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CHAPTER 3

Pension Liabilities: Distinguishing between Legal and True Economic Pension Obligations

LIABILITY AND FUNDING CONCEPTS

Tax structure provides a strong rationale for the growth in popularity of pensions during the post–World War II period. But it does not provide a direct link to pension asset growth itself. If pension arrangements were pay–as–you–go systems, pension assets would be zero even though pensions were widespread. Two key concepts provide the technical link between "pension demand" and its physical manifestation, pension assets: pension liability calculations and funding levels.

If all pension plans were defined contribution, pension liabilities by definition would equal the assets in the plan, and funding ratios would equal 100 percent. But more than 70 percent of pension liabilities are affiliated with defined benefit plans (see Chapter 6); in these plans, the relationship between pension liabilities and plan assets is not obvious. Clearly, assets must have a positive relationship to liabilities incurred; thus assets should grow with liabilities. But calculation and projection of pension liabilities alone are insufficient to project target plan assets over time. Funding level policies must also be ascertained. If funding levels are gradually increasing, for example, pension asset growth could be expected to be quite rapid even if pension liabilities are constant.

Pension liabilities and funding levels cannot be determined simply by taking actuarial calculations from firm financial records or annual pension plan 5500 reports (schedule B, question 6). Values reported in these documents reflect the "legal" concept of pension liabilities. That is, since the firm can legally terminate the plan anytime, thereby conferring nominal (or "terminated") pension benefits to workers, payable many years in the future, it is assumed that the firm cannot be considered to have incurred liabilities beyond this level. But from an economic and financial perspective, it is not obvious that pension liabilities are limited to this amount. If workers expect the firm to keep the plan intact and pay an indexed pension regardless of the firm's legal right to terminate—that is, if workers have an *implicit contract* with the firm that an indexed pension will be paid except and unless unusual market exigencies arise—then the economic liabilities incurred by the firm are far greater than suggested by a calculation of legal liabilities. The difference in pension liabilities implied by the legal and implicit contract theories is very large; as such, the resolution of the question "What are pension liabilities?" is critical to an understanding of the growth of pension assets, which, after all, are ultimately accumulated to meet *whatever* these liabilities are.

From an economic perspective, liabilities are not an arbitrary calculation; they are a reflection of pension promises made by the firm in return for explicit consideration by workers. Pensions are not provided gratis; firms must pay competitive compensation packages. If pensions are provided, they must be given in lieu of some portion of cash wage. As such, a pension liability is incurred at the point that workers implicitly forgo some portion of their wage in exchange for the promise of receiving a pension benefit some time in the future. The trick to calculating true economic pension liabilities is to determine the present value of workers' pension savings in the firm at any point in time.

Since these "deposits" are not explicit in defined benefit plans, they must be inferred indirectly. This chaper is devoted to the task of determining just what these deposits amount to. The goal is to estimate true pension liabilities incurred by the private sector in the United States. In the next chapter, we will turn to a discussion of funding levels in the United States over the post-World War II period. The liability concept and the funding policy together form the basis for projecting asset growth in defined benefit plans.

TERMINATED VERSUS REAL BENEFITS: AN ILLUSTRATIVE MODEL

It is useful to begin by introducing the difference between terminated and real pension benefits. These are critical concepts in the pension literature, ones that lie at the core of our understanding of what pension contracts really mean and what values should be attached to pension promises. It also turns out that these concepts underlie the legal and implicit contract theories.

Assumptions

Suppose that all workers expect their pension annuity at retirement to be indexed to their *final* wage. Thus, if a 55-year-old male worker has a salary of $10,000 and if expected wage growth (real wage growth plus inflation) is 10 percent per year, his expected wage at retirement at age 65 is $27,183. But if the plan terminates while he is still 10 years from retirement, his benefit will be proportional to his *current* salary of $10,000. Clearly, the worker stands to lose a substantial portion of his expected *real* pension benefit if the plan terminates immediately. If the worker *expects* a real pension (i.e., workers believe they have an implicit contract with the firm that the firm will keep the plan intact) then a plan termination clearly confers a capital loss to workers. This "loss" is the difference in liabilities calculated on the assumption that the firm has implicitly obligated itself to pay real pensions to workers; and those calculated on the assumption that the firm has an obligation merely to pay terminated benefits. That is, it is the difference between a real and terminated pension.

It is easy to show precisely how much a 55-year-old worker (with 20 years service) would lose in benefits from termination. To keep the example simple, suppose that, upon termination, the firm immediately starts a new plan identical to the old plan (without past service credit); as such, his last 10 years of service will yield him the exact benefit in the new plan that he would have received on that portion of his service after age 55 in the old plan. Also, for simplicity, suppose the probability that this individual will die or leave the firm prior to age 65 is zero, and similarly suppose that it is known with certainty that the firm will survive over the forseeable future and the workers incorporate this expectation (these assumptions are considered later in the discussion). Also, suppose that, upon retirement, the worker expects to die at age 78. The firm's announced policy is that no inflation adjustments will be made to annuities once retirement occurs. The following parameter values will also be specified:

1. The pension plan is a final salary plan. The pension formula provides 1.5 percent per year of service. Normal retirement benefits are, therefore, 1.5 percent × Years of service × Final salary. The plan is not amended (and is not expected to be amended) over the foreseeable future.[1]
2. The worker has 20 years of service at age 55.
3. Expected real wage growth is 2 percent per year; in particular, the worker expects to receive longevity raises in his real wage equal to 1 percent per year and to participate in an expected 1

[1]Even if the defined benefit plan is not technically indexed to the final salary but rather is expressed as a "flat" benefit, the same arguments hold as long as workers expect the "flat" benefit to *in effect* be indexed to the wage level. Suppose a pension plan offered $100 per year of service in the firm when most workers receive a final salary that approximates $10,000. If the benefit is increased to $200 when inflation (and other factors) increase the average final salary to $20,000, the expectations theory is still valid.

percent increase in overall productivity in the economy as a whole.

4. The salary of a 55-year-old worker with 20 years of service is \$10,000.
5. The real interest rate is 2 percent.
6. Expected inflation is 8 percent; thus, the nominal interest rate is 10 percent (2 percent real plus expected inflation), and expected growth in nominal wages is also 10 percent (2 percent real wage increases plus inflation).

Our task is to calculate the real pension benefits that a 55-year-old worker in this firm expects from a pension plan and to compare this to the benefit he will receive if the plan terminates immediately.

Real Expected Pension Benefit

In this example, we wish to calculate this worker's expected real pension benefit upon retirement, based on 20 years of service to date. Since the annuity is proportional to years of service and since the worker expects his annuity to be proportional to his final wage at retirement, his expected annuity is calculated as follows:

$$\begin{aligned}\text{Annuity at age 65} &= 1.5\% \times 20 \text{ years of service} \times \\ &\quad \textit{Final} \text{ salary (\$27,183)} \\ &= \$8,155 \text{ per year.}\end{aligned} \tag{3-1}$$

Thus, based on service to date, the individual expects to receive \$8,155 per year beginning at his retirement age 65. Since he expects to live 13 years during retirement, the lump sum value of his expected annuity (based on service to date) can also be calculated, evaluated at age 65. Since the firm's announced policy is that the plan will not make any adjustments for inflation during retirement,[2] and since the nominal interest rate is 10 percent then the lump sum equivalent of his annuity evaluated at age 65 is:

$$\begin{aligned}&\text{Lump sum value of annuity at age 65} \\ &\quad = \text{Annuity (\$8,155)} \times \\ &\quad\quad 7.27 \text{ (present value of an annuity collected for 13 years, discounted at 10 percent)} \\ &\quad = \$59,289.\end{aligned} \tag{3-2}$$

Since the worker is now age 55, not 65, the present value of his lump sum equivalent as of age 65 must be converted to a present value

[2] In actuality, workers who retire from large firms received increases during retirement equal to almost 50 percent of inflation. See Accommodating Post-Retirement Benefit Erosion in this chapter.

as of his current age. In particular, the \$59,289 lump sum at age 65 must be discounted over the 10 years between the present and retirement. Using the same 10 percent discount rate, we finally arrive at the present value of our 55-year-old worker's real expected pension benefit:

Real expected pension benefit (3–3)
= Lump sum at age 65 (\$59,289) ×
.367 (present value of one dollar 10 years from now, discounted (at 10 percent)
= \$21,758.

