NBER WORKING PAPER SERIES

CORPORATE PENSION POLICY AND THE VALUE OF PBGC INSURANCE

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Working Paper No. 1217

NATIONAL BUREAU OF ECONOMIC RESEARCH
1050 Massachusetts Avenue
Cambridge, MA 02138
October 1983

The research reported here was funded by the U.S. Department of Health and Human Services. I am grateful to Zvi Bodie and Bob McDonald for many helpful discussions. The research reported here is part of the NBER's research program in Pensions. Any opinions expressed are those of the author and not those of the National Bureau of Economic Research or of the USDHHS.

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Abstract

This paper derives the value of PBGC pension insurance under two scenarios of interest. The first allows for voluntary plan termination, which appears to be legal under current statutes. In the second scenario, termination is prohibited unless the firm is bankrupt. Optimal pension funding strategy under each scenario is examined. Finally, empirical estimates of PBGC liabilities are calculated. These show that a small number of funds account for a large fraction of total prospective PBGC liabilities, that those total liabilities greatly exceed current PBGC reserves for plan terminations, and that PBGC liabilities could be substantially reduced by the prohibition of voluntary termination.

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CORPORATE PENSION POLICY AND THE VALUE OF PBGC INSURANCE

Title IV of the Employee Retirement Income Security Act of 1974 established the Pension Benefit Guarantee Corporation to insure the benefits of participants of defined-benefit pension plans. The PBGC now insures the pension benefits of more than 28 million employees in single-employer plans, and provides less extensive coverage to participants in multi-employer plans. Firms initially were charged a premium of $1 per year per employee for this coverage. This premium structure was meant to be temporary, until the data required to establish an actuarially balanced plan became available. In 1980, the PBGC raised the premiums to $2.60 per employee per year. In 1982 the PBGC requested a further increase in the premium rate to $6.00, and warned that even this increase will be sufficient to cover prospective PBGC liabilities only if several currently precarious large plans regain financial stability.[1] This latest request has led to renewed interest in PBGC pricing policy and the assessment of PBGC liabilities. Although the Multiemployer Pension Plan Amendment Act of 1980 directed the PBGC to study the possibility of a graduated premium rate schedule based on risk, such recommendations have yet to be made, and the current proposals for rate changes are still independent of risk.

One approach to valuing PBGC liabilities is provided by the options pricing framework. The formal correspondence between put options and term insurance policies has long been noted and the option pricing methodology has been used to value insurance plans in other contexts (Mayers and Smith [1977], Merton [1977], Sosin [1981], Marcus and Shaked [1982]). In fact several authors (Sharpe [1976], Treynor [1977], da Motta [1979], Langetieg et al. [1981]) already have used option pricing methodology to study the valuation of PBGC insurance. The provisions of ERISA allow firms to transfer their pension liabilities to the PBGC in return for pension fund assets plus 30 percent of the market value of the firm's net worth. Thus, viewing PBGC insurance as a put option, the pension liabilities play the role of the exercise price while the fund assets plus 30 percent of net worth play the role of the underlying asset or stock price.[2]

However, while the analogy between put options and the option to terminate a pension plan appears straightforward, the correspondence between the two is not at all clear with respect to the effective time to maturity of the pension put. Taken literally, ERISA rules seem to imply that a firm may terminate an underfunded plan, transfer its net liability to the PBGC, and reestablish a new insured plan. Under this reading of the law, firms would immediately terminate any plan which became underfunded by more than 30 percent of net worth. The option would have instantaneous maturity and be indefinitely renewable.

In practice, however, virtually all terminations of underfunded pension plans occur as a byproduct of corporate bankruptcy. The lack of voluntary terminations suggests that there may be hidden costs to termination. Bulow (1982) suggests that voluntary termination might lead to unfavorable government treatment in other matters.[3] Other observers (e.g., Munnell, 1982) cite damaged labor relations as an implicit cost of termination. This seems less convincing, however, since the firm may replace the terminated plan with another plan of equal value. Both employees and employers can gain at the expense of the PBGC. More explicit costs of termination might arise from legal entanglements. In one widely cited case, the PBGC brought suit to block the voluntary termination and reorganization of the underfunded pension plan of AlloyTek. The two sides ultimately settled out of court in 1981, with the PBGC assuming the underfunded plan and AlloyTek agreeing not to establish a new defined-benefit plan. Instead, the firm was allowed to establish a defined-contribution plan for its employees by buying Individual Retirement Accounts (IRAs) for them (Munell, 1982).

Most authors have chosen to avoid the ambiguity regarding termination provisions. Treynor (1977) analyzes pension finance using a one-period model, in which the fund automatically terminates at the end of the period. Sharpe (1976) also uses a one-period model, which effectively transforms the termination put into a European option. In a similar vein, da Motta (1979) assumes an arbitrary finite maturity date. His model allows firms to drop out of the PBGC insurance program at interim moments when pension funding payments come due, but the firm cannot exercise the PBGC put until an exogenously given maturity date (p. 93). Harrison and Sharpe (1982) also study a multiperiod model in which the PBGC insurance is exercised only at the end of the last period. Bulow (1981, 1983), Bulow and Scholes (1982) and Bulow, Scholes and Menell (1982) generally pass over the issue of termination date per se, and focus instead on contingent liabilities at termination, whenever that may be. Finally, Langetieg et al. (1981) consider PBGC insurance in a general multiperiod contingent claims framework, but examine only the qualitative properties of the insurance, and do not derive a valuation function for the insurance.

While these models offer several important insights, the issue of the implicit termination date remains problematic. It is clear that any estimates of the value of PBGC liabilities will be sensitive to the assumed maturity of the insurance program. The sensitivity of the qualitative conclusions of these models to the imposition of an exogenous termination date remains an open question.

This paper presents models of the pension insurance program which also use the contingent claims methodology, but which do not impose an exogenous maturity date on PBGC insurance. The value of PBGC insurance is derived for two scenarios. In the first, the possibility of corporate bankruptcy is ruled out, and the pension plan is terminated only when that action is value maximizing for the firm. This scenario is motivated by the opportunity for profitable termination which ERISA seems to offer firms. The point of departure for this model is the AlloyTek case, the resolution of which indicates that a firm can terminate a pension plan with minimum explicit cost once, but only once. A one-time-only termination provision makes the pension put formally identical to an infinite maturity American option, which expires only upon exercise. The cost of termination is the opportunity cost of not being able to terminate in the future for possible greater benefits. The termination decision becomes an optimal-timing problem in which the option is exercised only if it is sufficiently in-the-money. Such a model potentially can explain the existence of so many underfunded plans which have not yet terminated without resorting to unspecified implicit costs of termination. Given the ability of a firm to replace the terminated defined-benefit plan with a defined-contribution plan, it is not clear that those costs would be significant for most firms.

The first model yields an upper bound estimate of the value of PBGC insurance because the plan is terminated only when that action is optimal for the firm. In contrast, the second model will provide a lower bound on the value of the PBGC insurance. In this model, an underfunded pension plan may terminate only at the occurrence of corporate bankruptcy. The motivation for this approach is twofold: First, it is consistent with the empirical fact that virtually no solvent firms exercise the pension put. Second, it is consistent with proposals for pension insurance reform which would disallow termination of underfunded plans by solvent firms. The value derived for this scenario should represent a lower bound on the true value of the insurance, since it rules out the possibility for firms to choose a value-maximizing termination rule. The true value of PBGC insurance should lie between the valuation bounds generated by these two models.

The models employed in this paper allow for an analysis and valuation of pension insurance in a model in which plan termination is determined endogenously. The models also offer a framework for studying corporate pension funding and investment policy. The implications of these models confirm and extend those of Bulow (1981) and Harrison and Sharpe (1982), who analyzed pension funding strategies for plans with a given maturity date.

The next section presents a model of pension insurance. The valuation of PBGC liabilities are derived for each scenario, risk-rated pension insurance premium structures are considered, and optimal corporate financial policy is examined. It is shown that a fund can be significantly underfunded before a firm would find termination to be a profitable strategy.

