

Pension Incentives and Sorting Effects
New Developments in Pensions, and Pension Economics

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Abstract: Since the mid 1980s, there has been a persistent shift away from traditional defined benefit plans and towards 401k plans cash balance plans. There are several factors that might explain this trend, but one important development is the enactment of prohibitive reversion taxes, which altered the property rights structure for pension assets. These taxes explain both the rapid defunding in the defined benefit pension sector, and the growing popularity of cash balance plans.

The shifts in plan types are not without implications for labor productivity. Many traditional incentive schemes have now been eliminated or sharply curtailed, leaving firms with the task of recreating incentives through some other vehicles. Recent work, however, suggests that perhaps the incentive effects of defined benefit plans have been overstated, and that their main role may have been in sorting for desirable workers. Defined contribution plans also have a potential to provide a powerful sorting tool for corporations that could be at least as good as the defined benefit plans they replace.

I. The New Pension Market

Historically, pension coverage was dominated by defined benefit plans that pay annuities to workers often based on final salary and years of service. These plans have been an important source of retirement income, and feature prominently in ‘implicit pension contract’ models that help explain lower quit rates and earlier retirement ages.¹ Since the mid-1980s, however, these plans have lost substantial market share to defined contribution pensions in the private sector.² Defined contribution plans usually provide benefits in

¹ Basic data describing pensions trends is found in U. S. Department of Labor (1999). Studies that include summaries of the implicit contract literature include Quinn et al. 1990; Gustman et al. 1994; Hanushek and Maritato 1996; Ippolito 1997.

² In this paper, I deal exclusively with private pension plans. Public pensions still heavily favor the defined benefit variety and evince little of the trend towards defined contribution plans observed in the private sector. See EBRI (1997). I also deal exclusively with single employer plans, and thus, ignore the minority of plans that are multiemployer plans (plans that cover unionized workers that work for any number of employers, like the Teamsters or Ladies Garment

the form of lump sums, even when workers leave the firm prior to retirement age.³ Since it is not obvious how defined contribution plans affect productivity -- indeed, a case can be made that they are merely tax-preferred savings accounts -- it is natural to be curious about potential productivity effects that might result from the switch.

Figure 1 shows primary coverage rates by pension plan type over the period 1979 to 1999. The line schedule with open circles depicts the overall pension coverage rate in the private sector, which has been roughly constant over the period. The declining schedule with no markers depicts the share of workers covered by a defined benefit plan. The rising schedule with closed triangles shows the share of workers covered exclusively by a defined contribution plan.⁴

It is apparent that the share of workers with a defined benefit plan fell dramatically over the period. Indeed, by the mid 1990s, defined benefit plans no longer were the plan of choice for the majority of covered workers in the private sector, a substantial descent from their dominant share twenty years earlier. As of 1999, the estimated market share of defined benefit plans was 42 percent, and reasonable extrapolations suggest that defined benefit plans will attain clear minority status over the next decade.

Part of the shift reflects employment shifts from traditional defined benefit firms and industries (for example, large, unionized firms in the manufacturing sector), to firms and industries that traditionally favored defined contribution plans (for example, smaller, nonunion firms in the service sector). Several studies have estimated that upwards of 50 percent of the lost defined benefit share may be attributable to employment shifts. But these studies also reveal a sharp decline in employer preferences for defined benefit plans across

Workers). Coverage in multiemployer plans has remained primarily defined benefit.

³ Workers can roll these amounts into Individual Retirement Accounts without triggering a tax penalty.

⁴ Using the methodology of the U. S. Department of Labor (1999), if a worker has two plans, and one is a defined benefit, then the worker is automatically classified as covered primarily by a defined benefit plan. Only when workers have only a defined contribution plan are they classified as covered by a primary defined contribution plan. Shares after 1996 assume that the overall coverage rate remains at 46 percent; pension type shares of this amount are based on information about labor market growth on the assumption that the absolute number of active participants does not decline further.

all portions of the private sector.⁵

There are perhaps many reasons to explain these preference shifts. I pose two that I believe are most importantly implicated. Firstly, the U.S. Congress authorized a new kind of defined contribution plan, the so-called 401k, that became available to the market in 1981. The introduction of a new choice made defined benefit plans more vulnerable to regulatory and tax changes that occurred during the ensuing decade. Secondly, with the competing plan firmly in place, Congress enacted a series of reversion taxes from 1986 to 1990, which altered the property rights, and therefore the economics, of defined benefit plans. These taxes explain the emergence of yet another kind of defined contribution plans, so called ‘cash balance,’ which is a defacto defined contribution plan disguised as defined benefit.⁶ These changes have combined to importantly alter the incentive structure in an evolving pension industry.

A. Introduction of 401k Plans

Arguably, 401k plans are a superior variety of defined contribution plans. Like traditional defined contribution plans, the 401k permits an unconditional employer contribution (either a fixed dollar amount or a percent of pay, or profits) to all employees. Beyond this, however, the 401k is unique. Workers can make voluntary pre-tax contributions to the plan, affording them more freedom to attain desired savings rates beyond the employer's contribution. The firm can match part or all of worker contributions. The matching feature permits the firm to selectively pay higher wages to workers who reveal themselves as savers.

The market penetration of 401k plans has been substantial. Over the period 1981-1996, while traditional defined contribution plans (that is, those without a 401k component) increased their share in the primary pension market over the period from 17 to 24 percent, 401k plans captured 26 percent of the primary

⁵ Several studies have used standard statistical methods to disentangle the portion of the reduction in defined benefit market share over time (Clark and McDermid 1993, Kruse 1995, Ippolito 1997), Gustman and Steinmeier (1992). Generally, these studies conclude that about half of the reduction in defined benefit share is explained by employment shifts, and the remaining half by preference changes away from these types of plans. Most of the shift is affiliated with new plan formation and not plan termination with defined contribution replacement (Kruse 1995; Papke et al. 1996; and Ippolito and Thompson 2000).

⁶ Added confusion about these plans is attributable to their characterization as ‘defined benefit’ plans, a feature that important for purposes of evading reversion taxes as I show below.

pension market. That is, in 1995, one in every four covered workers in the single-employer universe was covered exclusively by a 401k plan.⁷

B. Emerging Trend: Cash Balance Plans

As pronounced as it is, the recorded trend in favor of defined contribution plans is understated, perhaps substantially, because some plans counted as defined benefit have been converted to cash balance plans. The conversion has the same effect, though not the same legal ramifications, as termination of the defined benefit plans with subsequent recreation of a replacement defined contribution plan.

The cash balance plans is created by a plan amendment to the existing defined benefit plan. It has the effect of awarding each participant an individual 'account'.⁸ Typically, a worker's account is credited with the value of his or her accrued benefits (that is, the legally-mandated ERISA⁹ benefit) as of the date of the amendment.¹⁰ The plan guarantees a particular investment return on these monies that often is tied to a market instrument (for example, a Treasury bill rate).¹¹ This guarantee maintains the plan's legal status as 'defined benefit.' Future accruals are very much like traditional defined contribution plans; for example, the

⁷ This number excludes workers who had a 401k plan but chose not to contribute. The U. S. Department of Labor does not include non-contributors to the 401k plan. See U.S. Department of Labor 1999).

⁸ The account is a bookkeeping entry, which records the opening balance, plus new contributions made by the employer plus interest, but the assets backing the accounts are still held in a pool managed by the sponsor. The earnings credited to each account typically do not reflect actual earnings in the fund, but are guaranteed the interest rate as stated in the plan document. Thus, there is some chance that the overall fund could have less money than the sum of the 'accounts.'

⁹ ERISA, or The Employee Retirement Income Security Act of 1974, is the basis for much regulation of private pensions; it includes oversight of fiduciary, vesting, disclosure and funding issues, and authorizes the Pension Benefit Guaranty Corporation to provide mandatory pension insurance to all defined benefit plans. Termination benefits are regulated in non-forfeiture rules.

¹⁰ The ERISA benefit is that amount that is owed workers if the plan terminated immediately. Sometimes, the plan credits some participants' accounts with something less than this amount, but if the employee quits, he cannot receive a benefit with a value less than his accrued benefit at the time of his departure. Legally, the plan does not set up individual accounts for the participants, but instead maintains a pooled asset account that may hold investment instruments entirely different than the guaranteed return stated in the plan. But the plan reports 'account values' to participants as though they have individually owned accounts.

