP}$ by age. The downward sloping profile for the counterfactual scenario without severance pay reflects retirement decisions at older ages. Relative to the counterfactual we see a sharp increase in the disutility of work prior to the threshold for individuals who become eligible for severance pay. Right after the threshold the reservation cost of working drops below the counterfactual and moves more or less parallel as individuals stay eligible for severance pay if they retire at any age after the threshold.

Appendix Figure 7 plots the corresponding simulated profiles of the hazard rate into retirement h_t and h_t^{SP} by age. Not surprisingly the hazard rates reflect the profile of the reservation disutility with higher disutilities implying lower hazards and vice versa.

After having established the results at a single tenure/age threshold, we mix cohorts of individuals with different levels of tenure at age 55 in the second set of simulations. Specifically we choose initial levels of tenure $Ten_0 = s_0$ with s_0 ranging from 0 to 15 years. Individuals from the cohort with $Ten_0 = s_0$ have tenure $s = t + s_0$ at age t and reach the tenure threshold $s^* = 10$ at age $t = 65 - s_0$.

For this group of individuals we focus on the average hazard rate to retirement by tenure shown in Appendix Figure 8. This graph shows a constant average hazard of retirement in the counterfactual scenario, which results from averaging over different retirement ages. For the scenario with severance pay we see a dip in hazard rate prior to the tenure threshold reflecting the decline in the average hazards by age. We also see a large level shift in the hazard rate at the threshold and thereafter the hazard rate remains more or less constant.

The next graph, Appendix Figure 9, relates the average hazard rate to the frequency of retirements by the level of tenure. Given the initial cohort sizes we can compute retirement frequencies by age and tenure n_{ts} and obtain the aggregate retirement frequency by tenure from $n_s = \sum_{t=0}^{T} n_{ts}$. This figure represents the distribution of tenure at retirement or a simulated equivalent of Figure 3. The simulated distribution of tenure is remarkably similar to the pattern observed in the data in Figure 3. In the simulated distribution the spike in retirement frequencies at the tenure threshold is a result from two factors: (i) the level shift in the hazard rate and (ii) the fast decline in the population at risk of retiring after the tenure threshold. We further note that the in the simulated graph the frequency never goes to zero prior to the threshold, which is due to individuals retiring with very high values of $\bar{\alpha}$. In addition, the retirement frequency does not immediately drop to the counterfactual level in the period after the threshold, which reflects the constantly high retirement hazards as individuals stay eligible for severance pay if they retire in any period after the threshold.

Simulation Assumptions and Parameters

We assume that retirement decisions are made at a quarterly frequency from age 55 through age 65 (i.e. everyone is assumed to be retired at age 66). For simplicity, we assume that there is no uncertainty due to mortality; all individuals live to age 85 with certainty. The (quarterly) discount factor is $\beta = 0.40^{1/4}$. We specify the utility function as $u(c) = \frac{c^{1-\gamma}}{1-\gamma}$ with $\gamma = 0.5$. Quarterly earnings are $y = \frac{20}{4}$. Quarterly retirement benefits at age 55 are $b_{55} = \frac{12}{4}$; for individuals retiring beyond age 55, retirement benefits increase by 1% with each additional quarter of age beyond age 55. This increases in retirement benefits with retirement age continues up to a maximum level of retirement benefits equal to $0.99y$. For the disutility of work α_t, we set $\rho = 0$ and F_t as a uniform distribution over 0 and α^H; to ensure that the disutility of work is on a similar scale as consumption (i.e. to avoid scenarios in which all individuals work or all individuals retire), the mean of this uniform distribution is set to $\eta_t = \frac{[0.04*y]^{1-\gamma}}{1-\gamma}$ and $\alpha^H = 2\eta_t$. Next, following the rules of the Austrian severance pay system, we specify the severance payment amounts based on tenure and annual earnings. For expositional purposes, we scale the severance pay amounts by 0.25 (i.e. $\tilde{SP} = 0.25 * SP$).

To run the simulation, we specify the number of simulated individuals $N_0 = 10,000$. For each individual, we draw initial tenure from a uniform distribution over [0,15]; we round tenure to the nearest quarter so that tenure is computed at a quarterly frequency. Given the parameter values and distributional assumptions above, we compute compute the individual's value functions recursively and solve for the individual's optimal retirement decision. In each period that the individual continues working, tenure and age both increase by 0.25 and the work disutility α_t is randomly drawn from the uniform distribution described above. Once the simulated individual retires, we record the individual's retirement age, retirement tenure, work disutility (α_t) and reservation disutility ($\bar{\alpha}_t$) and then continue to solve for the next simulated individual's retirement outcome.

Appendix B: Retirement Age Elasticities

Conceptual Framework & Defining the Elasticity

This section presents a static model of retirement decisions in the presence of a budget constraints with notches from lump-sum severance payments. The model we use is common to both the public finance literature and the retirement literature. In the public finance literature, the model is a standard static labor supply model (for examples, see Saez 2010 and Kleven and Waseem 2013); in the retirement literature, the model is a standard lifetime budget constraint model (see Brown 2013). We start by describing the model of retirement decisions without severance payments and then introduce the payments. The model without severance payments can be interpreted as a model of counterfactual retirement decisions, i.e. what individuals' retirement decisions would be in the absence of any severance payment notches.

We assume that each individual decides on labor supply over the life-cycle be choosing his or her retirement age R. Following the public finance literature on responses to income tax notches and kinks, we assume that the individual has quasi-linear preference over consumption and labor supply. Consumption is based on total lifetime income from wages w while working and pension benefits b while retired. We assume that the individual lives for T periods and abstract from uncertainty and time discounting. Thus the individual chooses his retirement age by solving

$$\max_R wR + (T-R)b - \frac{\theta}{1+\frac{1}{e}}\left(\frac{R}{\theta}\right)^{1+\frac{1}{e}}$$

where the $wR + (T-R)b$ captures consumption based on lifetime income and $\frac{\theta}{1+\frac{1}{e}}\left(\frac{R}{\theta}\right)^{1+\frac{1}{e}}$ captures the disutility of labor supply. The parameter θ is distributed across individuals in the population according to density $f(\theta)$ reflecting that different individuals have different tastes for work and hence choose different retirement ages. The parameter $\frac{1}{e}$ captures the curvature in the disutility of work or how quickly the marginal disutility from work rises if the individual increases his retirement age. Moreover, from the individual's first order condition, we can see that the parameter e captures the labor supply elasticity, $e = \frac{d\ln R}{d\ln(w-b)}$. This elasticity reflects how much (as a percentage) an individual would increase his retirement age by in response to a 1% increase in the net wage $w-b$.

Next, we introduce lump-sum severance payments into the model; these payments create upward notches the budget constraint. Specifically, we consider the case when individuals receive a lump-sum payment SP if they retire at age R^* or later.[6] With the severance pay

[6] Here we focus on a single threshold and assume that the threshold occurs at the same age for all individuals. We focus on a single threshold since this seems to be the most empirically relevant scenario as most individuals retire between 55 and 60 and are likely to reach only 1 tenure threshold during this time. Since individuals reach age 55 with different years of tenure, individuals will face thresholds at different ages. We discuss how we account for thresholds occurring at different ages in more detail below.

threshold, each individual's optimization problem becomes

$$\max_R wR + (T-R)b + SP * 1(R > R^*) - \frac{\theta}{1+\frac{1}{e}}\left(\frac{R}{\theta}\right)^{1+\frac{1}{e}}.$$

Appendix Figure 10 illustrates optimal retirement decisions comparing the smooth counterfactual budget constraint, with the budget set in the presence of the severance pay notch. If an individual would have chosen a retirement age above the threshold under the counterfactual (i.e. $R > R^*$), her retirement decision is unaffected by the additional income from the severance payment. However, individuals who would have chosen a retirement age below the threshold might be induced by the severance pay to move to the threshold retirement age R^*. In particular, there is an individuals with taste θ_L who is indifferent indifferent between retiring earlier at $R_L < R^*$ without the severance payment and retiring later at R^* with the severance payment. All individuals who would have retired with $R \in (R_L, R^*)$ will be strictly better off with the severance payment, so they all choose to retire at the threshold R^*. The indifference condition is given by

$$\underbrace{wR^* + (T-R^*)b + SP - \frac{\theta_L}{1+\frac{1}{e}}\left(\frac{R^*}{\theta_L}\right)^{1+\frac{1}{e}}}_{\text{utility from retiring at } R^* \text{ with severance pay}} = \underbrace{w(R_L) + (T-R_L)b - \frac{\theta_L}{1+\frac{1}{e}}\left(\frac{R_L}{\theta_L}\right)^{1+\frac{1}{e}}}_{\text{utility from retiring early at } R_L \text{ without severance pay}}$$

Given that labor supply is chosen optimally, the indifferent individual's type is given by $\theta_L = \frac{R^*-\Delta R^*}{(w-b)^e}$, where we denote by $\Delta R^* = R^* - R_L$ the length of delay. After substituting the expression for θ_L, the indifference condition can be rewritten purely in terms of the threshold R^*, the length of delay ΔR^*, the net wage $w-b$, the severance payment SP and the labor supply elasticity e (see Kleven and Waseem 2012):

$$\left(1-\frac{\Delta R^*}{R^*}\right) + e\left(1-\frac{\Delta R^*}{R^*}\right)^{-1/e} - (1+e)\left(1+\frac{SP}{(w-b)R^*}\right) = 0.$$

This expression makes clear that we can use the indifference condition to recover the structural labor supply elasticity e given that we have estimates for $\frac{\Delta R^*}{R^*}$ and $\frac{SP}{(w-b)R^*}$. We can estimate the length of delay ΔR^* from the retirement frequencies at the tenure thresholds, as we show below. The net wage $w-b$ can be computed using average net wage for individuals retiring near the threshold age. Similarly, the after-tax severance payment SP can be computed by applying the severance payment rules and computing the average after-tax payment amount. The controversial parameter in the indifference condition is the threshold level R^*. It corresponds to the tenure threshold from the severance pay regulation, but in the model of life-cycle labor supply it translates to the retirement age at which the individual reaches the tenure threshold. This ambiguity rises an important scaling issue. The scale of R^* changes depending on the time horizon over which the individual makes her retirement decision, e.g. the full life cycle, the time since labor market entry, or the time since age 55.

From the form of the indifference condition we can see that the estimated elasticity is highly sensitive to the choice of scale of R^*, with higher values of R^* corresponding to smaller elasticities.[7] Relative to the sensitivity to the scaling parameter, the estimated elasticity is not very sensitive to the severance pay fraction $SP/(w-b)$, however. As the empirical estimation severance pay fraction is one of the main contributions of our paper, we discarded the elasticity concept based on the static labor supply model in the main analysis. In the empirical part of the elasticity computation in this Appendix section, we choose the main retirement age at which individuals reach the tenure thresholds as estimates for R^* .

The Length of Delay: Bunching and Adjustment Costs

The heterogeneity in tastes for work leads to a distribution of retirement age outcomes. We denote the distribution of counterfactual retirement ages, i.e. the distribution in the absence of the severance payments, by $h_0(R)$. Using this notation, and the result that all individuals who have counterfactual retirement ages $R^* \in [R^* - \Delta R^*, R^*]$ retire at the threshold, the excess mass of individuals retiring at the threshold is

$$B = \int_{R^*-\Delta R^*}^{R^*} h_0(r)dr \approx \underbrace{\left(\frac{h_0(R^*) + h_0(R^* - \Delta R^*)}{2}\right)}_{h_0}.$$

This equation for the excess mass (or bunching) implies that, given an estimate for B, the length of delay can be estimated as $\Delta R^* = \frac{B}{h_0}$.

