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REPLICATING DEFAULT RISK IN A DEFINED BENEFIT PENSION PLAN

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REPLICATING DEFAULT RISK IN A DEFINED BENEFIT PLAN A Stock Bonus Plan with Gradual Diversification

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Abstract

One characteristic of a defined benefit pension plan is that it exposes workers to default risk. In the event that the firm encounters serious financial difficulty, it terminates the pension, imposing the well-known pension capital losses on workers. Owing to the enactment of reversion taxes, however, funding in private defined benefit plans has fallen dramatically, and firms have shifted their focus towards defined contribution plans, and cash balance plans. The question arises whether a defined contribution plan arrangement can be created to replicate the classic default risks in defined benefit plans. I show that a stock bonus plan with a provision to permit diversification can come close to replicating this exposure. Since it imposes about the same risks on workers, there is no reason to expect that workers' compensation levels need to be adjusted in any other way to accommodate the new schedule.

Replicating Default Risk In A Defined Benefit Plan

A 50 percent non-deductible reversion tax is now assessed on excess assets from a terminated defined benefit plan, leaving corporate plan sponsors with 16 cents per dollar after figuring in corporate tax liabilities. These taxes, enacted in steps over the period 1986-1990, fundamentally altered the economics of defined benefit plans. They are the proximate cause for both the dramatic defunding of defined benefit plans, and the trend towards cash balance conversions. It now is more costly to make workers share in the risk of the firm through their traditional role as unsecured bondholders in defined benefit plans. I consider how this role can be recreated using a plan that is treated more favorably under the tax code. I also note that the discussion highlights the role of risk in discounting pension benefits, and offers a rationale why apparent capital losses imposed on workers by cash balance conversions may not be capital losses at all, once recognition is given to the reduced risk facing workers in the new plan.

How Reversion Taxes Affect Corporate Incentives

Contingent Benefits. A key element in defined benefit plans is the difference between promised, or 'ongoing' benefits and legal, or 'termination' pension benefits. Upon termination, the worker's final salary is frozen as of that date, even though an annuity is not forthcoming until retirement age. In the ongoing concept, the benefit at retirement is indexed to salary at retirement age. These concepts are well known and so I do not repeat them here.¹

The essence of the implicit pension contract is that, if the firm is successful, the plan will not be terminated, and workers will receive the full value of their ongoing pension benefits. If the firm encounters sufficient financial stress, however, it may terminate the plan, and pay workers termination benefits. We can think of the difference between ongoing liabilities, L, and termination liabilities, L*, as contingent benefits, C:

¹ See Regan and Treynor (1976), Sharpe (1976), Ippolito (1986; 1997).

$C = L - L^*.$

These benefits are collectable by workers as long as the firm experiences favorable financial outcomes. Put differently, workers are secured bondholders in the firm up to the amount of legal pension liabilities, L*. The amount, C, can be thought of as a kind of profit-sharing arrangement.²

Historically, firms were allowed to fund for both termination and contingent benefits. The fact that the firm held the option to cancel contingent benefits did not convey ownership of funding for these benefits in the eyes of the law. If the firm canceled contingent benefits, workers lost the amount C of their pension benefits. This loss represents workers' share of downside risk in the firm. Indeed, pension terminations have occurred most frequently in firms that evince financial stress.³ Upon termination, excess assets reverted to the firm, subject to normal corporate tax treatment.

Implications of the Reversion Tax. The reversion tax affects the value of defined benefit plans to the firm. Prior to 1986, firms could fund their plans so that pension assets covered both the termination liability and the contingent liability, but the firm held an option to cancel the contingent liability by terminating the plan and simultaneously removing the 'excess assets' backing the contingent liability. As a result of the reversion tax legislation, firms can continue to fund both components of the pension liability, but as long as the firm maintains excess assets in the plan, the payoff to canceling the contingent liability is severely diminished.

Effectively, the new rules mean that, to the extent that firms fund beyond termination benefits, they transform the contingent pension liability into additional secured debt, up to the amount of excess assets. Thus, if it terminates the pension, the firm now can reduce its pension debt burden by the full amount of contingent pension liabilities only if it maintains zero excess assets.