Section II presents empirical estimates of the value of PBGC insurance for a sample of Fortune 100 firms. The results of this Section indicate that the pension put has significant value for several firms, and that the true value of PBGC liabilities can differ substantially from the common measure of such liabilities, which is accrued benefits less the sum of fund assets plus 30 percent of firm net worth. Finally, the empirical results are used to evaluate the decrease in PBGC liabilities that would result from the prohibition of voluntary terminations by underfunded plans. Section III concludes.

I. A MODEL OF PENSION INSURANCE

A. Valuation of PBGC Pension Liabilities: Voluntary Termination

For simplicity, I will assume that all accrued benefits are vested and fully insured by the PBGC. In fact, guaranteed benefits typically account for between 90 and 95 percent of vested benefits, while approximately 80 percent of accrued benefits are vested (Amoroso, 1982). This simplification is necessary to derive analytic solutions below; it should not affect the qualitative properties of the solution.

Following Bulow, let A denote the value of accrued benefits, F denote the value of assets in the pension fund and .3E denote the firm liability beyond assets in the pension fund, i.e., 30 percent of net worth. F and E are measured as market values, while A is the present value of accrued benefits calculated by discounting at the riskless nominal interest rate. The benefits represent an obligation which will be paid with certainty, either by the firm or the PBGC.

At a termination, if the plan is sufficiently funded ($F+.3E \geq A$), the firm gains F and transfers assets of value A to the PBGC. Otherwise, the firm is liable only up to the amount F+.3E. The net proceeds to the firm at termination therefore equal[4]

$$F - \min(A, F+.3E) \qquad (1)$$

or equivalently,

$$F-A + \max[A-(F+.3E), 0]. \qquad (2)$$

Expression (2) highlights the nature of the firm's put option. Its net pension liability is F-A; however, it can default on that obligation and transfer its liability of A to the PBGC in return for only F+.3E.

There is no explicit maturity date associated with the insurance plan. In this sense, it is isomorphic to an American put option with infinite maturity and exercise price A. Just as the put can be exercised only once, the firm can voluntarily terminate just one defined-benefit plan. Thereafter, it may offer its employees only defined-contribution plans. These plans are akin to mutual funds. They neither require nor recieve PBGC insurance. Part of the firm's problem will be to choose a rule for voluntary termination which, in conjunction with its other policies, maximizes firm value.

To solve for the value of the pension insurance it is first necessary to specify the dynamics for accrued liabilities and the assets backing the plan. These will differ from conventional specifications because of the effects of firm contributions to the pension fund and the effects of new retirees and deaths on the dynamics for A.

For convenience, use S to denote the sum F+.3E. I will assume that S follows the diffusion process

$$dS = (C_S+\alpha_S)Sdt + \sigma_S Sdz_S \qquad (3)$$

where C_S is the rate of firm contributions into the pension fund <u>net</u> of payments to retirees expressed as a fraction of S,[5] and where α_S is a standard drift term attributable to the normal rate of return on the pension fund assets, F, and the firm equity, E.[6] C_s will be positive if firm funding for accruing benefits exceeds payouts from the pension fund for current retirees. In a steady state with no uncertainty, a constant interest rate, and a constant number of retirees, the present value of accrued benefits would be constant over time. A firm administering a fully funded plan could withdraw interest earnings from the plan to help it pay benefits to current retirees and still maintain full funding. In this case, new contributions into the plan would fall short of payouts to retirees by the amount of the interest earnings; C_S would be negative. In fact if 30 percent of the firm's equity were not included in the assets backing the fund, C_S would equal the negative of the interest rate. Firm contributions would fall short of current payouts by interest earnings on fund assets, which as a fraction of assets would simply be the interest rate.

The dynamics for A are more complicated. As a base case, consider a situation in which none of the firm's employees have yet retired and in which no further pension benefits will accrue. If the interest rate, r, is constant, then the present value of accrued benefits, A, which is the exercise price of the pension put, will increase at the constant proportional rate r. The growth in the exercise price derives from the definition of A as a present value, and differs from the more conventional situation in which the exercise price is specified as a dollar amount.

If long-term interest rates are stochastic, then so will be the present value of accrued benefits. Denote by α_A the expected rate of return on a bond with a payoff stream identical to that of accrued benefits. This will also be the expected growth rate in the present value of already accrued benefits. If interest rates were nonstochastic then α_A would equal r.

Demographics also affect the evolution of A. Accrued benefits increase when current workers increase their length of employment and decrease when plan participants die or have benefits paid to them. In a steady state with no uncertainty, and a constant level of accrued benefits, newly accruing benefits plus the increase in the present value of already accrued benefits would exactly offset the decrease in total accrued benefits due to retiree deaths. Denoting the net growth rate in accrued benefits attributable to demographic factors as C_A, the total growth rate in A would be C_A+r. Thus in the steady state, C_A would equal -r and A would remain constant. The evolution of A can then be summarized by the process

$$dA = (C_A + \alpha_A)Adt + \sigma_A A dz_A \qquad (4)$$

The stochastic component of (4) is due to uncertainty regarding long-term interest rates and the future pattern of additional net accruals. I will denote the correlation coefficient between dz_A and dz_S as ρ.

Following the analysis in Merton (1974), and letting P(A,S) denote the value of the pension put, one can show that P must satisfy the partial differential equation:

$$\tfrac{1}{2}P_{AA}A^2\sigma_A^2 + \tfrac{1}{2}P_{SS}S^2\sigma_S^2 + P_{AS}AS\sigma_A\sigma_S\rho - rP + (r+C_A)AP_A + (r+C_S)SP_S = 0 \qquad (5)$$

where subscripts on P denote partial derivatives and r denotes the rate of return on instantaneously riskless bonds. Equation (5) lacks a term involving calendar time because the put is of infinite maturity (Merton, 1973). The terms C_A and C_S have effects analogous to those of (negative) proportional dividends in the standard option pricing model (Smith, 1976).

The boundary conditions for P are:

a) At a point of exercise of the put (i.e., termination of the plan), P = A-S.

b) The limit of P as S approaches infinity is zero.

c) The limit of P as A approaches zero is zero.

d) The rule for voluntary exercising is chosen to maximize the value of the option.[7]

Following the analysis of McDonald and Siegel (1982), the solution to (5) can be shown to have the general form

$$P(A,S) = (1-K)A(S/A)^{\varepsilon}K^{-\varepsilon} \tag{6}$$

where K is the ratio of S/A at which the option is exercised. Equation (6) will satisfy p.d.e. (5) for

$$\varepsilon = -\left[\left(\frac{C_S - C_A}{\sigma^2} - \frac{1}{2}\right)^2 - 2\frac{C_A}{\sigma^2}\right]^{1/2} + \left(\frac{1}{2} - \frac{C_S - C_A}{\sigma^2}\right)$$

$$\sigma^2 = \sigma_A^2 + \sigma_S^2 - 2\rho\sigma_A\sigma_S$$

These conditions are derived by solving the quadratic equation which is generated by substituting (6) into (5). Choosing K to maximize the value of the option results in the condition

$$K^* = \frac{\varepsilon}{\varepsilon - 1}\ . \tag{7}$$

Equation (6) gives the value of the PBGC insurance plan (under the simplifying assumption of no bankruptcy). Given estimates of the parameters in (6) and (7) one could assess the value of the insurance to the shareholders of the firm. These values could serve as the basis for a risk-rated premium structure. Two such structures are discussed below in Section D.

Equation (7) gives the condition for voluntary termination of the pension plan. Second order conditions require that $\varepsilon<1$. One must further restrict ε to be negative since a feasible K^* must be positive (because A and S are always positive). Thus, $\varepsilon<0$, which implies $0<K^*<1$ so that the put will be exercised only for $S<A$, i.e., if fund assets plus 30 percent of net worth fall below accrued benefits. Parameters which result in non-negative values for ε would imply that the option would never be exercised.[8]

Equations (6) and (7) generalize the formula for the perpetual American put option presented in Merton (1973). In the special case that A is nonstochastic, that $C_S=0$ and $C_A=-r$ (which offsets the growth in A due to the time value of money and thereby causes the dollar value of the "exercise price", A, to be constant), ϵ equals $-2r/\sigma^2$ and (6) reduces to Merton's equation (52).