One shortcoming of applying this strategy for estimating the length of delay is that the model predicts holes in the distribution of labor supply outcomes with the notch. Specifically, the model predicts that for $e > 0$, no individuals should choose labor supply outcomes between the point of indifference and the threshold. Appendix Figure 11A illustrates the predicted distribution of labor supply outcomes with a gap between the point of indifference and the threshold. This prediction is at odds with what is observed in the data, so we consider two alternative strategies to address this shortcoming.

First, we assume that there is a fixed fraction of individuals who are constrained from adjusting or choosing their retirement ages optimally (i.e. these individuals face involuntary retirements and have exogenously given retirement ages). We denote this fraction by f. In this case, the length of delay can be estimated using $\Delta R^* = \frac{B}{(1-f)h_0}$; the previous estimate for ΔR^* is now re-scaled by $\frac{1}{1-f}$ to account for the fact that a only fraction $1-f$ can bunch at the threshold. As illustrated in Appendix Figure 11B, this predicts a flat number of individuals filling the pre-threshold gap in the distribution of of labor supply.

Because this first strategy does not capture the downward-sloping pattern in the pre-threshold distribution of labor supply, we also consider a second alternative strategy to cap-

[7] In our application a change of R^* from 10 to 60 years roughly corresponds to an order of magnitude reduction in the estimated elasticity.

ture pre-threshold retirements. Specifically, we consider heterogeneous adjustment costs.[8] We suppose that individuals each have an adjustment cost ϕ distributed according to density $g(\phi)$ on $[0, \phi^{\max}]$ with $\phi^{\max} > 0$ and ϕ is independent from θ. With the adjustment cost, individuals adjust their retirement decision rules to retire at the threshold if and only if the utility from retiring at the threshold net of the adjustment cost exceeds the utility from retiring earlier without the severance payment:

$$\text{retire at } R^* \text{ iff } u^{sev} - \phi > u^{no\ sev}.$$

The cost ϕ is therefore interpreted as a cost of adjusting from the counterfactual retirement age to the threshold age.

With heterogeneous adjustment costs, at any given counterfactual retirement age, there are some people with higher adjustment costs who do not move to the threshold and others with lower adjustment costs who do move to the threshold. At or just above the point of indifference, only individuals with 0 adjustment costs will choose to switch to the threshold. For counterfactual retirements closer to the threshold, more individuals will choose to switch. However, some individuals with counterfactual retirements just prior to the threshold may still face sufficiently high adjustment cots so that they choose not to switch. Thus, the model with heterogeneous adjustment costs does not predict a gap in the distribution of labor supply outcomes and it predicts a downward-sloping pattern prior to the threshold. This prediction is illustrated in Appendix Figure $11C$.

In the presence of heterogeneous adjustment cots, the length of delay can be estimated by estimating the point of indifference since 0 adjustment costs apply at this point. Using an estimated distribution of counterfactual labor supply outcomes, the point of indifference can be estimated either by estimating the point at which the excess mass is completely filled into the pre-threshold reduced mass or by estimating a point of convergence between the observed and counterfactual distributions. As we discuss in more detail below, we implement the second approach since it is more robust. We interpret the estimated elasticity from this strategy as an upper bound for the structural elasticity since the estimate is based on determining the maximum length of delay.

Estimating Procedures

The retirement age elasticity can be estimated given an estimate for the length of delay and values for the net wage, the severance payment, and the threshold retirement age. Since the other values can be directly observed or computed from the data, we focus on estimating the length of delay either using the amount of excess mass or using the point of convergence. The estimation strategy first uses the distribution of tenure at retirement

[8] To account for pre-threshold retirements, we focus on heterogeneous adjustment costs with a homogeneous elasticity rather than heterogeneous elasticities. We will investigate heterogeneity in elasticities in the empirical analysis below by splitting the sample into different groups. However, we find heterogeneous adjustment costs to be a more plausible explanation for pre-threshold retirements than heterogeneous elasticities. To explain pre-threshold retirements with heterogeneous elasticities, a large fraction of the population would need to have an elasticity of 0. It seems more intuitive that many people are constrained from adjusting rather than being completely ignorant or never responsive.

to estimate a counterfactual distribution of tenure at retirement, and this counterfactual distribution is then used to estimate the length of delay based on the two different strategies. The strategy then applies this estimated length of delay to multiple retirement ages to estimate elasticities at each retirement age, and finally we compute a weighted average of the elasticities over all of the retirement ages.

Identification & Estimating Counterfactuals

With the retirement age elasticities, the identifying assumption and estimation of counterfactual retirement frequencies are the same as in the case of the participation elasticities. To estimate counterfactual retirement frequencies, our identifying assumption is that, in the absence of the severance payments or increases in the severance payments, individuals retiring at the tenure thresholds would behave like individuals retiring further away or between the tenure thresholds. The identifying assumption would be violated if, for example, individuals who retire at the tenure thresholds would have a higher probability of retiring at the Early Retirement Ages than individuals who retire away from the tenure thresholds. Based on our empirical analysis, individuals retiring at the tenure thresholds are similar to individuals retiring away from the tenure thresholds on a rich set of observable dimensions. Therefore, we conclude that it is unlikely that there would be differences in unobservable characteristics that would lead to such differences in retirement decisions in the absence of the severance pay thresholds. Under this identifying assumption, we are able to consider a counterfactual setting around each tenure threshold in which there are no increases in severance pay.

As described with the participation elasticities, the counterfactual distribution of tenure at retirement is estimated in two distinct steps. Figure 13 illustrates each step of the estimation of the counterfactual distribution. First, we estimate seasonally adjusted frequencies by fitting 4th order polynomials in the intervals between the tenure thresholds to the observed monthly frequencies of retirement. Second, we use the seasonally adjusted retirement frequencies to estimate counterfactual retirement frequencies $\hat{n}_s$ to create the scenario without any increases in severance pay at any of the thresholds. Specifically, we fit a continuous polynomial over the entire range of tenure levels and add dummy variables for the months around the tenure thresholds. We then set the dummies equal to zero and predict values from this polynomial to construct counterfactual frequencies.

Estimation using Bunching

Based on the excess mass or bunching at the tenure thresholds, the length of delay is given by $\Delta R^* = \frac{B}{(1-f)h_0}$ where h_0 is the average density value $h_0 = \frac{1}{2}(h_0(R^*) + h_0(R^* - \Delta R^*))$ and f is the fraction of constrained individuals. Using the seasonally adjusted and counterfactual frequencies, we estimate the amount of bunching based on the excess retirements at and just after the tenure thresholds; i.e. for each tenure threshold $\tau = 10, 15, 20, 25$,

$$B^\tau = \sum_{s=0}^{6}[n^a_{\tau+s} - \hat{n}_{\tau+s}].$$

We estimate the average density value using $\hat{h}_0 = \hat{n}_\tau$ and we estimate the fraction constrained using the fraction of individuals who retire one month prior to the tenure threshold,

$$f = \frac{n^a_{\tau-1}}{\hat{n}_{\tau-1}}.$$

Thus, given each of these estimates, we are able to estimate the length of delay at each tenure threshold based on the bunching at the threshold and the fraction constrained just before the threshold.

Estimation using Point of Convergence

We also estimate the length of delay using the point of convergence between the actual and counterfactual distributions of tenure at retirement. This point of convergence captures the point of indifference between retiring earlier without the severance payment and retiring later at the tenure threshold with the severance payment. Furthermore, at this point of indifference, no adjustment costs apply by assumption. We estimate the length of delay based on the point of convergence for each threshold as the prior point closest to the threshold such that the difference between the actual and counterfactual frequencies is less than 5% of the counterfactual frequencies,

$$\min \; s > 0 \text{ such that } \frac{n^a_{\tau-s} - \hat{n}_{\tau-s}}{\hat{n}_{\tau-s}} < 0.05.$$

Accounting for Thresholds at Different Retirement Ages

While the counterfactual distribution is used to estimate a length of delay at each tenure threshold, the elasticity estimation must still take into account that individuals reach the tenure thresholds at different retirement ages. We account for this fact by using weights based on the fraction of people who retire at each age around each tenure threshold. Specifically, for each tenure threshold $\tau = 10, 15, 20, 25$, we identify all individuals who retire with tenure $t \in [\tau - 2, \tau + 2]$; we denote this group of individuals by N^τ. For each of these groups of individuals, we compute the fraction of individuals who retire at each age $a = 55, ..., 65$; we denote these fractions by p^τ_a. For each retirement age $a = 55, ..., 65$, we compute the average net wage and severance payment amounts directly from the data and we use the indifference condition with the estimated length of delay at the tenure threshold ΔR^*_τ to estimate labor supply elasticities e^τ_a. Using the retirement age fractions, we compute a weighted average of these elasticities,

$$e^\tau = \sum_{a=55}^{65} p^\tau_a e^\tau_a.$$

This strategy yields an estimated elasticity for each tenure threshold. We also compute a weighted average elasticity across the tenure thresholds using $e = \sum_\tau \left(\frac{N^\tau}{N}\right) e^\tau$ where $N = \sum_\tau N^\tau$

Estimation Results

Table $C1$ presents the estimation results at each tenure threshold for men and women separately The first row presents the excess retirement frequencies within each tenure threshold, B^τ for $\tau = 10, 15, 20, 25$. The second row presents estimates of the fraction of constrained individuals, f^τ, using the fraction of individuals retiring one month prior to a tenure threshold. The estimates across the tenure thresholds indicate that between 63% and 80% of men could be constrained while between 43% and 61% of women could be constrained. Using these fractions, the estimated length of delay is between 0.40 and 0.52 years for men and between 0.40 and 0.66 years for women. The estimated lengths of delay are used to estimate lower bounds for the retirement age elasticity, and these estimated retirement age elasticities are presented in the fifth row of Table $C1$. The estimated lower bound elasticities are close to 0. These estimated elasticities are relatively small because the estimated length of delay is on the order of 6 months, and the model requires a small labor supply elasticity if individuals are only willing to delay their retirements by 6 months in the presence of significant notches in their budget constraints from the severance payments. Intuitively, the disutility of labor supply must rise very quickly with additional time at work if individuals are only willing to delay their retirements by 6 months when there are sizeable financial incentives from the severance payments.

We also estimate upper bounds for the retirement age elasticity parameter using estimates for the point of convergence prior to each tenure threshold. The estimated points of convergence are between roughly 0.66 and 1.42 years prior to a tenure threshold for men, and between 1.00 and 1.42 years for women. These estimates indicate that individuals are willing to delay their retirements by longer periods of time then the estimated lengths of delay based on the excess retirements and fractions constrained implied. The estimated upper bound retirement age elasticities based on these estimated points of convergence are reported in row 6 of Table $C1$. We estimate elasticities between 0.007 and 0.015 for men and between 0.007 and 0.044 for women. Taking weighted averages over all of the tenure thresholds yields estimated elasticities of 0.01 for men and 0.02 for women.

