Intertemporal Substitution in Labor Force Participation: Evidence from Policy Discontinuities

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Abstract

This paper presents new empirical evidence on intertemporal labor supply elasticities. We use administrative data on the census of private sector employees in Austria and variation from mandated discontinuous changes in retirement benefits from the Austrian pension system. We first present graphical evidence documenting delays in retirement in response to the policy discontinuities. Next, based on the empirical evidence, we develop a model of career length decisions. Using a semiparametric estimator that exploits the graphical evidence, we estimate a relatively low intertemporal labor supply elasticity of 0.30.

1 Introduction

The theory of intertemporal labor supply is the workhorse theory of dynamic labor supply decisions in economics. In various applications of this theory in macroeconomics, labor economics and public economics, the intertemporal labor supply elasticity plays a central role in understanding business cycle fluctuations, life-cycle labor supply, and responses to income tax and transfer programs. Despite its importance in many macroeconomic and microeconomic models, there is wide-spread debate regarding the magnitude of this intertemporal labor supply elasticity with the higher and lower elasticities having vastly different policy implications.

In this study, we provide new empirical evidence on intertemporal labor supply elasticities using responses to policy discontinuities in retirement benefits in Austria. We first present nonparametric graphical evidence documenting individuals' labor supply responses to the policy discontinuities. Next, we develop a semiparametric elasticity estimator that exploits the observed labor supply responses. Based on the observed patterns in individuals' retirement decisions, we estimate an intertemporal labor supply elasticity of 0.30. Thus, standard intertemporal labor supply models that rely on high intertemporal labor supply elasticities would be at odds with the observed data presented in this study.

There has been significant research on intertemporal labor supply elasticities yielding a wide range of values.[1]. Some recent efforts to distinguish between higher and lower elasticities have focused on the distinction between the intensive and extensive margins of labor supply decisions (see Rogerson and Wallenius (2009) and Ljungqvist and Sargent (2010)[2]). Intuitively, elasticities based on intensive margin (hours of work in a given time period) decisions may be small while elasticities based on extensive margin (career length) decisions may be large. While some previous studies have focused only on intensive margin labor supply decisions, we are able to estimate an intertemporal labor supply elasticity while focusing explicitly on extensive margin decisions. In particular, we estimate an extensive margin Frisch elasticity, or more intuitively, an elasticity of career length with respect to

[1]See Blundell and MaCurdy (1999) for a survey of the microeconomic evidence of intertemporal substitution in labor supply. For macroeconomic evidence, see Prescott (2006), Mulligan (1999), Ohanian et al (2008), Rogerson and Wallenius (2009) and Ljungqvist et al (2006). Keane and Rogerson (2010) survey both microeconomic and macroeconomic evidence on intertemporal labor supply elasticities; these authors also discuss efforts to reconcile higher elasticities based on macroeconomic evidence with lower elasticities from microeconomic evidence.

[2]In earlier research, Heckman (1993) emphasizes the distinction between intensive and extensive margin labor supply decisions.

anticipated wages.

The policy discontinuities exploited in this study arise because retirement benefits in Austria increase discontinuously once individuals complete specific threshold amounts of tenure prior to their retirements. We examine behavior before and after these tenure thresholds to determine if individuals extend their careers in response to the anticipated discontinuous increases in benefits. Graphical evidence indicates excess retirements just after the thresholds and reduced retirements just prior to the thresholds. We then use a standard labor supply model to develop semiparametric estimator for the elasticity of career length with respect to anticipated wages based on the graphical evidence.[3] While previous structural estimation strategies have often been forced to make specific distributional assumptions to recover structural parameters, we are able to recover a policy-relevant structural parameter from a quasi-experimental design without having to make these parametric assumptions.

This paper is organized as follows. Section 2 discusses both the institutional background regarding the Austrian pension system and the administrative data from the Austrian Social Security Database. Section 3 presents a nonparametric graphical analysis of the data. Section 4 develops an intertemporal labor supply model based on the empirical evidence presented in section 3. Section 5 develops the elasticity estimation strategy and then presents the estimation results. Section 6 concludes.

2 Institutional Background & Data

2.1 Retirement Benefits in Austria

There are two forms of government-mandated retirement benefits in Austria: (1) government-provided pension benefits and (2) employer-provided severance payments. We start with the description of severance payments since these payments are the primary focus of the current study. The employer-provided severance payments are made to private sector employees who have accumulated sufficient years of tenure by the time of their retirement. Tenure is defined as uninterrupted employment time with a given employer and retirement is based on claiming a government-provided pension. The payments must be made within 4 weeks of claiming a pension according to the following schedule. If an employee has

[3] While this estimator relies on discontinuities in individuals' budget constraints, it is similar in spirit to previous bunching estimators that exploit kinks in individuals' budget constraints (see Saez (1999, 2009) and Chetty et al (2009)).

accumulated at least 10 years of tenure with her employer by the time of retirement, the employer must pay one third of the worker's last year's salary. This fraction increases from one third to one half, three quarters and one at 15, 20 and 25 years of tenure respectively. This schedule for the severance payments is illustrated in Figure 1. The payments are made in lump-sum and, since payments are based on an employee's salary, overtime compensation and other non-salary payments are not included when determining the amounts of the payments. Provisions to make these payments come from funds that employers are mandated to hold based on the total number of employees. Severance payments are also made to individuals who are involuntarily separated (i.e. laid off) from their firms if the individuals have accumulated sufficient years of tenure prior to the separation. The only voluntary separation that leads to a severance payment, however, is retirement.[4]

The Austrian income tax system, which is based on individual taxation, applies particular rules to tax income from severance payments. Specifically, all mandated severance payments are exempt from social security contributions and subject to a tax rate of 6%. The income taxation of the severance payments differs from the general income tax rules. Generally, gross monthly earnings net of social security contributions [5] are subject to the income tax with marginal tax rates in the different tax brackets of 0%, 21%, 31% 41% and 50%.[6] [7]

Because the timing of the severance payments relates to pension claiming, eligibility for government-provided retirement pensions interacts with the severance payment system. Austria has a public pension system that automatically enrolls every person employed in the private sector. Fixed pension contributions are withheld from each individual's wage and annuitized benefits during retirement are then based on prior contributions (earnings histories). Replacement rates from the annual payments are roughly 75% of pre-retirement earnings and there are no actuarial adjustments for delaying retirement to a later age. Individuals can retire by claiming Disability pensions, Early Retirement pensions and Old Age pensions. Eligibility for each of these pensions depends on an individual's age and

[4]For more details regarding the severance payments at times of unemployment, see Card, Chetty and Weber (2007).

[5]Contributions for pension, health, unemployment, and accident insurance of 39% are split in half between employer and employee and the employee's share is withheld from gross annual earnings up to a contribution cap.

[6]These tax brackets are based on legislation in 2002; there have subsequently been relatively small changes due to several small tax reforms.

[7]Additionally, Austrian employees are typically paid 13th and 14th monthly wage payments in June and December. These payments, up to an amount of one sixth of annual wage income, are also subject to a 6% tax rate; amounts in excess of one sixth of annual income are subject to the regular income tax rates.

gender, as well as having a sufficient number of contribution years. Beginning at age 55, private sector male and female employees can retire by claiming Disability pensions, where disability is based on reduced working capacity of 50% relative to someone of a similar educational background. At age 55, women also become eligible to claim Early Retirement pensions, but the Early Retirement Age is age 60 for men. Lastly, men and women become eligible for Old Age pensions at age 65 and 60 respectively.[8] Figure 2 illustrates survival functions for entry into the pension system for the sample of private sector employees. The graphs are presented separately for men and women given the different eligibility ages. The survival functions illustrate sharp declines at ages 60 and 65 highlighting a significant amount of entry into the pension system once individuals become eligible for the Early Retirement and Old Age pensions. Additionally, the figure demonstrates that, for both men and women, most retirements occur between ages 55 and 60. Further, the graph shows that roughly 25% of the male sample retire by claiming disability pensions prior to age 60.

2.2 Administrative Data & Sample Restrictions

Our empirical analysis is based on administrative registers from the Austrian Social Security Database (see Zweimüller et al (2009)), which is collected with the principle aim of verifying individual pension claims. This implies that the data provide longitudinal information for the universe of private sector workers in Austria throughout their working lives. Specifically, information on employment and earnings as well as other labor market states relevant for computing insurance years such as military service, unemployment, and maternity leave is collected. Detailed electronic records with employer identifiers that allow the measurement of tenure are recorded the period from 1972 onwards; here we use information up to 2006. For the years prior to 1972 retrospective information on insurance relevant states is available for all individuals who have retired by the end of the observation period. Together the two data sets provide information on complete earnings and employment careers of retirees. Because firm identifiers are available only from 1972 onwards, uncensored tenure can only be measured for jobs starting after January 1, 1972.

To investigate the effect of severance pay eligibility on retirement decisions we consider all individuals born between 1930 and 1945. For these individuals we observe sufficiently

[8] Benefits from disability and early retirement are entirely withdrawn if an individual earns more than about 300 Euros per month, therefore we see very few individuals returning to the labor force once they are retired.

long uncensored tenure at retirement.[9] We focus on workers who are still employed after their 55th birthday and follow them until entry into retirement or up to the age of 70. We make several restrictions to the original sample of about 650,000 workers, which are summarized in the top panel of Table 1. Most importantly, we exclude individuals who worked as civil servants or whose last job was in construction, because they are subject to different pension and severance pay rules. As we are interested in tenure at retirement, we further exclude workers with left censored tenure at retirement and we only consider retirement entries which occur within 6 months of the worker's last job. Individuals with longer gaps between employment and retirement are only followed until the end of the last employment. With these restrictions, we have a final sample of $269,411$ retiring individuals.

Table 2 presents summary statistics separately for the full retirement sample and for the sub-sample of individuals with more than 10 years of tenure at retirement, who are eligible for severance pay. The median retirement age is at 59 years in both groups, which reflects that most individuals retire through disability or early retirement (28% and 38% in the full sample, respectively).[10] Years of employment and annual earnings in the last year before retirement are slightly higher for workers with longer tenure and these workers also appear to be of better health given their average time spent in sick leave. Overall the differences between both groups are minor. Earnings relevant for the calculation of retirement benefits and therefore reported by the ASSD are top coded; roughly 14% of the sample has censored earnings at retirement.

3 Nonparametric Graphical Analysis

In this section we present graphical evidence on the individual labor supply responses to the severance payment thresholds at retirement. We start with a discussion of patterns in the distribution of tenure at retirement that is observed in the raw data. To confirm that these patterns correspond to reactions to the severance payment rule, we present three pieces of empirical evidence. First, we investigate the variation of other observables around the tenure thresholds and examine whether or not this variation in other observables can explain the observed patterns in the distribution of tenure at retirement. Second, we exam-

[9] In addition, these individuals retire after the pension reform in 1985, which changed the assessment basis for benefit calculation and the thereby the type of information recorded.

[10] The actual share of retirements through early retirement is higher than the presented number, as separate insurance categories for early retirement are only recorded as of 07/1993 and individuals retiring before the statutory pension age before that are coded as old age pension entries.

ine whether decisions earlier in life such as job changes at particular ages are responsible for the retirement patterns. Finally, we investigate how the patterns in tenure at retirement vary across various subgroups within the sample. We confirm that there is heterogeneity in the retirement patterns such that there are less (more) distinctive patterns amongst groups that we expect to be less (more) responsive to the severance payments. While this section focuses on highlighting the empirical evidence on labor supply responses to the severance payments, the next section presents a model of retirement decisions motivated by the empirical evidence.

3.1 Distribution of Tenure at Retirement

Figure 3 presents the distribution of tenure at retirement for the full sample with the number of individuals on the vertical axis and years of tenure at retirement on the horizontal axis; tenure at retirement is measured at a monthly frequency. Several features are immediately evident from this graph. First, the plot shows discontinuous spikes in the number of retirements at the tenure thresholds. Second, there are dips in the number of retirements just before the tenure thresholds, which are generally concentrated within 1 year before the threshold. These patterns are regularly repeated at each tenure threshold but are not apparent at any other point in the tenure distribution. This evidence suggests that individuals who would have retired just before the thresholds in the absence of the severance pay discontinuities end up delaying their retirements until they just qualify for the (larger) severance payments. The plot also indicates a seasonal pattern illustrated by small spikes in the number of retirement at each integer value of years of tenure at retirement. The seasonality can be explained by a relatively large fraction job starts in January and corresponding retirement exits in December.

Some noteworthy features are indicated by the pattern in Figure 3. First, the dips and spikes around the tenure thresholds are clearly separated from each other. This indicates that labor supply responses to each tenure threshold occur in a relatively narrow time window around the threshold. An impact of the severance pay schedule on intertemporal labor supply decisions beyond a five-year horizon is therefore not supported by the data. Second, the plot does not illustrate any evidence of income effects. In the presence of detectable income effects, individuals receiving larger severance payments would be more likely to retire than those receiving smaller payments. This would lead to discrete level changes between the tenure thresholds in the distribution of tenure at retirement since some individuals have sufficient tenure to receive a payment when they become eligible for retirement. Additionally, if wealth effects from the severance payments are relatively large, then individuals who qualify for the severance payments would end up retiring earlier than they would have in the absence of the severance payments. The observed patterns therefore suggest that wealth effects from the severance payments are relatively small. Third, even though there are decreases prior to the thresholds, the frequency of retirements never goes to zero just prior to the thresholds. This means there appears to be a substantial number of individuals who are unresponsive to the severance pay system at retirement. Our analysis of heterogeneity in labor supply responses will therefore concentrate on identifying the unresponsive groups; we will examine how health, earnings, firm size and job rigidity relate to responsiveness to the severance pay thresholds.

