Nonparametric Evidence on the Effects of Financial Incentives on Retirement Decisions

By Day Manoli and Andrea Weber*

This paper presents new evidence on the effects of retirement benefits on labor force participation decisions. The analysis is based on a mandated rule for employer-provided retirement benefits in Austria that creates discontinuities in the incentives for workers to delay retirement. The paper presents graphical evidence on labor supply responses and develops a conceptual framework that accounts for the dynamic incentive structure and for adjustment frictions. Using bunching methods, a semi-elasticity of participation is estimated, which ranges from 0.1 to 0.3 and is highest for incentives targeted at a delay in retirement by 6 to 9 months. (JEL D14, D91, H55, J22, J26, J65)

Labor supply of older workers has moved to the center of public attention as expenditures from government sponsored social security programs have become an increasing financial burden in many countries. A central task for economic models and policy design relates to understanding how financial incentives from social security benefits affect individuals’ retirement decisions. In this paper, we address the following question: how much are individuals willing to delay their retirement in response to anticipated increases in retirement benefits?

Our framework is based on a nationally mandated rule for employer-provided retirement benefits in Austria and exploits variation created by discontinuities in the intertemporal choice set of individuals. The nationally mandated rule is simple and salient: workers receive a lump-sum cash benefit (i.e., a severance payment) from their employer at entry into retirement. The amount of the severance pay depends on tenure at retirement in a step-wise function. Individuals are first eligible upon completing a tenure of 10 years, and further increases in benefits occur at thresholds of 15, 20, and 25 years of tenure. The key policy incentive is for workers to delay retirement to collect larger severance payments.

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A graphical investigation of retirement responses to the severance pay system provides clear evidence that the incentives work as expected. Plots of the distribution of retirement entries by tenure show spikes in the retirement frequencies exactly at each tenure threshold and dips in retirement frequencies just before the thresholds. However, there is also evidence of constraints or frictions as a substantial fraction of the population seem to be unwilling to delay retirement even by a few weeks if they face a large financial incentive.

In the spirit of recent evidence on frictions and labor supply responses to financial incentives (Chetty et al. 2011, Kleven and Waseem 2013), we present a conceptual framework that integrates the features found in the graphical analysis. In particular, our framework allows for constraints in the decision to delay retirement and it accounts for the dynamic nature of the incentives, which increase closer to the tenure threshold. Given these features we formulate a semi-elasticity of participation, which can be interpreted as a reduced form parameter that quantifies the degree to which individuals delay retirement and thus increase their participation rates in response to the financial incentives.

We estimate the semi-elasticity using a strategy based on bunching techniques (Saez 2010, Chetty et al. 2011). This estimation strategy allows us to express the distribution of participation semi-elasticities over a range of months prior to a tenure threshold and thereby to show how much responsiveness changes with the length of delay in retirement necessary to qualify for the severance payment. The results indicate average participation semi-elasticities between roughly 0.14 and 0.28, with highest estimated semi-elasticities at 6 to 9 months prior to a tenure threshold and lower semi-elasticities closer to the tenure thresholds or farther from the tenure thresholds. We discuss the policy relevance of the estimated participation semi-elasticities and emphasize both the potential effectiveness of bonuses targeted at short delays and the potential ineffectiveness of bonuses targeted at delays that are longer than nine months.

Our analysis relates to the literature addressing the relationship between retirement and pension benefits. In particular, Brown (2013) and Burtless and Moffitt (1985) use similar designs to ours that take advantage of kinked budget constraints created by pension programs to estimate retirement age elasticities. This literature generally finds small responses to financial incentives, but convincing causal evidence is rare due to interactions between social insurance programs at retirement and various selection and endogeneity problems. The empirical design of this paper has several advantages that largely overcome these difficulties, as we exploit multiple discontinuities from a simple and salient policy within an institutional setting that is characterized by a universal, government-provided social security and health insurance system.

The paper relates to the literature on labor supply and contributes estimates of participation (semi)-elasticities. Empirically, estimation of such elasticities has proven

1 See Gruber and Wise (2004); Asch, Haider, and Zissimopolous (2005); Coile and Gruber (2007); Liebman, Luttmer, and Seif (2009); and Mastrobuoni (2009).
2 Alternative approaches use structural models to capture detailed incentives from social security and other insurance systems, e.g., Gustman and Steinmeier (1985), Rust and Phelan (1997), and French (2005).
difficult because of a lack of credible research designs or limited data (Chetty et al. 2013). Our estimated semi-elasticities are particularly valuable given the wide variety of populations retiring and the high degree of precision and credibility stemming from detailed administrative, population-level data with minimal measurement error.

This paper is organized as follows. Section I discusses both the institutional background regarding the Austrian pension system and the administrative data. Section II presents nonparametric graphical analyses of retirement frequencies. Section III presents the quantitative analysis; it introduces the conceptual framework and defines the participation semi-elasticity, develops the estimation strategy, and presents the estimation results. Section IV concludes.