These estimated retirement age elasticities are consistent with previous estimates in the literature. In particular, using maximum likelihood and nonparametric estimation techniques based on a kink in the budget constraint, Brown (2013) estimates retirement age elasticities on the order of 0.02 (see Tables 2 and 3 of Brown 2013). While Brown's estimated apply to a sample of teachers in California, the elasticities reported in Table $C1$ are based on a large sample of private sector employees throughout Austria. Overall, the estimated elasticities indicate relatively low responsiveness to financial incentives to delay retirement. The estimated elasticities also highlight significant differences between men and women.

Appendix C: Tax Data and Severance Payment Information

Data on Severance Payments

Data on severance payments come from income tax records that can be matched with the administrative social security registers via an individual identifier. The tax data correspond to reports that firms have to send to the tax office at the end of each calendar year. Specifically, the employer reports each worker's annual salary and withholdings of social security contributions and income tax which are directly transferred to the tax office. The employer reports are sufficiently detailed, such that workers who are employed in a single job for the entire year are not obliged to file individual tax returns. Workers with more than one job have to file tax returns to correct the income tax withholdings and workers not employed the whole year may file tax returns to apply for refunds. Note that we do not have data on the final tax returns, but only on the employer reports.

In the tax reports the worker's gross annual earnings are split up into social security contributions, tax deductions, income subject to income tax, and income subject to the lower fixed tax rate of 6%. In particular, there is a separate category for severance payments, which only applies in the final year of the job. This category includes three different income components: (i) tenure-based severance pay according to the severance pay law, (ii) refunds for not consumed vacation days, and (iii) voluntary severance payments. Voluntary severance pay that can be claimed in this income category is tied to work experience in previous jobs for which the worker did not receive severance pay. The total amount of income that can be reported in the severance category is capped by 1.25 times the salary of the last 12 months, which equals 1.07 times the annual salary, because there are 14 monthly wage payments. There are no discontinuities in rules for vacation refunds by tenure, so we assume that refunds of vacation days evolve smooth through the tenure thresholds. Nonetheless, employers can make use of voluntary severance payments to smooth out the discontinuities in the schedule.

We have access to tax record data for the years 1994 – 2005, which we merge to the retirement data. We use information on income from the income tax records to compute the *severance pay fraction* at retirement as the ratio of the severance pay in the year of retirement to the average annual salary over the three years prior to retirement.[9] We use the income information from the tax records to compute this severance pay fraction since the income from the tax records is uncensored (i.e. values beyond the social security earnings limits are observed) and salary is more accurately measured than in the social security record data. Because we use income information from three years prior to retirement to compute the severance pay fraction at retirement, our final sample is restricted to individuals who retire in the years 1997 through 2005.

[9] Earnings over the last years prior for retirement are relatively stable for most individuals. We have experimented with alternative measures of the salary, but this one seems to be the most stable.

Evidence on Severance Payments

We now investigate evidence on the actual severance payments received by retiring workers in the final year of employment. As the schedule is specified in terms of severance pay as a fraction of earnings, we focus on the ratio of severance pay relative to annual earnings, which we call the *severance pay fraction*.

Appendix Figure 11 shows histograms of the distribution of the severance pay fraction for selected values of tenure around the severance pay tenure thresholds. Specifically, we present the distribution for individuals with $(9, 10)$, $(14, 15)$, $(19, 20)$, and $(24, 25)$ years of tenure in panels $A - D$. The histograms highlight variation in severance payments that is at odds with the severance pay schedule shown in Figure 1. This variation is due to voluntary severance payments and refunds for leftover vacation days which are also counted in the severance pay income category in the tax records. A second explanation for the variation is measurement error. In the tax data, the base salary for computing severance pay is potentially measured with error as the records do not include an employer identifier. However, the histograms also show clear spikes at the values of the legislated severance pay fractions. These spikes shift as the tenure level crosses the threshold. Looking at the panel corresponding to individuals with 9 years of tenure at retirement, we see a spike at zero severance pay but also a prominent mass point at a severance pay fraction of 25%, which corresponds to the legislated severance pay fraction for layoffs with tenure longer than 5 years. This indicates that some employers make side-payments to treat job exits at retirement similar as layoffs at a tenure below 10 years. Once the tenure level moves above the first threshold of 10 years in the second panel in Appendix Figure 11, the mass point shifts to 33%, which corresponds to the legislated severance pay fraction. In this graph, as well as in the graphs for higher tenure levels, there is still a fraction of individuals receiving zero severance pay, for which we do not have a good explanation. In addition there are individuals receiving higher severance payments than the legislated values, which can be due to voluntary severance pay and refunds for vacation days. The maximum severance pay fraction is slightly above one which corresponds to the tax rule. Overall, the histograms indicate that there are discontinuous jumps in severance pay fractions at the tenure thresholds, which might, however, be moderated by side-payments.

Appendix Table A1: Gross and Net Replacement Rates Across Countries and Earnings Levels

	Gross Replacement Rates						Net Replacement Rates					
		Individual Earnings, multiple of mean						Individual Earnings, multiple of mean				
	Median Earner	0.5	0.75	1	1.5	2	Median Earner	0.5	0.75	1	1.5	2
Australia	47.9	70.7	52.3	43.1	33.8	29.2	61.7	83.5	66.2	56.4	46.1	40.8
Austria	80.1	80.1	80.1	80.1	78.5	58.8	90.6	90.4	90.6	90.9	89.2	66.4
Belgium	40.7	57.3	40.9	40.4	31.3	23.5	64.4	77.3	65.5	63	51.1	40.7
Canada	49.5	75.4	54.4	43.9	29.6	22.2	62.8	89.2	68.3	57.4	40	30.8
Czech Republic	54.3	78.8	59	49.1	36.4	28.9	70.3	98.8	75.6	64.4	49.3	40.2
Denmark	83.6	119.6	90.4	75.8	61.3	57.1	94.1	132.7	101.6	86.7	77	72.2
Finland	63.4	71.3	63.4	63.4	63.4	63.4	68	77.4	68.4	68.8	70.3	70.5
France	51.2	63.8	51.2	51.2	46.9	44.7	62.8	78.4	64.9	63.1	58	55.4
Germany	39.9	39.9	39.9	39.9	39.9	30	57.3	53.4	56.6	58	59.2	44.4
Greece	95.7	95.7	95.7	95.7	95.7	95.7	111.1	113.6	111.7	110.1	110.3	107
Hungary	76.9	76.9	76.9	76.9	76.9	76.9	96.5	94.7	95.1	102.2	98.5	98.5
Iceland	80.1	109.9	85.8	77.5	74.4	72.9	86.9	110.9	92	84.2	80.3	79.7
Ireland	38.2	65	43.3	32.5	21.7	16.2	44.4	65.8	49.3	38.5	29.3	23.5
Italy	67.9	67.9	67.9	67.9	67.9	67.9	77.9	81.8	78.2	77.9	78.1	79.3
Japan	36.8	47.8	38.9	34.4	29.9	27.2	41.5	52.5	43.5	39.2	34.3	31.3
Korea	72.7	99.9	77.9	66.8	55.8	45.1	77.8	106.1	83.1	71.8	61.9	50.7
Luxembourg	90.3	99.8	92.1	88.3	84.5	82.5	98	107.6	99.8	96.2	92.9	91
Mexico	36.6	52.8	37.3	35.8	34.4	33.6	37.9	50.3	37.8	38.3	39	40
Netherlands	81.7	80.6	81.5	81.9	82.4	82.6	105.3	97	103.8	96.8	96.3	94.8
New Zealand	46.8	79.5	53	39.7	26.5	19.9	48.6	81.4	54.9	41.7	29.4	23.2
Norway	60	66.4	61.2	59.3	50.2	42.7	70	77.1	71.2	69.3	62.5	55.1
Poland	61.2	61.2	61.2	61.2	61.2	61.2	74.8	74.5	74.8	74.9	75	77.1
Portugal	54.3	70.4	54.5	54.1	53.4	52.7	67.4	81.6	66	69.2	72.2	73.7
Slovak Republic	56.7	56.7	56.7	56.7	56.7	56.7	71.9	66.4	70.6	72.9	75.4	76.7
Spain	81.2	81.2	81.2	81.2	81.2	67.1	84.2	82	83.9	84.5	85.2	72.4
Sweden	63.7	79.1	66.6	62.1	64.7	66.3	66.2	81.4	69.2	64	71.9	73.9
Switzerland	62	62.5	62.1	58.4	40.7	30.5	68.8	75	68.2	64.3	45.7	35.1
Turkey	72.5	72.5	72.5	72.5	72.5	72.5	103.4	101	102.9	104	106.4	108.3
UK	34.4	53.4	37.8	30.8	22.6	17	45.4	66.1	49.2	41.1	30.6	24
US	43.6	55.2	45.8	41.2	36.5	32.1	55.3	67.4	58	52.4	47.9	43.2
OECD	60.8	73	62.7	58.7	53.7	49.2	72.1	83.8	74	70.1	65.4	60.7
Women (where different)												
Italy	52.8	52.8	52.8	52.8	52.8	52.8	63.8	63.6	64.4	63.4	63.7	63.5
Mexico	31.1	52.8	35.2	29.7	28.5	27.9	32.2	50.3	35.7	31.7	32.3	33.2
Poland	44.5	46.2	44.5	44.5	44.5	44.5	55.3	57.5	55.3	55.2	55	56.4
Switzerland	62.6	62.8	62.6	59.1	41.2	30.9	68.1	75.4	68.9	65	46.3	35.5

Notes: Reproduced from Whitehouse and Queisser (2007). The gross replacement rate is defined as gross pension entitlement divided by gross pre-retirement earnings. The net replacement rate is defined as the individual net pension entitlement divided by net pre-retirement earnings, taking account of personal income taxes and social security contributions paid by workers and pensioners.

Appendix Table A2: Sample Selection

	Number of Individuals	Percentage change
Individuals in cohorts born 1930 - 1945,		
Still employed at age 54 with more than one year of work experience	700,590	
Excluding workers ever employed as civil servant	623,055	-11%
Workers retiring within 6 months of their last job	424,598	-32%
Excluding workers with last job in construction	381,239	-10%
Excluding left censored tenure in last job	293,824	-23%
Individuals with 6 - 28 years of tenure	194,086	-34%
Sample matched with tax data:		
Individuals retiring between 1997 and 2005	97,107	-50%
Matched severance pay in tax data	89,426	-8%

Notes: Numbers based on the ASSD.