3.2 Accounting for Covariates

We exploit panel variation in the probability of retirement to examine whether or not other observable characteristics change around the tenure thresholds. In particular, we estimate the following regression

$$r_{it} = \sum_{\tau=0}^{34} \gamma_\tau d_\tau + X_{it}\beta + \epsilon_{it}$$

where r_{it} is an indicator equal to 1 if individual i retires within time period t and d_τ is an indicator equal to 1 if the individual's tenure at time t equals τ. For computational reasons, time is measured at a quarterly frequency at January 1st, April 1st, July 1st and October 1st instead of the monthly frequency presented in Figure 3. We include a large set of time-varying control variables X_{it} relating to age, calendar years, industry, region, seasonality, earnings histories, firm characteristics, health and experience.[11] The set of observations per individual covers all quarters from age 55 to retirement or age 70. Thus the sample used for estimation includes all 380,737 individuals left at the last step of sample selection in Table 1, not only those observed retiring within 6 month of their last job. Including all job exits

[11] Firm size is grouped into the following categories: $\leq 5, 6-10, 11-25, 26-99, 100-499, 500-999, \geq 1000$. Health status through age 54 is based on the following categories of sick leave through age 54: ≤ 0.5 years, $0.5-1$ years, $1-2$ years, and ≥ 2 years. Health in the current quarter is based on the following categories for sick leave in the current quarter: 0 days, $1-30$ days, $31-60$ days, and ≥ 61 days. Earnings growth dummies are based on positive, negative, or zero growth relative to earnings in the corresponding quarter. Quarterly earnings for individuals with continuous employment during a calendar year are equal to total annual earnings divided by 4. Earnings for individuals retiring at the beginning of a quarter are set equal to earnings from the previous quarter. For women, the base controls also include a dummy for having kids.

allows us to examine whether or not regularities in general job exits (as opposed to just retirements) after 5, 10, 15, ... year intervals are responsible for the observed retirement patterns in Figure 3.

Figure 4 plots the coefficients on the quarterly tenure dummies from the estimated regressions. The graph shows a pattern of dips before and large spikes at the thresholds that is very similar to Figure 3. The yearly seasonality pattern is now removed by controls for quarter of the year. Overall, Figure 4 confirms that incentives in the severance pay system are driving the retirement pattern around the tenure thresholds rather than other observable characteristics or regularities in job-leaving behavior.

3.3 Job Starts

While the earlier figures highlight individuals' responsiveness to the severance payments at retirement, we now turn to investigating whether or not these payments affect individuals' decisions to begin new jobs. Specifically, we investigate whether or not individuals time the beginning of new jobs so that they can retire at the Early Retirement Ages (ERAs, respectively 55 and 60 for women and men) and also claim severance payments at the time of their retirements. To explore this idea, Figure 5 plots the number of individuals starting new jobs (vertical axis) against age measured at a quarterly frequency (horizontal axis). If individuals are timing the beginning of their new jobs so that they can just complete 10, 15, or 20 years of tenure at the ERAs, then we would expect to see sharp increases in the number of individuals starting new jobs at ages 50, 45, 40 etc. The evidence in Figure 5 shows no discernible change in job starts at any age prior to the ERAs. This smoothness across age emphasizes that, while there is evidence that some individuals delay their retirements to qualify for (larger) severance payments at retirement, there is no evidence that individuals reallocate their labor supply (or participation) at earlier ages in response to the sizeable anticipated incentives from the severance payments.

3.4 Heterogeneity

Above we have seen that, while there is a clear pattern in the frequencies of retirement around the tenure threshold, there are also retirements occurring in the months directly before a tenure threshold. This means that a substantial fraction of the sample seems to be unresponsive to the incentives created by the severance system. Here we examine differences in responsiveness along observable individual and job characteristics. In particular, we consider heterogeneity by health status, position in the earnings distribution, firm size, and job rigidity. This analysis serves two goals. First, less responsiveness due to intuitive obstacles such as ill health, supports our main assumption that the observed retirement pattern is indeed the result of intertemporal labor supply reactions to the thresholds set by the severance pay system. Second, excluding the unresponsive groups accounts for some of the retirements that we observe shortly before the tenure thresholds.

We start by investigating heterogeneity related to health status. We measure ill health based on the fraction of time between age 54 and retirement spent on sick leave.[12] We define an individual as unhealthy if the fraction of time between age 54 and retirement spent on sick leave above the median fraction of time for individuals with positive sick leave days. Figure 6 presents frequency plots for unhealthy and healthy individuals, respectively. As expected, unhealthy individuals are not very flexible in the timing of their retirements. We basically see no response to the thresholds among retirees with health problems. Thus, some of the pre-threshold retirement is likely to be driven by negative health shocks and also more permanently poor health status.

Next we turn to heterogeneity related to earnings. We group individuals by the calender year when they turn 55 and by tenure at the end of age 54; within each group, we compute percentiles of the distribution of average real earnings between ages 50 through 54. We condition on tenure at the end of age 54, because we want to account for returns to tenure and compare higher and lower earnings individuals with similar tenure levels at retirement. Figure 7 presents the distributions of tenure at retirement for different earnings percentiles. Because of the relatively small sample sizes, this graph shows frequencies for pooled observations in the two years before and after each of the tenure thresholds. The plots illustrate less pooling amongst individuals at higher earnings percentiles. These high-earning individuals are most likely affected by the social security earnings cap and therefore have other savings and private pensions. This makes changes in their budget sets due to the severance payments relatively small.

Job and employer characteristics are also likely to influence a worker's flexibility in timing his retirement date. Therefore we next examine retirement patterns by firm size. Intuitively, individuals employed in smaller firms may be more restricted in choosing their retirement dates around the tenure thresholds. Small employers may put more pressure on

[12] Roughly 35% of individuals in our sample have no sick leave days over their entire careers and 68% have no sick leave between ages 54 and retirement. Health status is highly correlated with the likelihood of claiming disability pension; about 64% of individuals with some sick leave between age 54 and retirement claim disability pensions as opposed to 15% of those with no sick leave between age 54 and retirement.

their employees to retire prior to qualifying for a (larger) severance payment. Additionally, employees at smaller firms may have less ability to leave their firms just after reaching a tenure threshold since their employers may rely on them to complete their projects since there are fewer substitutable employees available to do so. The evidence presented in Figure 8 is consistent with these intuitions as the plots indicate that the pre-threshold dips and post-threshold spikes increase monotonically with firm size.

As firm size plays a considerable role for individual retirement decisions, we examine also other rigidities that may be imposed by an individual's job situation. In particular, we use firm level information on job exits and retirements to infer the restrictions an individual may face in the choice of their retirement date. To summarize different impacts we create a job rigidity index based on three components. First, we measure the rate of exits from the firm in the year of retirement by the number of job spells with the employer ending during the year divided by the number of employees at the beginning of the year. We then rank jobs according to the firm level exit rates and define high exit rate jobs as the top decile. Second, the Austrian labor market is highly seasonal and we observe that many firms hire and let go workers only in certain months of the year. This seasonal demand pattern may also restrict the choice of retirement dates. Therefore we exploit the distribution of exits from the firm over the calender year and compute the level of exit concentration by the share of all exits that occur the calendar month with the highest exit rate. Jobs in the top decile of the exit concentration distribution are defined as jobs in firms with highly concentrated exits. Third, we investigate retirement behavior of coworkers at the firm around the tenure thresholds. Specifically, from all retirements at the firm in the past 5 years, we compute the share of retirements that occurred at a tenure level in the year after a threshold. The bottom decile of jobs in firms with the lowest shares of post-threshold retirements are defined as jobs in low post-threshold retirement firms. The rigidity index takes the values from 0 to 2 if the job hits none, one, or at least two of the three rigidity components (job in firm with high exit rate, with highly concentrated exits, or in firm with low level of post-threshold retirements). Figure 9 clearly shows that responsiveness to the severance pay thresholds decreases as the level of job rigidity increases.

Given that Figures 7 through 9 demonstrate that there is heterogeneity in responsiveness to the severance pay thresholds, we define a restricted sample based on excluding the least responsive or most constrained groups of individuals. The bottom panel in Table 1 summarizes the decreases in sample size resulting from excluding the least responsive individuals along each dimension of heterogeneity that we have examined. The distribution of tenure at retirement for the resulting sample of 154,484 individuals is shown in Figure 10. The basic patterns are the same as for the full sample.

Even in the restricted sample, we still observe several individuals retiring just prior to the severance pay thresholds. However, eliminating the unresponsive groups does reduce the probability of retirement shortly before the thresholds. In the full sample, the probability of retiring in a quarter within 1 year before a threshold is 22% lower than the probability of retiring in any other quarter. Each sample cut further lowers this probability so that in the restricted sample, the probability of retiring in a quarter within 1 year before a threshold is 29% lower than the probability of retiring in any other quarter.[13]

4 Theoretical Background

4.1 Preliminaries

We use the empirical evidence from the previous section to guide us in modeling labor supply responses to the severance payments. First, the empirical evidence indicates that individuals do not time their job starts earlier in their careers to be eligible for severance pay at the minimum retirement ages mandated by the government pension system. Therefore, we focus only on the effects of the severance payments on retirement decisions. Second, given the lack of long-term planning in relation to the severance payments and the relatively short time-space over which retirements takes place in Austria, the empirical evidence suggests that individuals' retirement decisions take into account at most one tenure threshold when deciding when to retire. We therefore model the decision to delay retirement based on the nearest, upcoming tenure threshold. Third, we find no evidence for income effects in the retirement patterns. Intuitively, the severance payments are small relative to lifetime income, and individuals may be unlikely to respond to such small changes in lifetime income. The lack of evidence for income effects guides the choice of the preference specification that we use below. For simplicity, we assume a preference specification that implies there are no income effects in individuals' retirement decisions. Lastly, the empirical evidence from the previous section indicates that, controlling for age and other observable covariates does not alter the observed retirement patterns. This suggests that tenure at age 55 is randomly distributed across individuals. As a consequence, we assume

[13] Results from linear probability models of the retirement indicator by quarter on a pre-threshold dummy and basic controls for gender, age, season, and a set of threshold indicators for different subsamples are available on request.

that the age or date until which each individual would need to work to reach the next severance pay threshold is varying exogenously across individuals.

In summary, the empirical evidence suggests a basic decision rule capturing labor supply responses to the severance payments. The decision rule is based a critical value that captures the maximum length of time an individual would be willing to delay retirement to qualify for a (larger) severance payment. An individual can determine how much he would actually have to delay retirement by first selecting a retirement date neglecting the severance payments and then determining how much additional tenure he would have to accumulate to reach the next severance pay threshold. In this scenario, the decision rule is the following: if the determined length of delay is less than the critical value, the individual will delay and retire at the tenure threshold; otherwise, the individual will retire at the date selected in the absence of the severance pay incentives.

This decision rule relates to a model of retirement decisions that can be exploited to relate the observed retirement patterns to an intertemporal labor supply elasticity. Specifically, the model highlights that, by focusing on an individual who is indifferent between retiring at an early date without severance pay and retiring later with severance pay, the implied indifference condition can be used to get at the curvature in the disutility of work. This curvature reflects the intertemporal labor supply elasticity. Therefore, an important identifying assumption in the estimation strategy will be that we can identify an individual at the point of indifference.

Before developing a model behind this decision rule, we recognize a potential concern relating to predicted gaps in the distribution of tenure at retirement. Specifically, if the above decision rule and the model behind it are applied to individuals with identical critical values, we would predict that no one retires just prior to a severance pay threshold but that there are gaps in the distribution of tenure at retirement just prior to the tenure thresholds. While the empirical frequencies do decline prior to the tenure thresholds, we do not observe any gaps in the distribution. We therefore interpret the decision rule and the model behind it as applying to individuals who can respond to the severance payments. Other individuals may not be able to respond to the severance payments and hence may retire just prior to the tenure thresholds. We discuss factors that may account for these pre-threshold retirements in more detail below. Importantly, individuals who are not responding to the severance payments cannot be used to identify the intertemporal labor supply elasticity. Following the estimation strategy that we develop below, we emphasize that we estimate the intertemporal labor supply elasticity using only individuals that do respond to the severance payments.

4.2 Model

To develop a model behind the above decision rule, we start by modelling retirement decisions in the absence of any severance pay thresholds. We consider an intertemporal labor supply model in which an individual has preferences over consumption in each period, c_t, and years of work, R. We assume that there is no uncertainty or time discounting and that the individual lives for T.[14] At time 0, the individual decides how much to consume in each period and how many years to work. In the absence of any severance payment thresholds, an individual chooses the optimal retirement date by solving the following optimization:

$$\max_{\{c_t\},R} \int_0^T u(c_t)dt - \frac{\theta}{1+\frac{1}{e}}\left(\frac{R}{\theta}\right)^{1+\frac{1}{e}}$$
$$\text{s.t.} \int_0^T c_t dt = \int_0^R w_t dt + x$$

where θ denotes the taste for work, w_t denotes the individual's wage rate at time t and x denotes unearned income.[15] The parameter e captures the convexity in the disutility of work. Motivated by the lack of evidence for income effects, we assume that the individual has quasi-linear preferences so that $u(c) = c$. We refer to these retirement dates chosen in the absence of the severance pay incentives as counterfactual retirement choices.