Thus, viewed at age 55, the worker has accumulated a present value real expected pension benefit equal to \$21,758. In other words, if this worker were given \$21,758 to roll over into an IRA immediately, this sum would be approximately as valuable to him as the promise of receiving an annuity of \$8,155 per year starting at age 65.

Value of Terminated Benefit

It is now interesting to calculate the same present value pension benefits if instead of continuing for at least 10 more years, the plan is terminated immediately when the worker is 55 years old.[3] In this case, the worker's annuity starting at age 65, based on service at age 55, is *not* based on his expected final salary at retirement (\$27,183); instead, his pension is based on his *current* salary at age 55 (\$10,000). Thus, his annuity is now calculated as:

Annuity at age 65 = 1.5% × 20 years of service × Current salary (\$10,000) (3–4)
= \$3,000

Thus, upon termination, the worker expects to receive \$3,000 per year beginning at his retirement age 65. Since he expects to live 13 years during retirement, the lump sum value of his expected annuity is:

Lump sum value of annuity at age 65 (3–5)
= Annuity \$3,000 ×
7.27 (Present value of annuity collected for 13 years, discounted at 10 percent)
= \$21,810.

[3]Recall that under the assumption of the calculation, a new (identical) plan is expected to be put in place immediately. If the new plan remains intact for at least 10 years, the worker's remaining 10 years of service will provide a real pension benefit for these years of service.

TABLE 3–1 Terminated versus Ongoing Pension Benefits for a 55-Year-Old Worker

Basis of Calculation	*Salary in Benefit Formula*	*Annuity at Age 65*	*Lump Sum Equivalent, Age 65*	*Lump Sum Equivalent, Age 55*
Ongoing	\$27,183	\$8,155	\$59,289	\$21,758
Termination	10,000	3,000	21,810	8,004
Ratio: termination/ ongoing	.37	.37	.37	.37

Again, recalling that the worker is now age 55, not 65, the present value of his lump sum equivalent at age 65 must be converted to a present value evaluated at his current age. In particular, the \$21,810 lump sum, at age 65 is converted to an age-55 equivalent as follows:

Terminated pension benefit (3–6)
= Lump sum at age 65 (\$21,810) ×
.367 (Present value of one dollar 10 years from now, discounted at 10 percent)
= \$8,004

Comparison of Real and Terminated Benefits

Compare the "terminated" *annuity* in expression (3–4) to the "ongoing" *annuity* in expression (3–1). It is apparent that the worker loses a substantial portion of his real expected annuity because of the termination (compare the \$3,000 annuity to the \$8,155 annuity). The reduction in his annuity translates into a reduction in his age-55 present value pension from \$21,758 (see expression 3–3) to \$8,004 (see expression 3–6). The reduction in his pension annuity or equivalently in his present value pension amount, is entirely attributable to the substitution of a *nominal* wage at retirement in the benefit formula, for an *indexed* wage. When inflation and real wage growth are substantial, the real economic impact of this substitution is dramatic. In fact, in this example, present value benefits of our 55-year-old worker are reduced at termination by \$13,754 (= \$21,758 − \$8,004), or 63 percent of expected real benefits. These numbers are summarized in Table 3–1.

The numbers in the first two rows of the table are reproductions of those cited above at different points in the calculations. The numbers in the third row of the table represent the ratio of the termination-to-ongoing calculations. What is noteworthy is that these ratios are identically .37 in every column. The salary level incorporated on a termination basis is only 37 percent of the salary included on an ongoing basis. Benefit levels in all calculations on a terminated basis are also only 37 percent of benefits calculated on an ongoing basis. This is not coincidental: the loss of real pension benefits is determined *solely* by the substitution of *current* salary in the pension formula under termination for a projected *final* salary at retirement in an ongoing calculation.* The inclusion of nominal instead of indexed wages in the pension formula ensures that real pension benefits will fall in proportion as a result of termination.

The bottom line in these calculations is this: if the worker expected a terminated or legal benefit, he would have deposited the sum of $8,004 with the firm as of age 55; if he expected a real pension, he would have deposited $21,758 with the firm as of the same age. Firm liabilities in the legal model in this example are only 37 percent of those in the implicit contract scenario.

This example illustrates the central concepts in the determination of true economic pension liabilities. To make headway toward actually calculating these liabilities for the United States as a whole, it is necessary to formalize these concepts into an economic model. This is the task we now undertake. While the next section is somewhat more technical, the payoff from formalizing the liability concepts is large. It permits us to derive a test from the formula to determine which concept of pension liabilities is supported by the data. Do workers save in their pension as if they expect a real pension or a nominal pension? In addition, after we determine which theory is most consistent with reality, the formula derived below can be used directly to calculate economic pension liabilities in the United States.

AN ECONOMIC MODEL OF PENSION LIABILITIES

The Basic Model

We begin by making two assumptions: (1) that firms do not provide pensions to workers for free, and (2) that workers will not sacrifice wages in excess of the true value of the pension. In short, it is assumed that workers pay firms an amount that is precisely equal to the present value of expected pension payments and that at any given point in time, workers will not have deposited any more or any less into the pension plan than the amount equal to the present value of the pension benefit they expect. These payments take the form of workers forgoing a portion of their total compensation throughout their work lives in the

*In a more complex model, the exact proportionality between relative wages and relative benefits on a termination versus an ongoing basis would not necessarily hold. But the main implications would remain the same.

firm in exchange for a pension at retirement. The economic pension liability incurred by the firm equals the summation of workers' contributions to the pension plan (through lower wages) plus accumulated interest, minus pension benefits already paid to retirees in payment status.

These pension savings cannot be observed directly; however, it is straightforward in principle to infer pension savings rates from the announced pension benefits.[5] If workers' implicit pension contributions equal the present value of expected pension benefits, presumably it is possible to infer what pension savings rates *must* be, given workers' evaluations of announced benefits. The trick to calculating true economic pension liabilities is to work backwards: first, to derive pension savings as a function of workers' beliefs; then, to use the empirical implications of these derived savings flows to see which savings flow—that is, which theory—best describes reality. Once we do this, we have "backed-in" to an understanding of the true nature of the pension contract between workers and firms.

To illustrate, suppose a firm has one worker who starts at the firm at age 0 and retires at age R. Thus age and service level can be denoted by a, where $0 \leq a \leq R$. In reality, a worker typically vests at some age a°, $0 < a^\circ < R$. If the worker dies or quits the firm, or if the firm fails or terminates the pension plan before attaining the age and service level a°, the worker collects nothing; if either of these events occur between the ages $a^\circ \leq a < R$, the worker collects the nominal value of his pension accrual as of service level a, payable at age R.[6]

Now consider the pension formula. Suppose the worker's pension at age R is given in the form of a lump sum, and that the amount of the worker's pension is proportional to years of service and the compensation level he is earning at the age of departure from the firm, say age j.[7] Usually the pension formula incorporates the worker's *cash* wage at retirement. But for our purposes, it greatly simplifies the exposition without affecting the results if we suppose the formula incorporates the worker's gross-of-pension-savings wage (i.e., cash wage plus the

[5] It is theoretically possible to measure these savings rates by estimating the cash wages of pension-covered versus uncovered workers over all ages. In practice, for a variety of reasons, this task has proven to be difficult and has not been successfully accomplished to date.

