

A Statistical Analysis of Defined Benefit, Defined Contribution, and Hybrid Plans

The Honors Program
Senior Capstone Project
Student's Name: Katie Heeder
Faculty Sponsor: James Bishop
May 2010

Table of Contents

Abstract	1
Introduction	2
Literature Review	4
Historical Data Comparing Number of DB and DC Plans	4
401(k) Plans: What You Should Know.....	6
Are Hybrid Plans the Answer?.....	8
Employee Impact from Plan Freezes	9
Research Methodology	12
Hypotheses	12
Method and Assumptions.....	13
Findings and Conclusion.....	14
Defined Benefit Results	14
Defined Contribution Results.....	14
Hybrid Results.....	14
Multiple Retirement Plan Results	15
Interest Rate Fluctuations.....	15
Analysis and Conclusion of Results.....	16
Limitations and Further Research	17
References	19

A Statistical Analysis of Defined Benefit, Defined Contribution, and Hybrid Plans
Senior Capstone Project for Katie Heeder

ABSTRACT

The purpose of this study is to compare three major types of employer sponsored retirement plans, Defined Benefit (DB), Defined Contribution (DC), and hybrid, and their impact on the employee. Employee careers are simulated to understand the employee's advantages and disadvantages of each type of plan, especially in the state of an economic depression. The study uses actuarial assumptions and the simulation varies a number of quantities to better understand the impact of employee savings. The variables which are simulated at different levels are: service start age, retirement age, current compensation, salary increase rate, rate of return on market investments, mortality rates, and interest rate. The simulation shows that traditional defined benefit plans typically give employees a higher benefit than both defined contribution and hybrid plans. Additionally, defined benefit plans are not subject to the market risk of many of the other retirement plan types. Finally, typical employees change plans at least once during their career and this has a significant negative effect on their retirement benefits.

INTRODUCTION

In the United States, retirement plans are voluntary instruments provided by employers that provide incentives and benefits for themselves as well as for their employees. Until thirty years ago, Defined Benefit (DB) plans were the main types of pension plans offered by middle and large sized companies. DB plans are formula based and are designed for workers holding career-long jobs with single employers; thus, they are most valuable to employees when they have worked for a company for many years. DB plans are expensive for a company to maintain because they often require the use of an actuary and are also very unpredictable due to the nature of annual investment performance and due to the changes in the long-term interest rates used to value plan liabilities (Kamenir, 2009). These plans are also considered riskless to the employee because the employer is obligated to provide the calculated monthly benefit to the retiree in the form of a life annuity regardless of how the company is performing financially. DB plans, for the most part, are also completely funded by the employer; no employee contributions are made.

Throughout the late 1900s, however, the relationship between employers and their workers started changing. Employees were no longer working for one company throughout their entire working career, they were working for several. Due to this phenomenon, the characteristics of DB plans that were once well-suited for United States employees, were not as effective for new, mobile workers and, as a result, Defined Contribution (DC) plans became the new trend (McGill, Brown, Haley, & Schieber, 2005).

The most common DC plans, known as 401(k) plans, are defined as individual account balances where the employee and/or employer contribute a specified percentage of the employee's monthly pay into an array of market funds chosen by the employee. At retirement, the accrued account balance is the employee's retirement benefit. Thus, the future amount of the employee's benefit is dependent on the performance of the stock market and how well individuals allocate their investments. For the purpose of this study, 401(k) plans are the only type of DC plan that will be considered.

A Statistical Analysis of Defined Benefit, Defined Contribution, and Hybrid Plans *Senior Capstone Project for Katie Heeder*

The shift from DB to DC plans was looked upon eagerly by employers and the media as a better design for the modern workforce because of its portability (Gold, Vorchhelmer, 2009). However, the restructuring of the retirement plans “brought new risks and responsibilities for individuals” (Hogg, 2009). Employees participating in DC plans are subject to market fluctuations and are responsible for allocating the lump sum benefit provided by the plan into income that will last the employee until death. Also, since DC plans are not entirely employer sponsored and participation is not required by many companies, many workers have opted out of deferring a percentage of their salary in order to pay for more immediate demands. Because of this, many retirement-age individuals have not saved up enough money in order to assure themselves an adequate lifestyle during retirement (Gandel, 2009).

As DC plans were becoming more and more popular among middle and large sized corporations, “hybrid” plans also emerged. Since the recent economic downturns, hybrid plans have become a popular, attractive alternative (Employee Benefit Research Institute, 2006). Hybrid plans combine the security of a DB plan with the portability and lower cost of a DC plan. The most common hybrid plan is a cash-balance plan. A cash-balance plan provides an employee with a hypothetical investment account, like a 401(k). Each year, the fund grows with an interest credit and a contribution credit designated by the employer. The contribution credit is usually expressed as a percentage of pay, service, or age and the interest credit is usually defined as an indexed or fixed rate. At retirement, the account balance is the benefit. Another type of hybrid plan is known as a pension equity plan (PEP). PEP plans are defined lump sum benefit amounts payable at age 65 in which contributions are indexed based on increases in participant compensation, rather than a specified interest rate (Watson Wyatt, 2003). For this study, a PEP plan is the only type of hybrid plan evaluated.

