Why are Defined Benefit Pensions Disappearing?

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Abstract

Workers are entering retirement today more exposed to longevity risk than they were twenty years ago. This paper examines the effect of declining job tenure as a motivation to switch from a defined benefit pension to other forms of retirement saving. I study compensation decisions of workers with heterogeneous survival rates in a life-cycle model with job turnover. A worker may take a defined benefit pension with his employer, and may also purchase an annuity through a competitive market. The return to each asset is determined endogenously given the terms of the contract and the average survival probability of pensioners and annuitants. Workers may be exogenously separated from their job, or leave voluntarily when they are given a better offer. I show that an increase in the separation rate leads to fewer workers taking defined benefit pensions. Furthermore, I show that without the pension, workers are more likely to quit their job following the arrival of a better job offer, thereby increasing the endogenous separation rate and creating a further decrease in average tenure. The model calibrated to match average tenure rates from 1992 and 2006 accounts for 71% of the fall in retirees with defined benefit pensions.

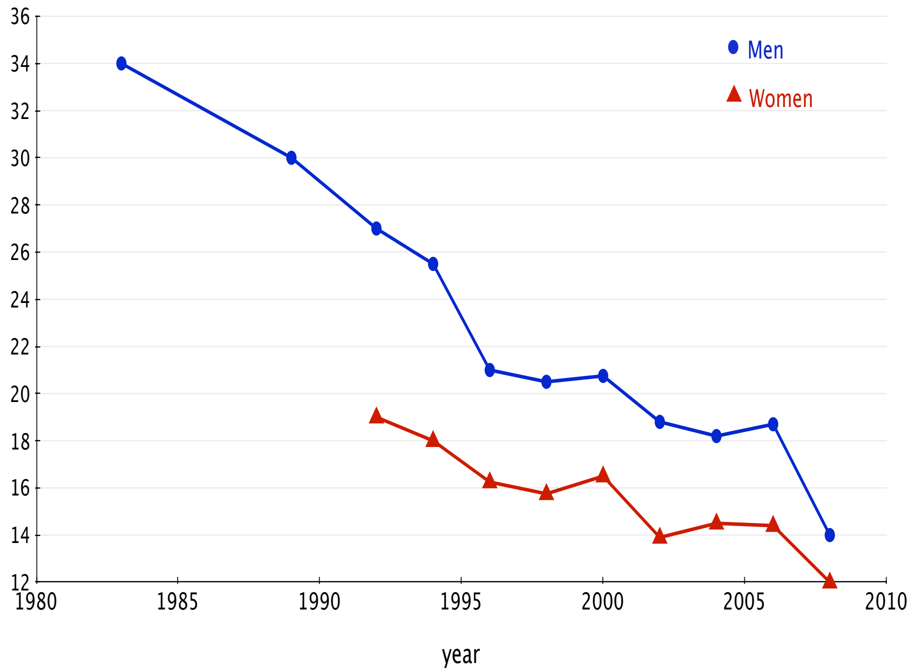
1 Introduction

Defined benefit pensions are employer promises to pay an employee a fixed annual (or monthly) amount in retirement every year. The payment is a function of wage, age and tenure. A defined contribution pension is more like a savings account, with a lump-sum distribution at retirement. The number of retirees covered by defined benefit (DB) pensions has declined over the past two decades. Figure 1 shows the downward trend for both male and female workers nearing retirement. From 1983 to 2008 the percentage of workers aged 51-61 with a defined benefit pension from their current employer fell 59% for men and 37% for women. The fall in DB pension coverage has received little attention from macroeconomists, even as financial analysts and policymakers worry about low pension coverage and over-reliance on 401(k) plans. Defined contribution (DC) plans have been replacing DB plans, but do not serve as longevity insurance. There is usually an option to roll the DC account into an annuity at retirement, but individual annuities suffer from adverse selection, driving up their price, see Finkelstein and Poterba (2002). The result has been a fall in longevity insurance coverage, and more workers enter retirement with the risk of outliving their savings.[1]

This paper asks if increased job turnover can account for the decline in DB pensions. Policy requires a fixed cost to insure against employer default. The contract also requires a vesting period before the worker can accrue any benefits. This makes the DB plan unattractive to employees who do not expect long tenure with a firm. DB pensions are attractive to those with longer expected tenure because they offer a higher return than the market option, an individual annuity. Employers are able to pool employees of different risk types with the same quantity. Contracts are not exclusive in the private market, so high risk types (high-survival) can purchase more insurance, driving up the price, or reducing the return to annuities. The higher return on DB pensions may not be enough to compensate for the fixed cost if expected tenure is too short.

[1] Data used are available from the Survey of Consumer Finances (1983-2007) and the Health and Retirement Survey (1992-2008)

Figure 1: Percentage of Workers Aged 51-61 with Defined Benefit Pensions with Current Employer 1983-2008



In the model, workers may be exogenously separated from their job, or leave endogenously when they receive a better wage offer. They are less likely to quit if they have already invested in a defined benefit pension with their employer. The exogenous separation rate will be increased to generate the fall in average tenure observed in the data over the past two decades. The result will be fewer workers taking defined benefit pensions and increased job turnover from not just exogenous separation, but also increased endogenous turnover. The model tests different mechanisms which could potentially affect pension demand: increased turnover, increased fixed costs and increased survival. The model predicts a large decline in defined benefit pensions, the largest effect from increased job turnover. Increased survival increases the demand for DB pensions, but this effect is reversed by higher insurance costs. The model accounts for two-thirds of the fall in DB pensions held by retirees from 1992 to 2006.

1.1 Background

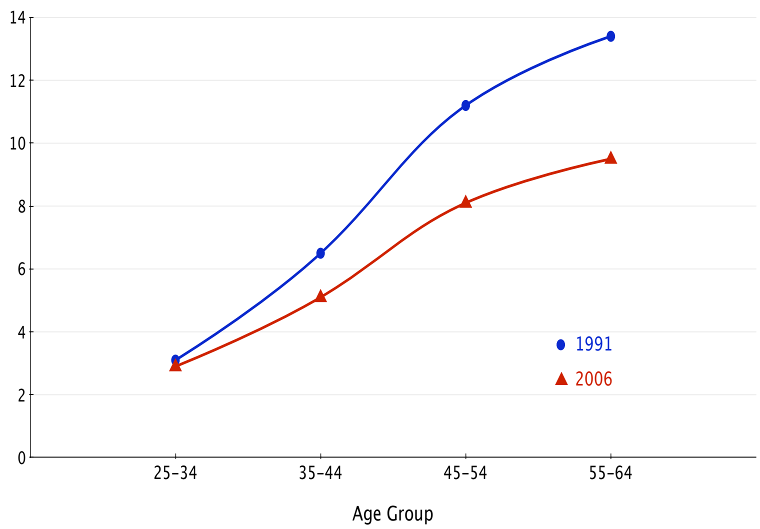
In the early 1970s some high profile companies defaulted on the defined benefit pensions they had promised employees. This lead to the 1974 Employee Retirement Income Security Act (ERISA), creating The Pension Benefit Guarantee Corporation (PBGC), with the purpose of insuring defined benefit pensions offered by the private sector. The legislation required employers to pay for the insurance. Average pension premiums have risen over the years. The model will take into account this increase in premiums, and determine how much rising fixed costs account for the decline in pensions.