The reversion tax creates an inescapable quandary for the firm. It can reestablish the full value of its

 $^{^2}$ We could think of workers as 'super' unsecured bondholder, in the sense that the bond can be made valueless upon the firm encountering a condition short of bankruptcy. Alternatively, we could view workers in the role of selling a call option to the firm that comes into the money upon the firm encountering a serious financial condition short of bankruptcy.

³ Most studies have shown a relation between reversion events and the financial condition of the plan sponsor. See, for

contingent pension debt by gradually reducing excess assets (through lower contributions). In so doing, however, it trades one tax for another: it rids itself of the prospects of a reversion tax by forgoing the benefits of tax-free accumulation of funding for contingent benefits. In this sense, the reversion tax not only discourages funding, it unambiguously increases the firm's cost of maintaining a defined benefit plan, and thus, its willingness to terminate. The termination alternative, however, is costly if the plan has excess assets. By reducing excess assets in its pensions, sponsors can firstly reduce the magnitude of the new legal liabilities that excess funding creates, and, secondly, improve the economics of a termination decision at some future period.

Developments in Pension Funding. The predictable reaction to reversion taxes has indeed played itself out in the pension industry. Beginning in 1986, and escalating since 1990, defunding in defined benefit plans has been both widespread and dramatic.

Figure 1 shows the average funding ratio for each year over the period 1980 to 1995 for a longitudinal sample of 1,900 pension plans. During the early 1980s, funding ratios generally increased, reflecting a rebounding from poor investment returns during the 1970s. But beginning in the mid-1980s, this growth noticeably flattened, and began falling significantly after 1990. In 1986, there was \$125 in pension assets for every \$100 in liabilities in the typical defined benefit plan. By 1995, there was only \$107 in assets for every \$100 in liabilities.

The reduction is not explained by changing interest rates used to discount pension annuities. The funding ratios in the figure are calculated using the same 6.5 interest rate in all years. Nor is it explained by poor investment performance. The <u>excess</u> return for a balanced portfolio over the 1986-1995 period was 5.4 percent per annum (the dashed line in the figure reflects cumulative excess returns). The pattern of funding ratios is not suggestive of gradual changes in the retirement market, say owing to increasing maturity of pensions. A more likely cause is some stimulus that plausibly explains rapid and systematic change throughout the industry over a relatively short period. Tax policy is an obvious candidate.

example, Ippolito & James (1992), Mitchell and Mulherin (1989), Petersen (1992), and VanDerhei (1987).

Cross-section distributions of funding ratios for 1986 and 1995 are shown in **figure 2**, where both distributions reflect liabilities for the same 1,900 longitudinal plans discounted at the same 6.5 percent rate. The bar distribution shows funding ratios in 1995, while the solid-line schedule shows the distribution in 1986. The change in funding policy over this period is apparent. In 1986, funding ratios are distributed widely, reflecting, among other things, a large difference in maturity levels across plans. By 1995, the right tail of the distribution is mostly eliminated and the mass of the distribution is shifted markedly to the left.

In 1986, 55 percent of plans had funding ratios in excess of 120 percent, and 30 percent were in excess of 150 percent. By 1995, these portions had fallen to about 30 and 10 percent, respectively. Clearly, a dramatic change in pension funding occurred over the period, which predominantly affected the best-funded pensions.

I have estimated the impact of reversion taxes on pension funding, holding constant pension funding limits, plan maturity and other confluences of time trends, and found strong evidence in favor of the reversion-tax theory of defunding (Ippolito 2001). My estimates suggest that as of 1995, excess assets in the universe of defined benefit plans had fallen by 60 percent, or about \$250 billion.

Avoiding the Tax: Cash Balance Plan Amendments. Why don't firms simply terminate their defined benefit plans, and replace them with defined contribution plans? Because, upon termination, all excess assets are subject to reversion taxes. The way in which sponsors have effectively accomplished this transaction *without* triggering a reversion tax liability is by amending the plan to a so-called cash balance variety.

The amendment has the effect of creating an individual 'account' for each participant. Typically, a worker's account is credited with the value of his or her accrued benefits as of the date of the amendment, which effectively is the termination benefit. The plan guarantees a particular investment return on these monies that often is tied to a market instrument (for example, a Treasury bill rate). This guarantee maintains the plan's legal status as 'defined benefit.' Future accruals are very much like traditional defined contribution plans; for example, the plan might award each account some percent of pay for each year of service

subsequent to the date of the amendment. Importantly, at the time of the switch to cash balance, pension assets in excess of the legal benefits in the old version of the plan are used to fund future contributions.

