Valuation of Stockholders' Claim/Liability on Pension Plans and Corporate Pension Policies

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JEL Classification: G11; G23; G33

Keywords: Growth Options, Future Pension Benefits, Pension Funding, Pension Risk

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Abstract

In this study, we derive the value of stockholders' claim on a pension surplus and stockholders' liability for a pension deficit in the post-ERISA of 1974 regulatory environment. Based on that valuation, we develop a model of corporate pension policies in which sponsoring firms weigh contributions to their pension plan against exercise of growth options for allocation of limited financial resources. The model shows how corporate pension funding and asset allocation policies are shaped by sponsoring firms' characteristics such as growth options, the time distribution of future pension benefits coming due, and regulatory variables such as deficit reduction contributions and variable-rate insurance premium. We discuss policy and empirical implications of the theoretical results.

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I. Introduction

This study examines the following three questions: (2) how much of excess pension assets are stockholders entitled to, and how much of unfunded pension liabilities are stockholders liable for?; (2) How does the pension insurance premium affect the pension funding and asset allocation by sponsoring firms?; (3) what determines the funding and asset composition of defined benefit (DB) pension plans? This study is partially motivated by Jin, Merton, and Bodie (2006) which devise a new method of measuring pension plan risk, and show that a sponsor’s equity risk reflects the risk of its pension plans. As Jin, Merton, and Bodie (2006) emphasize, accurate estimation of systematic equity risk (i.e., beta) is critical because of a key role of systematic equity risk in performance evaluation and estimation of cost of capital. The findings of Jin, Merton, and Bodie (2006) suggest that accurate valuation of stockholders' claim on excess pension assets and liability for unfunded pension liabilities is equally important for estimation of cost of capital and performance evaluation. The reason is that the cost of capital is influenced by both the value and risk of the pension plan.

Carroll and Niehaus (1998) empirically examine the relation between the DB pension funding and corporate debt rating. They find that one dollar of underfunded pension liabilities reduces debt ratings more than one dollar of excess pension assets increases debt ratings. This is because underfunded pension liabilities are an integral part of the firm’s liabilities while overfunded pension assets are not entirely considered as the firm’s assets due to excise taxes and other restrictions on the conversion of overfunded pension assets into the firm’s operating assets. Carroll and Niehaus (1998) do not attempt to measure the value of stockholders' claim on excess pension assets and stockholders' liability for unfunded pension liabilities.

Bulow, Scholes, and Menell (1983) are the first to suggest that sponsoring firms can withdraw excess pension assets from their pension plan without paying excise and corporate
taxes "by making small reductions each year in amounts contributed to the plan." However, they do not explore its implication on valuation of stockholders' claim on excess pension assets. With an overfunded plan, sponsoring firms are exempt from the minimum funding contributions that are required for those with an underfunded plan. As a result, sponsoring firms of an overfunded plan can use the saved minimum funding contributions for operation every year until the pension surplus is depleted. The annual minimum funding contributions in a given year are determined by the pension benefits accrued in the previous year. The value of stockholders' claim on excess pension assets, therefore, is equal to the present value of a stream of future pension benefits that can be covered by excess pension assets.

The pension plan risk is determined by both the funding level and pension asset composition that are, in turn, determined by corporate pension policies. Therefore, it is important to understand what drives corporate pension funding and asset allocation policies. To enhance our understanding of how sponsoring firms shape their pension policies, we develop a model of pension funding and asset allocation policies in the post-ERISA regulatory environment. In our model, sponsoring firms have two investment opportunities competing for limited financial resources: to exercise growth options and/or to make a voluntary contribution to the pension plan. The pension plans have two possible funding status: underfunded and overfunded. When sponsoring firms of an overfunded plan make the pension funding decision, they weigh the marginal expected after-tax return on growth options against the marginal corporate tax rate plus the expected pension asset return multiplied by the marginal pension surplus discount factor ($MPSDF$), which is determined by the time distribution of future pension benefits coming due. An additional one dollar contribution to their pension plan would save sponsoring firms the marginal corporate tax rate. In addition, an additional one dollar contribution to the overfunded plan would relieve
sponsoring firms of the minimum funding contributions they are otherwise required to make in the future when the pension surplus is depleted. The more imminently in the future sponsoring firms expect the pension surplus to be depleted, the greater the present value of an additional one dollar contribution to the overfunded plan. Furthermore, the sponsoring firms of greater pension benefits due in the near future would invest plan assets more heavily in equity securities since they can take advantage of more of the upside potential of stock market investment (i.e., meeting future pension obligations with a capital gain).

When sponsoring firms of an underfunded plan make the pension funding decision, they weigh the marginal expected after-tax return on growth options against the marginal corporate tax rate plus the expected pension asset return multiplied by the marginal pension deficit discount factor, which is determined by policy variables such as the deficit reduction contributions and the variable-rate insurance premium charged by the Pension Benefit Guaranty Corporation (PBGC). The sponsoring firms of an underfunded plan are required to make deficit reduction contributions to their plan and pay an insurance premium to the PBGC every year until their plan turns into fully funded. An additional one dollar voluntary contribution to their underfunded plan, therefore, would save sponsoring firms the deficit reduction contribution rate and the variable-rate insurance premium rate. It follows that for an underfunded plan, the pension funding decision of sponsoring firms is influenced by those policy variables along with profitability of their growth options.

This study shows that the pension asset allocation decision of sponsoring firms depends on $MPSDF$ for an overfunded plan, and the expected cost of severe underfunding associated with plan termination for a modestly underfunded plan. The reason is that $MPSDF$ determines the upside gain of stock market investment, and the expected cost of severe underfunding determines the downside risk of stock market investment. It is shown that with
a sufficiently small $MPSDF$, and a sufficiently large expected cost of severe underfunding, the optimal pension asset allocation is a mix of risky and riskless assets for overfunded and modestly underfunded plans. For a severely underfunded plan, however, the optimal pension asset allocation turns out to be the entire pension fund invested in the risky asset. The reason is that the firm with a severely underfunded plan has been already incurring the cost of severe underfunding, which is a sunk cost. We suggest that an exponentially rising expected cost of severe underfunding, which reflects better the reality, would discourage the sponsoring firm of a severely underfunded plan to make such an extreme allocation.