Expected job tenure is important because the insurance cost must be paid with every new employer. Declining job stability, or increased turnover in the U.S. labor market is well documented in the literature. Farber (2007) examines Current Population Survey (CPS) data from 1973-2006 and finds a downward trend of long-term tenure in the private sector. Kambourov and Manovskii (2008) look at the Panel Study of Income Dynamics (PSID) from 1968-1997 and find increased occupational and industry mobility over time for most age and education groups. Bernhardt et al. (2000) compare National Longitudinal Survey (NLS) data from 1966-81 to 1979-94 and find a higher separation rate for the younger cohort. The labor market has experienced increases in both dismissals and quits, especially for longer-tenure workers, Valleta (2007).

It has been proposed that incentives connecting workers to their jobs have changed, Neumark (2000). Haverstick et al. (2010) for example, show that workers with defined contribution plans and 5 to 10 years of tenure are 23% more likely to leave their job than similarly tenured workers with a defined benefit plan. Friedberg et al. (2006) is the first to connect the incentive structure of the defined benefit contract to the labor market with a search model. They find that either lower search costs or improved matching can lower the value of deterring search and reduce defined benefit offers by employers. This paper also endogenizes employee compensation, but instead of examining the supply side of pensions, employee incentives are considered. In practice, private pensions tend to be voluntary, Dorsey et al. (1998). In the model, they will be as well.

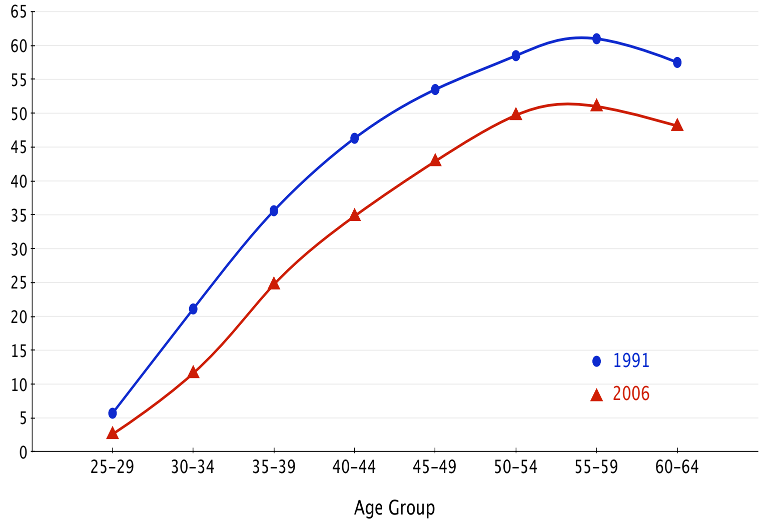
Figure 2 shows median worker tenure rates by age for men in 1991 and 2006. Tenure has fallen across every age group. Figure 3 shows the percent of employed workers with 10 years or more of tenure with their current employer. Long-term tenure rates also show a consistent drop across all age groups.

Figure 2: Median Tenure Rates for Men by Age Group



In practice, when a firm takes on a new employee with a DB pension, the insurance premium has to be paid every year until the firm has no further obligation to the employee. Annual insurance premiums consist of a fixed cost, and a variable cost depending on the funding level of the pension. A firm with a fully-funded pension account pays the same insurance cost for an employee who stays with the firm 10 years as an employee who stays 30 years. It should not be surprising that firms require a vestment period before workers earn any claim to future payments. Workers with very short tenure taking DB plans are very expensive to an employer. Other explanations for the vestment period include training costs for firm-specific capital as in Ippolito (1997), or delayed compensation as an incentive against shirking as in Lazear (1979). The insurance cost does not apply to defined contribution pensions because the employer has no future obligation to the worker

Figure 3: Percent of Men Employed with 10 Years or More of Tenure



which could end in default. This paper will transfer the insurance cost from the employer to the employee during the vestment period, so an employee will only take a DB plan when the expected benefits exceed the costs.

Why does the decline in DB pensions matter if workers have access to individual annuities? Data show that the annuity market is thin, and workers are not replacing their DB pensions one-for-one with annuities. Pashchenko (2010), for example, tries to account for under-annuitization in the U.S. Theoretically, all agents should fully annuitize their savings before any uncertainty is realized, see Davidoff et al. (2005). However, this requires full annuitization at birth. The model will show that defined benefit pensions are not subject to the same adverse selection effects that plague the individual annuity market. Information about earnings allows employers to pool agents of a similar earnings class with the same quantity-price contract. In the private market, high-risk (long-lived) agents will purchase more insurance than low risk (short-lived) agents, driving up the price. This is pre-retirement adverse selection. Further, low-risk agents can "cash out" their annuity early in retirement, while pensions are illiquid. Cashing out drives up the price of annuitites, as shorter-lived annuitants do not roll their variable annuities into immediate annuities, or do so, but cash out early. This is post-retirement adverse selection.

Adverse selection can make private annuities more expensive than employer-provided defined benefit pensions. However, the fixed cost attached to the DB pension may make it unattractive to workers who expect short tenure with a firm. Will decreases in expected tenure account for the fall in defined benefit pensions? Has the increase in insurance costs contributed to the decline? Has the increase in longevity increased the demand for DB pensions and annuities? The model is introduced in the next section. The calibration is discussed, and the paper will conclude with the model findings and implications for future work.

2 Model

Finitely-lived agents will have one job offer arrive every period during their working life. They may keep their old job or accept the new one. When an agent takes a new job, he makes a decision over compensation. he may accumulate defined benefit promises from his employer and recieve a wage, or receive a wage only and save in an annuity through a competitive market. The DB pension promises a fixed payment in retirement, every year, until the agent dies. The account is illiquid; an agent can never cash out his pension. This characteristic of DB pensions serves to evade some adverse selection effects post-retirement. The alternative annuity savings option is perfectly liquid. Purchases of any quantity of the one-period contract may be made, as in Hong and Ríos-Rull (2007).

The model will include default risk. Firms do not pay worker pensions until the worker reaches retirement, but the firm may die before the worker. To purchase insurance against firm default, as mandated by law, employees will pay the insurance fee upfront during their first period of employment. They will not accumulate any pension promises until their second period of employment with the firm, making the first period the "vestment period" usually observed in practice with DB pensions.