A.1 Comparative Statics

It is possible, although tedious, to show analytically that the value of the termination option increases with C_A and decreases with C_S. Conversely, the ratio of S/A at which it is optimal to terminate falls with C_A and increases with C_S. The intuition for these results is straightforward: when the gap between the growth rates of accrued benefits and the assets backing those benefits ($S = F+.3E$) increases, the expected profits from a future exercise of the put option increase and the value of waiting to exercise correspondingly increases. These results are illustrated in Table 1, in which optimal ratios, $K^* = (S/A)^*$, for pension termination and the value of the pension put are presented for various values of C_A and C_S and for an interest rate of .10 and a variance rate of .05[9]. Recall that the certainty equivalent drifts in A and S are respectively $r + C_A$ and $r + C_S$. Therefore the parameters presented in Table 1 correspond to combinations of sustained growth rates of -.08 to +.06.

The put values in the second panel are calculated assuming that A = S = 1.0. Therefore these entries may be interpreted as the value of the pension insurance as a fraction of total asset value when the pension put is exactly at-the-money, i.e., when the total assets backing the pension fund obligations equal the present value of those obligations. Remember, however, that this condition does not correspond to full funding of the pension fund since S includes the contingent liability of the firm of .3E. Of course, formula (6) could be used to generate actuarially fair values of the insurance for any initial values of A and S.

The table demonstrates that the value of the termination put can be substantial. As a base case, the zero drift configuration of C_A and C_S gives a pension put value of 18 percent of the value of accrued liabilities. Therefore even fully funded plans (where funding includes the firm's contingent liability of .3E) can pose significant risk to the PBGC. When $(r + C_S)$ is negative (i.e., when pension assets are being depleted because of payments to retirees) or when $(r + C_A)$ is positive, pension insurance values increase dramatically.

It is interesting to note that when $C_A = C_S = 0$, $\varepsilon=0$ and the pension put will never be terminated. In this case, the "exercise price," A, is growing at an expected rate equal to its cost of capital; therefore, in contrast to the standard put option, waiting to exercise does not impose a time value of money cost.

The table also can be used to examine the effects of equal changes in C_S and C_A. Reading down the diagonals from top left to bottom right demonstrates that the optimal voluntary termination ratio decreases for larger (algebraic) values for these growth rates. The value of the pension put correspondingly increases. These results derive from the effect of scale on the termination decision. If a pension fund is increasing in size (large positive C_A,C_S), then the dollar gain from a termination for any given <u>ratio</u> of S/A is larger. If the fund is growing, it pays to wait to terminate, and the ratio S/A must be smaller to induce early termination.

Thus, one should expect termination decisions to be more frequent in declining industries in which pension funds are shrinking. These results also can be verified analytically: Equal (algebraic) increases in C_A and C_S always increase the value of P(A, S) and lower the termination ratio, K*.

A.2 Corporate Pension Funding Policy

Bulow (1981) and Harrison and Sharpe (1982) examine pension funding policy in a model with taxes and with an exogenous termination date. They conclude that a firm should fund its plan either to the maximum or the minimum level permitted. This razor's edge characteristic is also a property of the voluntary termination model.

To confirm this point, compute the first and second derivatives of P(A,S) with respect to pension funding, S:

$$P_S = \varepsilon(1-K)S^{\varepsilon-1}A^{1-\varepsilon}K^{-\varepsilon}$$
$$= -[K/(S/A)]^{1-\varepsilon} \quad (8)$$

$$P_{SS} = \varepsilon(\varepsilon-1)(1-K)A^{1-\varepsilon}S^{\varepsilon-2}K^{-\varepsilon} > 0 \quad (9)$$

where the final form of equation (8) is obtained by substituting for ε from (7). From (8), for any nonterminated plan (i.e., $K<S/A$), we have that $0>P_S>-1$, so that each dollar contributed reduces the insurance value by less than 1 dollar, and by (9), each successive dollar contributed reduces the insurance value by progressively smaller amounts. In contrast, the marginal tax shield arising from contributions to the pension fund is independent of the level of current funding (Black [1980], Tepper [1981]).

Therefore, the firm will always be forced to a corner solution: At any interior point, if one dollar of extra funding results in an incremental tax shield which exceeds the marginal decrease in the value of pension insurance, then so must the next dollar contribution and so on. Conversely, if marginally decreased funding is optimal in the interior, then so must be further decreases until some statutory limit is reached. See figure 1.

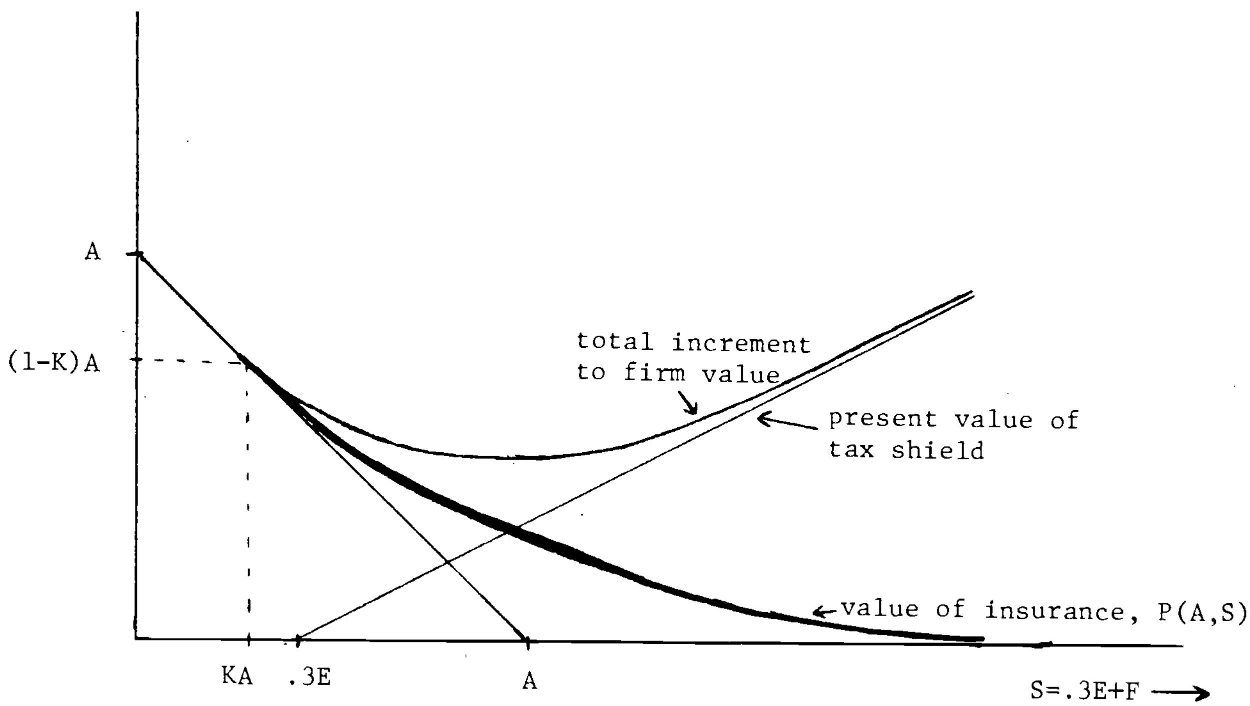
Bulow (1982) has argued that accrued benefits rather than projected benefits is the relevant variable for assessing corporate pension liabilities. The approach taken in this paper leads to an intermediate position in this debate. Although it is true that at a termination, the firm's liability is only accrued benefits, the model shows that in the presence of PBGC insurance, projected benefits (as represented by C_A) influence the decision to terminate as well as the present values of both PBGC and firm liabilities.

B. PBGC Liabilities with Termination Only at Bankruptcy

When the pension plan terminates only if the firm is bankrupt, the firm loses the special put option conveyed by the current pension insurance system. Instead, at bankruptcy, the PBGC simply assumes the pension fund.