We discuss policy implications of the theoretical results. In particular, we evaluate effectiveness of deficit reduction contributions and the variable-rate insurance premium which does not vary with pension asset risk. We find that even the deficit reduction contribution rule tightened by the Pension Protection Act (PPA) of 2006 would not induce sponsoring firms to make more voluntary contributions to their underfunded pension plan. However, the variable-rate insurance premium would encourage sponsoring firms of an underfunded plan to make more voluntary contributions. We suggest a simple structural change in the variable-rate insurance premium which would discourage sponsoring firms to underfund their pension plan. The model developed in this study produce several testable empirical implications. They include a negative relation between sponsoring firms’ growth options and pension funding, and a relation between the time distribution of future pension benefits and pension funding among others. The remainder of the paper is organized as follows. Section II makes a literature review. In section III, we develop a model of corporate pension funding and asset allocation decisions. Section IV and V discuss policy and empirical implications, respectively. Section VI sets forth conclusions.
II. Literature Review

With a defined benefit (DB) pension plan, sponsoring firms promise to provide a fixed amount of retirement benefit to their employees primarily based on employees’ tenure, age and salaries. Required by the ERISA of 1974, sponsoring firms are obligated to earmark a certain amount of assets to meet their pension obligations. These pension plan funds are generally invested in equities and fixed income securities. Sponsoring firms are also required to make financial contributions to their pension funds based on certain formula specified by laws and tax code. Despite a decline in their relative importance thanks to a shift of pension plans to defined contribution plans for last thirty years, DB plans still account for an important part of private sector retirement plans in US. About 20% of all public firms in Compustat, mostly large firms, have DB plans covering about 44 million US workers and employees, and aggregate DB pension plan assets in the US private sector amounted to $2.0 trillion as of the end of 2008.¹

Both academic researchers and practitioners have devoted considerable attention to the issue of optimal pension funding and asset allocation strategies for the DB plan-sponsoring firms. Subsequent to the passage of the ERISA in 1974, several earlier studies have made important contributions to the corporate pension plan management. In a pioneering work on the nature of corporate pension plans, Treynor (1977) proposes that pension liabilities and related assets should be analyzed in a context of the company balance sheet. Sharpe (1976) and Harrison and Sharpe (1983) illustrate that in the absence of taxes and given the structure of a fixed insurance premium charged by the Pension Benefit

¹ The data are from The U.S. Retirement Market 2008, published by Investment Company Institute. Total assets held in DB plans represents 14.3% of total employer sponsored plan assets (or $14 trillion) in 2008. For comparison, DC pension plans held $3.5 trillion in assets, among which the largest portion of assets is held in 401(k) ($2.4 trillion in assets).
Guaranty Corporation (PBGC), firms can maximize the put value (and accordingly maximize shareholders wealth) by employing a “mini-max” strategy in pension plan management – making a minimum level of pension funding while investing in a maximum level of risky assets. In contrast, Black (1980) and Tepper (1981) suggest a “max-mini” strategy from a tax benefit perspective – making a maximum level of plan funding and a minimum level of investment in the low-tax risky assets. Taking capital market imperfections into account, Bicksler and Chen (1985) argue that in the presence of the costs related to plan termination and the asymmetric structure of corporate taxes, neither a mini-max nor max-mini strategy is optimal. Rauh (2006) finds that pension sponsors decrease capital investment in response to a reduction in financial resources caused by required pension contributions. Franzoni and Marin (2006) examine the issue of market efficiency with firms with a DB pension plan and find evidence of overvaluation for firms with severely underfunded pension plans. Shivdasani and Stefanescu (2010) show that firms are substantially more levered when pension assets and liabilities are brought back on the balance sheet, and pension contributions provide significant tax benefits.

In regard to the corporate pension asset allocation policy, several authors attempted to explain why firms invest pension funds so heavily in risky assets. Most notably, Sundaresan and Zapatero (1997), and Lucas and Zaldes (2006) develop a model in which firms may invest in equity to hedge against increases in future pension benefits that are positively correlated with the stock market. Frank (2002) finds that firms' tax benefits are positively associated with the percentage of their pension assets invested in bonds. Bergstresser, Desai, and Rauh (2006) demonstrate that firms may inflate short-term earnings by increasing the assumed rate of return on plan assets, which would, in turn, result in a greater share of plan assets invested in equities. Rauh (2009) finds that firms with poorly-funded pension plans
and weak credit ratings allocate a greater share of pension fund assets to safer securities, whereas firms with well-funded pension plans and strong credit ratings invest more heavily in equity.

III. The Model

The model describes the behavior of a representative firm promising a pension benefit in the post-ERISA of 1974 regulatory environment. Therefore, we take the existence of the defined-benefit (DB) pension plan and the PBGC (Pension Benefit Guaranty Corporation), the government pension insurer, as given. We use the model to investigate two decisions the firm makes: how much of a free cash flow the firm would use to fund the pension plan in a given year, and how the firm would allocate their pension fund among various risk classes of assets.

A. Setting

In the model, the firm seeks to maximize the value of stockholders' equity. The firm is expected to operate infinitely. At the end of each time period, say time period \( t \), the firm is bestowed with a free cash flow \( X_t \) generated from previous period's operation and other assets in place. The free cash flow and other assets in place constitute total assets in place \( A_t \). Each time period the firm receives short-lived growth options \( G_{t+1} \) that would become worthless if not exercised immediately. The firm also expects a stream of growth options \( (G_{t+2,\infty}) \) that will arrive in the future. The firm has no debt outstanding. It follows that the value of stockholders' equity \( V_t \) at the end of a representative time period \( t \) is equal to

\[
V_t = A_t + G_{t+1} + G_{t+2,\infty}
\]

\( t \) is equal to

where \( A_t = X_t + \text{other assets in place}; \)

\[
G_{t+2,\infty} = \sum_{i=t+2}^{\infty} G_i.
\]
The firm has two choices on disposal of free cash flow $X_t$: (1) to exercise a subset or all of current growth options and/or to temporarily park in a risky financial asset we take to represent the aggregate stock market; (2) to make voluntary contributions to the pension plan. We are going to use the risky financial asset and the stock market interchangeably. Exercise of current growth options turn growth opportunities into operating assets. The growth option-turned operating assets are assumed to last just one period, and generate a gross return, $\bar{R}_G(y)$, with a mean of $\bar{R}_G(y)$ and a range of $[0, \infty)$ for $y$ amount of capital investment. The mean return $\bar{R}_G(y)$ is assumed to decrease in the amount of investment $y$ (i.e., a diminishing return on investment). The operating assets in place, a risky financial asset, and a riskless asset are assumed to produce a gross (one plus) return of $\bar{R}_A$ with a mean of $\bar{R}_A$ and a range of $[0, \infty)$, $\bar{R}_M$ with a mean of $\bar{R}_M$ and a range of $[0, \infty)$, and $R_f(> 1)$, respectively. The corporate capital gain tax rate is assumed to be the same as the corporate income tax rate.

The firm is assumed to sponsor the defined benefit (DB) pension plan and to be enrolled in the pension benefit insurance program of the PBGC. As a result, the firm possesses plan assets ($P_t$) and pension liabilities ($L_t$). The pension plan has two possible funding statuses: overfunded and underfunded. If the market value of plan assets exceeds the present value of pension liabilities, the pension plan is considered “overfunded.” Otherwise, it is considered “underfunded.”

B. Stockholders’ Claim and Liability on the Pension Plan

Stockholders’ claim on overfunded pension assets and liability for unfunded pension liabilities are complex and different with the funding status. In what follows, we derive the

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2 This assumption is made for the sake of simplicity. The assumption of short-lived growth option-turned operating assets can be relaxed so that they last more than one period without changing the main results qualitatively.

3 Without loss of generality, $\bar{R}_G(y)$, $\bar{R}_A$, and $\bar{R}_M$ are assumed to be stationary with the same mean and $R_f$ is the same for all time periods for the sake of simplicity.
value of stockholders' claim on a pension surplus and stockholders' liability for a pension deficit.

