Defined Benefit vs. Defined Contribution
Optimal Employee and Employer Retirement Plan Choice

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Paul Childs and Steven Ott gratefully acknowledge the funding received for this project from the TIAA-CREF Institute.

Abstract

When choosing among employment options, employees must consider the impact of their choice on total compensation: current and future salary earnings and retirement plan benefits. Employers offering retirement plans must decide whether to offer the employee the ability to participate in an employer sponsored defined contribution (DC) or defined benefit (DB) plan, or in some cases, both. The employer's decision on type of plan(s) and plan design will affect not only the salary needed to attract an employee, but also the expected tenure of the employee. In turn, employee tenure affects the level of employer hiring costs incurred to replace employees as they exercise of their option to switch employers. To address these interrelated issues, we solve the problems of optimal employee and employer plan choice in two stages. First, using a real options framework, we construct a dynamic programming model that determines the expected present value of the employee's lifetime earnings and plan benefits under varied current and competitive employer plan offerings. To take into account the employee's option to switch employers in the future, we use correlated diffusion processes to model the employee's current salary and an alternative employer's salary that can be earned by the employee exercising their option to switch. The optimal exercise of the employment switching option is affected by salary, retirement plan and years of service and is endogenously determined within the model. In the second stage modeling, we use the endogenous employee switch boundary determined from the first stage in a simulation to determine the employer's expected salary, benefit and hiring costs under either a DB or DC plan with varied plan design characteristics and competitive employer plan offerings. In our model, employers with DB plans have to offer employees higher salaries to compensate them for decreased value of the switching option. This higher compensation value tends to dominate the hiring cost savings that DB plans afford by helping retain employees. Numerical comparative statics are completed to show how retirement plan type, plan design, and employee characteristics affect the optimal plan choice by both employees and employers. In the majority of circumstances, DC plans are superior for both the employer and the employee which is consistent with the increased preference and prevalence of DC plans observed in practice.

1 Introduction

Pension plans offered by U.S. employers generally are either defined benefit (DB) plans or defined contribution (DC) plans. DB plans pay a life annuity to retired employees. The size of the fixed annuity payment is determined at employee retirement and typically depends on the employee's retirement age, years of service, and average salary over the previous several years. It is the employer's responsibility to make sure that sufficient funds are available to pay the pension benefits.[1] In a DC plan, an employer makes regular payments to an employee's retirement account such as a 401(k), a 403(b) or a Section 457 account. The individual has the choice as to how to invest the funds among the available stocks, bonds or other investment choices. The pension funds available to the employee at retirement are the accumulated value of the plan account.[2] Employers must decide whether to offer the employee the ability to participate in a DC or a DB plan, or in some cases, both.[3,4] The expected cost of the plan is affected by factors including vesting requirements and employee retention incentives.

Vesting schedules tend to be very different for DB plans than for DC plans. In DC plans, employee contributions vest immediately, and employer contributions usually vest either immediately, or after a wait of one year (a few require vesting periods of up to 5 years). The schedule for DB plan vesting tends to be much lengthier. Under the Employee Retirement Income Security Act (ERISA), private sector DB plans were allowed to offer employees cliff vesting after 5 years of service, and this was the typical vesting schedule. The Economic Growth and Tax Relief Reconciliation Act in 2001 mandated a vesting schedule of one-third after two years, two-thirds after four years, and full vesting after six years.[5] In the public

[1] Most DB plans are also guaranteed by the government through the Pension Benefit Guaranty Corporation.

[2] Note that a DC plan employee that prefers a life annuity benefit could take some or all of the DC plan account balance and buy a life annuity.

[3] In the private sector, employers offering pension coverage generally feature one type of plan only. In the public sector, many university employers and an increasing number of state and local governments offer employees the choice to participate in either a DB or a DC plan.

[4] This choice most often occurs at initial employment; however, some employers have provided current employees with the ability to change their initial decision and switch plans. The state of Florida may serve as a model for state and local governments around the country in this regard. In Florida, new employees will soon be offered a choice of plans. Current employees will be offered the option to switch from the existing DB plan to the new DC plan, with an option to switch back to the DB plan at a later date.

[5] Employees hired before 2002, however, are still subject to the old rules.

sector, ERISA does not apply and employers can and do offer less generous vesting. Just under half of state and local government employers offer vesting after 5 years, with a similar percentage offering vesting only after 10 years of service. These vesting requirements are so strict that a significant fraction of state and local government employees never earn any pension rights. In the state of Florida, for example, over two-thirds of the covered workers in the state DB plan who terminate employment leave prior to vesting (Trager, Francis, and SigRist (2001)).

An employee contemplating a move to another employer must consider the effect that switching has on future retirement benefits. While DC plans tend to be extremely portable, DB plans have characteristics that lessen employee mobility; thus, DB plans are more likely to retain employees. Vesting can be a strong deterrent to an employee that is considering changing employers. Even when a departing employee is fully vested, the salary at departure is used to calculate the retirement benefits. Thus, the value of the benefits are particularly susceptible to the damaging effects of inflation. While on the surface, increased employee retention appears to be an advantage, it comes at a cost. From an employer perspective, DB pensions are increasingly seen as a barrier to recruitment as employees consider the connection between their tenure with an employer, the benefits they can expect to receive and the effect of portability of DB plans on the decision to switch jobs.

There has been a dramatic change in pension coverage over the last twenty years, particularly in the private sector. In 1983, one year after 401(k) accounts were introduced, 40 percent of workers with pension coverage had a DB plan only, while 45 percent had a DB and a DC plan and only 15 percent had a DC plan (Friedberg and Owyang (2001)). And for those workers who had both a DB and a DC plan, the DB plan was in most cases the primary pension and the DC plan was a supplemental plan. By 1998 the situation had changed dramatically, with 59 percent having a DC plan only, while 20 percent had a DB plan and 20 percent had both. In addition, the number of DB plans has been falling as existing plans are closed and essentially no new plans are opened. By contrast, the number of DC plans has grown rapidly in the last two decades (Mitchell and Schieber (1998)). According to Salisbury (2000), in 1985 there were approximately 170,000 DB plans, but by 1999 this number had

fallen to 42,000.[6] The number of DC plans grew from approximately 460,000 in 1985 to 700,000 in 1999.[7] Workers' perceived preference for DC plans and their inherent portability may be reasons motivating a transition to DC plans in both the private and public sectors.

The transition between DB and DC plans has been examined by Fore (2001), who analyzed the circumstances under which DB plan participants would receive higher retirement income by switching to a DC plan. The analysis was done in a static framework, however, and considered the transition at only a few discrete points in an employee's career. Samwich and Skinner (2004) also examine the adequacy of DC plans relative to DB plans by simulating employees' benefit distributions under each type of plan, but without consideration of optimal employee plan choice or accounting for employee job and pension plan changes over time. This paper analyzes the problem of optimal employee pension plan choice in a dynamic framework, with explicit reference to the set of choice variables and employment options that employees confront over their lifetime. Additionally, we use the results from our employee choice model to examine the interrelated problem of optimal employer plan choice to minimize the costs of employee compensation and hiring.

To address the issues of employee and employer plan choice, we solve these problems in two stages. First, to address the problem of optimal employee choice of plans, this paper uses a real options framework to construct a dynamic programming model that determines the expected present value of the employee's lifetime earnings and plan benefits under varied current and competitive employer plan offerings. To take into account the employee's option to switch employment–and potentially switch plan types–we model both the employee's current salary and a best alternative salary that can be earned only by exercising the option to switch employers. We specifically recognize that prospective employees, when choosing among employment options, form rational expectations about job tenure, mortality, and

[6]The DB plan breakdown in 1985 was 167,911 single-employer and 2,261 multi-employer plans. In 1999 there were 40,000 single-employer and 1,800 multi-employer plans. For DC plans the breakdown in 1985 was 461,158 single-employer and 805 multi-employer plans. In 1999 there were 700,000 single-employer and 1,500 multi-employer plans.

[7]DB plans tend to be associated with larger employers, however, and so have more participants per plan (and a much higher percentage of annuitants), which explains why 40 percent of workers with pension coverage have DB plans, despite the large difference in plan numbers. This also explains why total assets in DB and DC plans are roughly equal, although assets in DC plans are growing at a much faster rate (Yakoboski (2000)).

eventual pension benefits, among other factors. The decision matrix varies with the worker's age. For example, younger workers, in particular, who often have most of their assets in the form of human capital, can be expected to switch employers multiple times over the course of their careers. Because a retirement plan's benefits are sometimes based in part on years of service with an employer, the model accounts for the fact that employees, when considering switching employers, determine the effect of their switch on their expected benefits from a pension plan in which they are currently participating. The decision to switch employment is path dependent because past decisions affect current decisions. For example, a DB plan's retirement benefits are based in part on years of service with an employer, and hence are affected by previous decisions to switch jobs. With a finite horizon that ends with an employee's anticipated retirement date, an employee may exercise the employment switch option at any time. Cognizant of and explicitly modeling these issues, the exercise of the employment switch option is endogenously determined within the employee model.

Based on the numerical results, the employee's optimal choice of plan and the expected present value of salary and benefits are influenced by a number of factors. We find that DB plans are preferred: when the employee can not, or is not likely to switch employers (i.e., for scenarios where the option to switch employers is unavailable or is not valuable); when the probability of exogenous (employer determined) job termination is low; when the employee is older; when a DB plan choice is available upon switch; when the required rate of return on employee labor capital is low; or, when the annual DB accrual rate is high. DC plans are preferred: when there is a valuable option to switch employment in the future; when there is a reasonable probability of switching employers due to exogenous (employer chosen) termination; the annual employer DC contribution rate is high; or, when the required rate of return on employee labor capital is high. We find that type of DB plan vesting schemes matter only for older employees, and that the shape of the term structure, the level of job switching costs and varying the level of salary growth rates over time have little effect on plan choice.

The employers decision on the type and design of retirement plan to offer and the employees decisions are interrelated. The employer's plan, in conjunction with competitive employer plans, will affect not only the compensation (salary and retirement plan benefits)

needed to attract an employee, but also the expected tenure of the employee with the firm. As a result, employer plan choice also has an effect on the level of expected hiring costs (rehiring, training and search costs) to be incurred when an employee leaves. In the second stage model of the employers decision, we use the endogenous employee switch boundary determined from the first stage model to simulate the expected employer salary, benefit and hiring costs under varied employer (both current and competitive) plan choices and plan design characteristics.

