Reinventing the Retirement Paradigm

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Chapter 6

The Future of Pension Plan Design

David McCarthy

Three decades ago, the Employee Retirement Income Security Act (ERISA) (1974) was passed, initiating a wave of change in US private pension provision. Since that time, many traditional private-sector defined benefit (DB) pension plans were replaced or augmented with newer defined contribution (DC) arrangements, including 401(k) plans. As the system matures, it is becoming increasingly clear that the problem of optimal pension scheme design has not yet been solved. The task ahead is to ensure that pension systems of the future are adapted to meet workers' retirement needs as well as employers' objectives, a task that will require substantial effort and focus.

In the past, it has been difficult to evaluate alternative pension scheme designs from an economic point of view. This is because there was no simple theory which clearly illustrated how firms and workers actually value their pensions: that is, real-world pension contracts were far more complex than those that could be modelled with economic tools. In recent years, however, the reduced cost of computing power has changed how analysts approach the problem. It is now possible to use numerical analysis to assess different pension plan designs using a coherent economic framework which is realistic enough to assist researchers and practitioners who study and design pension plans. In this chapter we develop a framework to design pension schemes and use it to present some illustrative results.

A key part of this framework is a model of employee preferences. A realistic model of preferences must include preferences for consumption and saving, the economic environment in which workers make their decisions (for instance, by including Social Security), the major risks to which individuals are exposed, and some assessment of changes in attitudes and exposures to risk[1] as people age. In this chapter, we argue that economic life cycle models are well suited for this purpose. Previous work has applied them successfully to examine saving and consumption patterns (Carroll 1997), lifetime investment allocation (Heaton and Lucas 2003), mortgage choice (Campbell and Cocco 2003), housing purchases (Cerny et al. 2004), and the impact of state pensions (Campbell et al. 2000), and of occupational pensions (McCarthy 2003). Here we show how life cycle models can be applied fruitfully to the issue of pension design, and, further, how these models can be used to help design pension schemes which fulfil the objectives of both workers and firms.

In what follows we first identify factors that must be taken into account when designing pension schemes. Next we briefly discuss life cycle models of employee preferences and then present a specific model of this type. After sketching some results, we offer conclusions and draw implications.

Elements of Pension Plan Design

Economists recognize that pension plans are an element of employee compensation. This means that the efficiency of pension plan design can only be analyzed as a component of the efficiency of overall employee compensation. Several aspects of compensation contracts are key in this discussion, namely taxation, labor markets, employee preferences, and firm attitudes to risk. We also must acknowledge that the government is a third party to compensation contracts. That is, firms and workers can structure employment contracts so as to minimize tax revenues transferred to governments. In many countries, pensions are tax-advantaged over other forms of compensation such as cash. In the USA, for instance, pension contributions are not taxed as income in the hands of employees, and investment income on pension assets is shielded from tax. This gives employees one reason to favour pension compensation over cash compensation. Of course, tax needs to be paid on pensions when they are eventually drawn as income; Poterba (2004) examines the value of the pension tax shield from the point of view of US workers. From firms' viewpoint, pension contributions are similar to other forms of compensation such as cash, as both can be written off as an expense against taxation reducing the firm's taxation liabilities. Pensions are therefore a tax-efficient method of compensation from the point of view of employees.

We now turn to the role that pensions play in labor markets. In the simplest labor market, often called the 'spot' labor market, rational employees sell their labor services to firms each period on an open market. In this setting, there would be no involuntary unemployment and no internal labor markets in firms such as 'regular' pay scales, service-linked promotion, or retirement. Under this approach, and if employees had free access to capital markets, their firms would provide pensions in an employment arrangement only because of the tax advantage: providing for retirement via a company pension is cheaper than outside the firm. In other words, if pensions were not tax-favored, firms would not offer them to employees at all.[2]

Labor economists have developed several theories to explain why, in fact, pensions are offered as an element of labor contracts beyond the tax rationale. One prominent explanation is the deferred-wage theory, which holds that pensions can be used to induce long employee tenure at the firm.

This would be valued by firms where tenure is associated with higher worker productivity—perhaps because skills are specific to the job at hand and can only be learned on the job. Long tenure also reduces recruitment and direct training costs. Under this view, pensions are a way to pass some of the rewards of this extra productivity on to workers. The mechanism is thought to involve workers posting a 'bond' with the firm, by working for lower wages early in their employment. The deferred compensation is then returned to them in later years, in the form of a pension (or perhaps also with an upward sloping wage-tenure profile). Workers will consent to this arrangement if it pays them compensation which, in expectation, exceeds what they would earn without a pension (or with a flat wage-tenure profile). This increase compensates the fact that the worker must remain longer with the firm, and hence it has been called an 'option loss' or 'indenture premium.' DB pensions are thought to be especially useful for such backloaded employment contracts, since they explicitly defer pay until later in the contract and because they are harder for firms to renege on than unsecured promises. DC pensions with a vesting employer match may have similar effects.[3]