I. Institutional Background and Data

A. Retirement Benefits in Austria

There are two forms of government-mandated retirement benefits in Austria: government-provided pension benefits and 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 four weeks of claiming a pension according to the following schedule. If an employee has accumulated at least ten 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 reported in Table 1. Given the fractions of annual salary specified in the severance pay schedule, the amounts of the severance payments are significant, but they are small relative to lifetime wealth. The payments are made in a 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 workers who are involuntarily separated from their firms and have accumulated sufficient years of tenure prior to the separation (for more details see Card, Chetty, and Weber 2007). The only voluntary separation that leads to a severance payment, however, is retirement. Employment protection rules hinder firms from strategically laying off workers to avoid severance payments and there is no evidence of an increased frequency of layoffs before the severance pay thresholds. In general, older workers approaching retirement age enjoy the highest level of job protection in Austria.

The Austrian income tax system, which is based on individual taxation, applies particular rules to tax income from severance payments. Specifically, mandated severance payments are exempt from social security contributions and subject to a tax rate of 6 percent. Income taxation of severance payments differs from the general
income tax rules. Generally, gross monthly earnings net of social security contributions are subject to the income tax with marginal tax rates in different tax brackets of 0 percent, 21 percent, 31 percent, 41 percent, and 50 percent (in 2002).

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 percent 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 disability pensions, where disability is based on reduced working capacity of 50 percent 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.

Figure 1 illustrates survival functions for exits from the labor force for the sample of private sector employees. The series are presented separately for men and women given the different eligibility ages. The survival functions show sharp declines at ages 55 and 60, highlighting a significant amount of entry into the pension system once individuals become eligible for the early retirement pensions. Additionally, the figure shows that, for both men and women, most retirements occur between ages 55 and 60. Further, the graph shows that roughly 25 percent of the male sample retire by claiming disability pensions prior to age 60. The vast majority of exits from the labor force shown in Figure 1 are permanent exits. Because benefits from disability and early retirement are entirely withdrawn if an individual earns more than about 300 euros per month, we see very few retirees returning to employment.

<table>
<thead>
<tr>
<th>Years of tenure at retirement</th>
<th>Severance pay amounts fraction of annual salary</th>
</tr>
</thead>
<tbody>
<tr>
<td>10–14</td>
<td>0.333</td>
</tr>
<tr>
<td>15–19</td>
<td>0.5</td>
</tr>
<tr>
<td>20–24</td>
<td>0.75</td>
</tr>
<tr>
<td>25+</td>
<td>1</td>
</tr>
</tbody>
</table>

Notes: 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 four weeks of claiming a pension according to the following schedule.
The early withdrawal of workers from the labor market in Austria can be largely explained by the generous public pension system. Pension replacement rates in Austria are high relative to those in the United States and other Organisation for Economic Co-operation and Development (OECD) countries (see Whitehouse and Queisser 2007 for a comparison). Online Appendix Table A1 shows that gross and net replacement rates for the median earner in Austria are roughly 80 percent and 90 percent, respectively. The corresponding replacement rates in the United States are roughly 44 percent and 55 percent, respectively; averaging across OECD countries, the gross and net replacement rates for median earners are roughly 61 percent and 72 percent. Given the generosity of the public pension system in Austria, private, voluntary pensions play a smaller role in Austria than in the United States and other OECD countries. In terms of health insurance, all private sector workers in Austria are covered by a mandatory government provided insurance system, which also covers retirees.

While pension rules were mostly stable beforehand, there have been multiple pension reforms in Austria in the last three decades. Reforms in the 1980s and 1990s generally aimed at reducing pension generosity and providing incentives for later retirement, and more recent reforms in the 2000s increased the early retirement ages for men and women (Manoli, Mullen, and Wagner 2015; Manoli and Weber 2016a). Since these reforms create variation that is orthogonal to variation in tenure at age 54, we do not focus on the details of these reforms for our analysis. Additionally, in 2003, the severance payment system was reformed so that the tenure-based schedule

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**Figure 1. Exits from Labor Force into Retirement**

*Notes:* The survival functions are computed at a monthly frequency using birth dates and last observed job ending dates. The solid line is the survival function for women; the early retirement age and normal retirement age for women are, respectively, 55 and 60. The dashed line is the survival curve for men; the early retirement age and normal retirement age for men are, respectively, 60 and 65. Prior to age 60, men can retire through disability pensions.
was replaced with employer contributions to individual pension accounts equal to a fixed fraction of the annual salary. Since the new system was grandfathered in and only applied to new jobs starting in 2003 and later, this reform is not relevant for our empirical analysis.

B. Data

Our empirical analysis is based on administrative registers from the Austrian Social Security Database (ASSD, see Zweimüller et al. 2009), which we merge with individual level tax records. The ASSD is collected with the principal aim of verifying individual pension claims and provides 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 are recorded in the period from 1972 onwards. 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. Combining the administrative data from 1972 onwards and the retrospective data prior to 1972 yields information on complete earnings and employment careers of retirees. Because firm identifiers are available only from 1972 onwards, uncensored tenure can be measured for jobs starting after January 1, 1972.