The elasticity of intertemporal substitution in labor supply is defined to capture how labor supply responds to anticipated wage variation. Intuitively, when a wage increase is anticipated, it is already factored into lifetime income so that the marginal utility of lifetime income can be assumed to be held constant. Thus, using λ to denote the marginal utility of lifetime income (the multiplier on the individual's budget constraint), the intertemporal labor supply elasticity is defined by $\frac{d\ln R}{d\ln w}|_\lambda$. Solving the individual's optimization problem,

[14]The assumption of no uncertainty is a useful approximation to describe the environment in which retirement decisions of higher-tenured workers in Austria takes place for multiple reasons. First, layoffs are concentrated amongst lower-tenured, younger workers. Second, collective bargaining agreements determine a significant portion of earnings based on age, experience, tenure and other observable employee characteristics.

[15]Formally, this model is similar to the model analyzed by Rogerson and Wallenius (2009).

the intertemporal labor supply elasticity in this model is given by

$$\frac{d\ln R}{d\ln w}|_{\lambda} = e.$$

Intuitively, when the marginal disutility from additional labor supply rises very rapidly, an individual will not adjust his labor supply very much in response to an anticipated wage increase. In this model without income effects, the intertemporal labor supply elasticity is reflected in the curvature in an individual's indifference curves.[16],[17]

Next, we introduce the severance payments. We assume that each individual has a threshold retirement date, denoted by $\bar{R}$, such that, when retiring after the threshold date, the individual receives a lump-sum payment denoted by dx. Following the empirical evidence, we assume that these threshold dates are randomly distributed across individuals. As a result, the amount of time between an individual's counterfactual retirement date and his threshold date, denoted by $dR = \bar{R} - R$, varies across individuals. Optimal retirement choices with the severance payments are presented graphically in Figure 11.

With the severance payments, several individuals will choose to delay their counterfactual retirements and retire at the thresholds. In particular, given the financial incentives, individuals who need to delay their counterfactual retirements by only a relatively small amount of time will choose to retire at the thresholds. The set of individuals who delay their retirements and pool at the tenure threshold is given by individuals with $dR \in [0, \Delta]$ where Δ denotes the critical value capturing the maximum length of time an individual is willing to delay his retirement to reach the tenure threshold. This critical value is determined by solving for the length of time that makes an individual indifferent between retiring early without the severance payment and retiring at the tenure threshold with the severance payment. Using the optimization problem from above, Δ is characterized by

[16] In this setting, the intertemporal (Frisch) labor supply elasticity coincides with the static income-constant (Marshallian) and utility-constant (Hicksian) labor supply elasticities. Though they are conceptually distinct, these labor supply elasticities coincide in this setting because there are no income effects by assumption (see Browning (2005)). Nonetheless, we refer to e as an intertemporal elasticity because the variation that will be used to identify and estimate this parameter will correspond to anticipated, within-person variation in wage rates over time periods.

[17] We assume that the intertemporal labor supply elasticity e is homogeneous across individuals. We do not see sufficient empirical evidence suggesting that this is a poor assumption. Additionally, we do not have sufficient moments in the data to identify heterogeneous labor supply elasticities across individuals. We have estimated separate elasticities across each of the separate tenure thresholds and obtained results similar to those presented below.

solving the following indifference condition and labor supply equation

$$\underbrace{w(\bar{R}-\Delta)+x-\tfrac{\theta}{1+\frac{1}{e}}(\tfrac{\bar{R}-\Delta}{\theta})^{1+\frac{1}{e}}}_{\text{utility if retiring early without severance pay}} \quad = \quad \underbrace{w\bar{R}+x+dx-\tfrac{\theta}{1+\frac{1}{e}}(\tfrac{\bar{R}}{\theta})^{1+\frac{1}{e}}}_{\text{utility if retiring at threshold with severance pay}} \tag{1}$$

$$\bar{R}-\Delta=\theta w^{e}. \tag{2}$$

Intuitively, a larger elasticity will correspond with more willingness to delay retirement for the severance payments, so the critical value Δ will be larger. Thus, this model implies the decision rule that was suggested by the empirical evidence: an individual delays his retirement and retires at the severance pay threshold if $\delta < \Delta$; otherwise he retires at his counterfactual retirement date.[18]

5 Elasticity Estimation

5.1 Estimation Strategy

Our strategy to estimate the intertemporal labor supply elasticity is based on the above indifference condition and labor supply equation, equations (1) and (2) respectively. Using the observed retirement patterns, the maximum length of delay for individuals who pool at the tenure thresholds can be estimated. This yields an estimate for the critical value Δ. With this estimate for the critical value (Δ) and the observed data on wages (w), severance payment amounts (dx) and the threshold dates ($\bar{R}$), the above indifference condition and labor supply equation can be solved to yield an estimate of the intertemporal labor supply elasticity (e). Intuitively, this estimation strategy is based on two steps. First, we estimate

[18] The model implicitly assumes homogeneous preferences, with all the variation coming form individual heterogeneity in dR. Alternatively, pooling at the tenure threshold can be seen in terms of individuals' types based on heterogeneity in tastes for work. Let $[\theta_L, \theta_H]$ denote the set of types that choose labor supply $\bar{R}$. Because there are no income effects, the highest type that locates at $\bar{R}$ is the type that would locate at $\bar{R}$ even in the absence of the discontinuity; that is, θ_H is characterized by θ_H such that $\bar{R}=\theta_H w^e$. The lowest type that locates at $\bar{R}$ is the type that is indifferent between choosing $\bar{R}$ and some earlier retirement date R_L. Therefore, θ_L is characterized by the θ_L that satisfies the following indifference condition

$$wR_L+x-\tfrac{\theta_L}{1+\frac{1}{e}}(\tfrac{R_L}{\theta_L})^{1+\frac{1}{e}}=w\bar{R}+x+dx-\tfrac{\theta_L}{1+\frac{1}{e}}(\tfrac{\bar{R}}{\theta_L})^{1+\frac{1}{e}}$$

where the left-hand side captures utility when retiring prior to the tenure threshold at R_L and the right-hand side captures utility when retiring at the tenure threshold $\bar{R}$. When retiring prior to the tenure threshold, the individual chooses his retirement optimally, so R_L is given by the labor supply equation $R_L=\theta_L w^e$.

the point of indifference that captures the maximum length of time an individual is willing to delay his retirement to get a larger severance payment. Second, we use this estimate and exploit the indifference between the two retirement dates to get at the convexity in the disutility of work, which reflects the intertemporal labor supply elasticity. We describe the steps to estimate the critical value Δ using the observed retirement patterns in more detail in the next section.

5.2 Estimation Procedures

To estimate the critical value Δ, we start by estimating a continuous approximation of the observed retirement frequencies so that we can accurately characterize the amount of excess mass at the tenure thresholds. Specifically, in each interval between two tenure thresholds, we regress the observed frequencies on a continuous polynomial in tenure at retirement. We then predict the fitted values and set the values at the tenure thresholds equal to the observed values. We re-scale the predicted values so that the total number of individual retirements based on the fitted values is equal to the number of observed retirements. We refer to the frequencies based on this continuous approximation as the *actual frequencies*. Figure 12 plots the observed frequencies against the actual frequencies when pooling across all of the tenure thresholds.

In the second step, we estimate *counterfactual frequencies* of tenure at retirement that would occur in the absence of the severance payments. For that purpose, we regress the actual frequencies in each interval between two thresholds on a continuous polynomial in tenure at retirement and a set of threshold dummies which are equal to 1 if the level of tenure is just before, at or just after a tenure threshold. We then set the threshold dummies equal to 0 and obtain the fitted values. Again, we re-scale the fitted values so that the total number of actual retirements is equal to the total number of counterfactual retirements. The identifying assumption implied by using dummies to capture retirement behavior around the tenure thresholds is the following: in the absence of the severance payment incentives, individuals with tenure around the thresholds would behave similarly to individuals away from the tenure thresholds. Thus, the counterfactual frequencies are identified based on individuals away from the tenure thresholds. Figure 13 plots the actual frequencies against the counterfactual frequencies when pooling across all of the tenure thresholds. The plot highlights that, in the absence of the severance payments, the counterfactual frequencies would be smooth through the tenure thresholds. While the first two steps treat each tenure threshold separately, the remaining steps in estimating the point of indifference are based on the frequencies when pooling across all of the tenure thresholds.

In the third step, we estimate the number of excess retirements at the tenure thresholds based on the cumulative differences between the actual and counterfactual frequencies at and just after the tenure thresholds. We select a post-threshold cutoff, R_H, to capture all of the excess retirements because the graphical evidence indicates that some of the excess retirements come from individuals who retiring just after the tenure thresholds rather than exactly on the thresholds. We use an iterative procedure to select R_H. We choose an initial R_H just above $\bar{R}$ and compute the excess retirements based on the sum of the differences between the actual and counterfactual frequencies at $\bar{R}$ through R_H. Next, we increase R_H and compute the number of additional excess retirements that are added to the previous measure of excess retirements. We continue to increase R_H until the number of additional excess retirements that is added to the previous measure of excess retirements is sufficiently small (i.e., less than some $\epsilon > 0$). The determination of R_H and the excess retirements are illustrated in Figure 14.

In the final step, the critical value Δ is estimated based on equating the number of individuals delaying their retirements with the number of excess retirements. Analogous to the estimation of the number of excess retirements, we estimate the number of individuals delaying their retirements using the sum of the differences between the actual and counterfactual frequencies just prior to the tenure threshold. In particular, Δ is determined by the pre-threshold value such that the number of individuals delaying their retirements is equal to the number of excess retirements. Intuitively, the point of indifference is therefore estimated as the maximum possible length of delay amongst individuals who delayed their retirements to qualify for a (larger) severance payment. This strategy for determining Δ is illustrated in Figure 14. As mentioned above, once the point of indifference is estimated, we can estimate the intertemporal labor supply elasticity by solving the indifference condition and labor supply equation, equations (1) and (2) respectively.

5.3 Estimation Results

Elasticity Estimate

Table 3 presents the estimation results. We estimate $\hat{R}_H = 0.75$ indicating that the excess retirements occur within roughly 9 months after the tenure thresholds. We estimate that the total number of excess retirements to be roughly $5,200$ individuals. To put this figure in perspective, we also report the excess fraction which computes the excess retirements as a fraction of the total number of counterfactual retirements between $\bar{R}$ and $\hat{R}_H$. We estimate the excess fraction to be roughly 0.40; this indicates that the number of excess retirements is less than half of the total number of individuals that one would expect to retire just after the tenure thresholds in the absence of the severance payments.

Next, we estimate the point of indifference to be $\hat{\Delta} = 1.25$, which indicates that the maximum length of delay amongst individuals retiring just after the tenure thresholds is roughly 1 year and 3 months. Additionally, we report the number of delayed retirements based on the pre-threshold differences and check to make sure that the difference between the estimated number of delayed retirements and the estimated number of excess retirements is close to 0. Finally, based on the estimated point of indifference, we estimate the intertemporal labor supply elasticity to be $\hat{e} = 0.30$.

While these estimation results indicate a relatively low estimate for the intertemporal labor supply elasticity, we next explore the plausibility of a relatively high intertemporal labor supply elasticity given the available empirical evidence. In particular, the low estimate for the elasticity is driven by (1) the relatively low estimate for the maximum length of time individuals are willing to delay their retirements for the severance payments Δ, and (2) the relatively large financial incentives dx.

Sensitivity Analysis

First, we examine the relationship between Δ and the intertemporal labor supply elasticity in Figure 15. This figure plots the elasticity on the vertical axis against the point of indifference on the horizontal axis. The plots highlights that the elasticity increases as the maximum amount of time that individuals are willing to delay their retirements for the severance payments increases. Intuitively, if individuals are willing to delay their retirements by a longer time, this would imply that they are more responsive to the anticipated benefits.

Figure 15 illustrates that to generate an elasticity greater than 0.75, we would need to estimate a critical value indicating that individuals are willing to delay their retirements by at least 2 years in response to the severance payments. If we add the estimated critical value of 1.25 years and the estimated post-threshold cutoff of 0.75 years from above, it is plausible that some individuals could end up delaying their retirements by a total of 2 years to receive larger severance payments. However, mechanically adding the two values assumes that all individuals expect that they have to keep working for 0.75 years beyond their threshold dates. We observe that individuals who pool at the tenure thresholds generally retire within a few weeks of the thresholds, which does not seem to be much evidence to justify such an assumption. Overall, we do not find much evidence suggesting that individuals who pool at the tenure thresholds are willing to delay their retirements by 2 years or more to qualify for the larger severance payments.

Second, we examine the relationship between the financial incentives from the severance payments and the estimated intertemporal labor supply elasticity. Figure 15 plots the implied intertemporal labor supply elasticity against the point of indifference if the size of the discontinuity in the budget line were either 33% larger and 33% smaller than the mandated amount. Intuitively, at each point of indifference, a smaller discontinuity implies a larger elasticity because individuals are similarly responsive to smaller financial incentives. Based on the the estimated point of indifference of 1.25 year before the tenure thresholds, a 33% smaller discontinuity would results in an estimated elasticity of roughly 0.40.

Uncertainty is one factor that could potentially reduce individuals' financial incentives to delay their retirements. To see this, consider the model above and suppose that an individual gets the severance payment dx at the threshold $\bar{R}$ with probability $p \in (0, 1)$, and with probability $1 - p$, the individual is forced to retire at some other date not of his choice and he does not receive a payment. Intuitively, such uncertainty could arise from either a health shock or a layoff. Additionally, if an employer offers early severance payments and tries to force some fraction of his employees to retire, this could be modeled similarly. In this scenario, the financial incentives to delay retirement are reduced to pdx. As indicated by Figure 15, the probability p would need to be smaller that 0.66 to generate an elasticity larger than 0.40. To generate a larger intertemporal labor supply elasticity, one would need to assume a significant amount of uncertainty in getting the severance payments at the tenure thresholds because the direct financial incentives from the payments are relatively large. The empirical evidence on health shocks and layoffs at older ages indicates a relatively low degree of uncertainty. Thus, there seems to be little empirical evidence suggesting that the financial incentives from the severance payments actually small enough to generate a relatively high estimate for the intertemporal labor supply elasticity.

