GRABBING THE TIGER BY THE TAIL,

A HYBRIDIZED RETIREMENT SYSTEM

MEASURED THROUGH THE STAKEHOLDERS' EYES

By

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Abstract: The changing landscape of retirement systems throughout the world presents many challenges for governments, employers, and participants. The future for employees have dimmed with the retreat of pension plans, and the shifting of investment and longevity risks to ill prepared employees. A hybridized model is created to limit the risk to the employer and to improve outcomes for employees who have behavioral obstacles to purchasing annuities at retirement. The model is measured for employers in two different fashions replicating current corporate funding constraints and financial accounting measures. A $3 billion company provides the census information in which to test the model. The model is also created to simulate distribution patterns utilizing the deferred annuity. The results show that the employer's risk is reduced by approximately 90% in the cost structure as compared to a traditional pension plan. We also find that employees can reduce their probability of total ruin by 90% using a deferred annuity at retirement as opposed to the typical 4% rule used in today's financial planning world. The hybrid model is a win-win for all stakeholders.

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CHAPTER I

INTRODUCTION

According to actuarial lore, an actuary for the Metropolitan Life Insurance Company, Reinhard Hohaus may have been the originator of the term for the three-legged stool of retirement. The first component of the stool was funded by the individual through private savings. The second leg of the stool was an employer-sponsored arrangement, originally a defined benefit plan or pension plan. The third leg of the stool was funded by the public is known in the United States as Social Security. It is well known that the savings rate for individuals in the United States is very low. There has been a significant drop in pension coverage for employees and Social Security has been stressed due to demographic shifts and longevity gains of the populace. Since each leg of the stool has serious problems, new thoughts regarding retirement systems must be investigated. The traditional roles of each player must be challenged and reconsidered. This paper looks to provide a different perspective on the risk sharing characteristics common in today's system.

Defined benefit plans (named because the benefit at retirement is defined in advance) became the staple of retirement income during the United States advancement in manufacturing during the

1950's and 1960's. These plans faced serious challenges, including a volatile financial system, a mobile workforce that did not remain with one employer during their career, and expensive government regulation. As a result of these changes, corporate and public plan sponsors disallowed new entrants from entering the plan, or froze the plan or simply terminated the arrangement. These plans eventually were replaced with defined contribution plans (named because the contribution was defined in advance, but the benefit at retirement was variable).

Defined contribution plans allow the plan sponsor to fix the cost of the plan in advance, thus allowing for simpler budgeting. The employees become responsible for investing the dollars and ensuring that their account can last a lifetime, whereas their prior pension would have been paid over a lifetime. Both defined benefit and defined contribution plans can produce similar results under an assumption regarding future contingent events. However, the risks inherent within each system are different with the employee retaining investment risk and longevity risk in the defined contribution plan. Plan sponsors retained the responsibility for the same risks in the defined benefit plan.

As a result of these issues, which are inherent in each system separately, this paper will investigate a new type of system that takes the best of a defined benefit plan and marries it to a defined contribution plan into one design. The defined contribution approach is meant to fund the early years of retirement. Once a limited time period is met, the defined benefit portion begins and hedges longevity risk. The defined contribution portion has a finite time period to fund the benefits, which changes the nature of the investment portfolio and distribution pattern for the participant. The defined benefit portion is mandatory and only payable if a person lives to the appropriate age. Each plan works together and forms a hybrid plan. It will be hypothesized that employers fare better under this arrangement than a typical defined benefit plan and employees will have better success through retirement income possibilities than a traditional defined contribution arrangement.

A key component to the hybridized system is the use of a longevity annuity within the scheme. A longevity annuity is simply a long-dated deferred annuity, such as beginning at age 85. Significant research has been performed to study the effects of a longevity annuity when purchased by an individual at retirement to hedge their longevity risk. Scott (2008) has shown that longevity annuities can assist in changing spending patterns by allowing a person to spend more in their earlier years when they may desire to utilize higher amounts of retirement dollars to travel, purchase items or whatever their desires may be. The longevity annuity, in conjunction with an account balance can produce better results than attempting to deplete a lump sum payout when your lifetime is uncertain.

Current research has focused on the underfunding of pension plans at the public sector level, the further deterioration of coverage of pension plans and its reasons, the distribution strategies at retirement of 401(k) balances and the use of behavioral techniques of implementing negative options including negative election and automatic increases. Negative options include automatically enrolling participants and also automatically increasing contribution rates. These are deemed negative since participants would have to negatively elect (or fill out a form) to deny the application of the option.

Recently, the distribution patterns at retirement have received some interest by modeling different withdrawal patterns with an eye towards minimization of risk and optimal payout schemes. However, the literature has been lacking in creating a model that also examines the input to the system, rather than the output and its effects on the sponsor. This paper will focus on a model that hybridizes a defined benefit and defined contribution design that maximizes a result for the employer (the input). This model will reduce the typical risks that sponsors bear when creating a retirement plan for its employees by sharing the risk in a different manner, and allowing the defined benefit scheme to function much like typical insurance by covering the tail risk, rather than the whole retirement risk as is the case in virtually all retirement schemes.

The paper will hypothesize that the risk the employer shares in providing a similar type of retirement program that a traditional defined benefit plan provides will be significantly lower than providing the defined benefit plan on its own. The metric that will be developed in this paper will be calculated from a stochastic process that compares the volatility of the contribution for the hybridized plan and a current traditional defined benefit plan. This measure will be called the Pension Efficiency Ratio. The Pension Efficiency Ratio will have in its numerator the standard deviation of the contribution for the hybrid plan based upon stochastic modeling of the pension contributions. The denominator will be the standard deviation of the comparative design's contribution, the defined benefit only plan. The ratio will reflect the fraction of volatility from one design to another.

In addition, the paper will also hypothesize that a participant will have a better outcome than a simple defined contribution approach. This will be demonstrated by modeling participant outcomes under a defined contribution approach against the hybridized approach. The measure for this approach will be to compare the probability of ruin for the defined contribution plan versus the probability of ruin for the hybridized plan. The probability of ruin will incorporate stochastic modeling of longevity.

The final hypothesis will test the efficiency of the distribution pattern by researching the remaining account balance at death while continuing use of stochastic mortality. It will be hypothesized that the hybridized approach will have a higher efficiency, with lower account balances at death.

Current State of Pensions

Before entering the current state, it is important to understand the role of pensions in our history and how we came to the present. Wooten (1998) provides a history of pensions and discusses the rise of pensions after World War II, with the auto companies leading the way in providing

pensions to the members of the United Auto Workers. Packard Motor Car Company had merged with Studebaker in the 1950's and had a failure of one of their pension plans when a factory was closed in 1958. This termination started the process in which the UAW began educating the government that a termination insurance program needed to be created. Eventually, Studebaker closed its last plant in South Bend, Indiana. This event precipitated the future law called Employee Retirement Income Security Act, or ERISA which was passed in 1974. When Studebaker failed, retirees would receive all their pensions, and so would those who were retirement eligible and age 60. These pensions would be provided by an insurance company. However, those who did not meet those eligibility requirements would receive something drastically different. If the participant was vested, they would receive 15 cents on the dollar. Those who were not vested received nothing.

Many people in the industry theorized that once the ERISA Act passed, that the day of pensions would be short lived. The main reason for this thought was that the flexibility that plan sponsors had enjoyed would now be curtailed through the implementation of minimum funding rules. ERISA also hailed the creation of the Pension Benefit Guaranty Corporation, which insured the possibility of failure of pension plans. The cost of this insurance was not free and any pension plan that was subject to ERISA would have to pay these premiums. Governmental and church pension plans were not necessarily subject to the law and, therefore, would not have to pay the annual premium (which is based on a head count and a percentage of unfunded liability).

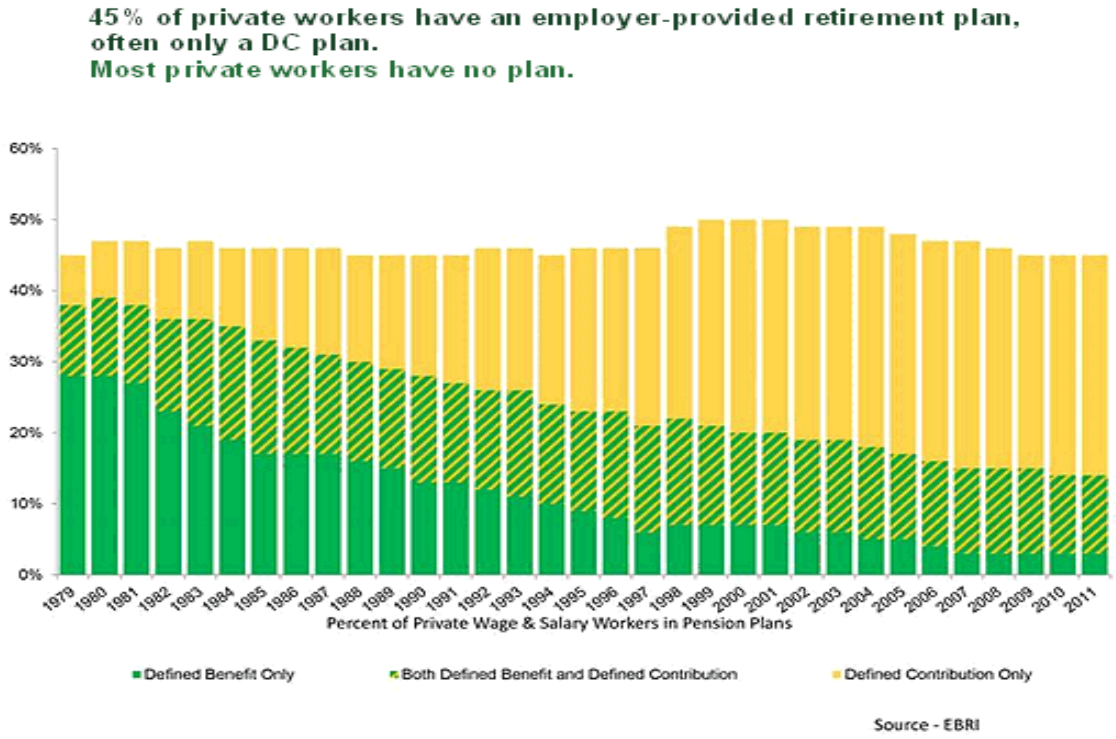
These pages are where you type in the title of your chapter and add the body (text, images, etc.) of your thesis. To best preserve the proper formatting and margin alignment, you should do this one chapter at a time. On the title page of the chapter, you can type in the title of your chapter over the placeholder text if necessary. Then, directly under the chapter title, you can begin either typing in or pasting the body of your first chapter. However, on this first page, you should **only** add enough content to fill this first page. If you typed in too much content or pasted in too much

content so that it created another page, delete this content on the second page and backspace until you are back on the first page. If you do not do this, the margins may be incorrect on the following pages.

Trends

After ERISA was passed, a downward trend in pension coverage began. In 1980, total defined benefit plan coverage peaked by covering nearly 40% of all people. This coincided with an IRS Code change in 1978, and further clarified in 1981, called Section 401(k) (EBRI, 2005). At this point, many large companies began implementation of 401(k)'s, leading to a large increase in the coverage of participants for the 401(k) benefit as shown on the following chart.

Figure 1



Another measure of the trend is to see the amount of asset growth in the plans. As might have been expected, there has been considerable growth in the asset position of defined contribution plans and a leveling of defined benefit plan assets.

Figure 2

Figure 1. Total Financial Assets in Retirement Accounts, 2007 to 2013 ($ trillions)

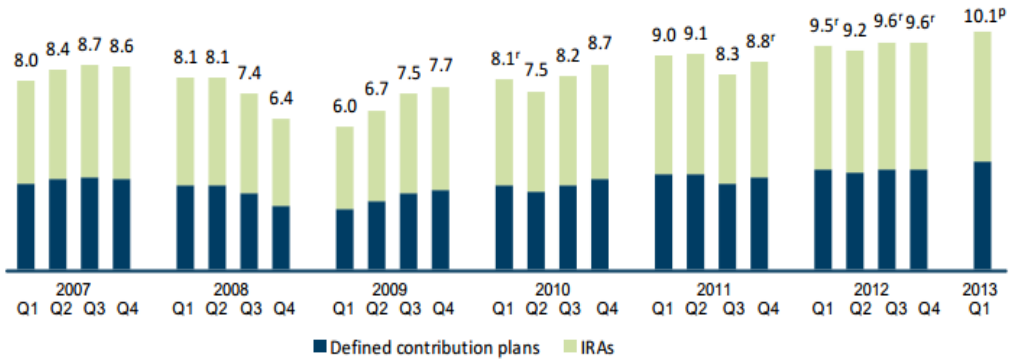
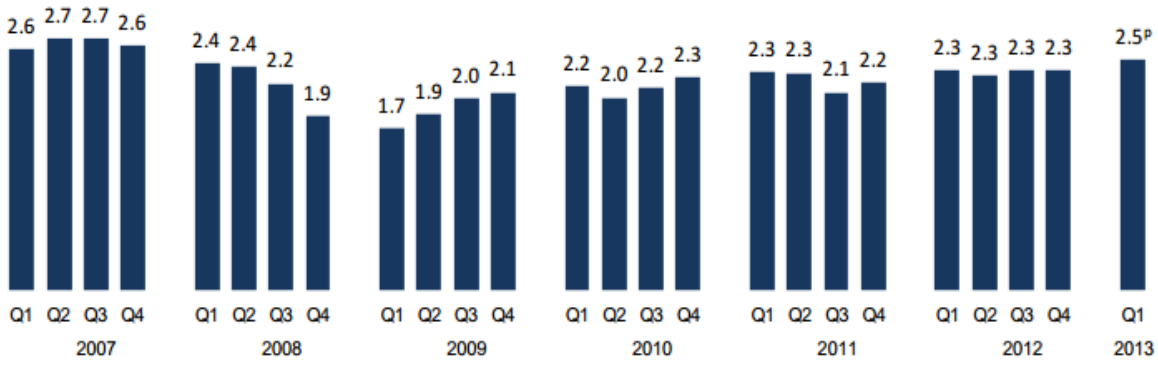


Figure 3

Figure 2. Total Financial Assets in Defined Benefit Plans, 2007 to 2013 ($ trillions)



The reasons for the shift from defined benefit to defined contributions plans have been studied by many academics. Munnell and Soto (2007) outlined a number of different reasons for the changes in retirement plan types. They mention that the workforce was changing and the youth preferred the defined contribution approach. Along with this, since the stock market was roaring, it made investing look easy. They also discovered that industry was changing and large legacy costs were making defined benefit costs higher. Defined benefit plans were very useful for large, established companies and were subject to those legacy costs. Since high-tech firms were becoming more prevalent, along with their associated volatile earnings, the discretionary nature of the defined contribution plans was much more appealing. They also note the increasing costs of regulations, including faster vesting, minimum participation rules and PBGC guarantees that reduced the attractiveness of pension plans.

Rauh and Stefanascu (2009) studied this further and concluded that companies that were freezing their pension had financial difficulty and needed to improve their balance sheet. Other companies made changes to their pension, such as converting to cash balance plans (another form of pension). These companies, however, were financially viable.

The funding position of pension plans have been improving since the market crash in 2008. Milliman (2014) reports that corporate pension plans are funded at 91% as of the end of January 2014. The actuarial assumptions regarding the funded status usually have an interest rate that tracks Moody AA corporate bond yields, as that rate is taken to be similar to a market equivalent. While pensions are settled by a lump sum rate (determined by the Internal Revenue Service) or through an insurance company, the Moody's rate is accepted by the accounting profession.

Public sector pension plans, which do not have ERISA as the governing law, show a much different result. Significant research has been developed regarding the funded status of public pension plans. Many different arguments have been made regarding the proper assumptions to

use for determining the funding status. Public Fund Survey (2014) calculates the funding status for 99 statewide systems (states may have more than one system). Utilizing the average return assumption of 7.9% and a smoothed actuarial value of assets, they calculate a funding ratio of 73% as of December 31, 2011.

The current situation for defined contribution plans also remains murky. Vanderhei, Holden et al. (2012) researched the data concerning account balances for 401(k) plans. They found that the average account peaked at $65,454 in 2007 but dropped to $58,991 in 2011 after the market crash of 2008. While the average balance in 1996 was $37,323, the median balance was $11,600 in 1996, rose to $18,942 in 2007, dropped to $12,655 in 2008, and was at $16,649 in 2012. The mean and median balances demonstrate skewness, but further, also demonstrate defined contributions plan assets are not sufficient to support a person in retirement. The volatility in the account balance may also hold some meaning to those nearing retirement. Gustman, et. al, (2009) concludes that the people most affected by the change in account balance are those with large balances and who may be wealthier. Therefore, they may not be nearly as impacted by the resulting market loss. They also note that because of defined benefit plans, people were not as necessarily impacted by the 2008 crash.

Defined Benefit or Defined Contribution?

Is there a correct plan for the populace? In many ways, a defined benefit plan is a paternalistic benefit according to Weiss (1991). Bodie, Marcus and Merton (1985) described the tradeoffs to each plan design in their National Bureau of Economics Research Working Paper. Overall they view that defined benefit plans have the advantage of providing a stable income at retirement if their utility is related to their replacement rate. They view defined contribution plans as savings plans that have value in high-inflation times. The employees also can value the defined contribution plan and it is fully funded at all times. Bodie et al. also propose that further

investigation should be done with plans that combine the best attributes of the defined benefit plan and defined contribution plan, as this paper will do. They propose the never-used floor offset plan, with a defined benefit floor and the upside of a defined contribution plan. The following table shows some of the advantages and disadvantages of the defined benefit and defined contribution plan.