The tax record reports the workers’ gross annual earnings split up into social security contributions, tax deductions, income subject to income tax, and income subject to the lower fixed tax rate of 6 percent, including a separate category for severance payments. We have access to tax record data with severance pay information for the years 1997–2005. For a detailed description of the tax data and construction of severance payments see online Appendix C.

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 long uncensored tenure at retirement. We focus on workers who are still employed after their 54th birthday with a minimum private sector work experience of one year and follow them until entry into retirement or up to the age of 70. We make several restrictions to the original sample of about 700,000 workers, which are summarized in online Appendix Table A2. 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 six 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. To exploit the severance pay discontinuities, we focus on individuals with 6 to 28 years of tenure at retirement, which reduces the sample to 194,086 retiring individuals. Given the selected birth cohorts and Austrian retirement ages, we observe individual retirements in the years 1985–2008, with about 95 percent of retirements occurring between 1986 and 2005 when the youngest cohort turns 60. In order to exploit
information on severance payments from tax records, we focus specifically on the subsample of individuals who retire in the years 1997–2005 and for whom we can match valid records of severance payments in the final year of employment. This leaves us with an estimation sample of 89,426 individuals.

Summary statistics for this sample are presented in Table 2. The median retirement age is 59 years, which reflects that most individuals retire through disability (21 percent) or early retirement (57 percent). The average worker has 15 years of tenure at retirement and 34 years of total employment. Because we exclude workers from the construction industry—a large male-dominated sector in the Austrian economy—about 50 percent of our sample is female. The average severance payment at retirement amounts to roughly 60 percent of the average annual earnings before retirement. At retirement, workers face a high implicit tax rate of about 80 percent, which is a combination of income taxes and social security contributions (30 percent) and foregone pension benefits (50 percent).

### II. Nonparametric Graphical Analysis

#### A. Distribution of Tenure at Retirement

Figure 2 presents the distribution of tenure at retirement, plotting the frequency of retirements at monthly tenure levels. The patterns are remarkably similar. Several features are immediately evident from this graph. First, the plot shows large discontinuous spikes in the number of retirements at each tenure threshold. Second, there are dips in the number of retirements just before the tenure thresholds. The pattern is regularly repeated at each tenure threshold but not apparent at any other point in the tenure distribution. Third, the plot indicates a seasonal pattern illustrated by small...
spikes in the number of retirements at each integer value of years of tenure at retirement. The seasonality can be explained by a relatively large fraction of job starts in January and corresponding retirement exits in December. Fourth, 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. It is worth noting that the above patterns by tenure are remarkably similar in the full sample of retirements of individuals born between 1930 and 1945, as can be seen in online Appendix Figure A1.

The retirement pattern of dips and spikes around the tenure thresholds in the graph 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 qualify for the (larger) severance payments. Thus, in absence of the tenure-based severance pay schedule, the retirement frequencies should be smooth across all thresholds. We check this hypothesis by plotting retirement frequencies for civil servants and construction workers—two groups that are not subject to a tenure-based severance pay rule. These plots, which are presented in Figures 3 and 4, respectively, only show very small discontinuities at some of the tenure thresholds. Unfortunately, the samples underlying these figures are small, because employment spells of civil servants are only available as of 1988 in the ASSD, and because short tenures dominate in the construction industry due to its seasonal nature. The evidence from the two control groups confirms our hypothesis that the

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**Figure 2. Distribution of Tenure at Retirement**

*Notes:* This figure plots the distribution of tenure at retirement at a monthly frequency. Each point captures the number of people that retire with tenure greater than the lower number of months, but less than the higher number of months. Tenure at retirement is computed using observed job starting and job ending dates.
pattern in Figure 2 is driven by the severance pay schedule and not by regularities in job-leaving behavior at specific tenure levels.

Individuals who retire right before a tenure threshold seem to act sub-optimally, because they forfeit a high return to a few more weeks of work. We consider four explanations for this phenomenon: measurement error, salience or information problems, frictions in the flexibility of retirement timing, and side payments or voluntary severance payments. The first explanation is not particularly relevant given the quality and precision of the administrative data; it is the primary data source for computing pension claims and measures employment spells at a daily level. Second, the severance pay schedule is in place over a worker’s entire career and primarily applies for workers affected by layoffs, who become eligible for tenure-based severance payments. Therefore, the system should be highly salient. Information on employer tenure should also be salient. Every employee in Austria signs a work contract at the start of a new job, which specifies the starting date. General knowledge about severance pay rules does not exclude some informational problems with the application of severance pay at retirement, though. We will explore the role of the other two explanations, frictions and compliance with the severance pay regulation by employers, in more detail below. In particular, we will investigate retirement patterns by health status, age at retirement, and gender. In addition, we will analyze data on actual severance payments from tax records to verify how closely severance payments follow the legislated schedule in Table 1.
B. 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:

\[ r_{it} = \sum_{s=0}^{85} \gamma_s d_s + X_{it} \beta + \epsilon_{it}, \]

where \( r_{it} \) is an indicator equal to one if individual \( i \) retires within time period \( t \). The set of observations per individual covers all quarters from age 54 to retirement or age 70. The sample used for estimation includes all job exits, not only the individuals retiring within six months of their last job. This allows us to examine whether or not regularities in general job exits (as opposed to just retirements) after 5, 10, 15, 20, or 25 year intervals are responsible for the observed retirement patterns in Figure 2. Given that many of the covariates do not change at more than a quarterly frequency, time is measured at a quarterly frequency instead of the monthly frequency presented in Figure 2.