For employers, we find that DC plans are preferred: when the costs of hiring new employees are lower; where the employee is young to middle-aged; when probabilities of termination by the employer are higher; and when there are high level of employee incurred job switching costs. Employers will prefer DB plans: when there are high levels of hiring costs upon employee termination; when they have older employees; and, when employees are not subject to high probabilities of employer determined termination.

In assessing the overall results from both of these models we can conclude that DC plans are, in the majority of circumstances, preferred by both the employer and the employee. We find that the expected tenure of the employee will increase with a DB plan and that this increased tenure can significantly reduce the employer's hiring costs. However, a DB plan that tends to retain employees also significantly reduces the switching option value of the employee, and hence employers must pay a higher annual salary to attract that employee. The lower hiring costs of DB plans tend to be more than offset by the higher salary costs. Since today's employees expect to switch jobs during their career more often than employees entering the market decades ago, we also can explain the increased preference and prevalence of DC plans over time.

The structure of this paper is as follows. Section 2 presents and analyzes the employee choice model. Section 3 uses the optimal switching behavior of employees and analyzes the employer plan choice model. Section 4 concludes.

2 The Employee's Model

2.1 Employee Model Description

We first examine the problem of an employee that has two employment alternatives. Each potential employer offers a salary and a benefit plan. In making the employment decision, the employee has a valuable option to switch employers (and move to a better salary or benefit plan) in the future. We use a real options framework to construct a dynamic programming model that determines the present value of the employee's expected earnings and plan benefits (less any switching costs) given that at all points in time, the employee makes optimal employment decisions.

Assume that an employee initially starts with an employer. We model both the employee's current salary, and a best alternative salary that can be earned if the employee switches employers. The current and alternative salaries will be modeled as separate, but possibly correlated diffusion processes. The evolution of the risk-adjusted salary of the initial employer, S_1, and the alternative employer, S_2, follow geometric Brownian motion:[8]

$$dS_i = (\alpha_i - \lambda_i \sigma_i)\, S_i\, dt + \sigma_i S_i\, dZ_i, \qquad \text{for } i = 1, 2 \tag{1}$$

where the drift rates, α_i, and volatility rates, σ_i, are constants. The market price of risk parameter, λ_i, is also constant. dZ_1 and dZ_2 are the increments of correlated standard Wiener processes with $dZ_1 dZ_2 = \rho dt$.

Our setting is homogeneous of degree one with respect compensation for each stochastic salary variable. This means that we can divide by the current salary variable and transform the problem from one involving two stochastic variables (the two salary levels) to one involving a single stochastic variable (the ratio of the two salaries).[9] We build a trinomial

[8]Note that if an employee switches employment to earn the alternative salary, the current salary amount then becomes the alternative, i.e., the employee can switch back and forth to either salary level.

[9]The choice of plan and the benefits accrued from a plan are affected by the employee's option to switch employment. In an option framework, Margrabe (1978) first analyzed, utilizing homogeneity to value an exchange option, the topic of choice between two risky assets. In this approach, the option to exchange asset one for asset two is a call option on asset two with an exercise price equal to the value of asset one. In this case where there is an option to switch employers, it represents a call option on the compensation of the alternative employer with an exercise price of the compensation of the current employer. Bacinello (2000)) and Sherris (1995) apply this methodology to value the ability to choose the "greater of benefit" in

tree structure to obtain numerical solutions of the model (see Hull and White (1990), Hull and White (1994) and Boyle (1986)). The world is discretized so that a finite set of values is possible for the stochastic variable. The set of possible values is centered around the initial value and other values take the form of the initial value times a multiplier. From any node, the tree can branch to only three other nodes-a node with the same ratio value, a node with a higher ratio value and a node with a lower ratio value. Given these node values, the up, over and down probabilities for the three branches of the trinomial sub-trees are set so that the drift and variance of the tree matches the drift and variance of the ratio variable (see Boyle (1986)).[10]

2.1.1 The Terminal Boundary Conditions

In determining the values in the tree, we start with the terminal date. The terminal boundary conditions are determined at the employee's retirement age, which is assumed to be at age 65. At the terminal date, T, the present value of any future salary is zero. If an employee is currently in a DC plan, no further contributions will be made; thus, the present value of the future DC benefits is also zero.[11] If the employee is currently participating in a DB plan, the present value of the benefits is calculated as the present value of a life annuity with the annuity payment determined as follows:

$$P_i^{DB}(S_i(T), Y) = S_i(T) \cdot Y \cdot A \cdot V(Y) \tag{2}$$

where $S_i(T)$ is the per period salary earned from employer i at the terminal date T, Y is the number of years of service that the employee has accrued with the current employer, A is the annual percentage accrual rate for the DB plan, and $V(Y)$ is the vesting percentage, which is a function of the accrued years of service.[12] The present value of the life annuity is based

alternative pension plans at retirement. We build upon this literature to model and value the options to choose plans and switch employers.

[10]See Childs and Triantis (1999) and Childs, Mauer, and Ott (2004) for a more detailed discussion of a similar numerical procedures.

[11]DC contributions are valued as they are received and vested by the employee.

[12]In most plans, the DB annuity is based not only on the salary level at the time of departure, but the average salary over the last few years prior to departure. We base the annuity solely on the final salary to avoid the path-dependency (tractability) issue raised when using the average salary over a number of years.

upon standard annuity valuation calculations and is a function of the payment amount (as defined in Equation 2), the risk-free discount rate and life expectancy probabilities.[13]

2.1.2 Determining Values Recursively

Working backwards through the tree from the terminal date, the sum of the expected present value of future salary plus benefits is determined at each node under each of the following scenarios: the employee stays with the current employer and current plan choice (either a DB or DC plan); the employee switches to the alternative employer and chooses a DC plan if available; and the employee switches to the alternative employer and chooses a DB plan if available. These cases are summarized below.

If the employee stays with the current employer, the present value of the expected future salary, $VS_i^j\left(S_1(t), S_2(t)\right)$, is,

$$VS_i^j\left(S_1(t), S_2(t)\right) = S_i(t) + e^{-r\Delta t}E\left(VS_i^j\left(S_1(t+\Delta t), S_2(t+\Delta t)\right)\right) \tag{3}$$

where r is the continuous risk-free interest rate, $i = 1, 2$ (for employer 1 or 2), and $j = DB$ for a defined benefit plan or $j = DC$ for a defined contribution plan. Note that all expectation calculations take into account not only uncertainty in salary, but also uncertainty in life expectancy.[14]

The present value of expected plan benefits for an employee currently participating in a DC plan (Equation 4) or a DB plan (Equation 5) is,

$$VB_i^{DC}\left(S_1(t), S_2(t)\right) = S_i(t)DCR_i + e^{-r\Delta t}E\left(VB_i^{DC}\left(S_1(t+\Delta t), S_2(t+\Delta t)\right)\right) \tag{4}$$

$$VB_i^{DB}\left(S_1(t), S_2(t), Y\right) = e^{-r\Delta t}E\left(VB_i^{DB}\left(S_1(t+\Delta t), S_2(t+\Delta t), Y+\Delta t\right)\right) \tag{5}$$

where DCR_i is the defined contribution percentage rate contributed by employer i on behalf of the employee.

[13] Life expectancy probabilities are based on a merged gender mortality table for cohorts born between 1935 and 1975, using data on population mortality from the Office of the Actuary of the Social Security Administration.

[14] The expected values assume that upon death, the employee accrues no further salary and defined contributions, and that any defined benefits that have accrued are lost.

If the employee switches to the alternative employer, the present value of the expected future salary is,

$$VS_1^j\left(S_1(t),S_2(t)\right)=S_1(t)(1-C_s)+e^{-r\Delta t}E\left(VS_1^j\left(S_1(t+\Delta t),S_2(t+\Delta t)\right)\right) \tag{6}$$

where C_s represents the transactions costs of switching employers expressed as a percentage of the employee's current salary. A similar expression holds if the employee switches from employer 2 to employer 1. We will omit the valuation equations moving from employer 2 to employer 1 because they are so similar the given equations.

If the employee is currently in a DC plan and switches to the alternative employer and chooses a DC plan (Equation 7) or a DB plan (Equation 8), the present value of the current and expected future benefit is,

$$\begin{aligned} VB_1^{DC}\left(S_1(t),S_2(t)\right) &= S_1(t)DCR_1+e^{-r\Delta t}E\left(VB_2^{DC}\left(S_1(t+\Delta t),S_2(t+\Delta t)\right)\right) & (7)\\ VB_1^{DC}\left(S_1(t),S_2(t)\right) &= S_1(t)DCR_1+e^{-r\Delta t}E\left(VB_2^{DB}\left(S_1(t+\Delta t),S_2(t+\Delta t),0\right)\right) & (8)\end{aligned}$$

Equation 8 reflects the condition that if the employee switches to the new employer and chooses a DB plan, for vesting and benefit purposes they will start with zero years of service in the new plan.

If the employee is currently in a DB plan and switches to the alternative employer and chooses a DB plan (Equation 9) or a DC plan (Equation 10), the present value of the current and expected future benefit is,

$$\begin{aligned} VB_1^{DB}\left(S_1(t),S_2(t),Y\right) &= PVLA_{65}\left(P_1^{DB}(S_1(t),Y)\right)\\ &\quad +e^{-r\Delta t}E\left(VB_2^{DB}\left(S_1(t+\Delta t),S_2(t+\Delta t),0\right)\right) & (9)\\ VB_1^{DB}\left(S_1(t),S_2(t),Y\right) &= PVLA_{65}\left(P_1^{DB}(S_1(t),Y)\right)\\ &\quad +e^{-r\Delta t}E\left(VB_2^{DC}\left(S_1(t+\Delta t),S_2(t+\Delta t)\right)\right) & (10)\end{aligned}$$

When the employee is currently in a defined benefit plan and switches, the value of the benefit is the sum of the accrued benefits from the previous plan and the expected benefits

from the new plan (or series of plans). The present value of accrued benefits from the previous plan are calculated as a life annuity to be received beginning at age 65, denoted as $PVLA_{65}\left(P_1^{DB}(S_1(t), Y)\right)$, with the payment amount based on Equation 2.

In our model framework, the payoffs for the defined benefit plan are path dependent. Specifically, the value of the accrued defined benefit annuity is a function of the number of years of service that have accrued with a particular employer. The years of service path dependency are handled in the dynamic program by calculating a vector of variables at each node. For example, at the terminal date (and assuming a maximum 40 years of service with one employer), the program does one calculation assuming 40 continuous years of service with the existing employer (and plan), another assuming 39 years of continuous service, and so on, down to 0 continuous years of service. That is, at each node, values must be calculated for all potential number of years of service. As you work backward through the tree, the number of calculations at every node shrinks. For example, at the intermediate date of the tree, values for only up to 20 years of service are necessary.