Even though hybrid plans are modern and provide secure benefits upon retirement, they have been widely scrutinized for discriminating against older employees when converting DB accumulations to cash balance or PEP plans. The contribution amount made by the employer depends on the estimated “present value of total future benefit obligations and its investment gains and losses, not on fixed or promised annual contributions to individual accounts” (Certner, 2005). Thus, employers are able to significantly reduce the periodic amounts

A Statistical Analysis of Defined Benefit, Defined Contribution, and Hybrid Plans ***Senior Capstone Project for Katie Heeder***

contributed to workers when the accumulated benefit amount exceeds that of the expected accumulated amount. Furthermore, in bull markets, accumulated amounts in hybrid plans fall short of those in DC plans due to the fact that hybrid plans are index-based and DC plans are market-based.

Even though hybrid plans provide many desirable features for both the employer and the employee, such as reduced plan costs and reduced future pension obligations for the employer and the security and portability aspects for the employee, hybrid plans are far from being perfect. The primary objectives of this paper are to compare the benefits received by the employee from typical retirement plans and to evaluate the impact of those benefits as a result of interest rate fluctuations. This study also examines the changes in benefit amounts received when an employer changes plans or when an employee is accruing benefits under multiple retirement plans. The results of this study are explored by analyzing the results of a simulation.

LITERATURE REVIEW

Historical Data Comparing Number of DB and DC Plans

According to the Pension Benefit Guaranty Corporation, in 1985 there were 114,000 DB plans. Today, there are about 38,000 (IRS, 2009). The decline in DB pension plans is a result of the emergence of 401(k) plans, a type of DC plan, which were initiated in 1981. Over the course of the following twenty years, “the popularity of 401(k) plans grew rapidly, particularly among smaller employers that were burdened by the increasing liability and costs associated with sponsoring a defined benefit plan” (McCourt, 2006). Generally, companies began offering 401(k) plans which served as either the sole pension plan or a supplemental pension plan. During this period, many companies also froze their DB plans and began offering only 401(k) plans (McCourt, 2006). Today, there are “more than 630,000 private-sector defined contribution plans covering more than 75 million active and retired workers” (American Benefits Council, 2009). The table below illustrates the decline in DB plans and the rise in DC plans since 1975.

***Changes in the Number of Private
Pension Plans***

1975-1999

Types of Plans	1975	1985	1995	1999
Private defined benefit	103,000	170,000	69,000	50,000
Private defined contribution	208,000	462,000	624,000	683,000

Source: McCourt, 2009

Even though there are significantly more defined contribution plans than defined benefit plans today, the resulting benefits received by employees differ, especially in times where the market is volatile. In a bear market economy, DB plan accumulations will most likely outperform DC plan accumulations since the market return rate will be lower than the interest rate used to value DB accumulations. On the other hand, DC plan accumulations can increase significantly in bull markets and have the potential to outperform DB plan accumulations since the market return is greater than the return on DB investments. Due to the change in the number of private pension plans over pension plan history, the amount of benefit received per individual has changed from being reliant on safe, low-risk investments that are not affected by the market to being reliant on volatile, high-risk market investments. As a result, shifts in the amount of benefit received at retirement are dispersed instead of controlled. An analysis completed by Buessing and Soto (2006) of the Department of Labor Form 5500 further supports the declining DB rates and the increasing DC rates. The study shows that the number of individuals who only participate in a private DB plan has declined from 9.6 million in 1990 to 6.6 million in 2003. The number of individuals participating in both a DB and DC plan throughout their careers remained constant at about 14 million and the number of individuals only participating in DC plans during their careers rose from 11.5 million in 1990 to 30.1 million in 2003 (Poterba, Rauh, Venti, & Wise, 2007).

A Statistical Analysis of Defined Benefit, Defined Contribution, and Hybrid Plans ***Senior Capstone Project for Katie Heeder***

401(k) Plans: What You Should Know

A simulation was created and examined by Poterba, Rauh, Venti, and Wise in 2007 which found that the mean and median DC benefit accruals for private-sector workers almost always exceeded the actuarial present value of DB benefits, assuming some equity exposure in the worker's DC funds. Thus, even though DC plans are risky, they are not necessarily riskier than DB plans as long as plan participants invest properly. However, most individuals do not.

DC plans are accused by the media of not helping individuals reach their retirement goals because wealth accumulation depends on the financial market and how well an individual chooses and allocates their deferments. Since the market crash of 2008, where average 401(k) balances among "consistent savers fell 24%" (Coombes, 2009), employees and employers grew weary of the DC plan. In 2007, when the stock market was at its peak, "the median balance on 401(k)s and IRAs combined was a mere \$78,000" (Farrell, 2009). Research has further shown that the 401(k) does not "help people save safely while they are working.... [, and as a result,] the amount of savings that the 401(k) is producing is not nearly enough" (Gandel, 2009). The individuals mostly affected by the riskiness of 401(k)s are older workers because of their exposure to short-term risk. Young workers are not affected as much.