B1. Stockholders' Claim on a Pension Surplus

For the sponsoring firm of an overfunded plans, its stockholders may be entitled to only a fraction of the excess pension assets. Existing law requires that the firm must pay an excise tax of up to 50 percent in addition to the normal 34 percent corporate tax or pay a lower excise tax and share the excess pension assets with the plan participants if the firm converts the excess pension assets into firm assets through a reversion. As a result, the reversion would potentially leave stockholders only 16 cents of each dollar of reversion.

As suggested in Burrow, Scholes, and Menell (1983), sponsoring firms have alternative ways of moving excess pension assets back to operation without paying excise and corporate taxes. One of them is to reduce the amount contributed to the pension plan each year.4 The ERISA of 1974 and several rounds of subsequent legislation (i.e., The Pension Protection Act of 1987, The Retirement Protection Act of 1994, and the Pension Protection Act of 2006) require sponsoring firms of an underfunded plan to make mandatory contributions that amount to the greater of the minimum funding contribution (MFC) and the deficit reduction contributions (DRC). MFCs consist of new pension benefits accrued in the current year ("the normal cost") and a fraction of the funding shortfall (currently 10%). DRCs comprise the first year's contribution of 18% to 30% of any underfunding, and installment payments of the rest of underfunding over a period of 3-5 years.

The sponsoring firm of an overfunded plan, however, is exempt from those mandatory contributions. As a result, the firm can gradually convert excess pension assets into firm

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4 Burrow, Scholes, and Menell (1983) discuss two other methods: to increase the fraction of total employee compensation in the form of promised pensions; and to increase early retirement benefits. Unlike the method considered in this study, these two methods may not be easily implemented since the compensation package must be negotiated with employees.
assets by applying the pension surplus toward the required minimum level of funding contributions until the pension surplus is depleted. As a result, the value of stockholders' net claim on a pension surplus ($NC_{PS}^{PS}$) is equal to the discounted value of a stream of new pension benefits to be accrued in the future.

\[
NC_{PS}^{PS} = \sum_{i=1}^{T-1} \frac{PB_i}{R_c^{i-1}} + \frac{\varphi PB_T}{R_c^{T-(T+1)}}
\]

\[
\equiv \lambda_{over} (P_T - L_T)
\]  

(2)

where $PB_i =$ the expected new pension benefits to be accrued at time $i$;

$R_c =$ the corporate cost of capital;

$T =$ final time period in which new pension benefits are covered by remaining excess pension assets.

$\varphi, 0 < \varphi \leq 1 =$ fraction of the final period's pension benefits that can be covered by remaining excess pension assets;

$\lambda_{over} =$ discount factor for a pension surplus.

The corporate cost of capital $R_c$ is an appropriate discount rate for future pension benefits since the financial resources saved by waiving of minimum funding contributions can be diverted to funding of the growth options. The final time period $T$ is determined by the relation: $P_T - L_T \leq 0$. Let $\bar{R}_{PA}$ denote a long-term average annual gross expected return on pension assets which is determined by the following relation:\footnote{As the pension surplus becomes smaller over time, the sponsoring firm may rebalance pension assets and change the asset composition which would, in turn, change the return on pension assets.}

\[
P_T = (\bar{R}_{PA,t+1} \times \bar{R}_{PA,t+2} \times \cdots \times \bar{R}_{PA,T})P_t
\]

\[
= \bar{R}_{PA}^{T-t}P_t
\]  

(3)
The value of pension liabilities at time $T$ consist of the future value of a stream of new pension benefits accrued from time $t$ to $T$ plus the future value of time $t$ pension liabilities. In practice, firms use the long-term Treasury bond yield to discount future pension liabilities. In light of the practice, we assume that pension liabilities grow at the gross riskless rate $R_f$ so that:

$$L_T = R_f^{T-t}L_t + \sum_{i=t}^{T} R_f^{T-i}PB_i$$

(4)

The relation between the pension surplus ($P_t - L_t$) at time $t$ and a stream of new pension benefits to be accrued from time $t$ to $T$ can be expressed as:

$$P_t - L_t = \sum_{i=t}^{T-1} R_f^{T-i}PB_i + \frac{qPB_T}{R_P^A} + \left(\frac{R_f^{T-t}}{R_P^A} - 1\right)L_t$$

(5)

Notice from (2) and (5) that $\lambda_{over} = 1$ if $R_C = \hat{R}_PA = R_f$, and $\lambda_{over} < 1$ if $R_C > \hat{R}_PA = R_f$. In a more plausible case where $R_C \geq \hat{R}_PA \geq R_f$, $\lambda_{over}$ can be greater or less than one, depending on $R_C$ relative to $\hat{R}_PA$. This suggests that the value of stockholders’ claim on excess pension assets could be greater than that of excess pension assets itself. We assume that $R_C \geq \hat{R}_PA \geq R_f$ throughout the paper.

B2. Stockholders’ Liability for a Pension Deficit

As discussed before, the firm with an underfunded pension plan is obligated to make the greater of MFCs and DRCs to the pension plan every year until the pension plan becomes fully funded. To resemble the structure of tax-deductible DRCs imposed on the sponsoring firms of an underfunded plan, we assume that the firm is required to make a constant fraction, $k$, $0 < k < 1$, of the pension deficit to the pension fund every year until the pension deficit is remedied. In exchange for providing insurance coverage, the PBGC requires the sponsoring firms of an underfunded plan to pay a variable-rate premium (currently $9$ per $1,000$ of underfunding) in addition to a fixed premium of $35$ per participant. Let $m$ denote the
variable-rate premium as percentage of underfunded pension liabilities. The value of
stockholders' net liability for a pension deficit (\(NL^{PD}_t\)) can be then expressed as:

\[
NL^{PD}_t = (1 - \tau)(k + m) \sum_{i=0}^{\infty} (1 - k)^{i-t} \left( \frac{\hat{R}_{PA}^{-i} \hat{R}_f^{-i} R_t}{R_{C+1}^{-i}} \right) \\
\approx (1 - \tau)(k + m) R_C \left[ \frac{P_t}{R_C - (1-k) \bar{R}_{PA}} - \frac{L_t}{R_C - (1-k) R_f} \right] \\
\equiv \lambda_{\text{under}}(P_t - L_t) \quad (6)
\]

where \(\lambda_{\text{under}}\) = discount factor for a pension deficit. Notice from expression (6) that if \(R_C = \bar{R}_{PA} = R_f\) and \(m = 0\), \(\lambda_{\text{under}} = 1 - \tau < 1\).

The ERISA of 1974 and several rounds of later legislation also state that if sponsoring firms of an underfunded plan fail to make minimum required contributions and unpaid amounts total more than $1 million, the PBGC can perfect and enforce a statutory lien on the firm’s all property up to 30 percent of its net worth. The "net worth" is widely interpreted as the fair market value of the equity of the sponsoring firm excluding pension assets and liabilities. As a result, the "augmented" pension assets consist of the pension plan assets plus 30 percent of the intrinsic value of the firm's equity without pension assets and liabilities. It follows that the value of stockholders' net claim on the "augmented" pension assets (\(NC^{APA}_t\)) is equal to:

\[
NC^{APA}_t = \max \{ 0.3V_t^{NP} + \lambda_{\text{under}}(P_t - L_t), 0 \} \quad (7)
\]

where \(V_t^{NP} = A_t + G_{t+1} + G_{t+2,\infty}\).