Another explanation offered by labor economists for pensions is that these contracts help manage the asymmetric information problem between the firm and potential workers, when firms are unable to verify the likely productivity of new hires. An employment contract which pays a pension defers payment to later in life, so jobs with pensions might be more attractive to workers who either have low discount rates, or who have greater expectations of salary increases, that is, those who expect to be more productive. Low discounters, it is believed, make better workers because they are willing to invest more in learning. As a result, offering a pension is likely to attract more productive workers, so this view is known as the 'sorting theory' of pensions.[4]

A related rationale for offering pensions is that firms which do can influence employee retirement patterns, an outcome of particular value to firms that use tilted wage profiles to control turnover (Fields and Mitchell 1982). This is because with tilted wage profiles, employees will earn more than their alternative opportunities before they retire, which is a disincentive to retire. Consequently, a firm can design its pension to induce workers to retire as part of the retirement contract. There are also sociological reasons why firms might wish workers to retire, including the transactions costs associated with forcing older employees with long service to retire if they are unable to fulfil their job responsibilities. Some types of pension are better at achieving these different goals than others: for instance, some pensions may have only a small effect on job turnover or sorting depending on how they are designed. The literature shows that DB pensions are especially effective at influencing retirement by means of nonactuarially neutral benefit formulas; by contrast, DC plans tend to be less influential of retirement outcomes, depending on the workers' accumulated values as they near retirement.

All of the labor market explanations of pensions have one factor in common: they downplay the fact that employees are more risk-averse than firms, yet they can access the same capital markets as can firms. Workers are believed to be more risk-averse because investors who own the firms can diversify their exposure by trading in securities, while employees are unable to do the same with their wage income.[5] Thus a financial economics approach to pensions would include the fact that different compensation arrangements can have very different implications for employees' portfolio costs in these plans. A further aspect of pensions to be considered in the financial economics context is the corporate finance aspect of pensions. That is, different pension strategies impose different risks on employers, which should be acknowledged in the modeling approach. For instance, DB pensions expose employers to investment risk and mortality risk. Also firms may have different risk preferences than their workers: for instance, a small family-owned business might react differently to risk than a public-sector employer. Some firms may also be able to hedge risks more easily: for instance, wage fluctuations might be reasonably well hedged by firm income in larger companies, while mortality risk would be very difficult for any firm but the government or a large life insurance company, to hedge effectively.

Another aspect of pension compensation which needs to be considered is the role that pensions play in workers' overall portfolios. Pension contracts change workers' risk exposures, and they also alter the allocation of compensation over the life cycle. For instance, DB pension arrangements magnify the risk exposure of an individual to salary risk, and both DC and DB pension arrangements defer the pay of younger workers to later in their lives. Younger workers might therefore value cash in hand highly, because they have immediate cash needs, while older workers might be more willing to defer compensation to later in life as they are saving anyway.

Both of these effects are portfolio costs that depend on how effectively employees can access capital markets on their own. To the extent that employees and employers can trade freely in capital markets, the portfolio efficiency of pension compensation is irrelevant, because well-informed employees will simply adjust their portfolios to achieve any desired risk exposure. By contrast, if employees cannot trade freely on capital markets—for instance because of portfolio restrictions, liquidity constraints, moral hazard or incomplete markets—then the portfolio efficiency of pensions becomes important. An example might make this clearer. For instance, imagine that employees were offered movie tickets as part of their compensation package. Two movie tickets per month might be an effective way of compensating employees who like to go to the movies. But if employees were paid a large fraction of their wages in movie tickets, the value they place on this compensation would decline dramatically because they cannot cheaply sell large numbers of movie tickets for cash. By choosing to pay employees in movie tickets, the firm imposes on workers a portfolio cost. We might therefore call this form of compensation portfolio inefficient, in this case entirely because of the transactions costs involved in regularly selling large quantities of movie tickets.

In some respects, paying individuals pensions is akin to paying them movie tickets: pensions cannot be traded or borrowed against, and they impose liquidity constraints on workers. Pensions also increase worker exposure to risks which cannot be traded, such as wage risks. Unlike movie tickets, of course, pensions produce income in retirement and may also protect workers from some risks.

A general framework for deciding optimal pension design should take account of all four of these aspects: tax efficiency, incentive compatibility, portfolio efficiency, and corporate finance. Yet only a partial list has been considered in previous studies. For instance, Ippolito (1994) assessed compensation strategies which account for some labor incentive aspects, but he ignores worker portfolios. Bodie et al. (1988) examine pensions from the point of view of portfolio efficiency, but they ignore labor market aspects, taxation, and corporate finance issues. McCarthy (2003) has a more complete model of portfolio efficiency and mentions firm risk, but he assumes that firms can hedge all their pension risks away.

