Explaining the Evolution of Pension Structure and Job Tenure

Leora Friedberg*
Department of Economics
University of Virginia
P.O. Box 400182
Charlottesville, Va. 22904-4182
and NBER

Michael Owyang†
Research Department
Federal Reserve Bank of Saint Louis
411 Locust Street
Saint Louis, MO 63102

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Abstract

Preliminary and incomplete. Workers have experienced a major shift in pension structure in the last twenty years. Defined benefit (DB) pensions used to be typical for most pensioned workers, but now most have defined contribution (DC) pensions like 401(k) plans. Fundamental differences in the structure of these pension plans affect the incentive to stay in a job. Past research offers theories to explain DB pensions but no unified explanation for DC pensions or for the change in pension structure. This paper uses a matching model with constraints on the structure of

*Friedberg is an Assistant Professor of Economics at the University of Virginia and a Faculty Research Fellow of the National Bureau of Economic Research.

†Owyang is an Economist at the Federal Reserve Bank of Saint Louis. The authors wish to thank Tim Cogley, Wouter den Haan, Douglas Fore, Ruben Hernandez, Rob Dittmar, David Laibson, Trish Pollard, and Robert Shimer for helpful comments. Partial funding was provided by TIAA-CREF, the University of Virginia's Bankard Fund for Political Economy, and the Federal Reserve Bank of Saint Louis. Abbigail J. Chiodo and Ganesh Seshan provided excellent research assistance. The views in this paper are the authors' alone and do not reflect the views of the Federal Reserve Bank of Saint Louis or the Federal Reserve System.

compensation to explain changes in pension structure and job tenure. An increase in uncertainty reduces the expected value of match duration and thus the appeal of DB pensions. We argue that uncertainty has increased because of the increasingly rapid pace of technological change, which has also altered the distribution of earnings, employment, and pension coverage.

1 Introduction

Workers have experienced a major shift in pension coverage in the last twenty years. Traditional defined benefit (DB) pensions have become steadily less common, while defined contribution (DC) pensions like 401(k) plans have spread, as shown in Figure 1. Among full-time employees with a pension in 1983, 69% had a DB plan and 45% had a DC plan; in 1998, 40% had a DB plan and 80% had a DC plan. Similarly, 64% of private retirement savings contributions went to DB plans in 1980, while about 85% went to DC plans in 1999.[1] At the same time, overall pension coverage declined somewhat, from 67% of employees in 1983 to 58% in 1998.[2]

Figure 1 about here

A pension is a form of deferred compensation.[3] Fundamental differences in the structure of pension plans affect the incentive to stay in a particular job. DB pension wealth accrues discontinuously with tenure; jumps in pension wealth at 5 years and later at 20-30 years of tenure reward a worker for staying. In contrast, DC pension wealth, equal to current contributions plus interest earned on accumulated contributions, accrues smoothly and is largely incentive-neutral.[4]

Past research offers a theory of DB pensions but no unified explanation for DC pensions or for the change in pension structure. This paper builds a model to explain changes in pension structure and associated changes in job tenure. We aim to bridge some key gaps in the literature on the structure of compensation. First, we develop a matching model with endogenous job destruction and moral hazard that can explain the use of a DB pension and the link between pension structure and job tenure. Second, we show what kind of shifts in the stochastic process governing productivity shocks can explain the decline in the use of DB pensions. Third, we demonstrate that the empirical implications of the model are supported by trends in pension structure, job tenure, and technological change. Thus, we present evidence that other factors

[1] Poterba, Venti, and Wise (2001).

[2] Weighted statistics computed from the Survey of Consumer Finances.

[3] By this definition, voluntary contributions by employees to 401(k) plans are not considered to be pensions. However, mandatory employee contributions, along with any employer contributions, are.

[4] Over the time period we study, cash-balance plans, which accrue in the manner of a DC pension but have other DB features and are classified as DB plans, were not widespread.

besides regulatory changes, which many researchers have focused on, can help explain the shift in pension structure.

The paper is organized as follows. In Section 2, we discuss pensions and pension regulation. While new regulations have made pensions more costly to administer, this has tended to affect pensions of all types. Moreover, the evolution of pension structure occurred at different rates across industries and occupations. Nevertheless, if regulatory changes do play an important role in explaining the shift in pension structure, our model provides a framework to understand the welfare implications of these interventions.

In Section 3, we review past research explaining the function of DB pensions. In a series of papers, Lazear argued that DB pensions are designed to encourage longer tenure and efficient retirement in a world of incomplete contracts. We discuss various reasons why longer tenure may be valuable, including moral hazard and match-specific investment.

In Section 4, we develop a matching model based on Den Haan, Ramey, and Watson (2000) and incorporate Lazear's notions of DB pensions. Workers face a choice of whether to shirk on the job; shirking offers a higher current payoff but leads the match to break up inefficiently. We show that a contract that defers compensation encourages optimal effort and longer tenure. The deferred payment is conditioned on tenure and shares some of the resulting match surplus with the worker – mimicking a DB pension. However, the contract breaks down in the face of certain types of technology shocks, which make it riskier to get bound into a long-term relationship. In the Appendix we broaden the notion of moral hazard by including match-specific capital which gradually decays in the absence of costly investment each period. We also argue that among the technology shocks that can cause the DB pension contract to break down is the introduction of new technologies that require a new set of worker skills.

In Section 5 (which remains unfinished in this draft), we discuss the empirical predictions that are generated by the model. We show trends in pension structure and job tenure. These trends are consistent with our explanation for the evolution of pension structure.

In Section 6 (which remains unfinished in this draft), we intend to use our model for a different purpose. Instead of generating an endogenous shift in pension structure, we analyze the outcome of government involvement in pension regulation. We show the consequences for job tenure, turnover, and hence welfare if the government prohibits or raises the costs of using DB pensions.

In Section 7, we discuss DC pensions. The modeling exercise makes it clear that contract-based theories of deferred compensation do not explain the existence of incentive-neutral DC pensions, which simply shift part of current pay into an account that is portable but often inaccessible until later in life. Other explanations for DC pensions rely on preferences either of workers or of the government for illiquid long-term saving. We conclude in Section 8.

2 Background on Pension Structure

In this section we set the stage by discussing the structure of DB and DC pensions, changes in the regulation of pensions, and past research on the shift in pension structure. Past research offers no theory of DC pensions nor a unified explanation for the change in pension structure.

2.1 The structure of pensions

DB pensions. A worker who qualifies for a DB pension will get an income flow until his death. The annual benefit is typically a proportion of either the worker's average or final salary, with the proportion increasing in tenure. We can summarize the flow in present value terms – pension wealth P_t is defined as the real present value, discounted actuarially to incorporate lifespan uncertainty, of the worker's expected future pension benefits, if the job ends at time t. Pension wealth accrual is the discounted change in pension wealth $\frac{1}{1+r}P_{t+1} - P_t$, if the employee works one additional year and then leaves.

The path of DB pension wealth accrual is characterized by sharp spikes. Figure 2 shows pension wealth accrual in a typical DB pension plan.[5] The first spike, in this case worth about $60,000, occurs when the worker vests, or becomes eligible for future benefits. Maximum vesting dates of 10-15 years were established in 1974 and have since been lowered to 5-7 years. While vesting yields a claim to future benefits, the claim is initially small. Pension wealth then accrues gradually as the future benefit rises with earnings growth, tenure, and the approach of retirement.

Figure 2 about here

Another spike worth over $100,000 occurs when the worker reaches the plan's early retirement date (ERD), often at ages 55-60 with at least 20 years on the job. At the ERD a retiree can first begin to receive cash benefits. The spike in Figure 2 results from an additional discrete jump in the pension benefit at the ERD. The early benefit is generally less than the full benefit available at the normal retirement date (NRD), and if it is significantly less, then another spike in pension wealth occurs at the NRD. Frequently, though, the penalty for retiring early is small, as is the case in Figure 2. At some point, pension accruals swing around and turn negative after the ERD or NRD, since the worker gets little or no further increase in the benefit level but foregoes income by not retiring.