2.1.3 Determining the Optimal Decision at Each Node

The value of the total compensation package at any given $(S_1(t), S_2(t))$ node is the maximum of the compensation of the available employment choices. For an employee currently with a defined contribution plan, the total compensation value is the best of as many as three alternatives: i) stay with the current employer, ii) switch to a new employer and choose a defined contribution plan if available, or iii) switch to a new employer and choose a defined benefit plan if available. That is,[15]

$$V_1^{DC}(S_1(t), S_2(t)) = max \begin{bmatrix} VS_1^{DC}(S_1(t), S_2(t)) + VB_1^{DC}(S_1(t), S_2(t)) \\ VS_2^{DC}(S_1(t), S_2(t)) + VB_2^{DC}(S_1(t), S_2(t)) \\ VS_2^{DB}(S_1(t), S_2(t), 0) + VB_2^{DB}(S_1(t), S_2(t), 0) \end{bmatrix} \tag{11}$$

[15] Again note that for convenience we have referenced the current employer as employer 1. Equation 11 holds in symmetry with employer 2 as the current employer and employer 1 as the alternative.

Similarly, the value of the total compensation package for an employee currently in a defined benefit plan is,

$$V_1^{DB}(S_1(t), S_2(t), Y) = max \begin{bmatrix} VS_1^{DB}(S_1(t), S_2(t), Y) + VB_1^{DB}(S_1(t), S_2(t), Y) \\ VS_2^{DC}(S_1(t), S_2(t)) + VB_2^{DC}(S_1(t), S_2(t)) \\ VS_2^{DB}(S_1(t), S_2(t), 0) + VB_2^{DB}(S_1(t), S_2(t), 0) \end{bmatrix} \quad (12)$$

Finally, the model takes into account, through the calculation of the expectation at each node, exogenous job termination and mortality probabilities that are a function of employee age.[16] At any point $(S_1(t), S_2(t))$, it is assumed that the employee can be terminated. Upon termination, the value at the node becomes the maximum of the choices restricted to those from alternative employers.

2.2 Analysis of the Employee's Model

For the numerical analysis of optimal plan choice, we start with the set of base-case inputs that are listed in Table 1. Later in the analysis, we provide the results of simulations that vary the levels of these base-case input parameters.

We assume that the employee has an anticipated retirement age of 65. The initial salary for the current employer is the numeraire. Salary growth rates are directly related to both employee age and the risk-free rate, and we assume that employee salaries grow faster than the risk-free rate for younger employees, with the rate of growth slowing as the employee gets older. The assumption about the age-earnings profile is based on the evidence that younger workers accumulate firm-specific human capital at a faster rate (Topel (1991), Murphy and Welch (1990), Cocco, Gomes, and Maenhout (2004)). We also assume the market price of risk is zero in the base case, which is equivalent to assuming risk neutrality. Because an employee's current and alternative employment are often in related fields or industries, we assume a positive correlation of 0.5 between the salaries. The volatility of salaries is assumed to be 10% annually (Viceira (2001)).[17] Finally, should an employee decide to

[16]Source: Trager, Francis, and SigRist (2001).

[17]This value is higher than reported salary volatilities based on aggregate data from the Employment Cost Index since the index reduces the effects of idiosyncratic volatility in individual salaries. Source: Economic Report of the President, 2001. Samwich and Skinner (2004) used 13% as an estimate of volatility in their

switch employers, an assumed cost of 10% of the employee's current salary is incurred as a deadweight cost. We assume no switching costs if the employee changes employers because of exogenous employer termination, assumed to take place at a level of 3.4% probability per year.[18]

Table 1: Base Case Salary, Employee and Other Parameter Values

Initial Salary	$S_1(0) = S_2(0) = 1$
Volatility of Salaries	$\sigma_1 = \sigma_2 = 0.10$
Salary Drift Rates as a Function of Age	
Ages 25-29	$\alpha_1 = \alpha_2 = r + 3\%$
Ages 30-34	$\alpha_1 = \alpha_2 = r + 2\%$
Ages 35-39	$\alpha_1 = \alpha_2 = r + 1\%$
Ages 40-44	$\alpha_1 = \alpha_2 = r$
Ages 45-49	$\alpha_1 = \alpha_2 = r$
Ages 50-54	$\alpha_1 = \alpha_2 = r - 1\%$
Ages 55-59	$\alpha_1 = \alpha_2 = r - 2\%$
Ages 60+	$\alpha_1 = \alpha_2 = r - 3\%$
Correlation Between Salaries	$\rho = 0.5$
Retirement Age	65
Job Switching Costs	10% of current salary
Exogenous Job Displacement Probabilities	3.4% per year
Mortality Probabilities	Merged gender, cohorts born 1935-1975
Market Price of Risk	$\lambda_1 = \lambda_2 = 0$
DC Plan	
Annual Employer Contribution Rate	$DCR = 6\%$
Vesting in Employer DC Contributions	Immediate, 100%
DB Plan	
Annual Employee Accrual Rate	$A = 1.5\%$
Vesting in DB Contributions	20% per year

The base-case retirement plan parameters are based on observed plans for state and

simulations

[18]The data on job termination were derived from the Florida Retirement System (FRS), one of the largest DB plans in the United States. The FRS consists of almost 800 employers and has 600,000 active members. The termination data aggregates voluntary and involuntary termination. The mortality data used are based on cohort mortality experience and expectations for the United States population, and are merged gender. Using cohort mortality data allows for the incorporation of expectations about future improvements in mortality.

local government employers that offer DB plans (Fore (2001)), higher education institutions offering primarily DC plans (TIAA-CREF 1992 Employee Retirement and Insurance Benefits Cost Survey) and a sample of private sector employers offering DC plans (Clark and Schieber (1998)).

The results from the simulations using the base-case parameters for an employee age 25, 40 and 55 are shown in Table 2. In determining the results for the one-employer cases, it is assumed that an employee does not have an alternative employer; therefore, we assume that exogenous job termination probabilities are zero. Thus, the one-employer cases reflect employment certainty, and provide results when the employee will not leave (switch from) the current employer as a result of either exogenous termination or endogenous choice. For all scenarios, including the employment certainty case described here, it is assumed that the standard mortality probabilities apply.

For the one employer certainty case with these base case parameters, it is clear that the DB plan is optimal. For an employee of age 25, the present value of expected lifetime salaries is the same regardless of type of plan chosen (47.91), but the present value DB plan benefits is more than twice as large as the DC benefits (5.85 vs. 2.87). Similar results, but with slightly lower magnitudes, hold for an employee of age 40 and 55.[19] This demonstrates that, with these base-case parameters, DB plans are clearly optimal if the employee is certain to stay with one employer over a lifetime.[20]

Once an alternative employer and the potential for changing employment are considered, either from optimal endogenous employee choice or exogenous termination, the choice of a DB plan no longer clearly dominates. First, note for an employee of any age and plan, the present value of expected salary increases significantly from the one-employer case. This occurs because of the option to switch employers to earn higher compensation. In the case of the DC plan, the receipt of higher salaries by switching also provides additional DC plan benefits, since DC benefits are simply a fixed percentage of these higher expected salaries.

[19]Of course, the present value of salary and benefits is greatly reduced for older employees because of fewer working years remaining until retirement.

[20]If you assume that there is no endogenous switching, but there is exogenous switching, the present value of benefits decreases for the DB plan but stays the same for the DC plan. For example, a 25 year old employee, that is currently in a DB plan, does not endogenously switch employers, and moves to another DB plan employer if there is an exogenous switch, has a present value of benefits of 3.20. Thus, while the DB plan still dominates with exogenous switching only, the difference between plan values is much smaller.

Note that the option to switch is significantly more valuable than the present value of the benefits.

In the case of a DB plan, switching employers for any reason significantly reduces DB retirement plan benefits. This occurs because the retirement annuity, which is accrued from the employer from which the employee switches or is terminated, will be based on a "frozen" salary, i.e., the salary of the employee at the time of the switch. The retirement annuity accrued from a previous employer will not reflect the expected increases in salary over the employee's remaining lifetime. This is often called the DB portability problem or the "backloading of DB pension accruals" (Samwich and Skinner (2004)). Additionally, the potential for losing benefits due to DB vesting requirements exacerbates the reduction in DB benefits that occurs as a result of job switching. When switching is considered, the present value of defined benefits is reduced 39.66%, 27.65% and 15.18% for an employee age 25, 40 and 55 respectively. However in all three cases, the increase in expected salary from the ability to optimally switch employers, more than offsets the reduction in DB retirement plan benefits. Relative to the no switching or certainty (one-employer) case, for an employee age 25, the option to switch adds 14.51% to the total salary and benefits for a DC plan, and 8.56% to the salary and benefits for a DB plan.[21]

In the case of uncertainty when an option to switch is present, the age 25 employee is nearly indifferent in the choice between a DB plan and DC plan scenario (58.35 in total salary and benefits for the DB plan vs. 58.15 for the DC plan.) Mixing DC and DB plans across employers, or providing multiple plans for the employee does not materially change the total present value for the employee. Simply allowing the employee the option to switch employers adds enough value to expected future salaries so that plan choice becomes a secondary consideration.

For an employee that is currently age 40, adding the option to switch provides similar results, but with lesser magnitudes. As an employee ages, there is less time to exercise the option to switch employers over the employee's remaining working lifetime. For an employee age 40, the option to switch adds 10.63% to the total salary and benefits for a DC plan and

[21]Note that these amounts do not reflect the full incremental value of the ability to optimally switch employers, since with uncertainty, there is also expected exogenous switching (non optimal termination) included in the calculations.

Table 2: Value of the Option to Switch Employers and Plans. Percentage increases in salary, benefits and total compensation relative to the one employer case are shown in parentheses.