A Model of Pension System Design

We have argued that a comprehensive framework for a theoretically optimal pension compensation strategy would recognize the key role of the following elements:

1. A *firm* which chooses a compensation strategy (i.e. designs a pension plan) based on some criterion, for instance, maximizing expected profits. Risk-averse smaller firms might take some of the risk they are exposed to by pension arrangements into account, too, in determining the optimal pension.
2. Workers who respond to the *incentives* provided by compensation strategies. Pension design affects firm profits via the direct cost of the compensation, and also via the effect that compensation has on worker recruitment and behaviour. This would include labor market aspects such as sorting, tenure and retirement.
3. An *incentive compatibility constraint* to ensure that the pension does not cause worker and firm incentives to be misaligned; and
4. A worker *participation constraint*, which ensures that the firm is able to recruit the quality and quantity of workers it needs to produce its output. To take into account worker preferences, this would need to be expressed not in terms of the wages that the worker is offered, but in terms of the lifetime utility that the worker expects to achieve. This

> measure takes into account the portfolio efficiency of the pension scheme within the context of the worker's entire portfolio. This portfolio includes worker's future wages, the major risks to which the workers are exposed (investment risks, mortality risk, income risk), the preferences of the worker, any portfolio restrictions on the worker, and how all of these factors change over working life and retirement.

These ideas may be illustrated using a simple three-period model of employment and pensions, building on Ippolito (1994) who examined indenture premia, and Bodie et al. (1988) who assessed the portfolio effects of different pension arrangements. Here we posit two work periods and one retirement period. Employers may pay remuneration during the retirement period which is the pension. Workers have access to capital markets but they can only save, not borrow against future wages. There is only one asset and it is not risky. Workers have no assets except what they have saved and their future wages, called here their human capital. Workers must save to smooth out consumption over their lifetimes. In this simple formulation, there is no Social Security system and compensation including only wages and (possibly) pensions. We further abstract from taxes and uncertain mortality. For simplicity, the interest rate on the risk free asset and workers' discount rates are assumed to equal zero. The model also assumes that per period hours of work are fixed and that the firm faces an infinite demand for goods at the current price.

The firm can choose a wage profile w_1 and $\tilde{w}_2$, and a pension $\tilde{p}$. At the beginning of period 1, the employee knows w_1 but not $\tilde{w}_2$ or $\tilde{p}$. The values of these are revealed at the beginning of period 2 and may be random. However, the worker knows the statistical distribution of likely second-period wages and pension payments. Then, given a compensation structure, the employee chooses his consumption in periods 1 and 2 to maximize:

$$U(w_1, w_2, p) = \max_{c_1, c_2} u(c_1) + E[u(c_2) + u(c_3)]$$

$$\text{s.t.} \quad 0 < c_1 \leq w_1,\ 0 < c_2 \leq w_1 - c_1 + \tilde{w}_2 \text{ and } 0 < c_3 = w_1 - c_1 + \tilde{w}_2 - c_2 + \tilde{p}.$$

The constraints come from the fact that the employee is assumed to start off with no assets and cannot borrow against future income. In the final period, the worker consumes all his assets. This is a particularly simple model of preferences: in principle, it could be made as complex as desired.

Let the pension $\tilde{p}$ be a final salary DB pension with accrual rate α. Contributions to the pension are deducted from cash wages, and because the interest rate is zero, expected contributions must sum to the expected pension. If we assume that $E[w_2] = w_1$ and that $p = 2\alpha w_2$, for $\alpha \geq 0$, and that the employer is risk-neutral, then the employer's optimization problem is:

$$(w_1, w_2, \alpha) = \arg \max_{w_1, w_2, \alpha} R(w_1, w_2, \alpha) - w_1 - w_2 E[\tilde{Z} + 2\alpha\tilde{Z}]$$

$$\text{s.t.} \quad U(w_1, w_2, \alpha) \geq \overline{U} \text{ and } \alpha, w_1, w_2 \geq 0$$

Here the term $R(w_1, w_2, \alpha)$ represents the revenue the firm earns from selling its products, net of training and recruitment costs. If the compensation structure makes workers work harder, then net revenue will be higher, which is why revenue is a function of the compensation structure.

The participation constraint $U(w_1, w_2, \alpha) \geq \overline{U}$ shows that employers design a compensation contract which attracts workers. In this model there is no incentive compatability constraint: this could be introduced by stipulating that in all periods, workers may not sell future labor for current wages.