Table 1

DB Pros to the Employer	DB Cons to the Employer
Excess investment return lowers contribution	Negative returns increases the contribution
Higher than expected mortality rates reduces the contribution	Costs of administration
Able to discount for future withdrawal decrements	Longevity risk
Can provide early retirement incentives	Contribution volatility
DB Pros to the Employee	DB Cons to the Employee
Predictable benefit stream	Do not benefit from investment gains
No investment risk	Lack of understanding of benefit
Insured by the government	Generally not a portable benefit
DC Pros to the Employer	DC Pros to the Employee
Determinable cost	Easily understood
	Portable benefit
DC Cons to the Employer	DC Cons to the Employee
Difficult to provide an incentive to retire	Must bear investment risk
	Must bear longevity risk

Poterba, Rauh, et. al. (2007) examined retirement wealth accruals for both defined benefit and defined contribution plans. They found that private sector defined benefit plans produced lower retirement wealth than defined contribution plans but were less likely to have very low retirement wealth incomes. This result was explained by the different asset allocations that could be utilized in the defined contribution plan. High concentration in fixed income would reduce the wealth in the defined contribution plan. The governmental side produced similar results if the individual in the defined contribution plan invested heavily into equities. If a person is a risk-averse investor, the defined benefit plans produce much larger results. It should be noted that the richer formula provided by governmental entities provide higher wealth than the private sector

An interesting question is what plan does a person choose when provided an option between defined benefit and defined contribution plans? Clark and Pitts (1999) studied a university plan to research this question. In this study, new university employees were given a choice between the two types of plans. They found that the choices followed the theory that people will choose the plan based upon future events and their own preferences. Older new hires chose the defined benefit plan and the rest strongly chose the defined contribution plans. They found that the most significant reason was the possibility of mobility in the position and whether the benefit would be portable in a job change.

This was also studied internationally by Cocco and Lopes (2011). They found that those who are on the fast track for earnings growth choose final average pay defined benefit plans. If a person has higher income risk, they may choose the defined contribution plan. They also found similar results to Clark and Pitts regarding those who expected to be mobile in their job. These tended to choose defined contribution schemes.

Overall, there are many reasons to select either the defined benefit or defined contribution plans. A person's pay, job prospects, mobility, risk profile, type of employer, etc. all are variables that may affect their choice, should they have one.

CHAPTER II

LITERATURE REVIEW

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The Purpose of Pensions

As has been shown earlier, pensions have played an important part in employees' careers with their companies. This section will discuss two different economic theories including the formation of pensions using annuities and the implicit labor contract.

Annuity Theory

ERISA and Internal Revenue Code Section 401(a)(11) require that defined benefit plans offer annuities as the default choice. If a participant is married, the default choice includes coverage for the spouse should the participant decease. However, plans may allow participants to choose a lump sum, but that is at the sole discretion of the plan sponsor. There is a theoretical argument to providing a life annuity at retirement.

The original research on this matter is presented by Yaari (1965). Yaari studied the effect of choosing an annuity in regard to theory of the lifecycle consumer. His report examined the role of annuities as opposed to risk-seeking assets in order to avoid lifetime economic ruin.

He found that annuities are a preferable choice to financial assets. Important to this analysis was the additional constraint regarding an uncertain lifetime. The three important assumptions he made were:

a. Investor maximizes their expected utility
b. All markets are complete.
c. Markets are frictionless and actuarial pricing is fair.

Davidoff et.al. (2005) furthered this research and relaxed several assumptions, including an actuarially fair assumption and confirmed Yaari's findings. This research was completed with an eye towards reasons why the annuity markets are not as developed as one would expect. They suggest that the reasons could be behavioral in nature.

Implicit Contract Theory

Why do pensions exist? Is it an agreement between workers and their employer for lower wages in exchange for deferred compensation?

Blinder (1982) attempts to define why pensions exist and discusses how classical economic theory is related to pensions. He demonstrates, under a Modigliani Miller Theorem for pensions, a neutrality of pensions. Under this approach, a dollar of income is no different than a dollar of savings. The five key assumptions are:

a. There is no uncertainty of any kind
b. There are no taxes, no governmentally imposed-pension system, or no laws regarding private pensions
c. Capital markets are perfect

d. Every worker is paid fairly (implicit in this approach is a defined contribution retirement plan)

e. No job has compulsory retirement

Blinder concludes that pension plans exist because of the tax advantages and the ability to reduce employee turnover. He also believed Social Security exists to redistribute income among the populace and provide a safer vehicle for saving. He ends with a question regarding why was the private system prior to Social Security non-existent, but after World War II it become a large part of society?

Another explanation is proposed by the legal theory of pensions where the amount accrued to date is what is important. Sharpe (1976) examined the effects of funding a pension plan under three different scenarios: 1) No insurance covering the risk of the pension plan and corporation failing, 2) partial insurance coverage and 3) complete coverage for the failure of the pension plan. The last scenario was developed in response to the formation of the Pension Benefit Guaranty Corporation in its role as government role insurer. Sharpe concluded that in the presence of insurance, the pension model doesn't present much of a risk to workers, therefore they may not be considered bondholders in the corporation.

Bulow (1982) argues against an "implicit labor contract". The implicit contract he discusses involves the promise of inflation protection while working, which is demonstrated by a typical final average pay pension plan where the benefit is based upon pay at retirement versus current pay. Implicit in this argument is whether younger people are accepting a lower pension accrual (therefore lower total pay) versus older people who have higher pension accruals. Bulow argues for the accrued benefit and resulting legal theory of pensions, that only the benefits earned to date are important in the analysis of the firm. Both Bulow and Sharpe argue that the plans can be terminated at any time with only the resultant accrued benefit being paid.

Implicit contract theory as stated by Ippolito (1985) views pensions in the context of the employer's balance sheet and the resultant claims that can be made. He uses prior research from Treynor (1977) arguing the pension must be looked at in context with the firm, rather than in isolation, as most actuaries perform their analysis. The implicit contract theory states employees view their compensation package in total, and pensions provide a reason to complete their career with their employer. The pension provides an incentive (due to its final average pay component) to have the employee "save" earlier. Another conclusion is that pension liabilities are larger due to the recognition of the complete career, essentially quantifying the final average pay into the liability of the pension. Ippolito found employees who were covered by a pension did have longer tenure than those that were not covered by a pension, thus showing that there is value that must be accounted for in the typical final pay scheme. The conclusion is that using nominal interest rates, rather than rates adjusted for inflation, would show underfunded pension plans versus overfunded pensions. Ultimately, the pension participants become bondholders to the company and since pensions accounted for approximately 25% of the equity value of companies, the stock price of the company is affected. Ippolito (1987) shows more data supporting the implicit contract theory and Lazear (1990) confirms the turnover results, when pensions are in place.

Pension Pitfalls

Pension plans and their effect on corporations and governmental entities have been a large part of media coverage over the last decade due to high profile failures and underfunding after the market crash of 2008. This section will summarize a number of the issues that pensions face.

Intergenerational Wealth Transfers

Currently, the unfunded condition of many municipal pension plans are an issue. Early work on the thoughts regarding funding led to a theoretical framework regarding the necessity of funding a

governmental pension plan. Initially, Samuelson (1958) tackled the problem by examining how individuals would save for retirement. He found that this would be difficult and therefore, the younger generations must make a compact with the older generation to solve their retirement income issue. This would be done with the knowledge that future generations would fund the current generation. Thus, the idea of a social compact exchange across generations was established. He concludes all generations are better off.

Aaron (1966) researched implicit returns on reserves for governmental pensions and found that if the sums of the rate of growth of wages and of the growth of population exceeded investment returns, there would be no need to fund governmental pensions. Breyer (1989) further reviewed this system and determined that if a pay as you go system is replaced by a funded system, you cannot make whole those pensioners in transition without negatively impacting a future generation. Homburg (1990) showed that the assumption of lump sum taxes are key to that design. Should taxes be levied on a flat rate basis, the scheme can become efficient. Brunner (1996) challenged this work by changing the assumptions of the generations to a more realistic group and found that the transition to a funded system creates intergenerational redistribution of wealth. Rauh and Novy-Marx (2008) in their analysis of intergenerational transfers state that simply prefunding and investing in equities to achieve a higher rate of return does not automatically reduce future generations' burden of supporting the past. They also cite the case of the Pension Benefit Guaranty Corporation and its recent decision to enter the equity markets. They argue that because the Pension Benefit Guaranty Corporation will be funding bankrupt companies' pensions, they should be short the market, not long. Finally, Findley and Caliendo (2008) discuss that if the internal rate of return of an unfunded system is less than the market return, some consumers may still succeed due to their lack of ability to estimate their benefits. They concluded that the results are mixed on whether the unfunded pension may produce better results when earning a lower market rate and attempted to offer behavioral reasons.

A different line of research regarding government funding was created by Asimakopolous and Weldon (1968) as they built models to examine the economic view that trust funds are not necessary for governmental pension plans. They also discuss how governmental pension plans are not developed to determine a future retirement income for a group, but to redistribute current income among the collective group. They develop a social welfare function that may subdivide the population into groups with different preferences. Overall, they conclude that governmental savings represent a collective activity. Weldon (1976) followed up the paper with a discussion confirming that there truly is a theory on intergenerational transfers. The issue becomes that the test periods are over generations that forgo the ability to set appropriate assumptions. Asimakapolous (1980) followed up this with further commentary that the future is uncertain and that economic theory must recognize this uncertainty for public pension plans. He also disputes Samuelson's (1958) results by postulating that classical economics fails by the lack of assumptions regarding the future.

Some municipalities have funded their pensions on a pay as you go basis, but most have set aside reserves to cover the future contingent liabilities. Novy-Marx and Rauh (2011) recently commented on the underfunding of municipalities, but that is not necessarily news as many are very aware of the problems facing governmental entities, including Detroit. Epple and Schipper (1981) had studied the underfunding of governmental pensions and attempted to research an answer. Their first conclusion was that the immediate compensation of municipal employees was increasing, which ultimately led to higher pension costs. They also postulate that with the baby boom generation producing a bulge of the cohort of children, the need for governmental services has increased faster than the tax base of the population, thus creating an underfunded situation. They believed that the costs would decline as the school-aged childrens' population declines.

On a worldwide basis, the treatment of funding pension plans was studied by Barr and Diamond (2010). They developed a three-tier system that reflected the type of country that sponsored a

plan. A first-tier country would be industrialized and fund a contributory pension with relieving poverty as the goal; a second-tier country would follow different schemes including pension and defined contribution arrangements. The third-tier would fund a pension that may initially operate on a pay as you go basis until growth allows a funded form of retirement. They also state that economic theory shows that pension systems have multiple objectives, there is no perfect system and the move to fund the plan must be carefully made as there is no right answer.

Effect of Regulation

Pensions have been regulated since 1875 with the American Express Company forming the first private pension plan (EBRI, website). The culmination of regulation was the passage of ERISA in 1974 as mentioned in the Introduction. At least 23 additional Acts were passed since ERISA, even before reaching the 21st century. Many of these regulations were imposed to provide either different benefits to employees or to reduce the risk of failure of the pension. However, intermingled within the regulation was also a notion that affected the tax collection of the government. For example, the highway funding bill of 2012 relaxed contributions to pension plans, which increased revenue to the government due to lower tax deductions. There is a question of how regulations affected pension plans.

As shown earlier in Table 1, there is a trend from defined benefit to defined contribution plans. Gustmann and Steinmeier (1992) analyzed this issue and found through testing Form 5500 data, that at least 50% of the shift has been because of trends in industry, firm size and unionization status. Regulation has been a part of this change, but not the majority. Ippolito (1988) also found the same results and also concluded that a large part of the shift was the creation of section 401(k) of the Internal Revenue Code (which is a regulation).

Ostaszewski (2001) tested governmental regulation effects versus other effects, including New Economic Theory (which says that employees view their whole benefit package including health

care in total) and Risk Averse Employer Theory (which says that employers wanted to reduce their risk). In his analysis, as opposed to common laymen thought, the New Economic Theory provided the highest level of explanation for the shift of companies to defined contribution approaches from defined benefit approach. The effect of regulation was shown to be negligible in relationship to the reduction in pension coverage.

For the studies that have been done in regard to the shift, the general consensus is that government regulation was not the cause of the shift, but the changing landscape of the employer drove the change to defined contribution plans.

Impact on Plan Sponsors

A pension plan can affect many different aspects of the plan sponsor, including cash flow, equity valuation, debt issuance and compensation for employees across all age bands (Bulow et. al. 1985). The highest level problem and risk that the plan sponsor may face would be bankruptcy, as was seen by Stockton, California, Detroit, Michigan, the State of Illinois and all the large steel mills, airlines and automotive manufacturers.

Rauh (2008) examined how plan sponsors invested pension assets in relationship to the financial viability of the plan sponsor. He found that plan sponsors became less risky as their financial condition worsened. This was interesting as many might expect that as a plan sponsor was closer to bankruptcy, the riskier the plan sponsor might behave.

Corporate debt ratings are important when companies need to issue debt. Carroll and Niehaus (1998) found that underfunded pension plans affected the bond rating more than an overfunded pension plan. They attributed this to the fact in an asset reversion for a terminated overfunded pension plan, the government exorbitantly taxes the excess to essentially leave nothing behind for the employer.

Bader (2004) makes the argument that in many ways (in absence of a governmental guarantee system) the plan sponsor is borrowing from the employee for the underfunded pension plan. An example of this could be Detroit as the pensioners may well be treated like any other bondholder and take a "haircut" for the underfunding of the plan.

Underfunding

Since pension plans are a promise to pay a benefit in the future, corporations are required to contribute assets in order to fund these promises. Governmental entities are exempted under ERISA to fund these obligations. However, as has already been noted, the underfunding of the plan has ramifications to corporations in their stock price and ability to issue debt. Governmental entities also are affected by the underfunding by the ability to issue debt as well. The next two sections will outline the effects of the underfunding for these organizations.

Public-Sponsored Pensions

The funding level of public pensions has received serious media scrutiny. However, the true level of the funding has historically been somewhat opaque. Novy-Marx and Rauh (2009) and (2011) use a different methodology to determine the interest rate in calculating funded status. Using zero coupon Treasury bills as the interest rate, they calculate a 43% funding level as of June 2009. Brown and Wilcox (2009) concur on the use of the risk-free rate, as the cash flows are riskless due to constitutional constraints. The Novy-Marx and Rauh methodology does not take into consideration pay inflation, which corporations are required to acknowledge. This would make the funding status of governmental pension plans worse than the 43% level. Overall, the underfunding may approach $3 trillion.

Brown, Clarke and Rauh (2011) examined the reasons of how the public sector became more underfunded than their corporate counterparts. They state that the public sector plans utilized higher equity allocations that often exceeded 70% of assets. They also mention that public sector

plans failed to make the necessary contributions suggested by actuaries. ERISA does not apply to public sector plans and the minimum funding standards for corporate do not exist in the public sector world. Thirdly, they note that public sector plans made benefit improvements during good times and no corresponding reductions in benefits in bad times. Verbon (1987) also noted the increase in benefit levels internationally in the same context. These reasons combined to produce the lower funding status. Finally, they note that defined contribution plans are becoming more prevalent for governmentals than in the past.

Private (Corporate)-Sponsored Pensions

An underfunded pension plan impacts many facets of the plan sponsor. Since cash contributions are mandatory under the Internal Revenue Code, the ability to generate cash is important. Also, as a pension plan can be under or over funded, the balance sheet of the organization is also affected. This can affect the corporation's ability to issue a bond or may affect its stock price.

Rauh (2006) analyzed corporation's ability to make capital expenditures when faced with mandatory pension contributions and found that the pensions did limit capital expenditures. He also found that firms that did not have pension plans were able to spend more on capital expenditures than their counterparts with pension plans.

Studies have been done by Feldstein and Seligman (1981), Bulow, Morck and Summers (1985) and Jin, Merton and Bodie (2006) that show that a firm's stock price is impacted by the valuation of its under or overfunded pension plan. They note difficulty in the ability of translating through opaque accounting numbers and also mention that firm's values do drop by a $1 per $1 increase in liability but not necessarily the same $1 per $1 per asset value as the assets cannot revert to the employer.

The tax status of the employer may have some relationship to defined benefit selection and funding. Thomas (1987) showed that if an employer had a higher tax rate, they were more likely

to have a pension plan and also more likely to contribute a higher amount. Higher taxed entities also had higher levels of funding and used more conservative assumptions.

Finally, does the presence of a pension affect the firm's capital structure? Shivdasani and Stefenescu (2010) showed that companies are more levered when considering their pension obligations directly on the balance sheet. They asked the question of why companies do not lever up to the point where the marginal tax rate starts declining. This may be answered in regard to debt conservativeness by the presence of a pension. Once that is considered, the employer feels that it may have enough debt.

Shift to Defined Contribution Plans

The shift to defined contribution plans has been unmistakable. Towers Watson, an actuarial consultancy shows the shift for Fortune 100 companies.