Appendix Table A4: Frictions in Expected Length of Delay Estimation Results

Panel A: 10 Year Threshold (N = 32379)						
Months Prior to Threshold	15	12	9	6	3	2
Participation Rate	-0.04	0.17	0.40	0.64	0.87	0.94
(in percentage points)	(0.04)	(0.05)	(0.07)	(0.08)	(0.05)	(0.03)
Change in Net of Tax Rate	1.25	1.57	2.09	3.13	6.27	9.40
(in percentage points)	-	-	-	-	-	-
Elasticity	-0.03	0.11	0.19	0.20	0.14	0.10
	(0.03)	(0.03)	(0.03)	(0.03)	(0.01)	(0.00)
Fraction Constrained	0.66					
	(0.03)					
Panel B: 15 Year Threshold (N = 28166)						
Months Prior to Threshold	15	12	9	6	3	2
Participation Rate	-0.01	0.18	0.42	0.67	0.89	0.95
(in percentage points)	(0.03)	(0.04)	(0.06)	(0.07)	(0.05)	(0.03)
Change in Net of Tax Rate	0.63	0.78	1.04	1.57	3.13	4.70
(in percentage points)	-	-	-	-	-	-
Elasticity	-0.02	0.23	0.40	0.43	0.29	0.20
	(0.05)	(0.05)	(0.06)	(0.05)	(0.02)	(0.01)
Fraction Constrained	0.62					
	(0.03)					
Panel C: 20 Year Threshold (N = 25455)						
Months Prior to Threshold	15	12	9	6	3	2
Participation Rate	0.05	0.23	0.45	0.70	0.91	0.97
(in percentage points)	(0.03)	(0.04)	(0.06)	(0.07)	(0.05)	(0.03)
Change in Net of Tax Rate	0.94	1.18	1.57	2.35	4.70	7.05
(in percentage points)	-	-	-	-	-	-
Elasticity	0.05	0.19	0.29	0.30	0.19	0.14
	(0.03)	(0.04)	(0.04)	(0.03)	(0.01)	(0.00)
Fraction Constrained	0.60					
	(0.03)					
Panel D: 25 Year Threshold (N = 19932)						
Months Prior to Threshold	15	12	9	6	3	2
Participation Rate	-0.06	0.06	0.23	0.47	0.77	0.87
(in percentage points)	(0.03)	(0.03)	(0.04)	(0.05)	(0.03)	(0.02)
Change in Net of Tax Rate	0.94	1.18	1.57	2.35	4.70	7.05
(in percentage points)	-	-	-	-	-	-
Elasticity	-0.06	0.05	0.15	0.20	0.16	0.12
	(0.03)	(0.02)	(0.03)	(0.02)	(0.01)	(0.00)
Fraction Constrained	0.55					
	(0.03)					
Panel E: Average Across Thresholds						
Months Prior to Threshold	15	12	9	6	3	2
Participation Rate	-0.02	0.16	0.38	0.62	0.86	0.93
(in percentage points)	(0.02)	(0.02)	(0.03)	(0.03)	(0.02)	(0.01)
Change in Net of Tax Rate	0.94	1.18	1.57	2.35	4.70	7.05
(in percentage points)	-	-	-	-	-	-
Elasticity	-0.01	0.14	0.26	0.28	0.20	0.14
	(0.02)	(0.02)	(0.02)	(0.02)	(0.01)	(0.00)
Fraction Constrained	0.61					
	(0.01)					

Notes: Numbers in parentheses are bootstrapped standard errors based on 1000 replications.

Appendix Table A3: Estimation Results

Panel A: 10 Year Threshold (N = 32379)						
Months Prior to Threshold	15	12	9	6	3	2
Participation Rate	-0.04	0.17	0.40	0.64	0.87	0.94
(in percentage points)	(0.04)	(0.05)	(0.07)	(0.08)	(0.05)	(0.03)
Change in Net of Tax Rate	1.25	1.57	2.09	3.13	6.27	9.40
(in percentage points)	-	-	-	-	-	-
Elasticity	-0.03	0.11	0.19	0.20	0.14	0.10
	(0.03)	(0.03)	(0.03)	(0.03)	(0.01)	(0.00)
Fraction Constrained	0.66					
	(0.03)					
Panel B: 15 Year Threshold (N = 28166)						
Months Prior to Threshold	15	12	9	6	3	2
Participation Rate	-0.01	0.18	0.42	0.67	0.89	0.95
(in percentage points)	(0.03)	(0.04)	(0.06)	(0.07)	(0.05)	(0.03)
Change in Net of Tax Rate	0.63	0.78	1.04	1.57	3.13	4.70
(in percentage points)	-	-	-	-	-	-
Elasticity	-0.02	0.23	0.40	0.43	0.29	0.20
	(0.05)	(0.05)	(0.06)	(0.05)	(0.02)	(0.01)
Fraction Constrained	0.62					
	(0.03)					
Panel C: 20 Year Threshold (N = 25455)						
Months Prior to Threshold	15	12	9	6	3	2
Participation Rate	0.05	0.23	0.45	0.70	0.91	0.97
(in percentage points)	(0.03)	(0.04)	(0.06)	(0.07)	(0.05)	(0.03)
Change in Net of Tax Rate	0.94	1.18	1.57	2.35	4.70	7.05
(in percentage points)	-	-	-	-	-	-
Elasticity	0.05	0.19	0.29	0.30	0.19	0.14
	(0.03)	(0.04)	(0.04)	(0.03)	(0.01)	(0.00)
Fraction Constrained	0.60					
	(0.03)					
Panel D: 25 Year Threshold (N = 19932)						
Months Prior to Threshold	15	12	9	6	3	2
Participation Rate	-0.06	0.06	0.23	0.47	0.77	0.87
(in percentage points)	(0.03)	(0.03)	(0.04)	(0.05)	(0.03)	(0.02)
Change in Net of Tax Rate	0.94	1.18	1.57	2.35	4.70	7.05
(in percentage points)	-	-	-	-	-	-
Elasticity	-0.06	0.05	0.15	0.20	0.16	0.12
	(0.03)	(0.02)	(0.03)	(0.02)	(0.01)	(0.00)
Fraction Constrained	0.55					
	(0.03)					
Panel E: Average Across Thresholds						
Months Prior to Threshold	15	12	9	6	3	2
Participation Rate	-0.02	0.16	0.38	0.62	0.86	0.93
(in percentage points)	(0.02)	(0.02)	(0.03)	(0.03)	(0.02)	(0.01)
Change in Net of Tax Rate	0.94	1.18	1.57	2.35	4.70	7.05
(in percentage points)	-	-	-	-	-	-
Elasticity	-0.01	0.14	0.26	0.28	0.20	0.14
	(0.02)	(0.02)	(0.02)	(0.02)	(0.01)	(0.00)
Fraction Constrained	0.61					
	(0.01)					
Panel F: Average Across Thresholds, 18-Month Window around Thresholds						
Months Prior to Threshold	15	12	9	6	3	2
Participation Rate	0.01	0.18	0.39	0.62	0.85	0.93
(in percentage points)	(0.02)	(0.03)	(0.03)	(0.03)	(0.02)	(0.01)
Change in Net of Tax Rate	0.94	1.18	1.57	2.35	4.70	7.05
(in percentage points)	-	-	-	-	-	-
Elasticity	0.01	0.16	0.26	0.28	0.19	0.14
	(0.02)	(0.02)	(0.02)	(0.02)	(0.01)	(0.00)
Fraction Constrained	0.60					
	(0.01)					

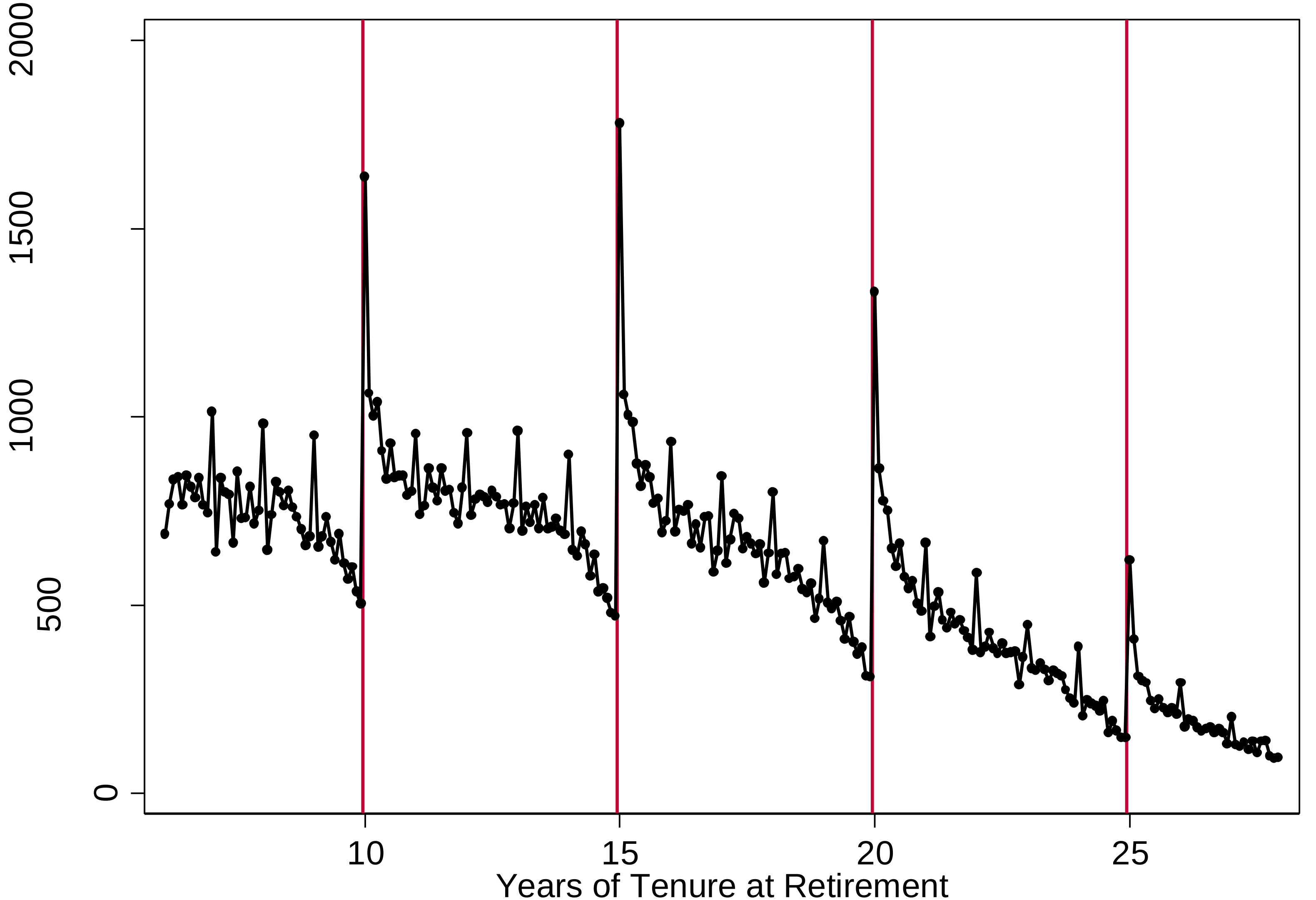
Notes: Numbers in parentheses are bootstrapped standard errors based on 1000 replications.