The regressors in the estimated equation are a set of indicators \( d_s \) equal to one if the individual’s quarterly tenure at time \( t \) equals \( s \). Further, we include a large
set of time-varying control variables $X_{it}$ relating to age, gender, calendar years, citizenship, industry, region, seasonality, earnings histories, firm size, health, and experience. All of the variables in the regression are demeaned so that the coefficients on the tenure dummies reflect the mean probabilities of retirement within each tenure level.

Figure 5 plots the coefficients on the quarterly tenure dummies from the estimated retirement regression. The graph shows a pattern of dips before and large spikes at the thresholds that is very similar to Figure 2. The yearly seasonality pattern is now removed by controls for quarter of the year. We also plot confidence intervals for the estimated coefficients. Because of the large sample size, these intervals are very tight. Overall, Figure 5 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.

In online Appendix Figures A2 and A3, we graphically investigate heterogeneity in retirement patterns by tenure related to health status, gender, and retirement age. The analysis shows that some of the pre-threshold retirement is likely to be driven by negative health shocks, and also more permanently, poor health status as the response among unhealthy individuals is much smaller (see online Appendix Figure A2). Interestingly, retirement patterns are remarkably similar across age and gender groups. An exception are men retiring prior to age 60, who are not yet eligible for early retirement and have to qualify for disability to be eligible for benefits (see online Appendix Figure A3).
III. Quantitative Analysis

A. Conceptual Framework

The graphical analysis of retirement frequencies in the previous section provides clear evidence that individuals respond to the financial incentives from the severance pay schedule by delaying their retirements to reach the tenure thresholds and collect larger severance payments. In addition, there is evidence of frictions or constraints in the timing of retirements, indicated by two features. First, a large number of individuals are retiring right before the thresholds, although they should face a huge incentive to continue working. Second, we observe excess numbers of retirements even in the months after the threshold. In this section, we provide a conceptual framework that captures the features in the graphical evidence and introduces a participation semi-elasticity which quantifies the magnitude of observed participation responses to the financial incentives.

The conceptual framework is based on the thought experiment of comparing a situation with a discontinuous increase in severance pay at a tenure threshold to a counterfactual situation without any increase in severance pay. We assume that, in the counterfactual situation, an individual chooses a retirement date at a tenure level \( t_0 \). This retirement date would be based on the conditions set by the government pension system and an individual’s situation given by employment and earnings histories, health, and family circumstances. As there are no discontinuous changes in severance pay for retiring at a specific tenure level in the counterfactual setting, the aggregate counterfactual retirement frequencies are smooth across tenure levels.

Now consider the impacts of the severance pay rule that sets a tenure threshold level \( t \) at which the worker becomes eligible for a one-time, lump-sum severance payment of amount \( \delta \times y \), where \( y \) is the worker’s annual earnings, and \( \delta \) denotes a fraction of annual earnings. The individual now faces an incentive to deviate from the counterfactual retirement plan and delay retirement until \( t \) in order to receive the severance payment. The individual decision to delay depends on a comparison of the utility gain from higher income to the disutility of working.

To model the participation decision due to the severance payment, we make the following set of assumptions. First, we assume that the disutility of labor is heterogeneous in the population, and therefore only a fraction of individuals with the same counterfactual retirement tenure \( t_0 \) will end up delaying retirement. The distribution of the disutility of labor is, however, constant across individuals with different counterfactual retirement tenure levels. Second, at every counterfactual tenure level, a constant number of individuals is unconstrained in their retirement decision, while the rest are constrained and therefore do not face the severance pay incentive. This is due to ignorance, health, or negotiations with an employer. Importantly, all constrained individuals continue retiring at the counterfactual retirement dates in the situation with severance payments. Third, we assume that all individuals who decide to delay retirement continue working until they reach severance pay eligibility. There is no uncertainty in eventually reaching \( t \) due to health reasons, layoff, etc. We think that this is a reasonable assumption as we will see that the maximum
length of delay due to severance pay observed in the data is 15 months, and thus not a very long horizon. However, we allow for frictions that create uncertainty in the length of delay required to establish eligibility for severance payment. Due to these frictions some workers who decide to delay retirement can only retire a few periods after tenure threshold.