Further research has shown that DC plans tend to favor high-income workers for several reasons. Since most DC plans are voluntary to enter into, many low-income workers choose to use the amount of money that would have been deferred for current income. This means that low-income workers who are enrolled in a voluntary 401(k) plan will not reap the benefits of the plan and therefore will not have a retirement savings account upon retirement. Also, higher-income workers "can take advantage of the tax subsidy – money put into a 401(k) plan is not taxed until withdrawn; lower-income workers have less incentive and ability to save to avoid taxes (Council of Institutional Investors, white paper)." High-income workers pay more taxes because of the amount of money earned; however, by deferring their money into a 401(k) plan, they do not have to pay taxes on that money until it is withdrawn. By deferring their money, high-income workers pay fewer taxes immediately and receive the added benefits of the plan. Low-income workers, however, aren't concerned with the amount of taxes paid since their income does not require them to pay a high amount in taxes. Thus,

A Statistical Analysis of Defined Benefit, Defined Contribution, and Hybrid Plans
Senior Capstone Project for Katie Heeder

low income workers have less of an incentive to defer a portion of their earnings. Studies have shown that 26 percent of employees eligible to participate in a 401(k) plan do not and among those who do, less than 10 percent contribute the maximum allowable amount (Munnell & Sunden, 2004). Among low-income workers, 63 percent of individuals reaching retirement have zero retirement fund savings compared to 16 percent of high-income workers. Low-income workers who do participate will accumulate an expected life annuity equivalent to \$1, 850 per year, a 10.3% replacement rate. High-income workers are expected to accumulate a life annuity equivalent to \$50,000 per year, a 33.8% replacement ratio (GAO, 2007).

Those individuals who do participate in a 401(k) plan tend to invest their assets all over the risk spectrum. Some individuals invest in very risky investments while others do not risk their money at all, merely in safe rates in which returns are equivalent to a bank savings account. Thus, it is more likely for participants with 401(k) plans to end up with a reduced pension because of how he/she allocated their investments (Council of Institutional Investors, white paper).

In an effort to encourage individuals to invest in 401(k)s, the Pension Protection Act of 2006 allowed companies to begin automatically enrolling their workers into the plan. If an employee does not want to defer the stated percentage of pay (usually around 3%), he/she would have to opt out. Companies thought that more participation would occur if individuals had to physically opt-out of a plan instead of choosing to physically opt-in to a plan. Today, nearly half of United States companies auto-enroll their employees (Koster, 2009) and only 5-10% of the employees choose to opt-out (Fried, 2009). Furthermore, the default investment options have changed from a stable-value type of account – like a low-interest earning bank account – to more aggressive types of accounts – like mutual funds – to help grow the investments of individuals. However, critics have claimed that the low percentage of contribution an employee is automatically set to defer is not nearly enough to provide for an adequate retirement. Auto-enrollment features have misled American workers into thinking that the company is taking charge of their retirement. Rather, individuals need to be aware of

A Statistical Analysis of Defined Benefit, Defined Contribution, and Hybrid Plans *Senior Capstone Project for Katie Heeder*

the amount that is being deferred and change the percentage being contributed to match his/her projections (Fried, 2009).

DC plans are also more expensive than DB plans for the individual. Professors Freeman and Brown found that investment advisory fees for DC plans are twice that of what DB plans pay, 0.56 percent of assets versus 0.28 percent (Freeman and Brown, 2001). Since maintaining millions of little accounts is more expensive than maintaining one big account, DC plan participants end up paying more for administrative costs than the company cost of a DB plan. Thus, too much money is being spent on fees and not enough money is going into their account. Another downfall for employees participating in a 401(k) plan as opposed to a DB plan is that the DB plan is federally insured by the Pension Benefits Guaranty Corporation (PBGC). If, for some reason, the employer is unable to pay out their benefit obligations, the PBGC insures these benefits up to a maximum monthly amounts at a cost to the employer (PBGC, 2009). If the stock market crashes and the 401(k) balance drops significantly, the money in the account is lost.

Since the recent economic downturn, the National Retirement Risk Index estimates that 401(k) and IRA investments 'as of mid-2009 signals that 51% of households are at risk at age 65 of not having enough retirement income to maintain their pre-retirement standard of living. That's up from 44% in 2007 and 43% in 2004, according to the index' creator, the Center for Retirement Research at Boston College" (Farrell, 2009). It is apparent that 401(k) investments are not providing workers with the adequate income needed post-retirement.

Are Hybrid Plans the Answer?

A study by GAO states that hybrid plans may be a good alternative to a typical DB plan and DC plans. The problem with hybrid plans, however, is that the plans are categorized as a DB plan because the benefit is defined. However, hybrid plans do not fit neatly under this category and because regulatory framework has failed to keep up with the changing designs of pension plans, the mismatch has caused "considerable regulatory uncertainty for employers as well as litigation with potentially significant financial liabilities" (GAO, 2005). Forty-five percent of companies, however, offered grandfathering when converting plans which protected workers from wearaway (GAO, 2005).