Appendix Table A5: Retirement Age Elasticities

	Men					Women				
	10 Year Threshold	15 Year Threshold	20 Year Threshold	25 Year Threshold	Weighted Average	10 Year Threshold	15 Year Threshold	20 Year Threshold	25 Year Threshold	Weighted Average
Excess Mass										
	553.9370	543.4282	654.0662	399.7941		1149.0970	1488.9650	1305.9290	388.8052	
	(40.7909)	(46.3852)	(43.7540)	(43.8715)		(52.1589)	(60.1331)	(69.9948)	(61.1119)	
Fraction Constrained										
	0.7962	0.7277	0.6640	0.6299		0.6092	0.5771	0.5259	0.4279	
	(0.0336)	(0.0184)	(0.0318)	(0.0461)		(0.0522)	(0.0432)	(0.0609)	(0.1116)	
Length of Delay										
	0.5176	0.4035	0.5222	0.4932		0.4582	0.5752	0.6603	0.4025	
	(0.0550)	(0.0432)	(0.0593)	(0.0980)		(0.0500)	(0.0573)	(0.0904)	(0.1264)	
Point of Convergence										
	0.6667	1.4167	1.3333	1.1667		1.4167	1.4167	1.0833	1.0000	
	(0.3756)	(0.0956)	(0.1582)	(0.3998)		(0.3376)	(0.1746)	(0.1486)	(0.2579)	
Elasticity, Lower Bound										
	0.0053	0.0023	0.0028	0.0022	0.0034	0.0060	0.0046	0.0044	0.0019	0.0048
	(0.0007)	(0.0003)	(0.0004)	(0.0006)	(0.0002)	(0.0010)	(0.0007)	(0.0008)	(0.0008)	(0.0004)
Elasticity, Upper Bound										
	0.0081	0.0151	0.0108	0.0073	0.0107	0.0439	0.0194	0.0092	0.0066	0.0236
	(0.0010)	(0.0021)	(0.0020)	(0.0016)	(0.0008)	(0.0219)	(0.0040)	(0.0021)	(0.0028)	(0.0072)
Tenure Weights										
	3211	3072	2562	1530		4497	4631	3486	1226	

Notes: Numbers in parentheses are bootstrapped standard errors based on 1000 replications. Tenure weights are used to compute the weighted average in the fifth column. The listed weights are the frequencies of retirement within one year following a tenure threshold; the weights are constructed by dividing the listed frequencies by the total of the frequencies.

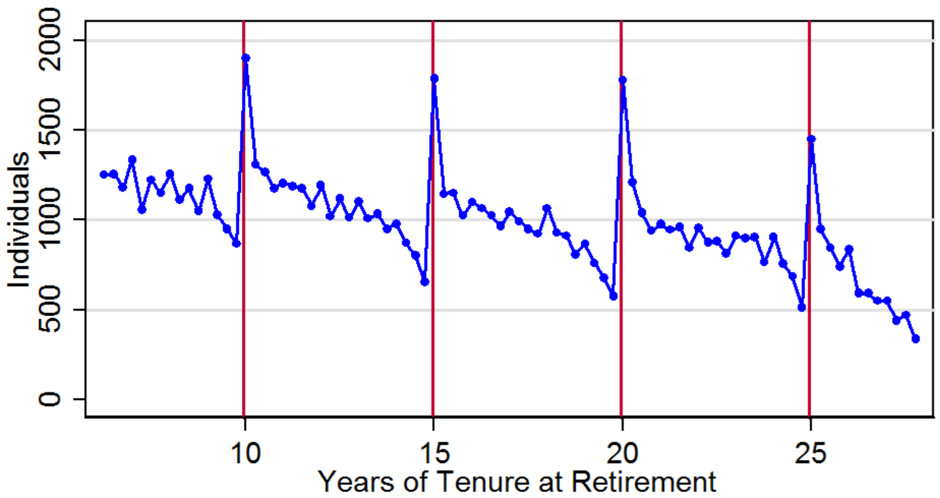
Appendix Figure A1. Distribution of Tenure at Retirement, Full Sample Born in 1930-1945



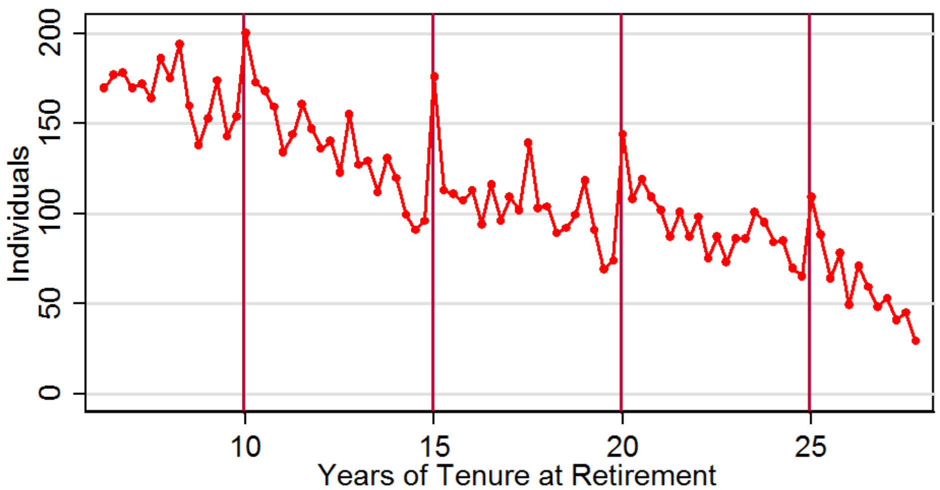
Notes: This figure plots the distribution of tenure at retirement at a monthly frequency. Each point captures the number of people that retire with tenure greater than the lower number of months, but less than the higher number of months. Tenure at retirement is computed using observed job starting and job ending dates. Since firm-level tenure is only recorded beginning in January 1972, we restrict the sample to individuals with uncensored tenure at retirement (i.e. job starting after January 1972).

Appendix Figure A2. Tenure at Retirement by Health Status

Healthy

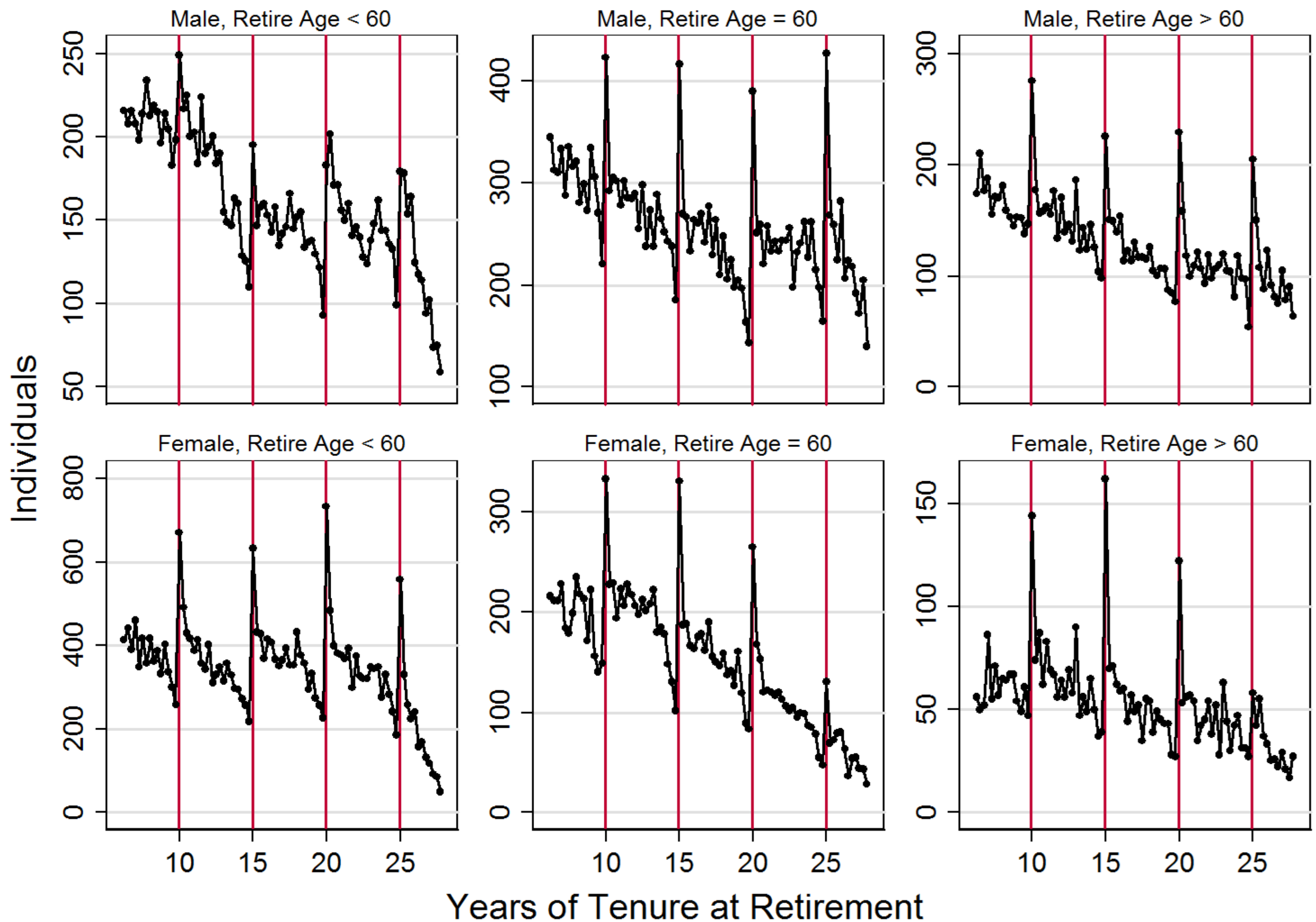


Unhealthy



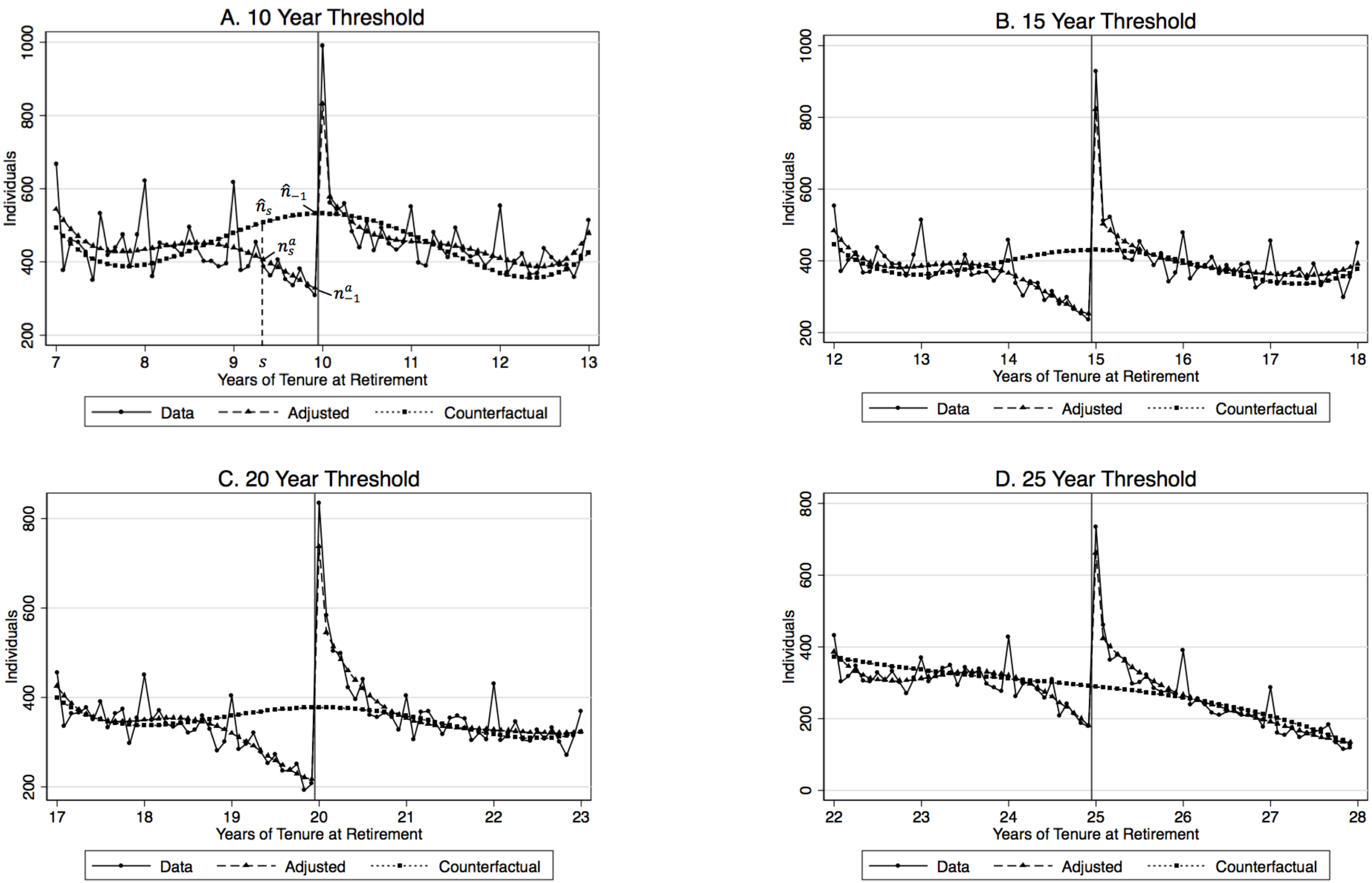
Notes: Health status is measured based on the fraction of time between age 54 and retirement that is spent on sick leave. An individual is classified as unhealthy if his health status is below the median level. The median health status is computed within the sample of individuals with positive sick leave; this median health status is 0.038.