Table 2

	1985	1998	2002	2004	2005	2006	2007	2008	2009	2010	2011	2012	Today
Total DB plans	90	90	83	73	62	57	53	47	43	37	33	32	30
Traditional plans	89	67	48	38	32	28	27	23	19	17	14	9	7
Hybrid plans	1	23	35	35	30	29	26	24	24	20	19	23	23
DC plan only	10	10	17	27	38	43	47	53	57	63	67	68	70

The shift has implications for both the employer and the employee. The following section details the resultant issues.

Effect on Plan Sponsors

Bodie (1985) , EBRI (2005), among others have discussed how the pension risks shift from the employer to the employee in the defined contribution world. Since the contributions are variable, corporations can now define their costs in advance (much like wages) and be able to budget more realistically. Obviously, this is better from strictly a financial perspective for the employer. Rubin (2007) found that freezing a pension and presumably switching to a defined contribution boosted firm value, though on a deferred basis. Comprix and Mueller (2011) found that employers had a downward bias in their accounting assumptions in order to stress the cost of the pension. They also found that earnings were immediately impacted.

There are other hidden aspects however, to this change. Ghilarducci and Sun (2006) examined Form 5500 information to determine employer costs in regard to the shifting of the retirement benefit. The administrative costs to provide the defined contribution benefit are generally smaller, due to the lack of an actuary and also the PBGC premiums. Investment expenses were not accounted for in this analysis. Also, the study did not account for hidden revenue sharing which is buried in the expense ratio that subsidizes recordkeeping costs. They did mention that there has been a significant shifting in costs to the employee. In a defined benefit plan, the employer bears all the investment costs and administration costs since the benefit to the participant must be paid in whole. In the defined contribution world however, the benefit is adjusted for the cost and the employers have been trending towards having the participants pay for the cost. The participants certainly do pay for the cost of the investment expenses in the plan. In total, employers are reducing their support for costs of retirement plans.

EBRI (2013) studies retirement confidence and has seen continued drop in worker confidence for retirement, even under better economic conditions. This may have negative impacts for employers as employees may work longer than the employer may want. Later retirement ages

may have some advantages including productivity, but the older ages have costs associated with them (Munnell, Sass and Soto, 2006).

Effect on Beneficiaries

In the past, employees who were covered by pensions did not have to have any skills for retirement planning. They did not have to sign up for the plan, they did not have to manage any assets, they did not have to compute what was necessary for their retirement and when they did retire, they simply received a check each month. In the defined contribution world, the employee now has to decide how much to save, choose the proper investments, take out the appropriate dollars at retirement and somehow ensure that the pot of money was not exhausted before they died. Employees now need to become financial accountants, investment experts, actuaries and finally financial planners. Is this even possible?

Shift of Investment Risk

The shifting of the investment making decision is one of monumental shifts in retirement plans. There has been research on the optimal methods of portfolio creation for those in defined contribution plans. Haberman and Vigna (2002) conclude that risk averse employees should be in investments which reduce equity exposure over time. Risk neutral employees should stay in risky assets for the full working career and never move out of them until retirement. Emms (2012) provides a similar model with annuitization on the back end. Both of these methods are similar to target date funds which are now prevalent within the defined contribution world, and viewed as solution to the investment risk.

Significant amount of research has been performed on target date funds including Bodie (2001) and Bodie (2007). He found that target date funds perform reasonably well, but also believed that there is further optimization necessary. He devised other methodologies to account for different

levels of risk aversion within a cohort and also suggested a hump like glide path versus a linear path.

In total return does a defined contribution plan produce better or worse results than a pension? Towers Watson (2013) examined returns from 1995 to 2011. This time period had significant market gains along with significant market losses. Their analysis showed that defined benefit plans produced an average 76 basis point excess return over this time period. The last five years, however, produced only a 39 basis excess return. The study also showed a dramatic reduction in equity exposure for defined plans over the last five year as opposed to defined contribution plans with defined contribution plans holding 14% more equity than defined benefit plans. The report also showed that the average fees for defined contribution fees for investments was 65 basis points, and completely paid for by the employee. Note that Towers database primarily included larger employers with lower fees. Olsen (2014) notes that defined benefit plans spend 43.7 basis points on investment managers.

Shift of Longevity Risk

Longevity risk is the risk that the participant would bear in regard to their life expectancy. As Laibson et. al. (2002) note, most defined contribution plans offer a lump sum as the standard choice in retirement as opposed to defined benefit plans which must offer an annuity. As mentioned earlier, Yaari (1965) showed that risk averse people would prefer annuities since it produces a higher utility. Behavioral forces could be responsible for people who do not to choose this option. Currently, advisors tell their clients to predominately use the 4% rule in retirement (Sun and Webb, 2012). This method, which says to spend 4% of the account each year, is assured to leave 96% of holdings in the final year.

Zelinsky (2004) summarizes the other risks with annuitizing the account balance in order to ameliorate this risk. The issues that a participant could face include understanding the pricing of

the product, health of the insurer, interest rate environment, locking in the benefit at an inopportune time, etc. This becomes a difficult decision for the employee.

Madsen and Tans (2012) propose another method to counter the longevity risk, by having an equilibrium retirement age. This age is individual specific and takes into account the current wealth of the participant and also the needs at retirement in order to have a floating retirement age.

Watson (2008) makes the argument that while defined contribution schemes may inject longevity risk to the employee, a defined benefit employee is subject to firm specific risk and that the pension plan may go bankrupt and the retiree may lose a significant balance. While this may be true, there are other factors at play including government insurance.

MacMinn et. al. (2006) once again make the argument along with Brown (2000) and Brown (2007) that annuities are simply the best way to hedge longevity risk. Unfortunately, the populace does not agree given the sales of annuities.

There is no question that longevity risk is a significant risk that defined contribution plans transfer to the employee, rather than having a defined benefit plan bearing that risk, but there is a solution, and it is in the insurance market. It is simply unused.

Alternative Pension Models

As McFarland of Towers Watson (2013) has reported, there has been a dramatic shift from traditional defined benefit plans to either a hybrid approach or defined contribution only type of plans. Typical hybrid approaches include a cash balance design which provides a notional account balance within a defined benefit plan (Laibson 2004) or a pension equity design which defines a final average pay lump sum in advance (Green 2003). Advances in defined contribution designs include age weighted profit sharing accounts with larger allocations to older workers and

new comparability designs which also drive larger allocations typically to highly compensated employees (Laibson 2004).

Cash balance plans were primarily developed in response to employers demanding a retirement product that would accommodate a mobile workforce, and also stress the numerical value of the retirement benefit in an easy to understand fashion (Clark and Schieber, 2004). A cash balance account is hypothetically created to appear to be similar to a defined contribution account, with a pay credit each year to be contributed and an interest amount to be added to the account. It would not be uncommon that a participant would receive a 5% of pay credit and an interest rate related to one year treasuries. The benefit is guaranteed, thus a defined benefit component. Employees supposedly liked to know the value of the benefit and also the opportunity to take the benefit and roll the pension over when they terminated employment. Employers were attracted to the benefit simply because it generated a cost savings since the assets were earning greater rates of return than the amount being credited to the employee. Also, another attractive feature included the lump sum benefit which would then remove an overhanging liability of retirees that ultimately threatened the airlines and manufacturers. Harper and Treanor (2014) hypothesized that wealth transfer and the tax situation of the firm also figured into the decision to convert the plans into cash balance plans. The Fortune 100 essentially adopted this model, but it wasn't without controversy since IBM engineers calculated the before and after benefits and discovered a reduction in benefit for their plan. This prompted an unsuccessful lawsuit, and ultimately a freezing of the plan for IBM.

Green (Bureau of Labor Statistics 2003) shows that a number of large employers switched to pension equity plans. This type of hybrid plan also shows a notional balance but the increase in balance each year is tied to actuarial factors, and thus not as easy for the participant to understand. Only about 1% of large plan employees were in this type of design.

There have been other approaches developed including the aforementioned cash balance plans, a risk averse defined benefit plan called Green DB from Vanguard as written by Inglis (2011) and the next generation defined contribution plan written by Vernon (2013). The Green DB plan involves changing the funding mechanism in pensions to a bondlike liability driven approach to protect against interest rate fluctuations, and Vernon's defined contribution designs include annuity purchases at retirement. Both of these designs do not fundamentally change the inherent disadvantages of defined benefit and defined contribution plans.

The new comparability and age weighted designs for defined contribution plans were generally developed to allow for a more defined benefit like accrual rather than a simple level percent of pay allocation in defined contribution plans. These designs became prevalent when the plan sponsor would freeze the pension plan and then convert to a defined contribution plan. It was meant to keep the person whole, rather than taking a reduction in their benefit.

Overall, the different designs that have been developed do not change the nature of the landscape in regard to the employee and the employer. Cash balance plans and pension equity plans still have the same pitfalls as other pension plans, they just simply look more attractive to the employee. The defined contribution designs reallocated money from some people and gave more to the older worker typically. The risks in each design were not necessarily mitigated.

CHAPTER III

HYBRIDIZATION MODEL

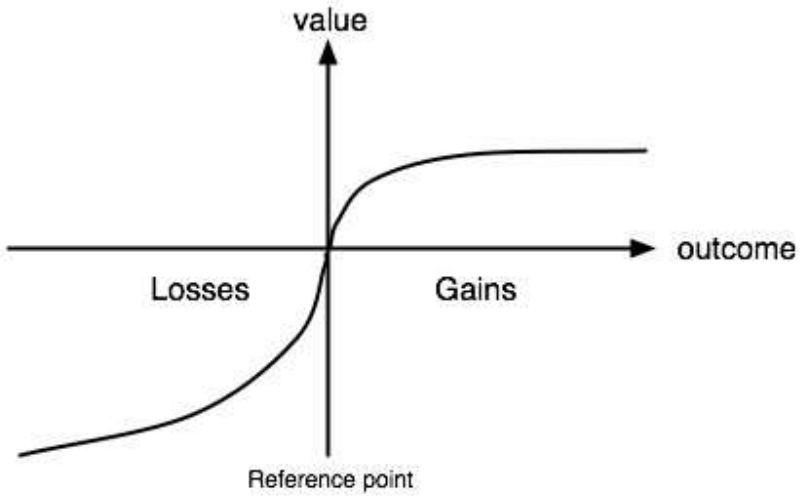
This paper investigates turning the hybridization technique upside down, by changing the risk sharing mechanisms within each plan. Currently, both the pension and defined contribution approaches share a distribution model that begins when the employee actually retires. This paper will change that model to having the defined contribution plan begin payment first, and having the defined benefit plan begin payment later.

Role of Annuities

Annuities form the basis of many pension plans, though they are allowed to offer a lump sum equivalent which is actuarially calculated under statutory rules for private pension plans. Defined contribution plans, however, do not offer annuities in any significant fashion (Kiplinger (2012)). However, given Yaari's view regarding annuities being an optimal solution when facing an uncertain lifetime, it could be expected that annuities are the payment form of choice when a person retires, since they can certainly annuitize outside the 401(k) in an IRA. This does not happen. Before examining the reasons, a discussion on prospect theory would be appropriate.

Kahneman and Tversky (1979) introduced prospect theory, a theory which proposes that people do not necessarily make decisions under classical utility theory. Generally, it has been understood that a risk averse decision maker would have a concave utility function. Kahneman and Tversky introduced the concept of a reference point and that the reference point could change the utility function from a risk averse status to a risk seeking status. Specifically they noted how people make decisions regarding gains and losses, and people tend to be risk averse on gains, and risk seekers on losses. The following chart displays the behavioral change:

Figure 4



They also performed experiments and attempted to ascertain how people view probabilistic events at the short end of the probability distribution or the tail end of the distribution. From their work, the found that people overestimate low probability events and underestimate high probability events. A chart displaying those results are below:

Figure 5

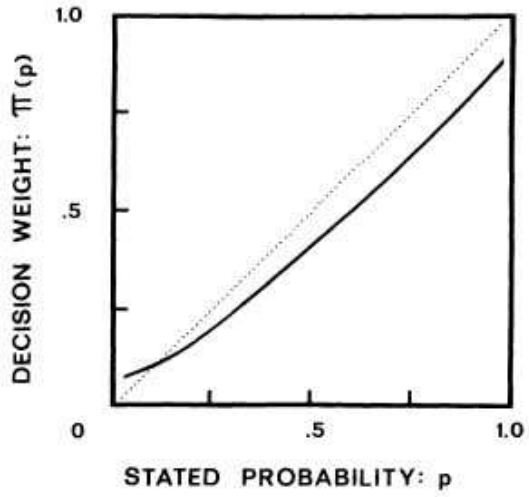


FIGURE 4.—A hypothetical weighting function.

Kahneman and Tversky (1992) along with editorial commentary from the Journal of Behavioral Finance (2003) summarize the phenomena of choice with evidence from experiments into the following five results (all stemming from behavior):

1. Framing effects: people make choices based upon how they are framed, versus typical theory which would not account for framing.

2. Nonlinear preferences: The expectation principle says that the utility of risky choices is linear in outcome probabilities. However, it has been shown that people view a change from 99% probability to 100% probability differently than moving from 50% to 51%.

3. Source dependence-the source of the bet is important as people are willing to bet in their area of expertise.

4. Risk seeking-people make risk-seeking bets such as lotteries, when the bet seemingly unwinnable, and they will also assume a risk-seeking position regarding losses, when a loss may be certain.

5. Loss aversion-losses are larger than gains.

From this theory, the next step is to understand how people make the choices to annuitize or not to annuitize their wealth at retirement. As Yaari mentioned and Benartzi et. al (2012) agree, it would seem that the rational choice under an uncertain lifetime would be to annuitize the full amount. However the real evidence shows that this does not occur. Schmidt (2012) furthered research by seeing the impact of prospect theory for insurance and saw that people's final wealth was important as the reference point for determination of whether to purchase insurance or not.

Hu and Scott (2007) note that basically no full annuitization occurs in the real market outside of defined benefit plans and Social Security. Bannerjee (2013) also shows low annuitization in defined benefit plans when the option to lump sum is given. Hu and Scott recount Ellsberg's (1961) work that people prefer risky bets versus uncertain bets (where the probabilities are unknown). From Hu and Scott's work, they explain that many people do not choose annuities because of behavioral issues and certain advances in the market, such as variable annuities, may reduce the ability to frame annuities (specifically longevity annuities) as an appropriate device. They also conclude that prospect theory, with its overweighting of small probabilistic event choices, may help in assisting people choose longevity annuities. This will be discussed later.

Brown (2007) notes that behavioral economics has not addressed the annuity decision in the literature and hypothesizes a number of different reasons for low annuity demand. These reasons are similar to Hu and Scott, and are grounded in prospect theory. He also discussed the use of default options in 401(k) plans and the advantages of longevity annuities. Using a longevity annuity as the default would reduce the probability that people would not choose the longevity annuity. Gazzale, et.al, (2012) confirm the behavioral biases and their effect on annuity market demand. They also make the argument that framing the decision can significantly change annuity purchase behavior in retirement.

Purcal and Piggot (2012) built a model to explain internationally the low demand for annuities and concluded that bequest motives, high insurance loadings making annuities expensive and the prevalence of social security in countries all contributed to low demand of annuities. Bryck and Montminy (2012) found that the main reason to purchase an annuity for retirees was to supplement social security. Scott, Watson and Hu (2011) examined many different reasons for low annuity demand and concluded that annuity purchases should only happen when the mortality discount exceeds insurance company expenses. Since mortality discounts are lower at younger ages, this would represent a problem for younger retirees and their choice to annuitize.

The Society of Actuaries, through a study by DiCenzenzo et.al (2011) showed that annuity decisions could be influenced by providing factual information including life expectancies. This could change their reference from an uncertain lifetime to a risky lifetime and they may make a different choice. They also found that those who had knowledge of annuities, were more likely to choose annuities, confirming source dependence by Kahneman and Tversky. Gazzale, Mackenzie and Walker (2012) also showed that if life annuities were provided as the default and listed first when given an option of lump sums, annuity choices were influenced with an increase in choice of annuity.

A review of the literature shows that current thinking involves the behavioral biases of the population have limited the role of annuities in retirement. A system which does not allow the behavioral bias into the annuity decision may have a different current result than seen in the marketplace today. The next area to be examined is the role of the longevity annuity and its application in retirement.

The key to the hybridized model is the concept of a longevity annuity. A longevity annuity is simply a life annuity with a deferred payout date with no death benefit. In practice, a deferred annuity to age 85 is a common age to defer payments, as will be demonstrated in the next paragraphs. One concept that would be important to understand is the idea of a tontine. Milevsky and Salisbury (2013) describe the historical tontines and future tontine improvements. In 1693, the British parliament passed the Million Act which attempted to raise funds to pay for a war against France. In this case, investors would purchase a share and dividends would occur as long as the person was alive. Essentially, the dividends were paid from deceased people's shares. Prior to this Lorenzo de Tonti (from whom the name came from) had designed other forms of the tontine. In its simplest form, assume 100 people of age 80 invested $100 into the tontine, with the payoff being splitting the investment of anyone deceased. If the probability of dying was 10% for this age group, you would receive a dividend of $11 (10 people dying at $100 split among 90 survivors) for a return of 11%. This is essentially how annuities are calculated and create a significant return at the older ages when the probabilities for death are high. Younger ages do not produce the same desired results. As anti-selection started occurring (meaning some people remaining in the tontine might force the issue of death for the remainder, through say murder), tontines became outlawed. However, they produce an insight into annuities.