¹¹ When the amendment is made, the sponsor calculates the present value of legal pension liabilities; and creates individual account balances usually in these amounts. Assets beyond these amounts ('excess assets') are retained in the plan. The firm awards future contributions to each worker's account on the basis of some formula (often a percent of pay). The key feature of the cash balance plan is that it requires only an amendment to the plan, not termination, and thus, does not trigger the reversion tax on excess assets in the plan. The firm can make future contributions to employees' accounts from excess assets.

plan might award each account x 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.¹²

The available evidence suggests that the conversions are an important part of what we label the 'defined benefit universe.' The U.S. Bureau of Labor Statistics estimates that six percent of workers covered by defined benefit plans in the private sector were in cash balance plans in 1997 (U. S. Department of Labor 1999). Moreover, this estimate is double the three percent calculation in the same survey just two years earlier (Elliot and Moore 2000; U. S. Department of Labor 1998). Other studies report findings that are broadly consistent with the BLS data.¹³

The logical question is, if cash balance plans are merely another form of defined contribution plan, why do firms not simply terminate their defined benefit plans, and replace them with defined contribution plans? The answer is found in the creation of a reversion tax assessed against excess assets in a terminated plan. This tax has altered the economic calculus of both termination and funding, and provides the core rationale for the existence of cash balance plans.

II. How Reversion Taxes Affect Corporate Incentives

In 1986, Congress enacted landmark legislation changing the corporate tax treatment of excess pension assets: It levied a 10 percent (non-deductible) excise tax on reversions from defined benefit plans (known as 'the reversion tax'). While the tax rate was modest, it signaled a major alteration in Congressional

¹² Upon termination, the sponsor is legally required to pay so-called termination benefits to participants; these benefits usually are lower than ongoing benefits in the plan. Assets in the plan that exceed termination benefits are called excess assets. For more detail see Ippolito (1998). Obviously, if the plan awards benefit amounts in excess of its legal obligations, its excess assets are reduced dollar-for-dollar.

¹³ There are several sources, none based on a systematic study of the plan universe. For example, in a longitudinal sample, John Thompson and I found that for the 217 plans from a 1987 longitudinal sample that still were defined benefit plans in 1995, 13 were cash balance plans as of 1996 (Ippolito and Thompson 2000).

A larger (unpublished) sample of form 5500s that I evaluated by the Pension Benefit Guaranty Corporation (PBGC) in the 1995 plan year found that of 264 salary defined benefit plans (to be distinguished from so-called flat benefit), 28 were cash balance. Niehaus and Yu (2000) report that based on commercial lists, there are at least 800 cash balance plan conversions. The uncertainty about market share should be resolved when the Form 5500 data for the 1999 plan year are made available, because they will include a reporting item for cash balance plans on the electronic version of the database.

interpretation on the ownership of excess pension assets, a signal that was reenforced in 1988 when the tax was increased to 15 percent. In 1990, Congress affirmed the new ownership paradigm by increasing the reversion tax to 50 percent.¹⁴

These taxes fundamentally alter the economics of defined benefit plans, because they penalize firms that fund their plans in excess of legal liabilities. The initial effect of the reversion tax sequence was to reduce funding in defined benefit plans. The longer-term impact is to discourage the creation and continuation of these plans. These taxes, for example, are almost certainly the proximate cause for both the dramatic defunding of defined benefit plans, and the trend towards cash balance conversions.

A. Contingent Benefits

A key element in defined benefit plans is the difference between promised, or 'ongoing' benefits and legal, or 'termination' pension benefits. The main difference in these concepts is that upon termination, the worker's final salary is frozen as of that date, even though an annuity is not forthcoming until retirement age, whereas in the ongoing concept, the benefit at retirement is indexed to anticipated salary at retirement age.

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 :

$$(1) \quad C = L - L^*.$$

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 additional amount, C , can be thought of as a kind of profit-sharing arrangement.¹⁵

¹⁴ The reversion also is subject to the normal 34 percent corporate tax, potentially leaving the firm only 16 cents for each dollar of reversion. If the sponsor gives 25 percent of the reversion to the participants (in the form of contributions to some other plan), the excise tax is reduced to 20 percent.

¹⁵ Perhaps, we could think of workers as either 'super' unsecured bondholder, in the sense that the bond can be made valueless upon the firm encountering a condition short of bankruptcy, or alternatively as workers selling a call option to the firm that comes into the money upon the firm encountering a serious financial condition.

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 portion 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.¹⁶ Upon termination, if the plan has excess assets (a normal condition in most plans) then the excess assets reverted to the firm, subject to normal corporate tax treatment.¹⁷ That is, upon canceling contingent benefits, the firm automatically freed the excess assets for corporate uses.

B. Implication 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 contingent pension debt by gradually reducing excess assets (through lower contributions). In so doing,

¹⁶ Most studies have shown a relation between reversion events and the financial condition of the plan sponsor. See, for example, Alderson & Chen (1986), Hay Huggins (1986), Ippolito & James (1992), Mitchell and Mulherin (1989), Mittelstaedt (1989), Petersen (1992), Thomas (1989), Stone (1987), and VanDerhei (1987).

¹⁷ Even if firms do not exercise the option to cancel contingent benefits, the existence of excess assets serves as implicit collateral for general creditors of the firm. In the event of bankruptcy, overfunded pension plans can be terminated with the excess assets distributed to the creditors. Generally, their pension funding positively influences firms' credit ratings; see Carroll and Niehaus (1998).

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.

C. 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 2 shows the average funding ratio for each year over the period 1980 to 1995 for a longitudinal sample of 1,900 pension plans that I studied over this period (Ippolito 2001).¹⁸ 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 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 excess 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).¹⁹ The pattern of funding

¹⁸ If I plot the distribution of funding ratios for the population of defined benefit plans, the results look similar to those in figure 2, except that the population numbers portray a somewhat larger reduction in funding.

¹⁹ I use a 50-50 mix of S&P returns and the Solomon bond index returns for the years 1986 through 1994. The excess return is $r = \frac{1}{2} r_s + \frac{1}{2} r_b - r_t$, where r_s is the nominal returns on S&P stocks, r_b is the nominal return on long-term corporate bonds, and r_t is the one-year treasury bill rate. All data are from Ibbotson Associates, *Stocks, Bonds, Bills and Inflation* (1998). Since pension data reflect beginning-year values, the returns I use are lagged one year to correspond to the observations on pension funding.

ratios is not suggestive of gradual changes in the retirement market, say owing to increasing maturity of pensions, but of some stimulus that plausibly explains rapid and systematic change throughout the industry over a relatively short period. Tax policy is an obvious candidate.²⁰

Cross-section distributions of funding ratios for 1986 and 1995 are shown in **figure 3**, 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 from inspection. In 1986, funding ratios are distributed widely, reflecting, among other things, a large difference in maturity levels across plans.²¹ By 1995, the right tail of the distribution is mostly eliminated and the mass of the distribution is shifted markedly to the left.

The dashed-line schedules show the corresponding cumulative distributions. 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.

New maximum full funding limits inaugurated in 1987 might explain some defunding.²² That is, since 1987, sponsors have been permitted to fund their plans only if assets are less than 150 percent of terminated liabilities, whereas prior to 1986, sponsors were permitted to fund for ongoing benefits without regard to termination liabilities. I chose the interest and mortality tables in the calculations of pension

²⁰ One idea we can rule out is the notion that defunding might reflect attempts by firms trying to defend themselves against a threatened takeover: The *raison d'être* of reversion taxes is to prevent the excess from being used for corporate purposes.

²¹ Maturity refers to how many young workers are in the firm compared to older workers and retirees. Plans that have disproportionate numbers of young workers means that wage projections in ongoing benefits are important, which makes the difference between legal and ongoing benefits quite large. Since contribution rules are tied to ongoing benefits, assets in the plan normally are much higher relative to termination liabilities (the index used in figure 3), as compared to plans that have mostly older workers and retirees.

²² Numerous restrictions have been made to limit the amount of overfunding in defined benefit plans. Most of these are redundant to the full funding limit of 1988. For a more complete description of all the limits, see ERISA Industry Committee (1996); also see Hay Huggins (1989).

liabilities to match these limits in 1995. If the rules were binding, then funding ratios would be bunched around 150 percent. It is apparent from figure 3 that the mass of the distribution no longer is close to this limit.²³

I have reported more extensive results based on systematic study of pension funding elsewhere (Ippolito 2001). I 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. 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.²⁴

III. Implications of DC Plans for Quits and Retirement

The decline of defined benefit plans means that we need to rethink the impact of pensions on quitting and retirement age. I will briefly review the economics of defined benefit plans to illustrate their main impact on quit and retirement incentives. Defined contribution plans do not have these incentives, which suggest an important impact on labor force tenure and retirement. I will argue below, however, that these first-round projects may be seriously overstated.

A. A Simple Model of Pension Capital Losses

To facilitate the discussion, I use a simple model of pensions. The age at which full benefits are available in the plan (the normal retirement age) is R . There is an early retirement 'window' starting at age a^* during which the worker can retire with a reduced benefit; the reduction is d percent for each year that early retirement precedes R . The pension annuity is equal to service times final wage w times some generosity

²³ Effective in 1988, Congress enacted a new full funding limit on defined benefit plans, which imposed the 150 percent limit. Prior to this time, they were permitted to fund for ongoing benefits. Numerous other restrictions have been made to limit the amount of overfunding in defined benefit plans. Most of these are redundant to the full funding limit of 1988. For a complete description of various interferences in pension funding and other regulations, see ERISA Industry Committee (1996).

