Intertemporal Substitution in Labor Force Participation: Evidence from Policy Discontinuities

Dayanand Manoli
UCLA

Andrea Weber
University of Mannheim

April 28, 2010

Abstract

How much are individuals willing to reallocate labor supply from periods with low wages to periods with high wages? We address this question using administrative data on the census of private sector employees in Austria and variation from policy discontinuities in retirement benefits from the Austrian pension system. The policy discontinuities refer to discontinuous increases in benefits upon completion of 10, 15, 20 or 25 years of tenure at retirement. We first present graphical evidence documenting delays in retirement in response to the policy discontinuities. Next, we develop a basic model of retirement decisions and estimate the elasticity of intertemporal substitution in labor force participation using a semiparametric estimator that exploits the graphical evidence. The graphical evidence and estimated elasticities indicate a relatively low degree of intertemporal substitution in labor force participation. These estimates have a high degree of precision due to both the minimal measurement error and large sample size from the administrative data and also the large changes in financial incentives from the policy discontinuities.

1 Introduction

Understanding individuals' willingness to reallocate labor supply from times with low wages to times with high wages is important for a variety of economic policies. However, estimating the degree of intertemporal substitution in labor supply has proven difficult because of the research design that is required to estimate the elasticities and parameters of interest. Ideally, to estimate the degree of intertemporal substitution in labor supply, one requires a research design where identification is based on exogenous variation in anticipated wage changes across individuals. Previous studies have taken a variety of approaches to simplify this research design, but the approaches have produced a wide range of estimates with different policy implications.[1]

In this paper, we present new estimates of the degree of intertemporal substitution in labor supply based on policy discontinuities in retirement benefits in Austria. We first present graphical evidence documenting individuals' labor supply responses to the policy discontinuities. Next, we develop a semiparametric elasticity estimator that exploits the labor supply responses observed in the graphical evidence.

The policy discontinuities arise because retirement benefits in Austria vary discontinuously based on the amount of tenure an individual has accumulated by his/her retirement. Specifically, if an individual accumulates at least 10 years of tenure by retirement, the Austrian pension system mandates that the employer must make a lump-sum payment to the individual at the time of his/her retirement equal to one third of the last year's salary. If the individual accumulates less than 10 years of tenure by retirement, no payment is made. If the individual accumulates at least 15, 20 or 25 years of tenure by retirement, the payment amounts are increases to one half, three quarters and one full year of the last year's salary. These discontinuities therefore discontinuously increase wage rates just prior to the thresholds. For example, the wage rate for the 10th year of tenure is discontinuously higher than other years since individuals will receive their standard annual wage rate plus the payment when they complete the 10th year. Furthermore, these wage increases can be fully anticipated at earlier years of tenure.

We examine behavior before and after these tenure thresholds to determine if individ-

[1] Microeconomic studies such as MaCurdy (1981), Altonji (1986), Blundell, Meghir and Neves (1993) and Ziliak and Kniesner (1999) present evidence of relatively low intertemporal substitution in labor supply. In contrast, macroeconomic studies (see Mulligan (1999), King and Rebelo (1999) and Chang and Kim (2007)) have presented evidence of relatively high intertemporal substitution in labor supply. More recently, Looney and Singhal (2006) present microeconomic evidence of relatively high intertemporal substitution in labor supply.

uals delay their retirements in response to the anticipated wage variation. The 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 intertemporal substitution in labor supply based on the graphical evidence. 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)).

Our research strategy contributes several innovations to the economics literature. First, we contribute to the retirement literature by focusing explicitly on the elasticity of intertemporal substitution (i.e. the Frisch elasticity) in retirement decisions. Previous studies have examined retirement responses to unanticipated changes in retirement benefits (for examples, see Krueger and Pischke (1992), Brown (2009) and Manoli, Mullen and Wagner (2010)). However, since social security reforms are infrequent, it is important for policymakers to understand how retirement decisions respond to anticipated changes in retirement benefits, and this exactly corresponds to understanding intertemporal substitution in retirement decisions (see Browning (2005)).

Second, this research contributes to the labor economics and macroeconomics literatures by focusing on an extensive margin Frisch elasticity. Many studies in both labor economics and macroeconomics have emphasized the empirical relevance of the extensive margin in the labor supply-wage relationship (see Heckman (1993) and Rogerson and Wallenius (2009)). However, previous microeconomics studies have generally presented evidence of intertemporal substitution based on intensive margin labor supply changes.[2] This study presents microeconomic evidence of intertemporal substitution based on extensive margin labor supply changes since retirement decisions are extensive margin decisions.

Finally, our empirical methodology presents multiple innovations to the literature on retirement and intertemporal substitution in labor supply. 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. Second, our empirical design allows for improvements to the estimates of intertemporal substitution in the literature with regard to statistical and economic precision.. The gain in statistical precision from our estimates follows from two factors. First, we are able to use

[2]See Blundell and MaCurdy (1999) for a survey of the microeconomic evidence of intertemporal substitution in labor supply.

administrative data from the Austrian Social Security Database, which minimizes measurement error in key variables. Second, the data present a longitudinal census of private sector employees and hence we have a large sample of 444,452 individuals. The economic precision of our estimates arises from the magnitudes of the policy discontinuities. Previous studies have exploited relatively small changes in financial incentives to examine intertemporal substitution. If small optimization frictions (for example cognitive costs) exist, estimates based on these small changes are unlikely to reflect the structural parameter of interest (see Chetty (2009)). In contrast, we exploit relatively large and transparent changes in financial incentives of 400% of an individual's monthly wage. Small optimization frictions are less likely to overwhelm the large financial incentives thereby permitting more robust or economically precise identification of the structural parameter of interest.

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. We present the graphical evidence in section 3. We develop the elasticity estimator and present the results in section 4. We discuss how alternative, more complicated models would affect the results in section 5 and we conclude in section 6.

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 focus first on the 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.[3] Tenure is defined as continuous employment time with a given employer. Retirement is based on claiming a government-provided pension as payments must be made within 4 weeks of claiming a pension. The payment schedule is as follows. If an employee has accumulated 10 years of tenure with his employer by the time of his retirement, the employer must pay the individual one third of his last year's salary. This fraction increases from

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

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 must be 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. Funds to make these payments come from funds that employers are mandated to hold based on the total number of employees.

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[4] are subject to the income tax with marginal tax rates in the different tax brackets of 0%, 21%, 31% 41% and 50%.[5] 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.

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 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 a Disability pension, 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 this Early Retirement Age is age 60 for men. Lastly, men and women become eligible for Old Age pensions at age 65 and 60 respectively.

[4]Contributions for pension, health, unemployment, and accident insurance of 39% are withheld from gross annual earnings up to a contribution cap.

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

Figure 2 illustrates survival functions for entry into the pension system for the sample of private sector employees. The survival functions are presented separately for men and women given the separate 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. In particular, the survival function for men highlights that roughly 25% of the sample of men retire by claiming disability pensions.

2.2 Administrative Data & Sample Restrictions

Our empirical analysis is based on data from the Austrian Social Security Database (see Zweimuller et al (2009)), which are collected with the principle aim of verifying pension claims. This implies that the data provide very detailed longitudinal information on employment and earnings for the universe of private sector workers in Austria. The period for which registers are available spans the years 1972 to 2006. To investigate the effect of severance pay eligibility on retirement decisions we consider all individuals born between 1920 and 1945 and make several restrictions to the original dataset which are summarized in Table A1 in the Appendix. Specifically, 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. Because we are interested in tenure at the time of retirement, 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. Furthermore, because we want to ensure accurate computation of tenure at retirement, we focus only on individuals with uncensored tenure at retirement. The censoring arises for individuals that are continuously employed from the start of the data in January of 1972 through their retirements. With these restrictions, we have a final sample of $596,897$ individuals.

Table 1 presents some summary statistics for the final sample. Summary statistics are presented for all individuals at age 55 and for all individuals at their retirement age if the individual is observed to retire. Because of the imposed censoring at age 70 and the natural censoring due to the end of the observation period in 2006, we observe $444,452$ retirements out of the $596,897$ individuals observed at age 55. We present statistics of monthly earnings since several individuals are observed to retire in the middle of a calendar year and thus their annual earnings are reduced in the year of retirement. Median monthly earnings in the month preceding retirement are roughly between 830 euros in 2004. Earnings increase with age, so average and median earnings at retirement slightly exceed earnings their respective counterparts at age 55. Average tenure at age 55 is relatively low (median of 4.75), but the fraction of individuals eligible for severance payments increases as individuals age and accumulate tenure. In particular, the median retirement age is roughly 4.75 years beyond age 55 and the median tenure at retirement is about 3 years greater than tenure at age 55.

3 Nonparametric Analysis

3.1 Full Sample Analysis

3.1.1 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 evident from this plot. First, the plot shows discontinuous increases in the number of retirements at and just beyond the tenure thresholds. Second, there are decreases in the number of retirements just before the tenure thresholds. The observed decreases and increases around the thresholds are generally concentrated within 1 year before and after the thresholds respectively. These two patterns are not apparent at any other points 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. Third, the plot illustrates increases in the number of retirement at each integer value of tenure at retirement. This seasonality is driven by several jobs beginning on January 1st and several retirements also beginning on January 1st, thereby leading high frequencies of integer values of tenure at retirement.

Some noteworthy features are not illustrated in Figure 3. First, even though there are decreases prior to the thresholds, the frequency of retirements never goes to zero just prior to the thresholds where wage incentives are highest. This lack of gaps suggests evidence of some uncertainties and frictions related to retirement decisions since models with no uncertainty or frictions would predict such gaps. 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. Intuitively, this may be plausible since the severance payments are small relative to lifetime income.

3.1.2 Accounting for Covariates

While Figure 3 presents cross-sectional variation in the distribution of tenure at retirement, we examine panel variation in the probability of retirement to examine whether or not other observables change around the tenure thresholds. Intuitively, if other observables change discontinuously around the thresholds, this would suggest that the patterns observed in Figure 3 could be driven by other factors in addition to or perhaps in place of the severance payments at retirement. To examine the role of other observables in driving the patterns illustrated in Figure 3, 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. Time is measured at a quarterly frequency at January 1st, April 1st, July 1st and October 1st. While tenure is measured at a monthly frequency in Figure 3, tenure is measured at a quarterly frequency when estimation this regression. We estimate this regression both with and without controls and plot the estimated coefficients on the tenure dummies from each regression.

Figure 4 illustrates the coefficients on the tenure dummies from the estimated regressions. Following the institutional background, we estimate separate specifications for men and women. Consistent with Figure 3, the coefficients illustrate distinct decreases and increases in the probability of retirement just before and after the thresholds respectively. The plots also illustrates that the pattern in the estimated coefficients does not change significantly when including a large set of base control variables. The base controls include dummies for the following variables: calendar year, age measured in years, blue collar job designation, two-digit industry classifications, nine geographic regions, quarter-of-year, firm size, health status at age 54, health in the current quarter, earnings growth over the past quarter, and earnings growth over the same quarter in the past year.[6] In addition, the base controls include 10 piece splines in total real earnings through age 54 and total real earnings in the current quarter. The plots in Figure 4 also show that, after including controls for experiences (dummies for insurance and contribution years), the retirement-tenure gradient in the coefficients becomes much flatter. This change highlights two features. First, individuals with higher years of tenure generally have higher years of experience. Second, after controlling for experience and other observables, there is little correlation between tenure and retirement. Comparing the plots for men and women, women appear much more responsive to the severance payments than men.

3.1.3 Gender Differences

To investigate the differences between men and women further, we return to the cross-sectional variation based on observations at retirement and re-weight the observations for men to be similar to those of women based on observables (see DiNardo, Fortin and Lemieux (1996)). We implement the reweighting in the following steps. First we pool the observations for men and women and estimate a probit, $\Pr(female_i = 1|x_i) = \Pr(x_i\beta + \varepsilon_i > 0)$. The observables x_i include the values at retirement for the base and experience controls in the regressions above. Next, we obtain the fitted probabilities for men and created weighted counts using these fitted probabilities. Figure 5 plots the distributions of tenure at retirement for men, women and the reweighted men. These plots indicate that differences in the observables do not account for the observed differences between men and women. In particular, while men and women do have differences in observables such as retirement age, earnings, health, experience, industries, and firm size, accounting for the differences in these and other observables does not account for the differential responsiveness to the severance payments. We discuss potential uses for the severance payments and corresponding unobserved differences that could explain this gender differential in more detail below.

[6] 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.

3.1.4 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 6 plots the number of individuals starting new jobs (vertical axis) against age measured at a quarterly frequency (horizontal axis). In 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) are earlier ages in response to the sizeable anticipated incentives from the severance payments.

3.1.5 Survey Responses

The full sample evidence aggregates over a variety of subsamples. To motivate and organize the analysis of heterogeneity across the subsamples, we present evidence on individuals' reasons for retirement, employment situations and expectations regarding lump-sum payments at retirement. Table 2 presents survey responses regarding reasons for retirement for men and women separately. For both groups, the most frequently cited reasons for retirement are (1) becoming eligible for a public pension and (2) own ill health. For men, employment circumstances (made redundant and being offered early retirement options) constitute the majority of the remaining reasons for retirement. For women, family circumstances (spending more time with the family and health of relatives) in addition to the employment circumstances constitute the remaining reasons for retirement. Table 3 presents responses to questions regarding job security, job satisfaction and expectations regarding lump sum payments at retirement. The responses indicate that most men and women have job security, are satisfied with their jobs and are aware of lump-sum payments at retirement. In regard to awareness, roughly 47% and 42% of men and women expect to receive lump-sum payments with their pension benefits, and these percentages are consistent with the distribution of tenure at retirement which indicates that about 38% and 45% of men and women respectively have more than 10 years of tenure at retirement.

These survey responses highlight they the types of individuals that are likely to be responsive to the severance payments and also the circumstances that are likely to cause or inhibit this responsiveness. Specifically, the responses motivate the following organization for the heterogeneity analysis below. First, we examine heterogeneity related to public pension eligibility and, more generally, the institutional framework of the pension system. Second, we examine heterogeneity related to health. Third, we examine heterogeneity related to wages and job separations.

3.2 Heterogeneity related to Public Pensions

Following the institutional background of the Austrian pension system, we study heterogeneity related to public pensions by separating men and women and grouping the retirement pensions into three categories: (1) disability pensions, which are based on reduced working capacity (2) early retirement pensions, which are based on eligibility prior to the statutory retirement ages (60 and 65 for women and men respectively) and (3) old age pensions. Table 4 presents retirement ages within each pension category. The table indicates that, for men, a significant amount of retirement occurs prior to age 60 through disability pensions. For women, a significant amount of retirement occurs between ages 55 through 60 through old age pensions.