Given this set of assumptions, we can use the graphical retirement patterns in Figure 3 to back out the probability of continuing to work at each tenure level $t_0$ prior to $t$, relative to the counterfactual situation, for individuals who are not constrained in their decision. Subsequently, we formulate a semi-elasticity by relating the probability of participation (i.e., $1 - \text{probability of retiring}$) to the percentage change in financial incentives of working due to the severance payment rule

$$
\varepsilon(t_0) = \frac{1 - r(t_0)}{\Delta(1 - \tau(t_0))},
$$

where $r(t_0)$ denotes the probability of retiring at tenure level $(\bar{t} - t_0)$ and $\tau(t_0)$ refers to the implicit tax rate on working the additional $t_0$ periods until the threshold is reached.

The concept of the reduced-form participation semi-elasticity can be motivated within a dynamic framework that has been used extensively in the literature on retirement decisions (see Stock and Wise 1990 or Berkovec and Stern 1991). In online Appendix A, we present a dynamic model of retirement decisions that generates a pattern of retirement frequencies with dips prior to the tenure thresholds and spikes at the thresholds similar to the ones we empirically observe in Figure 2.

An alternative elasticity can be derived from a static model of lifetime labor supply (see Brown 2013) where kinks in the budget constraint induce bunching of retirements. We present the detailed alternative elasticity estimates based on the static labor supply model in online Appendix B, along with a discussion of the differences between elasticity concepts based on the static and dynamic models, respectively. For the Austrian application, the reduced-form semi-elasticity concept based on a dynamic framework is more suitable, because the elasticity in the static model is not scale invariant; it can be arbitrarily rescaled depending on how labor supply is measured.

B. Estimation Procedures

Our setup and the nonparametric estimation strategy allow estimating the participation semi-elasticity $\varepsilon(t_0)$ at various levels of $t_0$. Because the fixed severance payment becomes more important relative to labor earnings over $t_0$ as the distance to the threshold decreases, the financial incentive rises as we get closer to the threshold. The response to this increase in financial incentives is reflected in the downward sloping retirement pattern leading up to the threshold in Figure 2. The estimation strategy will thus provide us with a distribution of participation semi-elasticities over a range of $t_0$. In addition, we can compare semi-elasticities across multiple tenure threshold samples.

Here we outline the estimation procedures for computing both the numerator and the denominator in equation (1) for one particular tenure threshold. The procedure
is then applied to the estimation samples around each of the tenure thresholds in the severance pay schedule. We divide the full range of tenure levels in Figure 2 into threshold estimation samples and normalize the tenure threshold \( t \) in each sample to zero. Then we measure tenure at discrete monthly frequencies \( s = (t_0 - t) \) with negative values denoting tenure levels prior to the threshold and positive values denoting tenure levels past the threshold.

**Counterfactual Retirement Frequencies.**—To measure the probability of delaying retirement we apply bunching methods based on the graphical retirement patterns (Saez 2010, Chetty et al. 2011), and start by approximating the counterfactual retirement frequencies by fitting a function that is smooth around tenure thresholds to the pattern in Figure 2.

In the first step, we generate smooth retirement profiles by fitting fifth-order polynomials, the observed retirement frequencies \( n_s \), on each side of the tenure threshold. Additionally, we adjust for seasonal spikes at full-year tenure levels by including a set of dummy variables for full years of tenure into the specification. This procedure makes sure that the spike in retirements at the tenure threshold is not overstated due to seasonality at the full-year tenure levels. Specifically, we regress observed retirement frequencies \( n_s \) at tenure month \( s \) on the following set of variables:

\[
(2) \quad n_s = g_1(s) \times 1(s < 0) + g_2(s) \times 1(s > 0) + \beta \times 1(s = 0) \\
+ \gamma \times 1(s = -24|s = 24) + \varepsilon_s,
\]

where \( g_1(\cdot) \) and \( g_2(\cdot) \) are fifth-order polynomial functions in \( s \). Based on this regression, we construct adjusted retirement frequencies as \( n_s^a = \hat{g}_1(s) + \hat{g}_2(s) + (\hat{\beta} - \hat{\gamma}) \times 1(s = 0) \). We further rescale the predicted seasonally adjusted frequencies so that the total number of retirements is equal to the total number of observed retirements.

Second, we use the adjusted retirement frequencies and estimate counterfactual retirement frequencies, denoted by \( \hat{n}_s \), to create the counterfactual scenario without an increase in severance pay. In this step, we fit a continuous fourth-order polynomial over the full range of tenure levels and add dummy variables for the months around the tenure threshold. Specifically, we regress seasonally adjusted retirement frequencies \( n_s^a \) on the following set of variables:

\[
(3) \quad n_s^a = h(s) + \sum_{k=-12}^{12} \alpha_k \times 1(s = k) + \eta_s,
\]

where \( h(\cdot) \) is a fourth-order polynomial function in tenure \( s \). We then set the dummies equal to zero and predict values from the estimated polynomial to construct counterfactual frequencies as \( \hat{n}_s = \hat{h}(s) \). The predicted counterfactuals are rescaled so that the total number of counterfactual retirements is equal to the total number of observed retirements.