Employer 1	Employer 2	Employee Age 25			Employee Age 40			Employee Age 55		
		Value of Salary	**Value of Benefits**	**Total**	**Value of Salary**	**Value of Benefits**	**Total**	**Value of Salary**	**Value of Benefits**	**Total**
DC		47.91	2.87	50.78	22.45	1.35	23.79	8.61	0.52	9.12
DC	DC	54.84 (14.46%)	3.31 (15.33%)	58.15 (14.51%)	24.82 (10.56%)	1.50 (11.11%)	26.32 (10.63%)	9.09 (5.57%)	0.55 (5.77%)	9.64 (5.70%)
DC	DB	54.81 (14.40%)	3.49 (21.60%)	58.30 (14.81%)	24.80 (10.47%)	1.75 (29.63%)	26.55 (11.60%)	9.07 (5.34%)	0.78 (50.00%)	9.85 (8.00%)
Both	Both	54.82 (14.42%)	3.89 (35.54%)	58.71 (15.62%)	24.80 (10.47%)	1.94 (43.70%)	26.74 (12.40%)	9.08 (5.46%)	0.95 (82.69%)	10.03 (9.98%)
DB		47.91	5.85	53.75	22.45	2.64	25.09	8.61	1.12	9.73
DB	DB	54.82 (14.42%)	3.53 (-39.66%)	58.35 (8.56%)	24.81 (10.51%)	1.91 (-27.65%)	26.72 (6.50%)	9.08 (5.46%)	0.95 (-15.18%)	10.03 (3.08%)
DB	DC	54.81 (14.40%)	3.42 (-41.54%)	58.23 (8.33%)	24.80 (10.47%)	1.71 (-35.23%)	26.51 (5.66%)	9.06 (5.23%)	0.81 (-27.68%)	9.87 (1.44%)
Both	Both	54.82 (14.42%)	3.89 (-33.50%)	58.71 (9.23%)	24.80 (10.47%)	1.94 (-26.52%)	26.74 (6.58%)	9.08 (5.34%)	0.95 (-15.18%)	10.03 (2.98%)

6.50% to the total salary and benefits for a DB plan. For an employee age 55, the option to switch adds 5.70% to the DC total value and 3.08% to the DB total value. Again, the option provides significant value and more than offsets the decline in benefits from the DB plan. Although the gap between the DB and DC plan is reduced for older employees, the DB plan remains superior. The negatives of DB plans, namely the lack of portability and vesting requirements, become less severe for older employees since switching will occur with less frequency.

It is sometimes asserted that benefits for long-tenured workers are higher in DB plans than in DC plans. However, in studies of DB and DC plans, Samwich and Skinner (1997), and Samwich and Skinner (2004)) found that DC benefits were on average about the same as DB benefits. Given that our base-case parameters are based on empirical evidence, the fact that our simulation results also show similar compensation totals for each plan type and for employees at all ages under uncertainty is not surprising.

Figures 1A and 1B examine the effects of volatility on the salary and benefit values for a 25 year old employee. In standard option pricing results, an increase in volatility increases the value of an option. Further, option value is particularly sensitive to changes in volatility. These effects are shown in Figure 1A for the case when both employers have a DC plan. There is a direct relationship between volatility and the value of the switching option. An increase in volatility generates a rapid increase in the present value of expected salary. DC benefits are just a percentage of salaries, so the benefits also increase rapidly as volatility increases.

Figure 1B displays the effect of volatility when both employers have a DB plan. As in the DC case, the value of the present value of salary increases quickly as the value of the switching option increases. Benefits, while increasing, are substantially below the certainty case since the graphed values have a positive probability of exogenous termination. Note that the rate of increase in the benefits is smaller in Figure 1B than in Figure 1A. There are two effects that switching jobs has on benefits. First, moving to a higher paying position has a positive effect on benefits because benefits from the new DB plan will linked to the new higher salary. Second, there are negative effects on benefits since the benefits from the original employer will either be lost due to vesting or "frozen" since benefits depend on the

departing salary.

The switching option becomes less valuable as the correlation between salary variables increases, since it is less likely that an alternative employer will have significantly higher salaries than the current employee, thus reducing the potential advantage of switching employers. This is shown in Figure 2 by the indirect relationship between correlation and the present value of benefits. The cases shown in the figure are the benefits when both employers have a DC plan and when both employers have a DC plan. With the correlation = 0, as the anchor for comparison, the percentage decrease in plan benefits is shown for increasing levels of correlation. A similar relationship holds for the present value of salaries, but it is not shown.

Table 3 shows the effects of varying the job termination probability. At the lowest job switching probability, 0%, we get the pure value of the option to switch since the employee will only switch optimally (i.e., non-optimal exogenous switches no longer occur). For an employee age 25, the option to switch employers is worth \$7.97 in the DC plan only scenario (58.75 vs. 50.78) or an additional 15.70% of the total value of salary and benefits. The option to switch employers is worth \$7.52 in the DB plan only scenario (61.27 vs. 53.75) or an additional 13.99% of the total value of salary and benefits.

Table 3 also shows that as exogenous termination probabilities increase, DC plans become relatively more attractive. With 0% termination probabilities, and when each employer offers a DB plan, the total present value of salary and benefits are 61.27, while they are only 58.75 when each employer has a DC plan. Thus, for scenarios when there is less chance of exogenous switching, the DB plan is more valuable. Once the exogenous termination probabilities exceed the base case parameters of 3.4%, the employee is then better off with the DC plan alternatives. DB plans suffer in comparison because of the portability problem of the DB benefits when switching employers.

Switching costs incurred upon an endogenous switch are frictions that reduce the value of the switching option. Table 4 shows results for an employee age 25 of increasing these costs from the base case value of 10% of current salary to 100% of salary. Increased switching costs reduces the number of times that an employee will find it optimal to choose an alternative employer, and thus reduce the present value of salary and benefits by approximately 3%.

Figure 1: The Effect of Volatility

Figure A: Each Employer has a DC Plan

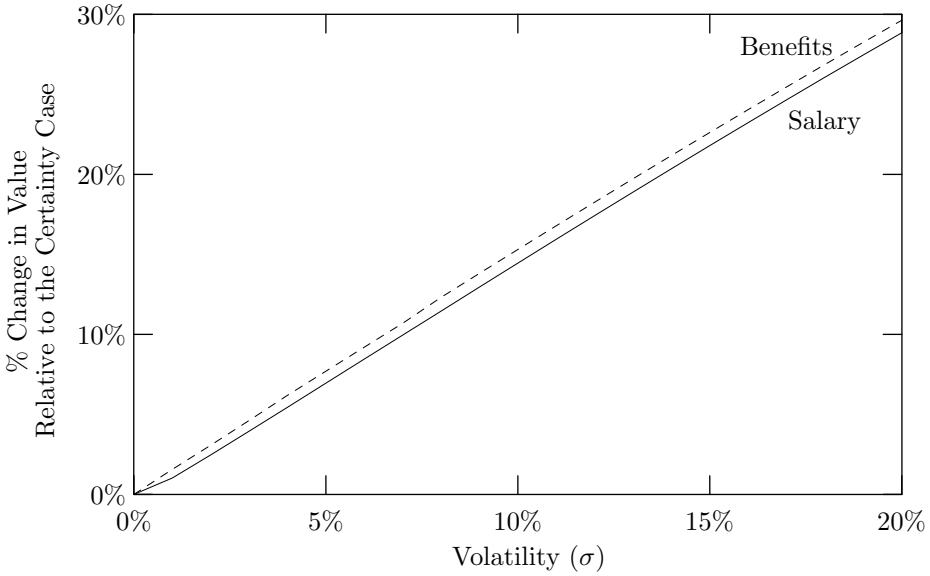


Figure B: Each Employer has a DB Plan

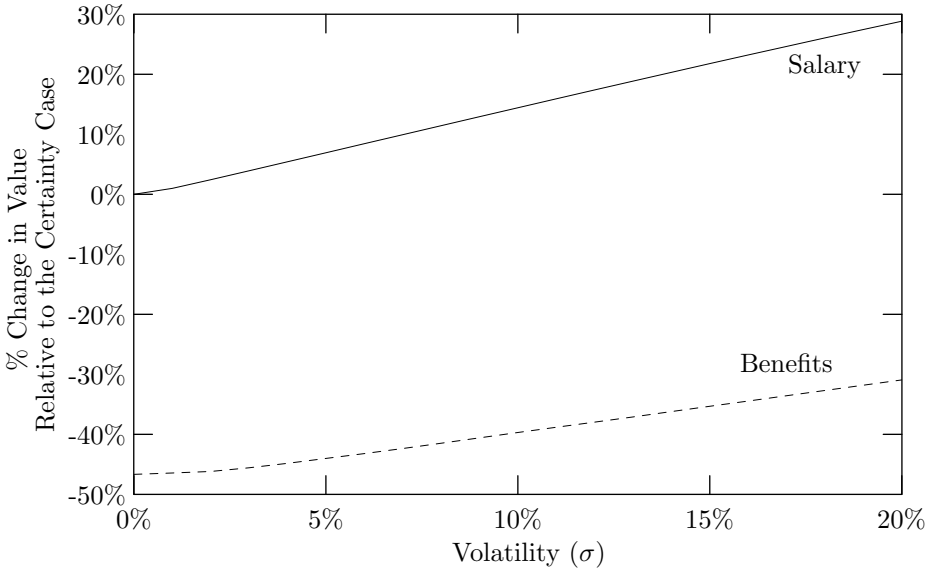
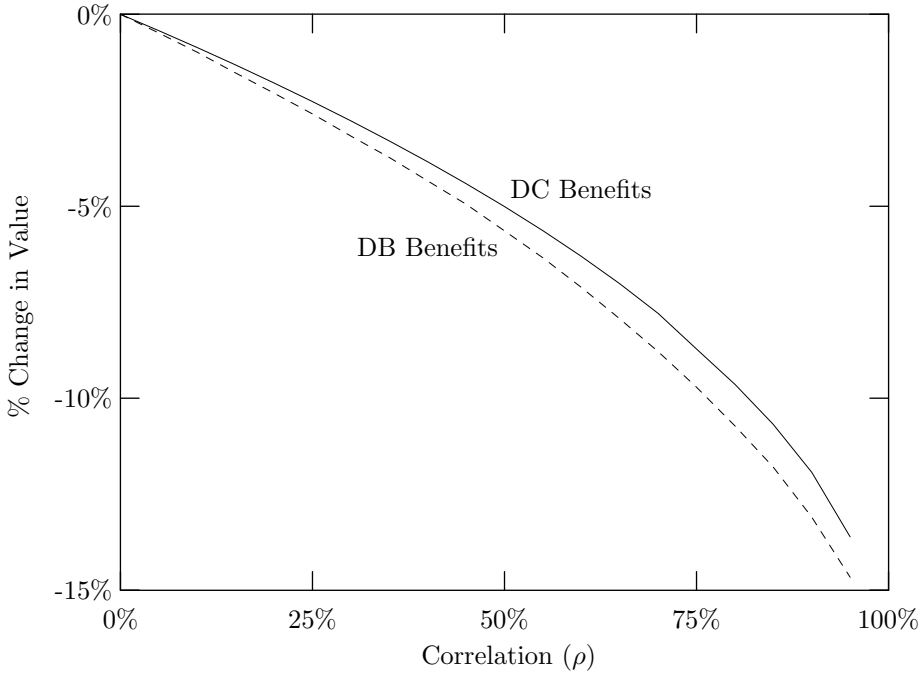


Table 3: Comparative Statics on the Exogenous Job Displacement Probabilities for an Employee Age 25. The base case exogenous job placement probability is 3.4%. Entries for each case are listed in the following order: Salary, Benefits, and Total.