[6] If the firm fails early and does not maintain sufficient assets in the plan to cover at least its nominal liabilities, the expression becomes somewhat more complicated. Thus, for present purposes it is assumed implicitly that the firm maintains at least this level of funding. As shown in chapter 4, most pension plans' funding status fall within the constraints of this assumption. In addition, since the passage of the Employee Retirement Income Security Act of 1974, pension-covered workers pay for insurance that guarantees receipt of nominal benefits in the event of plan termination.

[7] In fact, defined benefit plans almost always pay benefits in the form of annuities. The implications of this simplification will be considered below.

worker's implicit pension savings during that year); denote this compensation by W_j. If it is assumed that pensions are the only fringe benefit, as we do here, W_j can be thought of as the individual's value of marginal product at age j. Thus, the pension formula can be represented by:

$$PB_i = \text{b}\, a\, W_j, \tag{3-7}$$

where PB_i represents the lump sum pension benefit, payable at age R and b is a constant reflecting the generosity of the pension plan.[8] The firm's pension liability when the worker is age a depends on how much the worker has saved in consideration of receiving this pension which, in turn, depends on the worker's evaluation of the value of his promised benefits.

Regardless of the theory of the pension contract, liabilities attributable to unvested workers are very small. Thus, we can simplify the discussion without materially affecting the results by considering only the case of vested workers.[9] Under the assumptions of the model, a vested worker's expected pension benefit at age a depends on the pension formula and the probabilities that he will leave the firm early, or that the firm will terminate the plan early; thus, if the worker is vested, the present value of the pension can be represented by:

$$PV_a = \int_{j=a}^{R} \text{b}aW_j f_{ja} e^{-i(R-a)} dj, \tag{3-8}$$

where i is the nominal interest rate, j is the termination age, and f_{ja} is the conditional probability density of pension accruals stopping either because the individual leaves the firm or because the firm terminates the pension at age j, given that the individual is currently age a. The general expression in (3–8) provides the basis for beginning to differentiate the implications of the legal and implicit contract theories.

Consider the legal theory first. In this case, the firm's liability depends on the payment required if the firm terminates the pension im-

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[8] Most pension plans have benefit formulas that are similar to this specification. See, for example, Bankers Trust, *Corporate Pension Plan Study,* 1980; and Urban Institute, *Financial Retirement Incentives in Private Pension Plans,* Report submitted to the U.S. Department of Labor, 1982.

[9] Examination of annual pension report data using techniques discussed below suggests that the distortion is in the range of 10 percent. The distortion is small in the implicit contract model partly because unvested workers have low service levels and partly because the turnover among unvested workers is relatively high. For example, the annual quit probability of an unvested male worker under age 30 in a pension firm is between 10 and 25 percent depending on the worker's particular age and tenure level. See James Schulz, *Private Pension Policy Simulations,* (Waltham, Mass.: Brandeis University, 1980) pp. 116–18. In the legal model, the distortion is low because use of a high discount rate virtually evaporates benefits accrued by unvested workers who are usually far away from retirement age.

mediately. In order for this to be a meaningful definition of the liability in a market sense, it must also be true that workers' contributions up to that point are consistent with the computed liability. But this is true only if workers believe that the firm will in fact terminate the pension immediately (or that they believe they will either quit or be fired imminently).[10] In this case, the density function in expression (3–8) would become a point density at age $j = a$, and the present value of the pension would be:

$$PV_a = baW_a e^{-i(R-a)}. \tag{3-9}$$

We now have a derivation of the pension liability under the legal model of pensions: legal liabilities equal benefits given by the pension formula using current service and current wages, discounted from retirement age R to current age, a, using the nominal interest rate.

Now consider the implicit contract model. That is, suppose the worker believes the firm will maintain the pension plan intact, even though the firm could legally terminate the plan at any time.[11] To keep the expressions neat, assume that the empirically small probabilities that either the vested worker will quit or the firm itself will fail are approximately zero. We will show below that this assumption has no important consequences for the main results.[12]

Using these simplifications, the density function in the implicit contract model is again a point density but at age $j = R$. As a result, the present value of the pension in expression (3–8) can be written as:

$$PV_a = baW_R e^{-i(R-a)}. \tag{3-10}$$

Thus, we now have an expression for the pension liability under the implicit contract theory. Liabilities equal the benefit amount given by the pension formula using current service and *future* wages (at retirement), discounted by the nominal interest rate. We can now compare the pension calculations in expressions (3–9) and (3–10) to begin to compare to implications of the two theories.

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[10]Or if workers are so myopic that they believe their wage will never increase beyond W_a regardless of inflation, overall productivity growth, or the firm's age-service wage profile.

[11]The credibility of the promise need not rely solely on a belief that history will repeat itself. Workers and firms presumably understand the conditions of the wage penalty that would be imposed on any firm that reneged on its pension promises.

[12]Empirically, the vested quit-plus-death rate is approximately 2 percent. The annual death rate for the typical pension participant (starting with the firm at age 38, retiring at age 62) is .0075; the quit rate for this age and service group is approximately 1 percent. See James Schulz, *Private Pension Policy Simulations*. Comparison of plan termination data from the Pension Benefit Guaranty Corporation and Department of Labor pension universe data show that the probability that a pension-covered worker will find himself in a firm that terminates over a 25-year period is only 3 percent. It is shown below that since the quit probability is small, the implications of the zero quit assumption remain essentially unchanged (see note 16).

The implicit contract expression in (3–10) differs from the legal expression in (3–9) only because expression (3–9) incorporates the *current* compensation level W_a while expression (3–10) incorporates the *anticipated* compensation level at retirement W_R. To compare the expressions more easily, it is convenient to rewrite (3–10) in terms of current compensation at age a. Assume that workers expect their level of compensation to increase over their age by the rate g; these increases will reflect the firm's wage-tenure profile, overall productivity growth, and inflation. In this case, the expression in (3–10) becomes:

$$PV_a = \mathrm{b}aW_a e^{(g-i)(R-a)}, \tag{3–11}$$

The present value of benefits at age a can now be written succinctly to accomodate both these theories as:

$$PV_a = \mathrm{b}aW_a e^{(\lambda g-i)(R-a)}, \tag{3–12}$$

where λ is a parameter that can be set equal to zero or unity. In a legal interpretation of pensions, $\lambda = 0$; in an implicit contract model, $\lambda = 1$. This expression represents the key equation in the model: if we can test whether the parameter λ is zero or unity, we will be able to tell which theory is most consistent with the data. The expression in (3–12) makes it apparent that the so-called legal and implicit contract theories are just special cases in an economic model of pensions. In the legal theory, the worker is so pessimistic that he believes that either the firm's termination of the pension plan or his own departure from the firm is imminent. In this theory, the wage index g in the economic calculation in (3–12) is irrelevant to the worker; hence, pension benefits are based on *current* wages discounted from the retirement age R.

In an implicit contract theory, the worker believes the firm will keep the pension plan intact unless the firm fails. Since the failure probability for a defined benefit firm is very small (see Appendix 12–2), the worker approximates the probability of receiving his pension from an ongoing firm as unity; hence, benefits based on *indexed* wages are discounted from age R.