Taken together, the value of stockholders' equity of a sponsoring firm at the end of time \(t\) can be expressed as:

\[
V_t = 0.7(A_t + G_{t+1} + G_{t+2,\infty}) + \max \{ 0.3V_t^{NP} + \lambda_{PS}(P_t - L_t), 0 \} \quad (8)
\]
where \( \lambda_{PS} = \lambda_{over} \) if \( P_t \geq L_t \); 
\( \lambda_{under} \) if \( P_t < L_t \).

C. Pension Funding Decision

At the beginning of every period, the firm repeats the same pension funding and asset allocation decisions. The pension funding decision involves allocation of the free cash flow \((X_t)\) between exercise of current growth options and contribution to the pension fund, and the pension asset allocation decision entails allocation of the pension fund between risky financial and riskless assets. In this section, we analyze the firm’s pension funding decision given pension asset allocation. We consider two alternative circumstances: with and without external financing available.

C1. With No External Financing Available

We first analyze the firm’s pension funding decision in the circumstance where no external financing is available. Let \( \alpha, 0 \leq \alpha \leq 1 \), denote a fraction of the free cash flow \( X_t \) the firm allocates to exercise of current growth options and/or investment in the stock market. The remainder \( 1 - \alpha \) will be allocated to the pension fund. This study focuses on the pension funding decision in a given period, not a dynamic cash flow allocation decision between current and future growth options. Operating assets in place of the sponsoring firm are assumed to generate a steady stream of cash flow enough to fund growth options and the pension plan every period. If the firm chooses to contribute part or all of the free cash flow to the pension fund, the firm receives a tax credit on the amount contributed one time only. At the beginning of every period, the firm repeats the same pension funding decision to maximize the market value of stockholders’ equity:
\[
Max_{0 \leq \alpha \leq 1} V_t = R_C^{-1} E_t [V_{t+1}]
\]

\[
= R_C^{-1} E_t [0.7 \tilde{R}_C (A_t - X_t)] + \int_0^{\alpha} \tilde{R}_C (y) dy + R_C G_{t+2, \infty}
\]

(operating assets in place) (growth option-turned operating assets) (future growth options)

\[- \tau ((\tilde{k}_\alpha - 1)(A_t - X_t) + \int_0^{\alpha_x} (\tilde{R}_C (y) - 1) dy \} + \tau (1 - \alpha) X_t \]

(corporate tax paid) (tax saving from pension contributions)

\[+ \max [0.3 \tilde{V}_{t+1}^N + \lambda_{PS} \{ \tilde{R}_{PA} (P_t + (1 - \alpha) X_t) - L_{t+1} \}, 0]] \text{ (9)}
\]

(stockholders’ claim on the “augmented” pension assets)

where

\[\tilde{R}_{PA} = \text{gross (one-plus) return on pension assets, i.e., } \tilde{R}_{PA} (\alpha, \tilde{R}_M ) \equiv R_f + \alpha (\tilde{R}_M - R_f)\]

\[\alpha, 0 \leq \alpha \leq 1 = \text{fraction of the plan assets invested in the risky financial asset.}\]

The sponsoring firm of an overfunded pension plan weighs the marginal expected after-tax return on current growth options against the marginal expected return on a pension contribution. The marginal expected after-tax return on current growth options is a decreasing function of \(\alpha\) due to the diminishing return on investment. The marginal expected return on a pension contribution consists of the marginal corporate tax rate and the expected return on plan assets discounted by the marginal pension surplus discount factor (MPSDF), i.e., the present value of the furthest future one dollar pension benefit to be covered by the last one dollar contribution. MPSDF is a step function with discontinuity points where an additional one dollar contribution triggers a change in the time period when the farthest future one dollar of pension benefit is covered.

Let \(\alpha, 0 \leq \alpha \leq 1\), denote the allocation ratio at which \((1 - \alpha) X_t\) is equal to the maximum possible tax-deductible contribution the firm can make to the overfunded pension
plan. With no tax benefit available, the firm would rather use the free cash flow to exercise current growth options and/or to invest in the stock market. Therefore, the firm of an overfunded plan would allocate at least $\alpha X_t$ to exercise of current growth options and/or investment in the stock market.

**Proposition 1**

Suppose that objective function (9) is concave in $\alpha$. For an overfunded pension plan (i.e., $\text{PA}_R(\omega; \bar{R}_M) > 1 + tL$)

$$R_{PA}(\alpha, \bar{R}_M)(P_t + (1 - \alpha)X_t) \geq L_{t+1} \forall \bar{R}_M,$$

$\alpha^* \in (\alpha, 1)$ at which $\bar{R}_G(\alpha^*) - \tau(\bar{R}_G(\alpha^*) - 1) = \tau + \text{MPSDF}^* \bar{R}_{PA}(\omega; \bar{R}_M)$ where MPSDF

$$\equiv (R_C^{\tau(\alpha^*) - (t+1)})^{-1},$$

or at a discontinuity point if the former intersects with the latter at an $\alpha$, $\alpha < \alpha < 1$;\(^7\)\(^8\)

$$\alpha^* = \alpha \text{ or } 1 \text{ otherwise.}$$

Proof: Available upon request.

An additional one dollar contribution to an overfunded pension plan would provide two benefits for the sponsoring firm: immediate saving of the corporate tax, and earning a discounted expected pension investment return on the additional one dollar. As a result, the sponsoring firm would allocate the free cash flow to the pension plan until the marginal

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\(^6\) The DB pension plan-related laws set the maximum tax-deductible contributions beyond which the firm of an overfunded plan is not allowed to receive a tax credit. Furthermore, the firm may be subject to an excise tax on contributions above the maximum. The Retirement Protection Act (RPA) of 1994 and the Pension Protection Act of 2006 state that the maximum tax-deductible contributions may not exceed the greatest of (1) the minimum funding contributions; (2) the amount necessary to fully fund the plan’s current liability; or (3) the normal cost, plus the plan’s past service cost with the amortization periods reduced to 10 years.

\(^7\) In the case where the marginal expected after-tax return on current growth options passes a “step” of the marginal expected return on a pension contribution, $\alpha$ will be the one that corresponds with that particular discontinuity point.

\(^8\) Since the firm can park temporally the free cash flow in the stock market, it must be the case that $\bar{R}_G(\alpha^*) \geq \bar{R}_M$. Otherwise, $\alpha^*$ is determined at which $\bar{R}_C(\alpha) - \pi(\bar{R}_M - 1) = \tau + (R_C^{\tau(\alpha) - (t+1)})^{-1}R_{PA}(\omega; \bar{R}_M)$, and $\alpha^*$ is divided between current growth options and the risky financial asset. Division of $\alpha^*$ is determined at which $\bar{R}_G(\alpha) - \pi(\bar{R}_G(\alpha) - 1) = \bar{R}_M - \pi(\bar{R}_M - 1)$. Since this study focuses on the pension funding decision, we assume that $\bar{R}_G(\alpha^*) \geq \bar{R}_M$ for simplicity.
expected after-tax return on current growth options equals the sum of the corporate tax rate and the discounted expected return on plan assets. It should be noticed that the discounted value of an additional one dollar to cover future pension benefits depends on how far in the future the last one dollar of excess pension assets is used to cover pension benefits. As a result, if the size of the pension surplus is too large or few pension benefits are expected to be accrued in the near future, the marginal benefit of pension contribution would be less than the marginal expected after-tax return on current growth options (or the expected after-tax return on the stock market). In such a case, the firm would rather invest the entire free cash flow in current growth options and/or the stock market. In the other extreme case, if a large amount of pension benefits is expected to be accrued in the imminent future, the expected benefits from pension contribution would outweigh the expected return on exercise of current growth options. In such a case, the sponsoring firm would contribute the entire free cash flow to the pension fund.