Employer			Exogenous Job Placement Probabilities Per Year					
1	2		0%	1%	2%	3.4%	5%	10%
DC		PV Salary	47.91					
		PV Benefits	2.87	N/A	N/A	N/A	N/A	N/A
		Total	50.78					
DC	DC	PV Salary	55.41	55.24	55.07	54.84	54.57	53.82
		PV Benefits	3.34	3.33	3.32	3.31	3.30	3.26
		Total	58.75	58.57	58.39	58.15	57.87	57.08
DC	DB	PV Salary	55.29	55.18	55.03	54.80	54.55	53.72
		PV Benefits	4.78	4.27	3.89	3.49	3.17	2.70
		Total	60.08	59.44	58.91	58.30	57.72	56.43
Both	Both	PV Salary	55.31	55.18	55.02	54.81	54.57	53.81
		PV Benefits	5.96	5.04	4.33	3.89	3.71	3.46
		Total	61.27	60.22	59.36	58.71	58.28	57.27
DB		PV Salary	47.91					
		PV Benefits	5.85	N/A	N/A	N/A	N/A	N/A
		Total	53.75					
DB	DC	PV Salary	55.31	55.18	55.03	54.82	54.56	53.71
		PV Benefits	5.95	5.03	4.30	3.53	2.89	1.92
		Total	61.27	60.21	59.33	58.35	57.45	55.62
DB	DB	PV Salary	55.16	55.04	54.90	54.81	54.55	53.73
		PV Benefits	4.71	4.17	3.78	3.42	3.10	2.62
		Total	59.87	59.22	58.68	58.23	57.65	56.35
Both	Both	PV Salary	55.31	55.18	55.02	54.81	54.57	53.81
		PV Benefits	5.96	5.04	4.33	3.89	3.71	3.46
		Total	61.27	60.22	59.36	58.71	58.28	57.27

Figure 2: The Effect of Correlation on the Value of Plan Benefits



The reduction in option value from increased costs affect the DC plan scenario slightly more, since switches are more common in this scenario than when an employee has the choice of only a DB plan.

In Table 5 we compare across different age scenarios for the certainty (one-employer) case and report the parameter value regions where an employee would choose the DB plan employer. Employees prefer DC plan employers in the complement of the listed parameter value regions. The crossover point (if it exists) represents the indifference point, i.e., the value of the parameter at which an employee would be indifferent between the choice of a DB plan or a DC plan. Note that when there is no alternative employer, and therefore no switching option, there is no effect from volatility, correlation, or switching costs. Also, remember that for the certainty case, it is assumed that exogenous termination probabilities are zero. Since the DB benefits are not received until retirement, DB plans become less attractive with higher required rates on the the employee's labor capital (i.e., an employee's expected lifetime compensation) due to greater discounting. In the one-employer case for an employee age 25, the DC plan dominates the DB plan if the market price of risk greater than

Table 4: Comparative Statics on Job Switching Costs for an Employee Age 25. The base case job switching costs are 10%. Entries for each case are listed in the following order: Salary, Benefits, Total and the percentage change in the total relative to the base case.

Employer			Job Switching Costs		
1	2		10% of Salary	50% of Salary	100% of Salary
		PV Salary	47.91	47.91	47.91
DC		PV Benefits	2.87	2.87	2.87
		Total	50.78	50.78	50.78
		PV Salary	54.83	53.91	53.08
DC	DC	PV Benefits	3.31	3.29	3.28
		Total	58.14	57.20	56.36
		Change		-1.62%	-3.06%
		PV Salary	54.80	53.90	53.07
DC	DB	PV Benefits	3.49	3.53	3.54
		Total	58.30	57.42	56.61
		Change		-1.51%	-2.90%
		PV Salary	54.82	53.90	53.08
Both	Both	PV Benefits	3.89	3.88	3.85
		Total	58.71	57.79	56.93
		Change		-1.57%	-3.03%
		PV Salary	47.91	47.91	47.91
DC		PV Benefits	5.85	5.85	5.85
		Total	53.75	53.75	53.75
		PV Salary	54.82	53.90	53.08
DC	DC	PV Benefits	3.53	3.57	3.58
		Total	58.35	57.47	56.66
		Change		-1.51%	-2.90%
		PV Salary	54.81	53.89	53.06
DC	DB	PV Benefits	3.42	3.40	3.38
		Total	58.23	57.30	56.45
		Change		-1.60%	-3.06%
		PV Salary	54.82	53.90	53.08
Both	Both	PV Benefits	3.89	3.88	3.85
		Total	58.71	57.79	56.93
		Change		-1.57%	-3.03%

0.32. However, for an employee age 55, the DB plan dominates for all values of the market price of risk.[22] This result again shows that DB plans are attractive for older employees for a wider range of parameter values. For an employee age 25, the DB plan dominates unless the DC contribution rate exceeds 12.18% or the DB accrual rate is less that 0.74%. Similar results hold for older employees. These results reinforce the idea that a DB plan is superior for most reasonable parameter values, when it is assumed that the employee will remain with one employer over a lifetime.[23]

Table 5: Parameter Value Regions in the One Employer Case with Certainty. Entries denote the indifference parameter values and the region where the total compensation is higher for the DB Plan Employee. Employees prefer DC plan employers in the complement of the listed parameter value regions.

Base Case Parameter Value	Age 25	Age 40	Age 55
Market Price of Risk $\lambda_1 = \lambda_2 = 0$	DB Dominates for $\lambda_1 = \lambda_2 < 0.32$	DB Dominates for $\lambda_1 = \lambda_2 < 0.47$	DB dominates
DC Contribution Rate $DCR = 6\%$	DB Dominates for $DCR < 12.18\%$	DB Dominates for $DCR < 11.76\%$	DB dominates for $DCR < 13.01\%$
DB Accrual Rate $A = 1.5\%$	DB Dominates for $A > 0.74\%$	DB Dominates for $A > 0.76\%$	DB dominates for $A > 0.68\%$

In a world of uncertainty, when an option to switch exists and there is potential for exogenous termination, the DC plan becomes relatively more valuable. In Tables 6A-C, we show the results for the uncertainty cases where we compare across employee ages and exogenous displacement probabilities. For each combination, we again report the dominance regions from which the indifference point (i.e., the point at which an employee would be indifferent between the choice of a DB plan or a DC plan) can be inferred.

For an employee age 25, the DB plan is dominant for cases where the displacement

[22] A market price of risk of 0.20 is equivalent to a risk premium (added to the risk-free rate) of 2%. Doubling the market price of risk to 0.40 also doubles the risk premium. We did not do simulations for $MPR > 1$

[23] Results for the DC contribution rate and DB accrual rate are not monotonic across employee age due to the varying salary drift rates that are a function of employee age.

probability is low or the salary volatility is low.[24] This corresponds to the results of the certainty cases shown in Table 5. For increased levels of uncertainty when switching is more viable and likely, the DC plan is more valuable. The DB plan is relatively more valuable when switching costs are high since switching is less likely.[25] The DC plan becomes relatively more valuable when required rate of return on employee labor capital is higher. As the level of exogenous uncertainty increases, DC plans can offer lower contribution rates and remain competitive with DB plans. Conversely, as the level of exogenous uncertainty increases, DB plans must offer higher accrual rates to remain competitive with DC plans.[26]

Similar results occur for older employees ages 40 and 55 as are shown in Tables 6B and 6C. However, for older employees, the DB plan is the preferred plan for a wider range of parameter values. Once again this illustrates the value of a DB plan for older employees.[27]

Based on the these numerical solution results for the employee model, the optimal choice of plan and the expected present value of salary and benefits are influenced by a number of factors and we find that DB plans are preferred: when the employee can not, or is not likely to switch employers, i.e., for scenarios where the option to switch employers is unavailable or is not valuable; when the probability of exogenous job termination is low; when the employee is older; when a DB plan choice is available upon switch; when the required return on labor compensation is low; or, when the annual DB accrual rate is high. DC plans are preferred: when there is a valuable option to switch employment in the future; when there is a reasonable chance of switching employers due to exogenous termination; when the annual employer DC contribution rate is high; or, when the required return on labor compensation is high.

[24] In the simulations, we limit the volatility parameter to a maximum of 20%.

[25] We did not do simulations with switching costs in excess of 100% of salary, but there may be a level of switching costs above 100% that would reduce the value of the switching option (and the number of switches) to a point where the DB plan may be optimal. We feel that levels of switching costs above 100% are not realistic.

[26] Defined benefit accrual rates are limited to a maximum value of 4% in our comparative static simulations.

[27] We also find that DB plan vesting schemes matter only for older employees, and that the shape of the term structure, and the varying the level of salary growth rates have little effect on plan choice.

Table 6: Parameter Values Domination Regions Under Varying Levels of Exogenous Displacement Probabilities. Entries denote the parameter value region for which a given plan is optimal. For the remaining parameter values, the alternative plan dominates. The indifference point is the crossover between regions where the expected present value of salary plus benefits is equal across the two-employer/plan scenarios. If there is no indifference point, the entry will be labelled by the dominant plan, either DC or DB.