The value of the PBGC liability will depend in general upon the exact conditions which set off a bankruptcy. I will assume that bankruptcy is declared when the value of the firm, V, falls below the present value of the debt obligations of the firm where that value is computed under the assumption that the obligations will be fully met. (This notion of debt, rather than market value, is the appropriate one because limited liability assures that the market value of debt can never exceed V). Although this

Figure 1



The pension plan is terminated when $S/A \leq K$, or at $S = KA$. At termination, the obligation of the PBGC equals $A - S = (1 - K)A$. Before termination, the insurance is worth $P(A,S)$. The tangency at $S = KA$ is the termination point.

The present value of tax savings from pension funding increases with funding, or, holding E fixed, with S. The present value of tax savings is proportional to the level of funding.

The total increment to firm value is maximized at either the minimum or maximum permitted funding levels.

definition of bankruptcy is at odds with the technical definition that a firm fails to meet a coupon or principal payment, it still seems a useful way to model bankruptcy for the present purpose. Firms in practice have several overlapping debt issues outstanding with associated sinking fund covenants which would make the modelling of bankruptcy in a legal context exceedingly complex and firm-specific. Economic insolvency is a more straightforward approach.

Denote by D the present value of debt obligations computed by discounting at the riskless-in-terms-of-default interest rate. Then insolvency occurs at the first occurrence of $V \leq D$. At that moment, the PBGC inherits a net liability of $A - F$,[10] where F denotes the value of the funds in the pension plan. The PBGC's claim to 30 percent of firm net worth is irrelevant in this instance, since at bankruptcy, when $V \leq D$, equity has no value.

To derive the value of the PBGC insurance, we proceed as before. The dynamics for debt, pension funds and firm value are taken to be the diffusion processes

$$dD = \alpha_D D dt + \sigma_D D dz_D$$
$$dF = (\alpha_F + C_F) F dt + \sigma_F F dz_F$$
$$dV = \alpha_V V dt + \sigma_V V dz_V$$

where C_F denotes the rate of contributions to the pension fund as a fraction of F. In a nonstochastic steady state with a constant interest rate, C_F would equal $-r$. All fund earnings would be withdrawn to help pay benefits to current retirees so that total fund assets would remain unchanged over time. The covariances between the instantaneous rates of return on the variables will be denoted by σ_{DF}, σ_{DV}, and so on.

Letting $P(D,V,F,A)$ be the value of the PBGC liabilities, one can show that P must satisfy the p.d.e.

$$\frac{1}{2}(P_{DD}\,\sigma_D^2\,D^2 + P_{VV}\,\sigma_V^2\,V^2 + P_{FF}\sigma_F^2\,F^2 + P_{AA}\sigma_A^2\,A^2)$$

$$+ P_{DV}\sigma_{DV}DV + P_{DF}\sigma_{DF}DF + P_{DA}\sigma_{DA}DA + P_{VF}\sigma_{VF}VF + P_{VA}\,\sigma_{VA}VA + P_{FA}\sigma_{FA}FA$$

$$+ P_D rD + P_V rV + P_F(r + C_F)F + P_A(r + C_A)A - rP = 0$$

subject to the boundary conditions

a) $P = A - F$ when $D = V$

b) the limit of P as V approaches infinity is zero

c) the limit of P as D approaches zero is zero

d) the limit of P as F and A approach zero is zero.

The solution to this equation is

$$P = A(D/V)^{\phi} - F(D/V)^{\theta} \tag{10}$$

where

$$\theta = \frac{K}{M} + \left[\left(\frac{K}{M}\right)^2 - \frac{2C_F}{M}\right]^{\frac{1}{2}}$$

$$\phi = \frac{L}{M} + \left[\left(\frac{L}{M}\right)^2 - \frac{2C_A}{M}\right]^{\frac{1}{2}}$$

$$K = -\frac{1}{2}\sigma_V^2 + \frac{1}{2}\sigma_D^2 - \sigma_{DF} + \sigma_{VF}$$

$$L = -\frac{1}{2}\sigma_V^2 + \frac{1}{2}\sigma_D^2 - \sigma_{DA} + \sigma_{VA}$$

$$M = \sigma_V^2 + \sigma_D^2 - 2\sigma_{DV}$$

and where the solution is valid for parameters which result in positive values for θ and ϕ.[11]

Optimal corporate pension funding policy in the bankruptcy-only model resembles that in the voluntary termination model. The partial derivative of P(D,V,F,A) with respect to the funding level, F, is simply $-(D/V)^{\theta}$, which is independent of F. Thus, we again obtain a razor's edge property: If D/V is sufficiently small, then the tax benefits of additional funding will dominate the transfer of wealth to the PBGC and the firm will fund to the statutory limit. Otherwise, minimal funding will be value-maximizing.

C. The General Case

A general treatment of PBGC insurance would allow for termination either at the first occurrence of a voluntary termination point or at the first occurrence of corporate bankruptcy. As a general rule, however, there is no closed form solution for the value of PBGC pension insurance in this mixed case. The difficulty arises from the effects of debt on the variance rate of the firm's equity. Geske (1979) has shown that the variance rate evolves stochastically in this situation. Because the assets backing pension benefits, S, include 30 percent of firm net worth, σ^2 in equation (6) could no longer be taken as a fixed parameter, and the solution for the value of the pension insurance consequently would need to be modified. This effect, together with the fact that termination can result from either of two conditions, appears to make a numerical solution technique necessary. Even the numerical approach presents difficulties, however, since the problem would involve four state variables: A, S, V, and D.

Notwithstanding these complications, equations (6) and (10) still can be of use in valuing PBGC liabilities. (6) should be an upper bound on the value of pension insurance, since that valuation formula was derived using the termination rule which maximizes the value of the insurance. In contrast, the termination only-at-bankruptcy model provides a lower bound on the value of the insurance. For firms that are financially healthy but which have severely underfunded plans, (5) will be a close approximation to the true insurance value. In contrast, for firms near bankruptcy, (10) will be fairly accurate.

In practice, underfunded plans are associated with financially troubled firms. Therefore, the true value of the PBGC insurance falls somewhere in the interior of the valuation bounds. The models provide some clues as to why troubled firms should tend to maintain underfunded plans. One possibility is that such firms have low marginal tax rates due to loss carry-forward provisions, and therefore derive less tax benefit from pension funding. Another explanation is that underfunding the pension plan represents a source of implicit financing cheaper than that available in outside credit markets. This advantage will be greatest for firms with the highest borrowing rates. Finally, if bankruptcy causes the firm to forfeit the pension assets to the PBGC, overfunding of the plan would create a potential bankruptcy cost to which troubled firms would be more sensitive. This effect was made explicit in Section B in which it was shown that firms with large values of D/V will find that minimal funding is value-maximizing.

D. Risk-Rated Premiums

The valuation equations derived in Sections A and B provide the present value of PBGC liabilities under different scenarios. They do not, however, provide explicit means to calculate fair annual premium rates for pension insurance. Because fund termination dates are stochastic, the premium annuity which has an ex ante present value equal to the present value of PBGC obligations cannot be easily calculated. One approach which might provide a reasonable approximation to the fair premium rate would be to first calculate the expected value of the time to termination, and then calculate the annuity appropriate to the present value of PBGC obligations using a horizon equal to the expected time until termination and an interest rate equal to that paid on the firm's outstanding debt.

A different approach would require ex post settling up. At the start of each period, the present value of PBGC obligations would be calculated. At period end, that value would be recalculated, and the firm would pay (or be paid) the change in the value of PBGC liabilities. The advantage of this scheme is that it eliminates most of the moral hazard problems involved in prespecified rate structures. Any increase in risk would induce increased premiums. The firm would always pay a fair price for its pension-put option (or for its limited liability in the bankruptcy model) and would thus lose the ability and the incentive to underfund at the expense of the PBGC.