2.1 Preferences

Workers are finitely-lived and heterogeneous with respect to their survival probabilities, π_t^i. Survival type i is private information. All workers retire at the same age $t = R$ and may live up to age $t = T$. Preferences are given by

$$\mathbb{E}\left[\sum_{t=1}^{T} \pi_t^i u(c_t)\right].$$

2.2 Technology

Workers could have one to several employers over their working life. There is no capital in this economy, production is given by

$$Y = \theta N.$$

A firm is defined by its productivity θ, distributed discretely and uniformly over $(\underline{\theta}, \bar{\theta})$. Agents will vary by their productivity type j. An agent of productivity type j will only be matched with firms from a subset of the distribution, $(\underline{\theta}^j, \bar{\theta}^j) \subset (\underline{\theta}, \bar{\theta})$. Productivity type is fixed, but agents will meet higher θ employers within their earnings class $(\underline{\theta}^j, \bar{\theta}^j)$ over their working life. Endogenous job turnover allows earnings to increase over an agent's working life.[2]

Firms are also finitely-lived; they face a constant probability of dying δ every period. If a firm dies, any employees are separated from their job, and the firm defaults on all DB pension promises. For this reason, policy requires pensions to be insured. Whenever a worker accepts a DB pension, insurance cost I must be paid to the insurance company. If the firm dies before the worker does, the insurance company takes over the pension payments. When a firm dies, another firm, identical to the last, takes its place.

The combination of endogenous and exogenous separation will determine the expected tenure of an employee at a firm. Workers enter the model ready to work.

[2] Gottschalk (2001) finds that mean wage growth is largely due to movement between jobs.

All workers have a single job opportunity arriving at the beginning of each period. The constant returns to scale technology in labor allows firms to hire as many workers as they can be matched with. Workers randomly match with firms. There is no utility from unemployment, so agents will always be employed. When a worker is not separated he has the option of sticking with his old job or taking the new offer. When a worker is separated from his job exogenously (the firm dies), he has to start at the beginning of the wage distribution $\underline{\theta}^j$.

2.3 Assets

Workers accumulate savings s for retirement which are invested in one-period annuities. The actuarially fair return R_t^s is determined from the relative demand of high to low survival type agents of age t. A worker may also have a DB pension plan of size p accumulating promises for future retirement payments. The retirement payment $\bar{p}$ is a function of the total pension savings at retirement p_R. During working life the period return to a pension is also determined from the relative demand from low to high survival types, and is given by R^p. The interest rate is zero; returns are determined by survival probabilities only.

2.4 Government

The government will tax workers τ to fund a PAYGO social security system. When workers are retired they will receive a transfer T^j, depending on their productivity group, from the government. This is a public source of longevity insurance. In this sense the model recreates the three tier system observed in the US: publicly-provided, employer-provided, and individually-purchased annuities.

The government plays a second role. It insures worker pensions by charging a fixed cost I_t when a worker decides to take a defined benefit pension. The government will then take over the pension payments to the worker in the event of the firm's death.

2.5 Decisions

Workers have a choice of how to be compensated. Let θ^* be after tax wage: $\theta^* = \theta(1-\tau)$. Workers could take a wage only, equal to their marginal product after-tax, $w = \theta^*$. They could also choose to take a wage, $w = (1-\psi)\theta^*$, and accumulate a pension. If they opt for a pension, each period after the vestment period, their pension grows by $\psi\theta^*$. The fraction of earnings forgone each period for the pension, $\psi \in (0,1)$, is the same across all firms. Vestment is the first period after the worker accepts the new job with the pension.

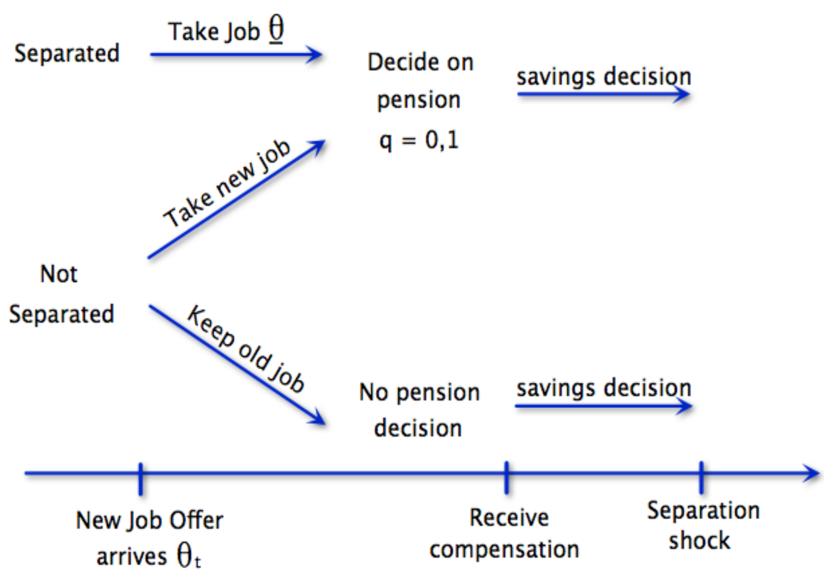


Figure 4: Timing

Instead of accumulating pension promises, the worker pays a fixed insurance cost I_t. Take-home wage will then be a function of the worker's job decision and pension decision.

A worker makes up to three decisions each period. After deciding on job placement, and compensation, the worker decides how much to save. Figure 4 summarizes the timing within a period. A worker who has been separated from his job starts at the bottom of the wage distribution with $\underline{\theta}$. He decided whether to take a pension, and how much to save. A worker who was not separated decides whether to keep the old job, θ_{t-1}, or take the new job θ_t. At the end of the period the separation shock hits.