Paying for the Pension: Formalizing the Assumptions of the Model

The next step is to utilize the general pension liability expression (3–12) to infer whether workers are setting the parameter λ to zero or unity for purposes of implicitly saving for their pensions. Toward this end, it is necessary to formalize some assumptions in the model: that expected pension benefits equal pension savings in a present value sense, and that workers' cash wage plus pension savings are equal to the value of marginal product in *each* period. These assumptions say that the workers' cash wages plus their implicit pension contributions equal the value of marginal product in every period:

$$CW_a = W_a(1 - S_a), \qquad (3\text{–}13)$$

where CW_a is the cash wage at age and service level a, and S_a is the change in the present value of the pension (net of interest earnings) as a percent of total compensation at age a. The accuracy of the assumption embedded in expression (3–13) are subject to test, and indeed are supported by results reported below.

Implications of the Model for Wage-Service Profiles

All of the necessary derivations have now been made to test which theory of pensions is most consistent with the data. The key to this test is held by the implications of the two models for the wage path over the worker's service levels with the firm. That is, the wage profile holds information about how workers save for their pensions over time; these savings flows in turn reveal expectations: workers only save an amount equal to what they expect to receive. The cash wage profile is given in equation (3–13). To translate the expression into a more useful form, the pension savings rate S_a in (3–13) must be solved explicitly. Given the assumptions of the model, the savings rate is derived by differentiating the present value pension amount shown in expression (3–12) with respect to age, and subtracting interest on past contributions.[13] Performing this exercise, it turns out that the implicit savings rate at age a (as a percentage of total compensation) is defined as:

$$S_a = [1+(1-\lambda)ga]be^{(\lambda g - i)(R-a)}. \qquad (3\text{–}14)$$

This equation tells us how much workers save each year (as a percent of their wage), assuming that they save exactly that amount by which their expected pension increases during the year. Naturally, how much they save therefore depends on their expectations, which is why the familiar parameter λ appears in expression (3–14).

It is apparent from expression (3–14) that in a legal theory ($\lambda = 0$), the pension savings rate increases rapidly at higher service/age levels in the firm: $S_a' > 0$ and $S_a'' > 0$. Under plausible conditions, the legal theory can imply drastic backloading of savings late in life. For example, suppose the nominal growth rate in wages and the nominal interest rate are each 10 percent ($g = i = .10$), the tenure level at retirement R

[13]In particular, even if no additional savings takes place, just by waiting one additional period in the firm, the individual receives interest on past contributions equal to iPV_a

is 30 years, and the pension benefit parameter b is .15.[14] In this case, the savings rate at starting age ($a = 0$) according to equation (3–14) is less than 1 percent; at age 30, the savings rate is 60 percent. Intuitively, distrustful workers are reluctant pension savers until they actually approach retirement.

In contrast, the savings rate in the implicit contract model is not dependent solely on the interest rate i but rather on the *difference* between the wage growth rate and the interest rate, $i - g$. To pursue the full implications of this model, it is useful to acquire a plausible parameter value for this difference. It turns out that as long as the long-term interest rate and expected wage growth equally reflect inflation, the difference $i - g$ will be significantly less than zero: the real rate of return earned by pension funds is substantially lower than real wage growth, by approximately two percentage points.[15] If the model is generalized to allow early quitting, firm failure, and premature death, it can be shown that in the extreme, the sum of these probabilities would act exactly like higher real interest rates. If we think of the interest rate as including these additional influences, it still would not dominate the influence of real wage growth.[16] Thus, in terms of the current notation, it is generally true that real wage growth weakly dominates an enhanced interest rate: $g \geq i$.

Consider the plausible case where the nominal growth rate in wages equals the nominal interest rate, $g = i$. In this case, the implicit contract model predicts that the change in the savings rate with respect to service level is zero: $S_e' = 0$. When workers and firms have an implicit long-term contract, workers are willing to save through the pension more evenly over their lives.

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[14] The average savings rate of covered workers through their pensions is approximately 15 percent: see, for example, the Social Security Survey of Newly Entitled Beneficiaries, 1970.

[15] The real rate of return earned by pension funds over the longest period over which data is available (1963–1982) has been approximately 1 percent. See Alicia Munnell, "Who Should Manage the Assets of Collectively Bargained Pension Plans?" *New England Economic Review* (July/August 1983), pp. 18–30. Wage growth reflects a presumably positive wage service profile in the firm as well as overall productivity growth. Gordon and Blinder have estimated a wage growth rate over the life cycle of work with the firm (holding firm productivity constant) in the vicinity of 1 percent. See Roger H. Gordon and Alan S. Blinder, "Market Wages, Reservation Wages, and Retirement Decisions," *Journal of Public Economics* 14 (October 1980), pp. 431–42. Real wage growth in the United States over the past 30 years has been in the vicinity of 2 percent (*Economic Report of the President*, 1982). Thus, assuming that wages and interest similarly reflect an expected inflation factor, it follows that $g - i$ is approximately 2 percent.

[16] To show this, take the extreme assumption that departure from the firm early or firm failure will have the same result as early death: no pension will be paid (instead of a nominal pension). In this case the sum (say q) of the quit rate, death rate, and firm failure rate will enter the model exactly like the interest rate. Since $g \geq q + i$, introducing this factor makes the equality a more likely approximation to reality but does not change the essence of the qualitative result: discounting as such will not occur during the worker's tenure in the firm.

The formal model of pensions has now yielded a large dividend: a clear crisp test of these theories. If workers expect legal pensions, the model tells us that workers sacrifice wages mostly at older ages to pay for the pension; if they expect real pensions, they save more or less proportionally over their tenure with the firm. Thus, under a legal theory, observed *cash* wages (what is left after workers save for the pension out of *total* wage) must be affected only at older ages compared to nonpension workers; they are affected across all tenure levels in an implicit contract theory. Put another way, other things constant, if the legal theory is correct, cash wage profiles should be flatter for pension-covered workers compared to uncovered workers. If the implicit contract theory is correct, these profiles should be no different (or perhaps even somewhat steeper) for pension-covered workers.

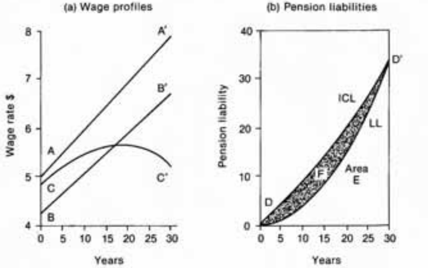
Graphical Representation

These concepts are depicted graphically in Panel (a) of Figure 3–1. The schedules in the figure represent an actual calculation of the model used above in the case where the interest rate and wage growth rate are 5 percent and retirement occurs after a 30-year career in the firm. The starting wage is arbitrarily set at $5. In the figure, the schedule labeled AA′ depicts the relationship between the wage, gross of pension savings, and the service level in the firm for workers of similar skill level; that is, the schedule reflects the wage that would be paid if the firm did not offer a pension. The schedule is upsloping, reflecting the realistic phenomenon that workers generally obtain higher wages as they acquire more experience in the firm; the relationship is depicted as a linear schedule, though the analysis would be the same if the wage rate increased at a slower rate at later ages.

The two remaining schedules in the diagram reflect the economic model of pensions derived above. The schedule BB′ reflects the wage rate net of pension savings in the firm under the assumption that the pension reflects an implicit contract. The vertical distance between the schedules AA′ (the gross wage) and BB′ (the cash wage) reflects pension savings S_xW_x; the vertical distance between schedules AA′ and BB′ grows with age but remains constant as a fraction of the gross wage.