A Statistical Analysis of Defined Benefit, Defined Contribution, and Hybrid Plans
Senior Capstone Project for Katie Heeder

When comparing a typical cash balance plan to a typical DB plan, GAO (2005) found that no matter the age of the employee at the time of conversion, a typical DB plan provided greater monthly benefit amounts compared to the cash balance plan. When comparing a typical cash balance plan to a terminated DB plan, the study found that, regardless of age, the cash balance plan experienced an increase in monthly benefits compared to a frozen DB plan. This study assumed median income among employees.

Employee Impact from Plan Freezes

Since many DB plans have been frozen by the employer, many companies have instituted hybrid plans or 401(k) plans to replace the old plan. According to a survey completed by GAO in July of 2008, about 21% of employees are affected by a freeze. Most large companies do not hard freeze their pension plan, which means that all future payments and accruals are stopped. Rather, a soft freeze is put in place which allows accruals to continue, however, the accruals stay constant and do not increase as work tenure increases. About 25% of small companies hard freeze their pensions compared to 9% of large companies. After a freeze has been put in place by corporations, about 83% offer an alternative retirement savings arrangement. Eleven percent do not.

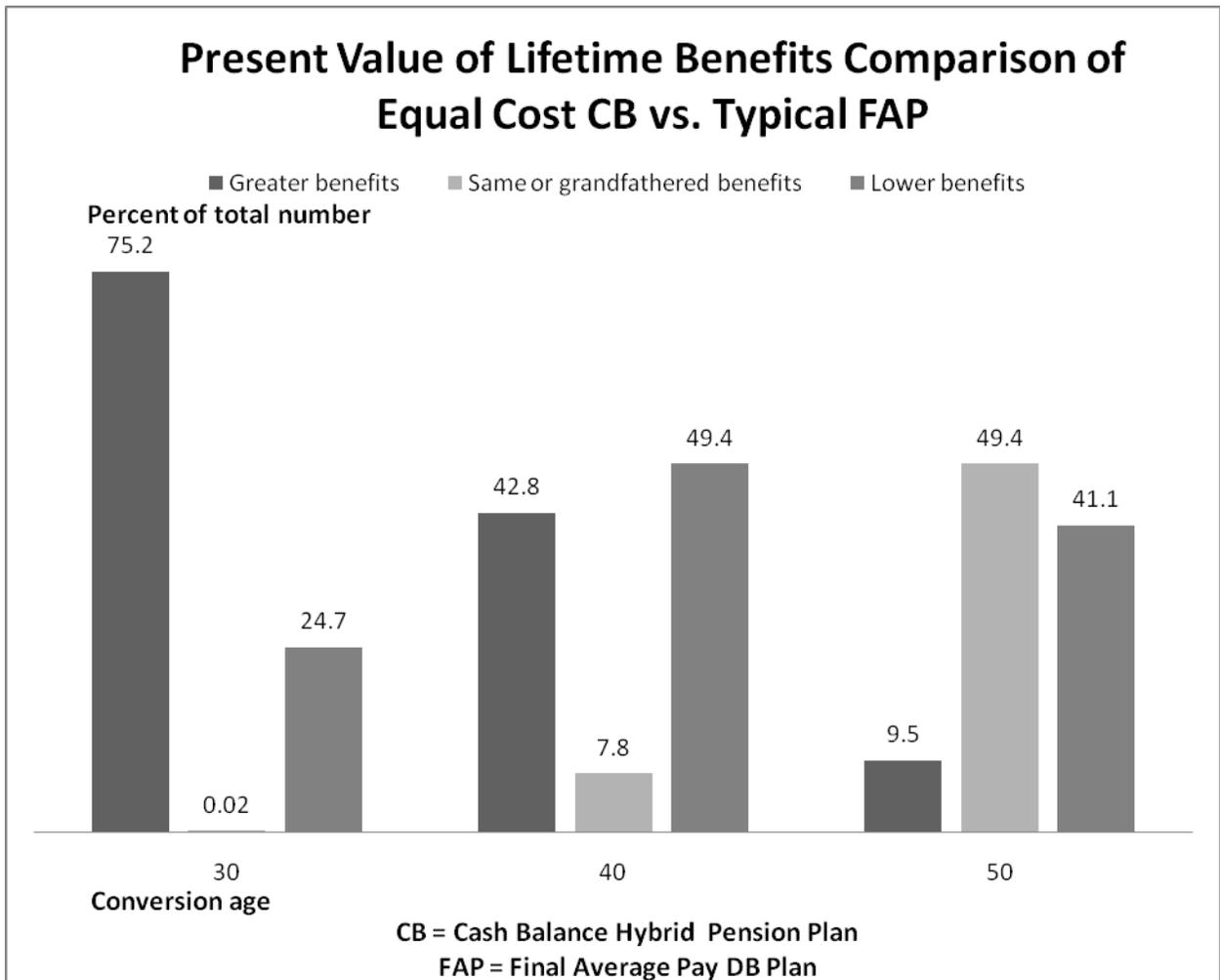
Even though this may save money for the employer in the long-run, the accumulated benefit for active employees is usually affected and may be one of the reasons why retirees are finding themselves with an inadequate amount of retirement income. A simulation done by VanDerhei in 2006 compared the accumulated wealth of a continued DB plan and a 401(k) plan that replaced the same DB plan, assuming the DB plan was frozen by the company. The study found that there was tremendous variability in trying to determine whether an individual's expected retirement income changed due to switching plans. However, the data found that "older, tenure[d] workers tend to be affected by a pension freeze more than younger workers because they do not have as much time left in their working careers in a 401(k) plan to offset the accrual loss from a pension freeze."