5.4 Model Simulations

While the model and estimation focus on individuals who can choose to delay their retirements to respond to the severance payments, we now present model simulations to examine features that can account for individuals retiring just before the tenure thresholds and slightly after the tenure thresholds.

To account for the pre-threshold retirements, we introduce a health cost associated with the additional work when delaying one's retirement beyond a counterfactual date without the severance payments. We assume that an individual who determines the utility gain dU from delaying retirement to the threshold date also draws a health cost ϕ capturing an exogenously given additional marginal disutility of work from delaying his retirement ($\phi > 0$). After comparing utility gain and the health cost, individuals delay their retirements if the amount of additional work is sufficiently low (i.e. $dR < \Delta$) and also if their utility gains exceed their health costs (i.e. $dU > \phi$). We assume that the health costs are independent draws from a random distribution. Hence, the probability of delaying retirement increases from close to 0 for a length of delay equal to the maximum length $dR = \Delta$ to a fraction m for a length of delay dR close to 0; in other words, the probability of delaying retirement is higher if an individual has to delay his retirement by only a relatively small amount of time. We determine m based on the actual number of pre-threshold retirements as a fraction of the counterfactual pre-thresholds retirements.

To account for the retirements slightly after the tenure thresholds, we introduce task completion constraints as additional noise added to individuals' optimal retirement dates. Specifically, we assume that, once an individual has chosen to retire at a tenure threshold, he draws a task that he must complete prior to retirement. The observed retirement date then becomes $\tilde{R} = \bar{R} + z$ where z captures the amount of time taken to complete the task. We assume that z is drawn from an exponential distribution with parameter $\lambda_{task} > 0$ capturing the average amount of additional time taken for task completion. This parameter is calibrated based on the excess retirements observed just after the tenure thresholds.[19]

Figure 16 plots the observed data against the simulated outcomes from the model with the health costs and task completion constraints. In this simulation, we use an elasticity of 0.30 and calibrate the parameter values for the health costs and task constraints to match the observed data. The figure highlights that the model is able to replicate the observed pre- and post-threshold patterns after introducing the health costs and task completion frictions.

[19] For simplicity we assume that task completion frictions only occur if an individual decides to retire at the tenure threshold. If we added the constraint to all retirements nothing would change??

Next, we examine the simulated patterns when using a relatively high intertemporal labor supply elasticity of 1.0 and the same parameter values for the costs and constraints. In this case, the simulated number of excess retirements is much larger than the observed number of excess retirements.[20] Intuitively, a relatively high intertemporal labor supply elasticity would imply many more excess retirements at the tenure thresholds than we can detect from the observed data. Overall, we find little evidence for a relatively high intertemporal labor supply elasticity.

6 Conclusions

This paper presents evidence on individuals' willingness to delay exiting the labor force in response to anticipated increases in retirement benefits. This evidence is based on discontinuous increases in retirement benefits upon completion of 10, 15, 20, and 25 years of tenure by retirement. The graphical evidence illustrates a relatively modest willingness to delay retirement in response to the discontinuous increases in benefits at the tenure thresholds. This evidence implies a low intertemporal labor supply elasticity of 0.30. Thus, either based on intensive or extensive margin labor supply decisions, economic models that rely on high intertemporal labor supply elasticities appear to be at odds with available empirical evidence.

[20] Importantly, this simulation is done using the cost and friction parameters calibrated using the elasticity of 0.30. Alternatively, one could calibrate these parameters when using the observed data and an elasticity of 1.0 and then examine how the excess mass just after the tenure thresholds changes when using a lower labor supply elasticity. However, in this case, the excess number of retirements is not responsive to the change in the labor supply elasticity because the simulated excess retirements are driven almost entirely by the costs and frictions. Intuitively, the intertemporal labor supply elasticity is not identified if the observed patterns are driven entirely by randomly drawn costs and frictions rather than by individuals choosing their retirements in the presence of relatively small frictions.

References

Blundell, R. and T. Macurdy (1999). Labor supply: A review of alternative approaches. In O. Ashenfelter and D. Card (Eds.), *Handbook of Labor Economics*, Volume 3 of *Handbook of Labor Economics*, Chapter 27, pp. 1559–1695. Elsevier.

Card, D., R. Chetty, and A. Weber (2007). Cash-on-Hand and Competing Models of Intertemporal Behavior: New Evidence from the Labor Market. *Quarterly Journal of Economics 122*(4), 1511–1560.

Chetty, R., J. N. Friedman, T. Olsen, and L. Pistaferri (2009). Adjustment costs, firm responses, and labor supply elasticities: Evidence from danish tax records. Working Paper 15617, National Bureau of Economic Research.

Heckman, J. J. (1993). What has been learned about labor supply in the past twenty years? *American Economic Review 83*(2), 116–121.

Keane, M. and R. Rogerson (2010). Reconciling micro and macro labor supply elasticities. Working paper.

Ljungqvist, L. and T. Sargent (2010). Career length: Effects of curvature of earnings profiles, earnings shocks, and social security. Working paper.

Ljungqvist, L., T. J. Sargent, O. Blanchard, and E. C. Prescott (2006). Do Taxes Explain European Employment? Indivisible Labor, Human Capital, Lotteries, and Savings [with Comments and Discussion]. *NBER Macroeconomics Annual 21*, 181–246.

Mulligan, C. B. (1999). Substition over time: Another look at life-cycle labor supply. In B. Bernanke and J. Rotemberg (Eds.), *NBER Macroeconomics Annual 1998*, Volume 13, pp. 75–152. MIT Press.

Ohanian, L., A. Raffo, and R. Rogerson (2008). Long-term Changes in Labor Supply and Taxes: Evidence from OECD Countries, 1956-2004. *Journal of Monetary Economics 55*(8), 1353–1362.

Prescott, E. C. (2006). Nobel Lecture: The Transformation of Macroeconomic Policy and Research. *Journal of Political Economy 114*(2), 203–235.

Saez, E. (1999). Do taxpayers bunch at kink points? Working Paper 7366, National Bureau of Economic Research.

Saez, E. (2010). Do taxpayers bunch at kink points? *American Economic Journal: Economic Policy* (forthcoming).

Zweimüller, J., R. Winter-Ebmer, R. Lalive, A. Kuhn, J.-P. Wuellrich, O. Ruf, and S. Büchi (2009). Austrian social security database. *NRN: The Austrian Center for Labor Economics and the Analysis of the Welfare State* (Working Paper 0903).

Table 1
Sample Selection

	Number of Observations	Percentage change
Individuals in cohorts born 1930 - 1940	1,578,549	
Still employed at age 55	651,336	-59%
More than one year employment experience before age 55	625,251	-4%
Excluding workers ever employed as civil servant	546,308	-13%
Excluding workers withlast job not in construction	487,019	-11%
Excluding left censored tenure in last job	380,737	-22%
Workers retiring withing 6 months of their last job	269,411	-29%
<u>Restricted sample of highly responsive individuals</u>		
Excluding individuals with high number of sick leave days	233,976	-13%
Excluding individuals with high or low average earnings	197,726	-15%
Excluding workers from firms with less than 10 employees	159,186	-19%
Excluding workers with in jobs with highest rigidity index	154,484	-3%

Notes: Numbers based on the ASSD

Table 2
Summary Statistics

	Full Sample	Tenure at Retirement ≥ 10
# of Individuals	269,411	142,332
Retirement Age	58.64	58.71
	59.00	59.25
	2.58	2.61
Tenure	11.11	17.27
	10.50	16.50
	7.76	5.06
Annual Earnings	18459.69	19572.48
	17983.05	19649.52
	13458.51	13571.58
Fraction Top-Coded	0.14	0.15
	-	-
	0.34	0.36
Years of Employment	32.71	34.08
	34.54	35.28
	9.59	8.36
Years of Sick Leave	0.48	0.43
	0.12	0.09
	0.88	0.81
Fractions:		
Claiming Disability Pensions	0.282	0.233
Claiming Early Retirement Pensions	0.375	0.401
Claiming Old Age Pensions	0.343	0.366
Agriculture & Mining	0.045	0.041
Manufacturing	0.255	0.240
Sales	0.193	0.167
Tourism	0.044	0.022
Transportation	0.051	0.045
Services	0.412	0.485

Notes: Except for the Fractions, the mean, median and standard deviations are reported for each variable. All earnings variables are expressed in 2008 euros. Summary statistics for lifetime earnings are based on birth cohorts beyond 1935. Employment Time and Sick Leave are measured in years.

Table 3

Elasticity Estimation Results

Excess Workers	Reduced Workers	ΔWorkers	Excess Fraction
5198.7270	5200.1261	-1.3991	0.3859
(106.7238)	(112.8092)	(35.4562)	(0.0111)

Δ	R_H	e
-1.2500	0.7500	0.2995
(0.1015)	(0.0199)	(0.0491

Notes: Bootstrapped standard errors based on 100 replications are in parentheses.