Stephenson (1978) demonstrated different facets in his paper called the High Protection Annuity. In his paper, he presented a few options to provide protection at minimal cost for someone who

retired at age 65. The basic math behind annuities shows that those who die early subsidize those who die later. He creates a protection metric that measures the amount of premium transferred from one risk pool to another as a function of the premium payment. For a straight deferred annuity purchased at age 65 and payable at age 85, he shows that the present value of the gain begins at age 78. In other words, those who expect to live from age 78 onward would benefit and be protected, though a high protection metric.

Milevsky (2005) furthers the concept and creates a term called Advanced Life Delayed Annuities (ALDA). This type of annuity is funded individually over time, has an inflation component and payable at a later date. The paper points out that the mortality credits (essentially the probability of death) functions similarly to investment return. This is the basis for annuity calculations. One of his main points is that "At advanced ages nothing beats the implied yield from a payout annuity". Using his calculations, the extra return at age 85 is 725 basis points. Milevsky, et. al. (2007) furthers this research and shows that annuitization should rarely begin before age 70. Huang, et.al (2013) created a new concept with the ruin contingent life annuity with payouts when the portfolio index is ruined. It is an option embedded in many variable annuity policies.

Furthering the research within the ALDA is Gong (2010) In addition to confirming the details of the calculations and benefits of the longevity annuity, he also modeled utilizing the annuity as a default for high mortality households. The losses for the longevity annuity were a fraction of those purchased as immediate annuities.

The longevity annuity has a special ramification as it deals with the decumulation phase of retirement. Cremer and Pestieu (2010) note that much of the literature has focused on the importance of accumulating assets for retirement, but the role of the decumulation phase is

equally important. Sun and Webb (2012) describe the three typical methods of decumulation phase:

1. Spend interest only, this process works for wealthy people and those willing to bequest the whole principal, but certainly is not efficient over a lifetime.

2. Life expectancy rule-base withdrawals on life expectancy. The main problem for this rule is that 50% of people will outlive their savings.

3. The 4% percent rule-retirees would withdraw 4% a year. This results in an inefficient outcome with significant wealth at date of death.

Milevsky, Moore and Young (2006) develop a model that mathematically computes the optimal amount a person should annuitize their investment at retirement. Obviously, the changes in the assumptions influence the results.

Scott (2012) shows that implementing a longevity annuity into the distribution phase can change the spending curve for a retiree. Since the tail end of longevity is now covered, a person can spend more in the early years, since they have paid a premium to insure their later years in life by purchasing the longevity annuity. He concludes that the longevity annuity is the optimal decision for those unwilling to annuitize the full amount of retirement income. Sexauer, Pesking and Cassidy (2012) create a portfolio where 88% of the portfolio is based upon a TIPs investment and 12% on a longevity annuity in order to create a reasonable distribution pattern at retirement.

The longevity annuity provides a useful tool that embodies what the ultimate purpose of insurance should be and that is to provide peace of mind for outlier events. Today's defined

benefit plans provide full coverage (rather than tail coverage), and defined contribution plans provide no coverage. The hybridization model attempts to bridge the gap between the two types of plans and avoid the behavioral obstacles found in today's annuity market when it is left to the consumer to make the choice.

Description of Hybridization Model

Retirement benefits are delivered in two different fashions which are called defined benefit and defined contribution. Defined benefit plans provide a predetermined formula for a benefit at retirement that is guaranteed by the sponsor of the plan. The benefit is also not subject to employees' whims of whether they participate in the plan. It is mandated. A defined contribution plan, however, provides a predetermined contribution to the retirement plan with no guarantee of a benefit at retirement. In the defined benefit plan, the plan sponsor is responsible for two major risks, investment return and longevity. In the defined contribution plan, these risks shift to individual participant.

As had been shown earlier, there has been a dramatic move to shift defined contribution plans across the United States. In these designs the defined contribution plan originally was used as a supplement to the defined benefit plan. However, in recent years, the plans are now the predominant source of income for participants.

A typical defined benefit design would guarantee a lifetime annuity at retirement for a person, generally based upon their pay at that time. Originally, it was designed to meet a predetermined target, such as 70% of final pay for the rest of a person's life. This traditional design allows for a simple way to provide a benefit to people that hits a target. Most employees, however, took these designs for granted during their working lifetime as there was no simple way to communicate the

value of the benefit. Once a person retired, however, the monthly check that came was easily appreciated and valued, much like Social Security. Over time, many additional features were added that included a preretirement death benefit, disability benefits, and cost of living adjustments. As these benefits are added, further costs are created due to the fact that people did not receive these benefits in the past.

To further complicate matters, the plans were redesigned to accommodate a workforce that was more transient. It did not make sense to provide an example 70% benefit to a person who might have only worked five years with an employer. These plans were adjusted to allow for accruals to match the working career of the participants. In this case, if a person worked a limited time frame with an employer would only earn a prorated portion of the final targeted benefit.

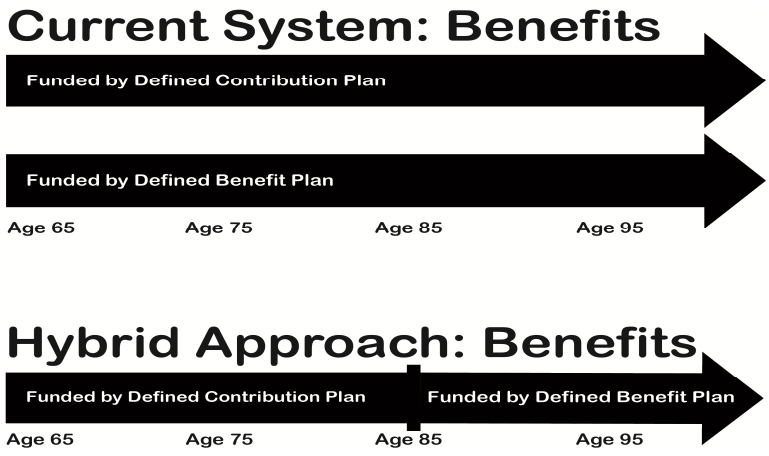
The next evolution of pension plans involved what is essentially a transfer of longevity risk and also an easier form of communication to participants. Plans began to offer a lump sum payment instead of an annuity for the person's lifetime. Under federal law, however, the plan could not eliminate the annuity and could only offer the lump sum as an additional optional form. Retirees found it easier to understand a $200,000 lump sum versus a $1,500 per month annuity at age 65. It may also be obvious that the retiree may appreciate the $200,000 lump sum more since the dollar amount seems so much greater than the $1,500 annuity regardless of the fact that they are actuarially equivalent. Participants, however, may not understand that they have now accepted both investment risk and longevity risk with the lump sum.

Defined contribution plans, on the other hand, are very simply designed. In general, they are composed of two different types of contributions, the employee and the employer. The employer either provides a contribution contingent upon the employee contributing (known as a match) or as a discretionary contribution regardless of the participant's actions. The participants know the

value of their account on a daily basis. While the employer may design their portion of the contribution to target a final result at retirement, there is no guarantee that the target will be met as the returns along with the contribution rate actually determine the benefit. Participants, however, do not have a very good basis for determining whether the account balances provide for a sustainable retirement in their latter years.

When the retirement systems are put together today, they produce a pattern of distribution which begin at retirement until the participant dies. Both the defined benefit plan and defined contribution plan start payments at retirement with no apparent connection in pattern with each other. Another way to provide the benefit stream is contrasted below with the current system to show how the systems could work in sync with each other in a different hybridized model:

Figure 6



The model proposed in this paper, stacks approaches and avoids the behavioral pitfalls of annuities.

The hybrid approach looks very similar to a longevity annuity by providing the backstop of a guaranteed income stream that begins when a person reaches age 85 that is designed to be a defined benefit approach. The longevity annuity is generally designed to be purchased at retirement at the choice of the participant. The hybridized system, however mandates a defined benefit plan for the tail purposes and a defined contribution plan approach for the early years of retirement in order to complement each other and provide a sustainable retirement to the person. This avoids the behavioral choice of the annuity through its mandated approach, and also reduces the risk to the employer since the risk of the approach is a fraction of the defined benefit approach. The employee benefits through a structured decumulation phase with the tail of their retirement covered by the defined benefit plan.

The model would be designed as follows:

Overall, a target replacement percentage would be determined for the full retirement stream. In this paper, we will attempt to replicate a 30% pay replacement for a 30 year employee. The typical pension plan that would produce this type of revenue stream would be a 1% three year final average pay times service plan. The target of a 1% three year final average pay plan generally produces a funding cost of approximately 6% of pay as will be tested in the report. We will call this base model “DB” only.

The second model will be the defined contribution plan. This plan will be designed around the same cost structure as the “DB” only plan. We will then test and reconfigure the benefit to be a new comparability design where the actual contribution in total will be the same as the “DB” only design, but the allocation will be based upon the age of the participant to drive a similar 30% pay replacement for a 30 year employee. Essentially younger employees will receive a smaller

benefit than older employers to account for the geometric progression of the compounding of interest.

The third model will be the hybridized model. The model stems from the actuarial formula for a life annuity:

$$\ddot{a}_x = \sum_{k=0}^{\infty} \frac{1}{(1+i)^k} \, {}_kp_x$$

The term on the left hand side of the equation denotes the life annuity, and the right hand size represents the time valued payment stream of $1 per year adjusted by the probability of death. This equation can be broken into two pieces, one which reflects a temporary annuity, still adjusted for death and the addition of deferred annuity which picks up payment after the temporary period expires. In this example the age is 65 at which payments begin, with a 20 year deferral period. The following equation shows the formulation:

$$\ddot{a}_{65} = \ddot{a}_{\overline{65:20|}} + {}_{20|}\ddot{a}_{65}$$

The follow table shows the actuarial computations for each component using a 4.5% interest rate and the 2013 mortality table based upon a unisex measure.

Table 3

	Life Annuity at 65	Temporary Annuity from 65 to 85	Deferred Annuity Beginning at 85
Present value of $1 annual payment	12.6	11.4	1.2
Percentage of life annuity	100%	90%	10%
Hybrid system	Total Hybrid	DC portion	DB portion

The formal model is now presented with each component pieces below allowing for the basic assumption of having equal costs (rather than equal benefits) for the employer:

Table 4

Name	DB Formula	DB Cost under PPA	DC Formula	DC Cost	Total PPA Cost
DB Only	1% FAP x Service, begins at age 65	6% of Pay	None	None	6% of Pay
DC Only	None	6% of Pay	6% of Pay	6% of Pay	6% of Pay
Hybrid	1% FAP x Service begins at age 85	.5% of Pay	5.5% of Pay	6% of Pay	6% of Pay

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CHAPTER IV

HYPOTHESES AND METHODOLOGY

Hypotheses

H1. Since the hybrid model combines the traditional DB only and DC only models, the hybrid model will provide smaller contribution volatility for the employer compared to the traditional defined benefit approach.

H2. The hybrid model provides a stacked distribution pattern which will reduce the probability of ruin for participants as compared to a traditional defined contribution approach.

H3. They hybrid model provides a more efficient distribution pattern for participants with the result that participants' balances at date of death are less than those using the 4% rule.

Hybrid Model and Effect on Plan Sponsor

Actuaries are trained in the mathematics of life contingencies and risk theory as the basis of the models that are used for life insurance, annuities, car insurance, health care insurance and pensions. This forms the basis for the methodology. Greene (1963) questioned whether a theory was appropriate on risk and mentioned there is no theory of insurance. He produced surveys on risk and found that people did understand risk to some extent was not able to affirmatively show whether this affected their desire to purchase insurance. Borch (n.d.) furthered the

concept with the help of utility theory and applied it to insurance and reinsurance to understand whether an insurance company should pay premium and cede risk. Under typical utility theory, the company should only cede a very little amount of risk in order to maximize their expected profit, but Borch moves on to discuss collective risk and the probability of ruin to further enhance the company's prospects to avoid ruin.

Classical risk theory is summarized by Debaen and Haezondonck(1987) and tested for inflation and interest. Risk theory encompasses a random amount of random variables and tests for the ultimate probability of ruin for an insurance company by examining the company's surplus. This is analogous to a self-insured pension plan which guarantees annuities and the possibility of bankruptcy with complete liquidation of assets. Furthering this work is Paulsen (1993) who used a stochastic process for inflation and return. Probabilities of ruin were able to be determined under various different assumptions.

In 2008, Kasas, Goovaertsz, Dhaene, summarized actuarial risk theory in its current forms including models on utility theory, individual versus collective risk, ruin theory, premium systems and credibility theory. These topics form the basis of actuarial pricing of product.

Exley, Mehta and Smith (1997) take basic risk theory, and also typical pricing models of actuarial science, include concepts from Modigliani and Miller (1958) to introduce a market based valuation system for funding pensions. This included valuing pensions as bond like instruments and utilizing a spot rate approach to the interest rates in measuring the cash flows.

The analysis for the dissertation will be performed using census information from a corporate entity which sponsors a pension plan for the corporate analysis. The calculations will include measures utilizing Pension Protection Act methodology and ASC 715 accounting methods for the

corporate member. The reason for utilizing different methods is to introduce a level of robustness into the calculations to ascertain whether the methodology could produce different results. The analysis will include projections of future costs for the next twenty years with both a deterministic model and a stochastic model, utilizing Winklevoss's Proval actuarial system and the methods described by Winklevoss in performing the projections per Winklevoss (1982).

The corporate illustration involves a $3 billion company that provides a pension to its employees. The census information has the following characteristics:

3,863 Active Employees	Average service of 13.7 years
Average age of 47.8	Average pay of $56,912

The corporate data utilizes actual census characteristics of an agricultural entity which has provided defined benefit accruals to its participants over 40 years and also provided defined contribution allocations during the last 20 years.

In order to calculate a necessary contribution to fund the benefit, an actuarial funding method must be chosen. Trowbridge (1979) discusses the numerous funding methods available, which each treat prior service and future service benefits differently, and allocate costs to different timeframes. The Pension Protection Act (PPA) methodology utilizes a pure unit credit approach. This approach creates units for each year of service and allocates costs based upon these units for persons actively accruing a benefit. The amount a person earns in a single year is called the normal cost. This is calculated by measuring the present value of the benefit earned at the end of the year, and subtracting the present value of the benefit as of the beginning of the year. The present value of all past normal costs are known as the accrued liability. The accrued liability is

measured against the market value of assets to determine if the plan is underfunded or overfunded. The Pension Protection Act methodology also provides a system to calculate the contributions. The system involves a combination of the normal cost and a method to amortize the unfunded accrued liability. Under this method, the unfunded state is amortized over seven years, and re-measured each year.

For ASC 715 purposes, an alternative form of the unit credit method is utilized and is called the projected unit credit funding method. The basis for the calculation is very similar to unit credit, with both a normal cost and an accrued liability being generated. However, the method calls for using pay at retirement in the calculations if the benefit is based upon a formula that is in some form a final average pay. This projected pay is resident within both the normal cost and the accrued liability. Under this method, the liabilities calculated are generally higher than those under a pure unit credit approach. The method for calculating the cost under ASC 715 purposes, includes a normal cost component (also called the service cost), an interest cost based upon the liability, an expected return on assets figure (which offsets the interest cost on the liability) and amortization components to pay off the unfunded liability over time. An interesting result that can occur under ASC 715 accounting is the possible presence of an income generation due to an overfunded pension plan. This cannot occur under the PPA methodology as the contribution is lower bounded at zero.

It is important to understand the typical valuation process and the underlying assumptions behind the calculations. The valuation process essentially discounts future benefit payments under a number of contingent events. Certainly, interest rates and life expectancy figure into the computation. Also, other decrements are included to essentially quantify the value of the benefit at retirement. This process involves calculations that are made for each individual person in the valuation and discounts the benefit from the last possible age that benefits can be received (which

is assumed to be age 110 under most tables) to our current time period. Since the age at which people die, quit, become disabled, etc., are unknown, the process involves making actuarial assumptions regarding each contingency and accounting for the cost.

The assumptions utilized under these methods are shared except for the funding methods and the interest rates. The interest rates will be based upon the rules that are currently in place for each methodology. For the corporate funding analysis, the rates will be the mandated IRS rates as of January 1, 2012. These rates are a 24 month average of corporate bond yields of differing durations. The rates are set for three different segments of the yield curve. The first segment represents the rates between zero and five years for the period. The second segment represents the rates between six and twenty years. The final segment rate is for the years twenty one and above.

For ASC 715 purposes, the rates generally approximate the rate at which the obligation can be settled. In practice, the rates are similar to Moody AA corporate bond yields, or a Citibank yield curve. A singular rate can be calculated from the yield curve to approximate the whole pattern. However, the rate must be used as of the date of the settlement, rather than a blending.

The next set of assumptions is the mortality tables, or the rate at which people decease. The Internal Revenue Service provided the 2008 table, and annually adjusts the table for mortality improvement. While the actuarial valuation process includes projections for the future, it is not required to account for future mortality improvement. The valuation for this report will not include mortality improvement.