DC pensions. DC pensions are simple: funds go into an account which earns a return, and the account is portable after vesting. Therefore, workers can take their accumulated funds with them when they leave their job. DC pension wealth after vesting is simply

[5] Information on these pension plans is taken from the Health and Retirement Study and has been slightly altered, as described in Friedberg and Webb (2000, 2002), to protect confidentiality. The HRS obtained detailed information about pension plans directly from employers of survey respondents.

$$P_t^{DC} = P_{t-1}^{DC}(1 + r_t) + c_t,$$

where r_t is the rate of return earned on assets accumulated through the previous period, and c_t is this period's contribution. Most DC pensions have vesting periods that are either immediate or less than two years.[6] The tax treatment of DB and DC plans is similar. Contributions are tax-deductible, and returns accumulate tax-free. Withdrawals from DC pensions, like DB pension benefits, are taxable.

The smooth path of DC pension wealth accrual shown in Figure 2 stands in stark contrast to the path of DB accrual. The positive and steady rate of DC pension accrual means DC pension wealth is largely age-neutral. In comparison, a DB plan tends to reduce worker mobility for many years after a worker starts a job and later encourages retirement when pension accruals turn negative.

2.2 Regulation of pension plans

Employer-provided pension plans were unregulated until the Employee Retirement Income Security Act (ERISA) of 1974. Since then, the government has frequently altered and tightened pension regulations. Clark and McDermed (1990) described the numerous legislative changes instituted through the late 1980s.

Regulatory changes. Changes in pension legislation and regulation have focused on three aspects of pension provision: funding of DB pensions, tax incentives for DC pensions, and constraints on the structure of both types of pensions. In terms of funding, ERISA established the Pension Benefit Guaranty Corporation (PBGC), which insures DB pensions and is funded by contributions that depend on the pension fund's actuarial projections. In addition, the government has set increasingly strict limits against both under- and over-funding. In terms of taxes, pre-tax contributions to DC pensions were circumscribed before ERISA. Since then, the government has established new tax breaks, particularly for voluntary contributions to 401(k) plans.

In terms of pension structure, federal laws have sought to further several goals. One goal has been to ensure that employers do not structure pension plans in order to provide disproportionate benefits to high-earning employees. Towards that end, the government has established ceilings on DB benefits and on DC contributions and has set minimum participation levels for voluntary DC plans. Another goal has been to ensure that workers who leave a firm early gain access to greater pension wealth. For example, ERISA established a maximum vesting period of 10-15 years, while subsequent legislation shortened it to 5-7 years. A third goal has been to ensure that workers who stay with a firm a long time continue to accrue pension benefits. Thus, the government prohibited an age cutoff on accumulation of DB pension credits, though tenure cutoffs are still allowed.

[6] 30-35% of DC plans vest immediately and another 20% vest in two years or less, while most DB pensions take five years to vest, according to Mitchell (1999).

Impact on pension structure. While some have argued that the rising costs of administering DB pensions explains the shift in pension structure, the actual impact on administrative costs has been somewhat complicated. The cost of running any type of pension – not just DB plans – has risen. Ippolito (1995) reported estimates from the Hay-Huggins Company (1990) indicating that only very small DB plans grew relatively more expensive compared to very small 401(k) plans, because fixed costs increased. For medium-sized and large firms, average administrative costs of DB and 401(k) plans rose at similar rates.

Clark and McDermed argued that many of the regulations on pension structure limited the extent to which DB plans could be designed as incentive contracts in order to, for example, encourage longer tenure. For example, before ERISA many DB pensions only vested at the normal retirement date (Ippolito 1988). However, pension wealth in DB pensions can still accrue highly nonlinearly; the plan in Figure 2 does not deliver a large fraction of pension wealth when it vests at 10 years.

2.3 Past research on trends in pension structure

Earlier researchers have offered a great deal of descriptive evidence on the nature of changes in pension structure. Most have used data reported by employers on Form 5500 to the Department of Labor. Form 5500 data covers the universe of plans with more than 100 participants, with comparatively little measurement error. The primary disadvantage is that Form 5500 reports no information about the characteristics of covered workers.

A series of papers, including Clark and McDermed (1990), Gustman and Steinmeier (1992), Kruse (1995), Ippolito (1995), and Papke (1999) have used the employer-reported data to investigate changes in pension coverage. Each of these papers showed that DB pensions remain more prevalent in large firms, industries such as manufacturing, and unionized jobs. Several of the papers also suggested that the proportion of workers in such jobs declined. For example, Ippolito (1995) argued that the movement of workers across jobs might explain half of the shift in aggregate pension structure.

Kruse (1995) and Papke (1999) used the Form 5500 data longitudinally. Kruse (1995) found that firms generally offered DC plans alongside existing DB plans, rather than terminating DB plans, during the 1980-86 period. He also analyzed reported data on administrative costs and concluded that changes in administrative costs might explain some but not all of the shift in pension structure. Using later data from 1985-92, Papke (1999) found that a substantial number of firms were shutting down both DB and other types of DC plans and replacing them with 401(k) plans.

In sum, it remains unclear to what extent changes in pension regulations – either by raising costs or by reducing the usefulness of DB pensions – explain the major changes in pension structure.

3 The Theory of DB Pensions

In this section, we discuss Lazear's research on defined benefit pensions. The existing theory of pensions was developed in a series of papers summarized in Lazear (1986), when DB pensions were the norm. Lazear focused on the incentive effect of DB pensions, which function as an efficiency wage. DB pensions encourage optimal effort and longer tenure when workers are young, then efficient retirement when they have aged.

DB pension incentives while young. In Lazear's model, employers structure compensation to deter shirking by workers whose effort cannot be observed perfectly. They do this by paying an efficiency wage, which exceeds what is available to a worker who is caught shirking and loses her job. A DB pension, whose value depends on the length of job tenure, functions as an efficiency wage in this framework. The gain in productivity from eliminating shirking funds the DB pension.

DB pension incentives while old. Lazear (1982) also argued that DB pensions function as severance pay that encourage efficient retirement when workers are older. The pension works in concert with a rising wage profile, another type of efficiency wage. If a fixed amount is to be paid over some duration as wages, the payments can be structured to rise over time, paying a worker less than her marginal product early and more than her marginal product later.

However, two problems arise with this element of compensation. First, it encourages workers to stay on after her wage exceeds her marginal utility of leisure. Second, the rising wage profile creates an incentive for employers to violate the implicit long-term contract by firing workers, since employers will get the benefits of the increased productivity sooner than workers. This credibility problem undermines the implicit contract; workers will not agree to a rising wage profile if they anticipate getting fired when their wages rise.

DB pensions help resolve both of these problems, especially following the elimination of mandatory retirement beginning in the 1970s. A DB pension encourages the worker to retire at the "right" age, since the real value of her pension accruals turn negative after a certain point. And that, in turn, reduces the incentive of employers to fire older workers, which helps maintain the credibility necessary for the implicit contract. Reputation effects are meant to discourage employers from firing workers just before they reach the major spikes in pension wealth accrual. Furthermore, age discrimination laws and union rules make it difficult to fire older workers systematically.

Other reasons to encourage longer tenure. Other motives besides moral hazard may explain the use of DB pensions. If hiring or firing entails fixed costs, then employers will only hire if a worker's expected tenure is long enough. Job-specific investments provide another motive to encourage longer tenure. Employers will only train workers if they are likely to stay afterwards; similarly, workers will only be willing to invest in job-specific training if they think the job will last long enough.

We incorporate moral hazard in our model to explain the use of DB pensions. In addition, we extend the model to include match-specific capital which gradually decays in the absence of additional costly investment each period.

4 A Model of Pensions

We develop a job matching model with incomplete contracting that incorporates insights from Lazear's research on DB pensions. Matching models offer a rich representation of the labor market and the effects of uncertainty. Many matching models are designed with a focus on the rate and duration of unemployment and feature exogenous job destruction. Our model emphasizes the duration of employment and features endogenous job destruction, which motivates the use of pensions.