Fig. 1. Payment Amounts based on Tenure at Retirement

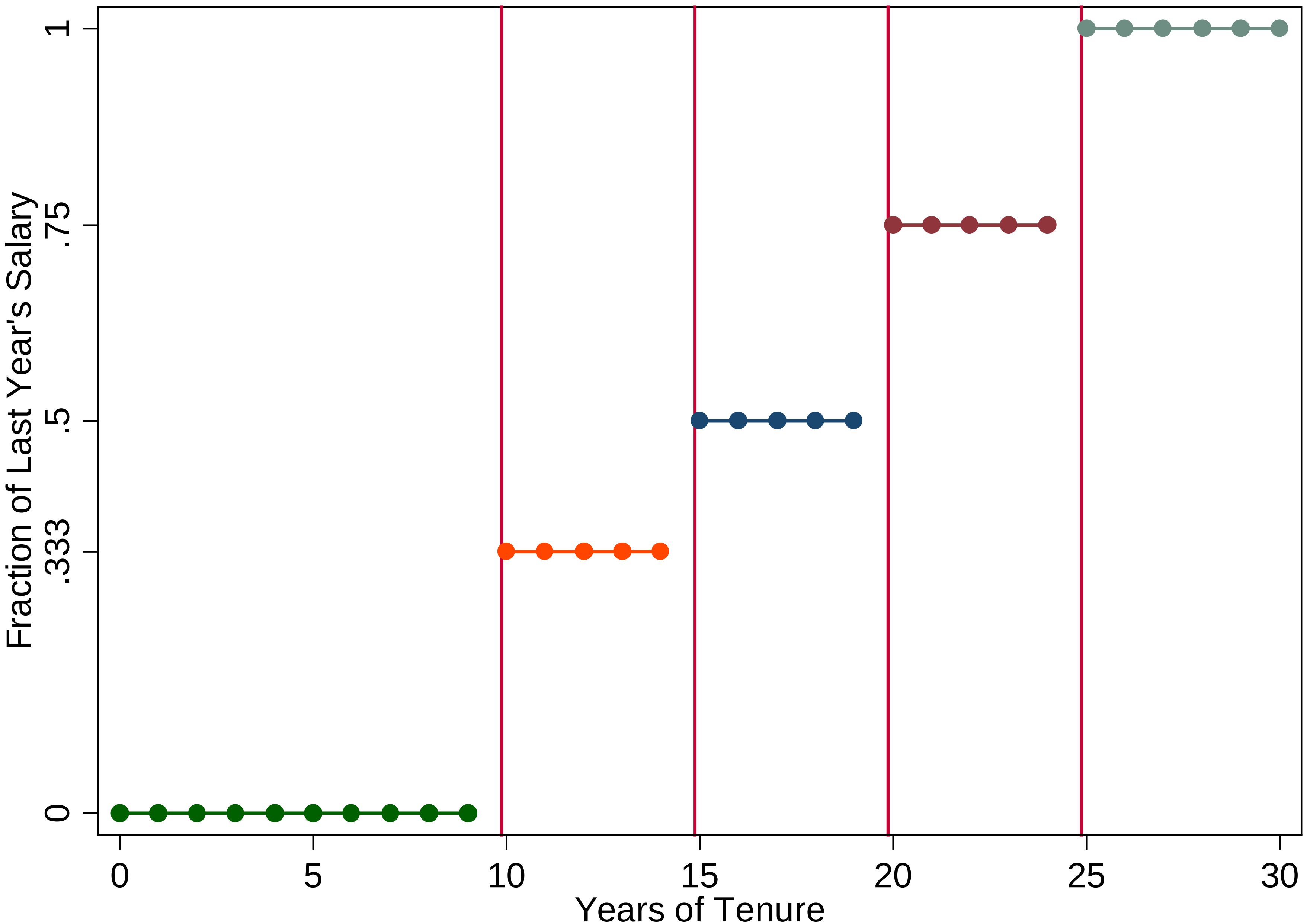


Fig. 2. Exits from Labor Force into Retirement

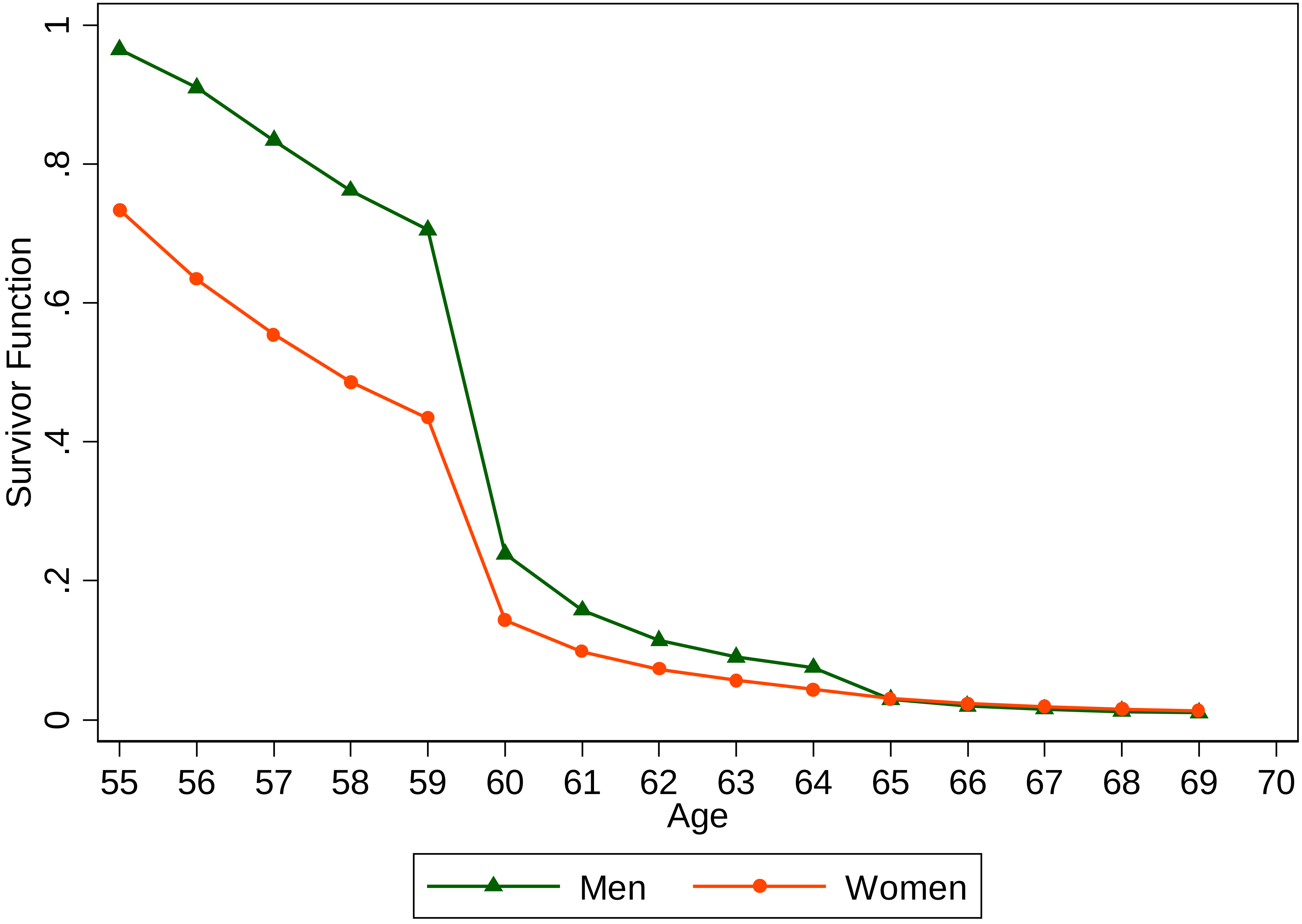


Fig. 3. Distribution of Tenure at Retirement, Full Sample

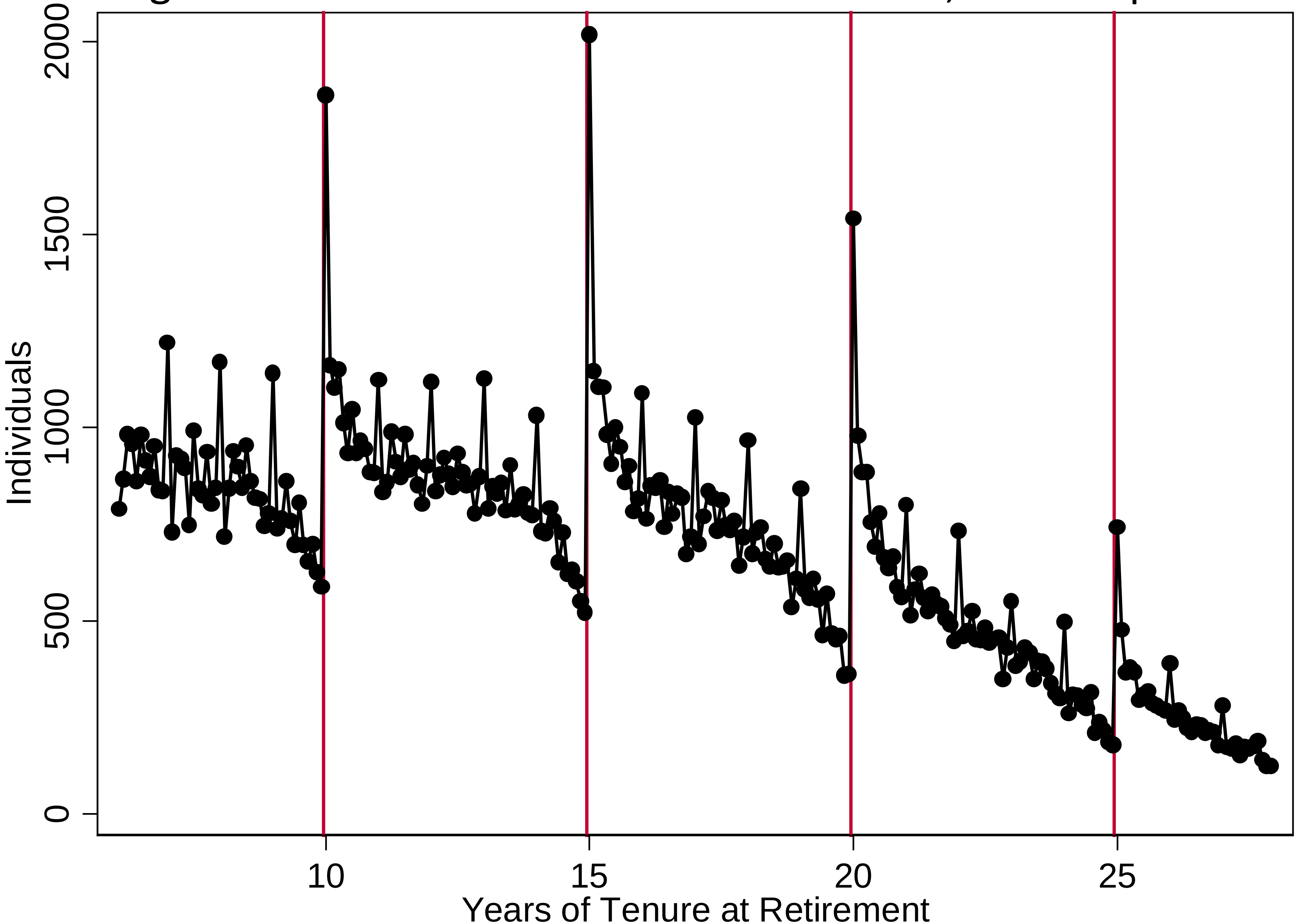


Fig. 4. Controlling for Covariates

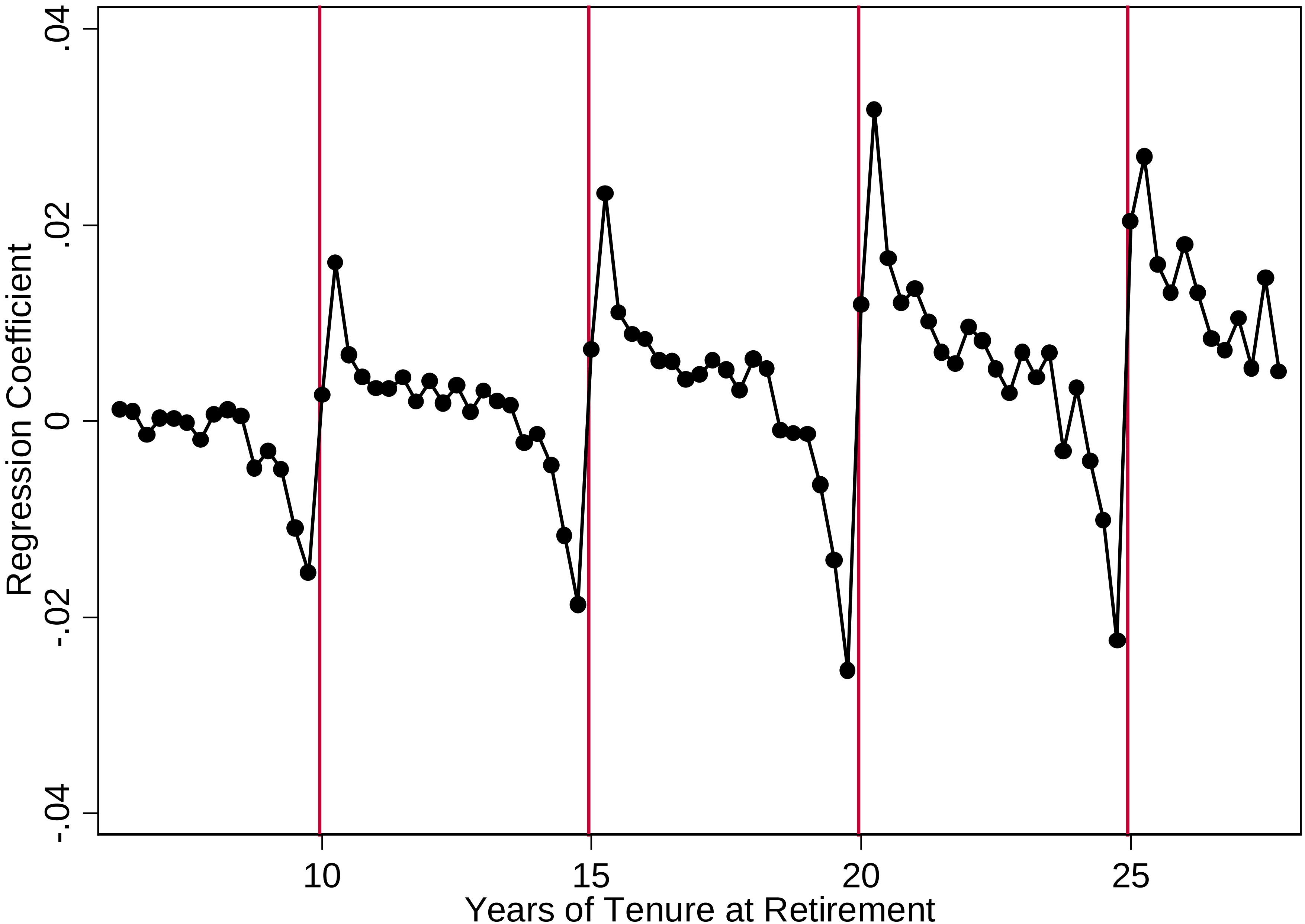


Fig. 5. Job Starts by Age

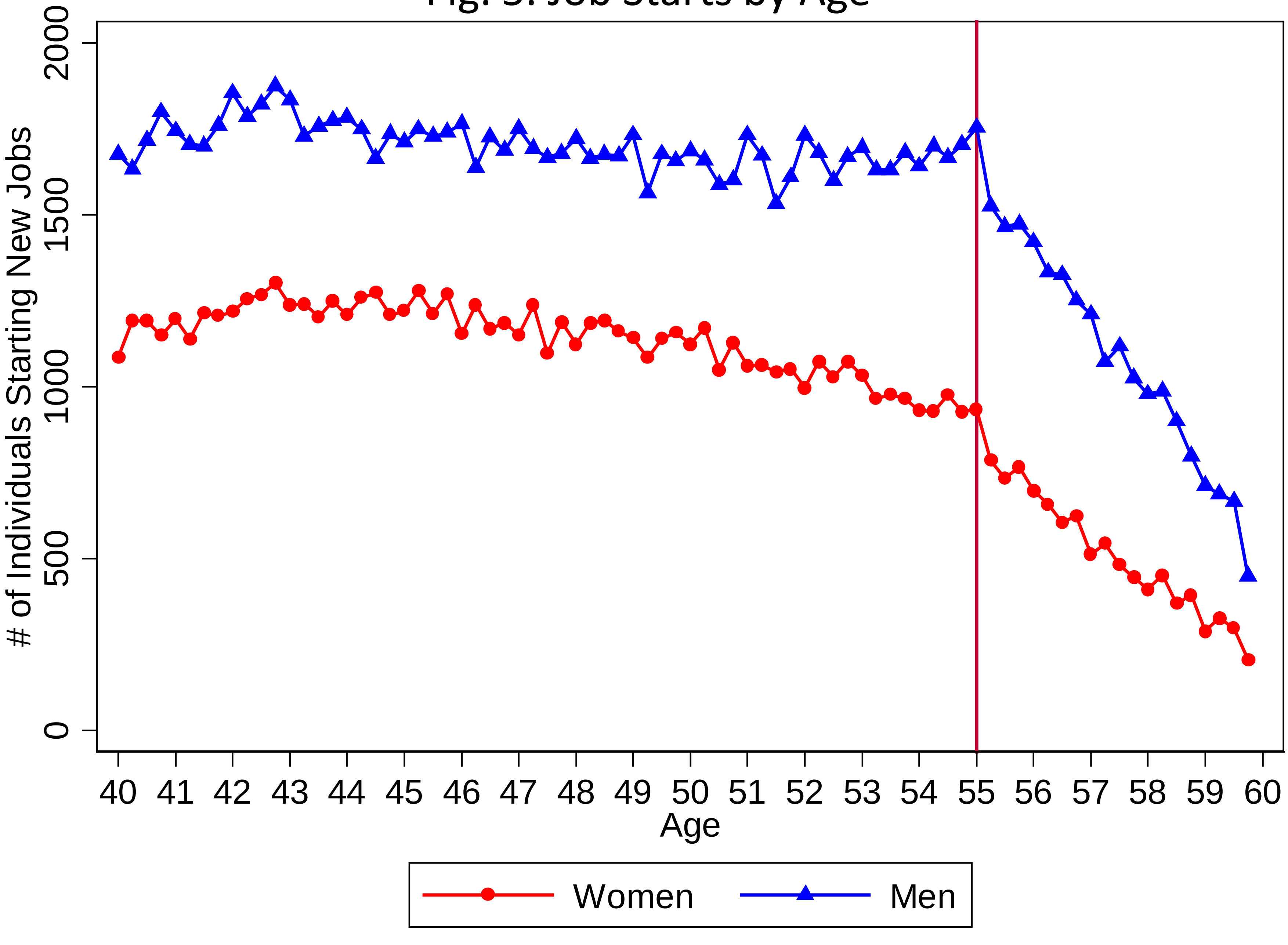
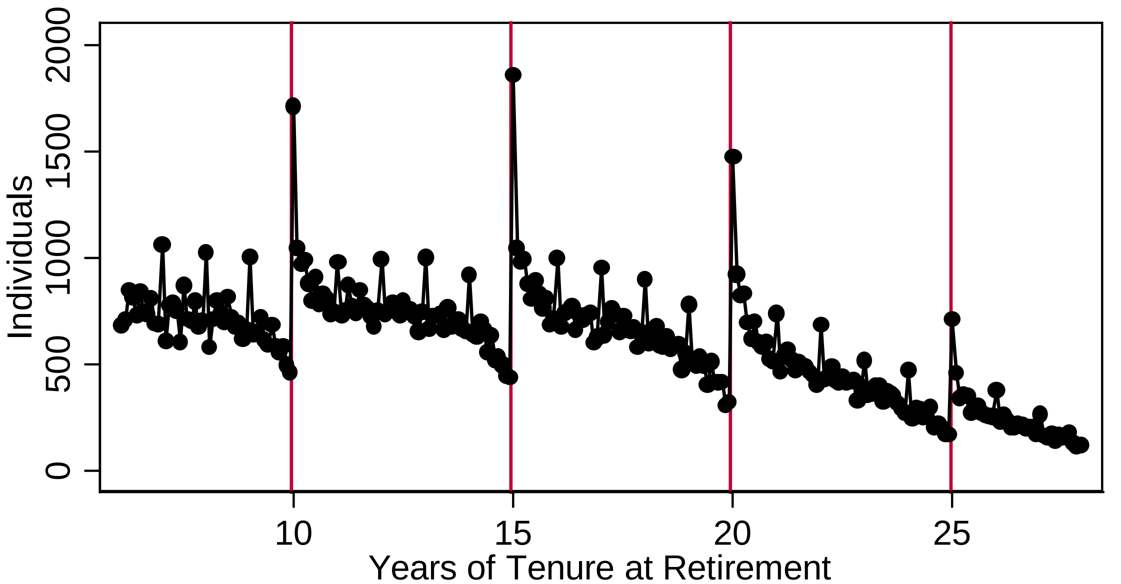