Figure 7 presents the distributions of tenure at retirement within each gender and pension type. Comparing the top figures to the bottom figures, the plots indicate that women are uniformly more responsive to the severance payments than men. We discuss the factors that could potentially account for this difference between men and women in greater detail below. Additionally, the plots indicate that men and women retiring through disability pensions are relatively unresponsive to the severance payment incentives. Intuitively, individuals who claim disability pensions may have poor health which inhibits them from responding to the severance payment incentives. We examine heterogeneity based on health in more detail below.

Plots of the distributions of tenure at retirement by gender and retirement age are consistent with the plots by gender and pension type. Amongst men, there is little pooling amongst those retiring prior to age 60, and individuals retiring at age 60 or beyond both demonstrate similarly noticeable pooling. For women, there is noticeable pooling at all retirement ages, though relatively more significant pooling amongst those retiring beyond age 60.

We next examine heterogeneity across individuals with different public pension benefits. Benefit levels are determined based on individuals' highest 15 years of earnings, and since earnings are generally increasing in age, the highest earning years tend to be the years prior to retirement. We therefore group individuals based on their gender and average real earnings between ages 50 through 54 and compare the distributions of tenure at retirement for the highest and lowest 15% within each gender. These distributions are presented in Figure 8. The plots indicate more distinctive pooling patterns amongst men and women with lower benefit levels. Intuitively, the severance payments represent larger fractions of wealth for these individuals with lower benefits and thus, these individuals face relatively larger incentives to delay their retirements. Continuing with this intuition, individuals with high earnings growth at older ages also face relatively larger incentives to delay their retirements since the severance payments are larger fractions of their wealth. Plots of the distributions of tenure at retirement for individuals with high and low earnings growth at older ages indicate that there is indeed more pooling amongst men and women with high earnings growth prior to retirement.

We investigate the differences between men and women further by focusing first on differences based on experience and children. Because of the institutional setting, women can retire at younger ages than men and will therefore have lower years of experience than men. If differences based on experience can account for the observed differences between men and women, then we expect women with high years of experience to have similar patterns to those of men. Additionally, since the pension system counts maternity leave toward years of experience when computing benefits, we also separate women with children from those without children with the hypothesis that women without children and with high experience are likely to be similar to men. Figure 9 presents the distributions of tenure at retirement for women based on experience at age 55 and children. High and low experience is based on the top and bottom quartiles of the experience distribution. These plots indicate no sharp differences based on experience, implying that experience alone cannot account for the observed differences between men and women. The plots also indicate noticeably more pooling amongst women with children. The presence of children may affect the potential uses of the severance payments thereby making women more responsive to the payments. We discuss potential uses of the severance payments and difference between men and women based on other observables in more detail below.

3.3 Heterogeneity related to Health

We measure health at retirement using the number of days of sick leave an individual has taken between age 54 and retirement. Roughly 35% of individuals have no sick leave over their entire careers and 68% have no sick leave between ages 54 and retirement. Amongst those with some sick leave between age 54 and retirement, we distinguish between those in the top quartile of the sick leave distribution within each gender (high sick leave) from those in the bottom three quartiles (low sick leave). This distinction is made to separate those with extremely poor health status from others.

Figure 10 presents the distributions of tenure at retirement based on gender and health at retirement. The plots indicate that there is no noticeable pooling amongst men and women in extremely poor health. Thus, some of the pre-threshold retirement is likely to be driven by negative health shocks and also more permanently poor health status. Amongst those with low sick leave, there is less pooling amongst men than women; this could reflect that men on sick leave tend to be in worse health than women on sick leave.

Consistent with the earlier evidence by pension type, roughly 64% of individuals with some sick leave between age 54 and retirement claim disability pensions as opposed to 15% amongst those with no sick leave between age 54 and retirement. To provide some context for the injuries causing sick leave and disability, Table 5 present the disability causes amongst those claiming disability pensions in 1995. The statistics indicate that back injuries and movement disorders are the most significant causes of disabilities as these injuries account for roughly 60% and 69% of disabilities amongst men and women respectively. The second-most significant cause of disabilities is cardiovascular disorders which account for roughly 15% and 9% of injuries for men and women respectively. Amongst the remaining disability causes, accidents at work and diseases of the respiratory system are more common for men while psychiatric disorders are more common for women. Since the 2000 pension reform, disability requirement have been increased so that there has been a reduction in disability due to back injuries and movement disorders and also an increase in disability due to mental illness.

We next examine industry-level differences in health at retirement. Table 6 presents statistics on the distribution of health at retirement across industries. Amongst men, poor health at retirement is prevalent amongst those in construction and manufacturing and less prevalent amongst those in the service industry. For women, those in sales and services have better health at retirement. The services industry thus has relatively low rates of disability for both men and women, but roughly 25% of men are in the services industry while 48% of women are in the services industry.

Figures 11A&B present the distributions of tenure at retirement across aggregated industries for men and women separately. The plots indicate less pooling amongst individuals in agriculture and mining, manufacturing and construction as compared to sales, transportation and services. Intuitively, individuals in more physically demanding jobs may have a high marginal disutility of work so that they are not likely to delay their retirements to qualify for a (larger) severance payment. Indeed, for both men and women, the plots for those within the services industry indicate more willingness to delay retirement, and these jobs are less likely to be very physically demanding. Analysis using further disaggregated industry classifications confirms the pattern observed using the aggregate industry classifications, namely that there is less pooling amongst individuals in industries with high fractions of individuals with poor health at retirement. Examples of disaggregated industry classifications with high fractions of individuals in poor health at retirement include manufacturing of chemicals and chemical products (men) and manufacturing of textiles (women). Examples of disaggregated industry classifications with high fractions of individuals in good health at retirement include financial intermediation (men) and real estate activities (women).

3.4 Heterogeneity related to Job Separations

Involuntary separations may inhibit individuals from delaying their retirements to qualify for (larger) severance payments. While it is not possible to directly distinguish between voluntary and involuntary separations using the administrative data, we present evidence in regard to involuntary separations in two ways. First, we examine the distributions of tenure at retirement at different points in the business cycle. In particular, we group calendar years based on having GDP growth rates above or below the average growth rate for the sample period and then examine the distributions of tenure at retirement within these above and below average growth categories. Intuitively, there may be less pooling amongst those retiring during times of low economic growth because a larger portion of these retirements may be involuntary during these times. Figure 12 presents this plot. While there is still noticeable pooling during the lower growth periods, the plot indicates more distinct pooling amongst men and women retiring during high growth periods. This evidence is consistent with the intuition that individuals are more able to delay their retirements in response to the severance payments during periods of strong macroeconomic growth.

We study pre-threshold retirement over the business cycle more explicitly in Figure 13. In this figure, we examine whether or not retirement before a tenure threshold varies over the business cycle. We define pre-threshold retirements as retirements occurring within one year prior to a tenure threshold. Our hypothesis is that some pre-threshold retirements may be involuntary so that, since overall involuntary retirements are countercyclical, the fraction of retirements that are pre-threshold will be countercyclical as well. Figure 13 presents the time series plot of the fraction of pre-threshold retirements and the time series for GDP growth. Consistent with the hypothesis, the fraction of retirements that are pre-threshold does follow a mildly countercyclical patter. Thus, the evidence in Figures 10 and 11 suggests that some of the observed pre-threshold retirements are driven by the presence of involuntary separations at retirement.

3.5 Discussion

The graphical analysis highlights excess retirements just after the tenure thresholds and reduced retirements just before the thresholds. The analysis of heterogeneity illustrates that interactions with public pension incentives, health status and job separations are important factors affecting individuals' responsiveness to the severance payment incentives. Overall, the graphical evidence indicates a relatively low degree of observed intertemporal substitution in retirement decisions. This conclusion follows from the observation that the reduced frequency of retirements just prior to the tenure thresholds occurs within roughly 1 year prior to the threshold even though individuals face wage increases based on sizeable fractions of their annual earnings.

We present evidence on individuals' uses of lump-sum gifts to gain some insights as to why the willingness to delay retirement decisions is seemingly low. Table 7 presents survey responses of older workers regarding their likely uses of an unanticipated lump-sum gift of 12,000 euros. While the question is in regard to an unanticipated gift, individuals uses of an anticipated gift may be similar. The results in Table 7 indicate that about two thirds of individuals would save some of the gift, and amongst the savers, about two thirds of the gift would be saved. Few individuals report that they would use any of the gift to pay off debts, though the individuals that would use the gift to pay off debts would use just over half of the gift. Of the remaining uses, both men and women are highly likely to give some of the gift to relatives or others and to use some of the gift to take a vacation. The responses for women indicate that they are more likely to give some of the gift to relatives, and conditional on giving, they would give larger gifts. In contrast, men report a higher likelihood of using some of the gift to purchase durable goods. Given these responses, it seems plausible that individuals may not be willing to delay their retirements by more than a year to increase their savings and take a vacation when beginning retirement.

4 Elasticity Estimation

4.1 Model

Consider an intertemporal labor supply model in which an individual has quasi-linear preferences over consumption in each period, c_t, and years of work, R. We assume that there is no time discounting and that the individual lives for T periods. We abstract from uncertainty in the presentation of the model. However, in the presence of uncertainty (e.g. wage uncertainty, mortality), the model can be interpreted as capturing decisions based on certainty equivalences because of the assumption of risk neutrality following from the quasi-linear preferences. At time 0, the individual decides how much to consume in each period and how many years to work. Heterogeneity in labor supply across different individuals results from heterogeneity in the taste for work, which is denoted by θ and distributed in the population according to the density function $f(\theta)$. Formally, the individual's optimization problem is given by

$$\max_{\{c_t\},R} \sum_{t=0}^{T} c_t - \frac{\theta}{1+\frac{1}{e}} \left(\frac{R}{\theta}\right)^{1+\frac{1}{e}}$$
$$\text{s.t. } \sum_{t=0}^{T} c_t = wR + x$$

where w denotes the individual's wage rate per year of tenure completed and x denotes non-wage income.

The assumption of quasi-linear preferences is motivated by the graphical analysis. Quasi-linear preferences imply that there are no income effects in individuals' labor supply functions. This lack of income effects is consistent with the graphical analysis which presents evidence that income effects are not detectable in the distribution of tenure at retirement. 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 elasticity of intertemporal substitution in labor supply is defined to capture how labor supply responds to wage variation holding the marginal utility of income constant, $\frac{d \ln R}{d \ln w}|_\lambda$ where λ denotes the marginal utility of income. In this model, the marginal utility of income is equal to 1, and from the individual's labor supply function, we have

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

This elasticity captures an individual's responsiveness to an anticipated wage increase. When a wage increase is anticipated, it is already factored into lifetime income so that the marginal utility of income can be assumed to be held constant by construction. 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 setting, the intertemporal (Frisch) labor supply elasticity coincides with the static income-constant (Marshallian) and utility-constant (Hicksian) labor supply elasticities. Though the 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.

4.2 Pooling & a Semiparametric Elasticity Estimator

In this section we introduce a discontinuity in the budget constraint and discuss how pooling at this discontinuity can be used to estimate the intertemporal elasticity. Optimal retirement choices with this discontinuity are presented graphically in Figure 14. Specifically, suppose that at a threshold level of tenure at retirement $\bar{R}$, individuals qualify for a lump-sum payment denoted by dx.

First, we characterize the types of individuals who locate at the threshold in the presence of the discontinuity. Let $[\underline{\theta}, \bar{\theta}]$ denote the set of types that choose labor supply $\bar{R}$. The highest skill level the locates at $\bar{R}$ is the highest skill level that located at $\bar{R}$ even in the absence of the discontinuity; that is, $\bar{\theta}$ is characterized by $\bar{\theta}$ such that $\bar{R} = \bar{\theta} w^e$. Next, the lowest skill level that locates at $\bar{R}$ is the skill level that is indifferent between choosing $\bar{R}$ and his counterfactual labor supply in the scenario without the discontinuity. Therefore, $\underline{\theta}$

is characterized $\underline{\theta}$ that satisfies the following indifference condition

$$w(\underline{\theta}w^e) + x - \frac{\underline{\theta}}{1+\frac{1}{e}}(\frac{\underline{\theta}w^e}{\underline{\theta}})^{1+\frac{1}{e}} = w\bar{R} + x + dx - \frac{\underline{\theta}}{1+\frac{1}{e}}(\frac{\bar{R}}{\underline{\theta}})^{1+\frac{1}{e}}$$

where the left-hand side captures counterfactual utility without the discontinuity and optimal retirement equal to $\underline{\theta}w^e$ and the right-hand side captures utility when locating at the threshold and receiving the lump-sum payment.

Second, we relate the set of types that pool at the threshold labor supply level to changes in wages and labor supply. Let $\underline{R}$ denote the counterfactual labor supply of type $\underline{\theta}$, $\underline{R} = \underline{\theta}w^e$. Thus, $dR = \bar{R} - \underline{R}$ captures the change in labor supply for this individual due to the discontinuity. For a type-$\underline{\theta}$ individual, the change in labor supply can be related to a wage change. In particular, the wage that would have lead type $\underline{\theta}$ to choose labor supply $\bar{R}$ in the absence of the discontinuity is given by $\tilde{w}$ such that $\bar{R} = \underline{\theta}\tilde{w}^e$. In computing $\tilde{w}$, the variation from the income discontinuity dx is converted into wage variation. Using these characterizations of wages and labor supply, the proportional change in labor supply due to the discontinuity is given by

$$\frac{dR}{\bar{R}} = \frac{\bar{R} - \underline{R}}{\bar{R}} = 1 - \left(\frac{w}{\tilde{w}}\right)^e$$

These changes in optimal retirement are depicted in Figure 15.

Next, we write the amount of pooling at the threshold labor supply in terms of the changes in labor supply and the counterfactual distribution of labor supply without the discontinuity. Let P denote the fraction of the population pooling (i.e. the excess mass) at the threshold labor supply level, and let $h_0(R)$ denote the density of the population choosing labor supply R when there is no discontinuity in the budget constraint. This density results from the labor supply function and the density of tastes for work; that is, the labor supply function $R = \theta w^e$ implies that $h_0(R) = \frac{1}{w^e}f(\frac{R}{w^e})$ where $f(.)$ denotes the density of tastes for work. Given the definitions and characterizations above, individuals with tastes $\theta \in [\underline{\theta}, \bar{\theta}]$ pool at the threshold and these individuals have counterfactual labor supply choices $R \in [\underline{R}, \bar{R}]$. The amount of pooling is then given by

$$\begin{aligned} P &= \int_{\underline{R}}^{\bar{R}} h_0(R)\partial R \\ &\approx dR\left(\frac{h_0(\underline{R}) + h_0(\bar{R})}{2}\right) \\ &= \bar{R}\left[1 - \left(\frac{w}{\tilde{w}}\right)^e\right]\left(\frac{h_0(\underline{R}) + h_0(\bar{R})}{2}\right) \end{aligned}$$

where the second line follows from a trapezoidal approximation of the integral and the last line uses the above characterization of the change in labor supply.