Panel A: Employee Age 25

	One Employer with A DC Plan Alternative Employer with a DB Plan			Two Employers Each with a DC and DB Plan		
Base Case	Exogenous Displacement Probabilities			Exogenous Displacement Probabilities		
Parameter Value	0%	1.7%	3.4%	0%	1.7%	3.4%
Volatility $\sigma_1 = \sigma_2 = 0.10$	DC for $\sigma_1 > 7.13\%$	DC Dominates	DC Dominates	DB Dominates	DB Dominates	DC Dominates
Correlation $\rho_1 = 0.5$	DC for $\rho < 0.74$	DC Dominates	DC Dominates	DB Dominates	DB Dominates	DC Dominates
Job Switching Costs: $JSC = 10\%$ of Salary	DC for $JSC < 1.53\%$	DC Dominates	DC Dominates	DB Dominates	DB Dominates	DC Dominates
Market Price of Risk $\lambda_1 = \lambda_2 = 0$	DC Dominates	DC Dominates	DC Dominates	DC for $\lambda_1 = \lambda_2 > 2.15\%$	DC for $\lambda_1 = \lambda_2 > 0.43\%$	DC Dominates
DC Contribution Rate $DCR = 6\%$	DC for $DCR > 5.60\%$	DC for $DCR > 3.22\%$	DC for $DCR > 1.99\%$	DC for $DCR > 9.84\%$	DC for $DCR > 6.61\%$	DC for $DCR > 4.34\%$
DB Accrual Rate $A = 1.5\%$	DC for $A < 0.87\%$	DC for $A < 1.38\%$	DC Dominates	DC for $A < 0.92\%$	DC for $A < 1.49\%$	DC for $A < 2.19\%$

Panel B: Employee Age 40

Panel B: Employee Age 40

Base Case	One Employer with A DC Plan Alternative Employer with a DB Plan			Two Employers Each with a DC and DB Plan		
	Exogenous Displacement Probabilities			Exogenous Displacement Probabilities		
Parameter Value	0%	1.7%	3.4%	0%	1.7%	3.4%
Volatility $\sigma_1 = \sigma_2 = 0.10$	DC for $\sigma_1 > 0.14$	DC for $\sigma_1 > 0.025$	DC Dominates	DB Dominates	DB Dominates	DC Dominates
Correlation $\rho_1 = 0.5$	DC for $\rho < 0.6$	DC Dominates	DC Dominates	DB Dominates	DB Dominates	DC Dominates
Job Switching Costs: $JSC = 10\%$ of Salary	DC for $JSC < 1.17\%$	DC for $JSC < 5.99\%$	DC Dominates	DB Dominates	DB Dominates	DC Dominates
Market Price of Risk $\lambda_1 = \lambda_2 = 0$	DC Dominates	DC Dominates	DC Dominates	DC for $\lambda_1 = \lambda_2 > 3.35\%$	DC for $\lambda_1 = \lambda_2 > 1.63\%$	DC Dominates
DC Contribution Rate $DCR = 6\%$	DC for $DCR > 5.87\%$	DC for $DCR > 4.35\%$	DC for $DCR > 2.61\%$	DC for $DCR > 9.58\%$	DC for $DCR > 7.54\%$	DC for $DCR > 5.91\%$
DB Accrual Rate $A = 1.5\%$	DC for $A < 0.92\%$	DC for $A < 1.18\%$	DC for $A < 2.75\%$	DC for $A < 0.94\%$	DC for $A < 1.20\%$	DC for $A < 1.50\%$

Panel C: Employee Age 55

Base Case	One Employer with A DC Plan Alternative Employer with a DB Plan			Two Employers Each with a DC and DB Plan		
	Exogenous Displacement Probabilities			Exogenous Displacement Probabilities		
Parameter Value	0%	1.7%	3.4%	0%	1.7%	3.4%
Volatility $\sigma_1 = \sigma_2 = 0.10$	DB for $\sigma_1 > 7.13\%$	DB Dominates	DB Dominates	DB Dominates	DB Dominates	DB Dominates
Correlation $\rho_1 = 0.5$	DB Dominates	DB Dominates	DB Dominates	DB Dominates	DB Dominates	DB Dominates
Job Switching Costs: $JSC = 10\%$ of Salary	DB Dominates	DB Dominates	DB Dominates	DB Dominates	DB Dominates	DB Dominates
Market Price of Risk $\lambda_1 = \lambda_2 = 0$	DC for $\lambda_1 = \lambda_2 > 6.26\%$	DC $\lambda_1 = \lambda_2 > 4.54\%$	DC $\lambda_1 = \lambda_2 > 2.81\%$	DB Dominates	DC Dominates	DC Dominates
DC Contribution Rate $DCR = 6\%$	DC for $DCR > 9.00\%$	DC for $DCR > 8.03\%$	DC for $DCR > 7.18\%$	DB Dominates	DB Dominates	DB Dominates
DB Accrual Rate $A = 1.5\%$	DC for $A < 0.81\%$	DC for $A < 0.86\%$	DC for $A < 1.25\%$	DC for $A < 0.83\%$	DC for $A < 0.88\%$	DC for $A < 0.96\%$

3 The Employer's Model

3.1 Employer Model Description

Given the employee switching behavior, employers determine which retirement plan to offer its employees. While an employee is working, the employer pays the salary and any defined contribution payments. In addition, when an employee departs, the firm commits to paying any vested defined benefits and also incurs a costly search that is necessary to hire a new employee. Overall, the employer wishes to maintain a workforce while minimizing the sum total of all salary, benefits and search costs.

We calculate expected employee tenure and the expected employer costs by using Monte Carlo simulation. We simulate N paths for the current employer salary and for the best alternative employer salary. Denote $s_1(t, n)$ to be the salary of the current employer, and $s_2(t, n)$ to be the salary of the best alternative employer at time t on path n of the simulation. The salaries follow geometric Brownian motion as described in Equation 1. We assume that the salaries are paid annually at the end of a year.

In any given year, employees either 1) retire, ii) die, iii) are terminated by the employer, iv) choose to switch jobs, or v) stay with the current employer. We assume these events occur immediately after the annual salary is paid. In each of the first four of these events, the firm incurs a cost, C_H, to search for and hire a new employee and the path is terminated. We model these alternatives in a series of steps. The order of the steps are as follows. Employees retire at age 65. Firms with defined benefits are committed to paying the appropriate life annuity (see Equation 2). For employees younger than 65, we use mortality probabilities to determine if an employee survives. Surviving employees may be terminated with an exogenous displacement probability. If the firm retains the employee, we use the switching boundary obtained from the employee model and the current and alternative employer salaries to determine whether the employee switches employers.[28] Employees that do not switch jobs stay with the firm another year.

As the simulation runs we calculate the number of paths that terminate for each of the

[28]The dynamic program of the employee's model has discrete salary states. We use interpolation between the discrete node values to approximate the continuous switching boundary used in the Monte Carlo simulation.

possible terminating events. Let $N_S(t)$ be the number of paths that terminate with the employee choosing to switch to the alternative employer at time t. Define number of paths that end at time t in death, $N_D(t)$, and employer termination, $N_T(t)$ in a similar fashion. The number of paths that terminate with employee retirement is N_R.[29] These path numbers can be used to calculate some sample probabilities. For example, the probability that an employee works until retirement with the original employer is $\frac{N_R}{N}$.

The type of retirement plan plays a role in the length of time an employee spends with a firm. We use a variety of measures to focus on the employee tenure. The expected employee tenure is the weighted average of all of the path lengths.

$$EET = \frac{TN_R + \sum_{t=1}^{T-1} t\left(N_S(t) + N_D(t) + N_T(t)\right)}{N} \tag{13}$$

This value measures the expected time until the employee departs the company for any reason (retirement, switch to the alternative employer, death or exogenous termination by the employer).

A second measure of tenure is the expected time to switch. This is calculated in a similar fashion to the expected employee tenure except that the full length paths (i.e., those paths that end in retirement) are not included in the weighted average.

$$ETTS = \frac{\sum_{t=1}^{T-1} t\left(N_S(t) + N_D(t) + N_T(t)\right)}{N - N_R} \tag{14}$$

This value measures the expected time the employee spends with the firm conditional on the fact that they depart prior to retirement.

A third measure of tenure is the expected employee switch tenure. This is the expected time that an employee spends with the firm conditional on the fact that they depart voluntarily (i.e., either retire or switch to a better paying alternative employer).

$$EEST = \frac{TN_R + \sum_{t=1}^{T-1} tN_S(t)}{N_R + \sum_{t=1}^{T-1} N_S(t)} \tag{15}$$

[29] In our model, retirement can only happen at age 65, hence there is no need for a time argument for N_R.

The costs on each path take three forms, salary, benefits and hiring costs. Denote $s(t,n)$ to be the salary cost for the employer at time t of path n. Similarly let $b(t,n)$ and $h(t,n)$ be the benefits and hiring costs. The salary cost for the employer is

$$s(t,n) = \begin{cases} S_1(t,n) & \text{If the employee works for the original employer on path } n \text{ at time } t \\ 0 & \text{otherwise} \end{cases} \tag{16}$$

The payment of benefits depends on the type of benefit plan offered. If the employer has a defined contribution plan, the benefits costs are

$$b(t,n) = \begin{cases} DCR \cdot S_1(t,n) & \text{If the employee works for the original employer on path } n \text{ at time } t \\ 0 & \text{otherwise} \end{cases} \tag{17}$$

That is, every period that the employee works for the original employer, the benefits cost is a fraction of the current salary.

If the employer has a defined benefit plan, retirement payments occur after age 65 and is based on the employee's amount of service and vested benefits. The present value of these cash flows is

$$b(t,n) = \begin{cases} PVS\left(P_1^{DB}\right) & \text{If the employee survives and leaves the original employer on path } n \text{ at time } t \\ 0 & \text{otherwise} \end{cases} \tag{18}$$

Any time that the employee leaves for any reason, the firm pays the hiring cost, C_H, calculated as a percentage of the employee's current salary to hire a new employee.

$$h(t,n) = \begin{cases} C_H & \text{If the employee leaves the original employer for any reason on path } n \text{ at time } t \\ 0 & \text{otherwise} \end{cases} \tag{19}$$

The length of the paths can be quite different depending on the reason the employee leaves. To compare costs across these differing horizons, we annuitize the values. Consider

the salary cost for example. First calculate the present value of all the salaries from all the paths

$$PV_S = \sum_{t=1}^{T} e^{-rt} \left(\sum_{n=1}^{N} s(t,n) \right) \tag{20}$$

To measure the salary costs, we calculate an equivalent annuity value. This measure is the equivalent annuity over the time of the expected employee tenure calculated in Equation 13 that has the same present value as the actual cash flows from Equation 20. A similar calculation is done for the annuitized benefits and for the annuitized hiring costs.

The annuitized costs represent the expected annual costs for salary, benefits and hiring over the expected tenure of the particular employee hired. In essence, with the additional assumption that an identical employee is hired upon any employee termination event, these costs represent the annual costs expected to be incurred over any future time period.

3.2 Analysis of the Employer's Model

For the first set of parameters, we use the base case parameters that were used in the employee model with the following additions and changes. We set all salary drift rates to be equal to the risk-free rate.[30] This allows us to accurately compare annuitized costs across cases with varied employee tenures and ages. After running these parameters through the employee model, we start the employer simulation at salary levels that represent the indifference point, which is defined as the point where the employee is indifferent between choosing the current employer or the alternative employer; therefore, the results of the simulation represent the expected cost and tenure of new employee hired in a competitive labor market. Specifically, we assume that the starting salary of employer 2 is the numeraire and adjust the starting salary of employer 1 to be equal to the indifference point. Additionally, we assume that if an employee leaves the employer, for any reason, there is an employer hiring cost of 100% of the employee's current salary.