Table 5 Mortality Rates

Age	Male Mortality Rate	Female Mortality Rate	Age	Male Mortality Rate	Female Mortality Rate
20	.000206	.000124	45	.001059	.000727
25	.000287	.000141	50	.001309	.001055
30	.000388	.000201	55	.001805	.002034
35	.000675	.000352	60	.003156	.003433
40	.000869	.000409	65	.005175	.005084

A large difference between defined benefit plans and defined contributions is the ability of the defined benefit plan to account for future terminations of employment prior to actual termination and appropriately discount the actuarial costs for this contingency. If a person is vested in the benefit, meaning they own the benefit and terminates employment, the cost is accounted for in the valuation. If the person is not vested, the cost is zero and is immediately recognized in the valuation. The withdrawal rates are based upon the population and summarized below:

Table 6 Withdrawal Rates

Age	Withdrawal Rate	Age	Withdrawal Rate
20	.25	45	.05
25	.20	50	.025
30	.15	55	.0
35	.10	60	.0
40	.075	65	.0

The next important assumption involves the rate at which people retire. These rates reflect the experience of the population. It is typical to see a large increase in early retirements at age 62 due

to the availability of Social Security. It is assumed that once a person reaches age 65, they will retire regardless of their Social Security eligibility for full benefits.

Table 7 Retirement Rates

Age	Retirement Rate	Age	Retirement Rate
<=54	.00	60	.10
55	.01	61	.05
56	.01	62	.30
57	.01	63	.15
58	.01	64	.30
59	.01	>=65	1.0

As this valuation will include stochastic future scenarios for the next twenty years, it is important to ensure that the population does not waste away. The following table includes the demographic makeup of the new employees that will join the plan sponsor. The demographics match the current demographic employer and essentially ensures that the population makeup does not change in a significant fashion. Whenever a person decrements the population in the future due to death, retirement or termination of employment, a new person replaces them in the fashion outlined below. As the weights constitute partial replacement, the new entrant is essentially spread among the age groups.

Table 8 New Entrant Profile

Age	Percent Male	Salary	Weight
25	80%	$30,000	10%
30	80%	$40,000	20%
35	80%	$45,000	20%

40	80%	$50,000	20%
45	80%	$55,000	20%
50	80%	$60,000	20%

The following table summarizes the assumptions and the methodology that will be employed in the projection of costs. As the table shows, the major changes involve the interest rates and the funding methods. The additional methodologies should provide some level of robustness check on the different scenarios that will be modeled.

Table 9 Summarization of Assumptions and Methodology

	PPA Methodology	ASC 715
Funding Method	True Unit Credit	Projected Unit Credit
Interest Rate	IRS Table – 24-Month Average	Spot Market Rate
Mortality Table	Current Mortality	Current Mortality
Withdrawal Rates	Sponsor Rate	Sponsor Rate
Retirement Rates	Sponsor Rate	Sponsor Rate

Scenario Projections

The methodology will include running various scenarios under each type shown above. These scenarios will be run in a deterministic and stochastic fashion. Under a deterministic projection, the liabilities are calculated on an expected basis using actuarial methodology. The assets, however, will be modeled stochastically per Winklevoss (1982) utilizing Morgan, J.P. (2014) capital market assumptions. The pension will be funded with an asset mixture composed of 60% equity, 40% fixed income. Specifically,

the mix is 20% long term government bonds, 20% long term corporate bonds, 20% US large cap equity, 20% US small cap equity and 20% international.

The J.P Morgan (2014) capital market assumptions (nominal) include the following extracts:

Table 10 Long Term Capital Market Assumptions

	Expected Return	Standard Deviation
Inflation	2.26%	1.50%
Long Government	4.11%	13.50%
Long US Corporate	5.67%	12.00%
US Large Cap Equity	8.49%	14.75%
US Small Cap Equity	9.24%	19.75%
International	9.01%	16.75%

There has been much literature written concerning the proper way to fund the pension plans due to Pension Benefit Guaranty constraints, utility of firms, risk of bankruptcy etc. per Ang and Lai (1988). Models using different bond and equity measures (Huang and Cairns 2006, Rauh 2013) are one variable, but so is the actuarial funding policy (Asthana 1999) which is necessary in the projections. For the benefit of the analysis, we will use the minimum contributions under each method tested for PPA, ASC and GASB.

For this paper, we will examine numerous measures to analyze the effectiveness of the design. As this section focuses on the effects on the employer, the volatility of the contribution will be the measure. The measure will be called the pension efficiency ratio and will have the following components:

1. The numerator will be the standard deviation of the contribution stream in each year under the proposed design.

2. The denominator will be the standard deviation of the contribution stream for our normative value, the "DB" only design.

Hybrid Model and Effect on Plan Participant

In order to test the effects on a plan participant, we will use similar stochastic methods to determine the individual results. The comparison points will be calculating a probability of ruin under collective risk theory as described above. A participant's account balance will be modeled at retirement age (age 65) and tested against two different scenarios assuming either an inflation adjusted 4% payment stream (the 4% rule) or an inflation adjusted 5% payment stream (the 5% rule).

The first scenario will be a typical defined contribution approach. A stochastic modeling (using the same Morgan, J. P. (2014) capital market assumptions) under an uncertain lifetime will be analyzed using current mortality rates (RP 2000 projected) and the probability of ruin will be calculated for the defined contribution plan. This will be run under a combination of software packages including Proval to model the portfolios.

The second scenario will model the hybridized approach and stochastically model the same portfolio. The probability of ruin will also be calculated under this scenario and ultimately be compared to the first scenario.

The scenarios will be tested using a portfolio comprised of a 25% long government fund, 25% long corporate bond fund, 20% US large cap equity fund, 20% small cap equity fund and 10% international fund. One thousand test asset scenarios will be stochastically modeled over a 40

year time frame. Each thousand scenarios will be run another thousand sequences with mortality stochastically modeled in order to produce a distribution of results.

CHAPTER V

RESULTS

The first set of results will focus on the impact for the employer in implementing the hybrid model. In order to avoid any initial underfunding issues, it was assumed to have the assets equal the liability at plan inception. The contributions that were received by the plan were according to the IRS minimum under the Pension Protection Act. Each set of charts will show both the defined benefit only option and the hybrid plan. The hybrid plan costs reflect the defined benefit portion of the cost plus the defined contribution portion.

Table 11 DB Assets Only

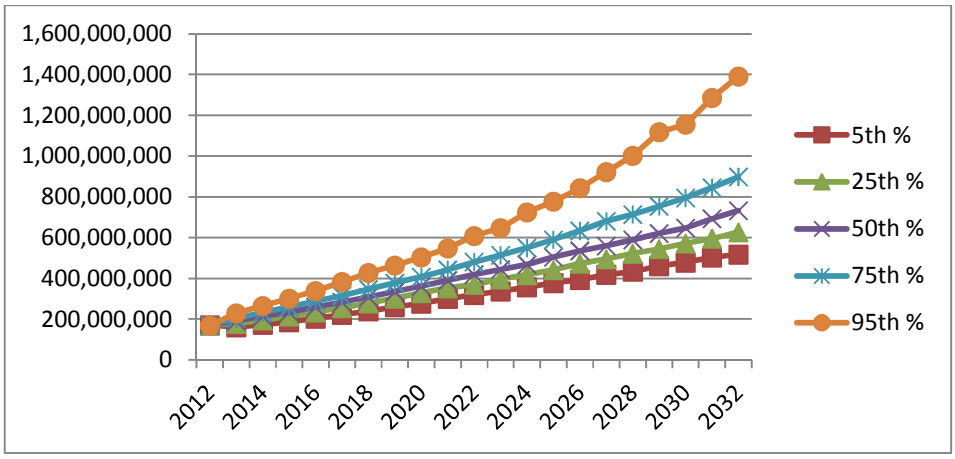
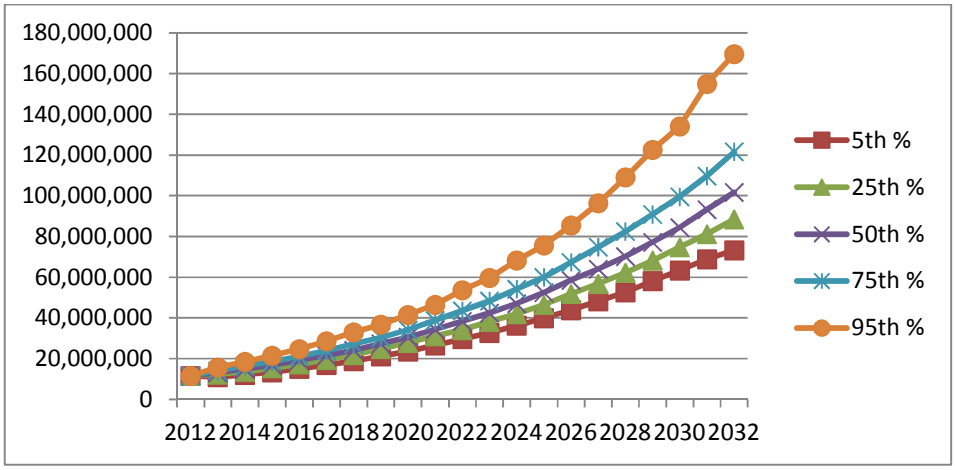


Table 12 Hybrid (DB Only)



Tables 11 and 12 show the asset projections stochastically projected for twenty years. Since the hybrid design only produces a benefit from age 85 onward, the liabilities produced are

approximately 10% of the liability of the traditional defined benefit that begins payment at age 65. Hence, the asset projections show the same type of relationship at least in the early years.

Table 13 Nominal Compounded Asset Return for Defined Benefit Only

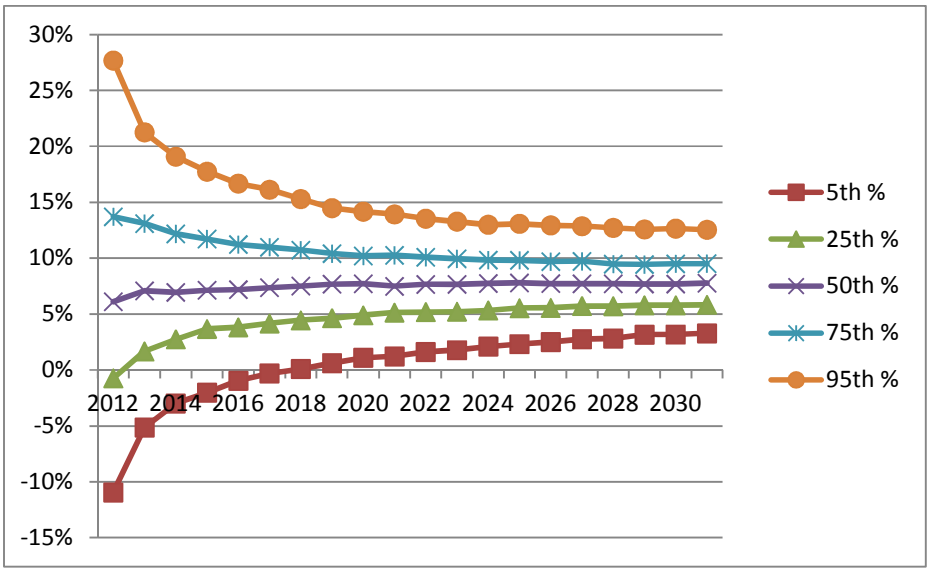
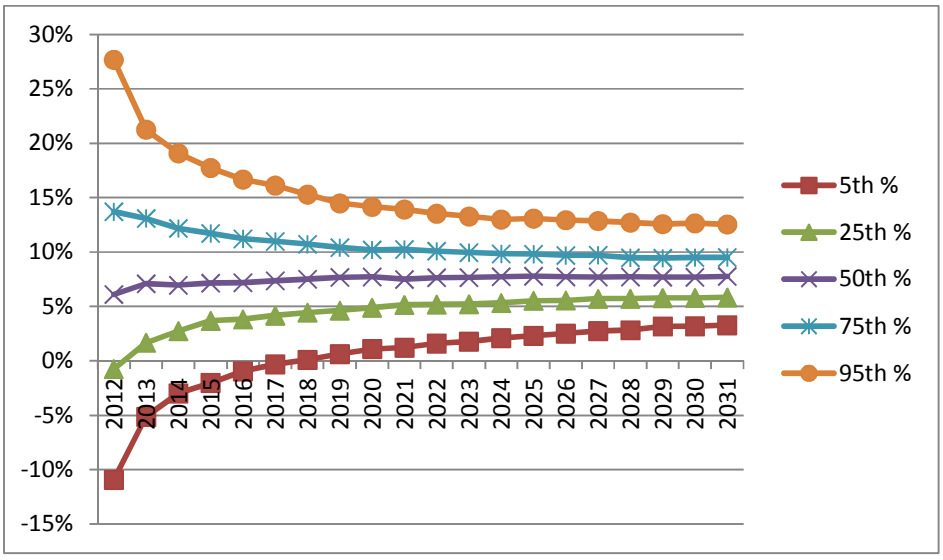


Table 14 Nominal Compounded Asset Return for Hybrid



Tables 13 and 14 show the compounded annual returns on a nominal basis. The mean return for the defined benefit only plan was 8.3% per year with a 11.9% standard deviation. The mean return for the hybrid plan was the same. The means were calculated over the twenty year time horizon.

Table 15 Employer Contribution to Defined Benefit Only

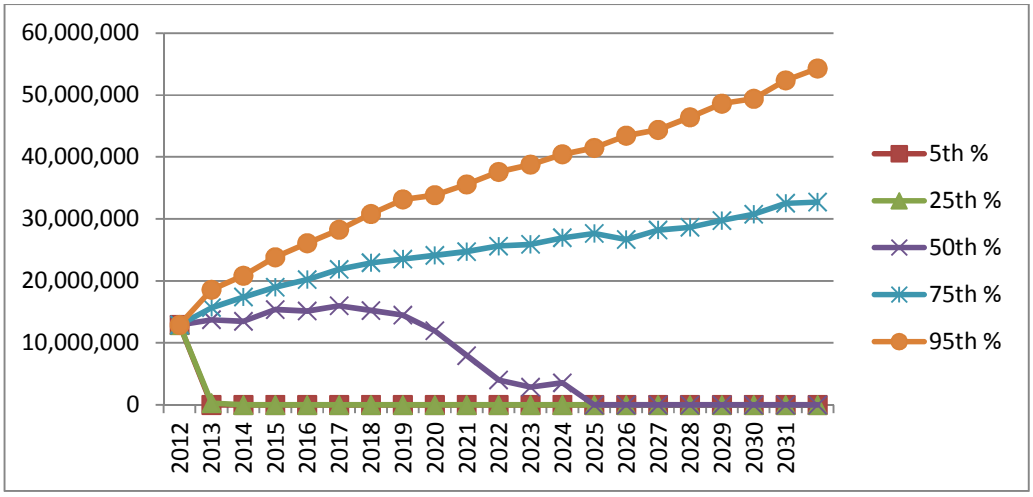
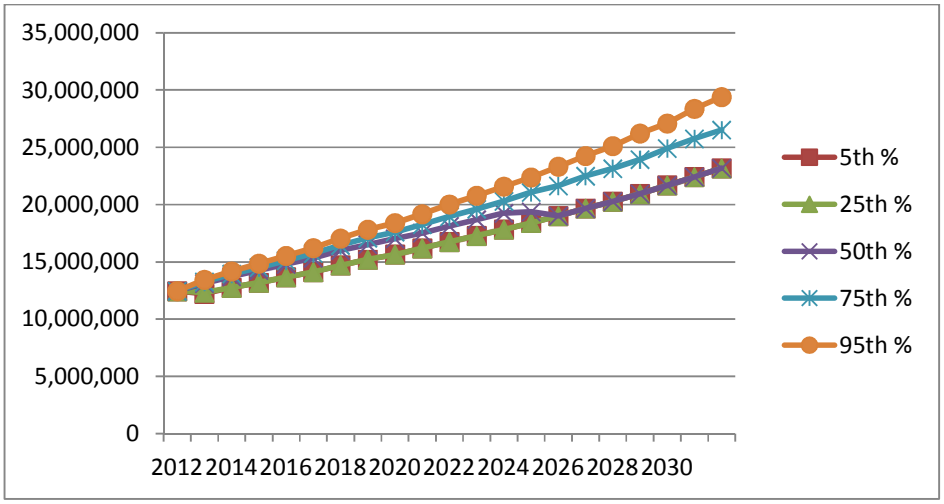


Table 16 Employer Contribution to Hybrid Plan



Tables 15 and 16 show the stark disparity in costs between the two programs. The hybrid approach includes the defined contribution program. Since the liabilities are deterministically valued using a static interest rate provided by the Pension Protection Act, the costs may have been initially inflated under actuarial valuation methodology. Since the returns from the portfolio average 8.3% over the long term, the plan becomes overfunded when measured against the static rate for the 50%. This results in zero contributions around the 2025 and 2026 for both plans. It should also be noted that since both plans began with assets to match the prior service costs, an environment which produces asset gains will leverage the contribution to zero fairly quickly. This is seen at the 5th and 25th percentiles.