This last equation yields an estimator for the intertemporal elasticity based on the amount of pooling around the threshold labor supply level. In particular, this equation can be solved to express the intertemporal elasticity in terms of observable parameters and estimable variables,

$$e = e(\underbrace{w, dx, \bar{R}}_{\text{observable}}, \underbrace{h_0(\underline{R}), h_0(\bar{R}), P}_{\text{estimable}}).$$

The wage, threshold and lump-sum payment are all assumed to be observable. The density at the cutoff and the threshold and the amount of pooling can be estimated using the empirical distribution of tenure completed by retirement.

4.3 Elasticity Estimator with Frictions

We introduce frictions into the model above to account for the observed, pre-threshold retirement patterns. The graphical evidence in Figure 3 illustrates positive numbers of individuals retiring just prior to the thresholds and also that the number of individuals retiring just before the thresholds decreases as the time until the threshold decreases.

We model frictions as adjustment costs in retirement decisions. let R_0 denote an individual's (counterfactual) retirement choice in the absence of the severance payment and let R_1 denote the same individual's retirement choice in the presence of the severance payment. We denote the utility gain from adjusting from R_0 to R_1 by ΔU. Given an adjustment cost ϕ, the individual will adjust his retirement choice only if the gain exceeds the cost, i.e. if and only it $\phi < \Delta U$. We assume that adjustment costs are randomly distributed on $[0, \phi_H]$ where $\phi_H > 0$ with density and distribution functions $\pi(.)$ and $\Pi(.)$ respectively.

The frictions affect the estimation of the structural parameter e since only individuals with sufficiently low costs can pool at the threshold. In particular, the amount of pooling at the threshold is given by

$$\begin{aligned} P &= \int_{\underline{R}}^{\bar{R}} \int_{0}^{\Delta U(R)} \pi(\phi) h_0(R) \partial\phi \partial R \\ &= \int_{\underline{R}}^{\bar{R}} \Pi(\Delta U(R)) h_0(R) dR \end{aligned}$$

This change in the excess mass at the tenure thresholds due to the frictions is illustrated in Figure 16. Using a similar trapezoidal approximation and also a similar derivation of dR as in case without frictions, the amount of pooling at the tenure threshold can be re-written as

$$\begin{aligned} P &\approx dR \left(\frac{\underline{\Pi} h_0(\underline{R}) + \bar{\Pi} h_0(\bar{R})}{2} \right) \\ &= \bar{R} \left[1 - \left(\frac{w}{\tilde{w}} \right)^e \right] \left(\frac{\underline{\Pi} h_0(\underline{R}) + \bar{\Pi} h_0(\bar{R})}{2} \right) \end{aligned}$$

where $\underline{\Pi} = \Pi(\Delta U(\underline{R}))$ denotes the probability of switching for individuals who are just indifferent between their choices with and without the discontinuities and $\bar{\Pi} = \Pi(\Delta U(\bar{R}))$ denotes the probability of switching for individuals locating exactly at the threshold. Notice that by the indifference condition, $\Delta U(\underline{R}) = 0$ and hence $\underline{\Pi} = 0$. The above equation can be solved to yield an estimator for the structural parameter e,

$$e = e(\underbrace{w, dx, \bar{R}, \bar{\Pi}}_{\text{observed}}, \underbrace{h_0(\bar{R}), P}_{\text{estimated}}).$$

Compared to the case without frictions, the estimator with frictions introduces one additional observable, $\bar{\Pi}$, which reflects that only a fraction of individuals near the threshold have sufficiently low costs to switch retirement choices. When allowing for these frictions, the responsiveness to wage variation will not be captured by the structural parameter e only. Intuitively, when there is wage variation, individuals will only respond to the wage variation if they have sufficiently low costs, so the intertemporal elasticity of substitution in labor supply is given by $E = \Pi(\Delta U)e$, i.e. the structural parameter must be adjusted by the probability of switching.

4.4 Estimating Pooling & the Counterfactual Density

The estimation of the counterfactual density and the amount of pooling at the threshold can be seen as follows. We start with the observed frequencies of individuals retiring at each level of tenure R_t; we denote these frequencies by $\{h(R_t)\}_{t=1...T}$. We estimate regressions of the form

$$h(R_t) = \tilde{h}(R_t) + \tilde{\varepsilon}_t$$

where the function $\tilde{h}(R)$ denotes a high-order (8th order) continuous polynomial function in tenure at retirement. We estimate separate regressions between each of the tenure thresholds to fully capture the observed discontinuous patterns at each threshold. Using the estimated polynomial function, we predict frequencies to obtain a continuous polynomial approximation for the observed frequencies.[7] Figure 17 illustrates this polynomial approximation against the observed frequencies. We adopt the frequencies from the polynomial approximation as the "actual" frequencies. By using the polynomial approximation, we are able to adjust for spikes at the integer values of tenure at retirement.

Next, we use these actual frequencies to obtain counterfactual frequencies. These counterfactual frequencies aim to capture what the frequencies would have looked like in the absence of the severance payment incentives. We assume that in the absence of the severance payments, individuals retiring at the tenure thresholds would behave similarly to individuals between or away from the tenure thresholds. With this identifying assumption in mind, we estimate the counterfactual density by regressing the observed density on a continuous (8th order) polynomial function and a set of dummies capturing behavior near the threshold,

$$\tilde{h}(R_t) = h_0(R_t) + \sum_{\bar{R}=10,15,20,25} \sum_j 1(R_j \text{ near } \bar{R}) + \varepsilon_t.$$

As illustrated in Figure 18, the estimated polynomial function $\hat{h}_0(R)$ reflects what the labor supply choices would have been in the absence of the severance payments. To obtain the final estimated counterfactual frequencies, we re-scale the fitted values $\{\hat{h}_0(R_t)\}_{t=1...T}$ so that the total number of predicted retirements across all tenure levels obtained using only the polynomial function equals the total number of observed retirements. This re-scaling is motivated by the reasoning that the total number of retirements would not change in the counterfactual and moreover, any changes in the total number of predicted retirements

[7] We re-scale the predicted frequencies so that the total number of predicted retirements equal the total number of observed retirements.

are assumed to spread across the tenure levels in proportion to the predicted number of retirements at each tenure level.

While there is no pre-determined method to determine which levels of labor supply are "near" the threshold, we will rely on a graphical method as illustrated in Figure 19. In particular, the graphical evidence suggests that responses to the discontinuities are generally within ± 1 year of each tenure threshold. We also rely on a graphical method to estimate the amount of pooling at the threshold labor supply level. While the model above predicts that individuals will choose to locate exactly at the threshold level of labor supply $\bar{R}$, it is plausible that individuals will delay their retirement to qualify for the bonus lump-sum payment and then retire shortly after the threshold. For this reason, we select a high cutoff level of labor supply $\overline{\overline{R}}$ based on the graphical evidence such that there is no graphical evidence for excess mass beyond this high cutoff. The amount of pooling or excess mass near the threshold is then captured by integrating the observed density net of the estimated counterfactual between the threshold and this high cutoff. The graphical evidence indicates that the excess mass beyond each tenure threshold is generally within 1 year after each threshold, so we select $\overline{\overline{R}} = \bar{R} + 1$.

To summarize, the estimators for each of the estimable terms are

$$
\begin{array}{lll}
h_0(\underline{R}): & \hat{h}_0(\underline{R}) = \hat{g}(\underline{R}) & \text{where } \underline{R} \text{ is selected graphically} \\
h_0(\bar{R}): & \hat{h}_0(\bar{R}) = \hat{g}(\bar{R}) & \text{where } \bar{R} \text{ is known by assumption} \\
P: & \hat{P} = \int_{\bar{R}}^{\overline{\overline{R}}} [h(R) - \hat{g}(R)] \partial R & \text{where } \overline{\overline{R}} \text{ is selected graphically.}
\end{array}
$$

4.5 Estimation Details

Given the observed and estimated terms, the estimator is implemented at each threshold using the following iterative algorithm. First, we start with an arbitrary positive elasticity, e_0. Second, we compute $\underline{\theta}$ using the given elasticity and the indifference condition. Third, we solve for $\tilde{w}$ using $\underline{\theta}$ and the given elasticity e_0. Fourth, we compute a new elasticity e_1 using the pooling equation and $\tilde{w}$. We then set $e_1 = e_0$ and iterate until there is convergence between e_1 and e_0.

4.6 Estimation Results

Before turning to the elasticity estimates, we focus first on the estimation results for the amount of excess mass at each tenure threshold. These results are presented in Table 8. The first column presents the estimated excess mass at each tenure thresholds where excess mass is capturing the corresponding shaded area illustrated in Figure 19. To put the magnitude of this area in better perspective, the second column of Table 8 presents this area as a fraction of the total amount of mass prior to each threshold between $\underline{R}$ and $\bar{R}$. Overall, the excess mass is a relatively low fraction of the total mass even though wage incentives are sizeable. Column 3 of Table 8 presents an alternative measure of excess mass based on the pre-threshold reduced mass illustrated in Figure 19. Theoretically, this measure of excess mass should be equal to that presented in the first column of Table 8 since the amount of individuals delaying their retirements should be equal to the amount of excess individuals pooling at or just beyond the thresholds. We formally (statistically) test for equality in these two excess mass measures in column 4 of Table 8 which presents the difference between these two measures and the corresponding standard errors of the difference. With the exception of the last threshold, it does not appear that there any statistically significant differences between the two measures. Thus, the estimation procedure appears consistent with the model presented above.

Table 9 presents the baseline intertemporal elasticity estimates at each tenure threshold using the full sample of retirements. The estimates in the first column are based on assuming that the discontinuity in the budget constraint dx is the same fraction of lifetime income at each threshold (0.5%). These estimates indicate very low intertemporal elasticities on the order of roughly 0.02. The small magnitude of these elasticities is driven by the relatively low excess mass measures and the high wage incentives. The estimates in the third column are based on an alternative calibration of dx in which the discontinuities are decreasing fractions of lifetime income at each threshold (0.5%, 0.367%, 0.233%, and 0.100% respectively). The smaller discontinuities imply lower wage incentives than those used to estimate the elasticities in the first column. As a result of the lower wage incentives, the elasticities in the second column are larger than the estimates in the first column.

The remaining columns present estimates when allowing for frictions. Column 3 of Table 9 presents estimates of $\bar{\Pi}$ which measures the fraction of counterfactual pre-threshold individuals that have sufficiently low frictions so that they can delay their retirements to just beyond the thresholds. These estimates highlight that relatively few individuals are predicted to have sufficiently low frictions.

Intuitively, the relatively few individuals with sufficiently low frictions will be predicted to be relatively responsive to account for the observed excess mass. Thus the estimated intertemporal elasticities with the frictions will be larger than those estimates in columns 1 and 2. Columns 4 and 5 present the estimated intertemporal elasticities when accounting for the frictions. Using discontinuities based on a constant fraction of lifetime income at each threshold, the estimates in column 4 are between roughly 0.02 and 0.18, about one order of magnitude larger than the elasticities without frictions. Assuming that the discontinuities dx are declining fractions of lifetime income, the estimates in column 5 are between 0.10 and 0.18. Thus, even when accounting for the frictions, the estimated intertemporal elasticities are small compared to estimates and calibrated values from previous studies because, at each threshold, the wage incentives from the severance payments are relatively large compared to the excess mass.

Table 10 presents separate elasticity estimates for men and women. The estimates elasticities in this table are all based on the model with frictions and the specification with dx declining across each threshold. Consistent with the graphical evidence, the estimated elasticities for men are lower than the corresponding estimates for women at each threshold. In particular, estimated elasticities for men range from 0.07 to 0.13 while the estimated elasticities for women range from 0.10 to 0.23.

Overall, the intertemporal elasticity estimates are relatively low in magnitude when compared to estimates and calibrated values from previous studies (for examples, see Mulligan (1999) and King and Rebelo (1999)). These low elasticity estimates result from the combination of relatively small excess mass and relatively large wage incentives at each tenure threshold.

5 Conclusion

This paper presents evidence on individuals' willingness to delay exiting the labor force in response to anticipated changes in wage rates. 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 indicates that most individuals do not delay their retirements by more than 1 year in response to 33% or larger increases in their annual wage rates. An analysis of heterogeneity indicates that poor health and business cycle fluctuations leading to involuntary job separations reduce intertemporal substitution. Additionally, women demonstrate more willingness to delay their retirements in response to the anticipated financial gains at the tenure thresholds. Estimated elasticities confirm the results of the graphical analysis. These results based on the extensive margin of labor supply suggest that intertemporal substitution in labor force participation may not be as high as suggested by some previous macroeconomic studies.

References

Altonji, J. G. (1986). Intertemporal substitution in labor supply: Evidence from micro data. *Journal of Political Economy 94*(3), S176–S215.

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.

Blundell, R., C. Meghir, and P. Neves (1993). Labour supply and intertemporal substitution. *Journal of Econometrics 59*(1-2), 137–160.

Brown, K. (2009). The Link between Pensions and Retirement Timing: Lessons from California Teachers. Working paper, University of Illinois at Urbana-Champaign.

Browning, M. (2005). A working paper from april 1985: Which demand elasticities do we know and which do we need to know for policy analysis? *Research in Economics 59*(4), 293–320.

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. (2009). Bounds on elasticities with optimization frictions: A synthesis of micro and macro evidence on labor supply. Working Paper 15616, National Bureau of Economic Research.

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.

DiNardo, J., N. Fortin, and T. Lemieux (1996). Labor market institutions and the distribution of wages, 1973-1992: A semiparametric approach. *Econometrica 64*(5), 1001–1044.

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

King, R. G. and S. T. Rebelo (1999). Resuscitating real business cycles. In J. B. Taylor and M. Woodford (Eds.), *Handbook of Macroeconomics*, Volume 1, Chapter 14, pp. 927–1007. Elsevier.

Krueger, A. and J. Pischke (1992). The Effect of Social Security on Labor Supply: A Cohort Analysis of the Notch Generation. *Journal of Labor Economics 10*(4), 412–437.

Looney, A. and M. Singhal (2006). The effect of anticipated tax changes on intertemporal labor supply and the realization of taxable income. Working Paper 12417, National Bureau of Economic Research.

MaCurdy, T. E. (1981). An empirical model of labor supply in a life-cycle setting. *Journal of Political Economy 89*(6), 1059–85.