Abstracting from the details, a cash balance conversion effectively terminates the defined benefit plan, transfers assets backing termination benefits to workers' accounts in a follow-on defined contribution plan, and transfers assets backing contingent benefits to a tax-free escrow account devoted exclusively to financing future accruals in the new plan. By accomplishing these transactions within the plan by amendment, they trigger neither reversion nor corporate tax liabilities.

Based on partial submissions of Form 5500 annual pension plan reports for the 1999 plan year, I estimate that about 17.5 percent of all workers covered by defined benefit plans in the private sector were in cash balance plans as of 1999.⁴ Together with the downward trend in defined benefit plans, the rise of cash balance conversions means that compared to the early 1980s when upwards of 80 percent of covered workers were defacto unsecured bondholders in the firm through the defined benefit pension, only about 33 percent remain in that category.

The Economics of Default Risk in The Employee Contract

The economics of default risk in the pension are not a 'natural' extension of a defined benefit plan. The firm can eliminate workers' exposure to pension default risk by funding the plan for ongoing liabilities, and writing the contract in a way that confers pension assets up to ongoing benefits to workers. Indeed, if firms had preferred this approach then the reversion tax legislation would have had no financial and economic consequences.

Virtually all firms, however, have elected not to confer the ownership of pension assets to workers. They explicitly expose workers to default risk in the event of serious financial difficulty. In so doing, firms require workers to invest a substantial portion of their wealth in an undiversified portfolio; that is, one heavily influenced by default risk in the firm that employs them. The premium required by workers to accept this risk must be considerable, particularly in view of the fact that they may already be heavily invested in the

⁴ I am indebted to John Thompson, with whom I am collaborating on a larger cash balance project, for helping me

firm in the form of firm-specific capital.

Most work on pensions, inclusive of my own, assumes that workers receive zero compensation for this risk. We discount the ongoing benefit by the riskless interest rate. If workers hold a diversified portfolio of bonds characterized by default risk similar to the firm that employs them, then a corporate rate might be a closer approximation to the correct discount rate.⁵ Since the firm requires workers to hold a non-diversified risky bond portfolio, however, it must compensate them with an extra risk premium. Why does the firm find it optimal to put workers at risk when it could sell this exposure at lower cost in the bond market?

One explanation is that the firm calculates that workers at risk will be less likely to pose agency risk on the firm. It is obvious how the bond makes sense when workers are unionized, because in this instance, workers can act in concert and may find it optimal to hold up stockholders midway in the contract.⁶

Even if workers are not unionized, however, this does not mean that the impact of collective default exposure on workers' long-term productivity is zero. If workers as a group have a common stake in the financial success of the firm then presumably they will help foster an environment where either shirking or an 'anti management' attitude is frowned upon by fellow workers. I do not wish to develop this hypothesis here, but rather to make the observation, which is essentially axiomatic, that firms must *think* that workers' exposure to default matters; else, they would not be willing to pay a (non-diversification) risk premium that exceeds the market rate. Put differently, if exposure to risks by workers can reduce default risks sufficiently, then the non-diversification risk differential must be offset by improved financial prospects of the firm.

Reversion taxes substantially increased the cost of creating this default exposure through the defined benefit plan. Can the firm find a way to replicate the default feature in a defined contribution plan? There may be several approaches. I describe one, namely, a stock bonus defined contribution plan, with a provision for diversification.

determine this estimate.

⁵ This is not correct either since the pension at risk is not the ongoing pension, but the *difference* between the ongoing and termination pension.

⁶ I have made this argument elsewhere (Ippolito 1985).

The Stock Bonus Alternative

I now consider the nature of the potential losses in a defined benefit versus a stock bonus plan. It is well known that worker losses from termination of a defined benefit plan are 'hill-shaped' as a function of a worker's tenure in the firm. Towards the early part of tenure, the worker has not accumulated much service and thus stands to lose little from a termination. Likewise, near retirement, while he has accumulated lots of service, the projected wage at retirement is very close to his current wage, and thus, the difference between ongoing and termination benefits is small. In the middle of the contract, however, the worker has accumulated substantial service, yet is still pretty far from retirement, meaning that the termination benefits are substantially less than ongoing benefits.