Figure 6 illustrates the results from this estimation procedure by plotting the actual retirement frequencies \( n_s \), along with the adjusted retirement frequencies
and the counterfactual frequencies \( \hat{n}_i \) by tenure, separately for each threshold sample.

For a detailed sensitivity analysis of this estimation procedure with respect to the polynomial degree or the window length of dummies around the threshold, please see Manoli and Weber (2011). There we document that the results are not sensitive to the choice of either parameter.

**Constrained Population and Participation Rate.**—Next, we determine the constrained and unconstrained populations based on the assumption that all individuals who retire within the last month before the tenure threshold are constrained in their decision, as they do not respond to a very high financial incentive. The number of unconstrained individuals is then given by the difference between the counterfactual retirements and the adjusted retirements in the month prior to the threshold, \( \hat{n}_{i-1} - n_{i-1}^a \). We use this estimate as a projection for the number of individuals unconstrained in their decision whether to delay retirement at any monthly tenure level prior to the threshold.

As a caveat, we note that the assumption of a fixed number of unconstrained individuals around the threshold is reasonable if constraints are due to health reasons or ignorance. If however, constrained workers bargained individual severance
payments agreements with their employers and employers are more willing to top up severance pay the closer the worker is to the threshold, this assumption might not hold. For more discussion see Section IIIC.

We then exploit the downward sloping pattern of observed retirement frequencies to the left of the tenure threshold, which splits the population of non-constrained individuals at each tenure level into a share retiring and a share who continue working and delay retirement. This establishes the definition of the participation rate at any tenure level \( s < -1 \) prior to the threshold as the fraction of unconstrained individuals at tenure level \( s \) who appear to delay their retirements. Formally, the participation rate at \( s \) is given by

\[
1 - r(s) = \frac{\hat{n}_s - n_s^a}{\hat{n}_{-1} - n_{-1}^a}.
\]

\textbf{Change in Financial Incentives.}—The measure of the net income change for working the additional \( t_0 \) periods relative to the situation without severance pay takes into account that severance pay and labor earnings are taxed at different rates. In particular, severance payments are defined as a fraction of gross annual earnings and taxed at a fixed rate of 6 percent, while labor earnings are effectively taxed at an implicit tax rate that considers income taxes and foregone pension benefits. Therefore, we express the change in financial incentive in terms of the net-of-tax rate.

More formally, we measure the percentage change in financial incentives to continue working at a given tenure level \( s < -1 \) prior to the threshold by the increase in the amount of severance pay that the individual receives if she delays retirement relative to the labor earnings from working \(|s|\) additional months. Let \( \tau_{\text{sev}} = 0.06 \) to denote the tax rate applied to severance pay, \( y \) to denote annual earnings, \( \tau = 0.80 \) to denote the implicit tax rate on annual labor earnings net of pension benefits, and \( \delta_{\text{SP}} \) to denote the changes in the severance pay as a fraction of annual earnings according to Table 1. Then the change in the net-of-tax rate at tenure level \( s \) is given by

\[
\Delta (1 - \tau(s)) = \frac{(1 - \tau_{\text{sev}})\delta_{\text{SP}} y}{(1 - \tau)|s| y} = \frac{(1 - \tau_{\text{sev}})\delta_{\text{SP}}}{(1 - \tau)|s|}.
\]

We have computed individual-level implicit tax rates using income tax records and imputed social security benefits based on observed earnings and employment histories. There was not much variation, so we use a common implicit tax rate of 80 percent across all individuals for transparency.

Finally, following equation (1), the semi-elasticity of participation at tenure level \( s \) relates the participation rate to the percentage change in the net-of-tax rate. The standard errors for \( r(s) \) and \( \epsilon(s) \) are computed as the standard deviation over bootstrapped estimates for these terms.

\textbf{Frictions in the Expected Length of Delay.}—To deal with frictions that create uncertainty in length of delay that is required to establish severance pay eligibility,
we exploit the downward sloping pattern in retirements after the tenure threshold, observed in Figure 2. In particular, we assume that the worker who decides to delay retirement is unable to target the tenure threshold $\bar{t}$ exactly, but she faces the risk of having to work some additional periods past the threshold, for example due to unfinished projects. We assume that the excess number of retirements relative to the counterfactual at the right-hand side of the tenure threshold is due to these frictions and use the pattern to estimate the average number of extra periods of delay in retirement beyond $\bar{t}$. We assume that the expected extra delay in retirement is the same for all counterfactual retirement tenure levels $(\bar{t} - t_0)$.

To implement this idea in the estimation of the participation semi-elasticity, we adjust the number of months until retirement $|s|$ in the denominator of the semi-elasticity to be based on the expected time to the threshold. The expected length of delay due to frictions is computed as the weighted average of excess retirements at the threshold and in the first six months after the threshold relative to the counterfactual retirement frequency. Specifically, the expected length of delay at tenure level $s < -1$ is given by

$$
|\hat{s}| = (|s|) \frac{n_0^a - \hat{n}_0}{\sum_{k=0}^{6} n_k^a - \hat{n}_k} + (|s| + 1) \frac{n_1^a - \hat{n}_1}{\sum_{k=0}^{6} n_k^a - \hat{n}_k} + \cdots + (|s| + 6) \frac{n_6^a - \hat{n}_6}{\sum_{k=0}^{6} n_k^a - \hat{n}_k}.
$$

In this case, the standard errors for the numerator, denominator, and overall semi-elasticity are all computed as the standard deviations of the respective values from bootstrapped replications.