Fig. 6. Distribution of Tenure at Retirement by Health Status

Healthy



Unhealthy

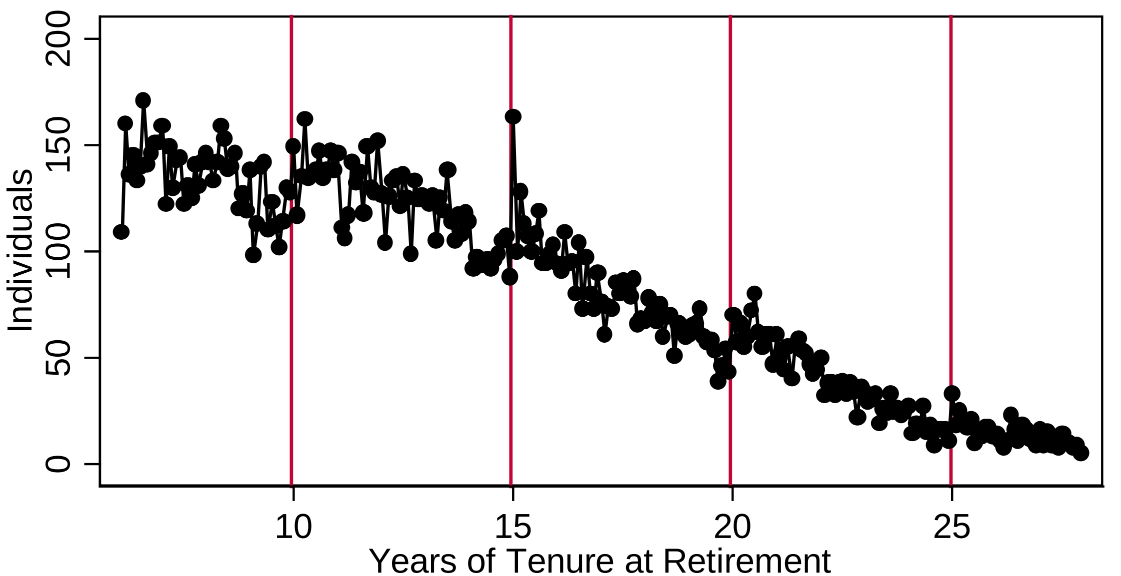


Fig. 7. Retirement at Thresholds by Earnings Groups

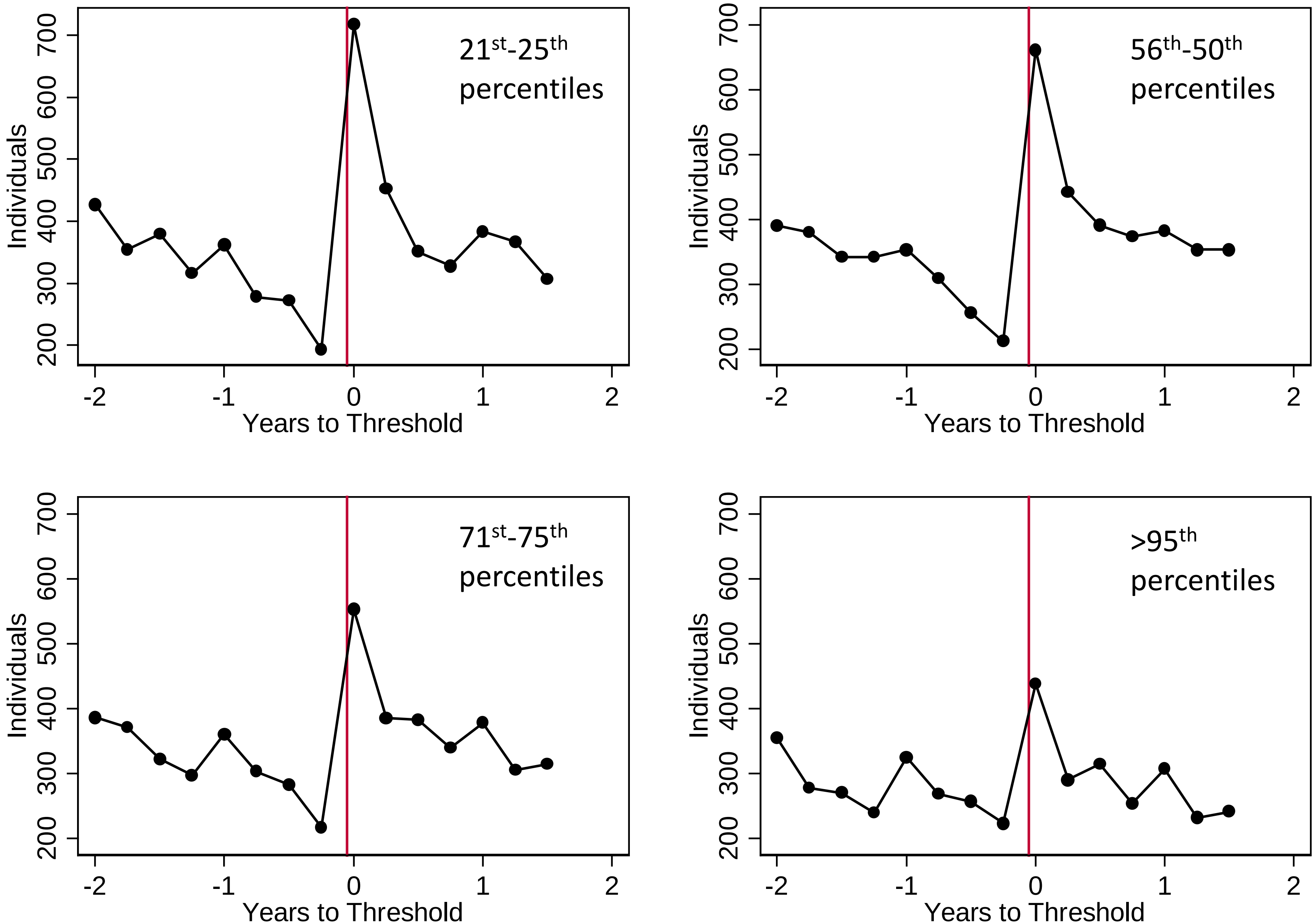


Fig. 8. Distribution of Tenure at Retirement by Firm Size

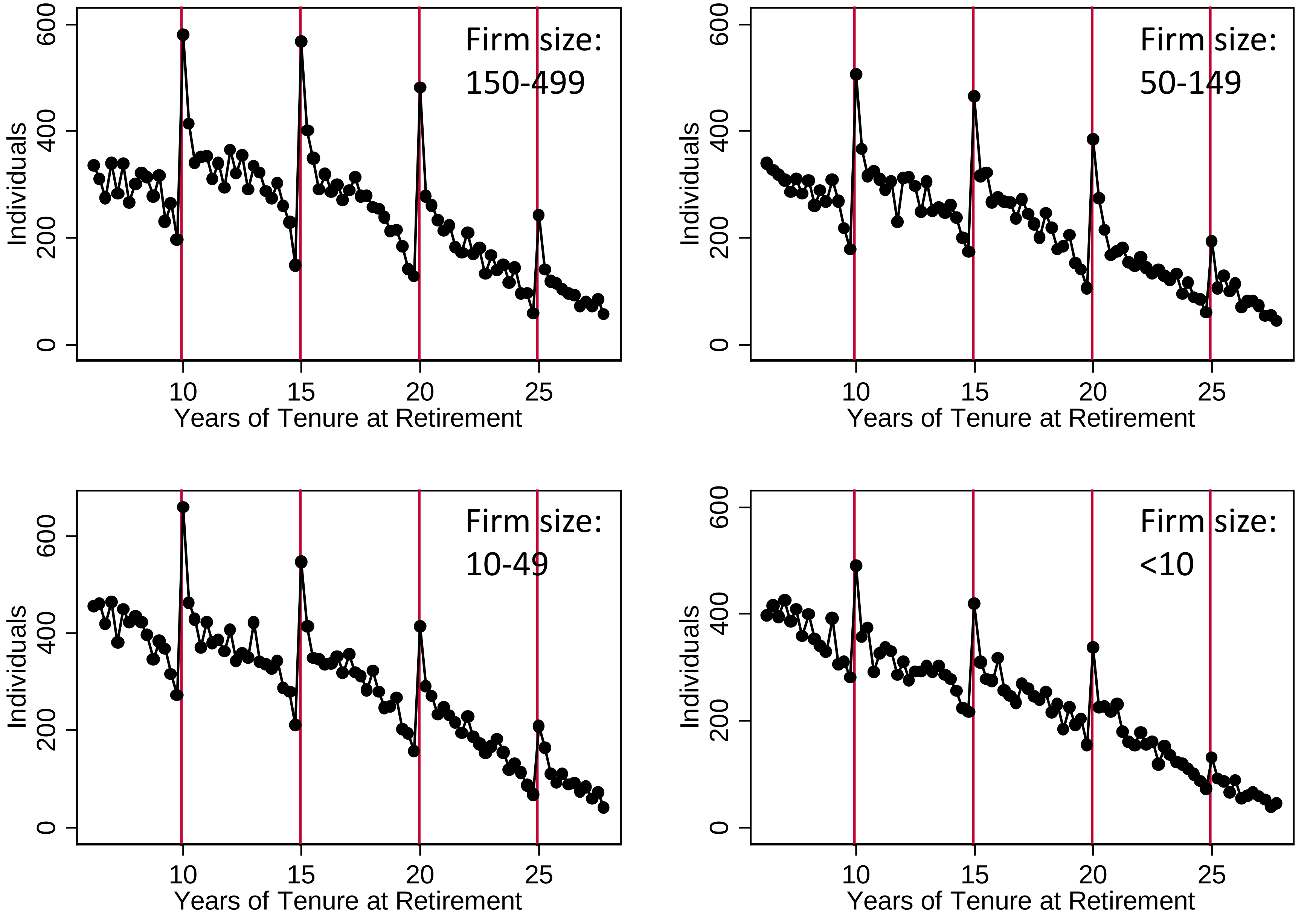