I portray this function by the hill-like schedule in **figure 3** on the assumption that the interest rate and wage growth rate both to 6.5 percent. I normalize a worker's start age to zero and retirement to age and service level 30. The vertical axis measures the contingent benefit as a percent of current wage.

The contingent loss structure in the defined benefit plan reaches a maximum about midway in the contract. It has the interesting feature, however, that is declines thereafter until it reaches zero at retirement. A straightforward stock bonus defined contribution plan cannot replicate this exposure.

Traditional Stock Bonus Plan. In a stock bonus defined contribution plan, in place of some portion of the wage, the firm gives workers company stock on a regular schedule. Specifically, the firm deposits some portion of the wage into the worker's pension account, which must be used to purchase company stock. I assume that workers are risk neutral and that the equity risk premium is zero.

This may seem like a strange assumption in light of my discussion above about default risk premiums. Suppose, however, that the default exposure in the stock bonus plan approximates the default exposure risk in the defined benefit plan. In this case, the additional discounting implied by market risk in the stock, plus the premium for workers to accept a non-diversified portfolio, ought to approximate the required return that workers earn for accepting default risk in a defined benefit plan.

Put somewhat differently, if I can find an alternative instrument to replicate risks in a defined benefit

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plan then I do not need to determine the appropriate discount rate for either security. I ignored the extra discounting owing to the implied beta component plus non-diversifiable risk in the defined benefit plan. To be comparable, I ignore these risks in describing the stock bonus alternative.

I assume that the firm awards the worker a percent of wage each year, where this percent is set to generate the same expected asset position as the defined benefit plan midway in the contract. I assume in the illustration that wages grow at the same rate as the interest rate. Also, since I assume away the risk premium, the value of the stock grows at the interest rate. For these reasons, the asset position in the stock bonus plan as a percent of wages grows linearly from age and service zero to 30, which I depict in figure 3.

If the firm fails, I assume that the stock is worthless, and so, the worker loses the balance in his stock bonus account. Thus, the linear segment in the figure gives the capital loss from firm failure. Notice that over the first half of tenure, the losses in the stock bonus plan fairly well replicate those in the defined benefit plan. After this point, however, potential losses in the stock account implied by firm failure continue to escalate, and indeed, they swamp the capital losses in the defined benefit plans late in tenure.

In effect, workers in defined benefit plans gradually exchange their portfolio of unsecured bonds for one that has a progressively higher proportion of secured bonds. As workers approach retirement, their entire pension portfolio is secured, which acts to mitigate their losses in the event of firm failure. In contrast, losses from a stock bonus plan put the entirety of the pension value at risk late in tenure. In comparison to a defined benefit plan, the stock bonus plan not only imposes more non-diversified risk on workers, but also concentrates it late in tenure, when workers might be least inclined to accept it. Thus, workers would demand additional risk premia to accept the stock bonus arrangement over their defined benefit plan.

Stock Bonus Plan with Diversification. The firm can alter the stock bonus plan so that it essentially replicates capital losses in the defined benefit plan. It can do this by permitting workers to diversify their stock holdings into assets unrelated to the performance of the firm, according to a formula that can be prescribed in the pension plan. For example, the pension might provide that 100 percent of a worker's account must be invested in company stock until midway in the contract. Beyond this point, the plan allows

higher-tenure workers to have a progressively higher portion invested in Treasury Bills.

To illustrate, consider the stock bonus plan I portray in figure 3. The way I matched contingent losses in this plan with those in the defined benefit plan at year 15 was to set the contribution rate to one-fifteenth of the wage. Now suppose that for any service level, s, greater than 15, the firm permits the worker to diversify the proportion (s/15) - 1 into Treasury bills. Until year 15, the worker's pension is completely undiversified. But, by the time his service level reaches 20, the worker can diversify one-third of his account into Treasury Bills; after service level 25, he can have two-thirds in Bills, reaching 100 percent by age and service level 30.