²⁴ My estimates suggest that new full funding limits were of minor importance, once account was taken of reversion taxes, a result consistent with Gale (1994). If the reversion tax were eliminated, and sponsors reverted to their pre-reversion tax contribution behavior then the impact of the limits would become binding for many more firms, thereby leading to larger marginal effects.

factor b ; there are no cost of living increases after retirement.²⁵

For any age within the window of early retirement then if a worker leaves immediately at age a , his pension evaluated at age a is worth:

$$(2) \quad PV^a(d) = b w_a s_a e^{-d(R-a)} \Omega_{aD}, \quad \text{where } \Omega_{aD} = \int_{t=a}^D e^{-it} dt, \quad a^* \leq a \leq R,$$

where a is current age, s_a and w_a are service and wage level at age a , i is the market interest rate, d is the early retirement reduction factor in the plan, and Ω_{aD} is the present value of a \$1 annuity collected from early retirement age a ($a^* \leq a \leq R$) to age of death D , evaluated at current age using interest rate i .

If the worker stays until age R then the value of the benefit based on current service evaluated at the same age a based on current service level s_a is:

$$(3) \quad PV^R = b w_a s_a e^{(g-i)(R-a)} \Omega_{RD}, \quad \text{where } \Omega_{RD} = \int_{t=R}^D e^{-it} dt,$$

where g is the per annum wage growth (including overall increases plus within-firm merit or seniority increases), and Ω_{RD} is the present value of a \$1 annuity collected from normal retirement age R to age of death D , evaluated at age a using interest rate i .

Economically-fair reduction factor. To obtain the economically fair reduction factor, say d_e , I set the two present values equal which gives:

$$(4) \quad d_e = [-\ln(\Omega_{RD}/\Omega_{aD}) / (R-a)] + [i - g].$$

Thus, if the firm uses the reduction factor d_e then the worker's pension asset value based on service to date is invariant to his decision to continue working. The firm imparts no bias to his decision to leave.

Actuarially-fair reduction factor. To obtain the 'actuarially fair' reduction factor, say d_{af} , I set the two present values equal to each other with one important difference: *In the actuarial calculation, the wage growth factor is set to zero.* It is straightforward to show that the solution to set d equal to:

$$(5) \quad d_{af} = -d_e + g;$$

²⁵ Some plans pay flat benefits instead of indexing the pension to service and salary, but these typically are union plans that are not overfunded in a termination sense, and hence are uninteresting from the perspective of study of cash balance conversions. Sometimes, annuities are indexed to the high-3 salary years, or the high 5. See U. S. Department of Labor (1998) for the distribution of defined benefit characteristics.

The actuarially fair reduction factor equals the economically-fair reduction factor plus the expected per annum growth rate in wages.

The actuary's calculation implicitly assumes that the worker's choice is either to retire now and wait until age R to start receiving his pension, or retire now and start receiving his pension immediately. He ignores the issue at hand: the decision for the worker to retire now and start collecting now, or retire later and start collecting later. Hence, by construction, the actuarial calculation cannot measure the incentive to leave or stay, since it assumes early departure in either calculation. The confusion of 'actuarially-subsidized' benefits with 'economically-subsidized' early benefits is the most common error in the literature on pension economics.

An 'actuarially-subsidized' early benefit exists anytime that the reduction factor is set to some number less than d_{af} . But of course this 'subsidy' implies nothing about incentives as such, unless it is compared against the economically fair reduction factor, d_e . As long as $d > d_e$, which is the usual condition, the pension encourages workers to postpone retirement.

'Quits'. If a worker leaves the firm prior to the earliest early retirement age a^* then he is a 'quit,' not a 'retiree,' and hence, his pension normally is calculated on the basis of an actuarially fair reduction.²⁶ Thus, a normal condition in defined benefit plans is that workers have a strong incentive to stay until early retirement age. Beyond this age, and prior to the normal retirement age, the incentive to stay or leave on the margin is determined primarily by the plan's early reduction factor.

Cost of leaving prior to normal retirement age. Assuming that the worker is vested (usually within 5 years of service), capital losses from leaving at any age prior to normal retirement age, CL_a , are calculated as follows:

$$(6) \quad CL_a = [PV_a^R - PV_a^a(d_a)] / w_a, \quad d_a = d_{af} \text{ if } a < a^* \text{ and } d_a = d \text{ if } a^* \leq a \leq R,$$

where d_a is the reduction factor that applies upon departure at age a . The capital loss from departing prior to

²⁶ Some plans will award the early retirement subsidy to one who quits prior to a^* , subject to a service and age condition. See U. S. Department of Labor (1999).

normal retirement age equals the difference between the present value of ongoing benefits, PV_a^R , and the present value of benefits using the plan's early reduction factor, $PV_a^a(d_a)$, all calculated on the basis of current service. The extra cost of leaving prior to a^* is imposed because the reduction factor for the plan d is replaced by the actuarially fair reduction factor d_{af} .²⁷ By convention, capital losses normally are indexed to current cash wages as shown in (6).

B. Incentives affecting Labor Supply in Defined Benefit Plans

The capital loss structure in (6) is straightforward, and a fixture in pension economics. The particular way in which a sponsor chooses the pension parameters can have a significant influence on the path of these losses over age and service levels (Ippolito 1998), but they all share a similar 'look,' namely, the hill-like function over tenure often with a discrete drop at the earliest age of retirement eligibility reflecting the switch of reduction factors, followed thereafter by various patterns between the early and normal retirement ages, depending on the plan's choice of its early reduction factor.

To show how this 'hill function' looks for the typical pattern, I use data reported by the Bureau of Labor Statistics in its survey of medium and large firms (U.S. Department of Labor (1998). The most popular normal and early retirement ages are 65 and 55 respectively.²⁸ As of 1997, the average early reduction factor was 4.9 percent,²⁹ and the mean generosity factor was 1.5 percent. (U.S. Department of Labor 1999). Cost of living adjustments after retirement in defined benefit plans are rare and so I set them to

²⁷ The focus on cash balance plans is early, not late retirement.

²⁸ About 30 percent of workers are eligible for full benefits prior to age 60, but these almost always are union plans that are unlikely candidates for cash balance conversion. Union plans sometimes offer full benefits at ages 55 or less. In these plans, the incentive to retire early is significant at young ages.

²⁹ This is the average for plans that use a uniform percent (43 percent of plans); the rest use a sliding scale with different reductions for each age prior to normal retirement age. BLS gives no information for plans in the latter category.

zero.³⁰

In my model, I do not use mortality tables, but instead assume that death occurs with certainty at 80. I have shown elsewhere that a reasonable assumption for 1997 is that nominal wages plus within firm increases are about the same as nominal interest rates, and thus, I set $g=i$ (Ippolito 2000a). The ten-year Treasury rate in 1997 was 6.4 percent (Economic Report of the President 1998).

Finally, I assume that workers who depart prior to early retirement age receive the 'actuarially fair' benefit; that is, that the actuarially subsidized rate becomes available only upon reaching eligibility for early retirement. I adopt this convention because it is commonly assumed to exist in the literature. In reality, about half of all private pension plans award the customary reduction factor to deferred quits, subject to the same age and service standards for early retirement eligibility.³¹ I will illustrate this alternative below.

The solid line schedule in **figure 4** shows the schedule of losses for my prototype plan for my stylized worker from age 40 (with 5 years of service) to normal retirement age 65 (30 years of service).³² At low service levels, the worker loses relatively little (as a percent of wage) if he quits, because he has not yet accrued much service in the plan. As he accrues more service, the stakes become higher, until he approaches eligibility for early retirement (age 55 in this case).

If the plan pays only actuarially-fair benefits at all ages prior to 65 then in pension parlance, we would say that there is no early retirement age; effectively all departures prior to normal retirement age are

³⁰ As of 1995, only 7 percent of defined benefit plans have awarded a cost of living increase to retirees over the past 5 years (U.S. Department of Labor 1998).

³¹ Thus, if early retirement is available to workers age 55 with ten years service then vested quits also are eligible at age 55 if they had at least ten years of service prior to retirement. Those plans that do not treat vested quits in this way have the following breakdown: 10 do not pay early benefits; 30 percent pay actuarially fair benefits (which is the same as paying benefits only at normal retirement age, and the 8 percent use a reduction factor that is less generous than for those who wait until early retirement age to leave.