The implications of this simple model are interesting. First, firms have an incentive to pay workers in ways which are beneficial for the worker. It is not necessary for firms to 'care' about workers for this to be so: by paying employees in a form the employees value, employers reduce their total compensation bills and potentially increase profits. Alternatively, by paying workers in a form they do not value, firms increase their total compensation bill and therefore earn fewer profits. A familiar example of this phenomenon involves taxation. Arguably, in the USA, firms are fairly indifferent between 401(k) pension and cash compensation from a tax point of view: both can be written off against income to reduce the firm's tax liability.[6] However, because workers face a lower tax bill on pension compensation, firms can give workers a higher post-tax wage by paying part of the wage as a pension. A less familiar example might be the form of the benefit itself: if workers are paid a risky pension which they cannot hedge, as in the above example, firms must boost wages to compensate employees for taking on this risk.

If we introduce into the above analysis risks that workers and firms can hedge by trading on capital markets, some perhaps surprising results obtain. For instance, firms derive no value from protecting workers from risks that workers can hedge, such as investment risk, and they will get no benefit from exposing workers to these risks. The reason for this is that workers could choose to buy this protection on the markets themselves, and they would pay the same price as the firm. In this setting, employees are indifferent between receiving protection from traded risks as part of their compensation (which they could then sell for cash if they wished), or receiving cash and buying the protection themselves. Of course, in the real world, workers cannot trade freely on capital markets for many reasons, one of which is the cost of learning how to manage assets. Yet this model suggests that the cost of prescribing an investment strategy for workers in their pension plans is relatively low, if workers are able to trade competently themselves. If workers are unable to trade competently, the benefits of prescribing an investment strategy may be quite high.

Two other implications of this analysis need to be mentioned. The first is the issue of underfunded DB pension plans. If promising workers a stake in an underfunded pension plan has no effect on effort, then this is an expensive way to pay workers. This is because workers already have substantial undiversifiable exposure to the firm: if the firm goes bankrupt, they stand to lose their jobs. Giving workers a claim on an underfunded pension is paying them partly with long-term credit notes on the company, which boosts their exposure to the firm's credit risk. If the firm is a publicly traded corporation, workers could hedge this risk by selling the company stock short, or by buying credit default swaps on the firm's debt instruments (assuming these can be purchased). Of course there may be incentive problems caused by the workers effectively holding a short position in the company stock, and workers will suffer transactions costs and will need to be reimbursed for these in the form of higher total compensation. The firm could thus reduce compensation costs by paying workers with a fully funded pension. If the firm is not publicly traded, then workers have no way of diversifying this risk away and will have to be compensated for the credit risk of the firm in the form of higher total wages. Paying workers in the form of insecure, underfunded pensions is therefore an expensive way to compensate them.

A second issue is compensating workers with 401(k) plans that contain restricted company stock. Exactly the same theoretical analysis as performed above applies: in the absence of incentive effects, this is an expensive way for firms to remunerate employees because they are already heavily exposed to company risk. Watson Wyatt (2004) reports the results of a US survey showing that workers routinely value options and restricted stock at a discount to their true cost. It is interesting that some employers say they pay employees in this form because they believe that it will help to align the incentives of workers and owners, partly to induce workers to sort themselves, and partly to retain workers.[7]

More Realistic Pension Designs

Next we turn to a life cycle model which extends the framework above, by using a computational approach that permits an evaluation of how workers might value pensions of different types, and how one might develop optimal pension compensation strategies for employers, under a range of economic and demographic assumptions. We build on McCarthy's (2003) life cycle model to characterize the major risks to which workers are exposed (investment risks, wage risks, and mortality risk), and how the workers exposure to these, changes as they age, retire, and finally die. In this approach, the worker is assumed to maximize utility and work until age 65 when he retires; death happens with certainty before age 100 but he might also die before retirement. (In practice, we use mortality patterns of

US females born in 1980.) Each period he works, he receives a risky wage which may be consumed or invested in stocks or bonds, with the asset allocation redetermined each year. The bond pays a constant real rate of return, while stocks pay a risky rate of return. The worker cannot borrow against future wages or stock holdings, and he cannot sell stocks short in order to buy bonds. To keep the analysis tractable, we abstract from a Social Security system and housing assets in this model. The structure of the model is outlined in Table 6-1.

To represent real-world earnings data, we assume that wages are subject to transitory and persistent shocks. The transitory shocks affect only current earnings and have no effect on future pay (e.g. a sales agent might have a bad week because she had a cold), while persistent shocks are

TABLE 6-1 Structure of the Life Cycle Model

	Working period				*Retirement period*		
Time	*1*	2	...	T	$t+1$	...	$t+s$
Income	W_1	W_2	...	W_t	*0*	...	*0*
Wealth	A_1	A_2	...	A_t	A_{t+1}	...	A_{t+s}
Pension	P_1	P_2	...	P_t	P_{t+1}	...	P_{t+s}
Consumption	C_1	C_2	...	C_t	C_{t+1}	...	C_{t+s}
Risky asset return		R_2	...	R_t	R_{t+1}	...	R_{t+s}