In contrast, the nonlinear schedule CC′ reflects the cash wage in a legal model. Recall in this model that workers postpone most of their pension saving until the end of their career; this is reflected in the ever-widening difference between the schedules AA′ (the gross wage) and CC′ (the cash wage) at higher tenure levels. In the legal model, the savings wedge in the first year of work is small (see the distance labeled A–C); this is to be compared to the larger savings rate in the implicit contract model measured by the distance A–B in the figure. By the year of retirement, this situation is exactly reversed. In the legal model, the

FIGURE 3–1 Legal vs. Implicit Contract Models



Legend: AA'-Gross wage-service profile
BB'-Cash wage-service profile, implicit contract model
CC'-Cash wage-service profile, legal contract model

Legend: ICL-Pension liabilities over service levels, implicit contract model
LL-Pension liabilities over service levels, legal contract model
Area E-Legal pension liabilities for firm, equal density assumption
Area E + F-Implicit pension liabilities for firm, equal density assumption

savings wedge is A′–C′ in the figure, much *larger* than the savings wedge A′–B′ in the implicit contract model.

Since data exist that describe earnings histories of large samples of workers, empirical tests can be run to distinguish which of these types of cash wage schedules bests depicts reality. Such estimates using two separate data bases are described in detail in Appendix 3–1. The results reported there support the hypothesis that underlies schedule BB′ in the figure, and reject the hypothesis that underlies the schedule CC′. That is, the tests confirm the validity of the implicit contract theory and reject the legal theory of pension liabilities. Workers pay for their pensions as if they expect to receive an indexed pension upon retirement.

The implications of these results are shown in Panel (b) of the figure. The schedule labeled ICL depicts the present value pension liability under the implicit contract model, which is the model most consistent with reality: these liabilities grow linearly over higher service levels in the firm; this schedule is a geographical representation of equation (3–12), shown above. The schedule labeled LL shows the growth in present value pension liabilities under a legal theory. It also begins at zero (point D) and it equals the same liability at retirement (point D'). But in all intermediate ages, the legal liability is lower than the liability actually incurred; this is so because in the legal model, workers do not actually deposit savings with the firm until late in their career and thus the firm's liabilities remain relatively low until the worker approaches retirement age.

The total pension liabilities of the firm can also be depicted using Panel (b) of the figure. Suppose the firm has an equal density of workers at every service level in the firm; also assume no deaths or quits prior to retirement. In this case, the legal liability is depicted by the area labeled E in the figure. The true economic liability is equal to area E *plus* area F. In this case, if reported liabilities are based on a legal concept, economic liabilities are underestimated by the amount represented by area F in the figure. It is shown below that the underestimate represented by the area labeled F is potentially very large in actual liability calculations.

Summary of Results

The results of this section can be summarized as follows. True pension liabilities arise when workers deposit savings with the firm in anticipation of receiving a pension upon retirement. These savings therefore depend on whether workers expect to receive a real or nominal pension. Through a series of manipulations, it was found that these savings rates would be very different over tenure levels in the firm depending on whether the legal or implicit contract theories are correct. This difference was exploited by using these implications to predict how observed cash wage profiles should be affected by pensions. After comparing pension and nonpension cash wage profiles for a large sample of workers whose wage histories are recorded, it was found that the implicit contract theory is supported by the evidence.

In brief, the data supports the use of the liability formula stated in expression (3–11). But this expression in turn is familiar: it corresponds to the so-called projected salary method of calculating pension liabilities. Put another way, it says that pension benefits should be discounted at zero interest rates for active workers, not nominal discount rates, as supported by the legal theory of pensions.

ACCOMMODATING POST–RETIREMENT BENEFIT EROSION

The above characterization of true economic liabilities provides the groundwork to calculate aggregate pension liabilities. But one final step is necessary before the calculations can be made in principle. To this point, it has been assumed that pension benefits are paid in lump sums. Retirees from defined benefit plans usually take annuities, not lump sums. Unless retirement annuities are perfectly indexed to the long-term interest rate, the lump sum assumption will not yield correct overall liability calculations. This assumption is now relaxed.

It is useful first to review what is known about firms' policies toward indexing post-retirement pension annuities. First, prior to the high-inflation period beginning in the late 1960s, the evidence suggests that post-retirement benefits may have been adjusted more than enough to accomodate inflation.[17] During the recent high inflation period, some erosion has taken place. A recent study suggests that during the 1970s firms on average increased post-retirement benefits by approximately 50 percent of the increase in CPI. Moreover, the same study shows that even this may understate the degree of response to inflation because firms appear to award increases with a lag. For example, in 1978, the 1965 retiree cohort was collecting benefits which were 80 percent of their real value in 1965.[18] Third, and finally, it has been convincingly argued that just because retirees during the 1970s lost some purchasing power, this does not imply that current workers expect to lose any purchasing power when *they* retire.[19]

Some thought must be devoted to the method by which the post-retirement benefit erosion should be incorporated into the model. Recall that, typically, actuarial calculations (operating on a legal concept) discount the annuity to the retirement age equivalent using an assumed interest rate; they then discount this value to the worker's current age, again discounting by the assumed interest rate. But we have determined from an economic perspective that for active workers, no discount should be used to express the value of the annuity at retirement age in terms

[17] See Gary Fields and Olivia Mitchell, *Retirement, Pensions and Social Security* (Cambridge, Mass: MIT Press, 1984).

[18] See Robert Clark, Steve Allen, and Daniel Sumner, "Inflation Adjustments in Pension Plans," Report submitted to the U.S. Department of Labor, 1983.

[19] See Martin Feldstein, "Should Private Pensions Be Indexed?" National Bureau of Economic Research, Working Paper No. 787, 1981. Essentially, the argument is that workers implicitly "approve" investment of some of "their" pension funds in long-term bonds. If future inflation falls, workers will get higher-than-inflation post-retirement increases, reflecting capital gains on bonds. If future inflation increases, capital loses are distributed to workers in the form of lower-than-inflation post-retirement increases. Just because retirees in the 1970s "lost" does not imply that future retirees *expect* to lose benefits in real terms during retirement.

of the worker's current age; and further that while they should discount post-retirement benefits by some amount, this discount is not expected to be large. Rather than deal with two discount rates for active workers in the economic value calculation, it is convenient to think of one discount rate which "averages" the (zero) pre-retirement and the (small, but positive) post-retirement discount rate.

For current retirees we need only deal with the post-retirement discount rate. Since current policy towards retirees now collecting pensions is observed, the actual discounting policy in the recent past can be used to discount these liabilities in the immediate future.

There are essentially two approaches to incorporate the post-retirement erosion problem. Both are used here. First, available information can be used to calculate back-of-the-envelope post-retirement discount rates. For example, the inflation adjustment policy during the 1970s suggests that one plausible assumption is that current retirees should expect their benefits to erode at half the expected inflation rate. Thus, in 1978, the Moody's (new issue) interest rate was 8.73 percent; assuming this reflects a real interest rate of 1.5 percent—one close to historical experience[20]—the expected inflation component equals 7.23 percent. In this case, the discount rate for current retiree benefits would equal 1.5 percent plus 50 percent of the 7.23 percent expected inflation rate (i.e., 8.73 nominal minus 1.5 real is 7.23 percent), a total of 5.1 percent.

In contrast, consistent with the implicit contract theory, it is reasonable to assume that current workers would not necessarily expect inflation erosion when they retire; hence, the post-retirement discount for them could be reasonably considered to be something like 1.5 percent (the real discount rate). When "averaged" with the zero discount rate that should be used to discount the retirement age lump sum equivalent to current age, the discount rate applied to active worker benefits would be quite low, perhaps 1 percent or less.