4.1 Introduction

Mortensen and Pissaredes (1999) offer a survey of matching models. Ours builds on Den Haan, Ramey and Watson (2000, hereafter DRW). In order to develop our arguments carefully, we present a baseline Nash bargaining model (Model N), then a Nash bargaining model with contemporaneous moral hazard (Model MH), and lastly a pension-contract model with moral hazard (Model MHP). DRW incorporated moral hazard to induce endogenous match destruction without resorting to downward drift in the productivity process. In the presence of moral hazard, a pension contract eliminates inefficient match destruction, although we do not demonstrate that it is the only contract that would do so. After presenting the MHP model, we discuss changes in the productivity process that would lead agents to abandon the pension contract. The Appendix contains a list of the variables used in the model.

4.2 The baseline model with Nash bargaining

The matching market. As in DRW, a continuum of atomistic workers and firms who are searching in the labor market in a given period meet each other with fixed probability λ. The matched worker and firm i get an output draw $Y_{i,t}$ and decide whether to produce. If they do not produce, they return to the matching market next period. They decide to produce if the output draw exceeds a threshold value R, reflecting the surplus from producing today and expected surplus from the option to produce in the future.

Output. Output $Y_{i,t}$ is drawn from a distribution $F(y_{i,t})$ which is the same for all new matches. For simplicity, we assume that $F(y_{i,t})$ is fixed over time; a more general version of the model relaxing this assumption appears in the appendix.

Production under Nash bargaining. In each period, the agents decide whether to continue producing or whether to draw their outside options and rejoin the labor market. They do this by comparing the match output with the outside options if they break up the match. If they produce, the agents split the match surplus, with a share θ going to the worker and $1 - \theta$ going to the firm.

If the agents break up the match, the worker expects ϕ^w and the firm expects ϕ^f from reentering the matching pool. If they continue to produce, the current value of the match is $Y_{i,t} + g\left(Y_{i,t}\right)$, where g is the continuation value of staying in the match. Suppose there exists a threshold output level R satisfying

$$R + g\left(R\right) = \phi, \tag{1}$$

where $\phi = \phi^w + \phi^f$. When $Y_{i,t} = R$, agents are just indifferent between continuing or breaking up the match.

Then, we can define the joint continuation value of the match as

$$g\left(Y\right) = \beta \int_R^\infty \left(y + g(y)\right) dF(y) + \beta \int_0^R \phi dF(y).$$

The continuation value equals the discounted value of the match next period if output exceeds the threshold value R, plus the discounted value of the outside option if output does not exceed R. The joint surplus from the match is the value of the match less the value of reentering the matching pool:

$$s\left(Y\right) = Y_{i,t} + g\left(Y_{i,t}\right) - \phi.$$

The joint continuation value g and joint surplus s are split between the worker and the firm according to the worker's relative bargaining share θ. Thus, each agent receives future value and surplus defined by

$$g^w\left(Y\right) = \beta\theta \int_R^\infty s(y)dF(y) + \beta\phi^w$$

$$g^f\left(Y\right) = \beta(1-\theta) \int_R^\infty s(y)dF(y) + \beta\phi^f$$

$$s^w\left(Y\right) = \theta\left(Y_{i,t} + g\left(Y_{i,t}\right) - \phi\right) + \phi^w$$

$$s^f\left(Y\right) = \left(1-\theta\right)\left(Y_{i,t} + g\left(Y_{i,t}\right) - \phi\right) + \phi^f.$$

The outside options ϕ^w and ϕ^f are given by

$$\phi^w = \lambda\beta \int_R^\infty \left(\theta\left(y + g\left(y\right) - \phi\right)\right) dF(y) + \beta\phi^w \tag{2}$$

$$\phi^f = \lambda\beta \int_R^\infty \left(\left(1-\theta\right)\left(y + g\left(y\right) - \phi\right)\right) dF(y) + \beta\phi^f. \tag{3}$$

These values depend on the probability of rematching λ and subsequently drawing a satisfactory level of output (exceeding the threshold R) or alternatively remaining in the matching pool until the subsequent period.

Solution. We assume that the distribution $F(y)$ is constant over time and not a function of $Y_{i,t}$.[7] Then, we define

$$\pi(R) = \pi = \int_0^R dF(y)$$

$$J(R) = J = \int_R^\infty y dF(y),$$

where $\pi(R)$ is the probability that the match is destroyed, and $J(R)$ is expected output conditional on the match persisting. Consequently, the model can be summarized by the following equations:

$$\begin{aligned} g &= \beta J + \beta(1-\pi) g + \beta\pi\phi \\ \phi &= \lambda\beta J - \lambda\beta(g-\phi) + \beta\phi \\ R &= \phi - g. \end{aligned} \tag{4}$$

The solution to (4), denoted N, is then:

$$\begin{aligned} R_N &= -\frac{\beta J(1-\lambda)}{k} \\ g_N &= \frac{\beta J(1-\beta(1-\lambda))}{(1-\beta)k} \\ \phi_N &= \frac{\beta J\lambda}{(1-\beta)k} \end{aligned} \tag{5}$$

where $k = 1-\beta(1-\pi)(1-\lambda)$.[8]

We can rewrite each agents' gain from re-entering the matching pool as

$$\phi_N^w = \frac{\beta\theta\lambda J}{(1-\beta)k}$$

$$\phi_N^f = \frac{\beta(1-\theta)\lambda J}{(1-\beta)k}.$$

The wage paid by the employer to the worker in the Nash model will be the worker's portion of the surplus plus his outside option, less his portion of the match continuation value:

$$w_N = \theta s_N(Y) - g_N^w + \phi_N^w \tag{6}$$

[7] The assumption $F_{t+1}(y) > F_t(y)$ yields the upward drift case of DRW, in which no jobs are destroyed in steady state. $F_{t+1}(y) < F_t(y)$ yields the downward drift case of Caballero and Hammour (1994, 1996), in which jobs are inevitably destroyed.

[8] R solves the fixed point of the first equation of (5) and is then used to determine the continuation value g and the value of the outside option ϕ. If we allowed $F_{t+1}(y) \neq F_t(y)$, R would be time-dependent.

To facilitate discussion, we offer the following definition:

Definition 1 *Joint Net Productivity is defined as* $Y_t + g - \phi$. *A match is Jointly Productive if*

$$Y_t + g - \phi > 0 \tag{7}$$

and Jointly Unproductive if

$$Y_t + g - \phi < 0.$$

In the above model, all matches are Jointly Productive.[9]

4.3 The moral hazard model

The following model illustrates the inefficiency that results when unobservable effort on the part of the worker affects future match productivity. While we specificy a simple form of moral hazard – low effort today destroys the continuation value of the match – we intend it to stand in for a richer model, developed in the Appendix, in which the worker decides whether to invest in human capital that keeps the output distribution from drifting down. We argue later that the need to replenish one's human capital may arise because of changes in technology which are complementary to specific skills.

Moral hazard. Consider now the earlier model, augmented with moral hazard which pays off x to the agents; for simplicity, we will limit consideration to moral hazard by the worker. A worker who shirks gains x^w this period, or Δx^w net of production; shirking does not affect contemporaneous production but decreases future match productivity and thus the continuation value g. The assumption that current period output is unaffected by the shirking decision amounts to the following payoff to the worker if he shirks:

$$x^w = \Delta x^w + w. \tag{8}$$

We assume further that shirking causes the future match value g to go to zero, so the match is severed.[10]

Production in the presence of moral hazard. With the addition of moral hazard, the model becomes:

$$g = \beta J + \beta(1-\pi)g + \beta\pi\phi \tag{9}$$

[9] If match productivity drifted downward, matches would inevitably become Jointly Unproductive even in a simple Nash bargaining model as more of the probability mass drifted below the reservation productivity. Also, in some specifications of the productivity process (if it is more persistent, for example) the continuation value is a function of Y. This can make R time-dependent and changes the steady-state separation characteristics (see Mortensen and Pissaredes (1999) for details).