When looking at the distribution of wealth in young and older workers, hybrid plans provide younger workers with greater benefits and as employees advance in their careers, less is contributed to their account. On the other hand, traditional DB plans provide young workers

A Statistical Analysis of Defined Benefit, Defined Contribution, and Hybrid Plans
Senior Capstone Project for Katie Heeder

with small benefits that increase as they get older. Thus, when DB plans are frozen and replaced by hybrid plans, older workers typically see reductions in their benefits – this reduction is known as wearaway. If the present value of the DB accrued benefit is greater than the present value of the participant’s opening retirement account, further contributions to the opening retirement account would not be made until the difference wears away (GAO, 2005). Younger, more mobile workers usually benefit from the conversion because they would receive higher benefits than they would have received from the DB plan.

Hybrid plans, because of the concept of wearaway, have come under scrutinization over the past couple of years. In order to fix the problem, about half of the companies converting from DB to hybrid plans grandfather in the DB benefit. Still, about 41% of workers whose company converted from a traditional DB plan to a hybrid plan experienced an expected lower present value of pension benefits (GAO, 2005). According to GAO’s simulations, the chart below illustrates the change in pension benefits when switching from a typical final average pay DB plan to an equal cost cash balance plan depending on conversion age.



Source: GAO, 2005

75.2% of workers age 30 who switched from a FAP DB to an equal cost CB plan experienced an increase in their expected benefits compared to 9.5% of workers age 50. Thus, the younger the age of the worker at the time of the benefit conversion, the better off the person is in the long term. It should be noted, however, that no matter what age, a significant portion of individuals experience lower benefits when switching plans.

The analysis indicates that pension plan freezes favor younger workers and are disadvantageous for older workers regardless of whether or not the participant is switching from a DB to a 401(k) plan, from a DB to a hybrid plan, or from a DB plan to no plan at all. Since workers accrue the greatest portion of their earnings in the latter part of their careers

A Statistical Analysis of Defined Benefit, Defined Contribution, and Hybrid Plans ***Senior Capstone Project for Katie Heeder***

under a typical DB plan, having the plan frozen significantly reduces their projected benefit the greatest. Older workers, thus, find themselves obligated to continue working long after their normal retirement date because the funds that they once thought would accumulate have been significantly reduced in such a short time.

RESEARCH METHODOLOGY

Hypotheses

The objective of the simulation is to evaluate employee impact on employer sponsored retirement plans. Focusing on interest rate variability as a result of the recent economic recession, two hypotheses (H1 and H2) have been formed.

H1: Young individuals (age 25) who enter the DB plan and stay in the DB plan for the duration of their career will accrue the largest benefit amount.

The longer an employee has worked for a company with a DB plan, the greater the accumulations increase. Therefore, it seems reasonable to assume that a young individual (age 25) who continues to work for a company in which he/she is participating in a DB plan for many years will accrue a higher benefit than an older worker (age 55) who starts participating in the plan.

H2: Employees who change from a DB plan to a hybrid plan, or vice versa, during their career will have a significantly lower benefit provided to them at retirement as opposed to staying in one plan during their entire career.

Changing jobs or having a company freeze a pension plan can have significant effects on an employee's benefit. Since defined benefit plans are most valuable to employees when they have worked for a company for many years, freezing a pension plan will reduce the future accumulated value of the pension by a significant amount. However, it is important to see whether this is true in times of high market performance. Another interesting observation is

A Statistical Analysis of Defined Benefit, Defined Contribution, and Hybrid Plans **Senior Capstone Project for Katie Heeder**

to see how the variable age at the time of conversion affects whether or not the benefit increased or decreased and by how much.

Method and Assumptions

The plan calculations are run by an Excel simulation that takes into consideration an employee's salary at the age of 55, service start age, retirement age, the average salary increase factor, average rate of return, mortality rates based on the 2010 PPA factors, and an employer contribution factor. Several assumptions, A1 to A6, were made when calculating future benefits:

A1: The current age of the participant is 55 with an annual salary of \$100,000.

A2: The annual salary increase of the participant is 2% per year. Since the average salary increase in 2009 was 1.66% and the average salary increase in 2010 is 2.88%, the conservative estimate 2% is used (Culpepper and Associates, 2009).

A3: The rate of return on the end-of-year 401(k) investments is 7.5% per year. This rate represents a mixed investment return across the S&P index of the past 60 years.

A4: For comparison, the employee is assumed to enter the plans at three different ages: 25, 35, and 55.

A5: Three retirement ages are considered: age 55 (a typical early retirement age), age 62 (the age at which a worker may electively start receiving social security payments), and age 65 (a typical normal retirement age defined in most retirement plans).

A6: No reductions are taken for early retirement and no social security offsets are considered.