**Corollary**

$$\alpha^* \in (0, 1)$$ decreases in \( MPSDF \), i.e., \( R_{C}^{T(\alpha^*)-(t+1)} \). 

Proof: Available upon request.

\( MPSDF \) measures the marginal rate of stockholders' claim on the excess pension assets. An increase in \( MPSDF \), therefore, would lead to a greater allocation of the free cash flow to the pension fund. It follows that the time distribution of pension benefits coming due is a determinant of the corporate pension funding decision for an overfunded plan. It can be also shown that \( \alpha^* \) increases in the marginal expected after-tax return on current growth options, and decreases in the marginal corporate tax rate and the expected return on pension assets.

Similar to the case of an overfunded plan, the sponsoring firm of an underfunded plan weighs the marginal expected after-tax return on current growth options against the marginal
expected benefits from a pension contribution. The marginal expected benefits from a pension contribution comprises the marginal corporate tax rate and the discounted expected return on plan assets conditional on stockholders’ claim on the “augmented” pension assets being positive in value. An additional one dollar of voluntary contribution to the pension plan would enable the sponsoring firm to save the marginal corporate tax immediately, and reduce the burden of making mandatory pension contributions in the future by the discounted expected return on plan assets. With an underfunded pension plan, however, the sponsoring firm is responsible for pension liabilities up to the "augmented" pension assets. If the pension deficit is so large that even the "augmented" pension assets fails to cover it, it would be in the best interest of stockholders for the sponsoring firm to walk away from the pension plan (i.e., file a distress termination), laying all the pension obligations on the PBGC.  

**Proposition 2**

Suppose that objective function (9) is concave in $\alpha$. For an underfunded pension plan (i.e.,

$$R_{PA}(\alpha, \bar{R}_M)(P_t + (1 - \alpha)X_t) < L_{t+1} \forall R_M,$$

$$\alpha^* \in (0, 1) \text{ at which } \{ R_G(\alpha) - \tau(\bar{R}_G(\alpha) - 1) \mid 0.3\bar{v}^{NP}_{t+1} + \bar{N}L_{t+1} \geq 0 \} + \{0.7(\bar{R}_G(\alpha) - \tau(\bar{R}_G(\alpha) - 1)) \mid 0.3\bar{v}^{NP}_{t+1} + \bar{N}L_{t+1} < 0 \} = \tau + \text{MPDDF} \{\bar{R}_{PA}(\omega; \bar{R}_M) \mid 0.3\bar{v}^{NP}_{t+1} + \bar{N}L_{t+1} \geq 0\},$$

where $\text{MPDDF} \equiv (1 - \tau)(k + m)(\frac{R_C}{R_C - (1-k)\bar{R}_{PA}})$ if the former intersects with the latter at an $\alpha$, $0 < \alpha < 1$.  

---

9 If a sponsoring firm issues a notice to intent to terminate its DB plan, the PBGC examines the financial condition of the sponsoring firm to determine whether the plan qualifies for a distress termination. Specifically, the PBGC determines whether the sponsoring firm satisfies one of several financial distress tests. The financial distress tests include whether it has been demonstrated that the sponsor or affiliate cannot continue in business unless the plan is terminated. If the PBGC approves of the application for a distress termination, the sponsoring firm and each controlled group member are jointly and severally liable to the PBGC under ERISA section 4062(b) for the total amount of the unfunded benefit liabilities determined in accordance with 29 CFR 4022 Subpart D. If the PBGC determines that a plan does not qualify for a distress termination, the plan will remain ongoing under close monitoring by the PBGC.

10 See footnote 6.
\( \alpha^* = 0 \) or 1 otherwise.

Proof: Available upon request.

For ease of understanding the results of Proposition 2, we may take a simpler case where stockholders' claim on the "augmented" pension assets is always positive in value. In such a case, the optimal \( \alpha^* \) is determined at which

\[
\bar{R}_G (\alpha^*) - \tau( \bar{R}_G (\alpha^*) - 1) = \tau + MPDDF \bar{R}_{PA} (\omega; \bar{R}_M)
\]

(10)

Notice from expression (10) that the only difference in the optimal funding conditions between overfunded and underfunded plans is the discount factor for the expected return on pension assets. For an underfunded plan, \( \alpha^* \) is determined by \( MPDDF \) (the marginal pension deficit discount factor) instead of \( MPSDF \). In the case where stockholders' claim on the "augmented" pension assets is negative in value, the sponsoring firm would surrender up to 30% of the equity value. In such a case, stockholders of the sponsoring firm and the PBGC would divide the marginal expected after-tax return on current growth options at a rate of 70/30.

For both overfunded and underfunded pension plans, there are common factors that determine voluntary pension contributions that would, in turn, determine pension funding. They include firm characteristics such as the marginal expected on current growth options, and the marginal corporate tax rate. For both overfunded and underfunded plans, a greater marginal return on current growth options would lead to lower pension funding. The effect of the marginal corporate tax rate, however, is not the same for overfunded and underfunded plans. Unlike an overfunded pension plan, in the case of an underfunded plan, an increase in the marginal corporate tax rate would not necessarily result in more voluntary pension contributions. While the sponsoring firm receives an immediate tax credit from a pension
contribution, an additional one dollar contribution to an underfunded plan would reduce stockholders' net pension liability only by one minus marginal corporate tax rate. The reason is that tax deductibility of pension contributions has been already factored into stockholders' net pension liability.

**Corollary**

$\alpha^*$ decreases in $k$ or $m$.

Proof: Available upon request.

The determinants of the pension funding decision are different between overfunded and underfunded plans. For an overfunded plan, the pension funding decision is partially determined by $MPSDF$ which is, in turn, determined by the time distribution of future pension benefits coming due. For an underfunded plan, it is determined by the marginal pension deficit discount factor which is, in turn, determined by the fraction of the funding shortfall, $k$, required to be made up every year, and the variable-rate premium, $m$. A higher $k$ or $m$ would increase the marginal expected return on pension contributions, and, thus, would lead to a greater allocation of the free cash flow to the pension plan.

For ease of explanation, we have assumed that neither additional pension funding nor a stock market movement would change the funding status. However, a greater allocation of the free cash flow to the pension plan and/or a large swing in the stock market could change the pension status from underfunded to overfunded or the other way around. If the funding status is changed from underfunded to overfunded as more free cash flow is allocated to the pension plan, the marginal expected return on a pension contribution would be initially equal to the marginal expected return for an underfunded plan and then that for an overfunded plan. Therefore, the results discussed above would not be changed since the optimal allocation of the free cash flow will be still determined at the point where the marginal expected after-tax
return on growth options intersects with the marginal corporate tax rate plus either the marginal expected return for an underfunded plan or that for an overfunded plan.