³² I do not calculate penalties for late retirement, because this is not the focus of cash balance conversions. However, using the information in note 27, the penalty for my worker at age 65 for staying one more year is 45 percent of one year's salary. It is lower in plans that continue to award benefit increases after 30 years of service. For more detail, see Ippolito (1998).

treated as 'quits.' This policy is reflected by the schedule of capital losses depicted by the triangle markers in the figure.

'Early retirees' are distinguished from quits because the pension plan switches to a reduction factor that is more favorable than 'actuarially fair,' giving rise to the term 'subsidy.' In my figure, the solid-line schedule of losses drops sharply at age 55 reflecting the use of a 4.9 percent reduction factor as compared to the actuarially fair reduction factor used at age 54.³³ Clearly, workers retiring after age 55 are treated more generously than those who quit prior to age 55. Notwithstanding the subsidy offer to early retirees, the plan does not favor retirement at age 55 as compared to normal retirement age 65, because the reduction factor is not economically fair. Indeed, there is some bias towards encouraging work until age 65. In effect, the typical pension plan charges an 'early exit fee' from early retirees.³⁴

The plan needs to set its reduction factor to the economically fair rate to generate conditions neutral to early retirement.³⁵ In 1997, this rate was about 3 percent. The schedule of closed circles from age 55 to age 65 depicts the capital losses from departing over this age range using a 3 percent reduction factor. This schedule of losses reflects a firm's intention to set up a pension plan so as to impart neutrality to the retirement decision over the age range 55 to 65. No more than ten percent of defined benefit pension used reduction factors as low as 3 percent in 1997 (U. S. Department of Labor 1999).

C How Defined Benefit and Cash Balance Plans Affect Incentives

By either adopting a defined contribution plan or converting to a cash balance plan, the sponsor

³³ At age 55, the actuarially-fair reduction factor is roughly 9.4 percent; hence, the switch to a 4.9 percent factor at age 55 is what explains the sharp drop in capital losses at this age.

³⁴ One efficiency reason why this schedule might be optimal is that early departures more likely are either leisure preferrers or unhealthy. In either case, these attributes might signify workers that are less valued by the firm (but not necessarily paid less if their health condition or zeal for leisure showed up late in tenure); hence, the firm has the opportunity to collect a rebate on compensation.

³⁵ The rate is somewhat different for every age; a uniform rate of 3 percent is approximately correct for calculating economically fair benefits.

eliminates three features of defined benefit plans normally affiliated with productivity effects in the firm.

Risk sharing. Prospectively, workers no longer participate through their pension in the future financial success of the firm. Thus, their risk-sharing role largely has been eliminated.³⁶

Quit rates. Since the value of the pension based on service rendered to date no longer depends on workers remaining with the firm, the pension-quit cost from these firms has been set to zero.³⁷ I have recently shown, for example, that the federal government's change to a new less generous defined benefit pension plan in the mid 1980 increased quit rates upwards of 50 percent (Ippolito forthcoming).

Retirement Age. Most defined benefit plans are designed to influence retirement ages. Most plans extract some reduction in pension value from those who take 'early' retirement; and penalize those who postpone retirement past the normal retirement date. Many studies have shown that these incentives dramatically alter retirement rates as predicted by the incentive structure in the plan.³⁸

Cash balance plans and defined contribution plans are poorly designed to mimic these effects. Wedges that develop between productivity and wages for some workers will either be tolerated, or the firm will find some other vehicle to influence retirement behavior. This job is made more difficult owing to various laws outlawing discrimination on the basis of age and disability make it difficult to reduce wages, or encourage less healthy workers to depart the firm. Firms that sponsor defined contribution plans will have to find other ways to encourage departures without increasing litigation risks.³⁹

³⁶ Workers continue to be exposed to other risks affiliated with firm failure; that is, if the firm encounters serious difficulty, wage rates may be depressed and the probability of layoff could be increased. But the pension source of risk is largely eliminated.

³⁷ The impact of defined benefit plans on quit rates is well documented. See for example Allen et al (1993), Mitchell (1982, 1983), Parnes (1974). The best summary articles are Gustman and Steinmeier (1994) and Dorsey (1995).

³⁸ The seminal article is Burkhauser (1979), but many other papers followed. For example, see Bazzoli (1985), Berkovec and Stern (1991), Fields and Mitchell (1984), Gustman and Steinmeier (1986), Ippolito (1997), Kotlikoff and Wise (1985), Lumsdaine and Wise (1990), Quinn et al. (1990), and Stock and Wise (1990)

³⁹ I have shown elsewhere that productivity effects attributable to cumulating health problems is a non trivial problem for employers, even for workers in their fifties (Ippolito 2000).

IV. The New Pension Economics

Most of the literature on pensions assumes that these vehicles affect behavior. Put differently, most of the existing models of pensions work just as well if the assumption is made that all workers are homogeneous. Workers enter the firm randomly, and are affected by the incentives in the pension structure. More recent work places greater emphasis on pension sorting effects. This development has an important bearing on the evaluation of defined contribution plans, with respect to their role in affecting productivity in the firm. Defined contribution plans have few if any incentive effects, as such, but hold lots of potential to attain desirable sorting. Viewed in this way, defined contribution plans are much more potent replacements for defined benefit plans than presumed in much of the pension literature.

A. Pensions as Incentive Contracts

The ‘behavior-modifying’ characteristics of defined benefit plans have dominated pension economics over the past two decades. This literature can be traced to Becker and Stigler (1974) who postulated a crime model, the main idea of which can be simply put. Consider a two-period model. A worker’s opportunity wage is W in both periods. The interest rate is zero. All workers are alike. Utility is a function of income only, and everyone is risk neutral. There is no borrowing or savings. A police officer can earn income from crime in the amount C .

To encourage honesty, the police department pays zero wage in the first period, but offers early retirement after period one, with pension P , whereupon the worker can take a job at wage W outside the police force in period two. Crime is detected with probability ρ . If caught, the pension is denied, and the offender loses the pension, and is not employable in period two.⁴⁰ The police department sets ρ and P such that crime does not pay for a police officer:⁴¹

$$(7) \quad C < \rho(P + W), \quad P \geq W.$$

⁴⁰ The model could either assume prosecution and jail, or inability to work in period two owing to the reputation earned as dishonest.

⁴¹ Write the condition, $C + (1 - \rho)(P + W) < P + W$, which simplifies to (1).

The magnitude of P is at least W ; else no one would enter police work. It can greatly exceed W if crime income is high and/or it is expensive to increase ρ , in which case the pension reflects a bond as well as an efficiency wage. The so-called Becker-Stigler bond encourages police to be honest.

Arguably, all subsequent pension-incentive papers are variants of this simple model. It is obvious that while the model is designed to bond honesty, it also generates low quit rates. More ‘realistic’ pension mobility models abound, but the essential features are reflective of Becker-Stigler. For example, replace ‘police’ by ‘worker’ and a 2-period model with a 3-period model. In exchange for sacrificing wage W in periods one and two, a firm awards a pension, P , to support retirement in period 3. Consider the following stark version of pension penalties: If the worker quits after period one, he loses his pension accrual; if he fails to retire after period 2, he loses his pension. The firm obtains zero quits and ‘on time’ retirement. While this model can be expanded to reflect more features, like opportunity costs, multi periods, regulations, and so on, none expand on the essential insight of Becker-Stigler.

B. Pensions as Sorting Devices

The line of thought I have been working on is that perhaps the most important feature of pensions is not so much in their power to affect the behavior of employees, but instead to help the firm select and retain high-quality workers. The idea is that worker attributes are more or less a given, and thus, it is difficult for employers to alter the behavior affiliated with these characteristics. In this approach, it is more profitable for firms to find ways to select in the kinds of workers that the firm wants in its employ, and to encourage those that are not suited to the firm to either not enter in the first place, or, if they do enter, or make a quick exit if they do enter. The interesting question is how pensions can help the firm attain these goals.

An important paper that introduced ‘selection effects’ to labor market literature is Salop and Salop (1976).⁴² They argued that there are two kinds of workers, ‘quitters’ and ‘stayers.’ In this model, any deferred wage scheme naturally attracts stayers because quitters tend to attach a lower probability of obtaining the deferred portion of the wage. Viewed in this way, a defined benefit plan does not so much sway workers’

decisions whether to quit or stay with the firm, but rather acts to select a disproportionate number of stayers to the firm's employ. The very act of setting up such a scheme accomplishes lower quitting.

C. A Simple Extension to Create a DB Sorting Model

Consider the simple Becker-Stigler model. If I add some heterogeneity to the workforce, I can transform the basic defined benefit 'incentive' model to a sorting model. Assume that workers are risk neutral, there is no borrowing, and the nominal interest rate is zero. All workers are identical except in their personal discount rates, ϕ , and inherent propensity to quit, q ; 'stayers' have quit probability $q = 0$; 'quitters' have quit probability, $q = q^*$. High discounters discount the future at rate $\phi = \phi^* > 0$; low discounters use discount rate equal to the interest rate, $\phi = 0$.