II. Empirical Estimates

Pensions and Investment Age (July 11, 1983) reports pension fund statistics derived from the 1982 annual reports of the Fortune 100 companies. The survey includes pension fund assets, vested benefits, and the assumed interest rate used to derive the present value of vested benefits. This information can be used for this sample of firms.

The survey expresses pension fund assets as market values. The market value of vested benefits can be approximated by multiplying the reported value of benefits by the ratio of the plan's assumed interest rate to the actual long-term market interest rate for 1982. This adjustment assumes that pension benefit payout streams have time paths similar to perpetuities. The average rate on 30-year U.S. government obligations in 1982 was 12.76 percent. The market value of equity is easily derived from stock market data at year-end 1982, and total firm value can be approximated as equity plus book value of long-term debt. I will calculate the value of PBGC insurance for 3 scenarios: a steady state scenario, for which there is no expected growth in pension fund assets or liabilities, a growth scenario, in which a 5 percent long-term growth rate is assumed, and a declining industry scenario involving a negative 5 percent growth rate.

The remaining inputs required to estimate the value of PBGC insurance are the variance and covariance rates on underlying securities. Table 2 presents the values assigned to these variables. These values are meant to be reasonable guesses only. The low variance rates on A and D and high correlation between the two reflect their similar natures as nominal liabilities. The variance rates on firm value and pension fund assets compare to a historical value for the S+P500 of approximately .05 annually. The variance rate for V is derived by unlevering the S+P500 variance using a debt-to-value ratio of 1/3 and then by doubling that variance to account for the lack of diversification of a single stock relative to the index. The variance rate on fund assets is set equal to that on the S+P500. The fund is probably less well diversified than the index but this effect is offset by debt held in the fund.

Tables 3a and 3b present estimates of the value of PBGC insurance for 87 of the Fortune 100 firms. Thirteen observations were lost because of missing data. Table 3a presents results based on the 12.75 precent yield on 30-year T-bonds during 1982, while Table 3b uses a 10 percent interest rate. Columns

1 and 2 of the tables are the present value of vested benefits for each plan, and the level of overfunding of each plan, respectively. Columns 3-8 are the ratios of the value of PBGC insurance to vested benefits for the voluntary termination scenario and the bankruptcy-only scenario under the 3 assumptions for the growth rate of the plan. These ratios can be interpreted as the fraction of pension benefits which are financed (in present value terms) by the PBGC. The ratios thus give a measure of the PBGC subsidy per dollar of pension benefits.

The results in the appendices are consolidated in Tables 4 and 5. Table 4 presents summary statistics and Table 5 presents frequency distributions for the insurance values. The most striking feature of the results is the skewness of the insurance values, which is revealed in Table 5. Most plans are sufficiently overfunded as to pose almost no termination risk to the PBGC. However, a small number of "problem firms" derive considerable value from the pension insurance. These tend to be the larger firms: the weighted averages of the insurance values are substantially greater than the means. In fact for the bankruptcy-only cases, the simple mean of the insurance values is negative even for r = 10 percent while the weighted average is positive. The negative values reflect my assumptions that if an overfunded plan terminates because of firm bankruptcy, the PBGC inherits the plan surplus, and so can have a negative liability.

As expected, PBGC liabilities are extremely sensitive to the interest rate used in calculating vested benefits. Table 4 shows that insurance values in the voluntary termination scenario are more than twice as large for a 10 percent interest rate as they are for the actual 1982 rate of 12.76 percent. Average insurance values in the bankruptcy-only scenario become positive as the interest rate falls to 10 percent. This reflects the sharp increase in the present value of benefits. The total underfunding of all underfunded pension plans rises from $.48 billion to $4.47 billion as the interest rate falls.

Consistent with the comparative statics results above, the value of pension insurance tends to rise with the assumed growth rates in A, S and F. Insurance values in the voluntary termination scenario more than triple as growth rates increase from -.05 to +.05. As noted earlier, this tendency reflects the effect of scale on insurance value. For growing funds, firms can increase the insurance value by delaying termination until a larger dollar gain can be realized.

The total values of PBGC insurance for the 87 firms are also presented in Table 4. The magnitudes of these numbers are quite impressive. Total insurance values for the voluntary termination scenario are between 1.25 and 3.6 billion dollars using the 12.75 percent rate and between 3.8 and 10 billion dollars using a 10 percent rate. These values compare with PBGC reserves for insured future benefits of only 1.14 billion (PBGC Annual Report, fiscal year 1982). Therefore, if the option to terminate voluntarily is to be taken seriously, the PBGC reserve calculations are wildly optimistic. The insurance values for individual firms also differ from the traditional measure of underfunding (A-F-.3E) by wide margins, and highlight the pitfalls of ignoring the option component of pension insurance in assessing PBGC liabilities. The bankruptcy-only insurance values are, as expected, far more favorable. In fact, for the higher interest rate, firms are sufficiently overfunded to drive aggregate net liabilities below zero. As interest rates decline, the PBGC is again at great risk although even in this case, PBGC liabilities would be halved by a reform in ERISA prohibiting voluntary termination. The steady state (zero growth) insurance value at a 10 percent rate is $2.54 billion. Keep in mind that these insurance values are summed over only the 87 firms in the sample. PBGC liabilities for all insured firms must be significantly greater.

III. Conclusion

This paper derives the value of PBGC pension insurance liabilities under two scenarios of interest. The first scenario allows for voluntary plan termination, which appears to be legal under current statutes. The second is a termination only-at-bankruptcy scenario, which has been proposed as a reform to current law. Optimal pension fund financing decisions are examined; extreme pension funding policies are shown to be optimal in both settings. This result corroborates and generalizes those of earlier authors. Finally, empirical estimates of PBGC liabilities are derived. These show that a small number of funds account for a large fraction of total prospective PBGC liabilities, and that those total liabilities far exceed current reserves for plan termination.

Footnotes

1. "Pension Agency Asks Congress to Approve Rise in Premiums for One-Employer Plans," The Wall Street Journal (May 20, 1982).

2. A put option gives its owner the right to sell to the issuer of the option share of stock at a prespecified price (the exercise price) regardless of the actual price of the stock. Thus, if the stock price, S, falls below the exercise price, X, exercise of the option yields a profit of X - S. Similarly, PBGC insurance gives firms the right to "sell" the assets of the plan plus 30 percent of net worth to the PBGC at a "price" equal to the present value of pension liabilities. The gain to the firm equals the pension liabilities it transfers to the PBGC less the assets the PBGC acquires.

3. Bulow cites Chrysler as an example of a firm for which the potential costs of a termination could be large if it affected the willingness of the government to participate in a bail-out scheme for the company. Such extreme examples are probably rare, however.

4. If the fund is overfunded, this equation implies that the firm receives F-A. This might be unrealistic: Bulow and Scholes (1982) cite an example of a terminating fund in which the surplus was split between the firm and its employees. However, this issue is of limited relevance for this paper. The PBGC is unconcerned with termination of overfunded plans and presumably would not block the establishment of a new fund. Overfunded

plans are not terminated in order to escape liablities and so fall outside of the scope of this paper.

5. I assume that C_S is constant. This assumption is necessary to derive analytic solutions below. However, it is unrealistic to the extent that firms with underfunded plans are forced to increase funding rates. In this case, C_S would be a function of the funding status, and would evolve stochastically. Numerical techniques would be required to compute the value of pension insurance.

6. I will treat σ_S as a constant. This treatment is appropriate when the firm has no debt outstanding other than its pension liabilities (Geske, 1979). Thus, this specification is suitable for the voluntary termination model, but would need to be modified for the more general case in which the firm can go bankrupt. I will assume that no dividends are paid out by the firm, and that all dividends received by the pension fund are reinvested in the fund, so that α_S may be equated with the expected rate of return on the assets backing the pension liabilities.

7. This condition does not necessarily imply that the firm's goal is to maximize the value of the pension option. It implies only that conditional on other decisions, the termination rule is option-value maximizing. For example, in some situations, tax considerations may lead a firm to pursue pension funding policies that reduce the value of the pension put. Nevertheless, the termination rule must maximize the value of the put given that funding policy.