If a swing in the stock market changes the funding status through the plan asset return, the marginal expected return on a pension contribution would be a weighted average of the marginal expected returns for overfunded and underfunded plans with weight being equal to the probability of each of the two possible pension funding statuses. The optimal allocation of the free cash flow will be then determined at the point where the marginal expected after-tax return on growth options is equal to the marginal corporate tax rate plus a weighted average of the marginal expected returns for overfunded and underfunded plans.

C2. With External Financing

We now relax the assumption and allow external financing. For simplicity, the firm is assumed to retain no free cash flow at the end of time $t$. The firm can borrow an external fund $F$ at a gross interest rate of $R_D(F)$ which increases in $F$. Since the PBGC’s claim receives a lower priority in the event of default, we assume that debt claims are senior to pension liabilities. At the beginning of the period, the firm makes external financing and pension funding decisions simultaneously. With external financing available, objective function (9) can be modified as follows:

$$\text{Max}_{F, 0 \leq t \leq 1} V_t = R_f^{-1}E_t[V_{t+1}]$$

$$= R_f^{-1}E_t[0.7\tilde{R}_t A_t + \int_0^{\alpha F} \tilde{R}_G(y)dy + R_f G_{t+2, \alpha} - R_p(F)F$$

$$- \tau\{(\tilde{R}_t - 1)A_t + \int_0^{\alpha F} (\tilde{R}_G(y) - 1)dy - (R_p(F) - 1)F \} + \tau(1 - \alpha)F]$$

$$+ \max[0.3\tilde{V}_{t+1}^{NP} + \lambda_{PS}\{ \tilde{R}_{PA} (P, (1 - \alpha)F) - L_{t+1}\}, 0]$$

$$| 0.7\tilde{V}_{t+1}^{NP} + \max[0.3\tilde{V}_{t+1}^{NP} + \lambda_{PS}\{ \tilde{R}_{PA} (P, (1 - \alpha)F) - L_{t+1}\}, 0] \geq 0]$$

(11)
where \( R_D(F) \) = gross external financing cost as percentage of the amount of external financing

with \( R_D'(F) > 0; \)

\[ F \] = amount of external financing.

Figure 1 demonstrates the sponsoring firm’s pension funding decision under alternative pension funding statuses. For both overfunded and underfunded plans, the optimal amount of external financing is determined at the amount with which the greater of the marginal expected after-tax return on current growth options conditional on the firm remaining solvent or the marginal expected return on a pension contribution conditional on the firm remaining solvent is equal to the marginal after-tax cost of external financing \( (R_D(F) - \tau(R_D(F) - 1) + (1 - \tau)R_D'(F)F) \). Once the optimal amount of external financing is determined, the optimal allocation of the external fund between current growth options and the pension plan is determined in the same way as it is without external financing available. The only difference is that with external financing, the marginal expected returns on current growth options and pension contributions are conditional on the sponsoring firm remaining solvent.

D. Pension Asset Allocation Decision

In this section, we analyze the pension asset allocation decision. We have so far assumed that there is no additional cost associated with a severe pension deficit on the part of the sponsoring firm. With a significant proportion of plan assets invested in the stock market, a large stock market correction could cause plan assets to fall in value significantly below pension liabilities. The Pension Protection Act of 2006 requires the employers with at least one plan that is less than 80 percent funded to report annually additional information so that the PBGC can closely monitor the situation. Therefore, the sponsoring
firm would bear an additional cost of meeting reporting requirements and being monitored by the PBGC. Furthermore, an increasing pension deficit would raise the probability of a pension plan termination by the PBGC which involves a plan termination-related cost on the part of the sponsoring firm. Upon plan termination, sponsoring firms must pay a termination premium of $1,250 per participant in the year of termination and in each of following two years (established by the Deficit Reduction Act of 2005). In addition, the sponsoring firms have to bear various types of direct and indirect costs of plan termination. Those costs include the transaction costs of disposing operating assets up to 30% of the equity value (if unpaid amount of minimum funding contributions exceeds $1 million). Bicksler and Chen (1985) also discuss legal expenses arising from lawsuits associated with plan termination, and costs associated with poor labor relations. In light of these observations, we assume that the sponsoring firm with a severe pension deficit incurs a percentage cost ($c$) proportional to the pension deficit exceeding a certain threshold level.

We then modify stockholders' net liability for a pension deficit as follows:

$$NL^{PD}_t = \lambda_{under}(P_t - L_t) = (1 - \tau)(k + m)R_C\left[\frac{P_t}{R_C - (1-k)R_P} - \frac{L_t}{R_C - (1-k)R_f}\right] \text{ if } \delta L_t < P_t \leq L_t,$$

$$= (1 - \tau)(k + m + c)R_C\left[\frac{P_t}{R_C - (1-k)R_P} - \frac{L_t}{R_C - (1-k)R_f}\right] \text{ if } P_t < \delta L$$

(12)

where $c$ is a constant with $c > 0$, and $\delta$ is a constant with $0 < \delta < 1$.

For a given pension funding decision, the sponsoring firm’s objective function for the pension asset allocation is reduced as:

$$\text{Max}_{0 \leq w \leq 1} \ E_{\text{max}}[0.3 \tilde{V}_t^{NP} + \lambda_{PS}\{(R_f + \alpha(\tilde{R}_M - R_f))(P_t + (1 - \alpha)X) - L_{t+1}\}, 0]$$

(13)
Objective function (13) indicates that the sponsoring firm is responsible for a pension deficit up to 30% of the equity value excluding pension assets and liabilities. If the equity value is large enough to cover the pension deficit, the firm has an incentive to make voluntary contributions to the underfunded pension plan. Otherwise, the firm would terminate the pension plan, and shift the burden of meeting unfunded pension liabilities to the PBGC, as discussed in the previous section.

In the following analysis, we assume that objective function (13) is concave in $\omega$.

**Proposition 3**

1. For an overfunded pension plan (i.e., $R_f(P_t + (1 - \alpha)X_t) \geq L_{t+1}$), there is a critical marginal pension surplus discount factor, $MPSDF_{t+1}^*$, such that the optimal pension asset allocation is a mix of risky financial and riskless assets (i.e., $0 < \omega^* < 1$) for $MPSDF_{t+1} < MPSDF_{t+1}^*$, and $\omega^* = 1$ for $MPSDF_{t+1} \geq MPSDF_{t+1}^*$.

2. For a modestly underfunded pension plan (i.e., $\delta L_{t+1} \leq R_f(P_t + (1 - \alpha)X_t) < L_{t+1}$), the optimal pension asset allocation is a mix of risky and riskless assets (i.e., $0 < \omega^* < 1$) for a sufficiently large $c$, and $\delta$ and $k$ are such that $\frac{\delta}{R_c - (1-k)R_{PA}} \leq \frac{1}{R_c - (1-k)R_f}$.

**Proof:** Available upon request.

The intuition behind this result is simple. A large $MPSDF$ means that the sponsoring firm expects large pension benefits to be accrued in the near future. In such a case, the firm with an overfunded pension plan can gain more of the upside potential of stock market investment, and, thus, invest the entire pension fund in the risky financial asset. Therefore, a sufficient condition for a mix of risky and riskless assets is a sufficiently small $MPSDF$.