Table 17 Employer Contribution to Defined Benefit Only % of Pay

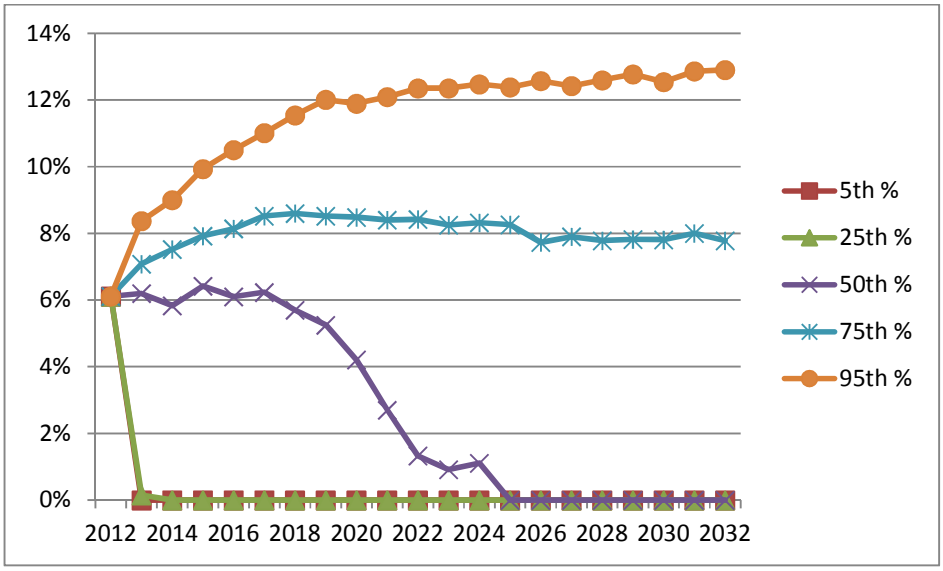
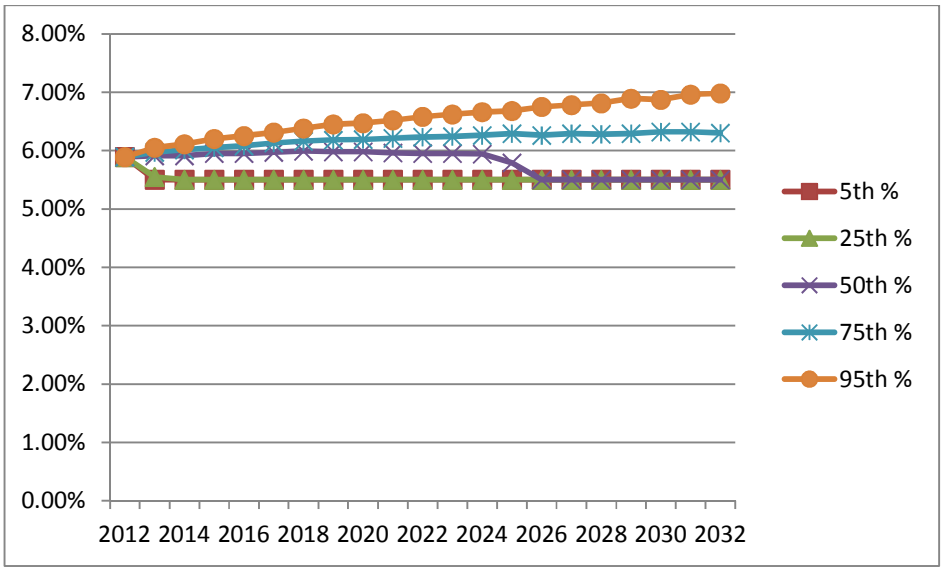


Table 18 Employer Contribution to Hybrid % of Pay



The percentage of pay contribution levels for funding the plan produce indicative results regarding the volatility of contribution levels. For the defined benefit only plan, the 95% produces costs in excess of 12% of pay which is double the original intended cost of the plan. The hybrid plan produces costs of 7.0% of pay at the long end of the 95th percentile. One way to show the difference in volatility is to see that the 95th percentile increases costs over 6% of pay for the defined benefit only plan, while the hybrid only produces a 1% increase of cost at that level. From an employer perspective, the reduction in volatility is a favorable result.

The mean for the defined benefit plan only as a percentage of pay was 4.2% with a standard deviation of 4.3%. The mean for the hybrid plan as a percentage of pay was 0.38% of pay with a standard deviation of 0.39%. The reduction in volatility is over 90%.

Table 19 Underfunding Defined Benefit Only

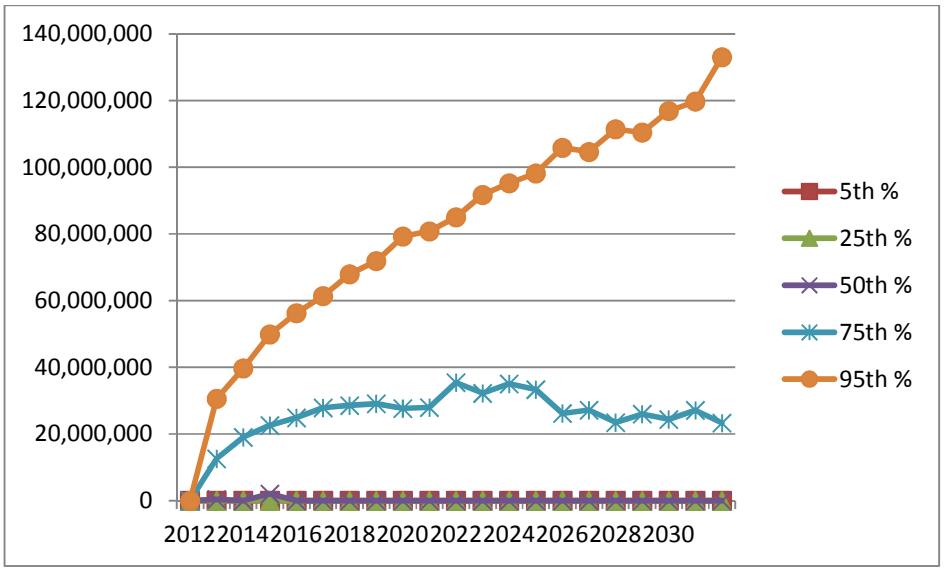
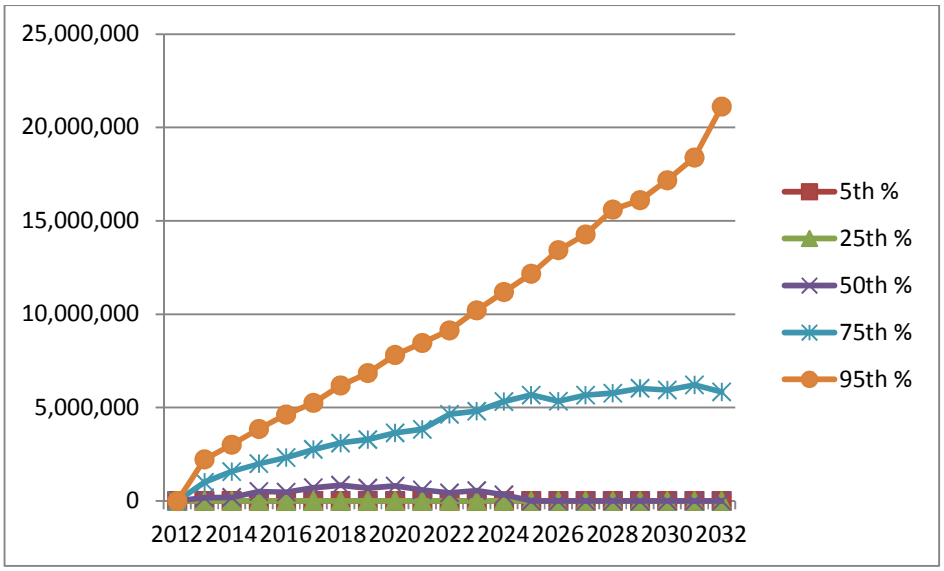


Table 20 Underfunding Hybrid Plan



Underfunding for pensions is defined to be the difference between the assets of the plan and the liabilities. Tables 19 and 20 measure the differences using the Pension Protection methods, versus a termination liability (or a direct market measurement) which could show significantly worse results. While the underfunding of the plan may not cause the plan to be in jeopardy of paying benefits to the participants, there is no question that the underfunded status affects the financial value of the firm in the market's eyes. In many cases, such as the airlines and steel mills, the underfunding of their pension plans jeopardized the survival of the firms as also previously noted by Studebaker. As expected, the charts show that the hybrid plan is much less at risk of having significant underfunded status in relationship to the size of the plan sponsor.

Table 21 Funding Percentage Defined Benefit Only

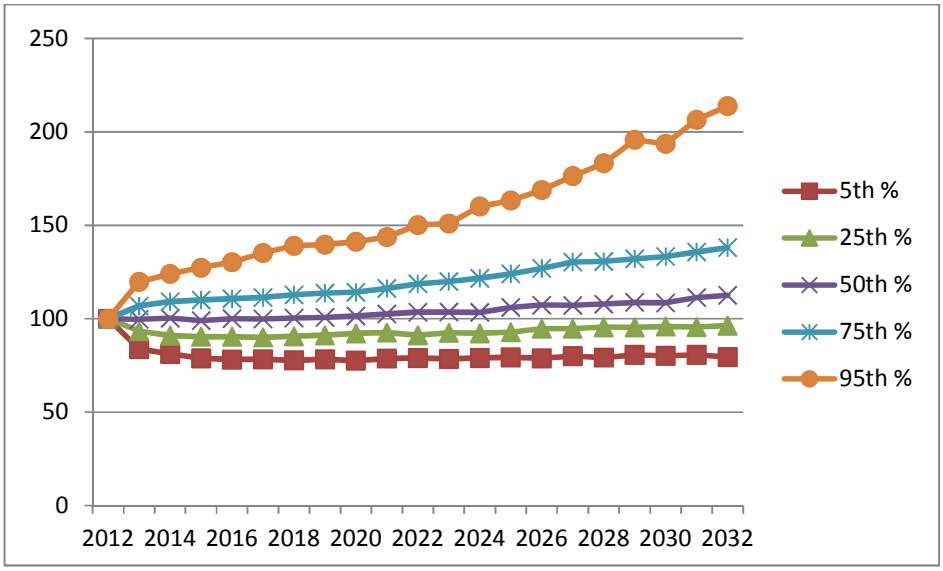
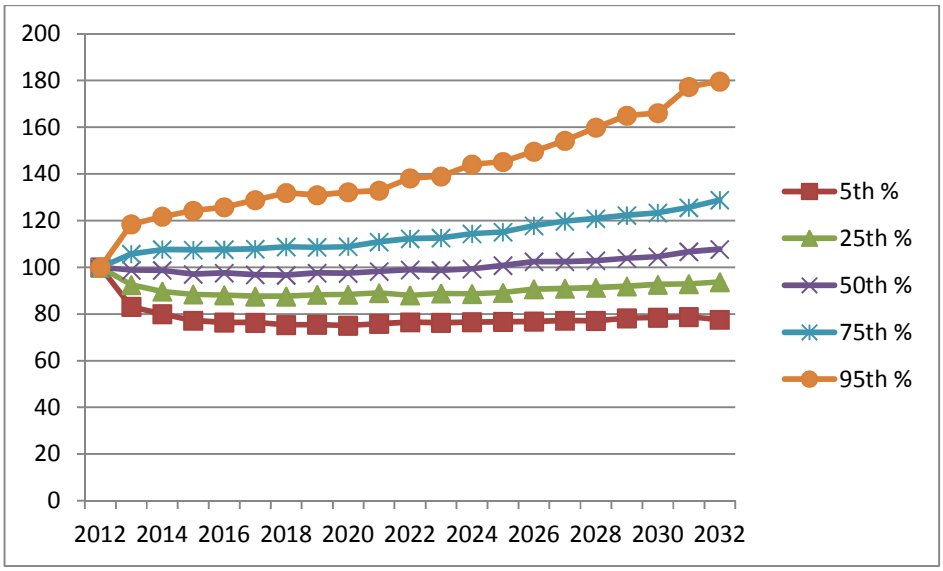


Table 22 Funding Percentage Hybrid



The funding percentage charts show the unfunded status in relationship to the liabilities. The percentage is calculated with assets in the numerator and liabilities in the denominator with percentages over 100% reflecting an overfunded plan. As the charts detail, the overfunded percentages tend to have high numbers at the 95% percentile, while the plans are not projected to fall in the low funded percentage ranges. This result is deceiving, since plans that are underfunded are required by the actuarial methodology to fund faster thus filling the gaps quickly, whereas the overfunding of the plan may continue unabated with no mechanism to reduce the rate of overfunding. The hybrid plan does not appear to have the same upside position as the defined benefit only design, primarily due to lack of leveraging that may occur due to their smaller liability state.

Table 23 Pension Expense Defined Benefit Only

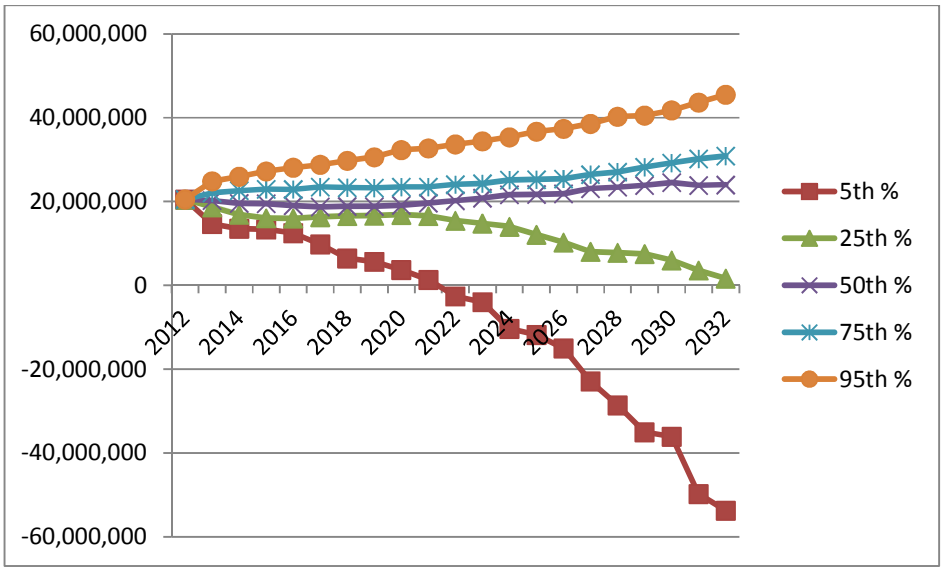
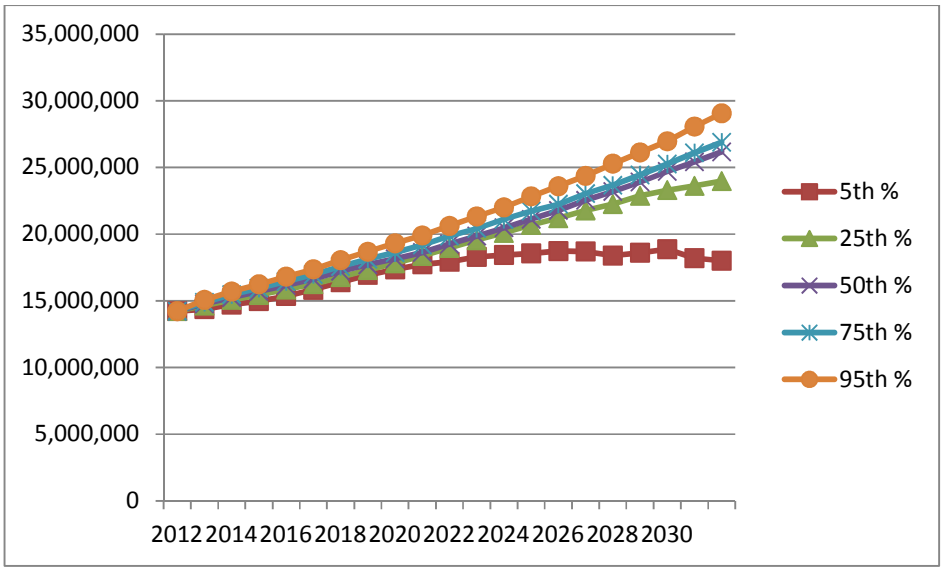


Table 24 Pension Expense Hybrid Plan



As opposed to funding methods where the interest rates used for actuarial liability measurement and techniques of amortization are one and the same, pension accounting uses a different methodology. Liabilities are measured using a market rate at which the liability could be settled and assets are measured using a long term rate. This creates scenarios where the pension expense could be a negative figure and actually provides financial income to the plan sponsor. Plan sponsors have limited ability to tap into this from a cash stand point therefore the measurement may be somewhat meaningless, however the rule remains. Tables 23 and 24 show the wide range of results for pension expense along with the 5th percentile possibility of income generation. The limited volatility of the hybrid plan is striking.