### C. Estimation Results

As indicated in Section IIIA, we present results for the distribution of semi-elasticities over a range of distances from the threshold $|s|$ and for each threshold sample. Estimation results for all thresholds showing the distribution of estimates over the range of distances to the threshold are presented graphically in Figure 7, panels A–C for distances of 15, 12, 9, 6, 3, and 2 months, respectively. The detailed estimates and standard errors underlying Figure 7 are presented in online Appendix Table A3. Online Appendix Table A4 presents estimates using the expected length of delay due to frictions instead of the exact distance to the threshold.

**Fraction Constrained.**—Let us start by discussing the fraction of constrained individuals in each threshold sample, which is defined by the share of actual retirements relative to the counterfactual retirements one month prior to the threshold. As noted in the discussion of Figure 3, constraints appear to be an important feature of retirement patterns in the Austrian application. We estimate that on average 61 percent of the individuals are constrained in their retirement decisions; see the last
column in Table 3. The share is highest around the 10-year threshold and declines gradually at the higher tenure thresholds, from 66 percent around 10 years of tenure to 55 percent around 25 years (online Appendix Table A3). How can we explain the high rate of constraints?

We can gain some insights from investigating the implementation of the severance pay rule at retirement from individual tax records. This data provide a crude measure of the amount of severance pay received relative to labor earnings over the

**Figure 7. Estimation Results**

*Notes:* These figures plot the estimation results shown in Table 2. The estimation procedures are explained in the main text.
last year before retirement, which we call the severance pay fraction. See online Appendix C for a detailed description of the tax, the data, and measures of severance payments. We find clear evidence that the severance pay schedule is binding for a significant part of the population, and we see distinct spikes in the probability of receiving the legislated severance pay fractions that shift sharply at the tenure threshold levels (see online Appendix Figure A11). However, there is also evidence for considerable deviations from the severance pay schedule. In particular, at any tenure level there is a significant mass of the population receiving either zero severance payment or payments close to the maximum severance pay amount. This indicates that workers and employers have ample discretion to negotiate alternative payment conditions in practice, and it helps us explain the large fraction of individuals who appear to be unresponsive to the severance pay rule.

In this context, we note that if the severance pay rule does not apply for some of the individuals, the data on actual severance payments suffers from censoring and selection. Observations of actual severance payments only provide information at the time of retirement and do not allow any inference on individual level incentives at counterfactual retirement dates. If workers selectively choose retirement dates based on individual incentives, observed severance payments before the threshold cannot be used as counterfactual for observed severance payments at or after the threshold. This means that as we are unable to identify the population whose incentives change at the tenure threshold, it is not possible to estimate the true financial incentive.

We will therefore only use the tax data to get some insights on the extent to which we can explain the fraction of constrained individuals by irregularities in the implementation of the severance pay schedule. In the tax data, roughly 30 percent of our sample population are observed receiving the legislated severance pay fraction. It is, however, not reasonable to assume that all remaining individuals face a zero change in incentives at the tenure thresholds and are therefore constrained in their decision. Instead, we use a simple approximation, which defines individuals with severance payment fractions that are either far higher or far lower than the legislated levels left and right of each tenure threshold as facing a nonbinding severance pay rule. With this definition, we can still explain more than half of the fraction constrained
around each tenure threshold that is reported in Table 3. The remaining part of con-
strained population is potentially unresponsive due to health reasons or due to lack
of salience of the severance pay rules at retirement. We have seen that unhealthy
individuals show little response, but based on our definition, the unhealthy are a
small fraction of the total population, and we cannot get at the true extent of health
effects on responsiveness.

Participation Rates and Changes in Financial Incentives.—After having speci-
fied the counterfactual distribution of retirements and pinned down the constrained
population, we can proceed with estimating the fraction of the unconstrained pop-
ulation who are delaying their retirement decision at each level of tenure prior to
the threshold. Figure 7, panel A, plots the estimates for each threshold sample. The
figure clearly shows that 15 months prior to the threshold the probability of delaying
retirement is virtually zero. Thus, we conclude that the maximum length that indi-
viduals are willing to delay retirement is less than 15 months. In the months leading
up to the threshold, the share of individuals delaying retirement is increasing almost
linearly. This pattern of increasing rates of delay is very similar across the different
thresholds, only somewhat lower prior to the 25-year threshold.

One concern with the participation rate estimates is that they might depend on the
choice of the 12-month window around the threshold that underlies the estimation
of the counterfactual retirement frequency. Especially the maximum length of delay
could be driven by the choice of window length. As a robustness check, we therefore
compare estimates based on an 18-month window in online Appendix Table A3,
panel F, and online Appendix Figure A4. Interestingly, the longer window hardly
affects the estimated participation rates. This confirms that our results are robust to
the parameter choice in the estimation procedures.