For an overfunded plan, the following comparative statics results are obtained.

**Corollary**
\( \omega^* \) increases in \( MPSDF_{t+1} \), i.e., \( (R_{C}^{(\beta_{t+1} - \hat{L}_{t+1} + (r+1))})^{-1} \).

Proof: Available upon request.

With a large \( MPSDF \), the sponsoring firm would allocate a greater share of plan assets to the risky financial asset in the expectation that an extra capital gain from stock market investment would help meet the imminent pension benefit obligations. In contrast, with a low \( MPSDF \), the firm would gain few benefits from stock market investment. Furthermore, in the event of a stock market correction which would cause the pension funding status to turn into underfunded, stockholders would have to absorb the resulting loss by being forced to make additional contributions to the pension plan. As a result, the firm would choose to allocate a smaller fraction of plan assets to the risky financial asset. This result suggests that pension asset allocation is partially determined by the time distributions of pension benefits coming due.

The firm with a modestly underfunded plan weighs benefits from a greater allocation of pension assets to the risky asset against costs. More investment in the risky financial asset would provide the sponsoring firm with the opportunity for curtailing deficit reduction contributions and saving the insurance premium by reducing the pension deficit, but it could cause the firm to incur the expected cost of severe underfunding. While the marginal expected gain of stock market investment is constant or decreasing, the marginal expected cost of severe underfunding increases with stock market investment since the probability of falling into a severely underfunded status rises with stock market investment. With a
sufficiently large cost of severe underfunding, the firm would find a mix of risky and riskless assets optimal.  

In contrast, the firm with a severely underfunded plan, has been already incurring the cost of severe underfunding, which is a sunk cost. As a result, benefits of stock market investment would outweigh its costs. In such a circumstance, it is possible that the firm with a severely underfunded plan finds entire pension assets invested in the risky asset optimal.

We have assumed a linear relationship between the pension deficit and the cost of severe underfunding. It is more plausible, however, that the cost of severe underfunding increases at an increasing rate with the size of pension deficit. With such an exponential relationship, the firm with a severely underfunded plan would find it optimal to take a more conservative approach in asset allocation.

IV. Policy Implications

The previous section shows that for a modestly underfunded plan, both the pension funding and asset allocation decisions are influenced by the (marginal) pension deficit discount factor ($\lambda_{under}$), which is, in turn, determined by policy variables such as the deficit reduction contribution rate ($k$) and the variable-rate insurance premium ($m$). In this section, we evaluate effectiveness of the deficit reduction contribution (DRC) rule and the variable-rate premium in shaping the corporate pension funding and asset allocation policies.

Our model implicitly assumes that sponsoring firms are required to fully fund their underfunded pension plan within a certain period. Prior to the PPA of 2006, however, sponsoring firms were generally required to fund only 90% of pension liabilities and could

\[ \frac{\delta}{R_C - (1-k)R_{PA}} \leq \frac{1}{R_C - (1-k)R_f} \]  

is a weak condition since it always holds unless both $\delta$ is sufficiently close to one and $k$ is sufficiently close to zero.

\[ 11 \]
delay funding of unfunded pension liabilities through accounting maneuvering for as many as thirty years (Brown (2008)). Such a partial funding requirement can be easily incorporated into expression (6), the value of stockholders' net liability for unfunded pension liabilities. It can shown that the partial funding requirement has the same effect on the pension funding and asset allocation decisions as the deficit reduction contribution rule.

The PPA of 2006 gradually phased in a 100% funding target, and tightened the DRC rule such that sponsoring firms are required to remedy their pension deficit in the period of four to seven years. We examine whether the tightened DRC rule can induce sponsoring firms to alter the funding and asset allocation strategies with the following plausible numerical example. For the numerical example, we take a value of 0.50 for $k$, 0.009 for $m$, 1.05 for $R_f$, 1.12 for $R_{PA}$, 1.20 for $R_C$, and 0.35 for $\tau$, reflecting evidence that sponsoring firms made an average annual return of 12% on their pension assets in the period of 1989-2007. For those parameter values, $MPDDF$ is estimated to be 62.0 percent. If we apply the estimate of 0.620 for $MPDDF$ along with $\bar{R}_{PA} = 1.12$ to expression (10), the optimal condition for $\bar{\alpha}$ in the case of stockholders' claim being always positive, the right-hand side of expression (8) equals 1.0448. This means that sponsoring firms of an underfunded plan make a meager 4.48% of return on each one dollar contributed to the pension plan. Such a relatively low return may explain why a majority of sponsoring firms made no voluntary contributions to their pension fund at all in the period of 1989-2007. In light of the estimate above, we expect a majority of sponsoring firms to continue to make no voluntary contributions with the current DRC rule. The new DRC rule mandated in the PPA of 2006 would certainly shorten the period in which underfunded pension plans are fully funded. However, the numerical example above suggests that the new DRC rule would not prevent sponsoring firms from underfunding their pension plan in the first place. The reason is that the reward for voluntary
contributions to the pension plan are relatively low. With respect to the pension asset allocation decision, however, we expect some change in the behavior of sponsoring firms. In the previous section, comparative statics shows that the optimal allocation ratio, $\omega^*$, decreases in $k$. Since the PPA of 2006 significantly increased $k$, we expect sponsoring firms to take a more conservative approach in pension asset allocation in the post-PPA of 2006 regulatory environment.

The PBGC charges sponsoring firms a fixed premium of $35 per participant (as of 2011), plus 0.9% of any unfunded vested benefits. The variable-rate premium, which is set by Congress, does not vary with pension asset risk, and, as a result, is widely believed to be below the economically fair level. However, it would be practically impossible for the insurance premium to be set commensurate with pension asset risk due to a high measurement and monitoring cost. This study shows that a higher variable-rate premium ($m$) would induce sponsoring firms of an underfunded plan to allocate more cash flow to their pension plan. The current structure of the insurance premium, therefore, is effective in inducing sponsoring firms to improve their pension status, even if the premium is not designed to reflect pension asset risk. Furthermore, this study shows that $k$ and $m$ are interchangeable and have the same effect on the corporate pension decisions. The DRC rule has been already tightened and it may not be practically possible to tighten it further. This study suggests that policy makers can adjust the variable-rate premium to obtain the same effect on the corporate pension funding decision as altering the DRC rule.

This study also suggests that sponsoring firms of a severely underfunded plan would choose to invest the entire pension fund in the stock market regardless of $k$ or $m$. The pension put (i.e., the ability of sponsoring firms to walk away from their pension plan by surrendering up to 30% of the equity value) makes such an incentive stronger. As discussed
in the previous section, an exponentially increasing cost of severe underfunding may dampen such an incentive. However, such a cost structure alone may not be sufficient enough to prevent sponsoring firms from taking an excessive pension asset risk. When sponsoring firms are bullish on the stock market, they may find the expected return on the stock market outweigh the expected cost of plan termination when making a pension asset allocation decision. A flat variable-rate premium rate is currently imposed on unfunded pension liabilities regardless of the size of the pension deficit. This study suggests that if the variable-rate premium is structured such that sponsoring firms of larger unfunded pension liabilities are more heavily penalized, they would have less incentive to underfund the pension plan. For instance, the variable-rate pension premium rate can be designed to be progressive so that a higher premium rate is charged to the sponsoring firms with a larger pension deficit.