Notes: At each time period the individual chooses how much to consume and how much to save from current income. The asset mix of savings (between bonds and equities) can be adjusted each period. Income is stochastic with permanent and temporary errors. Risky asset returns are assumed to be log normally distributed with a constant mean and variance. Retirement is assumed to be at age 65. The individual is assumed to face mortality while working and retired. The maximum possible length of the retirement period is 35 years. At time 0, the individual is offered a pension contract, which may be a defined benefit (DB) or a defined contribution (DC) pension. At retirement, the individual can choose to purchase an annuity from private savings on the private market. To model the costs of adverse selection, the annuity is not priced fairly but has a multiplicative loading factor incorporated into the price. This annuity pays a level annual pension for life. The individual can purchase an annuity regardless of the pension plan arrangement. Annuities that are mandatory do not attract an adverse selection charge; voluntarily-purchased annuities attract a charge for adverse selection. There is no bequest motive, labor supply is assumed to be exogenous and the individual is not permitted to borrow either stocks or bonds. The individual maximizes:

$$\max_{\{Y,\, C_i,\, \alpha_i\}} E_0 \sum_{i=1}^{t+s} \beta^i \pi_i u(C_i)$$

where

$$u(C) = \frac{C^{1-\gamma}}{1-\gamma},\ \gamma \geq 1,$$

and π_i is the assumed probability the individual is alive at time i conditional on being alive at time 0. The individual is offered one of several pension arrangements as described in the text.

assumed to influence future wages (e.g. a professional skier might have a serious accident). Such shocks cause wages to fluctuate around age and education-dependent wage profiles derived from US data (see the notes to Table 6-1). Workers with different educational backgrounds are permitted to have different mean earnings as well as different earnings shocks. The data also show that more educated workers tend to have more permanent wage shocks, a fact with important implications for pension design.

Just after retirement, at age 65, we assume that the retiree can buy an annuity in the private annuity market at an actuarially unfair price—which means that the expected present value of the lifetime benefit is below the annuity premium. The price is set to be unfair to reflect the possibility of adverse selection in the annuity market. During the retirement period, the retiree then receives income equal to any pension plan income, plus his private annuity income. The individual is assumed to choose his consumption, investment strategy, and annuitization to maximize his expected discounted lifetime utility. Using numerical techniques discussed in McCarthy (2003), we calculate the total expected discounted lifetime utility workers of different ages and types. By calibrating the parameters of the model to actual US data, we can use the model to approximate preference structure of US workers. This allows us to examine how these workers might value pensions of different types.

To implement the model, we must further specify tastes for consumption in each period, the worker's degree of risk aversion (which affects how much he would willingly pay for insurance against risk), and his personal discount factor (the higher the discount factor, the more valuable is consumption today versus tomorrow). We denote the expected discounted lifetime utility of the worker with no pension benefit as $U_0(1)$; the lifetime utility of a worker with no pension benefit but having an initial endowment and lifetime income is higher by a factor of m, so his utility may be written $U_0(m)$. To introduce different pension arrangements into the model, we let the lifetime utility of a worker with a pension of type i be denoted by $U_i(1)$. More details appear in Table 6-2.

The specific pension arrangements to be examined here include the following:[8]

1. *A noncontributory DB pension with varying replacement rates.* This pension pays a benefit from retirement (age 65) until the individual dies, with the benefit set to equal a fraction α of the individual's final salary (hence α is the pension replacement rate). We define the worker's expected discounted lifetime utility with this pension benefit as $U_1(1)$, and the expected discounted cost of this benefit to the employer is C_1.
2. *A DC pension with contributions over and above cash wages of 10 percent of pay; here there is no investment choice and no mandatory annuitization.*

TABLE 6-2 Model Parameterization

	Assumption[a]		
Risk aversion		5	
Time preference		4%	
Risk-free interest rate		2%	
Equity risk premium		4%	
Equity uncertainty		$\sigma_\eta = 0.157$	
Permanent income profile		Polynomial profile[b]	
Income uncertainty	$\theta = 1$ $\sigma_\xi = 0.130$ $\sigma_\varepsilon = 0.121$[c] (College)	$\theta = 1$ $\sigma_\xi = 0.136$ $\sigma_\varepsilon = 0.103$[c] (High School)	$\theta = 1$ $\sigma_\xi = 0.162$ $\sigma_\varepsilon = 0.102$[c] (No High School)
Mortality		US Females[d]	
Equity/permanent wage error correlation	$\rho_{\eta\xi} = 0.15$	$\rho_{\eta\xi} = 0.10$	$\rho_{\eta\xi} = 0.10$
Liquidity constraints		Imposed	
Private annuity market		$\lambda = 10\%$[e]	

Notes

[a] No bequest motive is assumed and labor supply is assumed exogenous.

[b] This profile, from Campbell et al. (2000), was estimated from the Panel Study on Income Dynamics (PSIS) separately for college-educated individuals.