Table 25 Pension Expense % of Pay Defined Benefit Only Plan

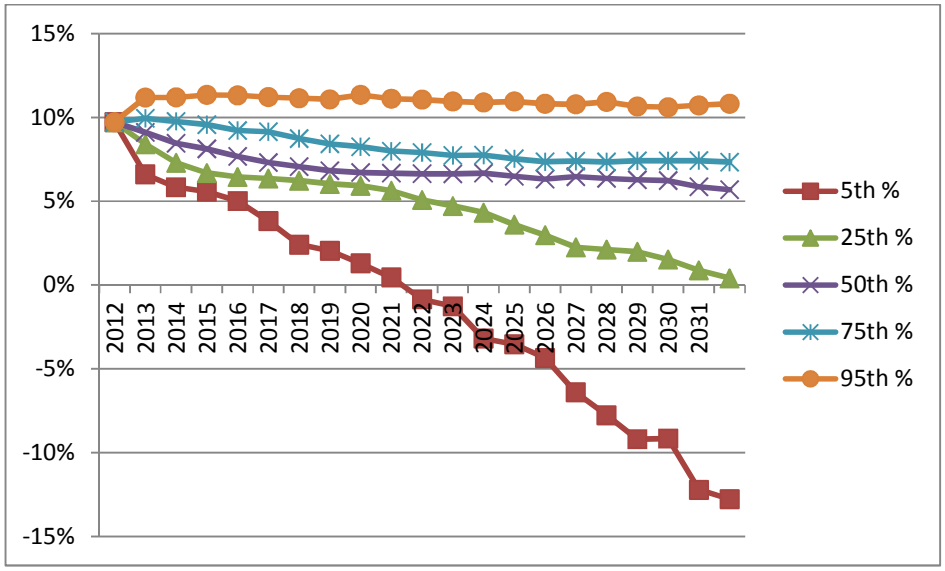
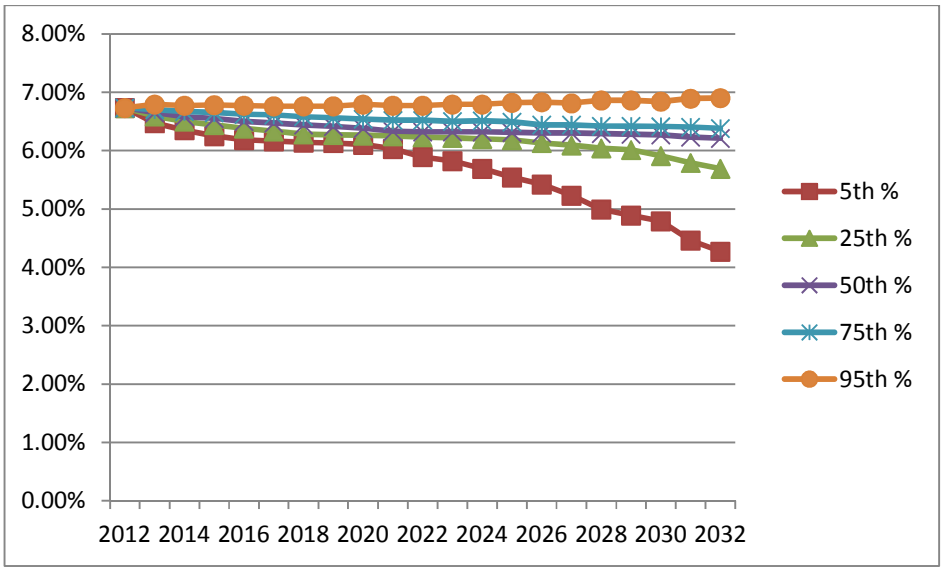


Table 26 Pension Expense % of Pay Hybrid Plan



Both Tables 25 and 26 take the pension expense hard dollars and convert them to a percentage of pay similarly to the funding contributions. The results are similar in nature, with a reduction in cost over time as the asset returns exceed the valuation interest rates.

Table 27 Defined Benefit Only PBO Funded Ratio

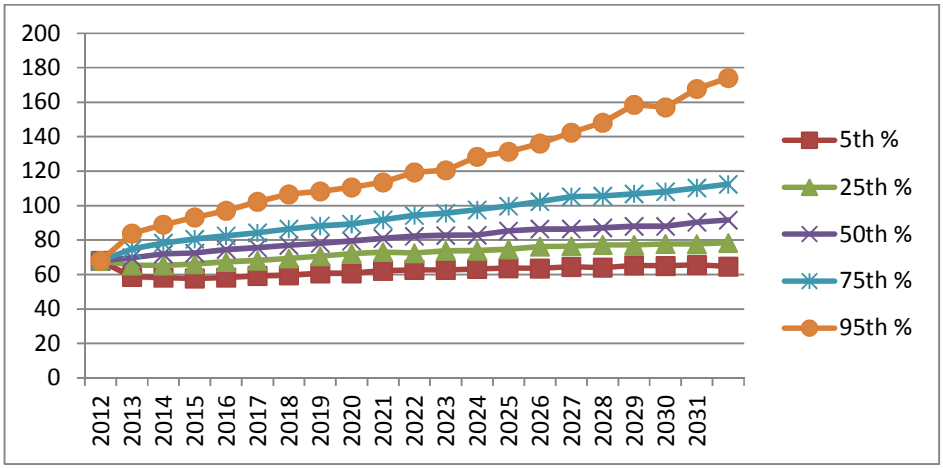
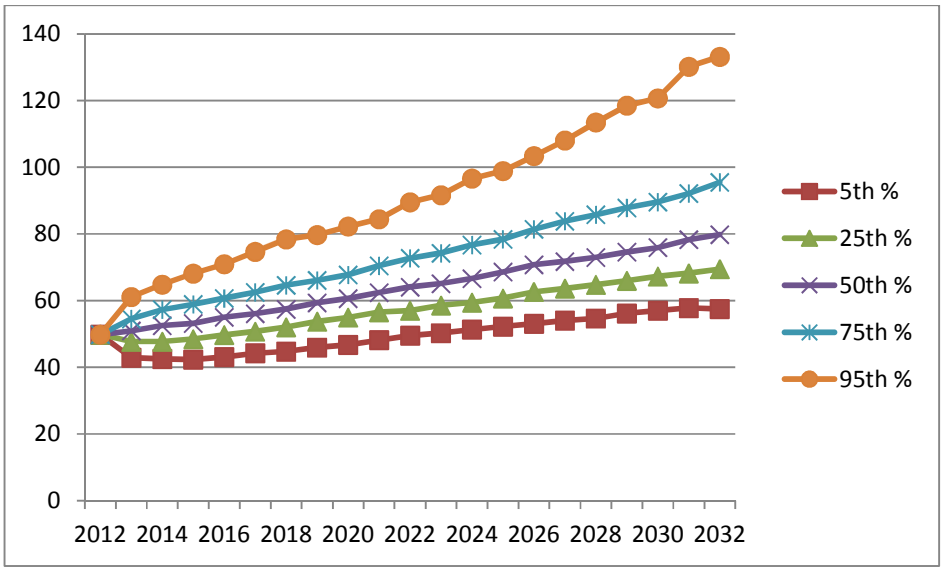


Table 28 Hybrid PBO Funded Ratio



The accounting concept of Projected Benefit Obligation or PBO, takes into account the salary assumption through retirement date. This inflates the liability measurement as future pay is accounted for directly. The result of this change increases the liability measurement as compared to the Pension Protection Act true unit credit approach for liabilities. Ultimately, the funded ratios are reduced for both the plans because of this measurement change.

Tables 11 through 28 summarize the projected liabilities and assets for the two defined benefit designs. Tables 29 and 30 show the pension efficiency ratios calculated by year for the cash contribution to the plan.

Table 29 Pension Efficiency Ratio –Cash Contribution % of Pay

Year	1	2	3	4	5	6	7	8	9	10
σ Hybrid	0	0.21%	0.24%	0.26%	0.28%	0.30%	0.33%	0.35%	0.36%	0.38%
σ DB	0	3.20%	3.61%	3.85%	4.04%	4.26%	4.46%	4.58%	4.60%	4.63%
PER	N/A	6.56%	6.64%	6.75%	6.93%	7.04%	7.34%	7.64%	7.83%	8.21%

Year	11	12	13	14	15	16	17	18	19	20
σ Hybrid	0.39%	0.41%	0.43%	0.45%	0.46%	0.48%	0.49%	0.51%	0.52%	0.54%
σ DB	4.68%	4.71%	4.73%	4.81%	4.75%	4.76%	4.77%	4.86%	4.81%	4.91%
PER	8.33%	8.70%	9.09%	9.36%	9.68%	10.0%	10.3%	10.5%	10.8%	11.0%

Table 30 Pension Efficiency Ratio –Pension Expense % of Pay

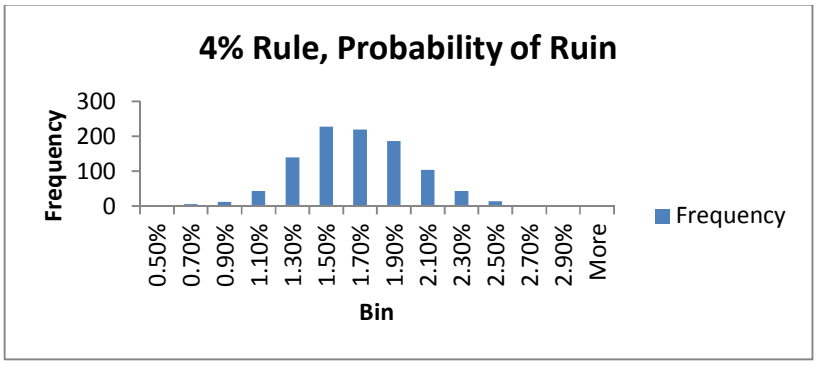
Year	1	2	3	4	5	6	7	8	9	10
σ Hybrid	0	0.09%	0.13%	0.16%	0.18%	0.19%	0.21%	0.21%	0.23%	0.25%
σ DB	0	1.33%	1.37%	1.87%	2.05%	2.32%	2.62%	2.75%	2.99%	3.27%
PER	N/A	6.77%	7.65%	8.55%	8.78%	8.19%	8.01%	7.64%	7.69%	7.65%

Year	11	12	13	14	15	16	17	18	19	20
σ Hybrid	0.28%	0.32%	0.37%	0.41%	0.46%	0.50%	0.57%	0.62%	0.67%	0.75%
σ DB	3.69%	4.14%	4.56%	4.97%	5.39%	5.71%	6.27%	6.50%	6.83%	7.30%
PER	7.59%	7.73%	8.11%	8.25%	8.53%	8.76%	9.09%	9.54%	9.81%	10.2%

Hypothesis 1 addressed the volatility of pension plan contributions of the hybrid plan relative to the defined benefit only design. The pension efficiency ratios are shown for each year of each 1,000 trials for each design. They range from a low of 6.56% to a high of 11.0%. This means that the volatility for the hybrid design is a fraction of the defined benefit plan and supportive of Hypothesis 1.

The next series of charts show the stochastic results from the participant's perspective utilizing a fixed asset mix and multiple withdrawal patterns. The purchase of the deferred annuity was chosen to be 10% based upon the relationship shown in Table 3, the value of the deferred to age 85 portion relative to the full annuity. The stochastic mortality was modeled upon male mortality using the adjusted RP 2000 mortality table. The charts display the distribution of the probabilities of ruin. The probability of ruin has been expanded to encompass two types of ruin for the deferred annuity purchase. The definition is total ruin with this case comprising the possibility a person deceases with no future income possibilities. The second definition is some ruin with the case of a person experiencing ruin in the account balance portfolio, but will still live to a point where they will receive some income from a deferred annuity in the future. For example, the person may experience ruin at age 82, begin a payment of the deferred annuity at age 85 and deceases at a later point. This was important to isolate since many annuity contracts allow for an earlier withdrawal date for a reduction in the annuity. This would allow the person to avoid complete ruin.

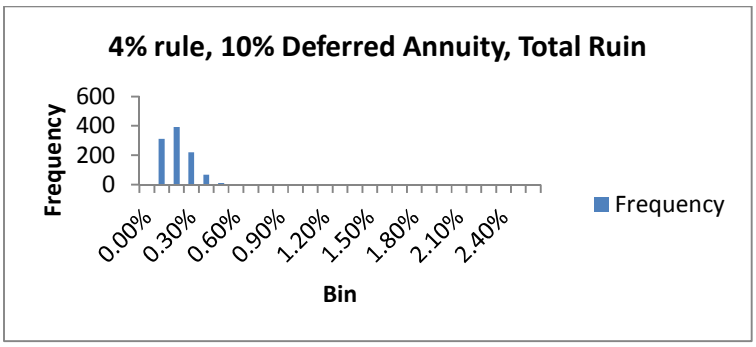
Table 31 4% Rule Probability of Ruin



μ=1.53%

σ=0.34%

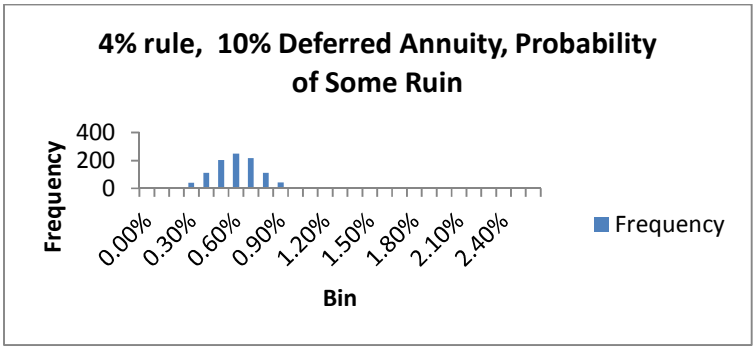
Table 32 4% Deferred Annuity Purchase, Total Ruin



μ=0.11%

σ=0.09%

Table 33 4% Rule Probability of Some Ruin

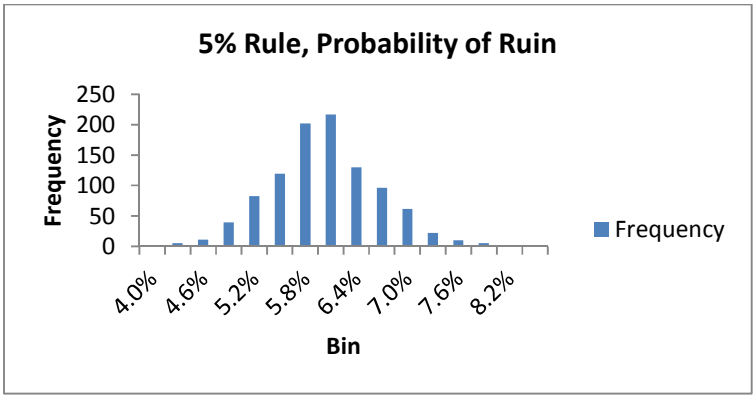


μ=0.50%

σ=0.16%

The 4% rule scenarios show a variety of results based upon whether the deferred annuity is purchased. The probability of ruin centers at a nominal 1.53% without a deferred annuity being bought. However, the probability of total ruin, using the same payment stream is a negligible 0.11%. There is a higher 0.50% chance of partial ruin, however this risk can be completely mitigated with the possibility of advanced payment of the annuity at a reduced amount.

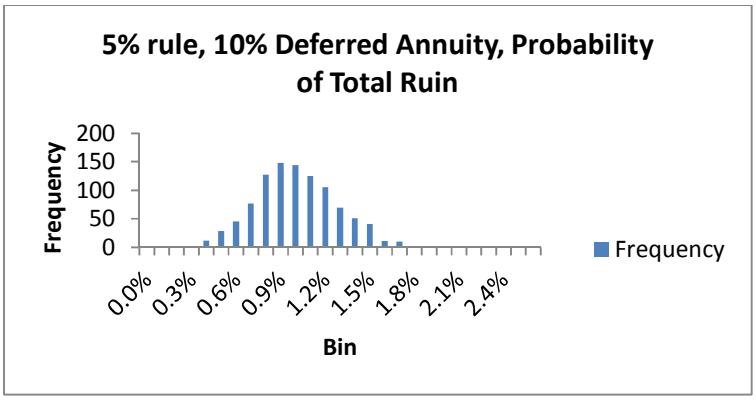
Table 34 5% Rule Probability of Ruin



μ=5.82%

σ=0.62%

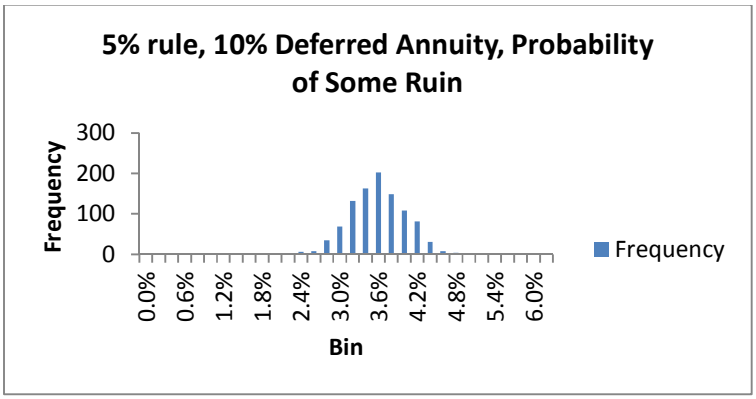
Table 35 5% Deferred Annuity Purchase, Total Ruin



μ=0.91%

σ=0.27%

Table 36 5% Rule Probability of Some Ruin



μ=3.44%

σ=0.42%

The 5% rule was modeled with the same portfolios as the 4% rule. The probability of ruin increased from 1.53% to 5.82%. The probability of total ruin using a deferred annuity in the 5% rule was 0.91% as opposed to the 0.11% in the 4% rule. The probability of some ruin for the 5% rule with a deferred annuity purchase equaled 3.44% as opposed to the 0.50% seen in the 4% rule.

Table 37 Probability of Ruin

Scenario	μ	σ
4% Rule	1.53%	0.34%
4% Rule, DA Some Ruin	0.50%	0.16%
4% Rule, DA Total Ruin	0.11%	0.09%
5% Rule	5.82%	0.62%
5% Rule, DA Some Ruin	3.44%	0.42%
5% Rule, DA Total Ruin	0.91%	0.27%

Table 37 shows the probabilities of ruin side by side along with their respective volatilities. The results support Hypothesis 2 by providing evidence that purchasing a deferred annuity provides a

lower probability of ruin as compared to the typical strategy of the 4% rule. The volatilities under the deferred annuity purchase are lower as well.