Fig. 9. Retirement at Thresholds by Job Rigidity

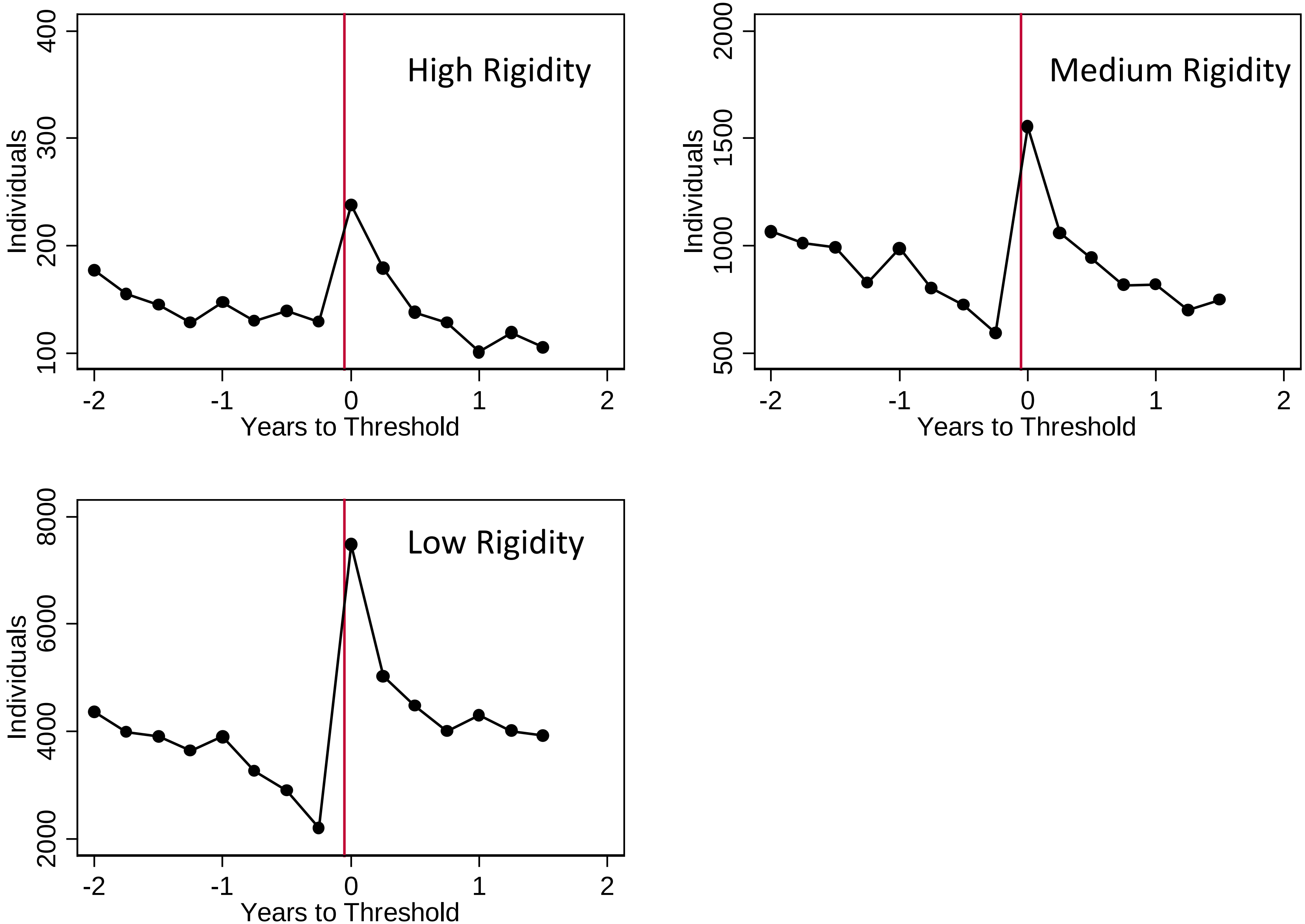


Fig. 10. Retirement at Thresholds, Restricted Sample

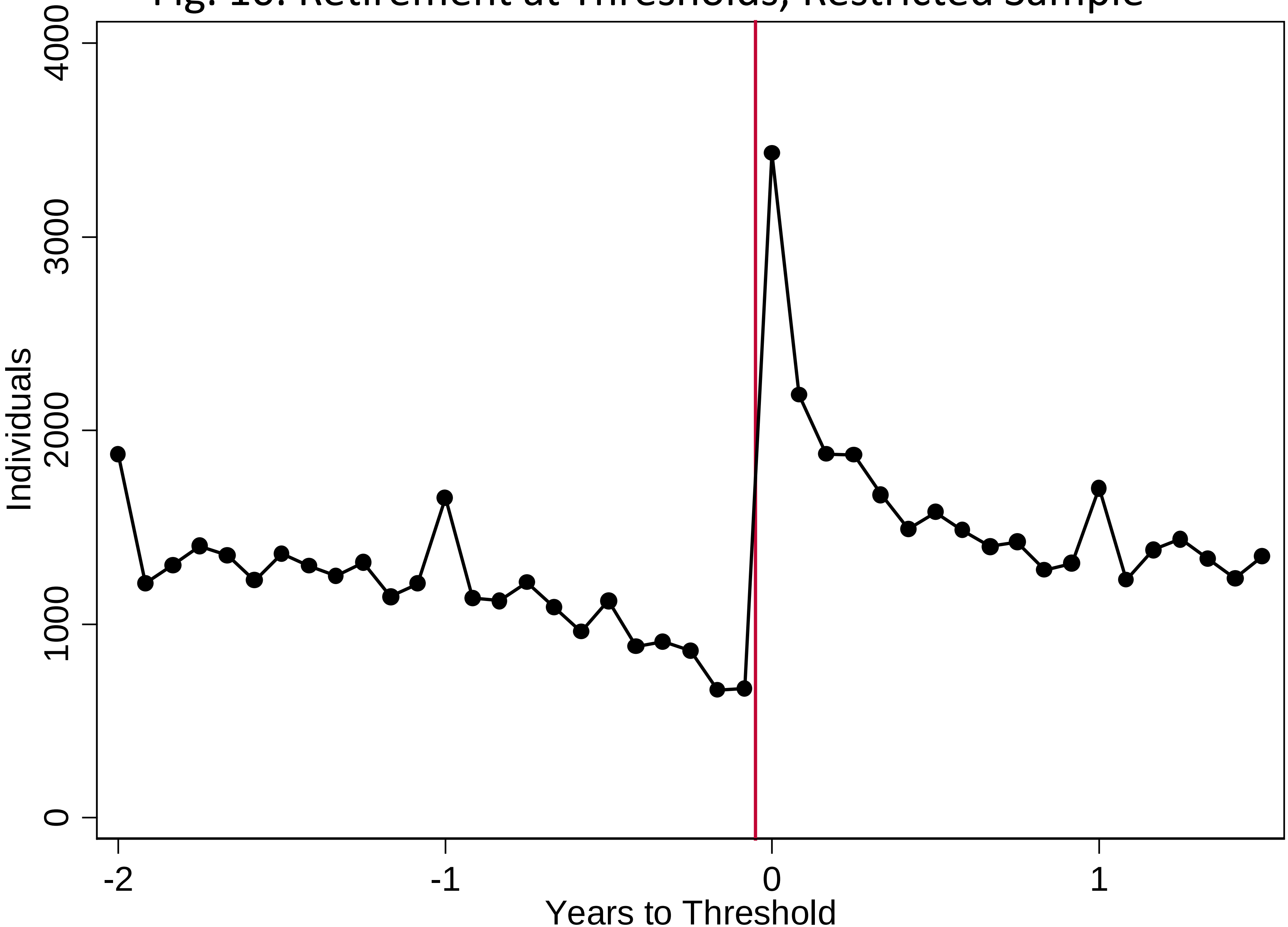
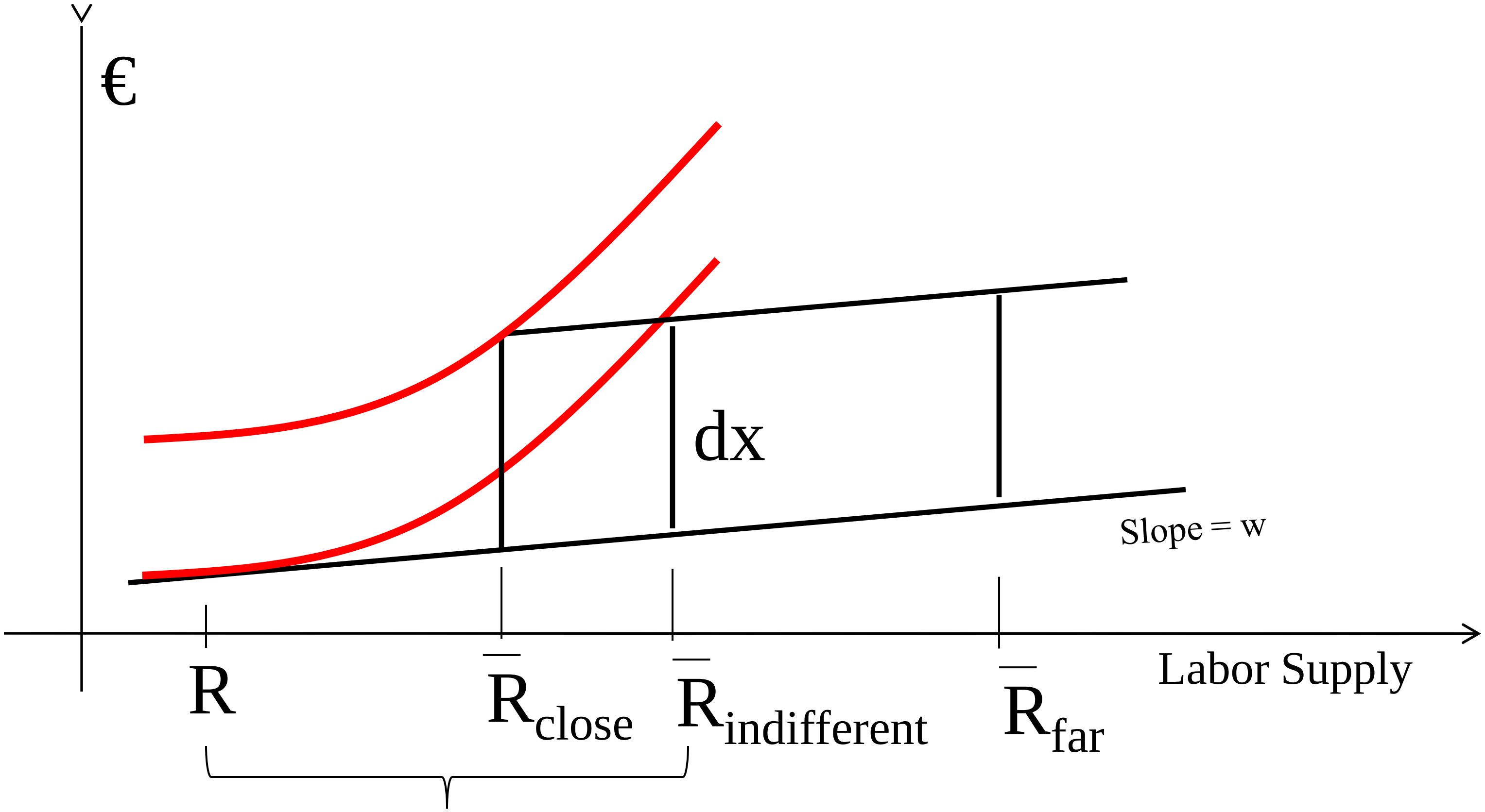


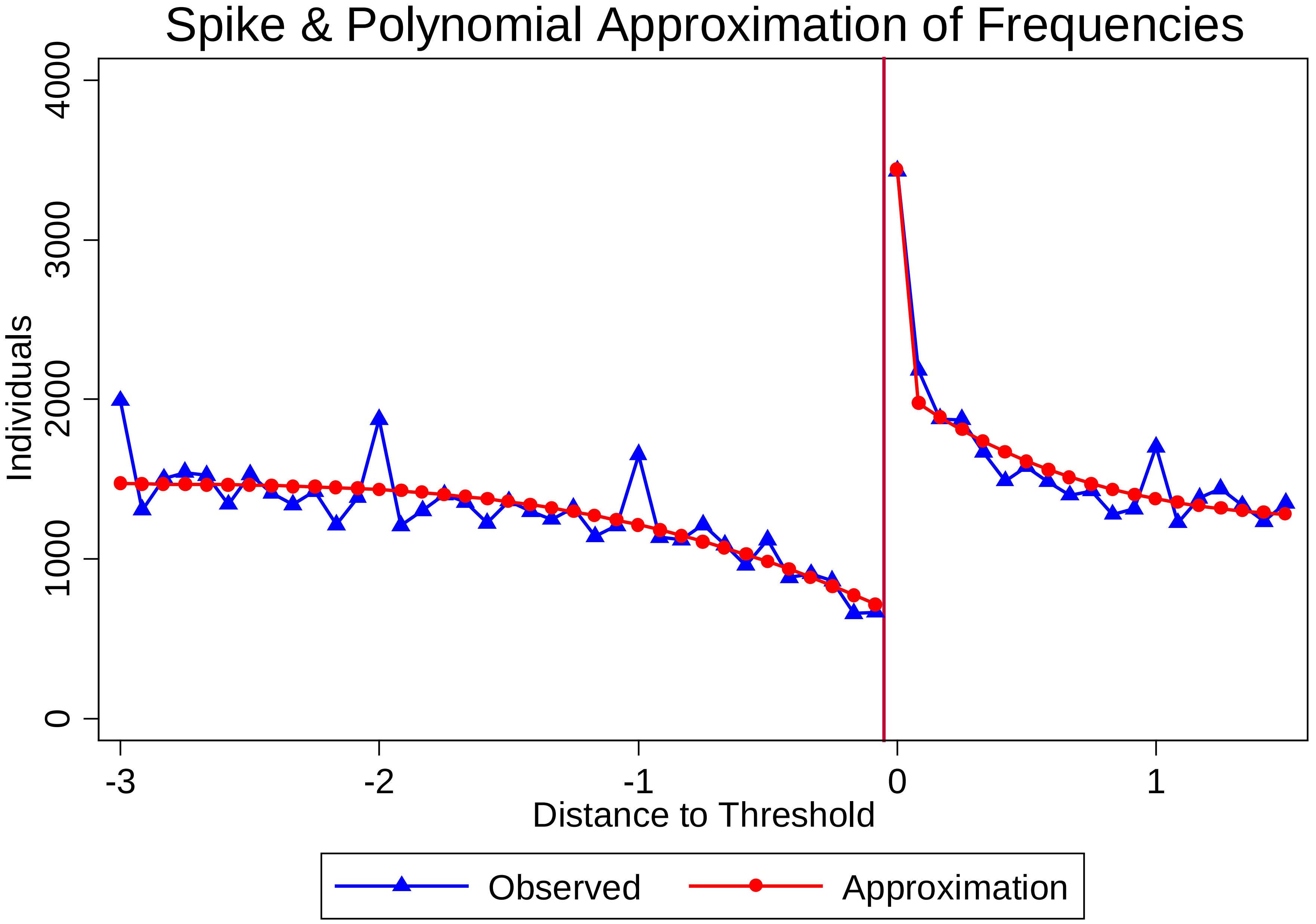
Fig. 11. Optimal Retirement Choices with Severance Pay