The second approach to take is to assume that the stock market correctly calculates pension liabilities using economic discount rates. Then stock market price data can be exploited to learn what the market's discount rate is. In this approach, a single discount rate is "averaged" for all participants in the pension plan. This exercise, which is carried out in the next section, yields the result that the best guess of the discount rate used by the stock market to evaluate true pension liabilities is 2 percent. Thus, stock market data is consistent with the back-of-the-envelope derivations.

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[20]R. Ibbotson, *Stock, Bonds, Bills and Inflation* (Chicago: R. G. Ibbotson Associated, 1984).

ESTIMATION OF THE PSEUDO–DISCOUNT RATE USING EVIDENCE FROM THE STOCK MARKET

Stock market participants have a vested interest in "seeing through" reported liabilities to properly evaluate the firm's true economic pension liabilities. Each \$1 of unfunded pension liabilities incurred by the firm translates to a reduction in future earnings available to stockholders in the amount of $(1-t_c)$ \$1 where t_c is the corporate tax rate. If the present value of pension liabilities minus assets is $L-A$, the firm must forgo current profits in the amount $(1-t_c)$ $(L-A)$ to put it on par with a fully-funded competitor; an efficient market will discount the stock value for the full amount of this liability.[21] It is a straightforward task to determine which particular discount rate has been implicitly used by the stock market to calculate the present value of pension liabilities L.

Consider the following specification designed to explain stock market value for the firm:

$$SV/EA = c_0 + c_1 \text{ UNFUND}(i)/EA + c_2 \text{ PROFITS}/EA + \text{error}, \quad (3\text{–}15)$$

where SV is the stock market value of the firm, EA is equity assets, and PROFITS measures current and past profits.[22] The variable UNFUND(i) reflects vested pension liabilities reported publicly by the firm based on some arbitrary interest rate i, less the market value of pension assets. Equation (3–15) is similar to those estimated in previous stock market value studies.[23] It is presumed that the coefficient c_1 will be negative, reflecting investors' discount of stock value in consideration of publicly disclosed unfunded pension liabilities.

Suppose the stock market is efficient, so that investors will incorporate all available information into the price of the stock. That is, assume that investors are not fooled by use of arbitrary actuarial dis-

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[21] Feldstein and Seligman have implicitly argued that the cost of funding a \$1 unfunded liability may exceed $(1-t_c)$. That is, if the liability is not funded immediately, investors must save outside the tax-free pension fund which imposes costs in the form of foregone tax advantages. See Martin Feldstein and S. Seligman, "Pension Fund, Share Prices, and National Savings," *Journal of Finance* 36 (September 1981), pp. 801–24. But if firms do not fully fund their pension plans over long periods of time—which is true in the United States (see Chapter 4)—it is reasonable to conclude that the underfunding occurs because the benefits of doing so outweigh the tax penalties. As such, stock values in underfunded firms are not expected to reflect a discount beyond $1-t_c$ for each dollar of underfunding.

[22] Equity assets are defined in Feldstein and Seligman, "Pension Fund."

[23] Oldfield and Feldstein et al. include "beta" coefficients for the firm to measure risk; these variables virtually never turn out to be statistically significant. Feldstein et al. also experiment with other variables including debt and R&D ratios and with inflation-adjusted data. See Martin Feldstein and Randall Morck, "Pension Funding Decisions, Interest Rate Assumptions and Share Prices," National Bureau of Economic Research, Working Paper No. 938, 1982; Martin Feldstein and S. Seligman, "Pension Fund"; and G. S. Oldfield, "Financial Aspects of the Private Pension System," *Journal of Money, Credit and Banking* 9 (February 1977), pp. 48–54.

count rates. Since the relation between assumed interest rates and vested liabilities is known, it can be presumed that the stock market reevaluates all firms' pension liabilities using a uniform interest rate assumption. In particular, the following transformation is made for the jth firm:

$$\text{UNFUND}_j(i^*) = \text{ADJ}(i,i^*) \cdot L_j(i) - A_j, \qquad (3\text{–}16)$$

where L_j is the present value of pension liabilities evaluated at the discount rate i, A_j is the market value of pension assets, i^* is the interest rate implicitly used by the stock market, and ADJ(i,i^*) is a function that transforms pension liabilities evaluated at interest rate y to liabilities evaluated at the interest rate i^*.[24]

The value of the stock market interest rate is not known. But it can be inferred by iterating on the interest rate i^* in equation (3–16) and running the regression in equation (3–15) using the variable UNFUND(i^*). Since the corporate tax rate is in the vicinity of 50 percent, the best estimate of the discount rate used by an efficient market is one for which the coefficient c_1 equals $-.50$. That is, for each \$1 of unfunded liabilities, stock value should be reduced by \$0.50 [$= \$1(1-t_c)$]. To illustrate, first assume that i^* equals the average assumed actuarial interest rate (6.7 percent in 1980). The results of this regression using the variable UNFUND($i^* = 6.7$) are shown in Table 3–2. The coefficients are reasonable and similar to those found in the past studies.[25]

The results support the notion that investors discount stock value in consideration of unfunded pension liabilities. The 95 percent confidence intervals are relatively wide, supporting per-dollar-offset hypotheses that range from \$0.32 to \$1.68. But the best guess supported by the data is a dollar-for-dollar trade-off. In particular, the results suggest that for each \$1 of reported unfunded pension liabilities using the discount rate $i^* = 6.7$, the stock market reduces the stock price by \$1.03. The use of such a high trade-off—approximately twice the expected \$0.50 trade-off—suggests that stock market estimates of economic liabilities exceed reported liabilities; that is, that the stock market discount rate is less than the average actuarial discount rate found in

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[24] The relationship between liabilities and assumed interest rate is estimated in Chapter 4. This estimate assumes that active and retired participants can be separated in the data; the effect of the interest rate on retirees is somewhat smaller than for active participants. Since Compustat data does not separate participants in this way, all liabilities were converted ignoring the retiree-active distinction. In particular,

$$\text{ADJ}(i,i^*) = \exp[-.077(i^* - i)].$$

[25] For example, see George S. Oldfield, "Financial Aspects"; Martin Feldstein and S. Seligman, "Pension Fund"; and Martin Feldstein and Randall Morck, "Pension Funding Decisions."

TABLE 3–2 Relation of Stock Market Value to Unfunded Pension Liabilities, 1980

Independent Variables	*Coefficient*
Intercept	.27 (9.52)
Profits (1980)	3.08 (8.60)
Average profits 1975–1979	1.67 (12.46)
UNFUND ($i^* = 6.7$)	−1.03 (2.98)
R^2	.62
Observations	1166

Dependent variable: stock market value.
All variables (including the dependent variable) are deflated by equity assets (see Martin Feldstein and S. Seligman, "Pension Fund"; numbers in parentheses are (absolute) t-statistics.
SOURCE: Compustat files, 1980.

publicly disclosed reports. If liabilities were properly calculated, the coefficient on UNFUND should equal −.50. It turns out that $c_1 = -.51$ when i^* is set equal to 2 percent. Our best guess of the discount rate used by stockholders to evaluate pension liabilities is therefore 2 percent: $i^* = .02$.

This estimate is consistent with the labor market evidence cited above. While the overall discount rate applied by the stock market is somewhat higher than one that would apply just to current employees, the results make it apparent that the market uses relatively low interest rates to discount unfunded pension liabilities. They are almost certainly not using long-term nominal interest rates; in 1980, 30-year bond rates exceeded 12 percent. Apparently, the market expects firms to pay real accumulated pension liabilities in the future, not nominal pension liabilities or liabilities calculated on the basis of arbitrary interest rates used for purposes of public disclosure.