Table 38 Residual Efficiency at Time of Death

Scenario	μ Account Balance	σ Account Balance
4%	$303,530	$314,995
4% Deferred Annuity	$198,628	$162,205
5%	$231,594	$389,587
5% Deferred Annuity	$150,937	$148,271

Chart 38 shows the residual balances at death under each scenario assuming full payment through death using 1000 trials. Ruin balances were considered to be zero. Residual balances may be appropriate for estate planning purposes, however, for efficiency purposes it also denotes that a person may have been able to spend more dollars during their retirement years as the money becomes worthless to a dead person. These results support Hypothesis 3 that the annuity purchase reduces the amount wasted, or considered inefficient, at death.

CHAPTER VI

DISCUSSION

As might be expected, the analysis on the employer when implementing the hybrid approach causes a significant reduction in risk from a volatility standpoint. Generally, employers are very concerned about providing a retirement plan that does not vary in cost, hence the trend towards defined contribution plans. The contributions under the Pension Protection Act methodology produce a much lower top end when implementing the hybrid plan. For example, the hybrid plan began at a 5.9% contribution level and ended at the 95% percentile twenty years into the future at a 7.0% contribution level. Contrast that result with the defined benefit only plan design with an initial contribution at the 6% of pay level. After twenty years, the 95^{th} percentile shows a more than doubling of the contribution to the 13% of pay level, which is a significant increase. Corporations would generally not be as concerned with a cost that varies at the 1% of pay level, but a volatility of 7% of pay produces a different reaction.

The possible underfunding of the plan over time is a hindrance to many companies wanting to maintain defined benefit plans. The possible use of the hybrid approach would mitigate these fears since the size of the liability is not projected to grow to the same levels as would be expected for a traditional approach. The hybrid plan produces an underfunding level of approximately $21,000,000 at the 95% level as opposed to approximately $135,000,000 for the defined benefit plan. This has been measured in the 20th year of projection. As underfunded liabilities affect both the balance sheet and the future contributions of the plan it would be imperative to avoid this possibility. The funded ratio normalizes the relationship of assets to liabilities. The hybrid plan is projected to have 180% funding at the 95% percentiles in twenty years and the 200% funded level for the defined benefit only. These levels show possible upside, but the downside may be limited due to the presence of heavy contributions to mitigate the underfunded status.

The accounting measures show similar type of results for the similar aspects that are being measured. The pension expense number is similar to the contribution figure except the expense may go negative to provide an income to the plan sponsor. The expense became 11% of payroll at the 95th percentile for the defined benefit plan only, and 6.9% of pay for the hybrid plan, both at the 20th year. The 5% scenarios at year 20 show income of 13% of pay for the defined benefit only and a cost of 4.25% of pay for the hybrid. While this shows high upside, in reality the plan sponsor cannot spend the pension income as it's a non cash item. Overall, the positions show favorable results for companies due to the reduction in volatility in costs and limitations on downside for the underfunding. This design is superior to the defined benefit only design.

The models showing the effect on the participants display an unexpected result. First, the model provides a framework for testing stochastic mortality against standard withdrawal patterns for retirement. Models have generally assumed average lifespans, fixed lifespans, and perpetuity

spans. This model expands knowledge through the stochastic modeling of longevity. Secondly, the model tests the effect of purchasing a deferred annuity, and its ability to reduce the probability of ruin for annuitants. Finally, the model shows whether the withdrawal pattern is efficient in utilization of dollars by quantifying the remaining balance at death.

The model implementing the 4% withdrawal rule shows a small probability of ruin of 1.53%. This is in line with other studies that propose the 4% rule due to its low risk nature. Should someone use 10% of their account balance to purchase a deferred annuity and still maintain the same 4% withdrawal rate, the probability of total ruin drops to an infinitesimal 0.11% rate. As mentioned earlier, a person could experience ruin prior to age 85, but have purchased an annuity and survived past age 85. This is the case for the concept of some ruin and the rate is 0.50%. Many retirees would certainly fear this event. This risk is mitigated by the ability to have a rider on the annuity contract allowing for early withdrawals at a reduced rate. This is similar to early retirement reductions for pension plans, and the early retirement reduction for social security. Purchasing a contract with this feature would completely eliminate the "some ruin" scenario. It would appear to benefit the participant to purchase the deferred annuity versus simply applying the 4% rule since the risk of ruin is smaller.

This breeds a different question of whether a person can increase their withdrawal rate, purchase the deferred annuity and reduce their risk relative to the 4% rule. The simulations show that the 5% rule produces a probability of ruin of 5.8%. Total ruin while purchasing the deferred annuity under the 5% rule is 0.91%. The some ruin amount is 3.44%. The results indicate that a person could use a 5% withdrawal pattern, purchase a deferred annuity and have lower total ruin risk than a person who simply applies the 4% rule. This is a very interesting result as it contrary to the financial world's current advice to retirees. It also allows the opportunity for retirees to spend more money in their earlier retirement years, where the value of those dollars may be

greater than at the end of the retirement years. While the some ruin probability may be higher at 3.44%, the ability to purchase an annuity early would once again mitigate this risk.

Another result that can be ascertained is how efficient is the distribution pattern? A distribution pattern, which would produce a payout stream with $0 available on the date of death would seem to be idea (except for those with estate planning goals). This can only be achieved by buying an immediate annuity with all dollars available at retirement. Practically speaking, people are fairly loathe to making this purchase as has been discussed earlier in the paper. In this paper, we calculate how efficient the payment pattern is by measuring how much of the person's account balance is available on the date of death. The lower the account balance, the higher the level of efficiency. As can be seen on Result Chart 28, the deferred annuity choices are a more efficient use of retirement dollars. Under the 5% rule with a deferred annuity, the account balances are the smallest, showing the highest level of efficiency but also with a corresponding higher level of risk.

Further research in this important topic is warranted due to the rapidly changing environment in retirement. This study provides a basic framework in which to model retirement success differently than in the past by modeling mortality stochastically. It would be important to model female mortality, increasing longevity patterns and different annuity purchase rates to quantify the difference in results. It would also be interesting to test different deferral ages to determine if some sort of stacked deferred annuity purchases would produce better results. It would also be important to add to the model a utility function that accounts for larger spending patterns at the early part of retirement along with smaller spending patterns at the back end, in order to simulate the reality of the utility of money for retirees.

1950's and 1960's. These plans faced serious challenges, including a volatile financial system, a mobile workforce that did not remain with one employer during their career, and expensive government regulation. As a result of these changes, corporate and public plan sponsors disallowed new entrants from entering the plan, or froze the plan or simply terminated the arrangement. These plans eventually were replaced with defined contribution plans (named because the contribution was defined in advance, but the benefit at retirement was variable).

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CHAPTER VII

CONCLUSION

This paper hopes to add to literature by modeling a new type of retirement program from the employer and employee's perspective. Given the current state of the world, with a decline in pension plans, a reliance on individual choices under uncertain outcomes and behavioral impediments to choosing the optimal path, a new style of retirement should be developed. Under the new approach, which would limit the employer risk, improve financial outcomes for participants, and reduce large intergenerational transfers that may not be able to be maintained if the population does not grow. This paper adds to knowledge by modeling stochastic results of mortality and its effects on distribution patterns, along with showing that a hybrid pension will reduce the risk for employers.

Employers would see 90% reduction in cost volatility for pension plans, with the defined contribution approach providing much of the engine for the benefit. Employees would see a better approach by having the ability to reduce their risk at retirement by purchasing a deferred annuity, but also possibly increasing their payment stream for the first 20 years. A win-win scenario for both the employer and the employee is rarely attained, but the hybrid design succeeds.

possible underfunding of the plan over time is a hindrance to many companies wanting to maintain defined benefit plans. The possible use of the hybrid approach would mitigate these fears since the size of the liability is not projected to grow to the same levels as would be expected for a traditional approach. The hybrid plan produces an underfunding level of approximately $21,000,000 at the 95% level as opposed to approximately $135,000,000 for the defined benefit plan. This has been measured in the 20th year of projection. As underfunded liabilities affect both the balance sheet and the future contributions of the plan it would be imperative to avoid this possibility. The funded ratio normalizes the relationship of assets to liabilities. The hybrid plan is projected to have 180% funding at the 95% percentiles in twenty years and the 200% funded level for the defined benefit only. These levels show possible upside, but the downside may be limited due to the presence of heavy contributions to mitigate the underfunded status.

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APPENDICES

The following charts depict the results of the stochastic simulations by asset class as a test after 1000 trials per year.

Appendix Chart 1-Projection of Stochastic Inflation

	Inflation		Unexp. Inflation	
Year	Mean	StdDev	Mean	StdDev
1	2.30%	1.20%	0.00%	1.20%
2	2.50%	1.30%	0.00%	1.20%
3	2.50%	1.40%	0.00%	1.20%
4	2.60%	1.40%	0.10%	1.20%
5	2.60%	1.40%	0.00%	1.20%
6	2.60%	1.40%	0.10%	1.20%
7	2.60%	1.40%	0.00%	1.20%
8	2.60%	1.40%	0.00%	1.20%
9	2.60%	1.40%	0.00%	1.20%
10	2.60%	1.40%	0.00%	1.20%
11	2.60%	1.40%	0.00%	1.20%
12	2.60%	1.50%	0.00%	1.20%
13	2.60%	1.40%	0.00%	1.20%
14	2.60%	1.40%	0.10%	1.20%
15	2.70%	1.40%	0.00%	1.20%
16	2.60%	1.40%	0.00%	1.20%

17	2.60%	1.40%	0.00%	1.20%
18	2.60%	1.40%	0.00%	1.20%
19	2.60%	1.40%	0.00%	1.20%
20	2.60%	1.50%	0.00%	1.30%
21	2.70%	1.40%	0.00%	1.20%
22	2.60%	1.30%	-0.10%	1.20%
23	2.60%	1.40%	0.10%	1.20%
24	2.60%	1.30%	0.00%	1.20%
25	2.70%	1.40%	0.00%	1.20%
26	2.70%	1.30%	0.00%	1.20%

Appendix Chart 2-Projection of Stochastic Returns by Asset Class

	LTGB Returns		LTCorp Returns		USL Returns		USSM Returns		INT Returns	
Year	Mean	StdD	Mean	StdD	Mean	StdD	Mean	StdD	Mean	StdD
1	4.4%	14.0%	5.4%	12.3%	8.7%	15.7%	10.4%	21.2%	9.5%	17.8%
2	5.2%	14.3%	6.8%	12.8%	10.5%	15.9%	12.6%	21.4%	11.3%	18.0%
3	5.2%	14.2%	6.7%	12.6%	9.8%	15.9%	11.3%	21.4%	10.8%	18.0%
4	6.1%	14.0%	7.0%	12.4%	9.8%	16.1%	10.9%	21.2%	10.7%	18.0%
5	5.2%	14.3%	7.0%	12.9%	9.9%	15.3%	11.6%	20.7%	10.9%	17.7%
6	5.5%	14.4%	7.1%	12.7%	10.2%	15.9%	11.8%	21.3%	11.3%	18.1%
7	4.9%	14.3%	6.7%	12.5%	10.1%	15.8%	11.9%	21.3%	10.9%	18.0%
8	4.8%	14.0%	6.2%	12.9%	9.9%	16.0%	11.5%	21.3%	10.5%	17.8%
9	5.2%	14.1%	6.8%	12.5%	10.8%	15.5%	12.4%	20.9%	11.7%	17.4%
10	5.2%	14.4%	6.6%	13.0%	10.1%	16.2%	11.6%	21.0%	10.7%	17.8%
11	6.2%	14.6%	6.9%	13.1%	10.0%	16.2%	11.1%	21.6%	10.4%	18.2%
12	5.4%	14.1%	6.7%	13.2%	10.0%	16.3%	11.1%	21.4%	10.8%	18.5%
13	4.6%	13.7%	6.7%	12.8%	10.8%	16.0%	12.5%	21.0%	12.0%	18.3%
14	5.5%	13.9%	7.6%	13.0%	11.0%	16.4%	13.3%	21.4%	12.2%	18.9%
15	5.9%	13.9%	7.0%	12.9%	10.1%	16.1%	11.9%	21.4%	10.6%	17.8%
16	5.5%	14.3%	6.9%	12.9%	10.4%	15.1%	11.7%	20.2%	11.2%	17.0%
17	5.3%	14.1%	6.6%	12.8%	9.6%	15.4%	11.2%	20.3%	10.3%	17.5%
18	5.9%	14.1%	7.0%	12.6%	9.7%	16.1%	11.5%	21.8%	10.7%	18.2%
19	5.6%	14.4%	7.5%	12.9%	10.6%	16.0%	12.2%	20.9%	12.0%	18.2%

20	4.2%	14.3%	6.0%	13.1%	10.7%	15.9%	12.8%	21.4%	11.3%	18.1%
21	5.8%	14.3%	7.3%	12.8%	10.4%	15.8%	12.2%	21.3%	11.1%	17.9%
22	6.1%	13.5%	6.9%	12.3%	9.3%	15.8%	10.2%	20.9%	10.3%	17.9%
23	5.5%	14.6%	7.4%	13.6%	11.2%	16.0%	12.8%	20.6%	12.1%	18.5%
24	5.3%	14.6%	6.6%	12.9%	9.8%	15.7%	11.3%	20.9%	10.4%	17.8%
25	5.6%	14.3%	7.0%	13.3%	10.2%	16.1%	12.2%	21.3%	10.7%	18.2%
26	5.7%	14.7%	7.5%	12.7%	10.9%	16.1%	12.8%	21.9%	11.8%	18.5%
27	5.4%	14.0%	6.8%	12.9%	10.1%	16.0%	11.3%	21.2%	11.1%	17.8%
28	5.1%	15.1%	6.6%	13.1%	10.4%	16.6%	12.0%	21.8%	11.3%	18.7%
29	5.1%	13.7%	6.6%	12.2%	10.9%	16.0%	12.7%	21.7%	11.6%	18.0%
30	5.2%	14.5%	6.6%	13.3%	9.9%	16.4%	11.6%	21.7%	10.6%	18.4%
31	4.2%	13.6%	6.2%	12.3%	10.6%	16.2%	12.8%	21.5%	11.1%	18.4%
32	5.2%	13.8%	7.2%	12.7%	10.8%	16.1%	12.4%	21.7%	11.8%	18.5%
33	5.1%	14.6%	6.6%	13.4%	10.1%	15.9%	11.3%	21.0%	11.3%	17.9%
34	5.1%	14.5%	6.3%	12.6%	10.1%	16.3%	11.6%	22.0%	10.7%	18.3%
35	5.8%	14.7%	6.8%	12.7%	9.8%	15.8%	11.1%	21.0%	10.3%	17.8%
36	5.1%	14.2%	6.7%	13.1%	10.5%	16.0%	12.4%	21.5%	11.2%	18.2%
37	5.3%	14.1%	7.0%	12.7%	10.4%	16.1%	12.3%	21.0%	11.4%	18.2%
38	5.6%	14.6%	6.8%	12.9%	10.4%	15.6%	12.4%	20.8%	10.9%	17.7%
39	5.0%	14.3%	6.7%	13.2%	10.6%	16.4%	12.6%	21.7%	11.1%	18.4%
40	5.4%	14.6%	6.6%	12.7%	9.9%	15.2%	11.0%	19.8%	11.3%	17.7%
41	5.2%	14.5%	6.5%	13.1%	10.7%	16.1%	12.3%	21.4%	11.4%	18.3%
42	5.7%	14.2%	7.0%	12.7%	9.8%	16.3%	11.0%	21.0%	10.7%	18.5%
43	4.9%	14.1%	6.2%	12.7%	10.2%	15.6%	11.5%	20.6%	11.2%	18.1%
44	6.1%	13.9%	7.5%	12.2%	10.1%	16.4%	11.7%	21.7%	10.8%	18.6%
45	5.1%	14.3%	6.6%	12.4%	10.0%	15.7%	11.5%	21.5%	11.1%	17.9%

Appendix Chart 3-Correlations

Nominal correlations:

	Inflation	LTGB	LTCorp	USL	USSM	INT
Inflation	1.00	0.29	0.36	0.41	0.38	0.39
LTGB	0.29	1.00	0.67	-0.18	-0.23	-0.17
LTCorp	0.36	0.67	1.00	0.38	0.39	0.46
USL	0.41	-0.18	0.38	1.00	0.92	0.90

USSM	0.38	-0.23	0.39	0.92	1.00	0.83
INT	0.39	-0.17	0.46	0.90	0.83	1.00

Real correlations:

	Unex. Inf	LTGB	LTCorp	USL	USSM	INT
Unex. Inf	1.00	0.22	0.29	0.38	0.37	0.36
LTGB	0.22	1.00	0.65	-0.25	-0.30	-0.23
LTCorp	0.29	0.65	1.00	0.33	0.35	0.43
USL	0.38	-0.25	0.33	1.00	0.92	0.90
USSM	0.37	-0.30	0.35	0.92	1.00	0.82
INT	0.36	-0.23	0.43	0.90	0.82	1.00

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