[10] In DRW, shirking drives both current output and the continuation value of the match to zero. In the appendix we generalize this assumption about the future value of the match. Match productivity becomes a function of skill-specific human capital which must be kept current at a cost Δx^w to the worker. When the worker fails to update his skill-specific human capital, match productivity falls enough to induce the firm to sever the match.

$$\phi = \lambda\beta J + \lambda\beta(1-\pi)(g-\phi) + \beta\phi$$

$$R = x + \phi - g.$$

The difference from the previous Nash model is the addition of the moral hazard premium x to the reservation productivity threshold. As we noted earlier, this can be interpreted as the loss of human capital when a worker chooses not to upgrade his skill set, reducing the ability of the firm to produce in the long-run. The result is the following structure for the continuation value:

g	firm	worker
shirk	$g^f = 0$	$g^w = 0$
don't shirk	$g^f = \theta\beta J\frac{(1-\beta(1-\lambda))}{(1-\beta)k} + \phi^f$	$g^w = \theta\beta J\frac{(1-\beta(1-\lambda))}{(1-\beta)k} + \phi^w$

Definition 2 *As above, a match with moral hazard is Jointly Productive if*

$$Y + g - \phi > 0.$$

The match is Incentive Compatible if both (i)

$$Y - w + g^f > \phi^f,$$

and (ii)

$$w + g^w > x^w + \phi^w.$$

Inequality (i) states that the firm's current period realized outcome plus continuation value $Y - w + g^f$ must exceed the outside option for the firm to remain in the match. Inequality (ii) indicates that the worker's payoff (wage plus continuation value, $w + g^w$) must exceed the value of shirking plus the outside option.

Figure 3 about here

The resulting Joint Productivity Threshold (Z) and the Incentive Compatibility (IC) constraints are graphed in Figure 3. The vertical axis shows $y + g(y)$, match output plus the continuation value, while the horizontal axis shows ϕ, the outside option. Note that the IC line lies a distance of x^w above the Z line (the 45° line), since moral hazard imposes additional requirements on the current productivity of the match to sustain the match. Matches below the 45° line are Jointly Unproductive and are destroyed. Matches above the IC line are productive enough that the worker chooses high effort. Matches in the region between IC and Z are broken up because workers choose low effort even though the matches are Jointly Productive.[11] These scenarios are summarized in the following proposition.

[11] Contemporaneous outside options of the form proposed by DRW would shift the Joint Zero Productivity frontier up, so there could be cases in which the outside option is sufficiently high that no moral hazard exists. In these situations, all matches that yield productivity below the IC threshold are severed because of the outside option.

Proposition 3 *Suppose that no steady-state displacements exist in the model without moral hazard (i.e., that (7) above holds). For any $\Delta x^w > 0$ and nondegenerate $F(y)$ with finite support, the probability of match dissolution is between zero and one.*

The proposition implies that even though matches are Jointly Productive, there exists some Y for any Δx^w such that the match is not Incentive Compatible. Essentially, Δx^w creates a wedge between efficient matches and Incentive Compatible matches, requiring extra productivity in order to overcome Δx^w.[12]

Solution. The solution to (9), denoted MH, that avoids the moral hazard problem is:

$$R_{MH} = x - \frac{\beta J (1-\lambda)}{k}$$

$$g_{MH} = \frac{\beta J(1-\beta(1-\lambda))}{(1-\beta)k}$$

$$\phi_{MH} = \frac{\beta J \lambda}{(1-\beta)k} \tag{10}$$

where, again, $k = 1 - \beta(1-\pi)(1-\lambda)$. The shirking premium drives up the minimum output required to sustain the match and satisfy Incentive Compatibility, changing the resulting values of g and ϕ.[13] The MH wage is:

$$w_{MH} = \theta s_{MH}(Y) - g^w_{MH} + \phi^w_{MH}. \tag{11}$$

This exceeds the Nash wage because the reservation productivity that solves the fixed point problem (10) is greater, so the MH wage compensates for forgoing the moral hazard payment.

The moral hazard assumptions. In order to understand the firm's decision when the worker shirks, we consider the following case. If the firm severs the relationship when the worker shirks, then the continuation value following shirking is zero, so the wage determined by (11) is θY and the shirking payoff (8) becomes

$$x^w = \Delta x^w + \theta Y. \tag{12}$$

The firm's payoff is its share of current output $(1-\theta)Y$.

The firm will sever the match for all realizations of Y that fall below zero net productivity. Match surplus becomes $s^* = Y + g - \phi = Y - \phi$ when the worker shirks, and the firm's share of match surplus is $(1-\theta)s^* + \phi^f$, so the firm's decision can be rewritten as follows:

[12] A formal proof of a similar proposition appears in DRW. They show that for output below the reservation threshold, the derivative of R with respect to x is strictly positive. Thus, if no steady state dissolutions occur, x can be raised such that $R > 0$, so some matches that are dissolved in the MH model would not be dissolved in the N model.

[13] This is under the assumption of no outside option, such as unemployment insurance. DRW included an outside option $b > 0$ available to both agents, and the critical value for R becomes $R = b + \frac{\beta(1-\lambda)(J-b(1-\pi))}{k}$.

$$\begin{aligned} \text{firm severance condition:} \quad (1-\theta)s^* + \phi^f &< \phi^f \\ Y &< \phi = \frac{\beta J \lambda}{(1-\beta)k}. \end{aligned}$$

The second inequality summarizes the firm's severance condition: The firm will server any match that produces current output below the joint payoff from reentering the matching pool. This occurs because the match generates no future output if the worker shirks, and the only surplus gained from the match is the amount by which current output exceeds the outside option. For a reasonable parameterization ($\beta = 0.9$, $\lambda = 0.75$, $\pi = 0.1$), this condition holds if the output draw is less than 7.5 times its conditional expectation J. Thus, the assumption that the firm severs the match when the worker shirks seems justified.[14]

Now we consider whether the worker will shirk under reasonable parameterizations. Given the model (9), the worker will shirk if the value of not shirking and sustaining the match (the wage plus continuation value) is smaller than the payoff from shirking (a share of current output plus the premium $\Delta x^w$and outside option):

$$\begin{aligned} \text{worker shirking condition} \quad &: \quad w + g^w = \theta s + \phi^w < \theta Y + \Delta x^w + \phi^w \quad (13) \\ \frac{\beta\theta J(1-\lambda)}{k} \quad &< \quad \Delta x^w. \end{aligned}$$

The first inequality follows from applying (11). Since shirking drives the continuation value to zero, substitute the match surplus and (10) to get the final result. The worker will shirk if the premium to shirking exceeds his share of the bargained surplus.

Does (13) make sense for reasonable parameter values? For the parameterization ($\beta = 0.9$, $\lambda = 0.75$, $\theta = 0.4$, $\pi = 0.1$), the worker shirks for a premium greater than 0.25 times the conditional output expectation J. Increasing θ, the worker's bargaining power and consequent share of future match rents, reduces the incentive to shirk. Increasing J also reduces the incentive to shirk by raising long-term match value. Increasing λ, the probability of re-matching, raises the incentive to shirk by raising the value of the outside option.

The MH model reveals that, under reasonable assumptions, moral hazard creates inefficiency by forcing the dissolution of matches that are Jointly Productive. The match is vulnerable to incentives that raise payoffs to the worker today but destroy the future value of the match. Next, in the MHP model, we show that a deferred payment conditioned on reaching a certain tenure reduces or eliminates inefficient match destruction.

[14] The threshold level of current output falls if we assume that the continuation value is strictly greater than zero and rises if agents possess a contemporaneous outside option.

4.4 The pension model

In the previous subsection, we assumed that the worker obtains her share of output θY plus the shirk premium Δx^w when effort is low. This gives the worker the incentive to collect the short-run benefit and re-enter the matching pool. Here, we show that a deferred payment conditioned on match tenure – structured like a DB pension – can change the worker's incentives. The contract induces the worker to devote full effort and satisfies the same Joint Net Productivity condition as the Nash model above, yielding efficient matches.

The pension contract. Suppose that the firm and worker write a contract $\{\overline{w}, W, T\}$ with the following elements:

- The worker collects wage $w = \overline{w}$ each period when $t < T$.
- The worker collects W, a lump sum, if he is still employed at time T. We will discuss the choice of T later.