Let the value from sticking with job θ_{t-1} for a worker of survival type i, productivity type j and age t be $W_{t,i,j}$, and the value from taking a new job θ_t, be $X_{t,i,j}$. With probability δ a worker will be exogenously separated from his job, and forced to take a job with productivity $\underline{\theta}$. With probability $(1-\delta)$ he will get to choose: $\max\{W_{t,i,j}, X_{t,i,j}\}$. At the beginning of age $t-1$ the agent has to make decisions to maximize his current utility and his future value. His future value during working years, $t < R-1$, is given by $V_{t,i,j}(s_t, p_t, q_t, \theta_{t-1})$, shown in equation 1. It depends on the savings and pension promises he brings into the next period, s_t and p_t, whether he is currently pensioned, q_t, and his job at age $t-1$, θ_{t-1}.

$$V_{t,i,j}(s_t, p_t, q_{t-1}, \theta_{t-1}) = (1-\delta) \sum_{\theta_t \in (\underline{\theta}^j, \bar{\theta^j})} \max\{W_{t,i,j}(s_t, p_t, q_{t-1}, \theta_{t-1}), X_{t,i,j}(s_t, p_t, \theta_t)\} \Pr(\theta_t) + \delta X_{t,i,j}(s_t, p_t, \underline{\theta}^j). \quad (1)$$

The full expression of $W_{t,i,j}$ is below. The value to a worker of survival type i of staying with his current job depends on his current savings, s_t, pension account balance p_t, whether he is currently pensioned q_{t-1}, and his wage θ_{t-1}. His value next period $V_{t+1,i,j}$ depends on future wage offers, as well as all of the variables just listed. If he is not pensioned, $q_t = 0$, his wage is equal to his after-tax productivity θ. If he is accumulating pension, he only receives fraction $1-\psi$ of this quantity; see equation 3. Pension promises accumulate by $\psi\theta^*$ if he is vested. If he did not choose a pension when he accepted the job, the pension grows at the rate of return on pension funds R_t^p, shown in equation 4. Like savings, the period return is the inverse of the average weighted survival probability of the agents holding the asset.

$$W_{t,i,j}(s_t, p_t, q_{t-1}, \theta_{t-1}) = \max_{s_{t+1}} \left\{ u(c_t) + \pi_t^i V_{t+1,i,j}(s_{t+1}, p_{t+1}, q_{t+1}, \theta_{t-1}, \theta_{t+1}) \right\} \quad (2)$$

$$c_t = w_t(q_t) + R_{t-1}^s s_t - s_{t+1}$$

$$w_t(q_t) = \begin{cases} \theta_{t-1}^* & \text{if } q_t = 0 \\ (1-\psi)\theta_{t-1}^* & \text{if } q_t = 1 \end{cases} \quad (3)$$

$$p_{t+1} = \begin{cases} R_t^p p_t & \text{if } q_t = 0 \\ R_t^p (p_t + \psi \theta_{t-1}^*) & \text{if } q_t = 1 \end{cases} \quad (4)$$

$$s_{t+1} \geq 0$$

$$q_t = q_{t-1}$$

If the worker takes the new job with productivity θ_t, his value is $X_{t,i,j}$, and he must choose compensation $q_t = 0, 1$, in addition to savings. $X_{t,i,j}$ also depends on his current amount of savings s_t and pension p_t. His value next period is a function of his savings, pension, pension status, and the wage he took with this job, θ_t. If he decides to take a pension, $q_t = 1$ in equation 6, he must pay the fixed cost I_t at this time. If he decides to not take the pension, $q_t = 0$, he gets paid the full after-tax marginal product θ^*. Pension quantity grows by the rate of return

$$X_{t,i,j}(s_t, p_t, \theta_t) = \max_{q_t, s_{t+1}} \left\{ u(c_t) + \pi_t^i V_{t+1,i,j}(s_{t+1}, p_{t+1}, q_t, \theta_t) \right\} \quad (5)$$

$$c_t = w_t(q_t) + R_{t-1}^s s_t - s_{t+1}$$

$$w_t(q_t) = \begin{cases} \theta_t^* - I_t & \text{if } q_t = 1 \\ \theta_t^* & \text{if } q_t = 0 \end{cases} \quad (6)$$

$$p_{t+1} = R_{t-1}^p p_t \quad (7)$$

$$s_{t+1} \geq 0$$

only regardless of his pension decision, because this is the vestment period; see equation 7. A worker who has been separated from his job will have value $X_{t,i,j}(s_t, p_t, \underline{\theta})$ where the wage schedule is given by

$$w_t(q_t) = \begin{cases} \underline{\theta}^* - I & \text{if } q_t = 1 \\ \underline{\theta}^* & \text{if } q_t = 0. \end{cases} \tag{8}$$

A worker's value in retirement depends on his survival type i, productivity type j, age t, his pension p_t, and the balance of his savings s_t. In retirement he consumes pension and social security payments, $\bar{p}$ and T^j, and decides how fast to run down his savings. In retirement a worker no longer has job decisions, so the future value is given by $V^R_{t+1,i,j}$ For all $t \geq R - 1$:

$$V^R_{t,i,j}(p_t, s_t) = \max_{s_{t+1}} \left\{ u(c_t) + \pi^i_t V^R_{t+1,i,j}(p_{t+1}, s_{t+1}) \right\} \tag{9}$$

$$c_t = \bar{p} + T^j + R^s_{t-1} s_t - s_{t+1}$$

$$s_{t+1} \geq 0$$

2.6 Equilibrium

Definition 1 A competitive equilibrium is a set of prices R^s_t, R^p_t and a set of decision rules $p_t(s_{t-1}, p_{t-1}, q_t, \theta_{t-1}, \theta_t), s_t(s_{t-1}, p_{t-1}, q_t, \theta_{t-1}, \theta_t)$ for all survival and productivity types such that

(i.) Decision rules solve the worker's optimization problem given prices.

(ii.) Firms earn zero profit.

(iii) Insurance companies earn zero profit.

The expected lifetime of an agent of survival type i at age t is given by ℓ^i_t. The annual pension payment once a worker retires at age $t = R$ is p_R/ℓ^p_R, where ℓ^p_R is the average expected retirement life of a pension holder. Let p^i_t be the total pension claims held at age t by survival types $i = L, H$. Then the average survival probability at age t of pension holders is

$$\pi_t^p = \frac{p_t^L \pi_t^L + p_t^H \pi_t^H}{p_t^L + p_t^H}.$$

The period return to a pension is $R_t^p = (\pi_t^p)^{-1}$.

Similarly, the period return to savings (individual annuities) is $R_t^s = (\pi_t^s)^{-1}$. If s_t^i is the total savings of agents of type i at time t, the expected period survival probability of an annuitant is

$$\pi_t^s = \frac{s_t^L \pi_t^L + s_t^H \pi_t^H}{s_t^L + s_t^H}.$$

The return to both pension accumulation and savings is a function of the average weighted survival probabilities of the agents demanding each asset. The greater the demand of an asset from a high-survival types relative to low-survival types, the higher the price, or the lower the return.

3 Calibration

3.1 Preferences

Workers enter the model at age 24, work until retirement at age 62, and then consume from savings, pension and social security payments until they die. The maximum age an agent may live is 102. Survival probabilities will be unity before retirement for both types. Agents will then face a constant chance of death every period after retirement, as shown in table 1. With equal measures of high and low-survival agents going into retirement, the 1992 expected lifetime is about 77 years. Changes in insurance costs, separation rates and survival probabilities from 1992 to 2006 will all be considered. Table 1 shows the period survival rates for high and low types after retirement in both 1992 and 2006 calibrations. A high-survival type in the 2006 calibration has a 7% chance of dying at the end of every two-year period.