CONCLUSION

The economic model of pensions forms the basis of our understanding of the true nature of the pension contract. True economic pension liabilities arise when workers give up current compensation in the expectation of receiving a pension upon retirement. If workers "deposit" an amount with the firm that equals the present value of the pension they have earned to date then the liability is equal to the present value of the perceived pension benefit. The central question is, do workers expect real or legal benefits?

The economic model makes explicit the nature of the difference between real and legal pensions. These concepts are critical because, among other things, they have dramatic implications for the size of pension liabilities in the United States, the capitalized value of the firm, and the capital loss to workers from either premature departure from the firm or pension plan termination. The model, and the evidence from the labor market and the stock market, support the hypothesis that pensions are *real*, not nominal obligations as actuarial calculations would suggest. Roughly speaking, *though not technically correct*, actual economic pension liabilities in the United States can be found by using a real rather than a nominal interest rate to discount pension promises. In other words, true economic pension liabilities—which form the basis for pension asset growth—can be found by converting reported liabilities based on arbitrary interest rates to a real interest-rate basis.

APPENDIX 3–1
Tests of Pension Contract Theories Using Data from the Labor Market

Specification of a Wage-Tenure Equation

For empirical purposes, we wish to choose a functional form for the wage function that is consistent with a positive but diminishing tenure effect but that also leads to a simple representation of the contrary predictions of the legal and implicit contract theories. We wish to make specific allowances for the possibilities that pension savings rates increase (or decrease) over the tenure cycle and that the spot market assumption in equation (3–13) is invalid. A wage function that satisfies these criteria is

$$CW_T e^{f + [\kappa + \gamma(\ln T)]P + [\delta(B)] + [\xi(B)\ln T]} = kT^{\alpha + \beta X} X^c e^{dP}, T > 0. \qquad (3\text{–}17)$$

This specification is somewhat unconventional because it implies that the starting wage is zero; while this could be a problem in theoretical models, it is unimportant for our purposes as long as the data is concentrated away from zero tenure levels.

The left-hand side of equation (3–17) represents total compensation for the worker at the tenure level T; the right-hand side represents the value of marginal product. The variable CW_T is the worker's cash wage; total compensation equals the cash wage, adjusted by the series of terms found in the exponential term. The parameter f reflects the nonpension fringe benefit as a percent of cash wage. The first bracketed term in the exponent which is interacted with a zero-one pension dummy P (=1 if there is pension coverage) reflects the pension savings rate. The parameter κ is a constant. The parameter γ is critical to a test of the theories: it reflects the influence of tenure on the pension savings rate. In the legal model, the wedge between gross and net-of-pension savings compensation grows with tenure: $\gamma >> 0$; in the implicit contract model (recall $g \geq i$), the parameter γ is either zero or slightly positive.

The second bracketed term in the exponent reflects a test of the spot market assumption. Total compensation may not equal the worker's value of marginal product in every period. For example, the firm could deliberately twist the cash wage profile so that workers get paid too little early in their career and too much later.[26] What makes this theory testable, however, is that compensation over the worker's tenure must equal his value of marginal product. But while workers in any given firm tend to retire around the same age, they begin over a wide range of ages.[27] It is easy to show that in order to "balance the books" in a nonspot model, the parameters δ and l in equation (3–17) must be set differently depending on the worker's beginning age in the firm, denoted by B.

The right-hand side of equation (3–17) is straightforward. The worker's marginal product is assumed to be related to his tenure level. The vector X is permitted to affect compensation directly and to influence the shape of the wage-service profile. The specification in (3–17) allows pensions to affect (or to be correlated with) productivity in a proportional way through the term: dP.

The most direct way of inferring the value of the parameter γ is to estimate the specification in equation (3–17) directly. Unfortunately, it is very difficult to estimate this equation using a cross section of workers because the selection on who accepts pensions will bias the estimate of γ (high wage earners are more likely to accept pensions compared to low wage earners). By exploiting individual wage history data, this problem can be circumvented. In particular, by comparing beginning (W_o) *and ending* (W_R) wages for each worker rather than comparing wages between pension-covered and uncovered workers, an estimate of the parameter γ can be made without encountering the nuisance

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[26] Edward P. Lazear, "Why Is There Mandatory Retirement?" *Journal of Political Economy* 87 (December 1979), pp. 1261–84.

[27] Work patterns in firms are clearly not homogeneous. For example, in a sample of 80 firms that reported at least 25 retirees during the period 1975–1978, the standard error on age retired within the firm averaged 3.5 years. The standard error for service length in the firm averaged 13 years. Source: U.S. Department of Labor, Survey of Pension Benefits, 1979. Since there appears to be a fairly narrow window around retirement age and since tenure levels have a wide variance, it is apparent that, in order for the firm to pay appropriate present value compensation to all workers, it must adjust workers' profiles according to the age started with the firm. Evidence from the same survey reported below contradicts this prediction (see Table 3–3).

selection problem present in a direct estimate specification. Writing the expression in equation (3–17) for the year of retirement (tenure T_R) and dividing by the same expression for the first year of work (tenure T_0)*in the last job, we have:*

$$\begin{aligned} \ln (CW_R/CW_0) = {} & c_0 + c_1 \ln (T_R/T_0) \\ & + c_2 \ln (T_R/T_0) \cdot X \\ & + c_3 \ln (T_R/T_0) \cdot P \\ & + c_4 \ln (T_R/T_0) \cdot B \\ & + \text{error}; \; T_0 \geqslant 1. \end{aligned} \tag{3–18}$$

The cash wages are adjusted by the nonagricultural wage index for the United States; hence the wage measures are purged of the influences of inflation and overall productivity growth. It is noted that in the transition from equation (3–17) to equation (3–18), several terms conveniently cancel, including the terms $\delta(B)$, X^c, and exp $[P\,(d - \kappa)]$; all remaining variables interact with relative tenure levels (except health problems at retirement which are specific to years late in the tenure cycle).[28]

In terms of the empirical model specified in equation (3–18), the legal theory of pension savings is supported if $c_3\,(= -\gamma) << 0$; in contrast, under plausible assumptions ($i = g$), the implicit contract theory is supported if $c_3\,(= -\gamma) = 0$. If $i < g$, the implicit contract theory is also consistent with the result $c_3 > 0$. Finally, the spot assumption is supported if the coefficient on the beginning age variable is zero ($c_4 = 0$).

Social Security Retirement Data

To test these predictions, equation (3–18) was run using two data bases; the first is the Social Security Administration Newly Entitled Beneficiaries Survey (SNEB). The advantage of this data base is that it includes information about pension-covered and uncovered workers. It does not include multiple observations per firm and thus no information is available to test the spot assumption. This shortcoming will be rectified (at a cost) using a second data base.

The SNEB survey describes the personal and job characteristics of several thousand recently retired workers who applied for social security benefits in 1970. Years of service in their last main job are reported. Their earnings histories are also reported as far back as 1951.

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[28]The empirical specification can be directly related back to the pension model used above. Using the expressions found in equations (3–12), (3–13), and (3–14) above, the ratio of cash wages at retirement relative to the start age divided by the same ratio of total compensation is

$$\Omega = (CW_R/CW_0)/(W_R/W_0) = \{1 - b[1 + (1 - \lambda)gR]\} / [1 - be^{(\lambda g - i)R}].$$

Thus, if the worker's tenure with the firm began prior to 1951, the beginning cash wage equals his earnings in 1951; his tenure variable is set equal to his tenure level in 1951. If workers reached the social security earnings maximum, their earnings are estimated based on an algorithm developed by Alan Fox.[28] The vector of other variables X in equation (3–18) includes the worker's occupation, industry, and personal characteristics.