Point of Indifference (Max Length of Delay) :

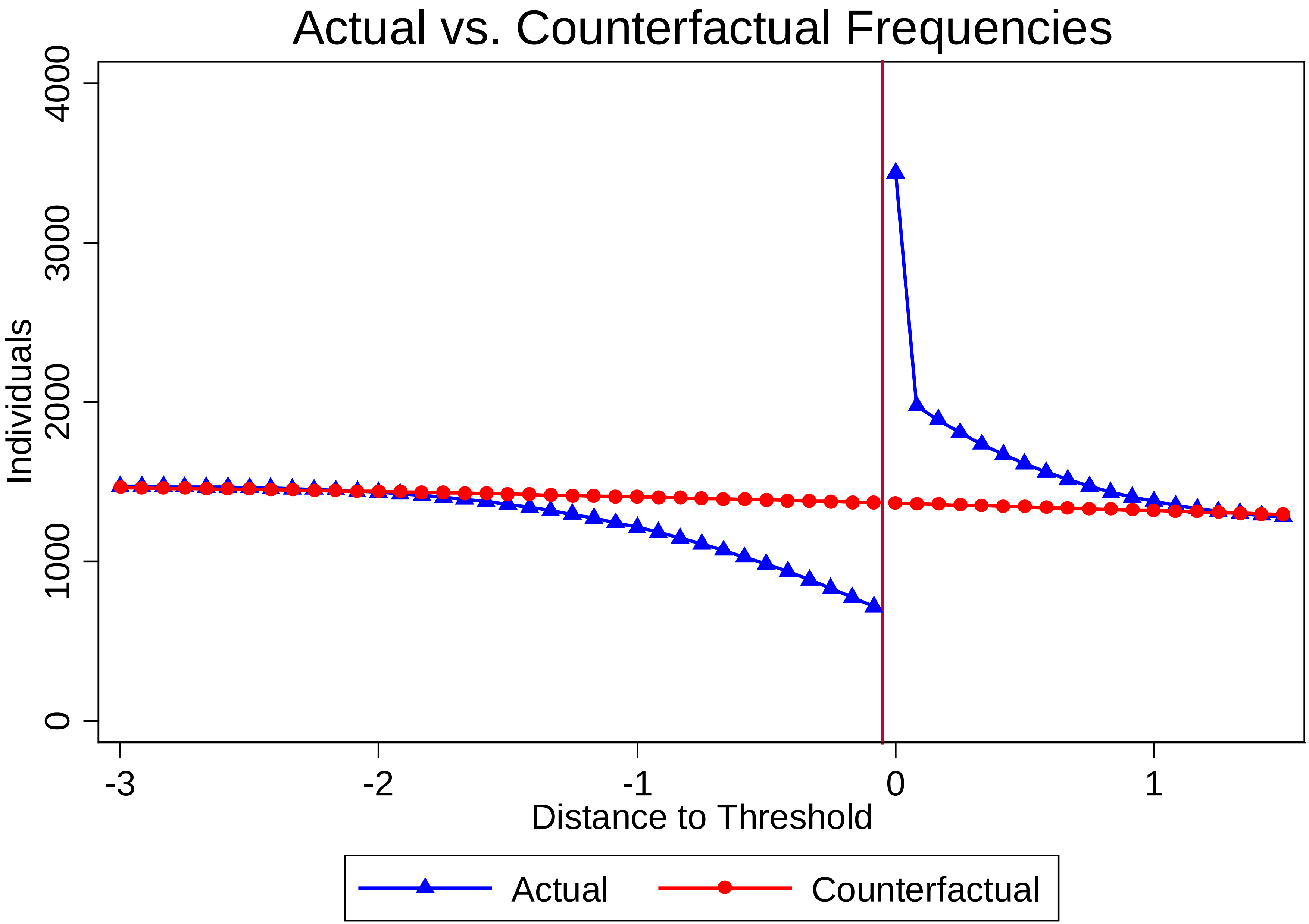
$\Delta = \overline{R}_{indifferent} - R$

Fig. 12.



Spike & Polynomial Approximation of Frequencies
Individuals
0
1000
2000
3000
4000
-3
-2
-1
0
1
Distance to Threshold
Observed
Approximation

Fig. 13.



Actual vs. Counterfactual Frequencies
Individuals
0
1000
2000
3000
4000
-3
-2
-1
0
1
Distance to Threshold
Actual
Counterfactual

Fig. 14.

Estimation Procedures

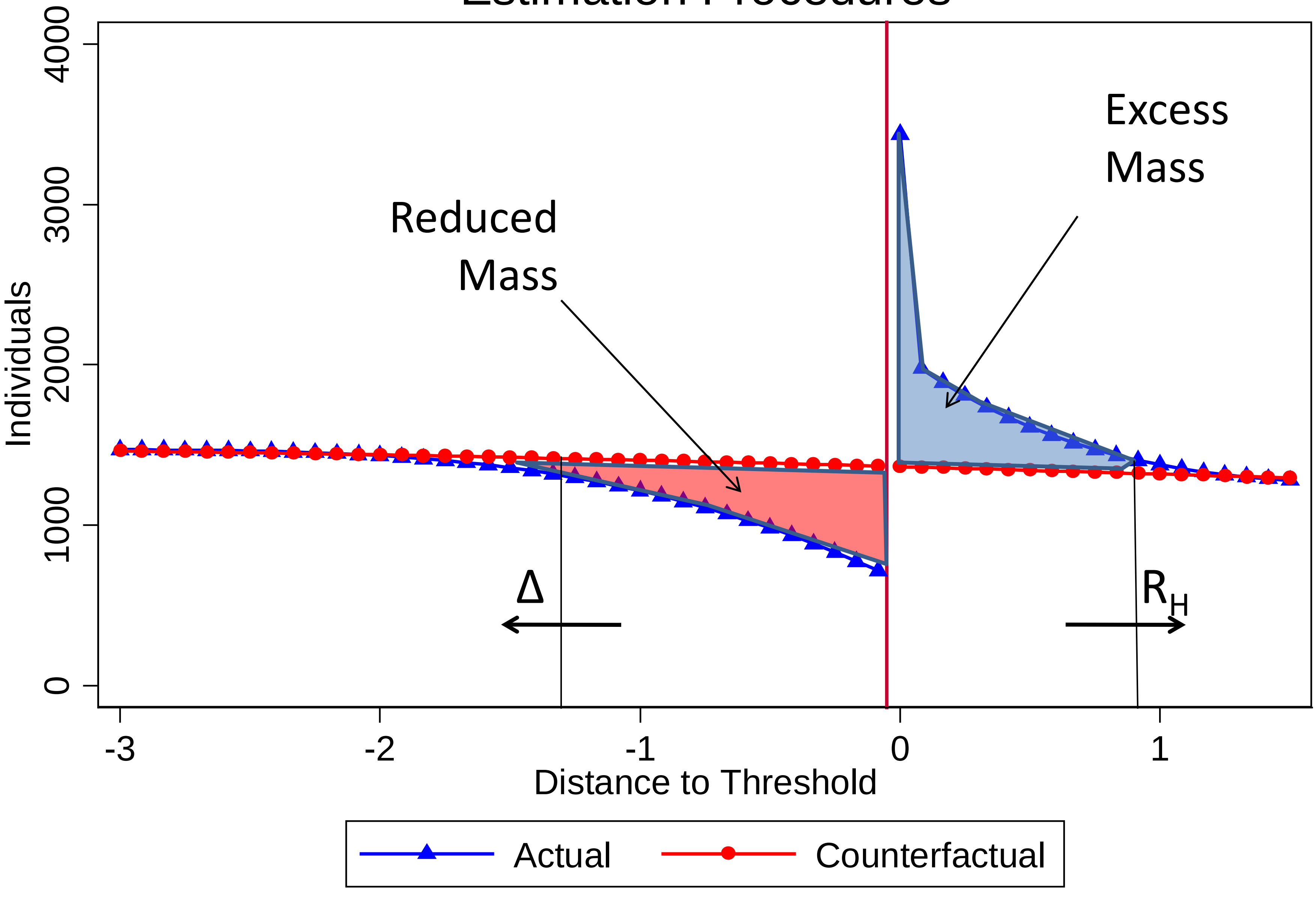


Fig. 15.

Elasticities by Point of Indifference & Amount of Sev. Pay

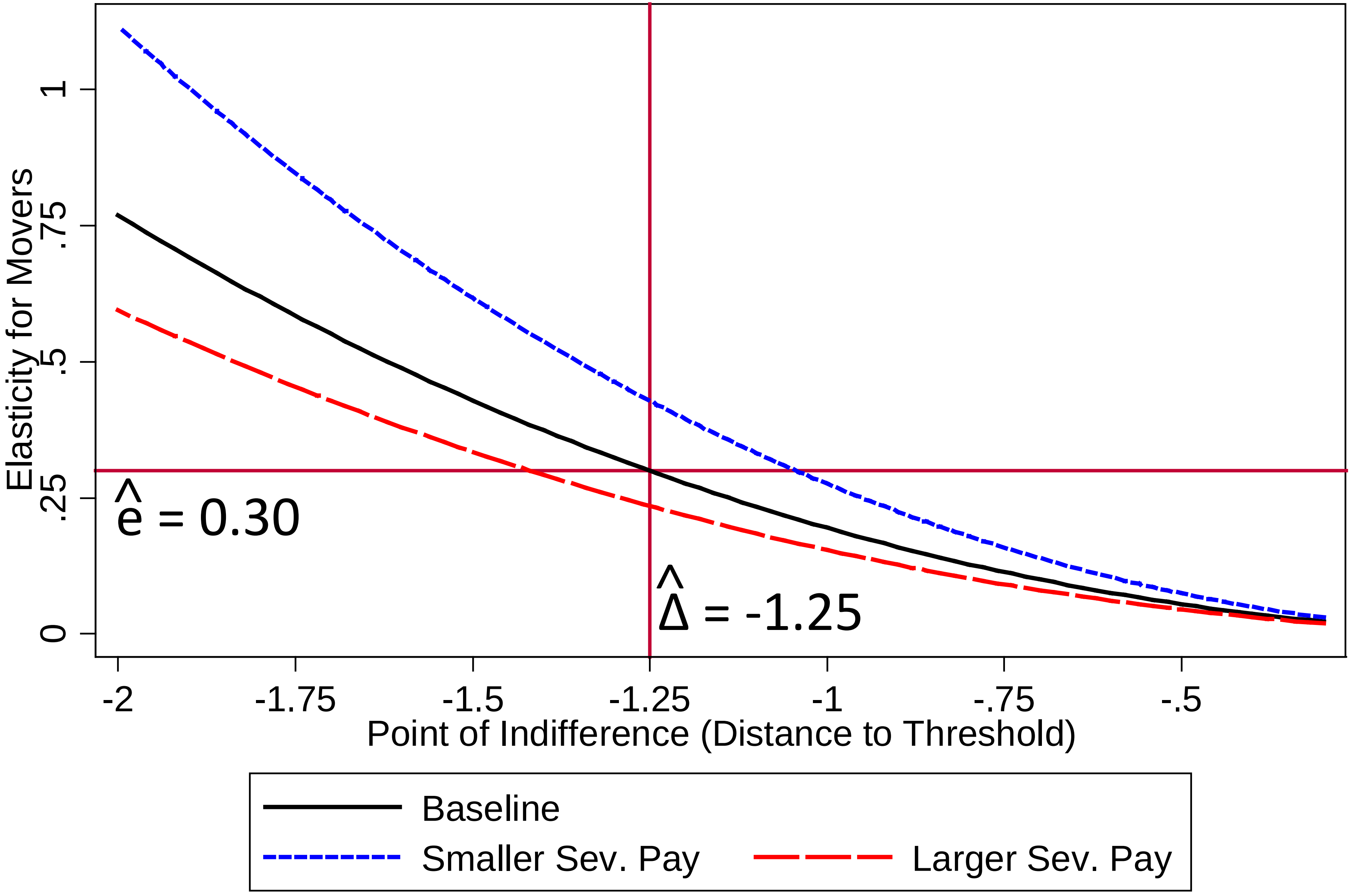


Fig. 16. Model Simulation