The wage outside pension firms is W in both periods. The pension firm pays zero wage in period one and two and awards pension P at the end of two periods. If the worker quits after period one then he forgoes the pension and receives wage W during period two. Payments are made at the beginning of periods; workers leave firms at end of periods. Retirement occurs in period three. It is profitable for workers to enter the pension firm if the expected discounted value of the pension exceeds the present value of wages paid outside the pension firm:

$$(8) \quad (1 - q) P / (1 + \phi)^2 + q W / (1 + \phi) > W + W / (1 + \phi).$$

If the worker enters the pension firm and does not quit (which occurs with probability $1 - q$), he collects pension P , which is discounted for two periods. If he quits after the first period, he receives only wage W discounted to the present. If the worker chooses a non-pension firm, he collects two periods of wages, W .

Rearranging (8), I have:

$$(9) \quad P > W (2 + \phi - q) (1 + \phi) / (1 - q).$$

Thus, if the firm chooses a value of P , that meets the following condition:

$$(10) \quad 2W < P < W (2 + \phi^* - q^*) (1 + \phi^*) / (1 - q^*),$$

then only low discounters who are also stayers enter the firm. The pension delivers the perfect sort.

In general, the pension is set to exceed the opportunity wage; that is

⁴² Also, see Jovanovic (1979) who had the same notion of natural stayers and leavers.

$$(11) \quad P = 2W(1+\delta),$$

where δ some positive number. The pension premium improves selection by making the pension firm the superior choice to low discounters who are stayers.⁴³ The premium is financed by the higher productivity generated by the selection of higher quality workers, or workers that are ideally suited for the firm's production function.

An interesting paper by Allen et al. (1993) provides evidence that is consistent with this idea. Their study reveals both a sorting and marginal incentive effect of defined benefit plans on quitting behavior. More recently, I reported evidence that an important effect of a new federal government pension plan that had lower capital losses is the selection in of workers with higher quit propensities.⁴⁴

D. Sorting in DC Plans

While defined benefit plans can accomplish desirable sorting, so can defined contribution plans. Gustman and Steinmeier (1993 1994) provided an important stimulus for the new interpretation of defined contribution plans. Their study of quit rates across different plan types revealed a dramatic finding, namely, that as compared to uncovered workers, quit rates were lower not only in firms that used defined benefit plans, but also in firms that offered defined contribution plans (though not as low as in defined benefit plans).

This is a somewhat peculiar finding in regard to the pension economics literature that has 'pension capital losses from quitting' as its central component, because defined contribution plans do not impart a substantial costs on those who quit.⁴⁵ This raises the question whether pensions in general provide a kind of sorting function for stayers, and, if so, how and why this sorting works.

⁴³ A premium also arises if quitting occurs because of the availability of higher-paying opportunities that arise, or for other circumstances that confer higher utility. A default premium also arises if there is some chance that the pension might terminate prior to retirement (Curme and Kahn 1990).

⁴⁴ In the 'old' federal pension plan, even though quit penalties were small early in the career, quit rates were tiny compared to private firms that offered less generous defined benefit plans. Upon introducing a new pension with capital losses less than 50 percent of the old plan, most of the impact was found in a dramatically higher up-front quit rate, say within the first few years of tenure. Beyond this level, quit rates in the new plan are the same as the old plan it replaced (Ippolito forthcoming).

⁴⁵ Apart from a short vesting period, the value of pension accounts belongs to workers, and thus, is not affected by their decision to leave.

One idea I have advanced is that the attribute that makes some workers ‘savers’ also makes them ‘high-quality’ workers. Thus, any compensation package that emphasizes pensions will naturally attract savers. Assuming that firms will expend more effort to retain its best workers (by paying them more, among other things), then it follows that high-quality workers will more often attain long tenure. We now have a potentially important nexus: pensions attract savers, who also are high-quality workers. Since the firms will work harder to retain its better workers (by paying them more among other things), it follows that savers will tend to exhibit the characteristic of being a ‘stayer’. Elsewhere, I have reported empirical evidence supporting the hypothesis that 401k savers have higher performance ratings, higher rates of and future promotions, less absenteeism, a lower likelihood of being fired or laid off, and so on (Ippolito forthcoming).

These findings imply that the use of ordinary pension plans can encourage desirable sorting at a lower cost than defined benefit plans. If firms use defined benefit plans, they must pay a premium to workers to sacrifice their opportunities to leave the firm midstream⁴⁶ – that is, workers will not indenture themselves for zero compensation. In addition, as shown above, firms are not permitted to fully fund defined benefit plans, particularly if they have an ‘immature’ age-service structure in the firm, and thus, are at a tax disadvantage compared to equally-generous defined contribution plans; confer more regulatory costs and constraints than defined contribution plans; and cannot terminate the plan without incurring confiscatory reversion taxes. They also are required to participate in a pension insurance system that poses the possibility of catastrophic risk on sponsors of defined benefit plans.⁴⁷ Thus, if defined contribution plans can accomplish important sorting effects, it follows that it may be economical to use these plans in place of their more expensive counterparts.

⁴⁶ That is, defined benefit plans award full value only to workers who stay until retirement age; those who leave early absorb substantial pension capital losses. This means that looking ahead, workers who enter these contracts know that they will find it uneconomical to take some higher-paying jobs that might arise over their tenure with this firm (Ippolito 1997).

⁴⁷ Defined benefit plans are covered by mandatory federal insurance in the event of underfunding at the time of bankruptcy (administered by the Pension Benefit Guaranty Corporation). The fees bear only a vague resemblance to market pricing, and more importantly, the insurance is not hedged. Thus, the bankruptcy of a few large firms can create dramatic deficits that pose the risk of substantial premium assessments on those who remain viable. The problem can

V. An Underlying Theory of the Sorting Principal

Why are savers better workers than nonsavers? Borrowing an idea from Fuchs (1982), I have advanced the notion that an important component of the explanation may lay in the worker's discount rate.⁴⁸ It is natural to think that the quality of being a low discounter enhances productivity. Low discounters are less likely to take a day off on a whim, instead valuing the long-term implications of absenteeism on their reputation for reliability. They are less likely to mistreat machines and equipment because they recognize the long-term benefit of being labeled a 'low-cost' employee. And they are motivated to work hard to gain the benefits of more promotions. In short, the self-motivation of low discounters economizes on firms' monitoring costs.⁴⁹

High discounters are influenced disproportionately by benefits realized over a short horizon, and thus the firm either must expend resources to encourage them to act as though they have a lower discount rate, or accept the implications of myopic behavior. I do not propose that high quality is defined exclusively by workers' discount rates, but rather that, for some firms, the dominant traits of a high-quality worker are highly correlated with this attribute.

A. Sorting of High and Low Discounters

All other things the same, it is natural to think that firms that offer pensions tend to attract low discounters. Low discounters attach a high value to a pension plan whereas high discounters attach a disproportionate value to cash compensation only. Thus, the first-order effect of pensions is to attract savers. In a perfect world, no high discounters would enter a pension firm. But information is not perfect in the job

become particularly acute in periods of poor stock market performance and low interest rates. While taxpayers as a whole presumably hold some portion of this implicit government guarantee, sponsors of defined benefit plans presumably are the first line of financing for catastrophic insurance events that befall the system.

⁴⁸ Also, see Maital and Maital (1977) and Lawrence (1991) who argue that discount rates may have an important bearing on persistent poverty in some families.

⁴⁹ Low discounters are also natural candidates for production functions that emphasize the development of firm-specific capital. But I limit the focus of the paper to the self-discipline aspects of low discounters. Thus, the efficiency of sorting arises from the simple proposition that low discounters require less monitoring.

market, and job choices may be limited to those that do not offer the worker's ideal mix of compensation components.⁵⁰

A natural outcome of this process is that firms set up to employ low discounters must contend with the entry of some high discounters. The firm's problem is to minimize the costs of these hires either by encouraging their early exit, or inducing them to pay themselves a lower wage. A shortcoming of defined benefit plans is that, once high discounters enter, there is no obvious way to encourage their departure. Defined contribution pensions plans are natural vehicles to effect these outcomes.

B. The Economics of Quitting a Defined-Contribution Firm

I now consider the efficacy of a defined contribution pension in correcting hiring errors. Suppose that a firm offers a simple defined contribution plan where it contributes some amount, αW , of workers' compensation to their pension accounts. Vesting is immediate. Borrowing is not permitted. The worker's utility is a function only of income, and all workers are risk neutral. The firm pays cash wage $(1-\alpha)W$ each period and pension P after two periods. Quitting is no longer a factor, since quits can take the proportional value of their balance upon departing.