Table 7 provides the base case simulation results for employees of ages 25, 40 and 55. It reports the per year annuitized costs for salary, benefits, and hiring, and the total of these

[30]For the employee model we had assumed that salary drift rates were a function of age.

costs. Four cases are presented for each of the employee ages: DCDC represents the case where the current employer and the alternative employer each have DC plans, DCDB case represents the case where the current employer has a DC plan and the alternative employer has a DB plan, DBDC represents the case where the current employer has a DB plan and the alternative employer has a DC plan, and DBDB represents the case where both employers have DB plans. The table also reports the probability of all types of departure and three expected tenure calculations.

For an employee age 25, if both employers have a DC plan (the DCDC case), the total annual annuitized cost of an employee is 1.3442 and the expected employee tenure is 7.2381 years. Assuming that the alternative employer continues to offer a DC plan and if the current employer decides to offer a defined benefit plan (DBDC), the expected tenure of the employee will increase to 8.4102 years, an increase of 16.19%. The increased tenure of the employee reduces the employer's hiring cost by 10.37%. However, employees take on the termination risk inherent with a DB plan due to the vesting and portability issues of DB plans. As a result employees with a DB plan expect to incur the cost of lost benefits when and if they switch employers. Given that the value of the employee's option to switch employers is reduced with a DB plan, the employee will demand a higher salary to compensate for this decrease in the switching option value. In the age 25 DB case, the employer must pay a 3.25% higher annual salary to attract the employee. The additional compensation for the lost option value means that the total costs will be higher if the firm offers a DB plan (1.3931 versus 1.3442). Unless the employer incurs high costs to hire new employees, total compensation costs are minimized with a DC plan.[31]

If the alternative employer offers a DB plan, the defined contribution plan (the DCDB case) still minimizes employer costs (1.3011 versus 1.3472). It is interesting to notice then when the current employer offers a DB plan, the expected time to switch tenure, which represents the time to a employee switch (excluding retirement) is reduced by 2.41% and 0.69%. This is because employees in DB plans will have a much greater tendency to stay a with the current employer until retirement (5.29% vs. 3.54%, a 49.12% increase in the

[31]When employer hiring costs are very high, the increased tenure that results from offering a DB plan becomes valuable enough to overcome the higher salary to the employee. Later in this section we will show the level of hiring costs at which the DB plan minimizes total costs.

Table 7: Base Case

		Annuitized Cost				Indiff.	Cumulative Probability of				Expected Employee		
		Salary	Benefits	Hiring	Total	Point	Switch	Retirement	Firing	Death	Tenure	Switch Tenure	Time to Switch
Employees Age 25	DCDC	1.1375	0.0682	0.1385	1.3442	1.0000	0.7083	0.0354	0.2442	0.0121	7.2381	5.9785	4.2758
	DBDC	1.1745	0.0945	0.1241	1.3931	1.0408	0.6480	0.0529	0.2839	0.0153	8.4102	6.8748	4.1726
	Change	3.25%	38.46%	-10.37%	3.64%		-8.52%	49.12%	16.27%	26.24%	16.19%	14.99%	-2.41%
	DCDB	1.0991	0.0657	0.1411	1.3011	0.9608	0.7285	0.0301	0.2304	0.0110	6.8218	5.6592	4.2419
	DBDB	1.1326	0.0878	0.1269	1.3472	1.0000	0.6739	0.0455	0.2668	0.0139	7.9056	6.4739	4.2125
	Change	3.50%	33.65%	-10.08%	3.55%		-7.50%	51.17%	15.81%	25.92%	15.89%	14.40%	-0.69%
Employees Age 40	DCDC	1.1202	0.0672	0.1585	0.0000	1.0000	0.6899	0.0753	0.2127	0.0221	6.3436	5.8292	3.7359
	DBDC	1.1303	0.1184	0.1331	1.3818	1.0192	0.5987	0.1161	0.2570	0.0282	7.7121	7.2603	3.8207
	Change	0.90%	76.14%	-16.03%	2.67%		-13.22%	54.10%	20.84%	27.78%	21.57%	24.55%	2.27%
	DCDB	1.0991	0.0659	0.1685	1.3336	0.9812	0.7216	0.0631	0.1958	0.0195	5.8465	5.3413	3.6230
	DBDB	1.1130	0.1121	0.1419	1.3670	1.0000	0.6392	0.0981	0.2371	0.0257	7.0886	6.5929	3.7692
	Change	1.27%	70.06%	-15.82%	2.51%		-11.42%	55.46%	21.05%	31.88%	21.25%	23.43%	4.04%
Employees Age 55	DCDC	1.0996	0.0660	0.2338	1.3994	1.0000	0.6129	0.2118	0.1393	0.0360	4.3574	4.4546	2.5387
	DBDC	1.0606	0.1381	0.1819	1.3805	0.9768	0.4556	0.3228	0.1747	0.0469	5.4959	5.8486	2.9072
	Change	-3.55%	109.28%	-22.21%	-1.35%		-25.67%	52.44%	25.41%	30.22%	26.13%	31.29%	14.51%
	DCDB	1.1170	0.0670	0.2648	1.4488	1.0237	0.6604	0.1815	0.1262	0.0318	3.9149	3.9513	2.2888
	DBDB	1.0817	0.1369	0.2037	1.4223	1.0000	0.5176	0.2826	0.1582	0.0416	4.9905	5.2103	2.5955
	Change	-3.15%	104.21%	-23.06%	-1.83%		-21.63%	55.67%	25.35%	30.68%	27.47%	31.86%	13.40%

probability of the employee retiring with the current employee).

Similar, but less dramatic results hold for 40 year old employees, i.e., DC plans are optimal and DB plans would minimize total costs only if hiring costs were more than approximately 2.5 times salary. For the 55 year old employee however, DB plans dominate in all cases (unless hiring costs are less than approximately 60% of salary). Older employees have fewer remaining working years (i.e., the maturity of the switching option is shorter), so the switching option has less value. While DB plan still significantly change the expected tenure, the change is option value is smaller. Thus, the tradeoff between option value and hiring costs starts to tilt toward the hiring cost. Age 55 employees are expected to gain higher expected benefits with a DB plan and the employer can actually offer a lower salary with a DB plan.

We now vary the parameters and run simulations to generate comparative statics. For these runs we show the results for a 40 year old employee. Table 8 Varies the DB accrual rate from 1.0% to the base case of 1.5% to 2%.[32] As the DB accrual increases, the expected tenure of the employee with a DB plan increases relative to the DC plan, but the large decrease in employer hiring costs that results is not enough to make a DB plan less costly in total for the employer. The bottom line is that increasing the DB plan accruals to keep employees even longer will reduce hiring costs but that the increased DB benefits and the feedback effect to the employee demanding a higher salary for being locked in (higher cost to switch and earn higher salaries) tends to dominate.

In Table 9 we show the results for varying exogenous displacement probabilities for a 40 year old employee. These probabilities range from 0 to the base case of 3.4% to 6.8%. When employees are secure in their positions (0% exogenous termination probability) and don't have to worry about termination risk of DB plans being imposed by the employer, then total costs with a DB plan are similar to a DC plan. On the other end of the spectrum, DB plans are much more costly with high probabilities of employer termination. In these cases employees demand much more salary and benefits due to termination risk and loss of DB benefits.

Table 10 shows the results for varying the costs an employee incurs upon making the

[32]We assume that for these comparative statics the alternative employer's accrual rate does not change.

Table 8: Vary Accrual Rates for Age 40 Employees

		Annuitized Cost				Indiff.	Cumulative Probability of				Expected Employee		
		Salary	Benefits	Hiring	Total	Point	Switch	Retirement	Firing	Death	Tenure	Switch Tenure	Time to Switch
Accrual Rate = 1%	DCDC	1.1202	0.0672	0.1585	1.3459	1.0000	0.6899	0.0753	0.2127	0.0221	6.3436	5.8292	3.7359
	DBDC	1.1496	0.0784	0.1419	1.3699	1.0343	0.6247	0.1043	0.2447	0.0264	7.3313	6.8501	3.8204
	Change	2.62%	16.71%	-10.46%	1.78%		-9.46%	38.41%	15.04%	19.77%	15.57%	17.51%	2.26%
	DCDB	1.0835	0.0650	0.1627	1.3112	0.9669	0.7139	0.0664	0.1993	0.0204	5.9697	5.4553	3.6379
	DBDB	1.1139	0.0739	0.1459	1.3337	1.0000	0.6530	0.0918	0.2304	0.0247	6.8911	6.3804	3.7622
	Change	2.80%	13.63%	-10.33%	1.71%		-8.53%	38.32%	15.61%	21.28%	15.43%	16.96%	3.42%
Accrual Rate = 1.5%	DCDC	1.1202	0.0672	0.1585	0.0000	1.0000	0.6899	0.0753	0.2127	0.0221	6.3436	5.8292	3.7359
	DBDC	1.1303	0.1184	0.1331	1.3818	1.0192	0.5987	0.1161	0.2570	0.0282	7.7121	7.2603	3.8207
	Change	0.90%	76.14%	-16.03%	2.67%		-13.22%	54.10%	20.84%	27.78%	21.57%	24.55%	2.27%
	DCDB	1.0991	0.0659	0.1685	1.3336	0.9812	0.7216	0.0631	0.1958	0.0195	5.8465	5.3413	3.6230
	DBDB	1.1130	0.1121	0.1419	1.3670	1.0000	0.6392	0.0981	0.2371	0.0257	7.0886	6.5929	3.7692
	Change	1.27%	70.06%	-15.82%	2.51%		-11.42%	55.46%	21.05%	31.88%	21.25%	23.43%	4.04%
Accrual Rate = 2%	DCDC	1.1202	0.0672	0.1585	1.3459	1.0000	0.6899	0.0753	0.2127	0.0221	6.3436	5.8292	3.7359
	DBDC	1.1120	0.1581	0.1243	1.3944	1.0058	0.5687	0.1293	0.2717	0.0304	8.1512	7.7706	3.8545
	Change	-0.73%	135.26%	-21.58%	3.61%		-17.58%	71.57%	27.73%	38.00%	28.50%	33.30%	3.17%
	DCDB	1.1136	0.0668	0.1759	1.3564	0.9942	0.7323	0.0591	0.1898	0.0188	5.6735	5.1800	3.5815
	DBDB	1.1117	0.1512	0.1381	1.4010	1.0000	0.6270	0.1038	0.2429	0.0263	7.2876	6.8053	3.7940
	Change	-0.18%	126.35%	-21.50%	3.29%		-14.38%	75.71%	27.98%	39.77%	28.45%	31.38%	5.93%