Appendix Figure A3. Tenure at Retirement by Gender & Retirement Age



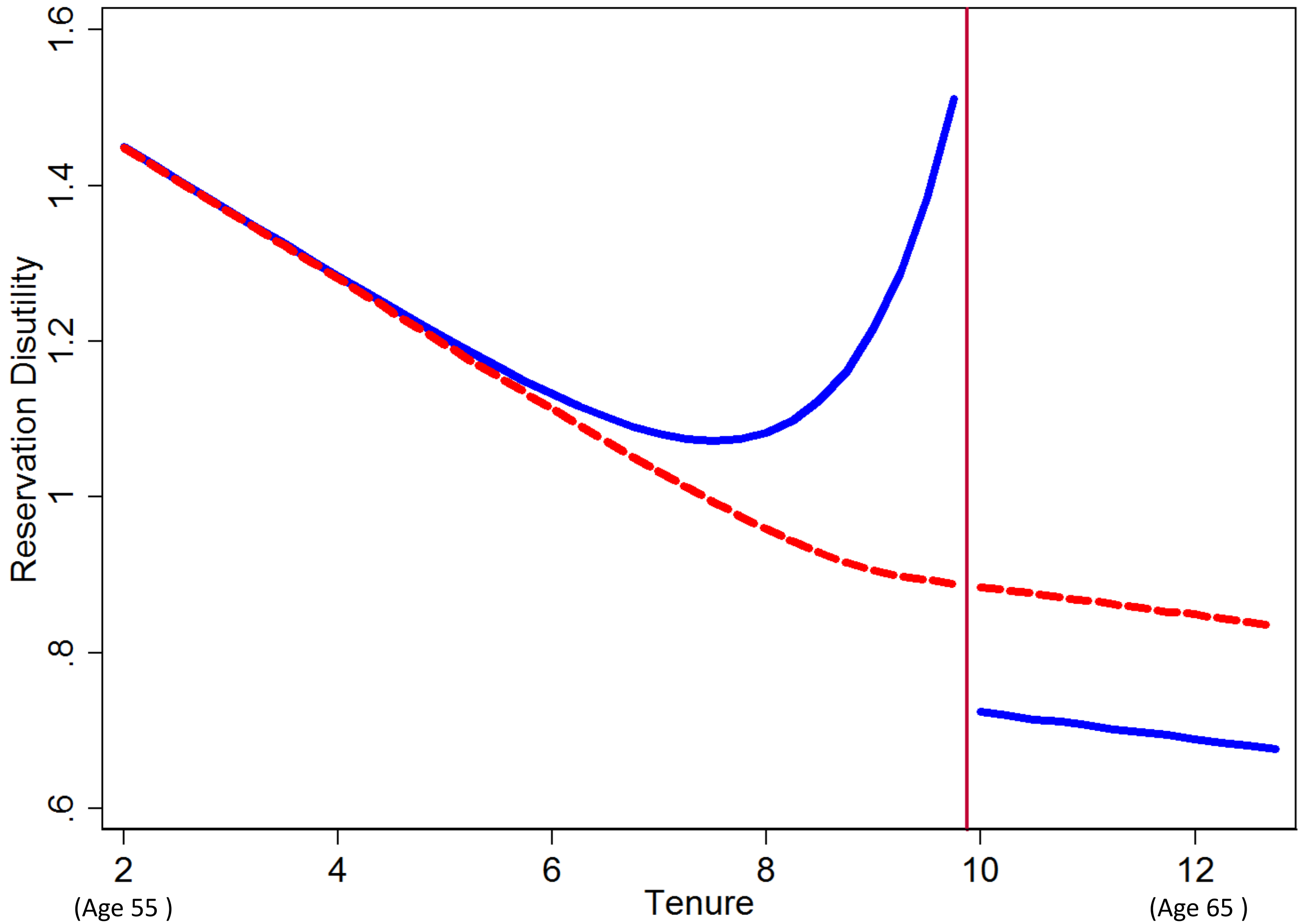
Notes: The age groups for men and women are chosen based on the survival curves illustrated in Figure 2. The Early Retirement Age and Normal Retirement Age for women are 55 and 60; the corresponding ages for men are 60 and 65 respectively. Prior to age 60, men can retire and claim disability pensions.

Appendix Figure A4. Retirement Profiles to Fit, Using 18 Month Window



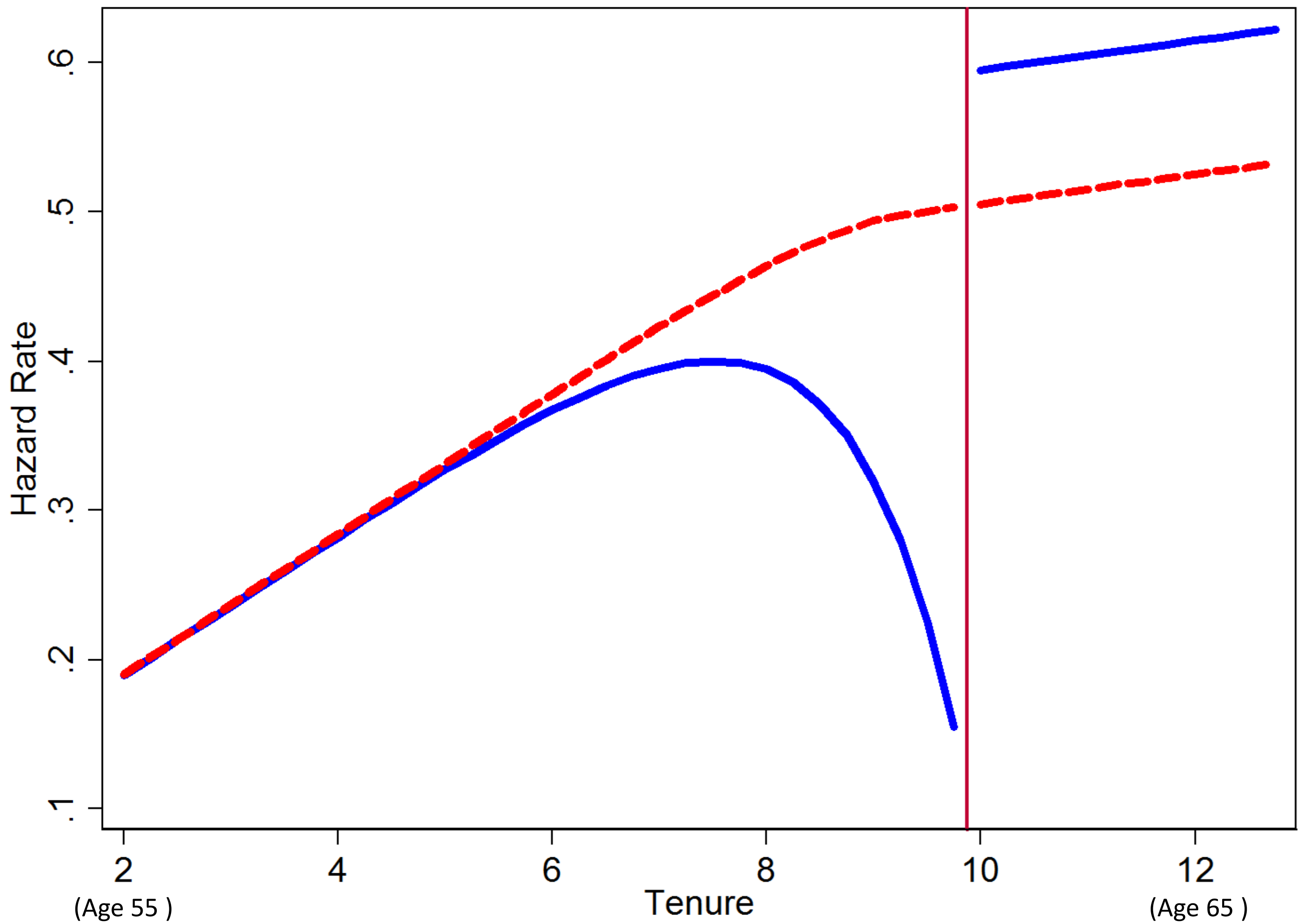
Notes: This figure combines plots for the observed retirement frequencies (black squares), the seasonally adjusted retirement frequencies (blue triangles) and the counterfactual retirement frequencies (red circles).