8. The insurance policy could have infinite value in this case. For example, for large C_A and $C_S=0$, the option would provide a claim on a payoff that would be growing faster than the rate of interest. The value would be infinite although the option would never be exercised. Obviously, one would not observe values of (constant) C_A and C_S leading to these singular cases.

9. Using a variance rate for S of .05 (which approximates the historical variance of the S+P 500), a variance rate for A of .01 and a correlation coefficient of .1 yields $\sigma^2 = .05 + .01 - 2(.1)(.0005)^{1/2} = .055$. I rounded down to account for the fact that pension funds hold some debt in their portfolios. The entries in Table 1 were not extremely sensitive to changes in σ.

10. According to this specification, the PBGC would gain by the bankruptcy of a firm with an overfunded pension plan, since it would simply inherit ownership of that plan. There seems to be some uncertainty as to the procedures that actually would be followed in such a circumstance, since in practice, bankrupt firms have had underfunded plans.

11. Negative values for θ or ϕ would indicate non-finite values for the insurance.

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Table 1: Termination Ratios and Option Values
(σ^2 = .05, S_0/A_0 = 1)

Optimal Exercise Ratio, K = (S/A)*

$r+C_S$ \ $r+C_A$:	-.08	-.06	-.04	-.02	0	.02	.04	.06
-.08	.69	.64	.58	.52	.44	.36	.28	.19
-.06	.72	.68	.62	.55	.48	.40	.31	.21
-.04	.75	.71	.66	.59	.52	.43	.34	.23
-.02	.78	.74	.69	.64	.56	.48	.38	.26
0	.80	.77	.73	.68	.61	.52	.42	.30
.02	.82	.79	.76	.72	.66	.58	.47	.37
.04	.83	.82	.79	.75	.70	.63	.53	.39
.06	.85	.84	.81	.78	.74	.68	.59	.46

Put Value

$r+C_S$ \ $r+C_A$:	-.08	-.06	-.04	-.02	0	.02	.04	.06
-.08	.136	.162	.196	.238	.290	.356	.440	.549
-.06	.120	.144	.174	.214	.264	.328	.412	.523
-.04	.106	.126	.153	.189	.236	.298	.381	.494
-.02	.093	.110	.134	.165	.208	.266	.347	.461
0	.082	.097	.116	.143	.180	.233	.310	.423
.02	.073	.085	.101	.123	.154	.200	.270	.379
.04	.065	.075	.088	.106	.131	.169	.230	.330
.06	.058	.066	.077	.091	.111	.142	.191	.277

Table 2: Assumptions Used to Compute Value of Insurance

		Variance Rate (annual)
Fund liabilities,	A	.01
Fund assets,	F	.04
Assets + .3 equity,	S	.04
Firm debt,	D	.01
Firm value,	V	.04

Correlation Matrix

	A	F	S	D	V
A					
F	n				
S	.1	n			
D	.8	.1	n		
V	.1	.5	n	.2	

Notes: n - correlation coefficient between these variables was not necessary for calculations

PBGC Insurance Values: Interest Rate = 12.76%

			Insurance Value as a Fraction of Vested Benefits					
			Voluntary Termination			Bankruptcy-Only		
			3 growth scenarios			3 growth scenarios		
Company	Vested Benefits	Over-funding	-.05	0	.05	-.05	0	.05
gulf&west	245.	132.	0.0005	0.0021	0.0116	-.0515	-.0658	-.0898
hewlett-pack	230.	270.	0.0	0.0	0.0	0.0	0.0	0.0003
ic indus	174.	103.	0.0036	0.0096	0.0297	-.1318	-.1559	-.1923
ibm	2909.	5481.	0.0	0.0	0.0004	0.0002	0.0009	0.0042
intl paper	401.	560.	0.0002	0.0011	0.0075	-.0131	-.0232	-.0476
itt	1039.	625.	0.0011	0.0040	0.0171	0.0	-.0011	-.0050
j&johnson	146.	218.	0.0	0.0	0.0	0.0	0.0001	0.0008
kerr-mcgee	41.	85.	0.0	0.0	0.0001	-.0704	-.1103	-.1920
litton indus	290.	289.	0.0001	0.0007	0.0057	0.0013	0.0036	0.0119
lockheed	1228.	1296.	0.0100	0.0197	0.0454	-.0260	-.0404	-.0701
ltv	1333.	115.	0.0694	0.0923	0.1355	0.0375	0.0419	0.0471
mcdermott	311.	270.	0.0036	0.0094	0.0286	-.0066	-.0114	-.0230
mcdonnell do	949.	1052.	0.0056	0.0127	0.0341	0.0002	0.0010	0.0051
3m	330.	403.	0.0	0.0	0.0002	0.0002	0.0008	0.0044
mobil	1315.	1643.	0.0001	0.0005	0.0045	-.0128	-.0222	-.0444
monsanto	803.	894.	0.0010	0.0036	0.0153	-.0001	-.0008	-.0040
motorola	43.	146.	0.0	0.0	0.0	-.0011	-.0031	-.0120
nabisco	261.	77.	0.0	0.0002	0.0030	0.0093	0.0182	0.0405
pepsico	111.	172.	0.0	0.0	0.0001	-.0022	-.0050	-.0138
philip morri	195.	296.	0.0	0.0	0.0	-.0269	-.0447	-.0842
phillips pet	445.	648.	0.0	0.0001	0.0020	-.0114	-.0207	-.0438
ralston pur.	81.	191.	0.0	0.0	0.0003	-.0530	-.0883	-.1659
rj reynolds	391.	475.	0.0	0.0	0.0009	0.0006	0.0019	0.0078
rockwell int	1322.	1436.	0.0030	0.0081	0.0257	-.0124	-.0210	-.0407
shell oil	715.	942.	0.0	0.0	0.0008	0.0	0.0003	0.0020
signal cos.	388.	322.	0.0006	0.0025	0.0126	-.2601	-.2994	-.3566
sperry	424.	618.	0.0011	0.0038	0.0157	-.0051	-.0101	-.0241
std oil cal	607.	584.	0.0	0.0	0.0005	0.0005	0.0018	0.0079
std oil ind	848.	585.	0.0	0.0	0.0011	0.0034	0.0077	0.0206
std oil ohio	494.	516.	0.0	0.0	0.0005	-.0059	-.0107	-.0229
sun co	486.	524.	0.0001	0.0005	0.0048	-.1028	-.1374	-.1971
texaco	541.	632.	0.0	0.0	0.0009	0.0010	0.0015	0.0013
texas inst	81.	258.	0.0	0.0	0.0001	-.2154	-.3133	-.4965
tenneco	374.	322.	0.0	0.0001	0.0017	0.0004	0.0013	0.0064
trw	586.	550.	0.0010	0.0036	0.0157	-.2344	-.2782	-.3441
union carb	945.	787.	0.0011	0.0038	0.0164	0.0011	0.0032	0.0117
union oil ca	325.	389.	0.0	0.0	0.0010	-.0180	-.0299	-.0563
union pacifi	107.	112.	0.0	0.0	0.0	0.0019	0.0033	0.0052
united brand	136.	79.	0.0221	0.0370	0.0709	-.4958	-.5046	-.5158
us steel	5003.	2236.	0.0367	0.0551	0.0933	0.0019	0.0052	0.0174
united tech	1205.	1650.	0.0024	0.0067	0.0224	-.3832	-.4526	-.5559
warner comm	26.	38.	0.0	0.0	0.0	-.0172	-.0300	-.0601
westinghouse	1832.	883.	0.0085	0.0182	0.0448	0.0024	0.0061	0.0192
weyerhaeuser	296.	175.	0.0	0.0	0.0008	0.0018	0.0048	0.0161
xerox	557.	386.	0.0003	0.0015	0.0091	0.0051	0.0078	0.0119

Table 3a:

PBGC Insurance Values: Interest Rate = 12.76%

			Insurance Value as a Fraction of Vested Benefits					
			Voluntary Termination 3 growth scenarios			Bankruptcy-Only 3 growth scenarios		
Company	Vested Benefits	Over-funding	-.05	0	.05	-.05	0	.05
allied	551.	259.	0.0080	0.0174	0.0436	0.0103	0.0145	0.0207
alcoa	1053.	322.	0.0064	0.0150	0.0401	0.0209	0.0299	0.0453
amer hess	37.	70.	0.0	0.0	0.0	-.1428	-.2015	-.3084
am brands	239.	97.	0.0	0.0001	0.0022	0.0062	0.0130	0.0316
am can	655.	247.	0.0259	0.0423	0.0785	0.0053	0.0058	0.0050
an-busch	149.	165.	0.0	0.0	0.0003	0.0005	0.0004	-.0015
armco	842.	328.	0.0177	0.0317	0.0648	0.0143	0.0197	0.0281
ashland oil	135.	205.	0.0002	0.0012	0.0078	-.1334	-.1831	-.2710
arco	878.	635.	0.0	0.0001	0.0017	0.0029	0.0038	0.0040
beth steel	2472.	-148.	0.1047	0.1284	0.1716	0.0811	0.1002	0.1288
boeing	1140.	1261.	0.0021	0.0063	0.0219	0.0011	0.0030	0.0105
borden	150.	92.	0.0	0.0003	0.0033	0.0074	0.0133	0.0264
burroughs	348.	223.	0.0005	0.0021	0.0114	0.0063	0.0096	0.0149
caterpillar	1260.	733.	0.0032	0.0087	0.0278	0.0024	0.0025	0.0010
chrysler	2277.	-329.	0.0942	0.1180	0.1616	0.1013	0.1249	0.1604
coastal	37.	71.	0.0	0.0001	0.0020	-.5738	-.6739	-.8214
coca-cola	139.	96.	0.0	0.0	0.0	0.0007	0.0022	0.0094
colg-palmol	211.	274.	0.0001	0.0005	0.0047	0.0015	0.0034	0.0085
cons foods	61.	80.	0.0	0.0	0.0003	0.0007	0.0011	0.0008
contl group	614.	304.	0.0088	0.0186	0.0455	-.0015	-.0034	-.0083
control data	120.	157.	0.0	0.0001	0.0019	-.4308	-.4975	-.5942
cpc intl	136.	17.	0.0	0.0	0.0008	0.0018	0.0051	0.0181
deere	569.	545.	0.0014	0.0046	0.0182	-.0035	-.0067	-.0154
digital eq	22.	151.	0.0	0.0	0.0	0.0	0.0	0.0
dow chem	655.	513.	0.0001	0.0005	0.0048	-.0129	-.0203	-.0360
dresser	326.	291.	0.0005	0.0023	0.0118	0.0037	0.0072	0.0151
du pont	3586.	4057.	0.0030	0.0080	0.0255	-.0337	-.0516	-.0878
east kodak	1276.	1466.	0.0	0.0001	0.0020	0.0001	0.0004	0.0026
exxon	1939.	2306.	0.0	0.0001	0.0012	0.0019	0.0041	0.0099
firestone	745.	256.	0.0177	0.0318	0.0651	0.0134	0.0231	0.0444
ford	4420.	2800.	0.0154	0.0281	0.0589	0.0059	0.0086	0.0127
gen dynamics	569.	726.	0.0016	0.0050	0.0187	0.0	0.0001	0.0012
gen elec	4208.	4474.	0.0004	0.0018	0.0102	0.0003	0.0011	0.0057
gen foods	397.	535.	0.0004	0.0017	0.0095	-.0059	-.0113	-.0258
gen mills	221.	102.	0.0	0.0001	0.0019	0.0028	0.0071	0.0213
gen motors	13195.	1237.	0.0216	0.0376	0.0739	0.0102	0.0203	0.0469
georia pac	97.	122.	0.0	0.0	0.0001	-.0319	-.0500	-.0879
getty oil	232.	255.	0.0	0.0	0.0006	0.0002	-.0003	-.0030
goodyear	983.	590.	0.0036	0.0097	0.0297	0.0081	0.0134	0.0238
wr grace	109.	240.	0.0	0.0	0.0007	-.1143	-.1703	-.2786
greyhound	656.	326.	0.0169	0.0303	0.0625	0.0111	0.0174	0.0291
gulf oil	1067.	856.	0.0005	0.0022	0.0116	0.0026	0.0037	0.0045

PBGC Insurance Values: Interest Rate = 10%

			Insurance Value as a Fraction of Vested Benefits					
			Voluntary Termination			Bankruptcy-Only		
			3 growth scenarios			3 growth scenarios		
Company	Vested Benefits	Over-funding	-.05	0	.05	-.05	0	.05
j&johnson	187.	177.	0.0	0.0	0.0005	0.0	0.0003	0.0044
kerr-mcgee	53.	73.	0.0	0.0	0.0018	-.0461	-.0767	-.1518
litton indus	370.	209.	0.0008	0.0043	0.0303	0.0029	0.0088	0.0361
lockheed	1567.	957.	0.0263	0.0481	0.1092	0.0016	0.0008	-.0059
ltv	1701.	-253.	0.1445	0.1750	0.2422	0.1384	0.1598	0.1907
mcdermott	397.	184.	0.0125	0.0288	0.0831	0.0151	0.0233	0.0378
mcdonnell do	1211.	790.	0.0167	0.0347	0.0909	0.0006	0.0027	0.0185
3m	421.	312.	0.0	0.0	0.0032	0.0005	0.0022	0.0163
mobil	1678.	1280.	0.0005	0.0032	0.0257	0.0032	0.0040	0.0014
monsanto	1024.	673.	0.0044	0.0138	0.0554	0.0092	0.0172	0.0358
motorola	55.	134.	0.0	0.0	0.0004	-.0002	-.0010	-.0082
nabisco	333.	5.	0.0002	0.0020	0.0216	0.0171	0.0358	0.0915
pepsico	141.	142.	0.0	0.0	0.0026	0.0038	0.0073	0.0140
philip morri	249.	242.	0.0	0.0	0.0015	-.0089	-.0169	-.0414
phillips pet	568.	525.	0.0001	0.0012	0.0153	0.0007	0.0	-.0069
ralston pur.	103.	169.	0.0	0.0001	0.0050	-.0369	-.0658	-.1425
rj reynolds	499.	367.	0.0	0.0005	0.0099	0.0014	0.0051	0.0259
rockwell int	1686.	1072.	0.0105	0.0252	0.0764	0.0067	0.0098	0.0124
shell oil	912.	745.	0.0	0.0004	0.0086	0.0001	0.0008	0.0091
signal cos.	495.	215.	0.0031	0.0111	0.0502	-.1106	-.1304	-.1637
sperry	542.	500.	0.0046	0.0140	0.0547	0.0037	0.0061	0.0087
std oil cal	774.	417.	0.0	0.0002	0.0068	0.0012	0.0046	0.0256
std oil ind	1082.	351.	0.0	0.0006	0.0112	0.0069	0.0174	0.0555
std oil ohio	630.	380.	0.0	0.0002	0.0071	0.0099	0.0160	0.0268
sun co	620.	390.	0.0006	0.0035	0.0272	-.0410	-.0580	-.0938
texaco	690.	483.	0.0	0.0004	0.0096	0.0080	0.0159	0.0367
texas inst	104.	235.	0.0	0.0	0.0017	-.1722	-.2615	-.4535
tenneco	477.	219.	0.0001	0.0010	0.0148	0.0008	0.0034	0.0219
trw	747.	389.	0.0046	0.0144	0.0571	-.1073	-.1310	-.1720
union carb	1206.	526.	0.0049	0.0152	0.0591	0.0023	0.0077	0.0349
union oil ca	415.	299.	0.0	0.0005	0.0105	0.0018	0.0013	-.0045
union pacifi	136.	83.	0.0	0.0	0.0012	0.0097	0.0191	0.0439
united brand	174.	41.	0.0529	0.0816	0.1512	-.1936	-.1977	-.2034
us steel	6384.	855.	0.0802	0.1115	0.1827	0.0037	0.0114	0.0467
united tech	1538.	1317.	0.0084	0.0213	0.0687	-.2328	-.2809	-.3610
warner comm	33.	31.	0.0	0.0	0.0003	-.0028	-.0066	-.0211
westinghouse	2338.	377.	0.0263	0.0496	0.1143	0.0046	0.0133	0.0507
weyerhaeuser	377.	94.	0.0	0.0004	0.0090	0.0036	0.0109	0.0443
xerox	711.	232.	0.0018	0.0076	0.0415	0.0211	0.0360	0.0690