The lump-sum payoff at the end of the contract can be set at the expected future discounted value of the match less the sum of each period's wage payments:

$$W = \sum_{i=1}^{T} \left(\frac{1-\pi}{\beta} \right)^i \left[\theta y_{t+i|t} - \bar{w} \right],$$

where $y_{t+i|t}$ is $E\left[y_{t+i}|\Omega_t\right]$ and Ω_t is the information available when the contact is written.[15] Without loss of generality, we will set $\overline{w} = 0$.[16] We also recognize that $y_{t+i|t}$ is identically $J(R^N)$; note that the reservation output is again the level that yields Jointly Productive matches. Since the contract fulfills the Incentive Compatibility condition ex ante, we need only concern ourselves with the output level necessary to sustain positive productivity. The lump-sum payoff at the contract expiration date is then

$$W = \sum_{i=1}^{T} \left(\frac{1-\pi}{\beta} \right)^i \theta J(R^N).$$

We assume that, if $y_t > R^N$ and the firm breaks up the match, then the firm is fined $-\infty$. This amounts to government enforcement of the firm's side of the contract and prevents the firm from severing at time $t = T-1$. We also assume that the match breaks up if $y_t < R^N$, even if $t < T$.[17,18] Thus, the firm pays out W at time T as long as $y_t > R^N$ each period.

[15] In fact, a range of values for W would be feasible, though other values would yield inefficient outcomes (according to the Joint Net Productivity definition) for some output draws. We focus on the value of W that places the problem in the context of the Nash bargaining framework.

[16] Enforcement considerations might govern the actual tradeoff between $\overline{w}$ and W.

[17] If the match is dissolved before T, the worker gets nothing. Nevertheless, a risk-neutral worker will agree to the contract, based on the expected value of W.

[18] The assumption that firms are prohibited from severing productive matches but allowed to sever unproductive matches rests on the observability of y_t and R^N. It is crucial, however, since, under the alternative assumption that a firm could not break up a match once a contract were agreed to, the worker would have no incentive not to shirk.

The worker's incentives. Under this contract, the worker's continuation values g^w depend on the wage contract $\{\overline{w}, W, T\}$. At the outset, $g^w = \beta^T W$ or

$$g^w = \beta^T \sum_{i=1}^{T} \left(\frac{1-\pi}{\beta}\right)^i \theta J(R^N). \tag{14}$$

We need to demonstrate several things about the worker's incentives in order to prove that the pension contract is feasible. First, if the worker accepts the contract in period 1, we can show that the worker will not sever the match later. Each period after the first, the continuation value grows since the value is fixed but the worker discounts it less. Thus, by induction, she will not sever the match at any period $t > 1$ unless there were a shift in the productivity distribution (which we have not allowed for yet) such that the worker's outside option increased.

Next, we summarize in the following proposition the worker's incentive to shirk after accepting the contract, along with the worker's incentive to accept the contract at the outset :

Proposition 4 *Suppose the worker's payoff to shirking is $\Delta x^w + w$. Then, the worker will accept the contract $\{\overline{w}, W, T\}$ as long as the shirk premium satisfies $g^w + \overline{w} - \phi^w > \Delta x^w$. Specifically for the case $\overline{w} = 0$, if $g^w - \phi^w > \Delta x^w$ in each period, then the worker will choose high effort.*

We can check to see whether the worker will accept the proposed contract in which she is paid $\overline{w} = 0$ until time T and W at time T. We need to show that for reasonable parameter values, the condition

$$g^w - \phi^w > \Delta x^w > \frac{\beta\theta J(1-\lambda)}{(1-\beta)k}$$

holds, where the second inequality results from (13) in the worker shirking condition above. Substituting (14) for g^w and the value of ϕ_N^w we solved for above, this requires

$$\beta^{-(T-t)} \left(\frac{1-\pi}{\beta}\right) \frac{1-(\frac{1-\pi}{\beta})^T}{1-(\frac{1-\pi}{\beta})} \theta J - \frac{\beta\theta J\lambda}{(1-\beta)\,k} > \Delta x^w > \frac{\beta\theta J(1-\lambda)}{k} \tag{15}$$

for all $t = 1, 2, ..., T$. For reasonable parameter values ($\beta = 0.9$, $\lambda = 0.75$, $\theta = 0.4$, $\pi = 0.05$) that satisfy $1 - \pi > \beta$ (so the worker's discount rate is smaller than the likelihood that the match persists), a range of values for Δx^w satisfy (15). Recall the assumption that the term of the pension contract (the payoff date T) is chosen exogenously. A consequence of (15) is that, for a fixed shirk premium, the term of the contract must fall when the likelihood of exogenous separation increases (i.e., $dT/d\pi < 0$). In the next subsection, we discuss more about the nature of the pension contracts that can be constructed to prevent moral hazard.

The firm's incentives. The firm will accept the contract as long it yields positive joint productivity, since it pays identically the future value of the Nash bargained wages and since we assume since the firm may dissolve the match otherwise. Thus, we conclude that the contract $\{\overline{w}, W, T\}$ is accepted by both agents and enhances efficiency for Δx^w satisfying (15). We consider the consequences of changes in the productivity process in the next subsection.

4.5 Expected Tenure and the Productivity Process

The previous subsection demonstrated how the DB pension (the lump-sum payoff at time T) can resolve the inefficiencies resulting from moral hazard. In the model we have considered so far, match productivity does not drift, so the continuation value remains constant; the pension contract will also be effective if match productivity drifts upward, in which case the continuation value is increasing. In this section, we analyze the implications of other specifications of the productivity process – either gradual downward drift or stochastic productivity-reducing shocks. We will demonstrate that these features reduce expected job tenure and, if severe enough, make the pension contract infeasible. The worker no longer accepts deferral of payment because the risk of exogenous separation becomes too high.

Expected tenure and the productivity process. For purposes of discussion, we define the following:

Definition 5 *A worker's expected tenure is*

$$E(\tau) = \frac{1}{1-\pi}.$$

Consider (7) in which matches are initially Jointly Productive. Suppose now that output each period is drawn from successively less favorable probability distributions, in the sense of first-order stochastic dominance. So, as in DRW, $F_{t+1}(y) > F_t(y)$ for all t.[19] This implies a time-dependent continuation value in which $g_{t+1}(y) < g_t(y)$. (4) then implies an increasing reservation productivity $R_{t+1} > R_t$, since $J'(y) > 0$ for all y. Therefore, a high draw from a worse distribution will make the agents willing to continue the match in the face of worsened long-term prospects. In the type of human capital model we outline in the Appendix, these shocks may result from the introduction of a new technology which erodes the value of existing skill-specific human capital.

The resulting condition $R_{t+1} > R_t$ has implications for job tenure. Since $\pi(R_t) = \int_0^{R_t} dF_t(y)$, the probability mass below the reservation threshold increases when either the distribution shifts down or reservation output rises, increasing the likelihood of separation. This lowers expected job tenure and thus the value of the pension, since the probability that the worker reaches tenure T and receives the pension declines. As the value of the pension falls,

[19] In DRW, the productivity distribution changes stochastically.

the worker is increasingly likely to shirk, and the contract breaks down. Initially, suppose $1 - \pi > \beta$.[20] Then as π rises and approaches $1 - \beta$, expected tenure $E(\tau)$ falls. Additionally, as $\frac{1-\pi}{\beta} \to 1$, we need $T \to 0$ to satisfy (15) for fixed Δx^w. This implies that, as the likelihood of exogenous separation rises, the payoff date in the contract must get increasingly close to the initiation date for the worker to sustain the risk of exogenous separation. Otherwise, if T is large, the worker does not expect to remain employed and the expected value of the pension payoff goes to zero. At some point expected tenure $E(\tau)$ becomes small enough that the worker will not accept the contract.