Manoli, D., K. Mullen, and M. Wagner (2010). Pension Benefits and Retirement Decisions: Income vs. Price Elasticities. Working paper, University of California - Los Angeles.

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.

Rogerson, R. and J. Wallenius (2009). Micro and macro elasticities in a life cycle model with taxes. *Journal of Economic Theory 144*(6), 2277–2292.

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).

Ziliak, J. P. and T. J. Kniesner (1999). Estimating life cycle labor supply tax effects. *Journal of Political Economy 107*(2), 326–359.

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
Summary Statistics

	Men		Women	
	Full Sample	Tenure at Retirement ≥ 10	Full Sample	Tenure at Retirement ≥ 10
# of Individuals	239,027	90,668	205,534	91,481
Age	59.61	60.00	58.06	58.14
	60.00	60.00	57.75	57.75
	2.21	2.21	2.64	2.81
Tenure	8.79	16.92	9.70	15.99
	7.08	15.67	8.67	15.17
	7.56	5.41	6.77	4.58
Severance Pay	5535.67	14593.61	2928.24	6578.99
	0.00	11809.12	0.00	4806.29
	9314.31	9824.80	5822.16	7220.87
Annual Earnings	23208.73	26808.22	11601.37	13007.33
	22656.78	26587.60	9971.90	11523.06
	11383.31	10797.06	10376.58	11285.80
Lifetime Earnings	794832.00	851188.40	455786.40	490604.80
	782837.30	835394.40	416443.50	449005.50
	281017.60	254134.50	231449.40	223546.80
Lifetime Employment Time	34.24	37.81	24.81	28.93
	37.77	40.36	26.50	29.89
	10.69	8.00	10.60	7.89
Lifetime Sick Leave	0.62	0.50	0.40	0.35
	0.28	0.17	0.08	0.06
	0.93	0.83	0.80	0.73
Fractions:				
Claiming Disability Pensions	0.442	0.352	0.154	0.110
Claiming Early Retirement Pensions	0.273	0.371	0.221	0.296
Claiming Old Age Pensions	0.285	0.276	0.626	0.594
Agriculture & Mining	0.065	0.066	0.029	0.021
Manufacturing	0.274	0.293	0.189	0.165
Construction	0.195	0.089	0.030	0.029
Sales	0.161	0.161	0.185	0.156
Tourism	0.021	0.012	0.064	0.031
Transportation	0.054	0.054	0.024	0.027
Services	0.231	0.325	0.479	0.571

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 2
Reasons for Retirement

	% Yes	
	Men	Women
1. Became eligible for public pension	65.84	65.41
2. Became eligible for private occupational pension	2.12	0.87
3. Became eligible for a private pension	1.06	0.15
4. Was offered an early retirement option/window (with special incentives or bonus)	5.31	2.62
5. Made redundant (for example pre-retirement)	5.84	4.80
6. Own ill health	23.54	16.72
7. Ill health of relative or friend	0.18	2.47
8. To retire at same time as spouse or partner	0.35	1.89
9. To spend more time with family	0.88	7.27
10. To enjoy life	2.30	1.74
# of Respondents	565	688

Notes: Data from Waves 1 & 2 of SHARE Austria. The percentages do not sum to 100 since respondents could select all reasons that apply.

Table 3
Employment Responses

	A. My job security is poor.	
	Men	Women
1. % Strongly Agree	5.56	3.85
2. % Agree	17.68	12.09
3. % Disagree	47.47	40.66
4. % Strongly Disagree	29.29	43.41
# of Respondents	198	183

	B. All things considered, I am satisfied with my job.	
	Men	Women
1. % Strongly Agree	45.45	48.63
2. % Agree	48.48	44.81
3. % Disagree	5.56	6.56
4. % Strongly Disagree	0.51	0
# of Respondents	198	183

	C. Expecting to receive lump sum payment with pension entitlement?	
	Men	Women
% Yes	46.91	41.67
# of Respondents	194	168

Notes: Data from Waves 1 & 2 of SHARE Austria. The number of respondents is reported in brackets.

Table 4
Retirement Ages by Pension Type & Gender

Age	Men: Disability Pension	Men: Early Retirement Pension	Men: Old Age Pension	Women: Disability Pension	Women: Early Retirement Pension	Women: Old Age Pension
55	12,510			7,570	24,349	33,480
56	18,161			6,693	6,963	9,613
57	25,250			5,668	5,466	6,553
58	22,417			4,733	4,776	4,674
59	16,245			3,406	3,418	3,324
60	6,976	43,898	48,856	1,957	360	52,206
61	2,095	12,046	5,359	662	23	7,193
62	977	6,111	2,849	351	15	3,872
63	540	2,143	1,601	214	9	2,450
64	314	1,064	949	142	4	1,730
65	97	97	6,462	93	7	1,673
Total	105,631	65,369	68,027	31,568	45,399	128,567

Table 5
Disability Causes by Gender

Disability Causes	Fraction Men	Fraction Women
Cancer	0.021	0.031
Endocrinopathies	0.020	0.019
Psychiatric Disorders	0.048	0.055
Diseases of the Nervous System	0.009	0.007
Cardiovascular Disorders	0.148	0.088
Diseases of the Respiratory System	0.046	0.021
Diseases of the Digestive System	0.014	0.006
Back Injuries & Movement Disorders	0.602	0.692
Accidents at work or on the way to work	0.017	0.007
Accidents not related to work	0.008	0.007
Other	0.067	0.067
Total	11,754	2,117

Notes: Statistics based on disability pensions claimed in 1995.

Table 6
Health at Retirement by Gender & Industry

Industry	Men: N	Men: Any Sick Leave	Men: Mean Sick Leave	Men: Median Lifetime Sick Leave	Men: Claiming Disability	Women: N	Women: Any Sick Leave	Women: Mean Sick Leave	Women: Median Lifetime Sick Leave	Women: Claiming Disability
Agriculture & Mining	28,486	0.356	0.124	0.258	0.405	8,156	0.206	0.069	0.079	0.212
Manufacturing	119,548	0.463	0.174	0.351	0.467	62,205	0.274	0.101	0.167	0.159
Construction	55,651	0.550	0.207	0.504	0.568	8,124	0.162	0.061	0.000	0.114
Sales	53,562	0.330	0.136	0.121	0.368	52,191	0.177	0.071	0.000	0.117
Tourism	5,778	0.435	0.186	0.266	0.476	14,853	0.329	0.112	0.167	0.264
Transportation	19,540	0.472	0.202	0.364	0.444	7,586	0.379	0.224	0.237	0.169
Services	92,180	0.222	0.087	0.082	0.286	142,688	0.190	0.068	0.033	0.124

Notes: These statistics include observations with left-censored tenure at retierment. Sick Leave measures the number of days on sick leave between ages 54 and retirement. Lifetime sick leave measures the number of sick days through retirement. Claiming Disability measures the fraction of individuals claiming disability pensions.

Table 7
Uses of Unexpected Gift of 12,000 Euros

	Men (N=647)			Women (N=935)		
	% Using Any	Average Amount	Average Amount Conditional on Using Any	% Using Any	Average Amount	Average Amount Conditional on Using Any
1. Save or invest	0.69	5910.82	8593.933	0.66	5329.31	8115.472
	(0.46)	(4871.54)	(3379.12)	(0.48)	(4829.60)	(3590.46)
2. Pay off debts	0.10	740.34	7257.58	0.07	475.40	6634.33
	(0.30)	(2495.16)	(3721.29)	(0.26)	(1993.01)	(3838.19)
3. Give to relatives or donation	0.45	2940.34	6470.75	0.57	4074.97	7161.84
	(0.49)	(4167.61)	(3920.77)	(0.50)	(4626.04)	(3936.06)
4. Buy durables	0.23	1137.56	4939.60	0.19	853.64	4483.99
	(0.42)	(2664.34)	(3475.26)	(0.40)	(2264.29)	(3268.65)
5. Holiday or journey	0.30	1270.94	4174.11	0.29	1266.68	4370.30
	(0.46)	(2681.27)	(3393.39)	(0.45)	(2637.03)	(3231.34)

Notes: Data from Waves 1 & 2 of SHARE Austria. Standard deviations are shown in parentheses.

Table 8
Excess Mass Estimates

Threshold	Excess Mass (P)	Excess Mass as Fraction of Counterfactual Pre-Threshold Mass	Reduced Mass	Excess Mass Minus Reduced Mass
10	282.4181	0.0837	257.7642	24.6540
	(14.1547)	(0.0045)	(27.8781)	(35.5396)
15	243.5809	0.1064	252.2882	-8.7073
	(11.2730)	(0.0054)	(21.3307)	(26.7132)
20	180.9516	0.1238	222.8940	-41.9424
	(10.1030)	(0.0077)	(16.4108)	(23.6186)
25	61.9577	0.0792	120.0253	-58.0676
	(8.6186)	(0.0122)	(15.7863)	(22.0346)

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

Table 9
Intertemporal Elasticity Estimates, Full Sample

	Elasticity Estimates, No Frictions		Elasticity Estimates, With Frictions		
Threshold	Constant *dx*	Declining *dx*	Friction, $\overline{\Pi}$	Constant *dx*	Declining *dx*
10	0.0316	0.0316	0.3630	0.1779	0.1779
	(0.0032)	(0.0032)	(0.0188)	(0.0238)	(0.0238)
15	0.0231	0.0300	0.4645	0.1062	0.1430
	(0.0021)	(0.0028)	(0.0205)	(0.0119)	(0.0161)
20	0.0181	0.0345	0.5473	0.0690	0.1429
	(0.0020)	(0.0041)	(0.0220)	(0.0096)	(0.0203)
25	0.0056	0.0206	0.5648	0.0217	0.0987
	(0.0030)	(0.0060)	(0.0354)	(0.0073)	(0.0350)

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

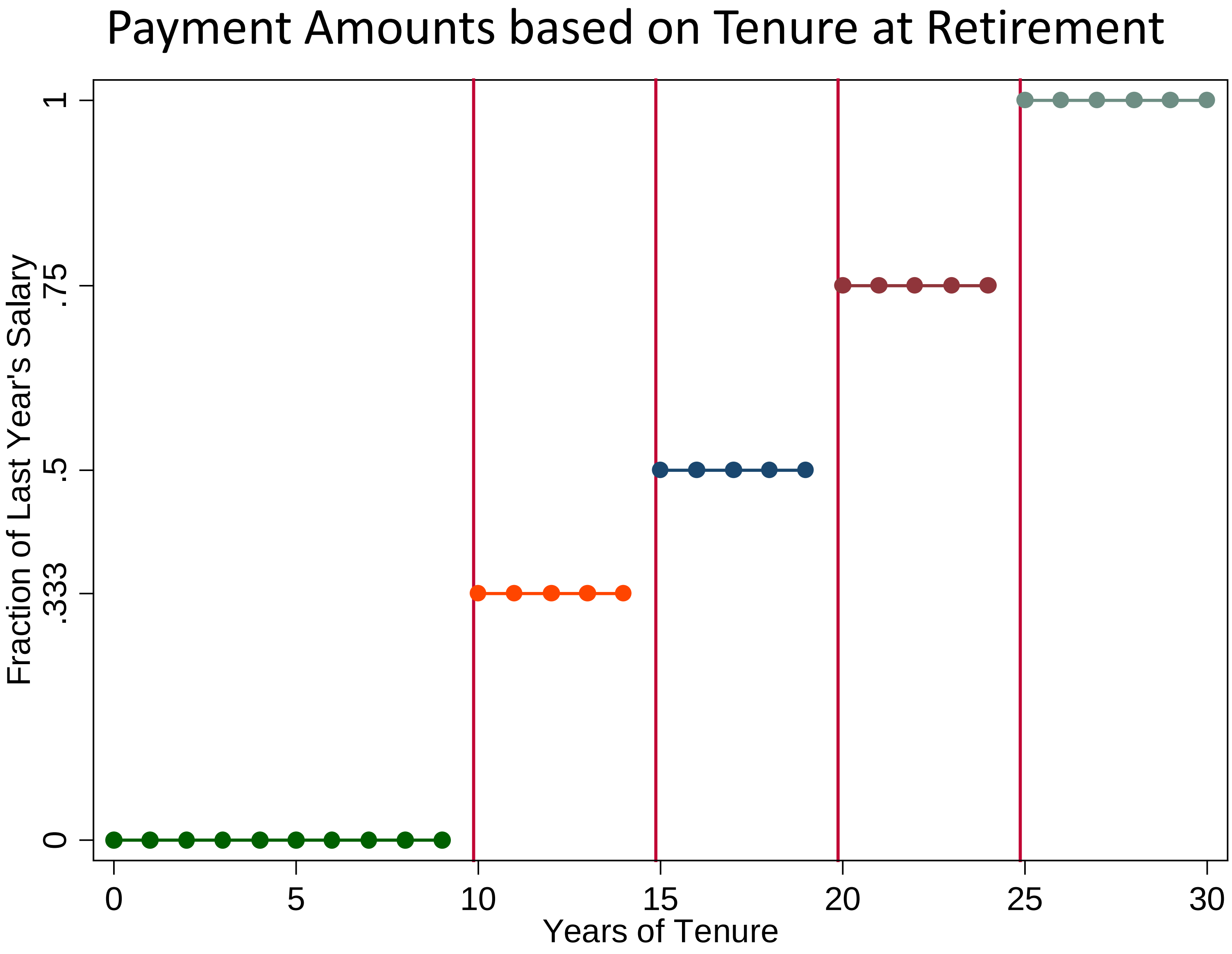
Table 10

Intertemporal Elasticity Estimates by Gender

	Men		Women	
Threshold	Excess Mass as Fraction of Counterfactual Mass	Elasticity Estimates,With Frictions	Excess Mass as Fraction of Counterfactual Mass	Elasticity Estimates,With Frictions
10	0.0621	0.1291	0.1037	0.2226
	(0.0062)	(0.0295)	(0.0066)	(0.0317)
15	0.0668	0.0655	0.1434	0.2307
	(0.0063)	(0.0133)	(0.0081)	(0.0325)
20	0.0845	0.0794	0.1603	0.2086
	(0.0097)	(0.0200)	(0.0104)	(0.0310)
25	0.0809	0.0973	0.0776	0.1025
	(0.0181)	(0.0536)	(0.0183)	(0.0537)

Notes: Bootstrapped standard errors based on 100 replications are shown in parentheses.
Elasticity estimates based on declining dx.