Table 1: Survival

	π^L	π^H
1992	0.88	0.90
2006	0.91	0.93

Risk aversion γ was chosen to be 2, within the standard range for utility given by

$$u(c) = \frac{c^{1-\gamma}}{1-\gamma}.$$

3.2 Technology

The number of values between $\underline{\theta}^j$ and $\bar{\theta}^j$ is important for turnover. If there are too few values, most turnover will be exogenous. If there are too many, too much turnover will be endogenous. The Bureau of Labor Statistics reports that about one-third of turnover was involuntary between 2000-2006.[3] Let P be the number of firms per productivity type. $P = 10$ generates a 1:3 ratio of exogenous to endogenous turnover in the 2006 calibration of the model.

Table 2: Earnings Distribution

Productivity type	j	$(\underline{\theta}^j, \bar{\theta}^j)$	weight
Low	1	(0,.25)	.57
Middle	2	(.25,.50)	.30
High	3	(.50,1)	.13

[3] Involuntary turnover has increased to one-half of total turnover in recent years, but this value is unusually large compared to historical data.

Social security accounts for 44% of average retirement income, Munnell et al. (2009). This proportion is higher for low-income brackets, and lower for higher income brackets. Since social security crowds out other forms of longevity insurance, it is important to have some kind of income distribution in the model. There will be 3 income groups, normalized to a (0,1) after-tax uniform distribution. Table 2 describes the range and weight of each group. Low productivity workers, $j = 1$, are only matched with firms with θ between 0 and .25. Similarly for the other types; high productivity workers, $j = 3$, are only matched with firms with θ between .5 and 1.

Weights are given to each productivity type to approximate the U.S. earnings distribution. Having various earnings groups is important for two reasons. First, crowding out effects are different for different income brackets. Second, without fixed effects any worker would become a high earner or low earner. This would make social security calculations difficult. The model approximates social security without adding to the computational intensity of the problem. More detail about the productivity groups is available in appendix A.

3.3 Assets

In the model, employees pay insurance costs. It will be a function of his expected lifetime, and the annual fee i. This fixed cost is 5.1% of the median annual salary for a 30-year old hire in 1992. It is 7.4% of the median annual salary for a 30-year old hire in 2006. These costs are 3.0% and 4.5% of median salary for a 50 year-old new hire in 1992 and 2006 respectively. Table 13 summarizes, and more detail on the calculations of i is available in appendix B.

The amount of wage forgone for pension accumulation is $\psi = 0.14$. Gustman et al. (1994) look at a nationally representative data set of workers with defined benefit pensions and found the average present value of pension wealth came to about $180,000 in 1992 dollars. This quantity is 14% of the cumulative discounted value of earnings from hire to retirement age. Table 4 describes the pension contract parameters. The period insurance cost i is used in the following formula to determine the fixed cost: $I_t = i \times \ell_t^P$.

Table 3: Insurance Costs of DB Pension in 2006 Dollars

		Insurance Cost	As % of Median Annual Salary
1992	30 year-old hire	\$2,249	5.1%
	50 year-old hire	\$1,329	3.0%
2006	30 year-old hire	\$3,498	7.4%
	50 year-old hire	\$2,118	4.5%

Table 4: Contract Parameters

Symbol	Description	Value	Source
ψ	fraction of wage contributed to pension	0.14	Gustman et al. (1994)
i	'92 insurance cost	0.000324	PBGC
	'06 insurance cost	0.000452	

3.4 Government

In the US, all workers face the same social security tax rate. The employee pays 4.2% and the employer pays a 6.2% rate. In the model, this will all come from the employee since he is paid his marginal product. Benefits depend on average earnings, but are progressive. A worker in the bottom half of the earnings distribution can expect about half of his wages to be replaced, while that ratio is much smaller for a worker on the upper half of the distribution. More on the social security benefit function is available in appendix A.

3.5 Turnover

Expected job tenure at a new job is important for the pension decision, and is available through the BLS. This will depend on both the exogenous rate, δ, and endogenous separation. The exogenous separation rate, δ, will be calibrated so that the model produces tenure rates that match those reported by the BLS for men in 1992 and 2006 respectively. If age groups are given the same weight, then average tenure in 1992 is 8.5 years, and drops to 6.9 years in 2006.

Table 5 gives a summary of all of the parameters. The separation rates which produce average tenure of 8.6 and 6.8 years for 1992 and 2006 are $\delta = 0.0485$ and $\delta = 0.0925$. These correspond to a 4.85% and a 9.25% chance of being exogeneously separated from a job over a two-year period in 1992 and 2006.

Table 5: Parameters

Symbol	Description	Value
	wage group 1	(0,0.25)
θ	wage group 2	(0.25,0.50)
	wage group 3	(0.50,1.00)
λ	group weights	(.57,.30,.13)
π^L,π^H	’92 2-year survival probability	0.880, 0.900
	’06 2-year survival probability	0.900, 0.935
γ	risk aversion	2
ψ	fraction of wage contributed to pension	0.14
i	’92 insurance cost[a]	0.000324
	’06 insurance cost	0.000452
δ	’92 separation rate	0.0485
	’06 separation rate	0.0925

[a] Insurance costs are per 2-year period.

4 Findings

This section compares the number of pensioners predicted by the 1992 and 2006 model calibrations. Two experiments isolate the effects from increased separation and increased insurance costs. Also, a welfare experiment separates the changes in welfare due to survival changes, and the changes due to changes in defined benefit coverage.

Table 6: Tenure (in years) for 1992 and 2006 Calibrations

	δ	Average tenure	Average tenure of pensioners	Average tenure (no pension)
1992	0.0485	8.6	12.9	6.2
2006	0.0925	6.8	9.8	6.0

Table 6 shows how tenure changes from the increase in separation rate by comparing the 1992 and 2006 calibration. The average tenure targets were 8.6 and 6.8. The average tenure of pensioners falls from about 13 years to just under 10. Could this be enough to make defined benefit pensions unattractive? The average tenure of agents without DB pensions falls only slightly, showing that pensioned workers are disproportionately affected by the change.

Table 7 highlights the main findings of the model. The percentage of retirees entering retirement with any amount of defined benefit pension is reported for the three earnings (productivity) groups. The model predicts that the group with the greatest change in DB pensions is the middle class. This is because the low productivity agents started off with lower pension coverage; the fixed cost was a greater deterrent. The high-productivity are less bothered by the fixed cost, and so they respond less to the threat of losing a pensioned job from increased turnover.