[c] These estimates are from Campbell et al. (1999) PSID analysis; his temporary standard deviations for college-educated individuals were halved to allow for measurement error. These values are slightly higher than those found in Hubbard et al. (1995), Heaton and Lucas (2000), and Carroll (1996).

[d] We use projected mortality for the 1980 cohort of US females calculated by the Berkeley mortality database with data from the Social Security Administration; see *demog.berkeley.edu/wilmoth/mortality*

[e] Mitchell et al. (1999) estimate adverse selection and loading costs to be around 10 percent of the cost of annuities.

Under this plan, contributions accumulate in a separate account which the worker will not be permitted to access before retirement. At retirement, the DC assets are added to the retiree's other assets and these may be used in whole or in part to buy a private annuity, or they could be consumed freely. We denote the expected discounted lifetime utility of the worker with this pension benefit as $U_2(1)$, and the employer's expected discounted cost of this benefit as C_2.

3. *A DC pension with contributions over and above cash wages of 10 percent of pay; here there is no investment choice but annuitization is mandatory.* In this case, the contributions accumulate in a separate account as before, but after retirement the worker receives a lifelong annual pension payment equal to the accumulated DC balance at retirement, divided by the price of a fair annuity. We denote the expected discounted

lifetime utility of the worker with this pension benefit $U_3(1)$, and the employer's expected discounted cost of this benefit as C_3.

To calculate the value of the different pension arrangements to the individual we solve for m_i in the following equation: $U_0(m_i) = U_i(1)$. In economic terms, m_i is the 'compensating variation' if pension arrangements change. It is the factor by which a worker's initial endowment and lifetime income would have to be changed, in order to exactly compensate him for the change in that pension. If m_i is high, we can conclude that this particular pension is more highly valued than when m_i is low. We solve this equation by noting that, from the preference function assumed, a change in m is nothing more than a change of currency or numeraire, and therefore that:[9]

$$m_i = \left[\frac{U_i(1)}{U_0(1)}\right]^{\frac{1}{1-\gamma}}.$$

It should be noted here that this specification only focuses on employee preferences: there is no explicit employer in this model so it includes only part of the more complete framework discussed previously.

Results

To make the different pension arrangements comparable, the results in Table 6-3 constrain the costs of each pension offer to the same proportion of workers' lifetime cash wages (this version of the model abstracts from taxes). These results have implications of offering an employee different pension schemes, each of which has the same cost. The cost for each DC arrangement is therefore set at 10 percent of lifetime income from the point that the worker joins the plan onward. The DB plan generosity is adjusted at each age to ensure that its cost is equal to that of the DC arrangement. For instance, for a worker with no high school education who joined the DB plan at age 30, a contribution of 10 percent of cash wages until retirement was sufficient to purchase a DB pension with a replacement rate of 40 percent; by contrast, for a worker with no high school education joining the plan at age 50, this contribution would only be sufficient to purchase a pension with a replacement rate of 12 percent. The generosity of the DB pension declines in a nonlinear way with the age at joining, because of the effect of earnings, mortality, and interest rates over the life cycle. Workers with different educational backgrounds who pay contributions worth 10 percent of wages into a DB pension plan will end up with pensions of slightly different generosity, because of different expected wage profiles.

A key variable of interest in the pension design arena is the difference between the cost of the pension, paid by the firm in this model, and the

TABLE 6-3 Pension Value Minus Pension Cost (Welfare Loss) Under Various Plans, as a Percentage of Pension Cost

	Age 30			*Age 40*			*Age 50*		
	College	*High School*	*No High School*	*College*	*High School*	*No High School*	*College*	*High School*	*No High School*
Model 1: DB plan									
	39	27	26	22	14	12	8.7	1.3	2
	(38)	(37)	(40)	(25)	(24)	(25)	(13)	(12)	(12)
Model 2: DC plan									
30% equities	5	8	15	10	7	8	7	12	14
70% equities	10	12	18	12	7	10	7	12	14
100% equities	15	16	22	14	9	12	8	12	15
Model 3: DC plan									
30% equities	12	17	21	19	15	7	6	11	14
70% equities	16	18	24	19	15	8	6	10	13
100% equities	22	24	28	22	16	9	6	10	13

Notes: The table shows the value of $(10\% - m_i)/10\%$, where m_i is the increase in lifetime cash wages required to compensate the worker for the loss of the pension arrangement described. The value m_i solves the equation:

$$m_i = \left[\frac{U_i(1)}{U_0(1)}\right]^{\frac{1}{1-\gamma}}$$

where $U_0(m_i)$ is the expected discounted lifetime utility of an individual with no pension (see Table 1), and $U_i(m_i)$ is the expected discounted lifetime utility of the same individual but with the pension arrangement described in the first column of Table 3. Model 1 is a DB final salary pension that pays a life annuity with a replacement rate shown in brackets, multiplied by the worker's final annual salary. The cost of each DB pension is 10 percent of lifetime income from that age until retirement. Model 2 is a mandatory DC scheme with contributions equal to 10 percent of earnings and with an investment mix as shown (the first number refers to equities), but with no mandatory annuitization. Model 3 has the same DC scheme but requires mandatory annuitization. The DC figures are evaluated with temporary wage fluctuations turned off. All figures assume non-pension wealth in the first year (e.g. age 30, 40 or 50) equal to expected wages in that year.