Other things being equal, the offer of a defined contribution plan will effect some favorable sorting up front. That is, all else equal, workers will find this job attractive relative to an all-cash compensation firm if the discounted value of cash wages, plus the pension, exceed the discounted value of cash wages:

$$(12) \quad (1-\alpha)W + (1-\alpha)W/(1+\phi) + P/(1+\phi)^2 > W + W/(1+\phi).$$

Rearranging terms, a worker prefers the pension firm if the pension is sufficient large to satisfy:

$$(13) \quad P > \alpha (1 + \phi)(2 + \phi)W.$$

Thus, the firm can attract savers by setting the pension such that it is attractive only to low discounters:

⁵⁰ It is natural to think that low discounters will more often be successful in their search for a job that is a good match. Job shopping is inherently an investment activity. Shopping costs incurred early in the career result in the long term benefits of finding the "right" job. Low discounters should thus invest more in the search process and have a greater likelihood of selecting a firm that values their long-term outlook. High discounters presumably are less-careful job shoppers, and thus, more frequently take jobs at firms with production functions designed for low discounters. Some evidence in support of this theory is presented in Curme and Even (1995) who show that credit-constrained individuals are less likely to work in a pension firm. I show that high-discount behavior like smoking and self-reported high-

$$(14) \quad 2\alpha W < P < \alpha(1 + \varphi^*)(2 + \varphi^*) W.$$

If this condition is satisfied then low discounters enter, while high discounters eschew the firm in favor of high cash wages.

I can set the pension to satisfy (14) in the following way:

$$(15) \quad P = (1 + \theta)2\alpha W,$$

where θ is some positive number that is set sufficiently high to attract low discounters into the pension job, but not so high as to attract high discounters.

Now suppose that selection is not perfect. High discounters are poor job shoppers because they cannot perceive the long term benefits of a good match, and so some enter the pension firm. Since the pension is portable, it is easy to encourage their departure after period one. Upon departing, quits can take the present value of savings in the amount αW .⁵¹ Thus, a worker will have an incentive to depart if the present value of the cash withdrawal plus the outside cash wage exceeds the cash wage from staying, plus the discounted value of the future pension amount; that is, if the following condition is met:

$$(16) \quad \alpha W + W > (1 - \alpha)W + P / (1 + \varphi).$$

Using (15), then (16) simplifies to the simple condition:

$$(17) \quad \theta < \varphi^*,$$

which also satisfies (14).⁵² When the pension-firm premium, θ , is less than the high discounters' discount rate, φ^* , then high discounters have an incentive to depart but not low discounters.

In effect, the plan continually sifts the work force for high discounters; thereby improving the composition of the firm's work force over time. In a multi-period model, workers with the highest discounters are most likely to quit with the shortest tenure: they are anxious to obtain access to the amount αW in their

discount rates are less likely to be in pension firms.

⁵¹ I have designed the pension so that the full value of the 'bonus' $\theta 2\alpha W$ is 'loaded' so as to effective only at completion of the contract. In the United States, this effect is accomplished by using a service-weighted formula to allocate more contributions to longer-service workers in defined contribution plans.

⁵² Substituting (15) into (14), shows that θ must be less than $\varphi^*(3 + \varphi^*)/2$, which is easily satisfied by (17).

accounts. Those with the next-highest discount rates are most likely to leave next. That is, at the end of the second period of tenure, the available lump sum is $2\alpha W$, and after the third period, $3\alpha W$, and so on.

Gradually, all the high discounters find it economic to depart the firm. Workers who demonstrate that they can resist the lump sum reveal their low discount rates. The firm accomplishes the desired effect without expending any resources.

We now have an economic function for defined contribution plans: The lump sum they provide upon quitting encourages high discounters to select themselves for early departure from the firm. A recent study provides convincing evidence in support of the selection out effect of lump sum offers.⁵³

C. The Economics of 401k Plans

I have thus far considered only defined contribution plans to which the firm contributes a fixed percentage of pay. I now consider a more flexible defined contribution plan, the so-called 401k. Such a plan can be characterized by fixed contributions like a plain defined contribution plan. But it also permits workers to make voluntary tax-deductible contributions, often with employer matching contributions.

Since 401k plans permit workers to choose their savings rate, they are more efficient savings vehicles than plain defined contribution plans. This proposition is apparent. But 401k plans also can play a sorting role in the firm. In contrast to ordinary defined contribution plans that rely entirely on the sorting out feature of plain defined contribution plans, 401k plans encourage workers to align their pay and productivity.

The economics of the matching provision in 401k plans is simply put: among otherwise identical workers, firms pay savers more than nonsavers. In a plain defined contribution plan, the firm can, and presumably does, reduce the cash wage in exchange for the pension contribution. But 401k contribution decisions are voluntary. Presumably, the firm does not ex post selectively reduce cash wages of particular

⁵³ The authors show that in response to a one-time buyout offer to U.S. Navy personnel to reduce the size of the military force, those who selected out overwhelmingly chose a lump sum alternative that had a far lower present value than the annuity alternative. Since military compensation is heavily tilted towards the end of the contract, so that mostly low discounters would be attracted in the first place, these findings suggest that many high discounters enter, but can be sifted out by offers of lump sums. Military personnel are entitled to a indexed pension after 20 years equal to 40 percent of salary, which presumably is attractive to low discounters. The one time buyout was intended to provide an alternative pension to those with less than 20 years, even though normally, vesting occurs at 20 years. The option was to accept

workers who receive matching amounts. It also is reasonable to assume that profit-maximizing firms do not award "extra" wages to workers unrelated to their value of marginal product. These facts suggest that firms that pay matching amounts in the 401k plan attach special value to workers who are inclined to save.

I advance the idea that firms employing matching formulas are effecting a valuable sort, albeit a more sophisticated one than the lump sum effects in plain defined contribution plans described above. By relying more on voluntary savings decisions, the employer sacrifices some of the benefits of forced savings that characterize plain defined contribution plans, and thus loses some of the sorting-out effects of available lump sums. In return, without expending monitoring costs, the firm encourages workers to align their pay and value of marginal product across discount rates.

Consider the two period model. Assume that the firm makes no unconditional contribution to the 401k, but instead matches contributions on a m -to-1 basis up to the amount V of voluntary contributions. I assume that V is not so high as to dissuade low discounters from taking full advantage of the offer.⁵⁴ The value of marginal product for a low discounter is 1. The value of marginal product for a high discounter is $1 - \Delta$. The firm sets the cash wage so as to compensate the high discounters appropriately:

$$(18) \quad W = 1 - \Delta.$$

Recalling the assumption of a zero interest rate, a worker chooses to save the amount V in the 401k unless his discount rate exceeds the 'rate of return' m ; that is;

$$(19) \quad V = 0 \text{ iff } \quad \phi > m.$$

Finally, I set the matching amount equal, m^0 , so that the matching amount, m^0V , is equal to the differential value of marginal product between low and high discounters:

$$(20) \quad \Delta = m^0V.$$

We can have a stable equilibrium if (21) can be satisfied without violating (19). I can write this condition as

payment over a set period of time, or take a dramatically lower present value in the form of lump sums.

⁵⁴ If V is sufficiently high, low discounters may be unwilling to postpone this much consumption unless they could borrow against the pension to arbitrage the opportunity. In the United States, it is illegal to use the pension as collateral for borrowing.

follows:

$$(21) \quad M^o = \varphi^* - \varepsilon, \quad \varepsilon \geq 0,$$

where ε is the wedge between the high discounter's discount rate and the match rate. That is, if high discounters have sufficient high discount rates to eschew the saving's opportunity when the match is set to align compensation with the values of marginal product between low and high discounters, then the firm has the desired distribution of wages across high and low discounters:

$$(21) \quad W_{\varphi^*} = 1 - \Delta, \quad \text{and}$$

$$(22) \quad W_0 = 1.$$

This is the final result. Without incurring monitoring costs, the firm encourages high and low discounters to pay themselves the values of their marginal product. The firm explicitly reduces wages in the amount, y , and returns the amount *exclusively* to low discounters. Since their pay is aligned with their values of marginal product, the continued employment of high discounters is economic.

VI. Retirement Age Effects

It is perhaps easier to see the potential for defined contribution plans to substitute for the sorting effects of defined benefit plans. It is perhaps less obvious how they might substitute for the other well-known attributes of defined benefit plans, namely, their impact on retirement age and the risk sharing profile as suggested by the capital loss structure in figure 4.

It has long been presumed that defined benefit plans importantly affect retirement age. And there is little doubt that, in empirical work, defined benefit plans are affiliated with the notion of 'on time' retirement.⁵⁵ There is also little doubt that, in the small, these plans influence behavior for any given individual. The literature, however, assumes that the entirety of the impact of defined benefit plans is through its effect on behavior. The unanswered question is, to what extent does this research commingle sorting effects with incentive effects.