Table 7: % with Positive Pension Wealth at Retirement by Earnings Group

j	1992	$\uparrow \delta$	$\uparrow \delta, i$	2006	change
1	58.5	55.6	45.3	52.2	-6.3
2	92.9	66.5	60.4	71.2	-21.7
3	96.2	72.5	69.7	83.2	-13.0
total	74.2	61.0	53.0	60.7	-13.5
data	70.0			51.0	-19.0

Table 7 also breaks down the effects from each change. The first experiment changes the separation rate δ only. This change alone accounts for a decline of 13.2% in retired agents with DB pensions. Increasing the insurance cost accounts for further decline of 8%. When survival probability increases in the 2006 calibration, longevity insurance demand increases 7.7%. This effect almost completely offsets the decline from the increased insurance costs. The model predicts a total change in the number of retirees with defined benefit pensions from 1992 to 2006 of 13.5%. A change of 19.0% was observed in HRS data. *The model accounts for 71% of the fall observed in the data.*

The next table focuses on a different subgroup: workers approaching retirement. Figure 1 from the introduction reports the number of 51-61 year olds who had a pensioned job at the time of interview. Table 8 compares these data from the HRS to model predictions for the same age cohort. While the model over-predicts the levels for this cohort, it predicts a change of 13 percentage points, the same change observed in the data. The model over-predicts older workers with pensions, and under-predicts younger workers with pensions because the fixed cost is a function of age. Younger workers have to pay higher insurance because they are riskier. In practice it is not clear if the higher insurance cost of younger workers is passed from the firm to the worker.

Table 8: Model Predections: % of Workers aged 51-61 with a Current Pension

	1992	2006	change
Model	52	39	13
Data	27	14	13

Not only are agents with DB pensions declining, the size of the pensions themselves are shrinking, see table 9. Retirement wealth in the model consists of the present value of social security, the present value of employer pension payments, and savings (annuities). The table presents the present value of the mean pension of that earnings group as a fraction of the mean retirement wealth for that group. The large change in mean pension size across all productivity classes suggests that the higher separation rate has had a significant impact on agents' abilities to accumulate large pensions, making the fixed insurance cost relatively more costly.

Table 9: Present Value of Mean Pension as % of Mean Retirement Wealth by Earnings Group

j	1992	$\uparrow \delta$	$\uparrow \delta, i$	2006
1	23	9	7	7
2	37	17	16	15
3	43	22	21	24
total	30	13	11	12

In the model agents have the highest utility per-period in the 1992 calibration. Increasing separation rate lowers utility because it knocks agents to the bottom of the earnings distribution more often. Increasing survival implies agents must consume less each period so that resources last longer. How much of the change in utility is due to increased separation? Table 10 shows the change in utility from the 1992 calibration when survival probabilities and prices are changed to the 2006 values. About half of the decline in utility from the 1992 to the 2006 calibration is due to higher prices and longer life, and the other half is due to higher separation.

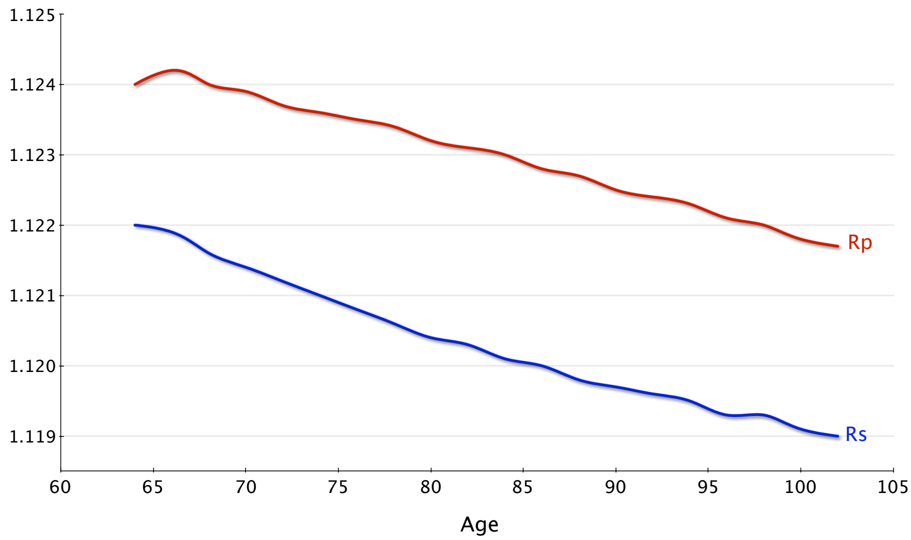
Table 10: % Change in Utility from 1992 Calibration by Earnings Group

j	2006 prices only	2006 Calibration
1	-4.2	-10.7
2	-4.6	-7.9
3	-5.4	-8.8
total	-4.5	-9.6

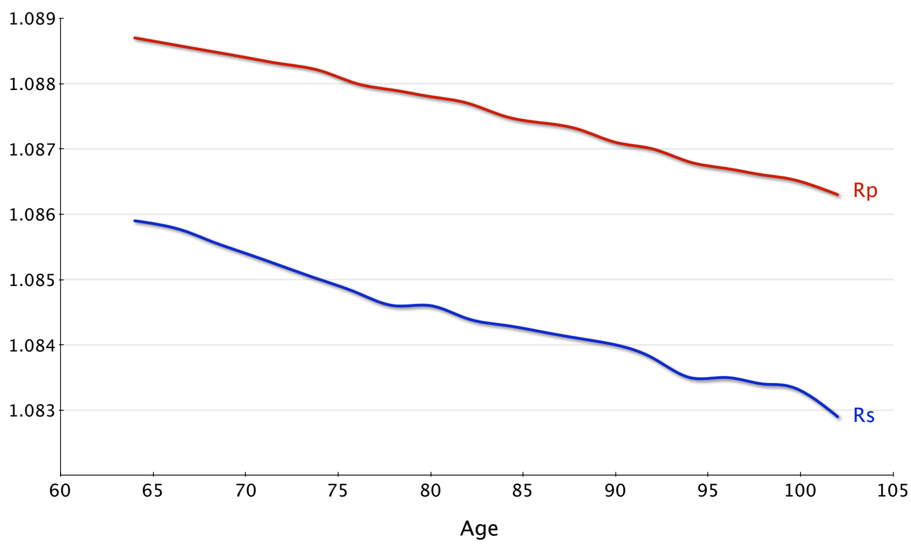
The period return on the two assets through retirement is shown in figure 5. The period return to a pension is higher than the annuity because it suffers less from adverse selection. There are two reasons pensions suffer less from adverse selection. First, the amount invested in the pension, 14% of earnings, is the same for both survival types. With annuities, high-survival types will save more than low-survival types, driving up the price, or lowering the return. The second reason is that both survival types run down their pension at the same rate because it is illiquid, and the payment function is fixed. With the annuity, low survival types may "cash out" much of the asset early on in retirement. The second explanation doesn't seem to be as important as the first, because the slope of the annuity returns seems very close to the slope of pension returns. The gap at retirement age persists throughout retirement, suggesting the majority of adverse selection occurs before retirement.