Table 3b:

PBGC Insurance Values: Interest Rate = 10%

Company	Vested Benefits	Over-funding	Voluntary Termination, 3 growth scenarios: -.05	0	.05	Bankruptcy-Only, 3 growth scenarios: -.05	0	.05
allied	703.	107.	0.0252	0.0482	0.1125	0.0375	0.0571	0.0959
alcoa	1344.	31.	0.0225	0.0447	0.1088	0.0498	0.0752	0.1256
amer hess	47.	60.	0.0	0.0	0.0007	-.0947	-.1398	-.2349
am brands	306.	30.	0.0001	0.0014	0.0177	0.0117	0.0266	0.0756
am can	836.	66.	0.0629	0.0934	0.1648	0.0551	0.0738	0.1052
an-busch	190.	124.	0.0	0.0001	0.0052	0.0093	0.0176	0.0377
armco	1074.	96.	0.0471	0.0756	0.1457	0.0459	0.0678	0.1096
ashland oil	172.	168.	0.0014	0.0061	0.0355	-.0779	-.1119	-.1820
arco	1121.	392.	0.0001	0.0010	0.0146	0.0210	0.0346	0.0633
beth steel	3154.	-830.	0.2078	0.2311	0.2880	0.1412	0.1791	0.2413
boeing	1455.	946.	0.0080	0.0209	0.0690	0.0024	0.0077	0.0329
borden	192.	50.	0.0003	0.0023	0.0224	0.0173	0.0334	0.0762
burroughs	445.	126.	0.0027	0.0101	0.0481	0.0236	0.0396	0.0747
caterpillar	1608.	385.	0.0121	0.0286	0.0840	0.0308	0.0462	0.0753
chrysler	2906.	-958.	0.2013	0.2236	0.2803	0.1605	0.2027	0.2722
coastal	48.	60.	0.0001	0.0011	0.0149	-.3921	-.4694	-.5955
coca-cola	178.	57.	0.0	0.0	0.0008	0.0014	0.0054	0.0292
colg-palmol	269.	216.	0.0006	0.0034	0.0264	0.0045	0.0112	0.0350
cons foods	78.	63.	0.0	0.0001	0.0049	0.0061	0.0128	0.0314
contl group	783.	135.	0.0269	0.0504	0.1152	0.0398	0.0552	0.0816
control data	154.	123.	0.0001	0.0011	0.0150	-.2579	-.3035	-.3770
cpc intl	174.	-21.	0.0	0.0004	0.0096	0.0034	0.0109	0.0480
deere	726.	388.	0.0059	0.0170	0.0623	0.0127	0.0208	0.0365
digital eq	28.	145.	0.0	0.0	0.0	0.0	0.0002	0.0018
dow chem	835.	333.	0.0006	0.0036	0.0279	0.0172	0.0247	0.0364
dresser	416.	201.	0.0028	0.0103	0.0481	0.0103	0.0216	0.0543
du pont	4576.	3067.	0.0104	0.0249	0.0757	-.0045	-.0089	-.0232
east kodak	1628.	1114.	0.0001	0.0012	0.0156	0.0002	0.0011	0.0112
exxon	2474.	1771.	0.0	0.0007	0.0117	0.0054	0.0131	0.0390
firestone	951.	50.	0.0478	0.0765	0.1468	0.0260	0.0479	0.1035
ford	5640.	1580.	0.0399	0.0663	0.1337	0.0247	0.0406	0.0746
gen dynamics	726.	569.	0.0062	0.0172	0.0617	0.0001	0.0004	0.0062
gen elec	5370.	3312.	0.0022	0.0085	0.0432	0.0007	0.0031	0.0200
gen foods	507.	425.	0.0019	0.0078	0.0405	0.0046	0.0076	0.0113
gen mills	282.	41.	0.0001	0.0012	0.0161	0.0055	0.0152	0.0550
gen motors	16837.	-2405.	0.0607	0.0915	0.1640	0.0175	0.0377	0.1001
georia pac	124.	95.	0.0	0.0	0.0031	-.0067	-.0126	-.0306
getty oil	295.	192.	0.0	0.0003	0.0077	0.0094	0.0176	0.0369
goodyear	1254.	319.	0.0134	0.0307	0.0873	0.0218	0.0389	0.0796
wr grace	139.	210.	0.0	0.0003	0.0079	-.0804	-.1260	-.2292
greyhound	837.	145.	0.0441	0.0717	0.1407	0.0290	0.0486	0.0926
gulf oil	1362.	561.	0.0027	0.0102	0.0480	0.0172	0.0297	0.0575
gulf&west	312.	65.	0.0027	0.0103	0.0490	0.0242	0.0290	0.0337
hewlett-pack	294.	206.	0.0	0.0	0.0014	0.0	0.0001	0.0019
ic indus	222.	55.	0.0134	0.0307	0.0873	-.0155	-.0204	-.0310
ibm	3711.	4679.	0.0	0.0002	0.0059	0.0006	0.0026	0.0162
intl paper	511.	450.	0.0013	0.0058	0.0348	0.0006	-.0003	-.0076
itt	1326.	338.	0.0053	0.0162	0.0620	0.0297	0.0441	0.0705

Table 4: Summary Statistics for the Value of PBGC Insurance

Assumed growth Rate:	-.05		0		+.05	
Discount Rate:	r=.1276	r=.10	r=.1276	r=.10	r=.1276	r=.10
Voluntary Termination:						
Mean: Insurance Value / Vested Benefits	.006	.015	.010	.023	.020	.053
Weighted Average	.015	.038	.024	.054	.045	.102
Bankruptcy-Only Termination :						
Mean: Insurance Value / Vested Benefits	-.037	-.008	-.045	-.006	-.060	-.0004
Weighted Average	-.005	.015	-.006	.025	-.003	.052
Total Insurance Value:						
Voluntary termination ($ billion)	1.25	3.82	1.93	5.50	3.60	10.35
Bankruptcy-Only ($ billion)	-0.46	1.53	-0.45	2.54	-0.27	5.29
Total Underfunding of Underfunded Plans	0.48	4.47	0.48	4.47	0.48	4.47

Table 5: Frequency Distributions

A. Voluntary Termination Scenario

Insurance Value as Fraction of Vested Benefits	growth=-.05		growth=0		growth=+.05	
	r=.1276	r=.10	r=.1276	r=.10	r=.1276	r=.10
0 - .001	55	45	45	30	27	6
.001 - .01	20	19	25	20	22	21
.01 - .025	7	8	6	15	15	13
.025 - .05	2	8	7	10	12	14
.05 - .10	2	4	2	8	8	17
.10 - .15	1	1	2	1	1	9
.15 - .20	0	0	0	1	2	4
.20 +	0	2[1]	0	2[2]	0	3[3]

B. Bankruptcy-Only Scenario

Insurance Value as Fraction of Vested Benefits	growth=-.05		growth=0		growth=+.05	
	r=.1276	r=.10	r=.1276	r=.10	r=.1276	r=.10
- .6 - 0	35	20	37	20	38	23
0 - .01	43	40	37	25	23	7
.01 - .025	6	15	9	19	15	9
.025 - .050	1	8	2	15	9	22
.050 - .10	1	1	0	5	0	18
.10 - .15	1	2	2	0	1	5
.15 - .20	0	1	0	2	1	1
.20 +	0	0	0	1[4]	0	2[5]

Notes:
1. Maximum value is .21
2. Maximum value is .23
3. Maximum value is .29
4. Maximum value is .20
5. Maximum value is .27