Figure 1



Payment Amounts based on Tenure at Retirement
Fraction of Last Year's Salary
0
.333
.5
.75
1
0
5
10
15
20
25
30
Years of Tenure

Figure 2. Survivor Functions for Men and Women

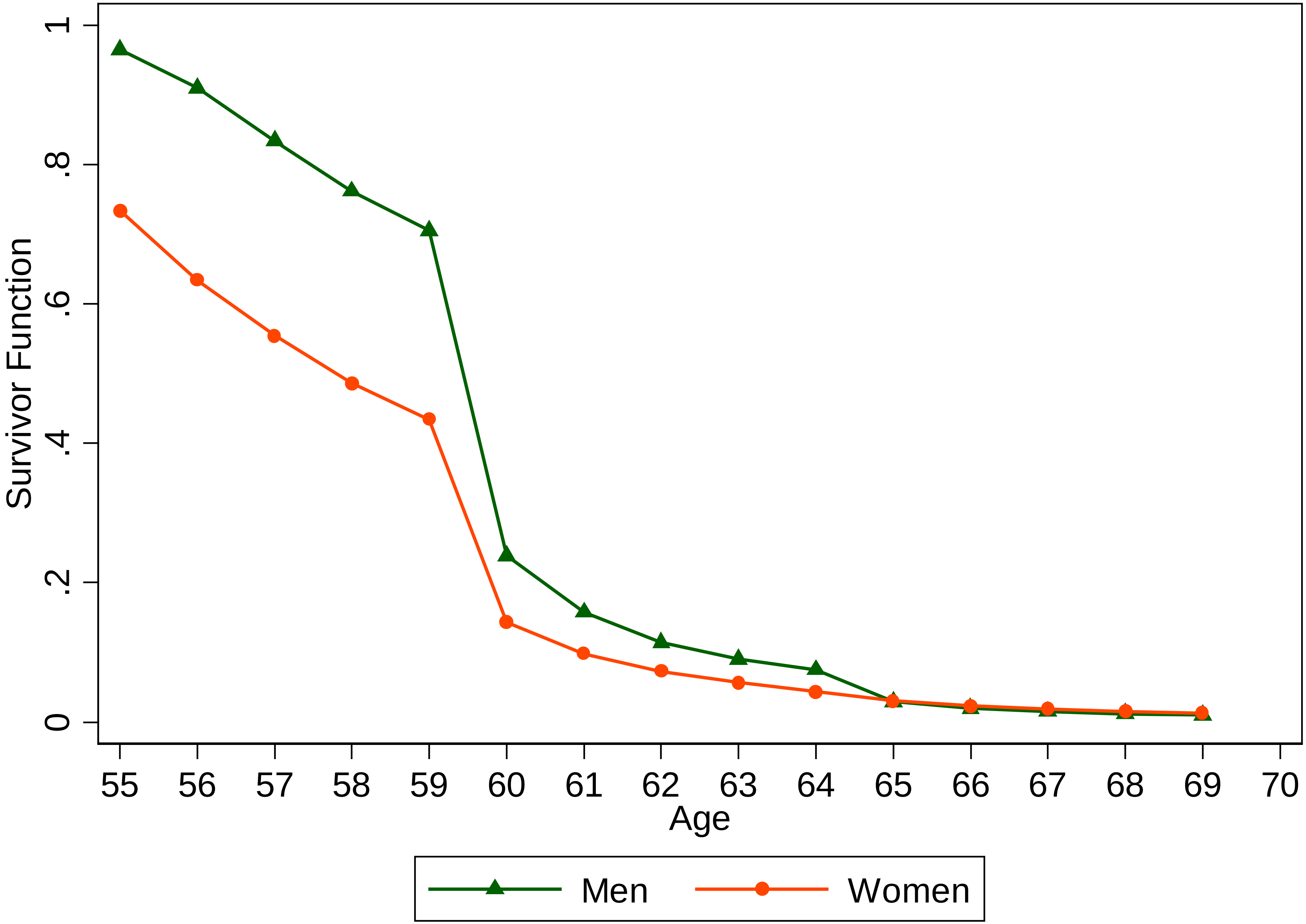


Figure 3: Distribution of Tenure at Retirement, Monthly Frequency

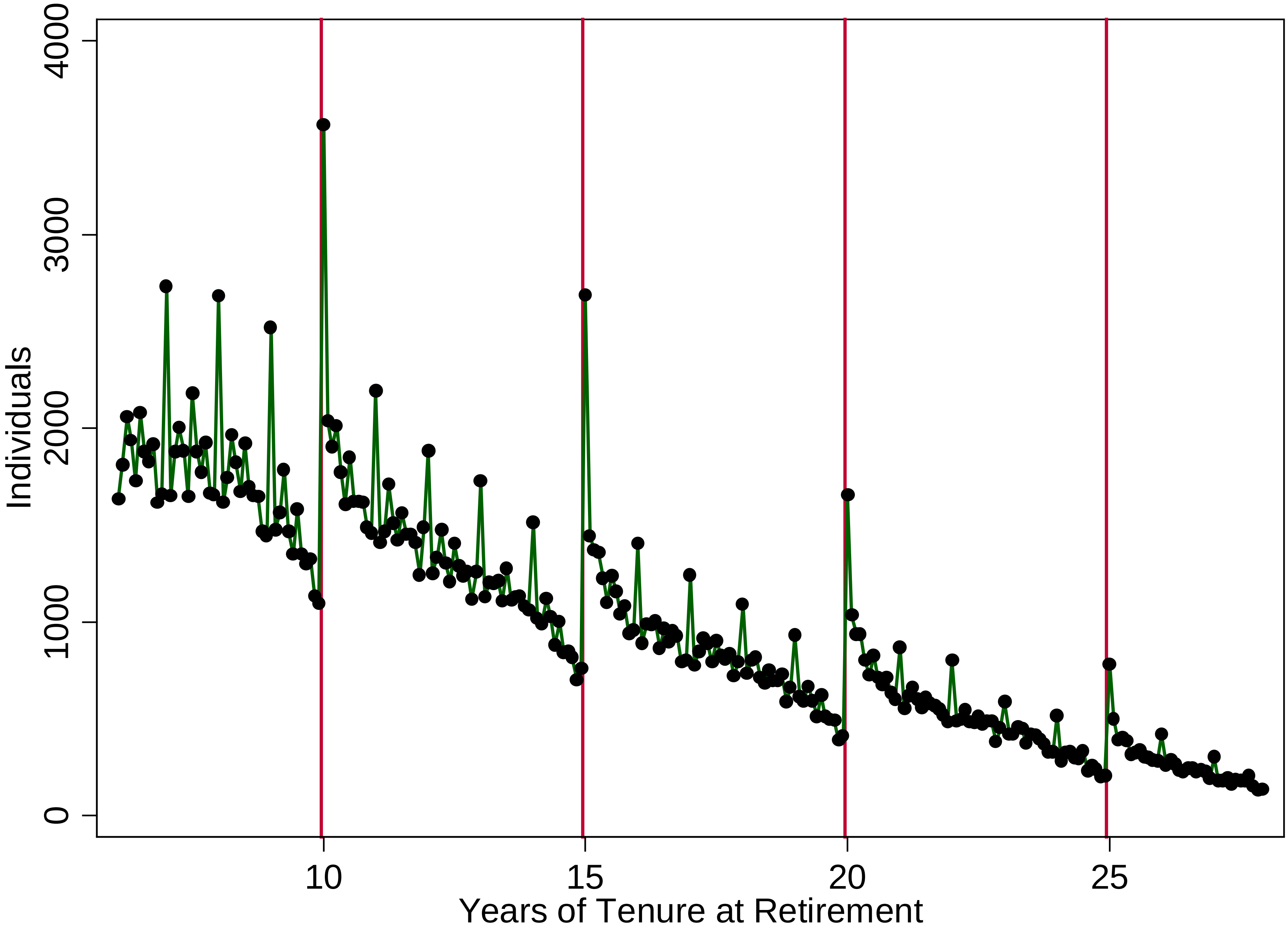


Figure 4A. Estimated Coefficients on Tenure Dummies, Men

Figure 4B. Estimated Coefficients on Tenure Dummies, Women

Figure 5: Distribution of Tenure at Retirement by Gender

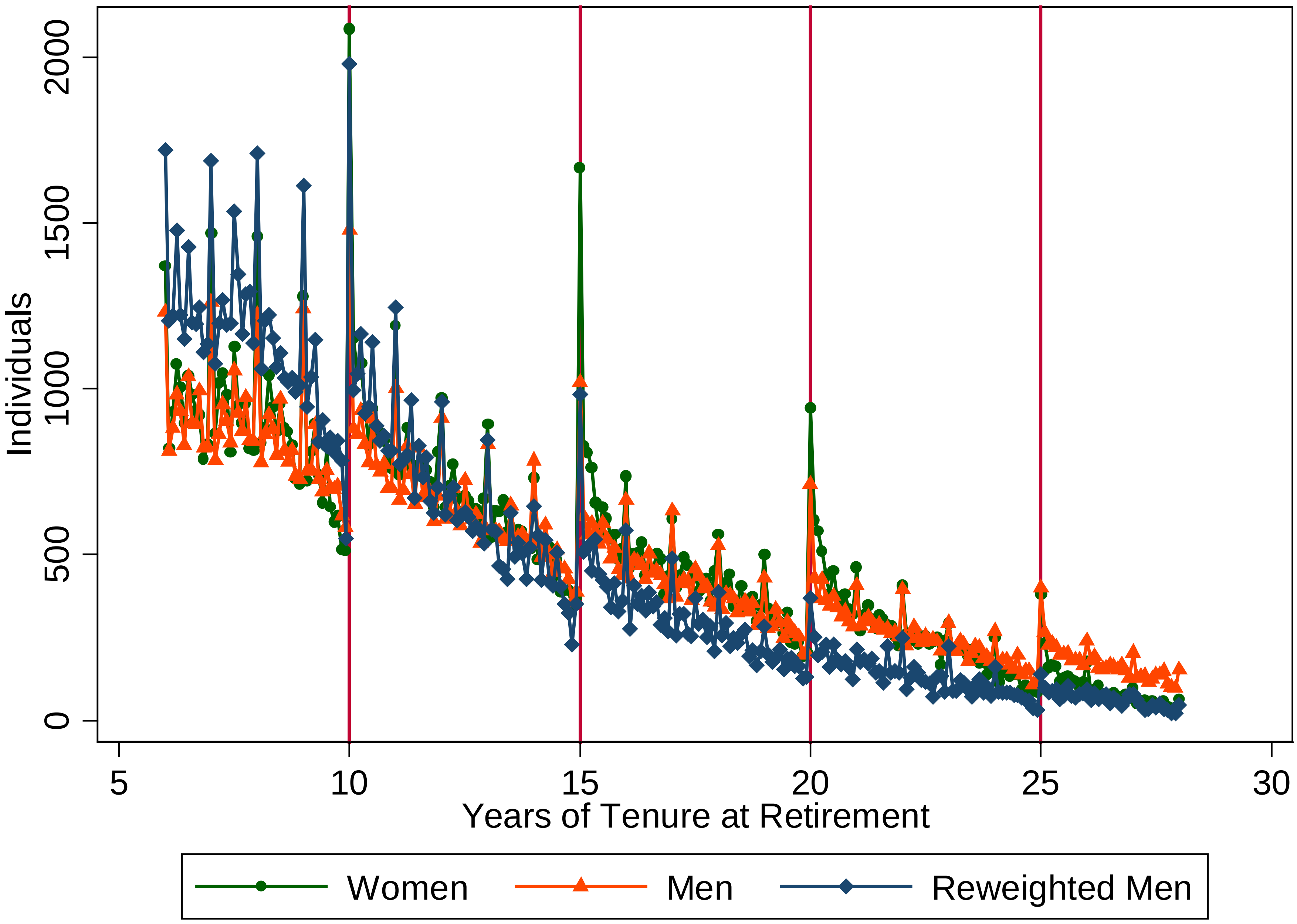


Figure 6: Number of New Job Starts by Age

Figure 7. Distribution of Tenure at Retirement by Gender & Retirement Pension Type

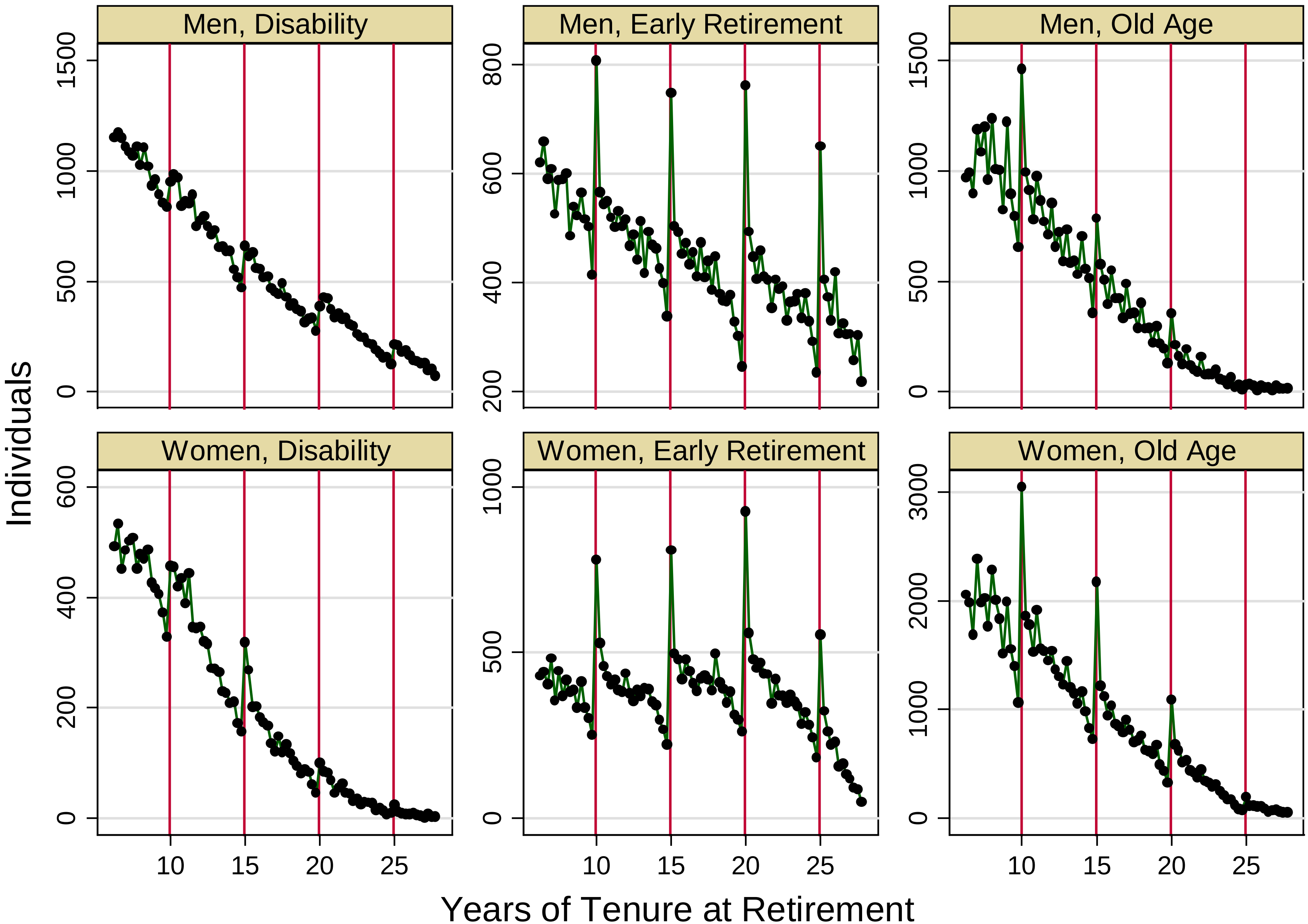


Figure 8. Distribution of Tenure at Retirement by Gender & Pension Benefits

Figure 9. Distribution of Tenure at Retirement for Women by Experience at Age 55 & Child Status