I portray the default losses in the diversifiable stock bonus plan (DSB) by the asterisks in **figure 4**. For comparison, I show the capital loss function for the defined benefit plan it replaces as a light solid line. The stock bonus plan essentially mimics the default losses in the defined benefit plan. In this sense, since the DSB imposes the same exposure to workers as the defined benefit alternative, it is of no consequence that I assumed either a zero risk premium or risk neutrality of workers. Both pensions imply the same compensating differential from workers (in the form of foregone wages), regardless of these parameters.

Further Discussion

Flexibility. There are many alternative defined benefit plan rules that can and do generate a myriad of capital loss structures.⁷ But stock-bonus plans are flexible; and indeed, can be set up to mimic capital losses in most defined benefit plans. For example, the diversifiable stock bonus plan accommodates early retirement with varying amounts of subsidies by simply altering the formula for permissible diversification (see appendix).

Additionally, while I assumed above that all workers start in the firm at the same age, in reality, there are many ages that workers can start at a firm. Many firms create their defined benefit plan to be most advantageous to workers who enter early and also retire early (for example, so-called '30 and out' plans or those with heavily subsidized early benefits). Since most firms are reluctant to discriminate against hiring

⁷ I articulate several in Ippolito (1997).

applicants who are older, this option is attractive to firms because it is a subtle way in which they can pay higher effective compensation to workers who are likely to retire before they become 'too old.'

A firm offering a diversifiable stock bonus plans can accomplish a similar incentive by permitting diversification as a function of *service*, and not age, and then setting wages to offer competitive compensation packages to workers who enter while young. Individuals who enter earlier will have the opportunity to diversify at earlier *ages* in the firm compared to those who enter later, and receive compensation commensurate with accepting this risk. Workers who enter the firm late essentially are forced to hold nondiversified portfolios until their retirement, but receive compensation levels set by workers who anticipate the opportunity to diversify at earlier ages. This condition makes it less likely that older applicants will be attracted to these firms.

Smoothness. There is a difference in the way that losses materialize in a defined benefit versus diversifiable stock bonus plan. The defined benefit plan has an 'all or nothing' feature: either it terminates or not. But this does not mean that the *value* of contingent benefits is independent of the financial viability of the firm. The implicit value of the default bond clearly is changing with the firm's financial condition, and therefore is highly correlated with the firm's stock value. The DSB is different only in the sense that its *explicit* value moves continuously with the market's assessment of the firm. Put differently, if a market existed whereby workers could sell their pension positions, it is unlikely that the prices of these two instruments would be different *solely* because of the discrete nature of realized losses that are specific to a defined benefit plan.

Discount rate. The discussion of default risk raises the issue of the appropriate discount rate to apply to promised benefits in a defined benefit plan. If the default risk is assumed to be zero, then a case can be made that the discount rate from retirement age to current age is the riskless interest rate (Ippolito 1986). While this assumption may be valid in valuing pensions promised by federal, state and municipal governments, and a reasonable approximation in firms with the highest debt rating, it becomes an ever poorer approximation, the greater are the long term default risks on the pension.

This is an area that requires more research. It is apparent that if the pension plan promise can be expressed as a security that has a known price then we could use a replication strategy to arrive at the correct discount rate.⁸ The pension plan is like a wage-indexed bond with default risk until retirement age. Its terminal value at retirement depends on the then nominal interest rate, but is independent of default risk. It is apparent from the ideas discussed above, however, that this contract is similar to one that gives workers a stake in a risk-free bond plus company stock, where the shares of these securities change over tenure according to a contractual formula. The equivalence of these contracts provides a promising way to derive the correct valuation of a defined benefit plan liability.

While I have sidestepped this issue by comparing two pensions of similar risk characteristics, the solution to the discounting problem has some important implications. For example, when firms convert from traditional defined benefit formulas to cash balance versions, they typically impose "losses" on workers equal to the difference between the value of ongoing benefits and termination benefits (the latter amount is the usual starting value of each worker's cash balance account). Sometimes, the firm offers amounts to older workers to cushion these losses, but not the full amount of the difference. What is the amount of the cushion that represents market compensation?

When it effects a cash-balance amendment, the firm essentially is converting a pension plan that has future default risks to a portfolio that is comprised of Treasury bills (because they guaranty a rate of return equal to a Treasury bill). Clearly, the sponsor ought to be compensated for absolving workers from this risk,

⁸ Petersen (1996) has done some initial work on this issue, but has not developed an algorithm that determines the

which means that the cushion must be less than the full difference between ongoing and termination benefits. We cannot know the fair value of the conversion amounts without knowing the appropriate discount rate to value traditional defined benefit plan promises.