cash-equivalent value of the pension, which is the compensating variation to the worker. If a worker felt that the cash equivalent of a pension was worth less than the cost of the pension to the firm, then that pension would be an inefficient way to pay people (or the difference would have to be due to some other aspect not in the model, such as tax efficiencies or labor market effects of the pension on sorting and turnover). Table 6-3 shows the difference between the cost of the pension (assumed at 10 percent of cash wages for all pension types), and the compensating variation of the pension; the gap is then expressed as a percentage of the cost of the pension.[10]

One striking result in Table 6-3 is that all the values are positive: that is, the compensating variation of pensions is always less than the cost of the pension. This is because, in the absence of tax effects, workers are always better off with cash than with pensions because of the undiversifiable risks to which pensions expose them, and because of the forced savings aspects and illiquidity of pensions. Consider a worker age 30: in the DB plan, the figures in parentheses show the pension replacement rates that could be purchased by contributions worth 10 percent of cash wages. For a college-educated 30 year old, 10 percent of lifetime cash wages will purchase a DB pension with a replacement rate of 38 percent. But the table shows that this worker would receive equal lifetime utility from a boost in cash compensation worth 39 percent *less* than the pension plan's cost. In other words, unless the labor market and taxation effects of paying a DB pension are worth 39 percent of the pension cost, it is an expensive proposition to pay the worker such a DB pension. Workers of the same age but with less education value a DB plan only slightly more: the welfare loss is 27 percent of the cost of the pension for those with a high school education, and 26 percent for those with no high school education.

It is of interest that, under Model 2, the loss from a DC plan is lower than for a DB plan for some individuals but not others, such that college-educated individuals have a lower loss (15 percent for a plan invested all in equities) than the less educated (22 percent for the same portfolio). It is also worth noting that the value of a DB plan is relatively higher for low-educated workers than for highly educated, particularly for those entering the firm at older ages. We also find that mandatory annuitization under the DC plan reduces the welfare loss of DC pension arrangements by roughly 7 percent, comparing Model 2 with the voluntary annuitization results for Model 3. This result may overstate the appeal of annuitization to the extent that other alternatives are available (cf. Yaari 1965).

The impact of mandatory investment policy in the DC plan on welfare losses is much smaller than some may have anticipated: for instance, the welfare loss grows by only about 10 percent of the pension cost, when the investment strategy changes from 30 percent to 100 percent equities. The reason is that the investment strategy is only important while workers are liquidity-constrained. Once they have amassed sufficient assets outside the pension plan, they can alter the investment mix of those other assets to achieve any desired overall asset allocation.

We now examine the results for a worker aged 40, with 25 years until retirement. Here the DB pension plan imparts a lower welfare loss than before, because wage uncertainty for older workers is lower due to the fact that fewer years remain until retirement. In addition, because they are nearer to retirement, the liquidity constraint associated with forced saving in pensions is not as binding because these workers are starting to anticipate retirement and increase their savings. The DB plan is still less favorable for college-educated workers than for other types of workers, for the reasons discussed. For DC pensions, the welfare loss is smaller for older workers because the natural propensity to save of workers increases with age. Therefore the forced savings aspect of DC pensions is smaller, and the illiquidity of the DC pension wealth is less of a factor. In addition, the DC investment strategy has a much smaller effect on wellbeing, because of the fact that with higher savings, the range of achievable overall investment strategies is greater despite the pension investment restrictions. Differences between subjective valuations of the DC pension by different classes of worker are surprisingly large. This may be due to the different age-wage profiles of the different classes of worker or the different pattern for wage shock variance and persistence.

By age 50, the welfare loss associated with the DB plan is less than that associated with the DC plan, for low-educated workers. This is due to the effect of declining human capital and increasing financial capital on the valuation of DB pension plans, as discussed above. The welfare loss of DC pension falls due to the fact that most workers at age 50 are saving for their retirement which looms near, at age 65. There is now almost no difference between the welfare losses of DC pensions with very different investment strategies, as most individuals are saving enough to ensure that they are able to achieve their optimal desired overall asset allocation. Once again, there are surprisingly large differences between workers of different types.

Implications and Conclusions

Though many forms of pensions have been tried in the marketplace to date, it is fair to say that the pension environment is in flux around the world. Much work remains to design pension systems that best meet employee needs as well as employer objectives. This chapter draws together the literature on pension compensation and optimal portfolio choice to seek solutions to the 'pension design' problem.