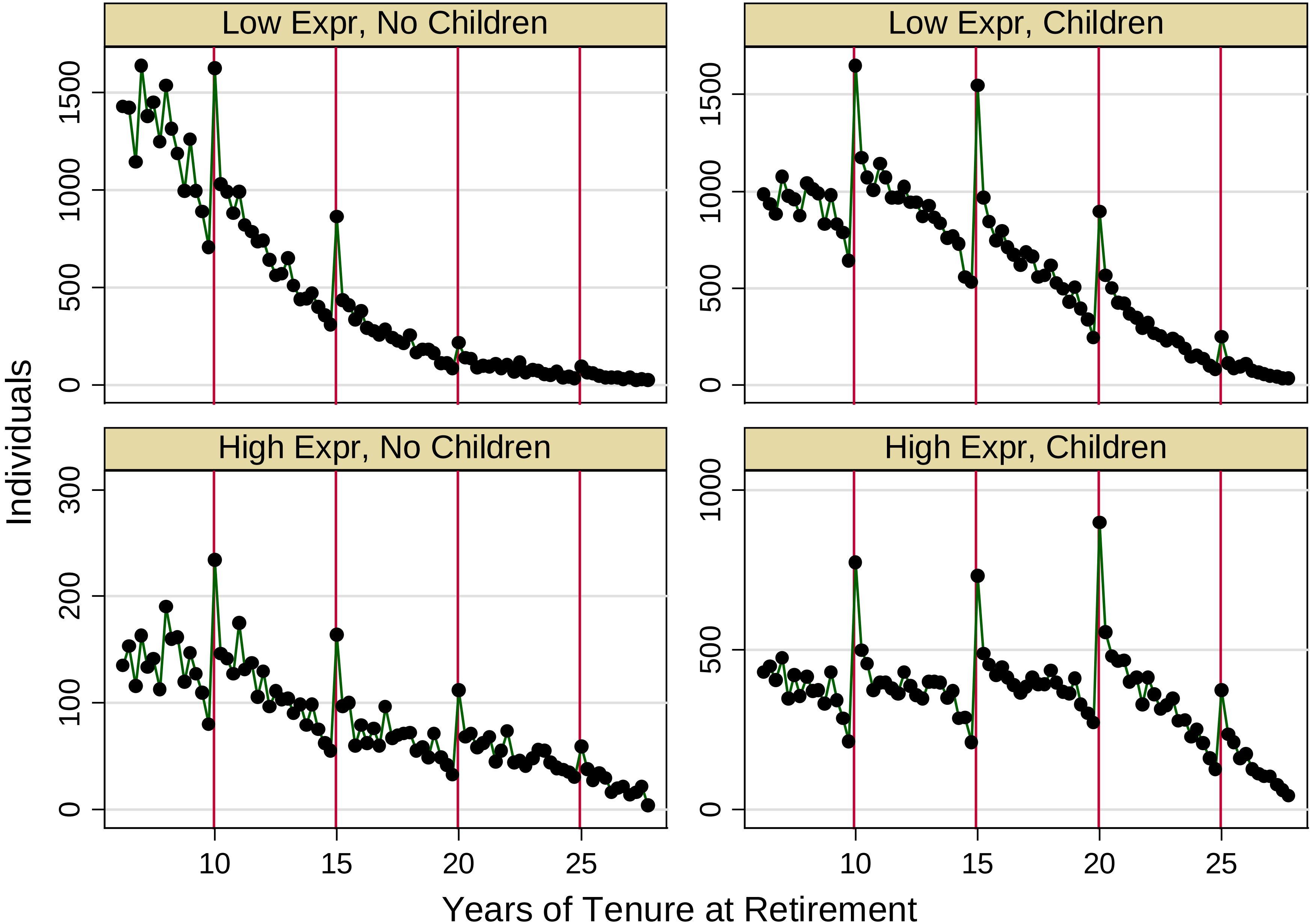


Figure 10. Distribution of Tenure at Retirement by Gender & Health Status

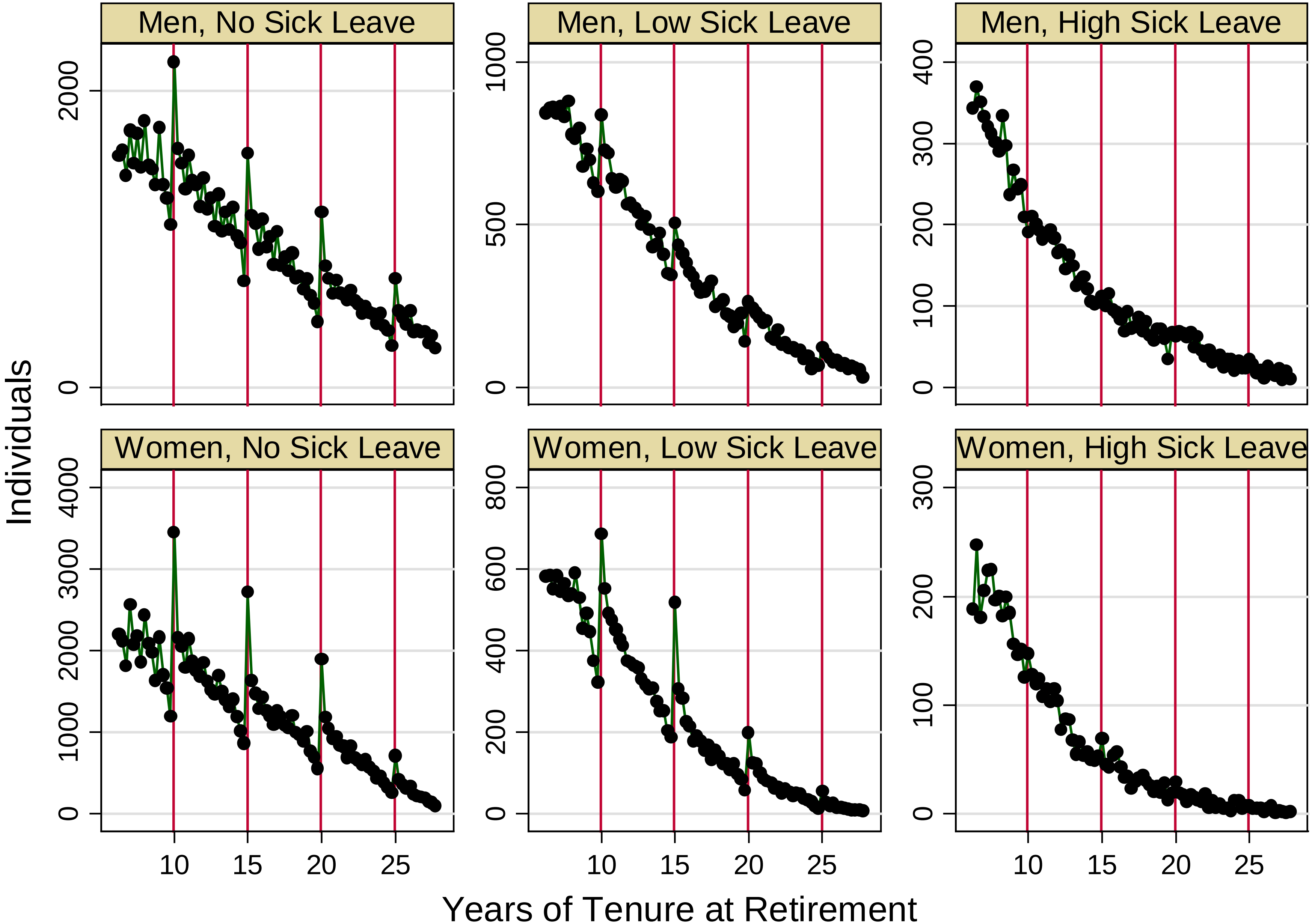


Figure 11A. Distribution of Tenure at Retirement by Industry, Men

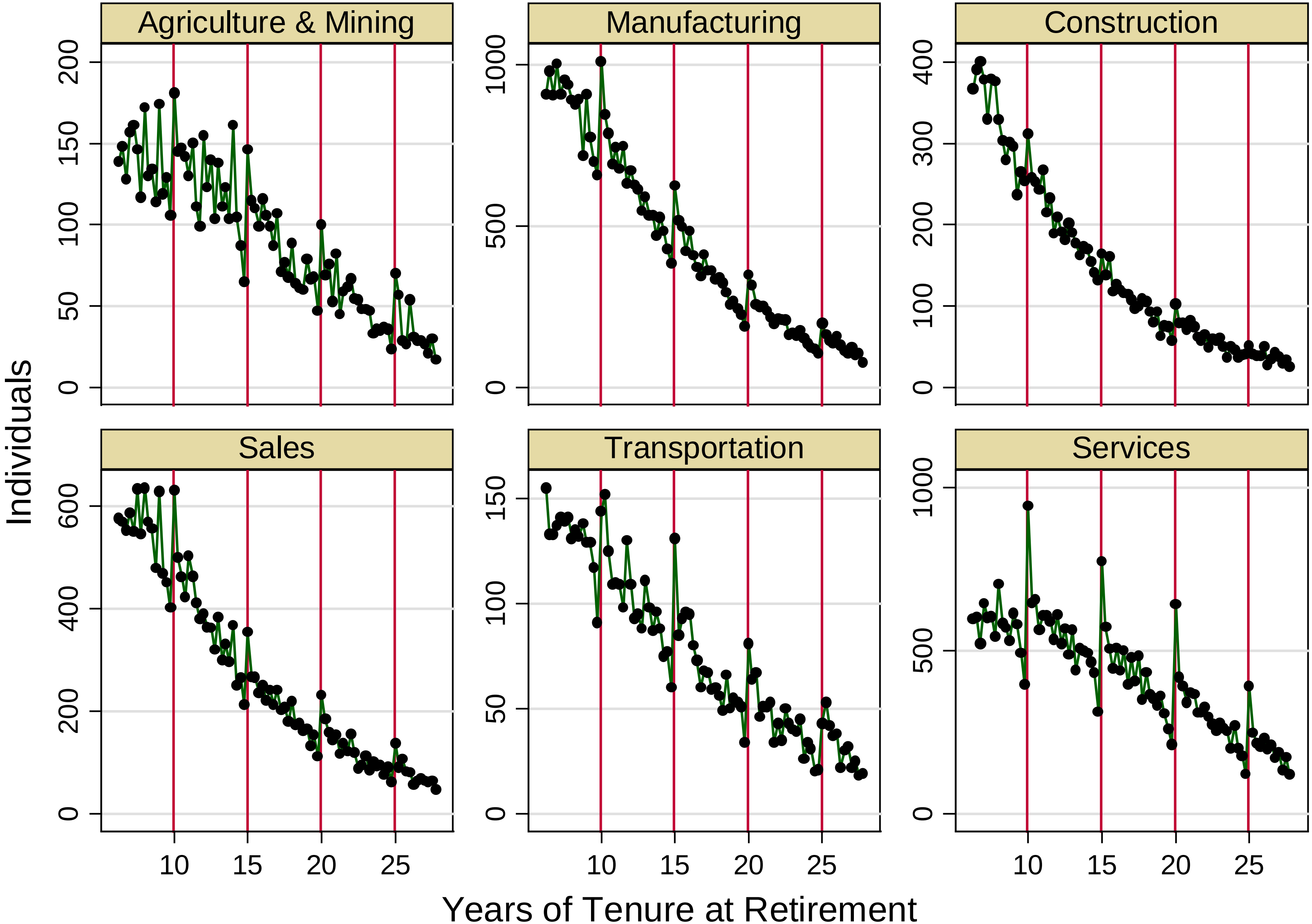


Figure 11B. Distribution of Tenure at Retirement by Industry, Women

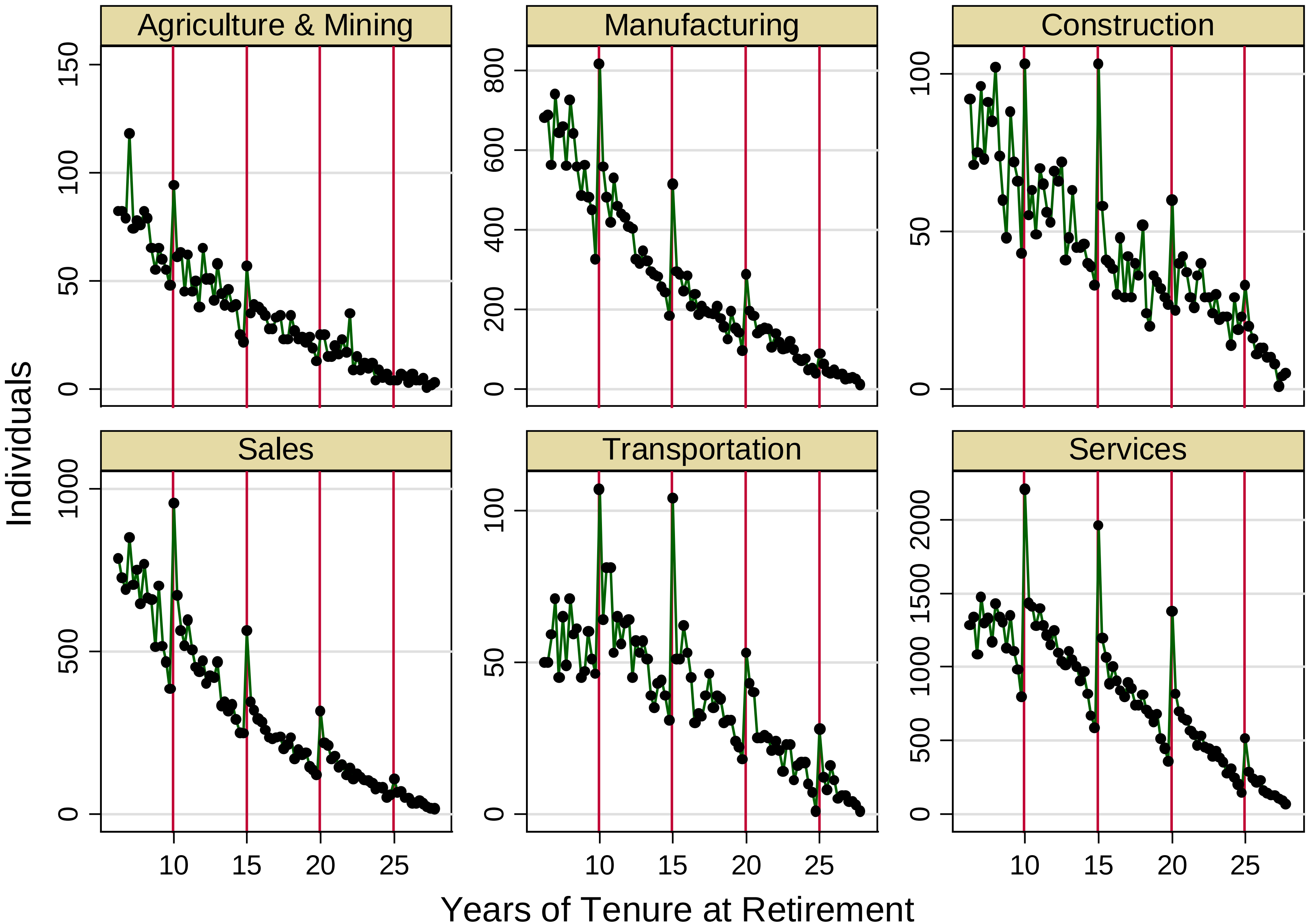


Figure 12. Distribution of Tenure at Retirement by Gender & GDP Growth

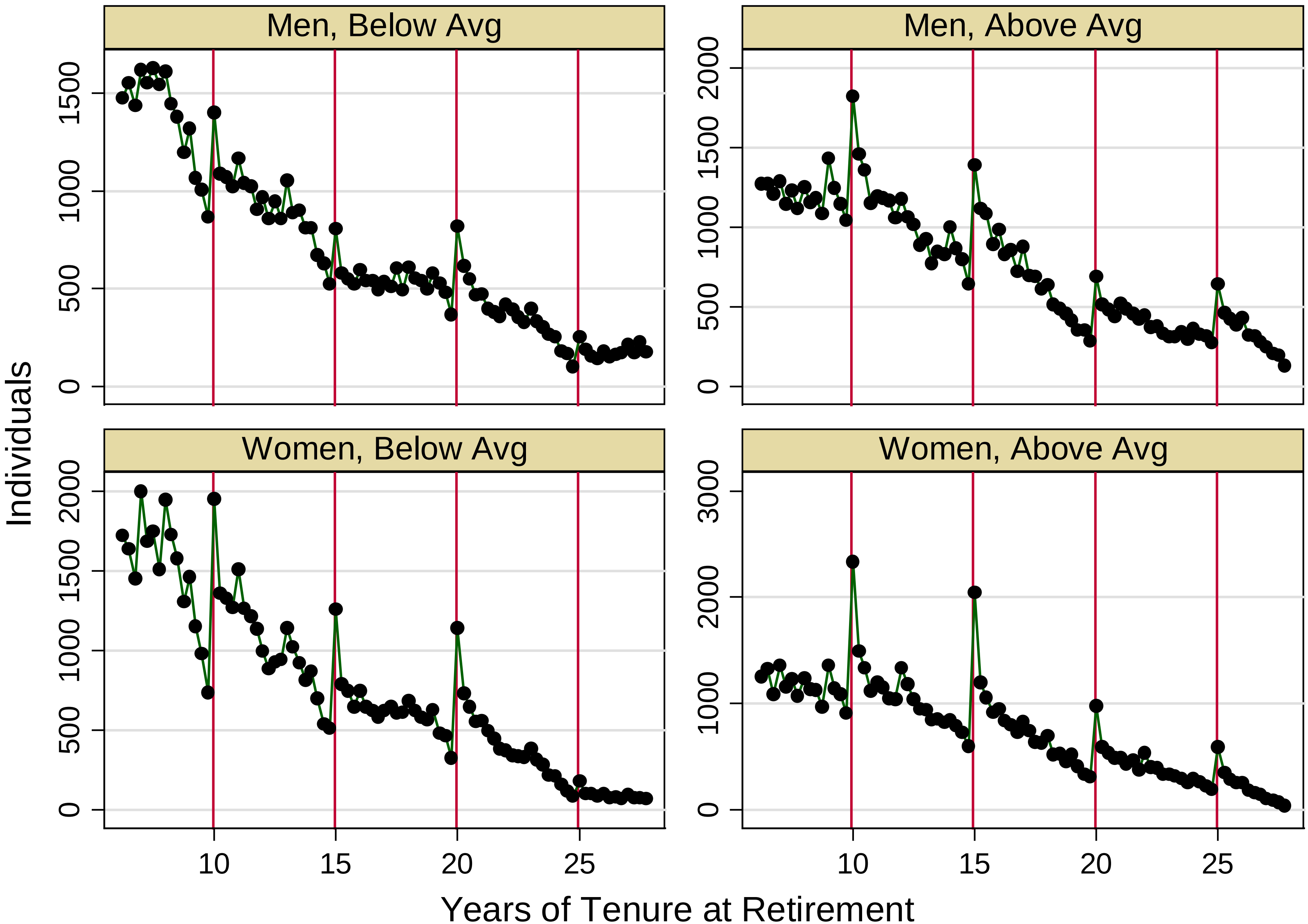