A Statistical Analysis of Defined Benefit, Defined Contribution, and Hybrid Plans
Senior Capstone Project for Katie Heeder

FINDINGS AND CONCLUSION

Defined Benefit Results

Considering a final average pay (FAP) DB, the table below illustrates the lump sum values of the projected benefits. The percentages inside the parentheses represent the annual amount received each year divided by the final salary (also known as the salary replacement ratio). The FAP DB formula used for calculation is 1.5% x the average of the last 5 annual salaries x years of service enrolled in plan (Retirement Age – Service Start Age).

	Service Start Age			
Retirement Age	25	35	45	55
55	\$ 288,297.01 (20%)	\$ 192,198.00 (13%)	\$ 96,099.00 (7%)	-
62	\$ 608,173.01 (41%)	\$ 443,801.93 (30%)	\$ 279,430.84 (19%)	\$ 115,059.76 (8%)
65	\$ 833,151.08 (57%)	\$ 624,863.31 (42%)	\$ 416,575.54 (28%)	\$ 208,287.77 (14%)

Defined Contribution Results

Based on the above assumptions, the table below illustrates the lump sum values of projected DC benefits. The salary replacement ratio is expressed inside the parentheses.

	Service Start Age			
Retirement Age	25	35	45	55
55	\$ 348,486.90 (24%)	\$ 168,971.09 (11%)	\$ 62,796.70 (4%)	-
62	\$ 624,553.57 (42%)	\$ 326,728.03 (22%)	\$ 50,579.50 (10%)	\$ 46,396.68 (3%)
65	\$ 794,791.33 (54%)	\$ 424,803.59 (29%)	\$ 205,974.82 (14%)	\$ 76,548.83 (5%)

Hybrid Results

The Pension Equity Plan (PEP) results are shown below. The plan assumes a 9% employer contribution and a 3.5% rate of return. The rate of return is based on a risk-free investment rate. The 9% employer contribution is based on the average of the range of contributions among plans (Lowman, 2000). The 3.5% interest rate is used to mimic a risk-free interest rate, which is often used in such plans.

	Service Start Age			
Retirement Age	25	35	45	55
55	\$ 190,176.88 (13%)	\$ 117,338.82 (8%)	\$ 54,394.48 (4%)	-
62	\$ 413,422.13 (28%)	\$ 278,866.13 (19%)	\$ 162,587.14 (11%)	\$ 62,102.54 (4%)
65	\$ 580,078.57 (39%)	\$ 401,938.37 (27%)	\$ 247,995.29 (17%)	\$ 114,964.60 (8%)

A Statistical Analysis of Defined Benefit, Defined Contribution, and Hybrid Plans ***Senior Capstone Project for Katie Heeder***

Multiple Retirement Plan Results

Computed below is the sum of two pension plans: a frozen DB plan and a hybrid PEP plan. The DB plan is assumed to have been frozen ten years after the start of the employee's career. As noted above in the literary review, many workers are switching jobs more than once during their working career. Also, companies have been freezing traditional DB plans and offering hybrid plans or 401(k) plans in its place. The results below illustrate a snapshot of the reduced pensions an employee may receive due to pension plan changes.

	Service Start Age		
Retirement Age	25	35	45
55	\$ 318,432.13 (26%)	\$ 234,481.08 (19%)	\$ 170,868.52 (14%)
62	\$ 447,981.47 (32%)	\$ 334,315.72 (24%)	\$ 245,024.68 (18%)
65	\$ 516,927.98 (35%)	\$ 388,166.99 (26%)	\$ 285,831.12 (19%)

Next, the situation in which a PEP plan is frozen and a DB plan is put in place is examined. Although the occurrence of a company replacing a PEP plan with a DB plan is rare, workers may experience the conversion when switching jobs. Illustrated below are the results, assuming the PEP plan is frozen after ten years.

	Service Start Age		
Retirement Age	25	35	45
55	\$ 255,665.51 (21%)	\$ 173,465.54 (14%)	\$ 94,309.38 (8%)
62	\$ 507,269.43 (37%)	\$ 356,797.38 (26%)	\$ 209,369.14 (15%)
65	\$ 688,330.82 (47%)	\$ 493,942.08 (34%)	\$ 302,597.15 (21%)

Interest Rate Fluctuations

Since Defined Contribution plans are affected by market fluctuations, it is important to examine the impact of fund performance upon retirement. Based on the normal distribution z-score and average means and standard deviations, the table below illustrates the probability of loss (when the return is less than zero) when the money is invested in the market 5, 10, and 20 years.

A Statistical Analysis of Defined Benefit, Defined Contribution, and Hybrid Plans
Senior Capstone Project for Katie Heeder

	Number of Years		
	5	10	20
Mean Increase	7.8%	7.7%	7.3%
Standard Deviation of Increase	6.9%	4.7%	3.2%
Probability of loss	13.0%	5.3%	1.0%

S&P annual increases from 1950 – 2008
Source: Bishop, Heeder, Schumacher, 2010

The results above show that DC plans are relatively safe investments when the money is invested over long periods of time. However, it is important to note that if an employee is nearing retirement age, a high probability of loss when investing in the market a short number of years is prevalent. Based on past S&P returns, a person age 60 who invests their money in the market until age 65 has a 13% chance of incurring a loss.