Pensions are not free of adverse selection however. The low-survival types may decide not to take a pension. If only high-survival agents accumulate pension, the return could be even less than annuities.

Figure 5: Asset Returns under the 1992 and 2006 Calibrations



(a) 1992



(b) 2006

5 Conclusion

The decline of defined benefit pensions is puzzling, because they are not being replaced one-for-one with annuities. People are living longer, but they are entering retirement with less longevity insurance than previous generations. One of the possible explanations for the switch from defined benefit to defined contribution pensions is declining job tenure. This mechanism was tested by introducing job turnover in a life-cycle model and calibrating separation to match average tenure from 1992 and 2006. The model also considered higher the increasing insurance cost of DB pensions, and increased survival probability. The model predicts that the increase in separation alone is responsible for a decline of 17.8%. Increased insurance costs account for an additional decline of 13.1%, but it is reversed by the increase in DB pensions caused by longer survival.

Adverse selection drives up the price of individual annuities, creating demand for employer-provided defined benefit pensions. DB pensions suffer less from adverse selection because employers are able to offer a pooling contract: agents of different survival (risk) types must take the same quantity. The private market cannot offer quantity pooling contracts because contracts are not exclusive. High-survival (high risk) agents purchase greater quantities of the annuity and drive up the price. Despite the price advantage the DB pension has over individual annuities, it may not always be more attractive. Policy requires an insurance premium to insure against firm default. When exogenous separation increases, workers expect shorter tenure with the firm, and that may make the fixed cost too high for some.

The model accounts for 71% of the fall in defined benefit pensions among retirees, and matches the change in working agents approaching retirement with DB pensions. Other factors driving the decline could be related to firm incentives. The model also abstracts from DB pension contract complications. For example, most DB pensions reward employees with long tenure at the expense of employees who leave the job with short tenure. In this model firms pay workers their marginal product every period. Future work will examine the effects these incentives have on worker decisions. There is a preview of this work in appendix C.

Is there anything the government can do to encourage greater coverage of longevity risk? Workers would be better off with coverage, but the market price is high. The key is to recreate the quantity pooling that was possible with employer-provided DB pensions. An option could be an industry-specific pension system, instead of employer-specific. In this sense, the worker could avoid repaying the fixed insurance cost when he or she switches employers. If she is able to roll over her DB pension, as one does with a DC pension, increased turnover will have less of an effect on pension decisions.

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A Income and Social Security

The US Census Bureau reports an earnings distribution for men in 2010 as shown in table 11. The formula used by the SSA is shown in below. If E is annual earnings, social security benefits are b.

Table 11: Full-Time Male Earnings Distribution 2010

Earnings	Percent	Cumulative
<$25,000	23.8%	23.8%
$25,000-49,999	33.4%	57.2%
$50,000-74,999	20.9%	78.1%
$75,000-100,000	9.5%	87.6%
>$100,000	12.4%	100.0%

Source: US Census.

$$b = \begin{cases} .9*\text{E} & \text{if } E < 8,998 \\ .9*8998 + (\text{E-8,998})*.32 & \text{if } 8,998 < E \leq 54,204 \\ .9*8998 + (\text{54,204-8,998})*.32 + (\text{E-54,204})*.15 & \text{if } 54,204 < E \leq 106,800 \\ .9*8,998 + (\text{54,204-8,998})*.32 + (\text{106,800-54,204})*.15 & \text{if } E > 106,800 \end{cases}$$

Period earnings θ are distributed $(0, 1)$. There are three income classes, which are divided as $\theta_1 \in (0, .25)$, corresponding to earnings $< \$50,000$, $\theta_2 \in (.25, .5)$, corresponding to earnings between $\$50,000$ and $\$100,000$ and $\theta_3 \in (.5, 1)$ corresponding to earnings greater than $\$100,000$. The three classes have the following population weights, taken from table 11: $\lambda = (.57, .30, .13)$. To calculate social security benefits for each period in retirement, earnings E in the benefit equation are scaled down by $\$200,000$.

B Fixed Costs and Survival

In 1992 DB pension insurance was a fixed rate of \$ 19/year, plus an additional \$9 per year per \$1,000 underfunded, with a maximum rate of \$72 for underfunded plans. As many plans are severely underfunded, the PBGC phased out the maximum rate by 1997. By 2006 the fixed rate had increased to \$33/year, and the variable cost remained the same, but without any cap, PBGC (2011).

Table 12: PBGC-Insured Plans by Premium Paid (2005)

Variable Rate per Participant	Plans	% of All Plans
\$19 (No Variable-rate)	15,309	51.7
\$19.01-\$38.99	1,684	5.7
\$39.00-\$58.99	2,048	6.9
\$59.00-\$78.99	1,839	6.3
\$79.00-\$98.99	1,609	5.4
\$99.00-\$118.99	1,190	4.0
\$119.00-\$218.99	2,941	10.0
\$219.00-\$318.99	1,036	3.5
\$319 or more	1,949	6.6

Source: PBGC databook (2006).

The following statistics from the PBGC databook 2006 table S-40, shown here in table 12, allow for an estimate of average annual fees. The average annual insurance fee comes to about \$69. If we assume the distribution of under-funded firms was similar in 1992, and keeping the cap in mind, we estimate an annual insurance fee of \$32 in 1992 dollars (\$46 in 2006 dollars).

The formula for computing the fixed cost of the defined benefit plan is

$$FC = i * \mathcal{E}_t[l].$$

It will be a function of age, where $\mathcal{E}_t[l]$ is the expected lifetime of a newly-hired agent of age t, and the annual insurance fee i. Expected lifetime of a 60-year old man has increased: he could expect to live an additional 18.9 years in 1992, and by 2006 he expects to live an additional 20.7 years.[4] The fixed cost of a pension for a newly hired 30 or 50 year-old employee is described below in table 13. The median annual salary for men in 1992 and 2006 in current dollars is $30,796 and $47,586 ($44,346 and $47,586 in 2006 dollars).

Table 13: Fixed Costs of DB Pension in 2006 Dollars

		Insurance Cost	As % of Median Annual Salary
1992	30 year-old hire	$2,249	5.1%
	50 year-old hire	$1,329	3.0%
2006	30 year-old hire	$3,498	7.4%
	50 year-old hire	$2,118	4.5%

The cost is probably large enough to deter short-term employees from taking defined benefit pensions. Normalizing the period insurance cost to the $\theta \in (0,1)$ income distribution

The average period earnings in the model are $\bar{\theta} = 0.3112$. Two-year periods imply annual earnings are 0.1556. The annual insurance cost is $69 in 2006, which is %0.145 of the median annual salary. So this amounts to $.00145 * 0.1556 = 0.000226$ per year for the 2006 2-year periods economy. The annual insurance cost of $32 in 1992 was 0.104% of the median annual salary, making the model cost $0.00104 * 0.1556 = 0.000162$ per year.