Appendix Figure A5. Individual Reservation Disutility by Tenure



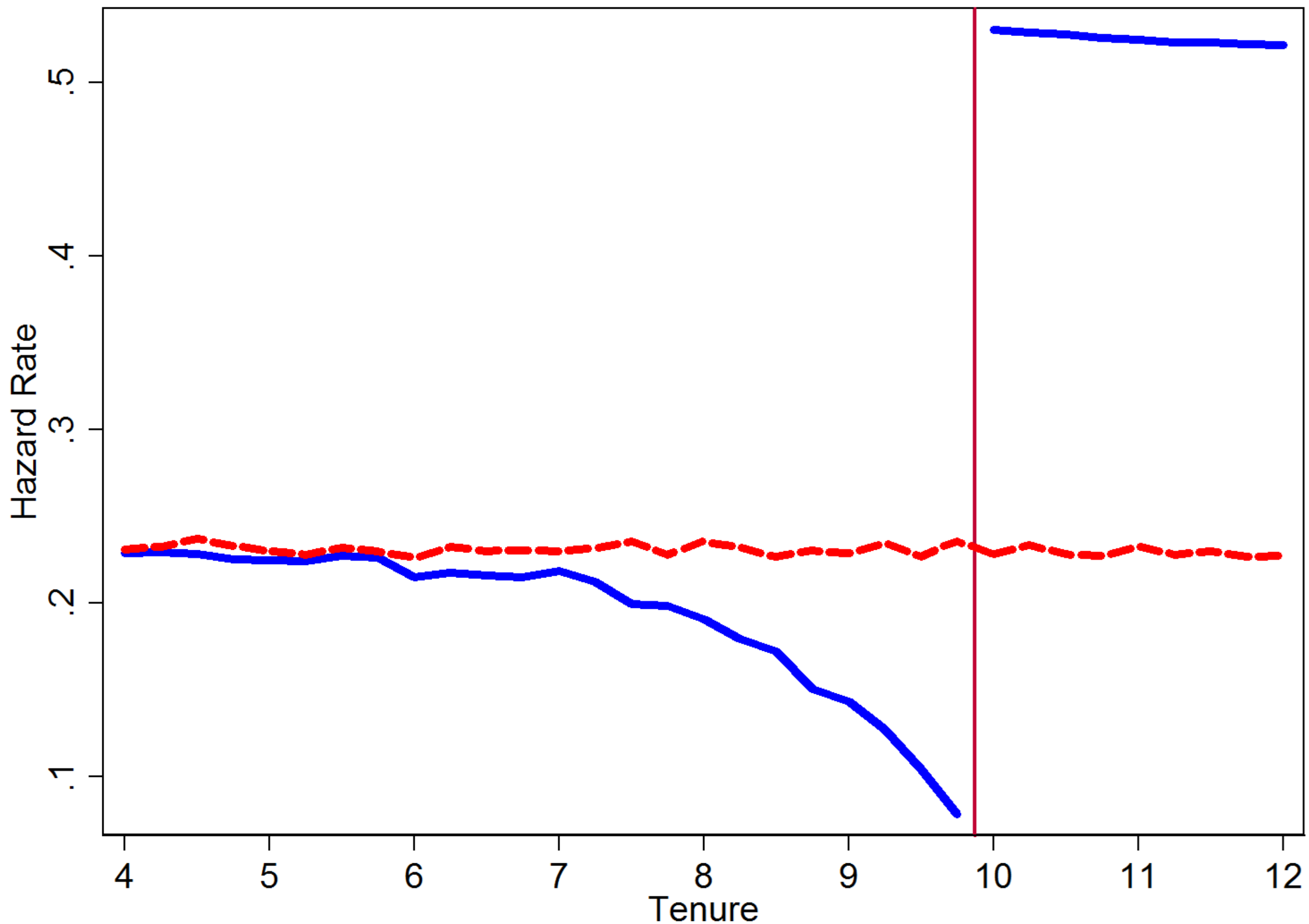
Notes: This figure plots the simulated profiles of the reservation disutility across years of tenure for a given individual who starts with 2 years of tenure at age 55. Following the model, the individual ages as he accumulates more tenure. The solid blue line presents the profile in the presence of the severance pay policy. The dashed red line presents the counterfactual profile with no severance pay. The curvature in the counterfactual profile reflects changes in retirement benefits at older retirement ages. Please see the simulation appendix for technical details on the simulation.

Appendix Figure A6. Individual Retirement Hazard by Tenure



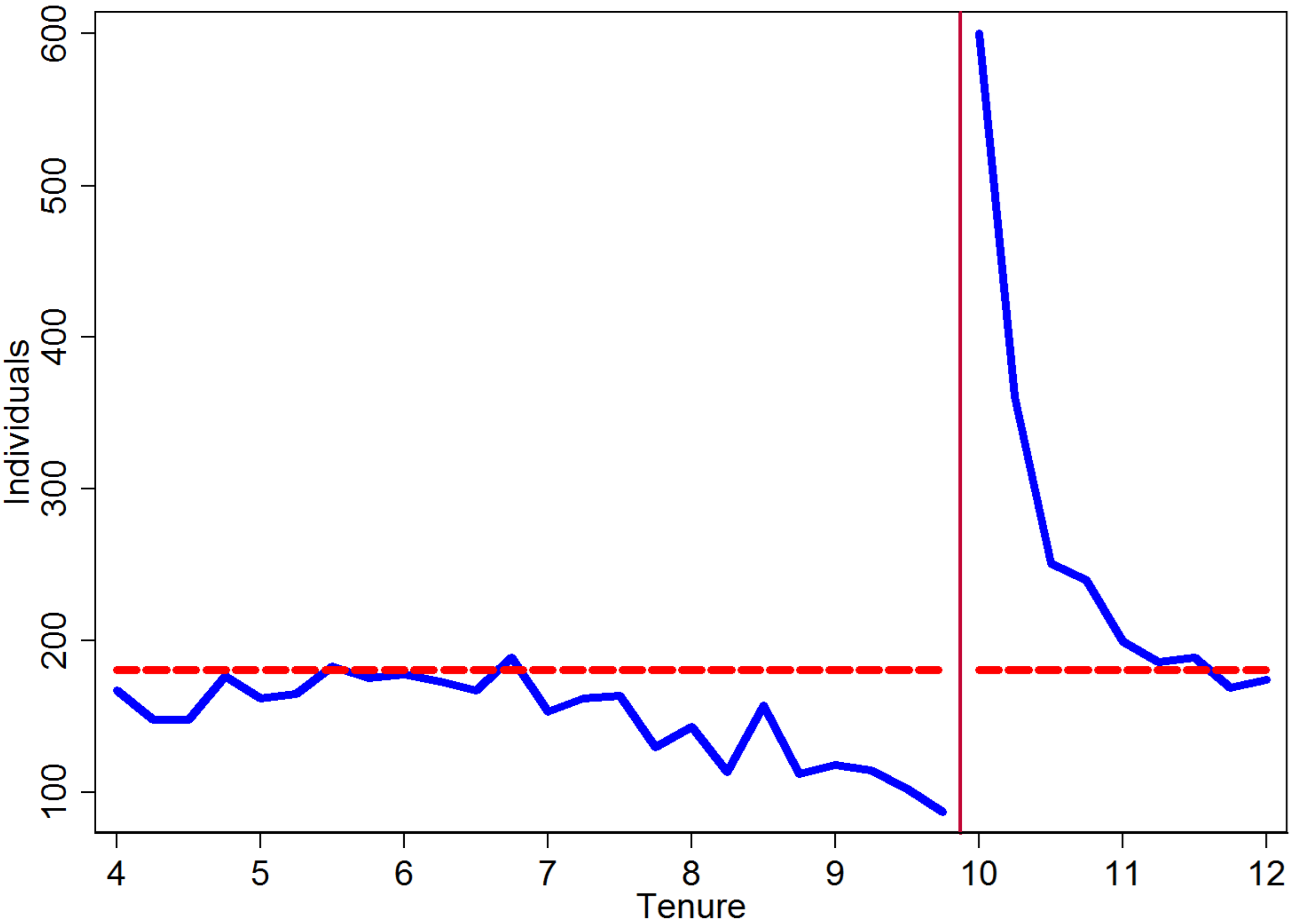
Notes: This figure plots the simulated profile of the retirement hazard rate (i.e. the probability of retirement conditional on remaining in the labor market) across years of tenure for a given individual who starts with 2 years of tenure at age 55. Following the model, the individual ages as he accumulates more tenure. The solid blue line presents the profile in the presence of the severance pay policy. The dashed red line presents the counterfactual profile with no severance pay. The curvature in the counterfactual profile reflects changes in retirement benefits at older retirement ages. Please see the simulation appendix for technical details on the simulation.

Appendix Figure A7. Average Retirement Hazard by Tenure



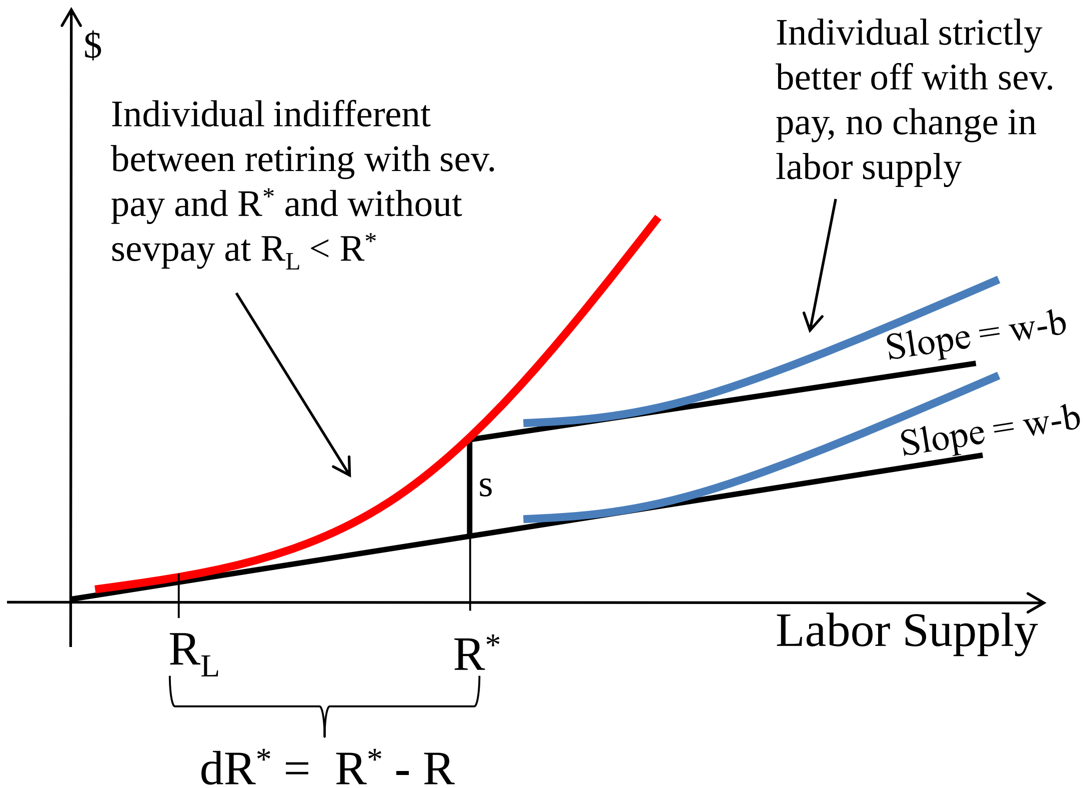
Notes: This figure plots the average simulated retirement hazard rate, conditional on remaining in the labor market, by tenure. The average retirement hazard rate at each level of tenure is computed by the following steps. First, retirement outcomes are computed for each simulated individual. Second, at each observed retirement, the reservation disutility and corresponding hazard rate are computed. Third, at each level of tenure at retirement, the average retirement hazard rate is computed by averaging over individuals retiring at different ages. The solid blue line and triangle present the hazard rates in the presence of the severance pay policy. The dashed red line and circle present the counterfactual hazard rates with no severance pay. Please see the simulation appendix for technical details on the simulation.