Compared to the retirement delays, the change in financial incentives, plotted in
Figure 7, panel B, follows a convex shape over the months leading up to the thresh-
old with steeper increases in the last months before the threshold. The financial
incentive is already substantial at 15 months prior to the threshold with a change
in the implicit tax rate ranging from 0.6 to 1.2. This means that the net-of-tax rate
increases by 60 percent or 125 percent in the case with the severance pay increase
at the tenure threshold, compared to the case without the severance pay increase at
the threshold. Two months prior to the threshold, the increase in the severance pay
causes the net-of-tax rate to increase roughly five to ten fold.

Estimated Semi-elasticities.—The estimated semi-elasticity relates the participa-
tion rate to the change in the net-of-tax rate according to equation (1). Over the
months prior to the threshold, the distribution of semi-elasticities follows a hump-
shaped pattern, which indicates some heterogeneity in responsiveness. Figure 7,
panel C, shows the maximum responsiveness around six to nine months prior to the
threshold. Across the thresholds, the maximum semi-elasticity varies between 0.2
and 0.4; around a given threshold, the semi-elasticity is about twice as large at the
maximum than either very close or very far from the threshold.

The second row in Table 3 shows estimation results when allowing for frictions
in the length of delay, which force some individuals to work beyond the tenure
threshold. Taking the excess mass in retirement in the months after the tenure threshold into account implies an additional delay in the retirement date by about 1.4 months on average. Across threshold samples, the additional time beyond the tenure threshold varies between roughly 0.75 and 2 months (online Appendix Table A4). As we assume that all individuals face the same expected delays due to frictions, irrespective of their counterfactual retirement date, allowing for frictions leads only to small changes in the estimates. Overall, the estimated semi-elasticities increase by no more than 0.05.

The remaining rows in Table 3 present estimated semi-elasticities by health status and gender. Focusing on the average estimates across the tenure threshold samples, we find that semi-elasticity estimates are slightly higher for the healthy individuals than for the total population, but the difference is not statistically significant. Comparing men and women, we find statistically significant differences with men being less responsive to financial incentives at all tenure levels prior to the threshold. We also find a gender difference in share of constrained individuals, which is lower among females. This could imply that the higher responsiveness we observe among women is due to stronger financial incentives faced by women.

### IV. Conclusions

In this paper we use policy discontinuities in the Austrian pension system to address the following question: how much are individuals willing to delay their retirement in response to anticipated increases in retirement benefits? Our analysis of behavioral responses to the policy rule is based on high-quality data from administrative registers. The data show a clear pattern of spikes in retirement entries at threshold tenure levels for severance pay eligibility. However, graphical evidence also highlights the importance of taking frictions and constraints in individual decisions into consideration. We discuss that in the Austrian application, an important source of frictions are deviations from the legislated rule via worker-employer negotiations over individualized severance packages that ignore the legislated discontinuities.

After accounting for frictions, our empirical estimates point toward an overall limited responsiveness to financial incentives at retirement, a result which strongly confirms previous quasi-experimental evidence. However, our analysis allows a more nuanced view on participation responses based on exploiting the dynamic nature of the incentives.

We show that the overall limited responsiveness is mainly driven by the individuals’ unwillingness to delay retirement for longer periods. Specifically, we find that virtually nobody is willing to delay retirement entry for more than 15 months in response to severance pay increases that are larger than 25 percent of the annual salaries.

We estimate average participation semi-elasticities of roughly 0.1 to 0.3. But there is evidence of heterogeneity in responsiveness by the length of delay that is necessary to reach severance eligibility. Responsiveness is highest at a horizon of six to nine months, and the corresponding semi-elasticity range from 0.2 to 0.4. These findings apply in the steady state as we observe steady state responses to the
severance pay schedule in Austria instead of short-run responses to unanticipated policy changes.

The interpretation of our results in terms of policy relevance is complicated by the large amount of frictions. In order to identify the participation semi-elasticity, we have to make relatively strong assumptions on the nature of constraints. For example, we assume that constraints do not vary by the distance of the counterfactual retirement date from the threshold. If these assumptions hold, we can draw the following policy conclusions.

First, replacing the discontinuous severance pay schedule with a continuous schedule with incremental increases in the severance pay fraction might induce strong incentives to delay retirement by six to nine months. The overall effect is driven by two countervailing factors. On the one hand, the incentivized population would be larger as everybody faces the same incentive irrespective of the counterfactual distance from a tenure threshold. On the other hand, the financial incentive from a continuous increase in severance pay fraction would be smaller.

Second, a lump-sum financial incentive could be designed to delay retirement beyond the popular retirement age of 60 years. This type of incentive would also affect a large fraction of the population. The policy would be most effective if it were targeted at creating short delays in retirement entry of 6 to 9 months as the results indicate that few individuals would delay retirements by more than 15 months.

REFERENCES