The results of the regression are listed in the first column of Table 3–3. The estimates reveal a coefficient on the pension variable PENSION that is slightly negative but insignificantly different from zero, suggesting that cash wage profiles are unaffected by pension coverage; that is, implicit pension savings rates are approximately constant over the tenure of pension-covered workers. In short, the results support the implicit contract theory and contradict the legal theory.

Department of Labor Pension Data

These results can be verified using alternate data. In particular, the Department of Labor holds a data base that reports social security wage histories for 1,642 retirees from 61 defined benefit pension plans. While the data excludes firms with no pensions, the wage profile test can still be performed by substituting the generosity of the pension plan (PENSION SIZE) instead of a simple pension dummy variable. Pension generosity is measured by the parameter b used above (see equation 3–7), which is easily estimated for each plan.[29] From expression (3–14) in

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[28]Separate analyses of Fox's wage estimates against observable earnings data in the survey reveal no bias in the estimation method. Actual ending (but not starting) wage earnings in the worker's last main job are reported in the survey. Comparing these actual earnings to the Fox-estimated earnings for those facing the social security maximum earnings in their last year of full-time work, the Fox-to-actual ratio turned out to be .965; thus, it is apparent that Fox's estimation method (based on quarters-of-coverage information in the social security files) comes on average remarkably close to predicting actual earnings. See Alan Fox, "Earnings, Replacement Rates and Total Income: Findings from the Retirement History Survey," *Social Security Bulletin* 45 (October 1982), pp. 3–23. In any event, the regressions in Table 3–3 were run separately using only those observations that were not Fox-estimated. The qualitative results (not reprted) remained essentially unchanged.

[29]Most large pension plan formulas resemble the specification in equation (3–7); that is, the pension benefit is log-linear in service level and wage at retirement. Benefits are usually actuarially reduced for "early" retirement relative to normal retirement age and joint and survivor election, and increased for "late" retirement. Normally, benefits are higher in firms that have later normal ages of retirement. As such, for estimation purposes, pension plan formulas can be represented by the equation ln PENSAMT = a_1 ln WAGE + a_2 ln SERVICE + a_3 JOINT AND SURVIVOR ELECTION + a_4 AGE RETIREMENT + a_5 EARLY + a_6 LATE + a_7 YEAR RETIREMENT + b_1 PLAN 1 + b_2 PLAN 2 + . . . + b_{61} PLAN 61, where PENSAMT is the retiree's annual pension as of 1978. EARLY and LATE refer to retirement before or after the plan's "normal" retirement age, thereby signaling an actuarial adjustment. Accounting for "early" and "late" retirement, AGE RETIREMENT refers to the normal age of retirement in the plan. The variable WAGE is the worker's final wage in the firm, and SERVICE is the individual's service in the firm at retirement. Finally, PLAN *i* denotes a dummy variable equal to unity for all observations in the *i*th plan, zero otherwise. After estimating this equation using 1,642 retirees in 61 plans, the 61 b-parameters were estimated.

TABLE 3–3 The Effect of Pension Coverage and Pension Amounts on Wage Profiles

Independent Variables	(1) *Social Security Administration Retirement Data*	(2) *Department of Labor Pension Data*
Log of tenure ratio: ln (T_R/T_S)	.030 (1.06)	−.075 (1.11)
Health problems at retirement	−.020 (1.53)	—
[all remaining variables are interacted with ln (T_R/T_S)]		
PENSION	−.004 (.40)	—
PENSION SIZE[a]	—	.129 (2.93)
College graduate	.007 (.41)	—
High school graduate	−.015 (1.06)	—
Female	.060 (4.82)	.018 (1.56)
Black	−.001 (.02)	.054 (3.82)
UNION[b]	—	.002 (.67)
UNION · PENSION SIZE	—	−.029 (.64)
Average (annual) wage in firm[c] (sample mean $18.4 thousand)	—	.0086 (4.52)
Average starting age in firm	—	.002 (1.81)
Worker's start age minus average starting age in firm	—	−.006 (.94)
Industry dummy variables[d]	X	X
Occupation dummy variables[d]	X	X
Firm size dummy variables[e]	—	X
Year of retirement dummy variables[f]	—	X
Observations	3413	1642
R-squared	.054	.106

Dependent Variable: ln (CW_R/CW_S); (absolute) t-statistics are in parentheses.

[a]PENSION SIZE is found by estimating the parameter "b" in the pension formula for each of 61 plans represented in the sample. See equation (3–7) and note 30.

[b]UNION equals one if the pension plan is collectively bargained, zero otherwise; 37 of 61 plans were characterized by UNION = 1.

[c]The average wage in the firm is taken as the average of (real) final wage of the sample of retirees in each plan in the sample.

[d]Eight industry dummy variables and eight occupation dummy variables were included.

[e]Seven firm size dummy variables were included.

[f]Nine year-of-retirement dummy variables are included. They are not included in the first regression because the nature of the survey incorporates year and age of retirement in the same variable.

Data for the first regression is from the Social Security Administration, Survey of Newly Entitled Beneficiaries, 1970. Data for the second regression is from the U.S. Department of Labor, Survey of Pension Benefits which includes Social Security Administration earnings histories of workers from 61 pension plans who retired during the period of 1967–1977.

the text, it is apparent that in a legal theory, as the generosity of the plan is increased, the pension savings wedge that grows with tenure becomes even more exaggerated: $\partial^2 S_s/\partial a \partial b > 0$; in an implicit contract model (in the plausible case when $i = g$), the wage-service profile is either unaltered: $\partial^2 S_s/\partial a \partial b = 0$; or, if $g > i$, $\partial^2 S_s/\partial a \partial b < 0$. Thus, if the coefficient on PENSION SIZE is negative (and large), the legal theory is supported; if it is zero or positive, the implicit contract theory is supported.

This data base has several advantages over the social security data. For example, since all individuals in the sample are covered by pensions, the selectivity problem on persons who seek pension coverage is reduced. The data base also reports the union status of pension plan participants and the date of plan creation; thus, union influence on wage profiles can be measured, and further, all observations for which the starting year wage (CW_0) is observed is earlier than the date of plan creation can be excluded from the data.[31] Finally, because the 61 plans in the sample have an average of 27 retirees,[32] the influence of the average wage and the average starting age in the firm on wage profiles can be measured. The starting age of each worker relative to the average in the firm can be used as a test of the spot equilibrium model.

The results of this regression are presented in the second column of Table 3–3. Again, the results contradict the legal theory of pensions. Far from being negative and large, the coefficient on PENSION SIZE is significantly positive. The results are consistent with the implicit contract theory if $g > i$. Assuming the validity of the implicit contract theory, it is straightforward to determine that the results suggest that the exponent in equation (3–12), namely $(i - g)$, equals $-.005$.[33] It is also interesting to note from the results that while wage profiles are affected by the average wage level and the average starting age in the firm, they are not sensitive to the relative starting age of workers in each firm, providing some evidence in support of the spot model.

The results using either data base are therefore inconsistent with the legal theory of pensions, which predicts a negative and large value for the pension coefficient. Instead, the results support the implicit contract theory in the special case when the interest rate is approximately equal to, or slightly lower than, the expected growth rate in nominal wages.

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[31] In the Social Security Administration data file, it was assumed that retirees were covered in the year their first wage was reported. Statistically, two thirds of all pension plan participants were in plans established prior to 1951. Thus, some noise in the pension variable is present in that data.

[32] To prevent some large plans from dominating the results, no more than 100 retirees were selected randomly from the large plans.

[33] The coefficient on PENSION SIZE is an estimate of $\Omega'(b)$ in note 28. Calculating $\Omega'(b)$ and setting $\lambda = 1$ (which assumes the validity of the implicit contract model), the implied estimated discount rate is determined.