V. Empirical Implications

In this section, we discuss empirical implications of the theoretical results we have obtained in section III.

Implication 1: *Young firms with ample growth options have lower pension funding relative to pension liabilities, while mature firms with limited growth options have higher funding.*

Young firms may have more growth options than mature firms since mature firms may have already exhausted most of their growth options. As a result, young firms with ample growth options may prefer to use limited financial resources for exercise of growth options that are expected to produce a higher return than pension contribution. The sponsoring firm's unobservable growth opportunities may be measured by Tobin's Q and firm age.
Implication 2: The firm with a higher MPSDF maintains higher pension funding relative to pension liabilities.

Proposition 1 shows that for an overfunded plan, MPSDF is a determinant of the pension funding decision. The higher MPSDF, the greater share of the free cash flow would be allocate to the pension plan.

MPSDF is determined by the pension surplus and the time distribution of future pension benefits. An average of pension benefits the sponsoring firm pays in the current year and following two to three years may be used as a proxy for the pension benefits to be accrued in the near future. For instance, we suggest that MPSDF may be estimated as follows:

\[
MPSDF_{i,t} = \begin{cases} 
1 & \text{if } PS_{i,t-1} \ (\text{Pension Surplus}) \leq PB_{i,t}; \\
R_C^{-1} & \text{if } PB_{i,t} < PS_{i,t-1} \leq PB_{i,t} + R_C^{-1}PB_{i,t+1}; \\
R_C^{-2} & \text{if } PB_{i,t} + R_C^{-1}PB_{i,t+1} < PS_{i,t-1} \leq PB_{i,t} + R_C^{-1}PB_{i,t+1} + R_C^{-2}PB_{i,t+2}; \\
\min(R_C^{-3}, \frac{PB_{i,t} + R_C^{-1}PB_{i,t+1} + R_C^{-2}PB_{i,t+2}}{PS_{i,t-1}}) & \text{if } PB_{i,t} + R_C^{-1}PB_{i,t+1} + R_C^{-2}PB_{i,t+2} < PS_{i,t-1}
\end{cases}
\]

Implication 3: Pension funding is negatively related to the marginal expected return on growth option-turned operating assets.

When making the pension funding decision, the firm weighs the marginal expected return on growth options against that of a pension contribution. Proposition 1 and 2 indicate that the higher the marginal expected return on growth option-turned operating assets, the smaller share of the free cash flow would be allocated to the pension plan. In light of the finding of Francesco and Marin (2006), the hypothesis may be tested with those sponsoring firms with no financial constraints. The reason is that the sponsoring firms with binding credit
constraints may fail to fund their pension plan simply because of a lack of financial resources available. The expected return on growth option-turned operating assets may be estimated by the difference between EBIT in the current year and a historical average EBIT scaled by the annual change in gross property, plant and equipment plus the annual R&D expenditure. This is only our suggestion, and further research is warranted for a refined estimation method.

Implication 4: *For overfunded pension plans, pension funding is positively related to the marginal corporate tax rate. For underfunded pension plans, pension funding has a weaker tax effect.*

For an overfunded plan, a higher marginal corporate tax rate would enable the sponsoring firm to save more tax from a pension contribution. For an underfunded plan, however, an increase in the marginal corporate tax rate has two opposing effects. It would allow the sponsoring firm not only to save more tax but also to reduce stockholders’ claim on the pension investment return by the marginal corporate tax rate. Therefore, the corporate tax effect is weaker for an underfunded plan.

Implication 5: *The firm with a low credit rating or a high debt ratio maintains lower pension funding relative to pension liabilities.*

With the pension plan financed by an external fund, the cost of external financing is another factor for the pension funding decision. Other things being equal, the firm with a lower credit rating or a larger debt outstanding would incur a higher cost of external financing. With a high cost of external financing, pension funding is more likely to produce a negative return. Carroll and Niehaus (1998) report evidence on the impact of unfunded pension liabilities and excess pension assets on corporate debt ratings. Our model suggests that such causality may
run the other way around. That is, the pension plan is underfunded simply because of a high borrowing cost which results from a low credit rating. Such an external financing constraint would eventually lead to pension plan underfunding.\textsuperscript{12}

Implication 6: \textit{The firm with a higher MPSDF takes more pension investment risk.}

Corollary of Proposition 3 reveals that the firm with a higher MPSDF has an incentive to take more pension investment risk since the firm can gain more of the upside potential of stock market investment.

Implication 7: \textit{Since passage of PPA of 2006, pension asset composition has been shifted to a safer one.}

The PPA of 2006 tightened the DRC rule so that the time period within which sponsoring firms are required to remedy the pension deficit has been significantly curtailed. Corollary 2 of Proposition 3 suggests that such a tightened DRC rule would induce sponsoring firms to take a more conservative approach in pension asset allocation.

VI. Summary and Conclusion

In this study, we derive stockholders' claim on excess pension assets and stockholders' net liability for unfunded pension liabilities. Based on that valuation, we develop a model of corporate pension funding and asset allocation policies in the post-ERISA of 1974 regulatory environment. The model shows how corporate pension policies are shaped by sponsoring firms' characteristics such as growth opportunities, the time distribution of future pension benefits coming due, and policy variables such as minimum funding requirements and

\textsuperscript{12} Similar theoretical results are also provided by Cooper and Ross (2002).
variable-rate insurance premium. We discuss policy and testable empirical implications of the theoretical results. As an extension of this study, we are currently testing the empirical implications, and find that the preliminary test results strongly support the empirical predictions.

This study is complementary to Jin, Merton, and Bodie (2006). Jin, Merton, and Bodie (2006) derive the relations between pension plan risk and firm equity risk on the assumption that the values of pension assets and liabilities are correctly taken into account. This study offers new valuation of stockholders' claim/liability on the pension plan. A possible extension of Jin, Merton, and Bodie (2006) is to modify their net pension plan risk measure (see page 11 of their paper) with our measures on pension assets and liabilities, and investigate how such modifications would change the empirical relation between pension plan risk and firm equity risk. We leave it for future research.
References


Technical Explanation of H.R. 4, as Passed by the House on July 28, 2006 and as Considered by the Senate on August 3, 2006.


Figure 1: Pension Funding Decision with External Financing
For both overfunded and underfunded pension plans, the optimal amount of external financing is determined at the amount where the greater of the marginal expected after-tax return on current growth options or the marginal expected return on a pension contribution is equal to the marginal after-tax cost of external financing. Once the amount of external financing is determined, the optimal allocation of the external fund between current growth options and pension contributions is determined at the ratio where the marginal expected after-tax return on current growth options is equal to the marginal return on pension contributions. For simplicity, the following graphs illustrate the optimal external financing and pension funding decisions with no possibility of bankruptcy.

A. With an Overfunded Plan

Case 1: An external fund is raised

Case 2: No external fund is raised
B. With an Underfunded Pension Plan

Case 1: An external fund is raised

Case 2: No external fund is raised