Title: **Equity Indexed Ideas for Old Age Security**

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Abstract: The current US Social Security System cannot deal with the changes in the demographics of the baby-boom type. A pay-as-you-go system in general is not well suited to deal with the issues of an exploding retiree population and a stagnant working population. Our paper offers a solution in the form of a new system based on the three classic designs found in the equity indexed annuity market: the "point-to-point" design, the "annual reset" design, and the "continuous lookback" design. This will be a defined contribution plan design with various adjustments to alleviate some of the problems inherent to such models. These adjustments include: an independent agency decides how and where the investments go, relieving the people of their investments duties; the investment rate of return will be tied to the return on a wide ranging market index such as Wilshire5000; and there will be a minimum guaranteed rate of return that will be credited when the index is below this threshold. Our paper shows that the new system exhibits very good replacement ratios, no intra-generational conflict, flexibility in dealing with changing demographics, and minimum risk of ever being insolvent. There will be high costs associated with the move to a new system, but the costs of doing nothing would be a lot higher.

Keywords: equity indexed, old age security, US Social Security, baby-boom generation

Executive Summary

Even though the current US Social Security System was initially intended to be at least pre-funded, over time it shifted to a true pay-as-you-go system. This type of system cannot deal with the big changes in the demographics experienced over the last century. When the system was initialized the average expected lifetime was around 50 years. Today that average is about 78 years. Yet, the retirement age has barely moved from 65 to 67. The pay-as-you-go system is just not capable of dealing with this issue: people living longer in retirement and getting paid a lot more than what they paid into the system. If we add into the mix a baby-boom generation followed by a baby-bust generation, we have the current predicament of the US Social Security System. It is estimated that the Social Security funds will be exhausted by the year 2042. That is 36 short years from now.

Our paper offers a solution in the form of a new system: a defined contribution plan with various adjustments to alleviate some of the problems inherent to such models. One of these adjustments is that the government decides how and where the investments go, relieving the people of their investments duties. We can do this by assigning the funds to certain credentialed investment companies (preferable) or the government could run the program alone (politically impossible – we think). The investment rate of return will be tied to the return on a wide ranging market index such as Wilshire5000, Russell2000 or S&P500. There will also be a minimum guaranteed rate of return that will be credited when the index is below this threshold. These ideas are based on the three classic designs found in the equity indexed annuity market: the point-to-point design, the annual reset design, and the continuous lookback design.

The new system exhibits very good replacement ratios for all three designs. A 35%-45% replacement ratio is a very good start to one's retirement considering that only about 80% is necessary to keep the same life standard prior to retirement. The flexibility in dealing with the participation rates of these equity indexed designs allows for covering the costs associated with pre-retirement survivorship and disability benefits as well as minimum guaranteed benefits. The retirement benefits will be pre-funded and we show that the earlier one starts saving, the lower their contributions towards their retirement benefits. There will be no intra-generational conflict with the new system, since everybody will get whatever they contributed plus interest. In light of the historical data available for the returns on equities globally over the last century, we think that this system runs minimal risk of ever becoming insolvent. Many, many years of depression need to be strung together for the system to become insolvent. If we ever get there, we would probably have bigger problems to worry about anyway.

The costs associated with the move to a new system will be high for sure. But the costs of doing nothing would be a lot higher.

1. INTRODUCTION

When introduced, the U.S. Social Security System was intended to be a funded program to help with retirement costs and to provide funds for orphans and widows. At the time, the life expectancy was approximately 50 years, and benefits were payable at age 65.

Seventy years later, the U.S. Social Security System is a pay-as-you-go system that is relied upon as a major source of retirement income. Life expectancy in the United States is now approaching 80, and benefits are still payable at age 65 (increasing over time to age 67). In addition, the benefits were significantly improved over the years.

Because of these changes, the U.S. faces an expensive problem that is further complicated by the baby boom generation. The retirement of the baby boom generation will change the ratio of workers to retirees from 3.2:1 in the early 1990's to 2.1:1 by the year 2030.

This problem is not unique to the U.S. In fact, most European economies face even greater aging issues than the U.S. All European economies in the OECD except for Iceland and Ireland expect to have a greater percentage of population over sixty years old in 2030 than the U.S.(see [6]) In addition, most European social security systems currently provide greater replacement rates than does the U.S. system. The U.K. is the only country in Europe that has moved to provide social security benefits from a defined contribution system, and that is a voluntary move by participants. While our paper will focus on a solution to the U.S. problem for future generations (as opposed to solving the funding problem for the current generation), we believe that the concepts would be useful in Europe as well.