Conclusions. The preceding discussion provides intuition as to the breakdown of DB pensions. Initally, we show that matches with stable or increasing continuation values can benefit from deferring payment to the worker in order to provide incentives that are unavailable in a standard Nash bargaining model. These contracts preserve jointly efficient matches that would ordinarily be severed under Nash bargaining. However, if, either through technological shocks or simple erosion of skills, the continuation value of the match falls over time, then the pension contract may be infeasible and the agents revert to Nash bargaining.[21]

5 Trends in Pensions, Tenure, and Technology

In this section, we discuss trends in pension coverage and then show that average job tenure has declined. Next, we demonstrate a link between pension structure and job tenure, using data from the Survey of Consumer Finances, and between job tenure and technological change using data from the Current Population Survey.

Since Form 5500 data lacks information on jobs and workers, we use data on individuals from the SCF and the CPS. The SCF reports information on job tenure and pension coverage. It takes place every three years and began in 1983, offering the longest consistent information on pension coverage among individual-level data sets.[22] The primary disadvantages of the SCF are relatively small sample sizes (roughly 5000 individuals per survey) and very aggregated information on industry and occupation (only 6-7 classification codes reported). Therefore, we also use the CPS, which has reported consistent information on job tenure since 1983; the CPS offers a much larger sample (over 50,000 individuals per survey) and three-digit industry and occupation data.

[20] Recall that this condition is necessary for the worker to agree to the pension contract.

[21] At this point, one must consider other possible contracts. Ramey and Watson (1997) show that contracts with severance payments or punishments can sustain matches in the efficient but incentive-incompatible region. However, we do not believe these contracts are easily enforceable, and they may produce socially inefficient litigation upon separation.

[22] We omit data from the 1986 SCF, which was less comprehensive and representative than the others. The Health and Retirement Study is much more detailed but began in 1992 and, for the most part, covers workers aged 51-61 in that year. The Current Population Survey has asked brief questions about pension coverage at irregular intervals, and the questions have changed over time.

5.1 Trends in pension coverage

In order to begin to understand the aggregate shift away from DB and towards DC plans, we show how pension coverage changed in particular types of jobs. The SCF provides pension coverage data by industry and occupation.

Various patterns in disaggregated pension structure are consistent with the aggregate shift away from DB and towards DC pensions; none of them are mutually exclusive. At one extreme, pension structure may have shifted uniformly from DB to DC in all types of jobs. At another extreme, pension structure may not have changed at all in particular types of jobs, but workers may have shifted from jobs with DB plans to jobs with DC plans. In an intermediate case, pension structure may have changed more in some types of jobs than in others.

The data suggest that neither of the first two possibilities explain all of the aggregate shift in pension coverage on their own. Pension coverage did not shift uniformly in all types of jobs, and workers have not moved enough across types of jobs to account for the magnitude of the changes.[23] Rather, pension coverage has evolved at varying rates by industry, occupation, and education level – in other words, by type of job and type of worker.

We can show this by using analysis-of-variance methods to see how pension coverage changed over time. Table 1 shows how time trends in pension coverage differed by type of job and worker. Year main effects explain just under half (48%) of the over-time variation in DB pension coverage – so half of the decline occurred uniformly across types of jobs. Year-industry interactions explain 22%, indicating different changes in DB pension coverage across different industries; year-occupation interactions explain 13%, and year-education interactions explain 15%. When we regress DC pension coverage on the same variables, year main effects explain 34% of the variation across years; the other important factors are year-industry interactions (explaining 32% of the time variation) and year-occupation interactions (explaining 25%).

5.2 Trends in job tenure

Table 2 shows average job tenure for full-time employees from the SCF.[24] We distinguish between men and women, since women exhibited a secular increase in their attachment to the labor force over this time period.

Table 2 about here

Average job tenure declined, especially for younger male employees – those most likely to be exposed to DC pensions. Average tenure of male employees

[23] In the SCF, little of the aggregate trend can be explained by movements of workers across industries and occupations; within-occupation and within-industry changes in pension structure dominate. As discussed earlier, research using Form 5500 data has indicated that half or less of the shift in pension coverage arises from workers moving from DB jobs to DC jobs.

[24] Similar trends are observed in the Current Population Survey.

with five or fewer years of potential experience declined from 3.0 years in 1983 to 1.8 years in 1998. Average tenure of those with 6-15 and those with 16-25 years of potential experience declined from 5.1 to 4.5 years and from 10.0 to 8.7 years, respectively. Among younger workers, tenure fell more at the higher end of the tenure distribution, for example at the 75th percentile; among older workers, it fell more at the lower end of the tenure distribution.

Among female employees, average tenure generally rose from 1983 to 1992 and then fell 1992 to 1998. For example, average tenure of female employees with 16-25 years of experience was 7.7 in 1983, 8.2 in 1992, and 7.4 in 1998. Female employees with less experience experienced less of an increase early on, but a similar decrease later, so some cohort effects are apparent.

5.3 Pension structure and job tenure

Regressing job tenure on pension structure. We find a strong relationship when we regress tenure on pensions and other characteristics. Coefficient estimates are reported in Table 3. Those who have any pension have been in their jobs 2-3 years longer than those without a pension, depending on the specification; those with a DB pension have been in their job an additional 2.75-3.25 years longer than those with a DC pension only. It is unclear whether we want to control for characteristics of the job or for year effects; for example, job characteristics like industry and occupation may help explain pension struture and job tenure. Nevertheless, these controls have little effect on the estimated coefficients.

If we ascribed a causal interpretation to these estimates, it would imply the following. 49.0% of the sample had a DB pension in 1983, compared to 24.9% in 1998. The estimates from the most complete specification for males in column (4) imply a decline in tenure of 0.65 years, or 70% of the observed decline of 0.92 years.

Regressing job tenure on technological change. As with other labor market trends, the shift in pension structure may be rooted in the diffusion of information technologies over the last twenty-odd years. Technological change is a leading explanation for the rise in earnings inequality between skilled and unskilled workers. Rapid shifts in skill requirements associated with new technologies may also have reduced the value of long-term jobs and thus altered not only the level but also the structure of compensation.

In order to begin to understand this potential link, we regress job tenure by industry on TFP growth by industry. We use the CPS because of its detailed industry data; the earliest consistent tenure information is reported in January 1983, the latest in February 2000. We computed the change in average job tenure by industry from 1983 to 2000. We use TFP growth from the Jorgenson Total Factor Productivity Series. The Jorgenson series reports annual TFP growth for 21 manufacturing sectors, along with 14 other non-manufacturing sectors of the economy. The data is available from 1959 to through 1996; as a start, we tried using average TFP growth over the five- and ten-year periods ending in 1996.[25]

Thus, we regressed the change in average job tenure on average TFP growth, weighted by the quantity of labor input in each sector in 1996.[26] The coefficient estimate on the ten-year average of TFP growth is -32.4 (14.6), which is significant at the 95% confidence level. Across industries in 1996, a one-standard deviation change in average TFP growth was 0.0111 (the range is -0.0148 to 0.0416). The estimates suggest that an industry with TFP growth that exceeded the average by one standard deviation experienced a decrease in average job tenure of 0.36 years; recall that average job tenure declined 0.92 years between 1983 and 1998.

Preliminary conclusions. Our results show that individuals with DB pensions have higher average job tenure, and thus the declines in DB pension coverage and in job tenure may be related. Our results also show that industries with higher rates of productivity growth experienced greater declines in job tenure. These preliminary results provide evidence supporting the view that DB pension coverage and job tenure are linked, and that changes in technology may explain the declines in both.

6 The Model of Pensions and Government Regulation

If pension structure changed because of government regulation, instead of changing endogenously, we can use our model to evaluate the efficiency consequences and the effect on job duration and mobility. *To be completed.*

7 Why Do DC Pensions Exist?

The discussion above explains the purpose of DB pensions but says little about DC pensions. Deferred compensation alters the path of wages and, for workers who face borrowing constraint, the path of consumption and saving. This should reduce the appeal of pensions, according to conventional economic theory. In light of this, there are three possible explanations for the use of DC pensions:

- features such as matching rates and short vesting periods in DC pensions mimic DB pensions and encourage longer tenure;
- heterogeneous workers who are attracted to deferred compensation have other productive characteristics;
- workers or the government have some preference for deferred compensation which lies outside the standard model of rational foresighted agents.