After averaging non-overlapping periods of the S&P 500 historical returns since 1950 and adding up the number of negative average returns over periods of 5, 10, and 20 years, the results show that in 5 year periods, 3 out of 12 periods had negative returns, representing a 25% probability of loss. For 10 year periods, 1 out of 6 periods had negative returns, representing a 16.7% chance of loss. Lastly, when averaging non-overlapping 20 year returns, 0 out of 3 year periods had negative returns equating to a 0% probability of loss.

Analysis and Conclusion of Results

The results of the benefits received from typical pension plans and plan conversions show that traditional defined benefit plans typically give employees a higher benefit than both defined contribution and hybrid plans. If the employee is enrolled in the plan for 40 years (from age 25 to age 65), the DB plan provides the employee with 57% of his/her annual income compared to 54% if he/she is enrolled in the DC plan, and 39% if he/she is enrolled in the hybrid plan. Based on the above results, the DB plan provides the highest salary replacement ratio in all scenarios, regardless of when the employee enters and leaves the plan. This analysis supports hypothesis #1 and hypothesis #2. Additionally, defined benefit plans are not subject to the market risk of many of the other retirement plan types. Thus, defined benefit

A Statistical Analysis of Defined Benefit, Defined Contribution, and Hybrid Plans *Senior Capstone Project for Katie Heeder*

plans are safe and predictable investments and because of this, DB plans are considered more valuable.

When comparing the DC plan to the hybrid plan, the DC plan fares better for younger workers (ages 25-35) than the hybrid plan if invested until ages 55, 62, or 65. Conversely, the hybrid plan provides greater benefits to older workers (ages 45-55) than the DC plan. The role interest rates play in DC plans is one of the main reasons hybrid plans are more valuable to older workers than younger workers. In order to illustrate this point, the probabilities of loss when investing in the market 5, 10, and 20 years were calculated. It was found that DC plans are relatively safe investments when the money is invested in the market for 20 years. Based on a z-score and traditional averaging of the S&P 500 returns since 1950, there is a 0-1% chance of the investment losing money. When the money is invested over 10 years, there is a 4-5.3% chance of losing money and a 11-13% chance when the money is invested over 5 years.

After evaluating the lump sum and salary replacement ratios for an employee who has two retirement plans (one that was frozen after 10 years and a new continued plan), the results show that except for early retirement (age 55), being enrolled in a continued DB plan throughout ones career provides the greatest benefit during his/her retirement years. The DB plan is also considered costless to the employee - the DB plan is funded by the employer. This is another advantage of being enrolled in this type of plan.

In summary, the simulation shows that the defined benefit plan is the best plan for the employee. Since the employer decides on the type of plan being offered, and from the employer's perspective the DB plan is the most expensive plan to offer, improvements to other plans need to become a priority in order to help workers maintain retirement standards currently in place in the U.S.

LIMITATIONS AND FURTHER RESEARCH

As employers are converting their DB plans to hybrid plans or offering DC plans as their main pension plan, employees are finding it harder to realize their investment goals at the

A Statistical Analysis of Defined Benefit, Defined Contribution, and Hybrid Plans
Senior Capstone Project for Katie Heeder

time of retirement. After the recent economic downturn, 401(k) investments plummeted, leaving millions of retiree-aged workers to cope with their insufficient funds. Hybrid plans have been under fire by many, being accused of wearaway and, like the 401(k), not providing enough money upon retirement due to the non-aggressive investments of the funds. Thus, in order to meet the needs of both the employers and the employees, a new plan or the revision of an old plan still needs to be determined. Several sources have suggested changing the rules of the hybrid plans. Currently, they are under the category of a DB plan; however, many think the IRS needs to develop new laws for the plans and place them in their own category. More research needs to be done in order to support this point.

Also, in order to more accurately predict future benefits, one should consider social security amounts, reductions for early retirement, employee breaks in service, changing pension plans more than twice during an employee's career, and varying the interest rates and pay increases which were not included in this simulation. Furthermore, the simulation only used one formula for each plan and did not look at all types of pension plans (i.e. Target Benefit plan, Profit Sharing plan, Age-Based Profit Sharing Plan, etc.) that employers offer.

A Statistical Analysis of Defined Benefit, Defined Contribution, and Hybrid Plans
Senior Capstone Project for Katie Heeder