Inasmuch as pension schemes are an element of employee compensation, we propose that pension design must be evaluated in terms of how well any given plan format fits into the objectives set for employee compensation more generally. Our financial economics approach to pension design recognizes the fact that compensation arrangements can have very distinct impacts on employees covered by these plans. In particular, pension contracts alter workers' risk exposures and the allocation of compensation over the life cycle. As a result, having a pension, changes the value that an employee would ascribe to different pension and compensation arrangements.

Our results suggest that DB pension arrangements magnify the risk exposure of an individual to salary risk, and both DC and DB pension arrangement defer the pay of younger workers to later in their lives. Younger workers therefore value cash more highly, and DC plans in particular, because they have immediate cash needs. In contrast, DB pensions may be a cost-effective method of compensation for older, less well-educated employees. We also conclude that promising workers a stake in an underfunded pension plan is an expensive way to pay employees, particularly if the underfunding has no positive impact on effort. Of course, giving workers 401(k) plans holding restricted company stock is also an expensive way to remunerate employees, because they are already heavily exposed to company risk.

Our results also imply that a hybrid scheme might be designed to better suit both types of employees. Such a plan would have workers beginning their careers with a DC pension heavily invested in bonds, and then later they would switch to a fully-funded DB scheme; this would likely be a cost-effective way of remunerating employees. Several factors which have not yet been incorporated in our model strengthen this conclusion. The first has to do with job turnover, which makes DB plans riskier for younger employees because of the fact that most vested DB pensions in the US are not indexed to inflation after workers terminate. This exposes individuals to inflation risk in their DB pensions and imposes a pension capital loss on these workers. Awareness of such risk would further reduce the attractiveness of DB plans for younger employees.[10] Also if employees find it is costly to make pension investment decisions, having the employer select a DC investment strategy would benefit the employees while imposing few costs on those workers able to adjust their own portfolios to compensate for the imposed pension investment mix. An alternative design might be a form of fully matched cash balance plan for younger workers, which changes to an explicit salary link for older workers.

We must note that our model here does not include taxes, which prevents us from inferring the overall level of pension generosity relative to cash wages. Poterba (2004) computes the value of the current tax shield accorded to US retirement accounts, and he finds that in the case of fixed-income assets, the tax shield is not very large unless very long time horizons are used (and even then only for workers with high marginal tax rates and high interest rates). For equity investments, the tax protection of pensions is significantly lower in all cases. While the tax effects might have been larger in the past, currently the tax effects appear small, implying that the labor market effects of pensions—and especially DB pensions—would have to be substantial, to justify their use as a compensation tool for younger workers.

Future work will extend our analysis of optimal pension design. We anticipate including worker preferences more explicitly within this framework to derive optimal pension compensation strategies for workers of different types, who are engaged at firms having varying attitudes toward risk. A further area needing more work in the financial economics context is the corporate finance aspect of pensions. That is, different pension strategies impose different risks on employers, which should be acknowledged in the modeling approach. We also expect to evaluate the sensitivity of results to assumptions regarding worker responses to pension incentives, and we hope to test model predictions using firm-level pension data.

Endnotes

1. This is a simple model of the labor market which ignores issues such as transactions costs, skills specificity, on-the-job training, customs, indenture premia, differences in risk aversion between firms and employees, asymmetric information and incentives, all of which may have implications for pensions. Bulow (1982) presents an early discussion of labor markets and pensions from a financial point of view.
2. Lazear (1979) discussion of wage-tilt and tenure, and Ippolito (1997) covers the compensation aspects of DC pensions.
3. Allen et al. (1993) and Ippolito (1997) discuss pensions and sorting.
4. Of course, some firms may be more risk averse than others: for instance, the attitude to risk of a small family-owned business is likely to be very different to that of a publicly traded multinational company.
5. This abstracts from the fact that 401(k) contributions are subject to social security payroll tax.
6. See Oyer and Schaefer (2004) for an empirical investigation of why employers pay employees with stock options.
7. Euler equations are derived in McCarthy (2003).
8. The model was checked by solving the same equation numerically, and the results were found to agree with the analytical results to the degree of precision reported in the tables.
9. It should be noted that further assumptions are required to interpret the results as speaking to the efficiency of different pension formats. If pensions have no labor market effects, and the firm is risk neutral or can hedge all pension-related risks (such as wage changes and mortality changes) perfectly, then the results may be interpreted as informative about the efficiency of pension compensation from the firm's point of view. The results can also be used to assess how large the labor market effects of pensions need to be, to make them an efficient compensation strategy.

10. Of course, if the presence of a DB pension plan had significant effects on the turnover of younger employees, this higher cost might be offset by lower recruitment and training costs.

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