[25] Additional information is available in Jorgenson, Gollop, and Fraumeni (1987) and at : http://post.economics.harvard.edu/faculty/jorgenson/data/35klem.html.

[26] The quantity of labor input is computed as the value of labor inputs divided by the price of labor inputs.

The first explanation still requires some other explanation for the decline of DB pensions; as a result of that decline, agents designed features of DC plans to mimic DB plans. At this time we are not considering the second explanation, which has quite different implications for a theory of the labor market.

The third explanation coincides with predictions of psychologically-based behavioral models and accounts for the findings of many researchers that both 401(k) plans and DB plans raise personal savings rates. Laibson, Repetto, and Tobacman (1998) used simulation models to show that people who recognize their self-control problems will use 401(k)-like plans to make wealth available to their future selves. According to their results, 401(k) plans always raise aggregate private saving because of their tax advantages. Their additional value as a means to commit to a long-term saving plan provides an extra boost of 17-60% to the aggregate saving rate, if people have self-control problems.[27]

Alternately, the government may establish tax preferences for retirement saving because it believes people do not save enough. This may occur because the government thinks that people have trouble saving, even if they do not, or because the existence of social insurance programs that induce moral hazard. The implications of these two explanations are quite different. In case of the former, government intervention lowers social welfare by inducing people to save more than they would otherwise choose to. In case of the latter, the government may rationally choose to force people to save in order to reduce the welfare costs of free-riding.

[27] The range of increase depends on the particular features of the 401(k) and assume a value of one for the rate of relative risk aversion.

8 Appendix

8.1 Model Variables

$$
\begin{aligned}
y &= \text{current period output (a random variable)} \\
F(y_{i,t}) &= \text{cumulative distibution function of output} \\
Y_{i,t} &= Y = \text{realized current period output} \\
g(Y_{i,t}) &= g = g^f + g^w = \text{match continuation value for firm (f), worker (w)} \\
s(Y_{i,t}) &= s = s^f + s^w = \text{match surplus} \\
\phi &= \phi^f + \phi^w = \text{value of reentering matching pool} \\
R &= \text{reservation level of output } y \\
\gamma &= \text{probability that output } y \text{ is drawn from the cdf } F(Y) \text{ next period} \\
\lambda &= \text{probability of finding a match when one is searching} \\
\beta &= \text{discount rate, } 0 < \beta < 1 \\
\theta &= \text{worker's relative bargaining power, } 0 < \theta < 1 \\
x^w &= \text{worker's payoff to shirking} \\
\Delta x^w &= \text{worker's premium (above output) to shirking} \\
w &= \text{current period wage} \\
W &= \text{pension payoff at tenure } T
\end{aligned}
$$

8.2 A Generalized Pension Model

In this appendix we present a generalized version of the moral hazard model and show that there exists a contract akin to the pension contract in the pension model MHP. Consider a matching market in which a firm and worker are paired with fixed probability λ from a unit mass of workers and an infinite number of firms, both with constant discount rate β. The period- t match specific marginal productivity is $Y_{i,t}$. For simplicity, we can suppress the idiosyncratic subscript i. The continuation value g_t satisfies the following conditon:

$$g_t = \beta \int_{R_{t+1}}^{\infty} (y + g_{t+1})\, dF_{t+1}(y) + \beta \int_{0}^{R_{t+1}} (b + \phi)\, dF_{t+1}(y), \tag{A.1}$$

where the period- t match productivity is drawn from $F_t(y)$, R is the productivity at which the match is severed, b is the value of the outside option, and ϕ is the return from re-entering the matching pool. Assume the value of re-entering the matching pool is time-invariant and the initial draw is taken from $F_0(y)$:

$$\phi = \beta\lambda \int_{R_0}^{\infty} (y + g_0 - \phi)\, dF_0(y) + \beta\,(b + \phi)\,. \tag{A.2}$$

The reservation productivity can, in general, be determined by the following relationship:

$$R_t = \max\{x, b\} + \phi - g_t. \tag{A.3}$$

In the generalized version of the model, the reservation productivity is time-dependent since the productivity distribution, and hence the continuation value, varies over time.

We introduce match-specific human capital a, which evolves according to

$$\alpha_t = (1 - \delta + Ae_t)\alpha_{t-1}.$$

where $\alpha_0 = \bar{\alpha}$, $0 < \delta < 1$ is the depreciation rate of human capital, A represents the rate of human capital investment and $e_t \in \{0, 1)$ is the effort choice required to learn new capital. Effort for the worker has a disutility Δx^w measured in units of production. If $A > \delta$, the worker exhibits learning-by-doing, provided the required effort is exerted. If $A = \delta$, the worker is just able to replace the human capital lost over time (possibly due to technological innovation).

We also assume that the productivity process depends on α:

$$dF_t(y|\alpha') < dF_t(y|\alpha) \forall \alpha' > \alpha.$$

A higher value of α leads to a stochastically preferred output distribution.

We can then rewrite (A.1) as

$$g_t(\alpha_t) = \beta \int_{R_{t+1}}^{\infty} (y + g_{t+1}(\alpha_{t+1}))\, dF_{t+1}(y|\alpha_{t+1}) + \beta\,(b + \phi) \int_0^{R_{t+1}} dF_{t+1}(y|\alpha_{t+1}), \tag{A.4}$$

The model (A.2), (A.3) and (A.4) is sufficent to describe employment behavior of the economy. Assuming that the initial draw is taken from a fixed distribution, (A.2) can be solved under certain conditions imposed on the nature of the distribution $F_0(y)$. It is then possible to solve the linear Fredholm integral equation (A.4) by imposing similar regularity conditions on the sequence of conditional distributions $\{dF_t(y|\alpha)\}$. Transition dynamics are similar to those of DRW where $A > \delta$ is the model of upward drift.

To capture the properties in the simplified model above, we require the following conditions:

- δ must be sufficiently large to induce separation should the worker shirk
- $A \geq \delta$ in order to assure that the match is mutually beneficial in the long run
- $x > b$

The last condition allows matches that are jointly productive (i.e., matches in which $Y_t + g(Y_t) - \phi - b > 0$) to break up with positive probability. In the main text, we only allowed for moral hazard. Here, the contemporaneous outside option pushes out the productivity frontier toward the Incentive Compatibility threshold. For $x < b$, the contemporaneous outside option is sufficiently high that the worker chooses high effort for all matches that are jointly productive. If the magnitude of the worker's shirk premium x^w is

$$x^w = \theta Y_t + \Delta x^w$$

as before, a wage contract $\{w, W, T\}$ will prevent the worker from shirking through time $T - 1$.

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Table 1: Analysis of variance in pension coverage

variation in pension coverage explained by year effects:	Dependent variable				
		Has a:		Among those with a pension, has a:	
	pension	DB pension	DC pension	DB pension	DC pension
all year effects (fx)	100%	100%	100%	100%	100%
year main fx	12.1	48.0	33.9	20.4	21.4
year*education fx	16.7	15.4	5.0	21.2	18.8
year*occupation fx	26.7	13.2	24.9	25.1	27.7
year*industry fx	35.1	21.9	32.4	12.1	27.9
year*union fx	9.4	1.4	3.8	21.3	4.2

The columns of this table reports results from ANOVA estimates, each with a different dependent variable. In addition to the year effects and interactions, the estimation includes age and age squared; employer size; main effects for education (4 categories), occupation (6 categories), industry (6 categories) and union coverage; interactions of education and occupation and of industry and occupation; gender and interactions of gender with education, occupation, and industry.

Data: Survey of Consumer Finances from 1983, 89, 92, 95, 98; full-time employees; weighted using survey weights. The surveys from 1989 and later include five sets of multiply imputed variables (called implicates). While other estimates in this paper correct for the presence of multiple imputations using the methods introduced in Rubin (1987), the estimates in this table do not; rather, the estimates treat each implicate as independent data. However, ANOVA estimates done on each implicate separately did not deviate by more than two percentage points in either direction from those reported here.