Contract Risk: The Trust Factor. Finally, it is worth noting a distinct advantage for the stockbonus plan approach to imposing default risk: It can guaranty that contingent benefits will not be appropriated by some future management team except upon conditions that satisfy the contingent nature of the contract. More particularly, the contingent benefits in a defined benefit plan are set to zero upon a plan termination. There are two events that can trigger a termination. Firstly, the sponsor incurs serious financial difficulty, and consequently cancels benefits upon conditions that are consistent with the contingent benefit contract. Normally, we think of this as default risk.

Secondly, the sponsor simply terminates the plan, even though the firm is not encountering financial difficulty. Often, we label this kind of termination, 'contract risk,' meaning that one party will not faithfully execute its part of the bargain. In an implicit contract environment, workers' mistrust of the firm's reliability can lead to a reluctance to sacrifice cash wages commensurate with the value of the benefit.

From the perspective or covered workers, they will limit the wages they are willing to sacrifice in exchange for a pension firstly because of traditional default risk, and secondly, because they are unsure whether the plan sponsor will abrogate the contract midstream. If a firm is trustworthy, in the sense that it has no intention of terminating the plan except when it encounters serious financial difficulty, but cannot convey this trustworthiness to workers, then the firm will pay a higher total wage to offset workers' distrust.

The stock bonus alternative eliminates this problem. Workers own the stock deposited in their defined contribution accounts. Once vested, the sponsor cannot take any portion of it.⁹ Nor can it reduce its value, *except* in the case where it encounters the condition that is the underpinning of default risk. If the firm encounters serious financial difficulty, the market reduces its stock value, which imparts losses to workers.

appropriate discount rate.

⁹ Vesting cannot be more than five years, but most firms vest their defined contribution plans much earlier than this; many have no vesting requirement.

Otherwise, workers are insulated from other actions taken by the firm to reduce the value of workers' pension wealth. Owing to this feature, firms will not need to compensate workers for contract risk. All else equal, stock bonus plans ought to be cheaper than defined benefit plans.

Concluding Remarks

A key feature of defined benefit plans is the contingent nature of their benefits. In effect, covered workers are unsecured bondholders in the firm up to the difference between ongoing and termination value benefits. In the event that the firm encounters financial difficulty, it can terminate the pension, thereby conferring large losses on workers. Owing to the nature of the contingent benefits in defined benefit plans, workers gradually lose exposure to default risk as they approach their retirement age. Reversion taxes make these plans uneconomic for many firms, which begs the question whether defined contribution plans can replicate this risk at similar cost.

I showed that firms can replicate workers' exposure to default risk in defined benefit plans with a simple stock bonus defined contribution plan, albeit with a twist: The firm permits workers to gradually diversify their pension portfolio out of company stock as they attain more tenure. The formula that regulates the diversification allowance is determined by the particular exposure profile that the firm wants to invoke. We can call these plans diversifiable stock bonus plans, or DSBs.

If the firm sets the diversification formula in the DSB that replicates default exposure in its current defined benefit plan, then workers ought to willing to accept this benefit for about the same reduction in cash wage they did in exchange for the defined benefit plan. Indeed, the stock bonus plan is free of the contract risk that has plagued defined benefit plans, particularly as growing numbers of firms have either terminated these plans, or converted them to cash balance varieties. In a diversifiable stock bonus plan, workers are *only* exposed to risks presented by the firm's poor financial performance, and are free of contractual risk. Properly crafted, the firm can include workers as investors in the firm, and enjoy the implied incentive benefits it provides, without imposing more non-diversifiable risk on high-tenure workers than these workers traditionally have been willing to bear.

I am indebted to Mitchell Petersen and Jack VanDerhei for helpful discussion, and to the referee who

made several productive suggestions for revision.

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Appendix: Illustration of Flexibility

In this appendix, I illustrate how the diversification formula in a DSB can be altered to accommodate variations of traditional defined benefit plans. In particular, I look at a plan that permits retirement of workers prior to normal retirement ages using a so-called early retirement subsidy. First, I show the formula I used for the illustration in the text, then modify it to accommodate the early retirement provision.