For example, if one plan offers retirement with full benefits at age 55 with 30 years of service, it is

⁵⁵ See note 38.

not unreasonable to presume that this firm is relatively attractive to individuals who prefer a compensation package with lots of tax-preferred savings that permits them the opportunity to take an earlier retirement. Individuals who prefer more spending and less savings for retirement, will not gravitate towards this firm, because other things the same, it will be characterized by lower cash wages. Indeed, in a frictionless world, assuming that the plan was characterized by economically unfair pension adjustments after age 55, the only workers who would apply for this job would be savers, 25 years old or less, who preferred a longer retirement.

Viewed in this way, the defined benefit plan may seem to influence behavior, but all the while, it merely acts to sort workers with particular preferences for savings and retirement. A firm that wants to set up a production function that attains its highest value if workers stay for long periods, but depart before workers' reliability is diminished, will opt for the aforementioned plan, in which case it should expect a disproportionate number of applicants with attributes consistent with this preference. While information and job opportunities are not infinitely available, still one would expect an important selection effect from compensation packages, even from the perspective of retirement effects.

A defined contribution plan can partly replicate the sorting effect of a defined benefit plan on retirement, albeit incompletely. To see this, consider a firm that pays only cash wages and no pension. We would expect that this firm will be overpopulated with nonsavers; and hence, we would expect later retirement in the firm simply because workers who do not save cannot finance an early retirement early.

In contrast, consider a firm that offers a plain defined contribution plan. Above, I argued that this plan would have favorable selection in the applicant pool, by encouraging a disproportionate number of savers to enter. It also would exhibit favorable sorting out of nonsavers that enter the pool inadvertently. 'Savers' are likely not only to be disproportionately represented in firms offering pensions, but are likely to have more outside wealth as well.⁵⁶ But even if some high discounters stay, the fact remains that all older

⁵⁶ There is a large literature on the pension-wealth substitution controversy, but both sides in the debate accept the constraint of the positive correlation across wealth categories, a reality that makes it difficult to disentangle pension-wealth substitution effects. See, for example, Gale (1998) and Poterba, Venti and Wise (1996). In a recent study,

workers who accumulate long tenure, have the wherewithal to retire early. As long as the probability of retirement is positively related to accumulated wealth then we expect earlier retirement in firms that have defined contribution plans.⁵⁷

Indeed, defined contribution plans have one advantage over defined benefit plans in retirement effects. Defined benefit plans are indiscriminate in who they encourage to leave; they ‘sweep away’ entire cohorts, even though the firm itself would perhaps prefer to ‘pick and choose’ who left and who stayed.⁵⁸ A plain defined contribution plan ensures that retirement resources are available to all workers. The group that selects to stay arguably is disproportionately represented by workers that firms otherwise would choose to stay if they could. Older workers who have either a health problem or a preference for earlier retirement will leave earlier rather than later, albeit perhaps with somewhat less predictability than in the defined benefit plan. Healthy workers with a preference for work over leisure will opt to work to later ages. We can query whether it is a ‘bad’ for the firm to be left with an older age cohort that is the most work preferring of their cohort.⁵⁹

The 401k variety of defined contribution plans suffers a disadvantage relative to a regular defined contribution plan, because it permits high discounters to remain in the firm, albeit at a lower compensation. This outcome is satisfactory in the short run, but can be problematic when workers become sufficiently old and sufficiently unreliable to interfere with production in the firm. If they have no savings, they will be

Friedberg and Webb (2001) show that retirement occurs earlier in DB plans, but that DC plans also generate substantial retirement rates at older ages as well. Their work does not use data for the uncovered, which makes it difficult to gauge the impact of pensions, and then the relative impact of DB plans. Also see

⁵⁷ For example, in a classic study by Fields and Mitchell (1984), they found that the present value of (DB) pension plus social security wealth exerted an impact on retirement age that was twice as large as the incentive effect. See their table on p. 67. Including dummy variables for each pension plans they studied, they found that for every \$1,000 in wealth at age 60 (calculated for all workers in the sample) resulted in a reduction in retirement age of .1 year. Holding constant the wealth effect, they found the contribution of the incremental wealth accumulated to age 65 to have a positive impact on retirement age of about .055 of one year per \$1,000.

⁵⁸ For example, I have shown that the federal government has ridded itself of virtually the entire cohort of eligible workers within 5 years of eligibility for retirement (Ippolito 1997).

⁵⁹ A defined contribution plan can marginally reduce wages for those who stay by putting a limit on the number of years of contributions they make to the plan, for example, 30 years.

unlikely candidates to voluntarily depart until they are entitled to social security benefits. These firms, however, have one tool available to them to increase the odds that they will be disproportionately populated with savers.

That is, they can set the match rate higher than required to appropriately compensate high and low discounters. Using the variables from the model above, the firm can set the match rate to \tilde{m} , just below the level, $m^0 + \varepsilon$. At this match rate, high discounters still do not participate, and the amount, εV , becomes an efficiency wage paid *exclusively* to low discounters. By embedding the efficiency wage in the match, the firm can attract a disproportionate number of savers to the firm, increasing its odds of having fewer unproductive workers without wealth in the firm later on.

VII. Risk Sharing

We have now come full circle to where this paper started, namely, the demise of defined benefit plans, and in particular, the impact of the reversion tax on the cost of offering contingent benefits in these vehicles. Participants in defined benefit plans are defacto unsecured bondholders in the firm, at least up to the amount of pension benefits in excess of termination benefits. Since reversion taxes make these bonds more costly, the natural question that arises is whether some other vehicle can be used in its place to effect the same risk sharing characteristics.

It turns out that it is not difficult for a defined contribution plan to replicate the essence of the default risk in a defined benefit contract. It is easiest to illustrate the point in the context of a stark example. Consider a two period model. The pension firm wants to make a contract for one period. Workers then can work elsewhere in period two. Utility depends only on income. Make the strong assumption that workers are risk neutral, and the stronger assumption still that all investors are risk neutral, so that we can calculate risk differentials by comparing present values; that is, the equity risk premium is zero. All workers are alike and discount at the interest rate, which I assume to be zero.

Jobs outside a defined benefit pension plan receives wage W in both periods. A pension job pays zero wage in period one, but awards a pension, P , at the end of period one, if the firm does not encounter

serious financial difficulty. Assuming that the upside state occurs with probability $1 - \rho$, the firm is worthless at the end of period one with probability ρ . Since everyone works outside the pension firm in period two, then workers join the pension firm if the pension is sufficient high to compensate for default risk; that is, if

$$(21) \quad (1 - \rho)P > W,$$

which means that the compensating differential required to offset the risk of default, δ , is,

$$(22) \quad \delta \geq W \rho / (1 - \rho).$$

If workers cannot influence the likelihood of success in the firm, then there is no economic function for workers to hold default risk. The argument has to be that the threat of large losses upon financial failure, encourages workers as a group to be less willing to shirk and more willing to help the firm achieve financial success. Put simply, the argument is that ρ is partly influenced by the pension bond.

This arrangement, however, can be replicated simply by replacing the defined benefit plan with a stock bonus defined contribution plan. Instead of receiving a wage, the firm gives workers shares in the company with the same expected value, $W + \delta$. If the firm is successful, workers receive the proceeds from their plan, which they can cash out at the end of period one; else, they receive nothing.

It is reasonable to ask whether this replication is possible in a multi-period model, and within the context of regulations that approximate those that prevail in the United States. To show that it is, I return to the 30-year model I used to generate the capital losses shown in figure 4. Assume that the worker starts at age 0, retires at age 30, and dies with certainty after 15 years of retirement. There is no early retirement. The starting wage is normalized to unity, and grows at rate g per year. The interest rate is i , and the pension generosity parameter is b . In this case, the capital loss imposed on workers from firm failure (and thus, pension termination) is:

$$(23) \quad CL = a b \Omega [1 - e^{-i(30-a)}],$$

where Ω is the present value of \$1 collected for 15 years of retirement discounted at rate, i . As above, I set $i = g = .064$. I set the generosity parameter, b , so as to generate midstream losses at 100 percent of the annual wage (hence, $b = .0085$). This loss schedule is shown by the solid hill-like schedule in figure 6.

Assume that the firm wants to replicate these losses on workers using a stock bonus plan. The firm deposits some portion, v , of the wage into the worker's account, which must be used to purchase company stock. Since I assume risk neutrality and thus zero equity premium, I assume that the stock value grows at the interest rate i . Hence, as of age and service level a , the worker's account has the asset value, S_a :

$$(24) \quad S_a = \int_{a=0}^a v e^{(g-i)a} = va .$$

If the firm fails, workers lose the amount S_a . I choose a value of v to that S_a equals the capital losses in the defined benefit plan midstream in the contract. Since I normalized the generosity factor to yield a capital loss from default on a defined benefit pension at unity midstream, then I can approximate this same loss midstream if I set $v = 1/15$. The linear segment in the figure gives the expected value of company stock. Indeed, the capital loss function fairly well replicates the first part of the defined benefit capital loss structure. A problem, however, is evident. Losses implied by firm failure continue to escalate until they are approximately double the capital losses midstream, and swamp the capital losses in the defined benefit plans later in tenure.