Table 2: Average job tenure

	Men				Women			
	Average job tenure, by years of potential experience							
	0-5	6-15	16-25	26-35	0-5	6-15	16-25	26-35
1983	2.6	4.9	9.9	14.2	2.2	4.9	7.7	9.9
1989	2.0	4.8	8.9	14.7	1.6	4.0	7.6	10.5
1992	2.2	4.8	8.1	14.1	2.1	4.8	8.2	11.8
1995	1.8	4.5	8.5	12.9	1.8	4.4	8.4	10.7
1998	1.6	4.4	8.6	13.6	1.4	4.0	7.4	11.1

Data: Survey of Consumer Finances from 1983, 89, 92, 95, 98; full-time employees; weighted using survey weights. Years of potential experience equals age minus years of completed education minus six. We excluded those who reported tenure that exceeded potential experience plus two years (about 1.5% of the sample) due to likely misreporting.

Table 3: OLS regression results

Independent variables:	Dependent variable: years of tenure			
	Men (mean of dependent variable = 8.81)			
	(1)	(2)	(3)	(4)
has a pension	2.89*** (0.37)	2.01*** (0.37)	2.86*** (0.38)	2.23*** (0.37)
has DB pension	3.13*** (0.30)	2.71*** (0.29)	3.10*** (0.30)	2.69*** (0.30)
has DC pension	0.42 (0.32)	0.92*** (0.31)	0.46 (0.32)	0.79** (0.32)
	Women (mean of dependent variable = 7.58)			
	(5)	(6)	(7)	(8)
has a pension	2.65*** (0.47)	2.22*** (0.48)	2.64*** (0.47)	2.24*** (0.46)
has DB pension	2.18*** (0.38)	1.72*** (0.40)	2.23*** (0.38)	1.83*** (0.40)
has DC pension	0.40 (0.40)	0.41 (0.42)	0.37 (0.40)	0.41 (0.41)
Also includes:				
age	yes	yes	yes	yes
job variables	no	yes	no	yes
year effects	no	no	yes	yes
year*job variables	no	no	no	yes

Sample: Survey of Consumer Finances from 1983, 89, 92, 95, 98; full-time employees excluding those who report tenure in excess of potential experience plus two; weighted using survey weights. The regressions account for the multiple implicates provided from 1989-98. All regressions are weighted using sample weights. Standard errors robust to unspecified heteroscedasticity appear in parentheses; * indicates a confidence level of at least 90%, ** 95%, *** 99%.

Regressions (1) and (5) includes age and age squared. (2) and (6) include variables from (1) along with 4 education, 6 industry, 6 occupation, and 6 firm size dummies, union status, and interactions of industry with occupation and occupation with education. (3) and (7) includes variables from (1) along with year dummies. (4) and (8) includes variables from (2) and (3) along with year dummies interacted with industry, occupation, education, and union status.

Figure 1: Full-time employees

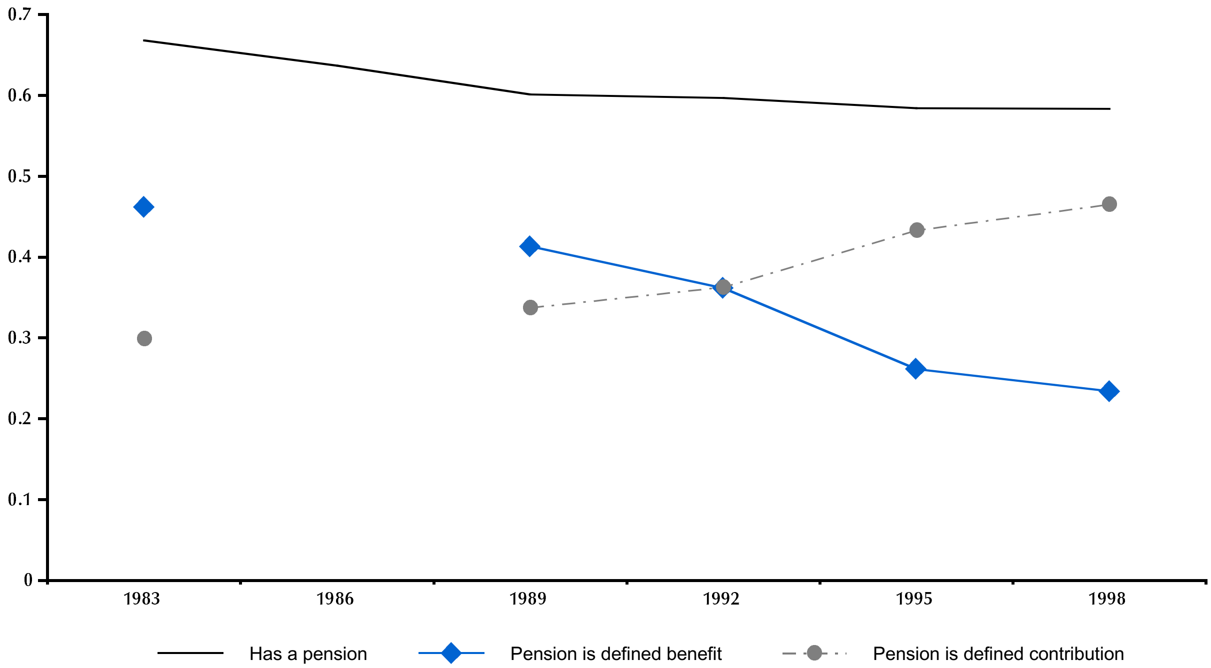

Figure 2: Accrual of Pension Wealth

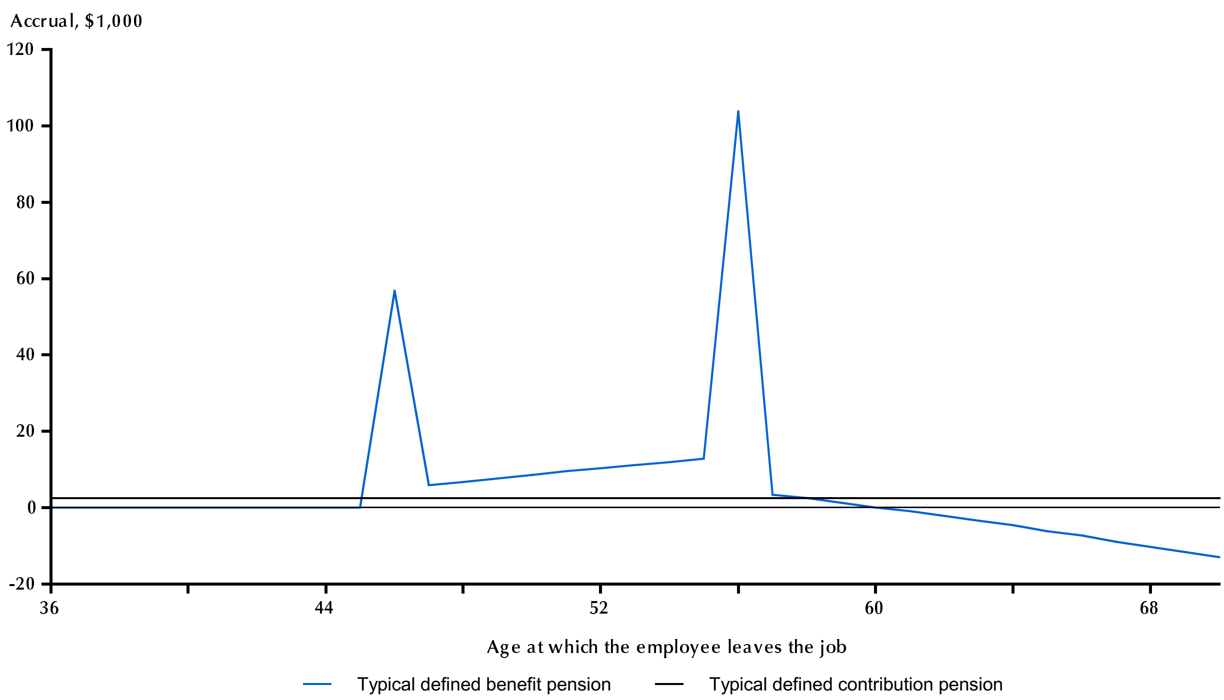

Figure 3