Figure 13. Probabilities of Pre-Threshold Retirement over the Business Cycle

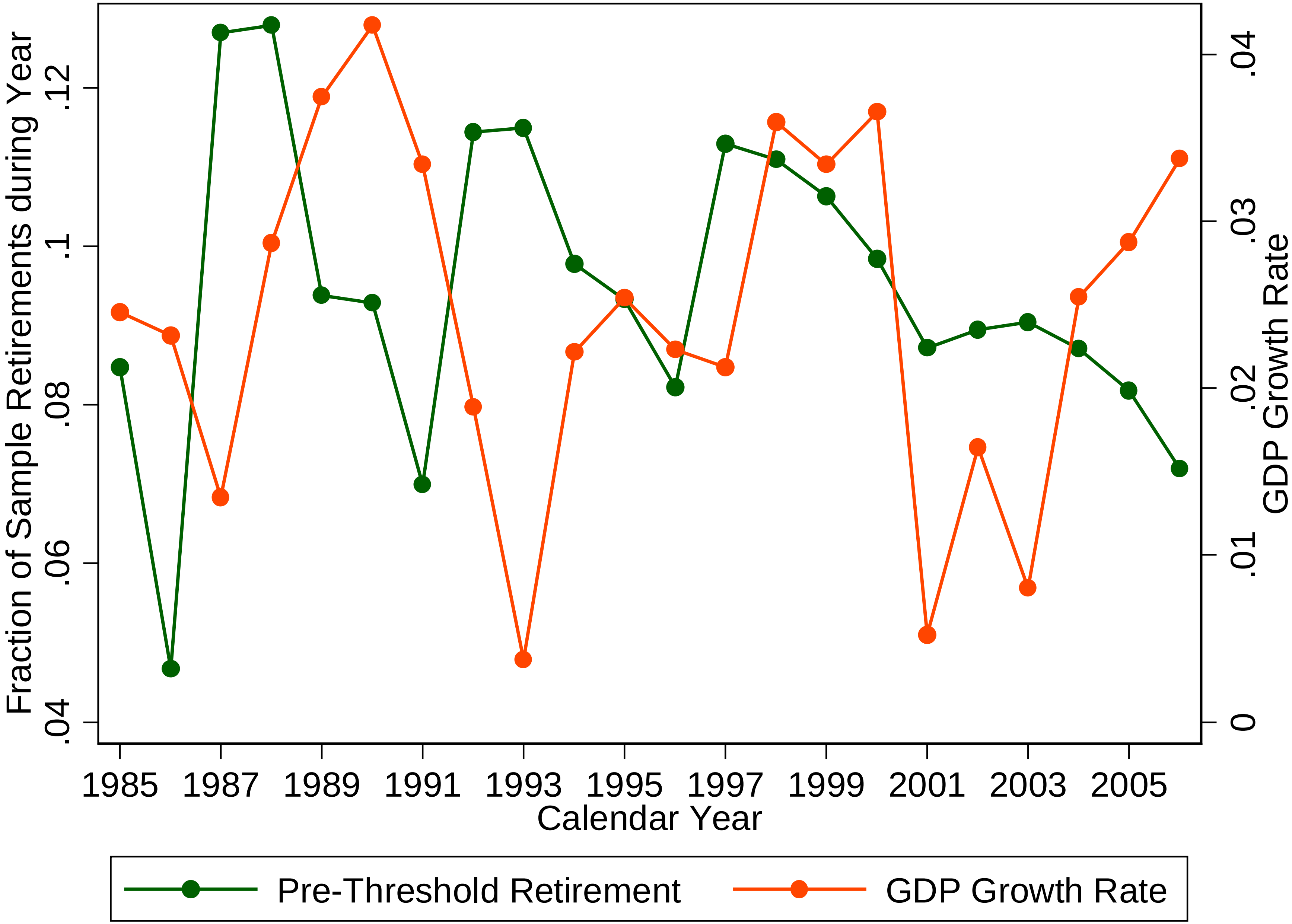


Figure 14. Optimal Retirement Choices with Discontinuity

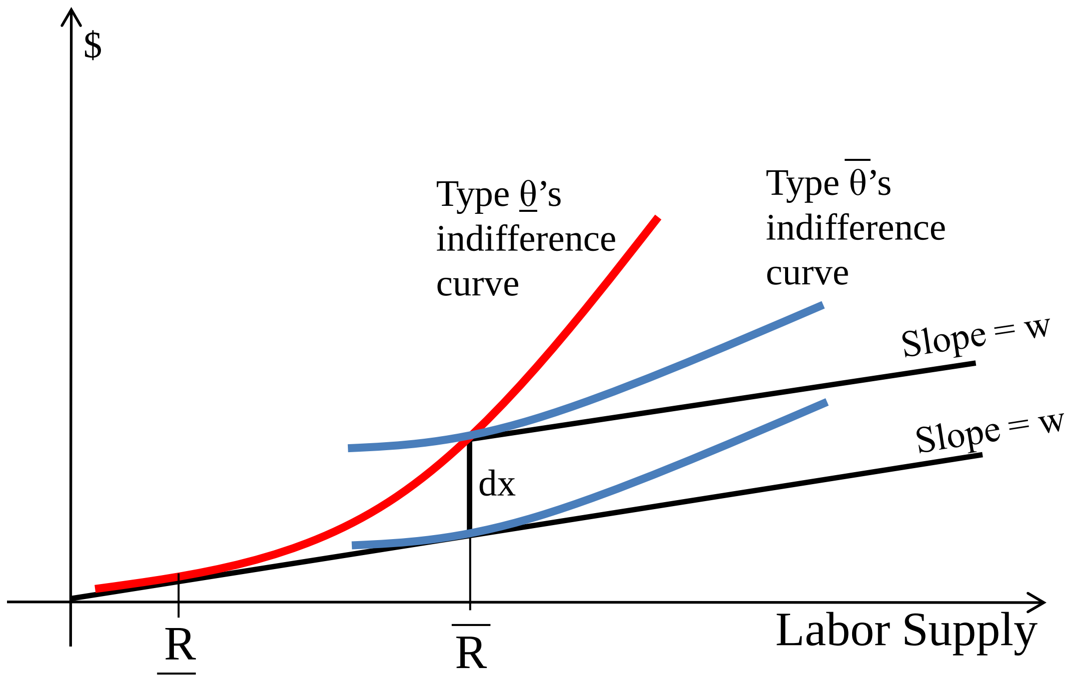


Figure 15. Changes in Optimal Retirement

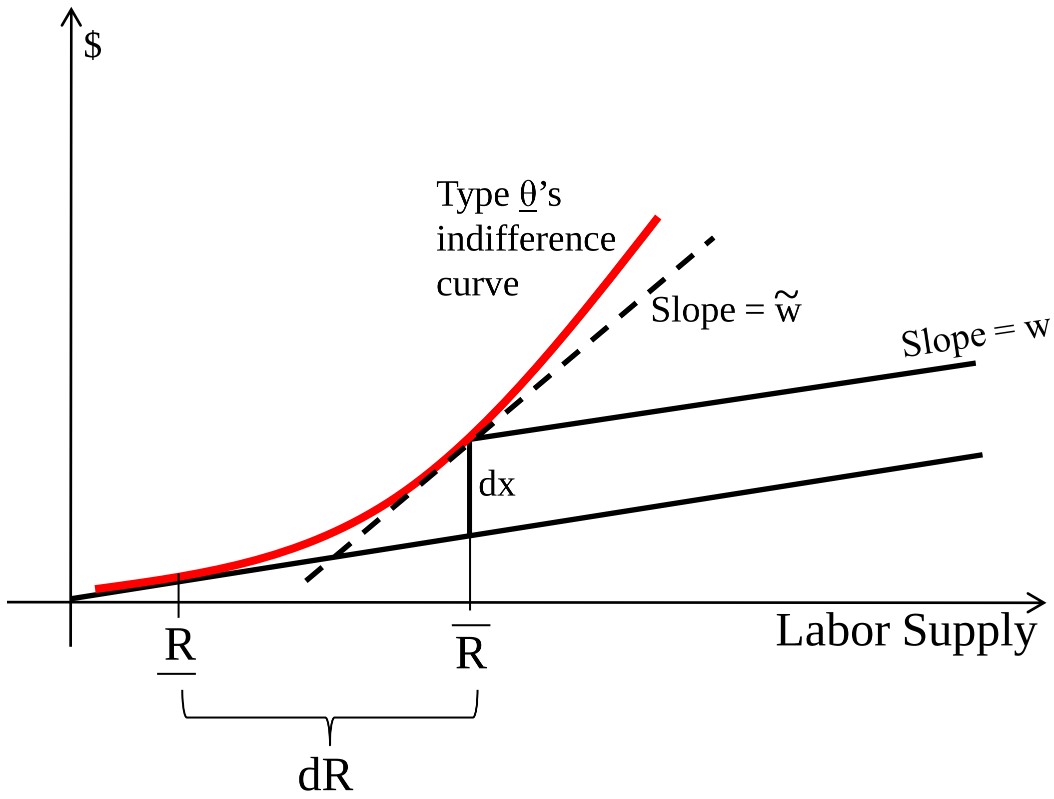


Figure 16. Predicted Retirement Outcomes
With Frictions vs. Without Frictions

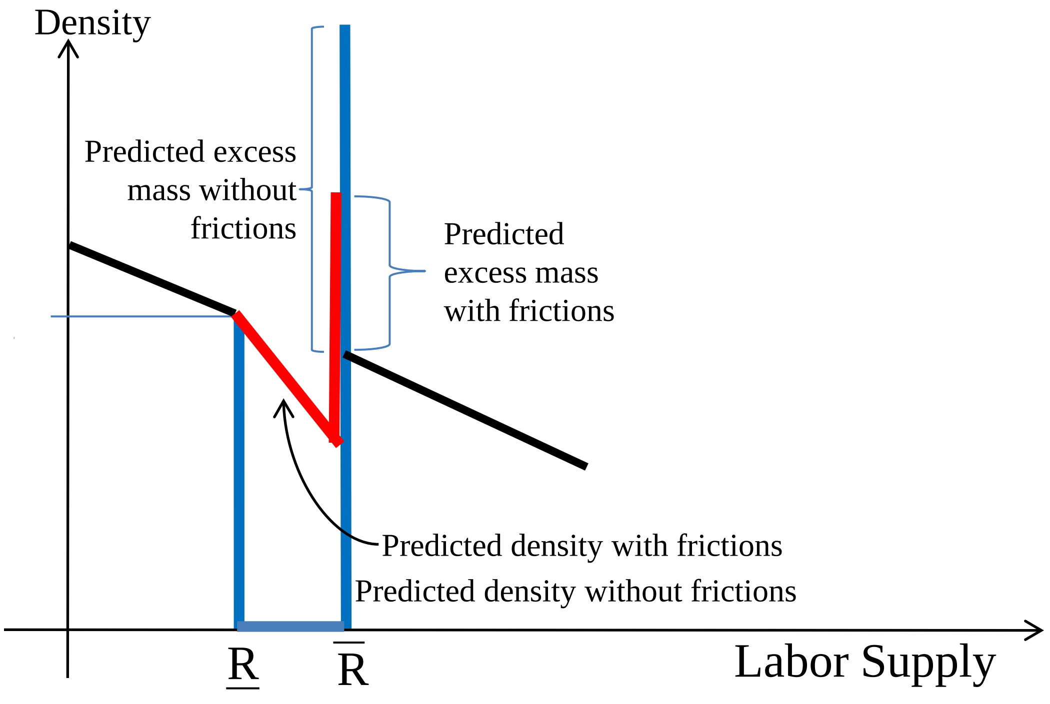


Figure 17

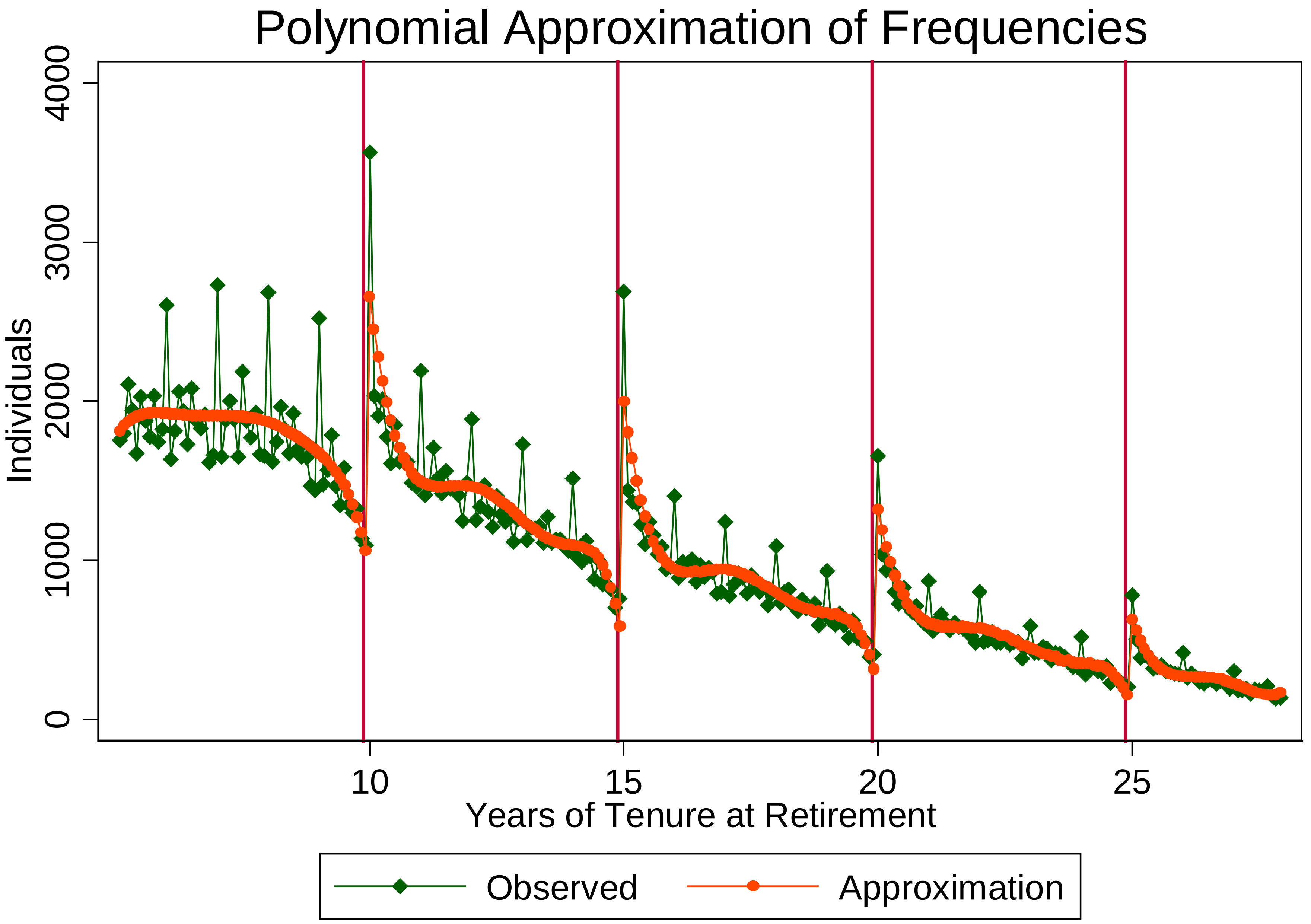

Polynomial Approximation of Frequencies