Table 9: Vary Displacement Probabilities for Age 40 Employees

		Annuitized Cost				Indiff.	Cumulative Probability of				Expected Employee		
		Salary	Benefits	Hiring	Total	Point	Switch	Retirement	Firing	Death	Tenure	Switch Tenure	Time to Switch
Disp. Prob. = 0%	DCDC	1.1327	0.0680	0.1237	1.3244	1.0000	0.7997	0.1684	0.0000	0.0318	8.1160	7.9457	4.3535
	DBDC	1.0936	0.1413	0.0890	1.3239	0.9856	0.6570	0.2954	0.0000	0.0476	11.1407	10.9766	4.6710
	Change	-3.45%	107.92%	-28.09%	-0.04%		-17.85%	75.38%		49.45%	37.27%	38.15%	7.29%
	DCDB	1.1498	0.0690	0.1387	1.3575	1.0146	0.8273	0.1443	0.0000	0.0284	7.3340	7.1726	4.0626
	DBDB	1.1153	0.1402	0.1017	1.3573	1.0000	0.7089	0.2501	0.0000	0.0410	9.8732	9.6923	4.2928
	Change	-3.00%	103.29%	-26.66%	-0.01%		-14.30%	73.28%		44.28%	34.62%	35.13%	5.67%
Disp. Prob. = 3.4 %	DCDC	1.1202	0.0672	0.1585	0.0000	1.0000	0.6899	0.0753	0.2127	0.0221	6.3436	5.8292	3.7359
	DBDC	1.1303	0.1184	0.1331	1.3818	1.0192	0.5987	0.1161	0.2570	0.0282	7.7121	7.2603	3.8207
	Change	0.90%	76.14%	-16.03%	2.67%		-13.22%	54.10%	20.84%	27.78%	21.57%	24.55%	2.27%
	DCDB	1.0991	0.0659	0.1685	1.3336	0.9812	0.7216	0.0631	0.1958	0.0195	5.8465	5.3413	3.6230
	DBDB	1.1130	0.1121	0.1419	1.3670	1.0000	0.6392	0.0981	0.2371	0.0257	7.0886	6.5929	3.7692
	Change	1.27%	70.06%	-15.82%	2.51%		-11.42%	55.46%	21.05%	31.88%	21.25%	23.43%	4.04%
Disp. Prob. = 6.8%	DCDC	1.0998	0.0660	0.1958	1.3616	1.0000	0.6064	0.0324	0.3454	0.0158	5.1260	4.3419	3.2386
	DBDC	1.1351	0.0932	0.1820	1.4104	1.0359	0.5557	0.0422	0.3839	0.0182	5.7155	4.9666	3.4462
	Change	3.21%	41.25%	-7.03%	3.58%		-8.36%	30.22%	11.15%	15.12%	11.50%	14.39%	6.41%
	DCDB	1.0625	0.0638	0.1984	1.3247	0.9654	0.6285	0.0274	0.3292	0.0149	4.8825	4.1511	3.2406
	DBDB	1.0973	0.0872	0.1846	1.3691	1.0000	0.5809	0.0363	0.3655	0.0173	5.4376	4.7182	3.4505
	Change	3.27%	36.77%	-6.95%	3.35%		-7.58%	32.28%	11.03%	16.28%	11.37%	13.66%	6.48%

choice to switch employers. As the cost of switching becomes higher, switching becomes more expensive and the value of the option to switch is reduced. With higher switching costs, the employee is likely to stay longer with the same employer (DCDC expected tenure of 6.3436 years with 10% switching costs versus 10.9253 years with 100% switching costs for a 40 year old employee). With longer tenure the DB plans look more attractive as vesting and portability risks are mitigated. However, employees are also more likely to stay longer with either a DB or DC plan, so the relative savings in hiring costs of a DB plan is still not enough to justify the increased salary for the employee. Again for the 40 year old employee DC plans dominate unless employer hiring costs are very high.

Table 11 provides the level of hiring costs above which a DB plan is optimal, and below which a DC Plan is optimal. High required levels of hiring costs in this table reflect the cases where DC plans are generally optimal. DC plans are also better in those cases where the employee is young to middle-aged, displacement probabilities are higher, and there are high levels of employee job switching costs. DB plans are optimal when there are high levels of hiring costs upon employee termination, older employees and when employees are not subject to high probabilities of employer termination.

4 Conclusion

In this paper we address the interrelated issues of employee and employer pension plan choice. We first construct and numerically solve an employee model that determines the expected present value of the employee's lifetime earnings and plan benefits under varied current and competitive employer plan offerings. In this model we value the employee's option to switch– a compound option where the employee can switch to an alternative employer at any time to gain higher compensation. In the second stage model, we use the endogenous employee switch boundary determined from the first stage modeling to simulate the expected employer salary, benefit and hiring costs under varied current and competitive employer plan choices and plan design characteristics.

Based on the numerical solution results we show that, unless employees are older and/or are not likely to switch employers over time, DC plans are generally superior for both the

Table 10: Vary Switching Cost for Age 40 Employees

		Annuitized Cost				Indiff.	Cumulative Probability of				Expected Employee		
		Salary	Benefits	Hiring	Total	Point	Switch	Retirement	Firing	Death	Tenure	Switch Tenure	Time to Switch
Switching Cost = 10%	DCDC	1.1202	0.0672	0.1585	0.0000	1.0000	0.6899	0.0753	0.2127	0.0221	6.3436	5.8292	3.7359
	DBDC	1.1303	0.1184	0.1331	1.3818	1.0192	0.5987	0.1161	0.2570	0.0282	7.7121	7.2603	3.8207
	Change	0.90%	76.14%	-16.03%	2.67%		-13.22%	54.10%	20.84%	27.78%	21.57%	24.55%	2.27%
	DCDB	1.0991	0.0659	0.1685	1.3336	0.9812	0.7216	0.0631	0.1958	0.0195	5.8465	5.3413	3.6230
	DBDB	1.1130	0.1121	0.1419	1.3670	1.0000	0.6392	0.0981	0.2371	0.0257	7.0886	6.5929	3.7692
	Change	1.27%	70.06%	-15.82%	2.51%		-11.42%	55.46%	21.05%	31.88%	21.25%	23.43%	4.04%
Switching Cost = 50%	DCDC	1.0996	0.0660	0.1090	1.2746	1.0000	0.5275	0.1301	0.3084	0.0340	9.2453	9.4673	5.6351
	DBDC	1.0983	0.1203	0.0997	1.3183	1.0059	0.4554	0.1659	0.3399	0.0388	10.1806	10.7068	5.4987
	Change	-0.11%	82.29%	-8.56%	3.43%		-13.66%	27.51%	10.20%	14.18%	10.12%	13.09%	-2.42%
	DCDB	1.0968	0.0658	0.1153	1.2779	0.9941	0.5680	0.1116	0.2894	0.0310	8.6791	8.7627	5.5726
	DBDB	1.0966	0.1168	0.1050	1.3184	1.0000	0.4985	0.1457	0.3202	0.0357	9.6005	9.9178	5.5102
	Change	-0.02%	77.46%	-8.93%	3.17%		-12.24%	30.55%	10.63%	15.00%	10.62%	13.18%	-1.12%
Switching Cost = 100%	DCDC	1.0872	0.0652	0.0924	1.2448	1.0000	0.4244	0.1708	0.3635	0.0414	10.9253	12.0504	6.8393
	DBDC	1.0786	0.1219	0.0864	1.2869	0.9977	0.3623	0.2034	0.3887	0.0456	11.6783	13.2353	6.6313
	Change	-0.79%	86.83%	-6.51%	3.38%		-14.63%	19.09%	6.94%	10.24%	6.89%	9.83%	-3.04%
	DCDB	1.0931	0.0656	0.0969	1.2557	1.0023	0.4630	0.1507	0.3477	0.0386	10.4251	11.3182	6.8661
	DBDB	1.0861	0.1200	0.0905	1.2967	1.0000	0.4031	0.1833	0.3709	0.0427	11.1610	12.3941	6.6628
	Change	-0.64%	83.01%	-6.63%	3.27%		-12.94%	21.63%	6.69%	10.58%	7.06%	9.51%	-2.96%

Table 11: Level of Hiring Costs above which a DB Plan Minimizes Total Costs for the Current Employer. Total Costs = Salary + Benefits + Hiring Costs. Entries denote the level of hiring costs times an employee's salary, above which a DB plan is optimal, below which a DC Plan is optimal.

Parameter Values:	Employer 2 has a DC Plan			Employer 2 has a DB Plan		
	Employee Age			Employee Age		
Exception to the Base Case	25	40	55	25	40	55
All Base Case Parameters	4.40	2.41	0.64	4.24	2.25	0.57
DB Accrual Rate for Employer 1 $A = 1\%$	5.40	2.45	0.62	4.73	2.29	2.02
DB Accrual Rate for Employer 1 $A = 2\%$	4.14	2.42	0.64	3.83	2.24	0.14
Displacement Prob. $= 0\%$	1.52	0.99	0.24	1.65	1.00	0.21
Displacement Prob. $= 6.8\%$	Always DC	4.54	1.00	Always DC	4.22	0.91
JSC $= 50\%$ of Current Salary	Always DC	5.69	1.09	Always DC	4.94	0.95
JSC $= 100\%$ of Current Salary	Always DC	7.99	1.38	Always DC	7.38	1.22

employer and the employee. DC plans tend to be favored because the employee has a valuable switching option and DB plan vesting and backloading lead to higher employee retention that decreases the switching option value. In order to attract employees, DB employers must compensate employees for the decrease in the option value. This increase in compensation costs tend to overwhelm the cost savings from having to hire new employees less frequently.

We find that the optimal choice of employer plan, i.e., where the total expected annuitized costs of salary, benefits and hiring costs are minimized, is influenced by a number of factors. For employers, we find that DC plans are preferred: when the costs of hiring new employees are lower; where the employee is young to middle-aged; when probabilities of termination by the employer are higher; and when there are high level of employee incurred job switching costs. Employers will prefer DB plans: when there are high levels of hiring costs upon employee termination; when they have older employees; and, when employees are not subject to high probabilities of employer determined termination.

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