REFERENCES

- American Benefits Council. (2009). *Defined contribution plans: a successful cornerstone of our nation's retirement system*. Retrieved from http://www.americanbenefitscouncil.org/documents/dc_success_summary020509.pdf
- Benefit Systems, Inc, Initials. (2008). *Cash balance plans*. Retrieved from <http://www.benefitsystems.com/newsinfo/newsfiles/cashbalance.pdf>
- Bishop, Heeder, Schumacher. (2010). *Comparison of Retirement Benefit Plans in a Changing Economy*. White paper.
- Buessing, M. & Soto, M. (2006). *The state of private pensions: current 5500 data*. Issues in Brief IB42, Center for Retirement Research.
- Certner, D. (2005, June 5). *Hybrid (cash balance) pension plans: testimony before the subcommittee on retirement security and aging*. Retrieved from http://www.aarp.org/aarp/presscenter/testimony/articles/cash_balance.html
- Coombes, A. (2009, October 6). *Steady savers gained over 5-year period*. Retrieved from <http://www.marketwatch.com/story/401ks-took-big-but-not-devastating-hit-in-2008-2009-10-06>
- Council of Institutional Investors. *Protecting the nest egg: a primer on defined benefit and defined contribution retirement plans*. White paper.
- Culpepper and Associates. (2009, September 9). *2010 salary increase budgets projected to rise worldwide*. Retrieved from <http://www.shrm.org/hrdisciplines/compensation/Articles/Pages/SalaryBudgets.aspx>
- VanDerhei, J. (2006, March 8). *Defined benefit plan freezes: who's affected, how much, and replacing lost accruals*. Retrieved from http://www.ebri.org/pdf/briefspdf/EBRI_IB_03-20063.pdf
- Employee Benefit Research Institute. (2006, March). *Hybrid retirement plans: the retirement income system continues to evolve*. Retrieved from http://www.ebri.org/publications/ib/index.cfm?fa=ibDisp&content_id=80
- Farrell, C. (2009, November 11). *The case against retirement*. Retrieved from http://www.businessweek.com/investor/content/nov2009/pi20091111_309880.htm
- Freeman, J, & Brown, S. (2001). *Mutual fund advisory fees: the cost of conflicts of interest*. *The Journal of Corporation Law*, 609-673.

A Statistical Analysis of Defined Benefit, Defined Contribution, and Hybrid Plans
Senior Capstone Project for Katie Heeder

- Fried, C. (2009, October 16). *Why 401(k) auto-enrollment is seriously flawed*. Retrieved from <http://moneywatch.bnet.com/retirement-planning/blog/retirement-beat/why-401k-auto-enrollment-is-seriously-flawed/111/>
- Gandel, S. (2009, October 14). Is there a 401(k) fix?. *Time*, Retrieved from <http://www.time.com/time/business/article/0,8599,1929976,00.html>
- GAO. (2005, October). *Private pensions: information of cash balance pension plans*. Retrieved from <http://www.gao.gov/new.items/d0642.pdf>
- GAO. (2007, July). *Pension plans: low defined contribution plan savings may pose challenges to retirement security, especially for many low-income workers*. Retrieved from <http://www.polsim.com/GAO-08-8.pdf>
- GAO. (2008, July). *Defined benefit pensions: plan freezes affect millions of participants and may pose retirement income challenges*. Retrieved http://www.appwp.org/documents/gao_pensionfreeze072308.pdf
- Gold, P, & Vorchhelmer, A. (2009). *Everything old is new again: applying defined benefit solutions to defined contribution programs*. (Cover story). *Benefits Quarterly*, 25(1), 38-40. <http://search.ebscohost.com>
- Hogg, B. (2009). *The tides of retirement: navigating the sea of change in dc plans*. (Cover story). *Benefits Quarterly*, 25(1), 7-10. <http://search.ebscohost.com>
- IRS. (2009, September 5). *Choosing a retirement plan: defined benefit plan*. Retrieved from <http://www.irs.gov/retirement/article/0,,id=108950,00.html>
- Kamenir, J. (2009). *How to make defined benefit pension plans attractive to 21st century employers*. *Benefits Quarterly*, 25(2), 51-56. <http://search.ebscohost.com>
- Koster, K. (2009, September 29). *Auto-enrollment remains a crowd pleaser*. Retrieved from <http://ebn.benefitnews.com/news/auto-enrollment-remains-a-crowd-pleaser-2682058-1.html>
- Lowman, T. (2000, July 7). *Actuarial aspects of cash balance plans*. Retrieved from http://www.soa.org/files/pdf/actuarial_aspects.pdf
- McCourt, S. (2006). *Defined benefit and defined contribution plans: a history, market overview and comparative analysis*. Retrieved October 25, 2009, from <http://www.ifebp.org/PDF/webexclusive/06feb.pdf>
- McGill, D, Brown, K, Haley, J, & Schieber, S. (2005). *Fundamentals of private pensions*. Oxford, NY: Oxford University Press.
- Muksian, R. (2009). *Mathematics of finance and insurance*. United States: Pearson Custom Publishing.

A Statistical Analysis of Defined Benefit, Defined Contribution, and Hybrid Plans
Senior Capstone Project for Katie Heeder

PBGC. (2009). *How pbgc operates*. Retrieved from
<http://www.pbgc.gov/about/operation.html>

Poterba, J, Rauh, J, Venti, S, & Wise, D. (2007). *Defined contribution plans, defined benefit plans, and the accumulation of retirement wealth*. NBER Working papers 12597, National Bureau of Economic Research, Inc

Watson Wyatt. (2003, September). *Court rules that cash balance plan and pep are age discriminatory*. Retrieved from
<http://www.watsonwyatt.com/us/pubs/Insider/showarticle.asp?ArticleID=11812>