Individuals
0
1000
2000
3000
4000
10
15
20
25
Years of Tenure at Retirement
Observed
Approximation

Figure 18

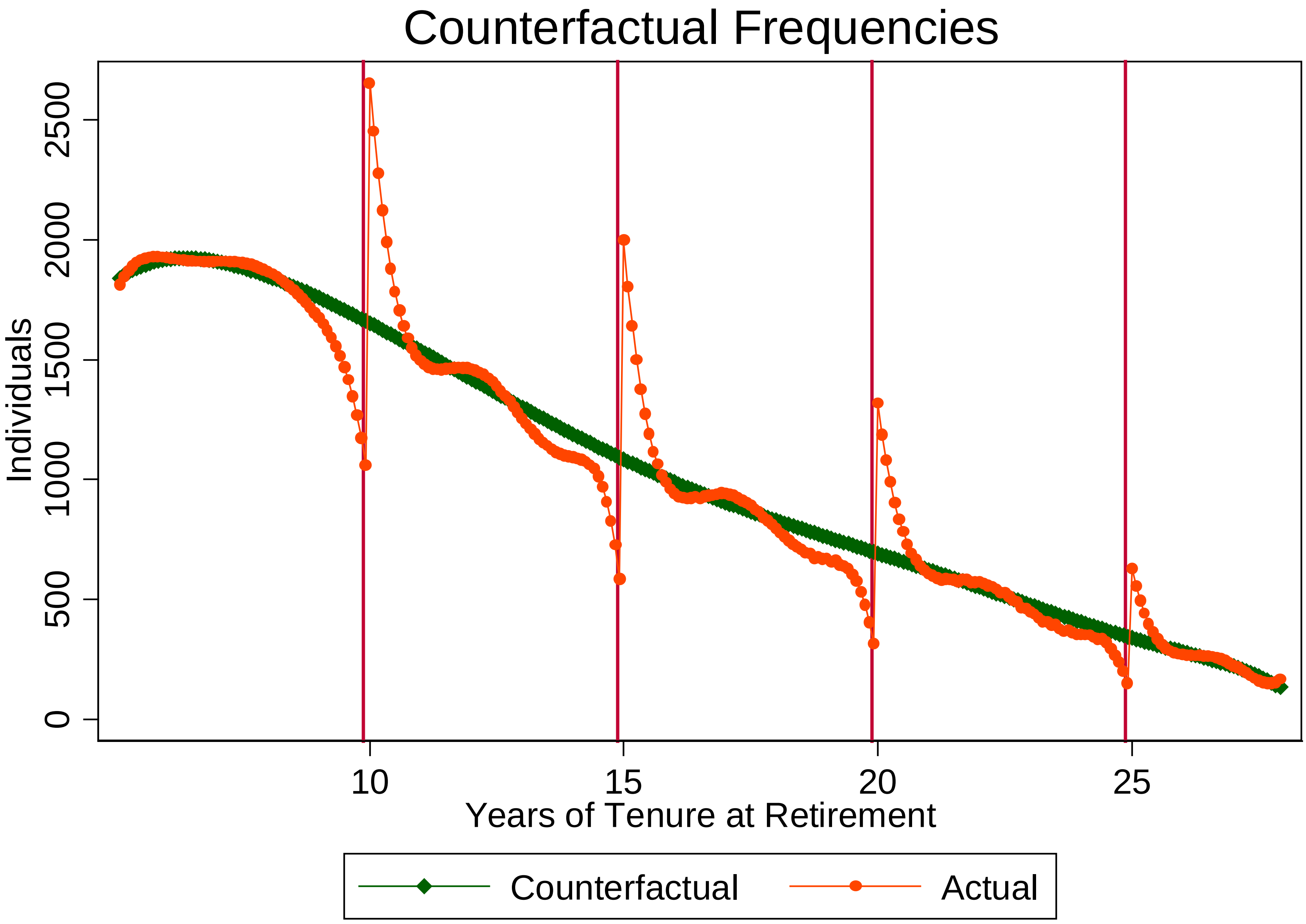
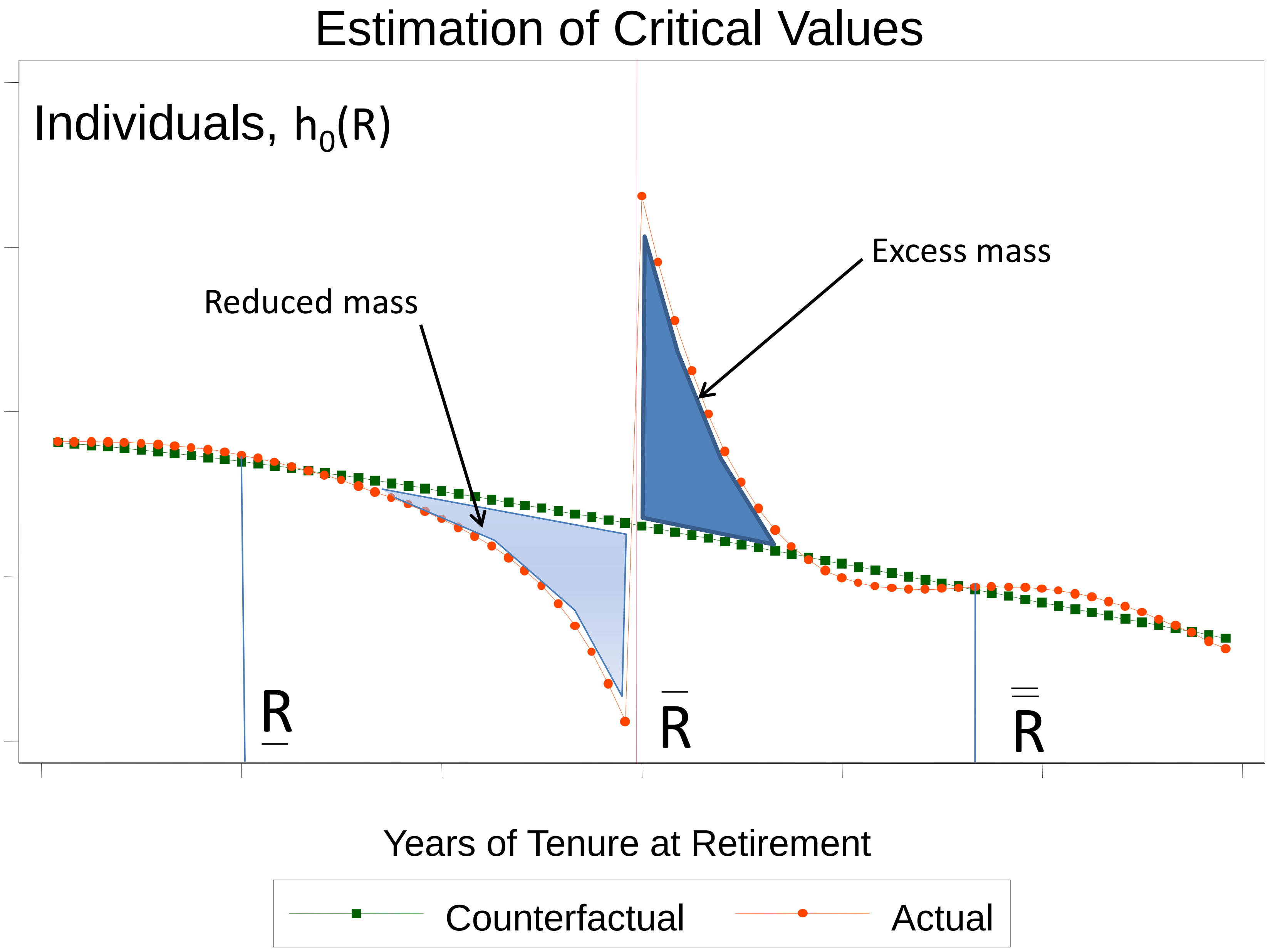

Counterfactual Frequencies
Individuals
0
500
1000
1500
2000
2500
10
15
20
25
Years of Tenure at Retirement
Counterfactual
Actual

Figure 19


Estimation of Critical Values
Individuals, $h_0(R)$
Reduced mass
Excess mass
$\underline{R}$
$\bar{R}$
$\bar{\bar{R}}$
Years of Tenure at Retirement
Counterfactual
Actual