[4] 1992 lifetables and 2006 lifetables from National Vital Statistics Report.

C Extension: Contract with Tenure Rewards

The vestment period and fixed cost make DB pensions unattractive to short-term employees. However, there is an additional mechanism embedded in pension contracts that attach a worker to a firm. Benefits tend to be tied to tenure and wage in the last years of employment, Blake (2006). The schedule of earned benefits over tenure is displayed in table 14. DB plans may cross-subsidize workers with long tenure at the expense of those with short tenure, Friedberg and Turner (2010). This extension will explore the importance of this feature.

Table 14: Value of Pension Benefits as a Proportion of Salary

Year of employment	Present value of new benefits earned (%)	Value of accrued benefits (%)
1	0.32	0.32
10	0.98	6.88
20	3.10	32.58
30	9.18	115.68
40	26.08	365.14

Source: Blake (2006).

Table 14 gives evidence for strong cross-subsidization from low-tenure workers to longer-tenured workers. Every ten years the present value of new benefits earned per year increases threefold. The model without tenure rewards accounts for one-half to two-thirds of the fall in DB plans. Pensioned workers are not as attached to their employer as they will be under tenure rewards. This section asks how do these additional tenure incentives change pension decisions with an increasing separation rate?

In order to model the cross-subsidization from low-tenure to high-tenure workers, the equations of motion defining pension accumulation will change. Wage as a function of pension decisions remains the same as the baseline model. The only changes show up in equation 10. The values for ξ_{ten} are described in table 15. The subscript *ten* tracks the years of tenure with a firm.

$$p_{t+1} = \begin{cases} R_t^p p_t & \text{if } q_t = 0 \\ R_t^p (p_t + \xi_{ten}\psi\theta_{t-1}^*) & \text{if } q_t = 1 \end{cases} \tag{10}$$

In this environment ξ_τ is an increasing function of tenure, shown in table 15. From 2 - 12 years the fraction of forgone earnings that translate into pension promises from the employer increase from 0.25 to 0.75, an increase of a factor of 3. From 12 to 22 years ξ increases again to 2.25, an increase of 3 times. Finally, ξ increases to 6.75 by 32 years of tenure, another increase of 3 times. Should a worker obtain tenure for over 30 years, the benefits are substantial. However, a worker who is let go within 15 years of tenure loses quite a bit of compensation.

Table 15: Tenure Rewards

tenure	2-3 years	4-5	6-7	8-9	10-11	12-13	14-15	16-17
ξ_{ten}	.25	.35	.45	.55	.65	.75	1.05	1.35
tenure	18-19	20-21	22-23	24-25	26-27	28-29	30-31	32+
ξ_{ten}	1.65	1.95	2.25	3.15	4.05	4.95	5.85	6.75

The change in tenure from the increase in separation rate can be seen in table 16. To meet the decline in average tenure, the separation rate was increased by 68% (less than the baseline model). The difference between the average tenure of pensioners and non-pensioners is much larger than the baseline case, and closer to the data. According to the HRS, workers entering retirement in 1992 with defined beenfit pensions had an average job tenure of 17.6 years; the 1992 calibration predicts 17.4 years. In 2006 the HRS reports the average tenure of DB pensioners to be 16.8 years. The model predicts 15.5.

Table 16: Tenure

	δ	Average tenure	Average tenure of pensioners	Average tenure (no pension)
1992	0.0550	8.6	17.4	6.5
2006	0.0925	6.8	15.5	6.4

Table 17 compares results from both the extension and the baseline model to the data. The extension over-predicts the decline in pensions of workers approaching retirement, but closely matches the 1992 level reported in the HRS.

Table 17: Model Predections: % of Workers aged 51-61 with Pension

	1992	2006	change
Baseline Model	52	39	-13
Tenure Rewards	25	7	-18
Data	27	14	-13

Table 18 shows the change in the percent of retirement wealth provided by pensions for households who have accumulated pensions. The data shows a fall in the mean present value of a DB pension from 39% of retirement wealth to 24%, a decline of 38.5%. The baseline model over-predicts the decline of pension size, reporting a 60% decline. The extension under-predicts the fall in pension size, reporting a mere 25.0% fall. This is not surprising; under the tenure-rewards environment workers are less likely to voluntarily leave a pensioned job.

Table 18: Present Value of Mean Pension as % of Mean Retirement Wealth

(a) Baseline

j	1992	↑ δ	2006
1	23	9	7
2	37	17	15
3	43	22	24
total	30	13	12
data	39		24

(b) Tenure Rewards

j	1992	↑ δ	2006
1	47	44	35
2	47	45	35
3	56	55	43
total	48	46	36
data	39		24

It is easy to see the substitution away from pensions towards savings in table 19. Social security is increasing as a percent of retirement wealth because workers are entering retirement with less retirement wealth in 2006. This is due to two reasons: longevity insurance is more expensive due to worse adverse selection, and higher separation rates means more workers are bumped to the bottom of the wage distribution decreasing average lifetime earnings.

Adverse selection works differently under tenure rewards than the baseline model. Figure 6 shows the returns from 1992 and the first experiment, where only separtion rate is increased. In the baseline model, pension returns are consistently higher than returns to annuities. Under tenure rewards, this is not the case. Returns decrease for pensions because many of the low survival agents who were taking DB pensions in the 1992 calibration choose not to under the experiment with increased separation. Adverse selection becomes a problem for pensions under some cases with tenure rewards because pension decisions are more sensitive to tenure expectations, and the first to turn down the pension contract will be those who demand longevity insurance he least: the low survival agents.

This environment provides useful insights on the implications of tenure rewards. Workers become more hesitant to take pensions under the 2006 calibration with high turnover, because it takes longer to accumulate benefits, and they may be exogeneously separated from their job early. The extension has a drawback: the

Table 19: Wealth Sources as % of Mean Retirement Wealth

	class	1992	$\uparrow\delta$	2006
PV pension	1	20	5	3
per capita	2	30	9	7
	3	38	15	14
Savings	1	17	19	20
per capita	2	16	24	26
	3	24	36	37
PV Social	1	63	76	77
Security	2	54	67	67
	3	38	49	49

equilibrium described in the baseline model is altered because workers are no longer paid their marginal product every period. Workers with low tenure are paid less, and workes with high tenure are paid more.

Figure 6: Asset Returns