Appendix Figure A8. Simulated Distribution of Tenure at Retirement

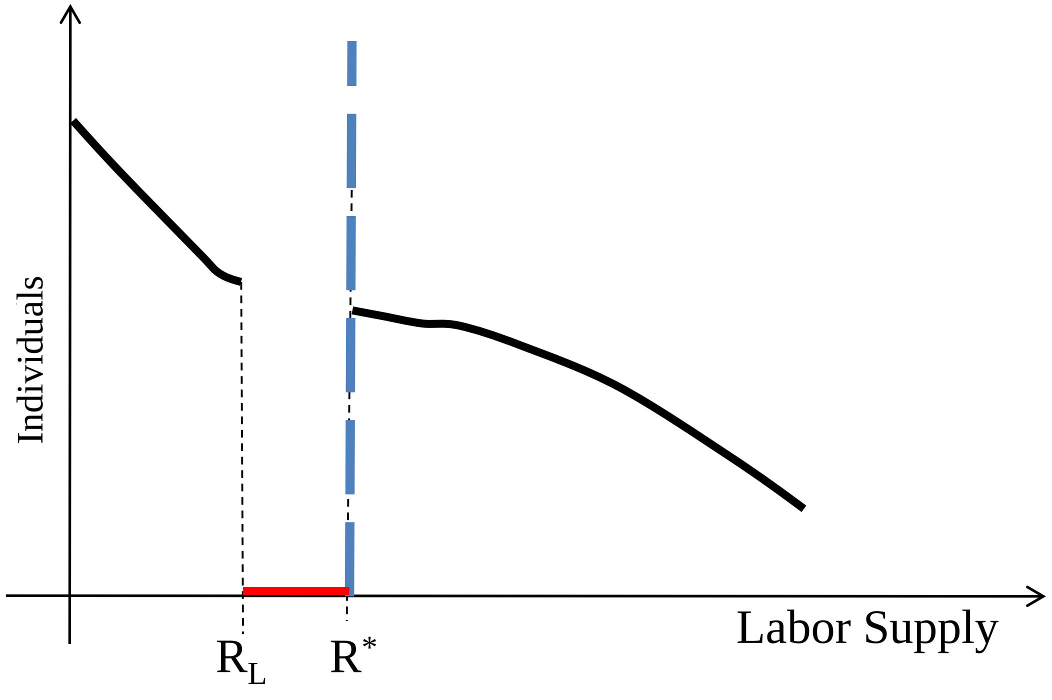


Notes: This figure plots the simulated distribution of tenure at retirement based on simulated retirement outcomes for 10,000 simulated individuals. The solid blue line presents the distribution in the presence of the severance pay policy. The dashed red line presents the counterfactual distribution with no severance pay. Please see the simulation appendix for technical details on the simulation.

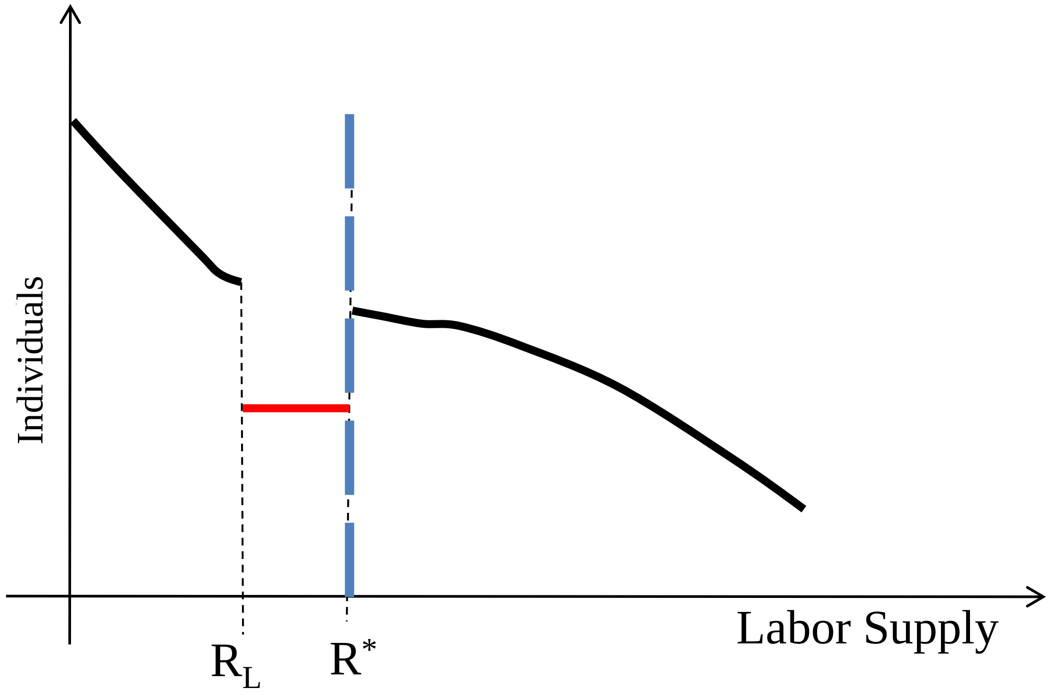
Appendix Figure A9.
Optimal Retirement Choices with Severance Pay Notch



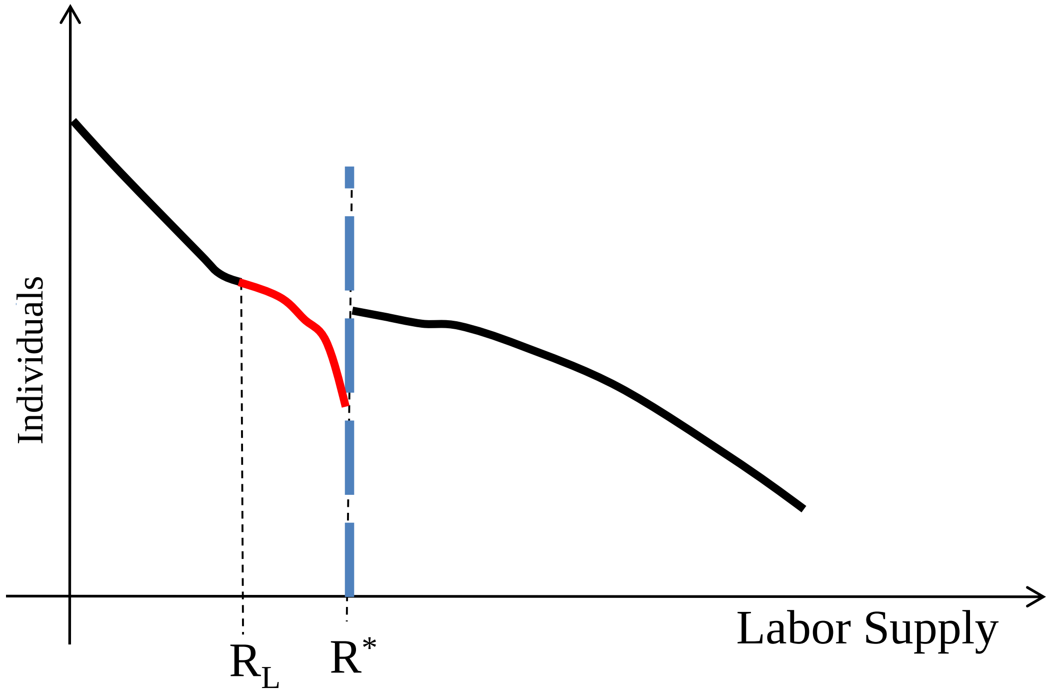
Appendix Figure A10A. Bunching Patterns, No Constraints



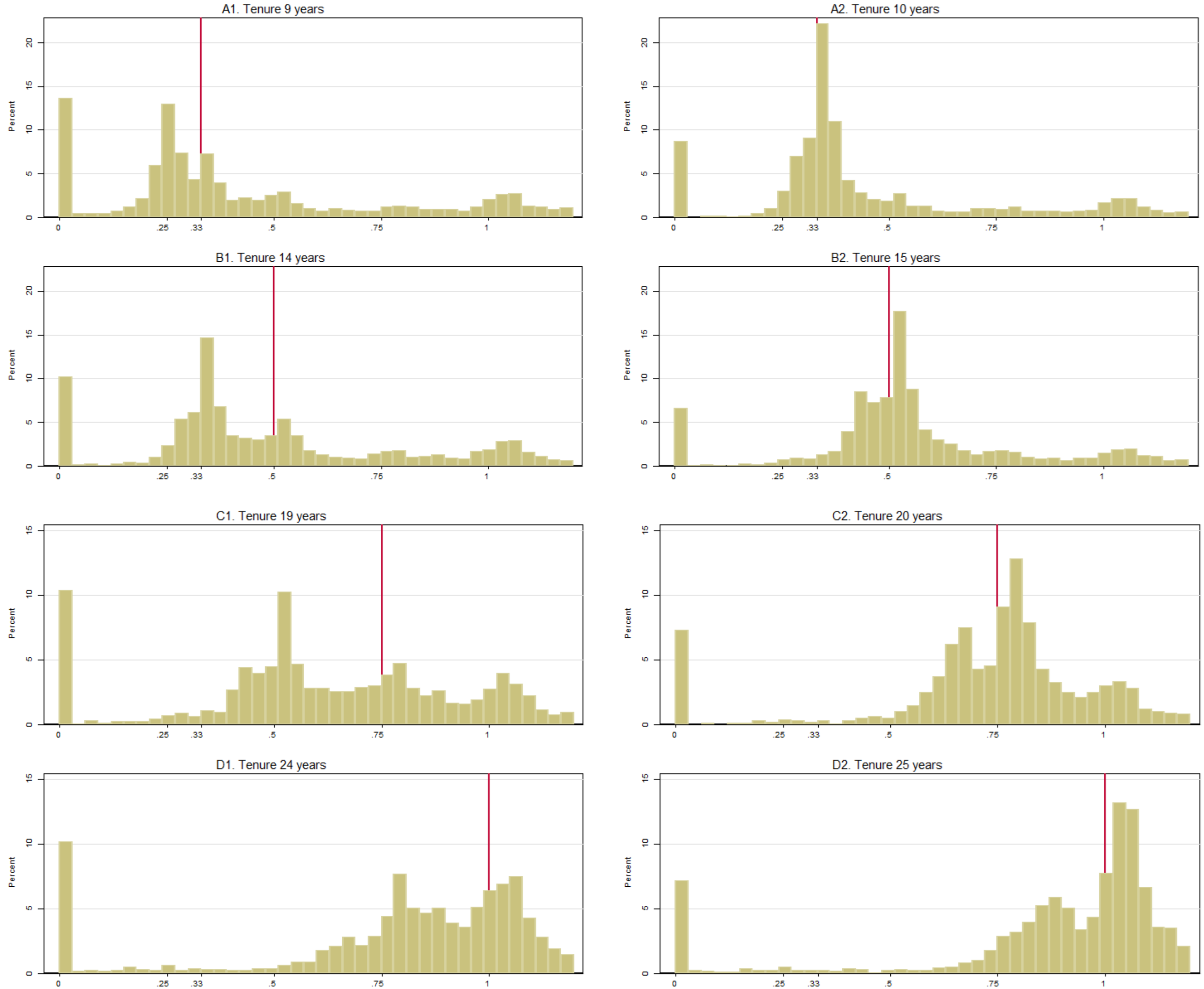
Appendix Figure A10B. Bunching Patterns, Constant Fraction Constrained



Appendix Figure A10C.
Bunching Patterns, Heterogeneous Adjustment Costs



Appendix Figure A11. Severance Pay Fractions at Different Tenure Levels



Notes: This figure presents the distribution of the severance pay fraction at a given level of tenure at retirement. The severance pay fraction is computed using data from income tax records. Specifically, the fraction is computed as the severance pay in the year of retirement divided by average income in the 3 years prior to retirement. Years of tenure at retirement are computed using job start and exit dates from social security records. The vertical red lines in each plot indicate the legislated severance pay fraction at the threshold closest to the given level of tenure at retirement.