Essentially, in the defined benefit contract, workers gradually exchange their unsecured bond for one that is secured, so that it is entirely secured by the time they reach retirement. This means that if firm failure occurs late in tenure, their losses are mitigated. In contrast, the losses from a stock bonus plan continue to escalate, putting the entirety of the pension value at risk late in tenure.

The firm can alter the stock bonus plan, however, 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, starting midstream in the contract. Let the plan set the portion of the worker's funds that the firm requires workers to invest in company stock at age and service a be denoted by λ_a . In this case, worker losses from firm failure are:

$$(25) \quad CL_{SB} = \lambda_a v a .$$

Suppose the firm sets λ_a in the following way:

$$(26) \quad \lambda_a = 1 \quad \text{if } a \leq 15$$

$$\lambda_a = 1 - v(a - 15) \quad \text{if } a > 15$$

In effect, the firm allows workers to diversify out of the firm gradually over the latter part of their career. Recalling that $v = 1/15$ then the capital loss function is:

$$(27) \quad \begin{aligned} CL_{SB} &= a / 15 && \text{if } a \leq 15 \\ CL_{SB} &= (30 - a)a / 15^2 && \text{if } a > 15. \end{aligned}$$

I show this capital loss function in figure 7 by the schedule denoted by asterisks. For comparison, I show the capital loss function for the defined benefit plan it replaces in a light solid line. The stock bonus plan does a pretty good job of mimicking its defined benefit counterpart in exposing workers to default losses. In this sense, since the stock bonus plan yields the same exposure to workers at the defined benefit alternative, it is of no consequence that I assumed either a zero risk premium or risk neutrality of workers: both pensions fetch the same price from workers (in the form of foregone wages), regardless of these parameters.

VIII. CONCLUDING REMARKS

Owing to various factors, including changing employment patterns, and ill-fated public policies such as reversion taxes, defined benefit plans now cover only about 40 percent of private sector workers with pensions. The long-term cost of losing defined benefit plans is partly hidden in the form of lower productivity in some firms. Defined benefit plans have been tied to numerous productivity factors, including their ability to help the firm reduce quit rates, manage retirement ages, and to provide workers a kind of ownership share in the financial performance of the firm. If replacement plans are less likely to be as efficient in controlling worker behavior and if some of this drift is attributable to regulatory and tax interference in the choice of pension plan, then some loss in productive efficiency is inevitable.

I have a more skeptical view of this outcome. While it appears in the data that pensions affect behavior, this may partially hide their true influence, which is to exert powerful selection effects on who joins and stays with a firm. Recent evidence shows that savers are better workers than nonsavers, and exhibit far lower quit rates. Defined contribution plans not only can effect selection of savers in the applicant pool, but

can also encourage high discounters that enter inadvertently to depart early in tenure. 401k versions can be arranged so as to pay savers more than nonsavers, and indeed can pay efficient wages to savers to encourage their employ. In this sense, it is not apparent that firms' collective ability to select and retain high-quality workers is remarkable different than in the old equilibrium.

Perhaps as importantly, it is not clear that the large influence of DB plans on retirement age is entirely or even mostly attributable to their 'price effects' intended to tilt retirement at particular ages. I showed that the typical defined benefit plan is more-or-less neutral in its impact on retirement until normal retirement age. Defined contributions plans can offer similar wealth positions to older workers. To the extent that wealth effects drive retirement, perhaps the marginal impact of DB plans on retirement age has been overstated. This is especially true if these pensions merely sort workers across plans according to their preferences for earlier or later retirement.

Finally, while defined benefit plans have long been viewed as a risk sharing of workers in the financial success of the firm, it is apparent that this function can be replicated by judicious use of a defined contribution plan. A stock-bonus plan with a diversification option that gradually kicks in starting around mid tenure does a remarkably good job of approximating the default exposure in the traditional DB framework.

If sorting effects work to mitigate the productivity impact of the switch to the defined contribution variety, it is likely they also work to dampen changes in retirement income patterns that will emerge. Those who did not want to save in the 'old world' presumably avoided pensions; and those that wanted pension savings sought out pension firms. There is no reason to believe that this pattern will be much different in the 'new world' characterized by more defined contribution coverage, even if most DC plans are the 401k variety.

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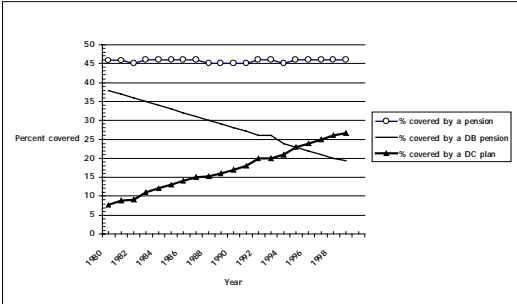
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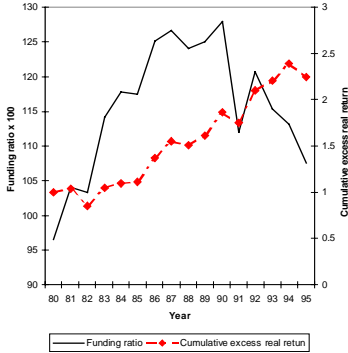
Slide 1

Figure 1: Percent of Private Labor Force Covered by Type of Pension, 1980-1999



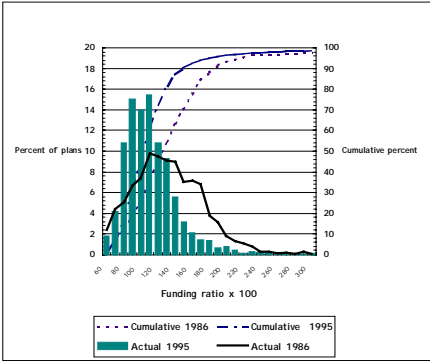
Source: U.S. Department of Labor, *Private Pension Plan Bulletin: Abstract of 1995 Form 5500 Annual Reports*, Pension and Welfare Benefits Administration, Number 8, Spring 1999. Participants in 401(k) plans who do not contribute are not included as pension covered in these data.

Figure 2
Funding Ratios, 1980-1995



Source: Funding ratios: Longitudinal data base, from 5500 annual pension reports. All liabilities are adjusted to a 6.5 percent interest rate and GDM 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, Stocks, Bonds, Bills and Inflation 1926-1998.

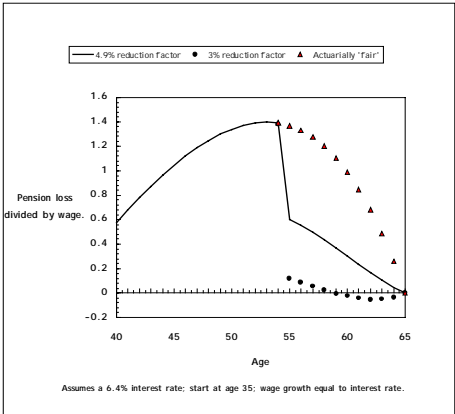
Figure 3
Funding Ratios, 1986 versus 1995



Source: Longitudinal data base, from 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.

Slide 4

Figure 4
Pension Capital Losses From Departing at Various Ages



Slide 5

Figure 5
Pension Capital Losses When Actuarial Subsidy is Awarded to Vested Inactive Participants

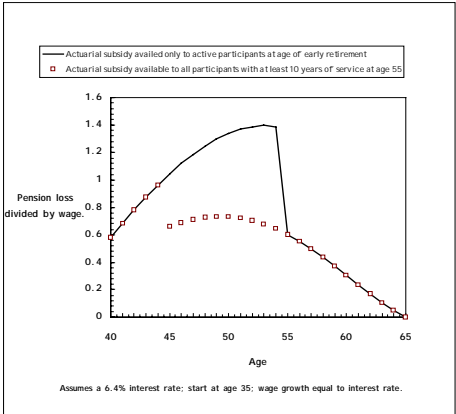


Figure 6
Pension Capital Losses From Firm Failure
A Stock Bonus DC Plan

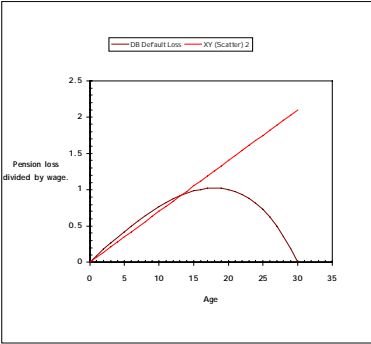


Figure 7
Pension Capital Losses From Firm Failure
A Stock Bonus DC Plan with Constrained Diversification