Illustration in the text. Suppose that the firm deposits into a worker's account, a percent of wage equal to v. As long as wages grow at the same rate as the interest rate, and if we assume away the equity risk premium and the nondiversification premium (for reasons discussed in the text) then the balance in the worker's account at age and service level a, is *va*. If the portion a worker's account that must be invested in company stock at age and service, *a*, is λ_a , then the worker's losses from firm failure are:

(1)
$$CL_{SB} = \lambda_a v a$$

In the problem I illustrated in figure 4, I supposed that the firm sets λ_a in the following way:

(2)
$$\lambda_a = 1$$
 if $a \le 15$
 $\lambda_a = 1 - v(a - 15)$ if $a > 15$

Workers must be fully invested in company stock during the first half of tenure, but may diversify an ever-growing portion of his account over the latter part of their career. Recalling that v = 1/15 then the capital loss function is:

(3)
$$CL_{SB} = a / 15$$
 if $a \le 15$
 $CL_{SB} = (30 - a)a / 15^2$ if $a > 15$.

A plan with subsidized early retirement. To illustrate the flexibility of the plan, consider a defined benefit plan exactly like the one I portray in figure 4, except that it offers early retirement at reduced benefits after the worker attains age and service level, a = 20. I set the early reduction factor at 4.9 percent per year,

which imparts some actuarial subsidy to early retirements.¹⁰ This means that if a worker departs the firm at age and service level, a = 19, he must wait until age 30 to collect his full pension. But once he attains eligibility for reduced benefits, namely a = 20 in my illustration, he can collect a reduced pension starting immediately. This creates a well-known 'kink' in the capital loss structure at the early eligibility age. I show this new schedule by the solid line in figure 5.

I now must search for a new diversification formula in a stock bonus plan that replicates this capital loss structure. I do not search for one that exactly matches the defined benefit plan. I simply choose one that comes close to replicating the 'kinked' capital loss function in the defined benefit plan. Its parameters are as follows:

$$\begin{array}{ll} (4) & \lambda_{a} = .9 \; \lambda_{a\text{-}1} & 15 < a \leq 18 \\ \\ \lambda_{a} \; = \; .5 \; \lambda_{a\text{-}1} & 18 < a \leq 30 \end{array}$$

The asterisks in figure 5 show the capital losses imposed by the stock bonus plan using this formula. Once again, the stock bonus plan matches the exposure in the defined benefit plan.

Consider one final example. Suppose that the firm sets the reduction factor for early retirement to 3 percent per annum. This alternative has a 'kink' like the one in figure 5, but the capital loss is essentially zero after 20 years of service. I can mimic this alternative with a stock bonus plan with the same diversification formula in (4) for service levels zero to 18, but alter the schedule for age-service levels 19-30, so that $\lambda_a = .15 \lambda_{a-1}$. This alternative comes close to permitting full diversification at age and service level, a = 20.

Other adaptations would follow in a similar way.

¹⁰ An actuarial subsidy means that present value of taking the early retirement is higher than the present value of having to wait until normal retirement age to start collecting. It does not mean that the pension provides an economic incentive to retire early (see Ippolito 1997). A distribution of early benefit reduction factors and other pension provisions is found in U. S. Department of Labor (1998).

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Figure 1 Funding Ratios, 1980-1995



Source: Funding ratios: Longitudinal data base, form 5500 annual pension reports. All liabilities are adjusted to a 6.5 percent interest rate and GAM 83 mortality table. Numbers reflect beginning-year values. Excess returns are equal to the return on a 50-50 portfolio of stocks and bonds minus the one-year Treasury bill rate from Ibbotson Associates, <u>Stocks, Bonds, Bills and Inflation 1926-1998.</u>

Figure 2 Funding Ratios, 1986 versus 1995



Source: Longitudinal data base, form 5500 annual pension reports. All liabilities are adjusted to a 6.5 percent interest rate and GAM 83 mortality table. Numbers reflect beginning-year values Longitudinal data base.

Figure 3

Pension Capital Losses From Firm Failure A Stock Bonus DC Plan



Figure 4

Pension Capital Losses From Firm Failure A Stock Bonus DC Plan with Constrained Diversification





Stock Bonus Plan with Diversification Formula: With Subsidized Early Retirement