In the U.S., under current law and projections, the U.S. Social Security System will be insolvent by 2042. The only solutions possible under the current system are to decrease benefits or to increase cashflow to the system. Increases to cashflow could occur through higher taxes or through changes to the investment philosophy of the system, i.e. invest in non-government equities and bonds.

Given the relatively short time horizon at this point, clearly benefit reductions and tax increases are the most logical choices. Both options are difficult. If you reduce benefits, beneficiaries may perceive that the system has broken its promise. If you increase taxes, the burden may be too great for the working generation to bear.

Once a solution is found to the funding of current benefits, it is logical to suggest that a new system might be more effective in dealing with the new facts of life today. This paper proposes a new structure based on a defined contribution base. However, the investments, guarantees on returns, and minimum benefits are structured so that a reasonable return may be earned by participants and so that the system can meet its ability to provide for those individuals who do not have significant accruals within the system.

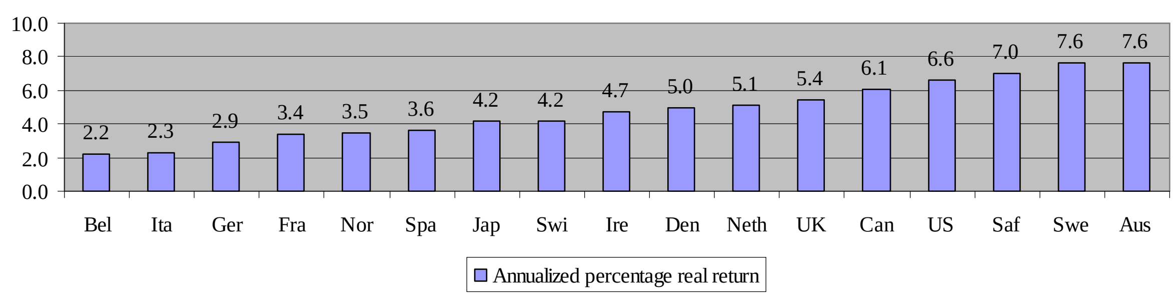
Our solution presumes a funded, defined contribution system. Clearly, arguments for a funded, defined benefit system can be made and can be very persuasive. However, the risk associated with benefit increases (granted by politicians) in a defined benefit system is real, and we believe that our proposed design helps to significantly reduce the risk of endangering social security systems due to political "give-aways."

We do not attempt to answer the issue of funding current benefit promises. In addition, any transition to a defined contribution system will cause additional funding issues. Our solution is a long-term solution that reduces the risk of future social security funding problems.

2. ANALYSIS OF INVESTING IN EQUITIES

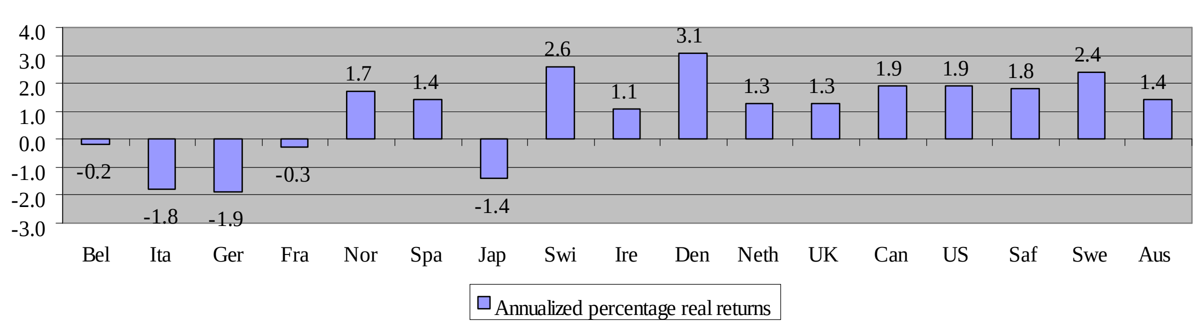
In Figure 1 we have the return on equities around the world over the last century.

Figure 1: Annualized returns on equities internationally, 1900-2004



It is important to note that the above returns are real rate of returns, not nominal. As we know the real rate of return is the nominal rate of return minus inflation rate. The average inflation over the last century was around 3.2% (see [4]). The countries above represent about 92% of the world markets. It is fairly easy to conclude that over the last 100+ years the return on equities globally was tremendous. If we were to look at the second half of the century we would see even higher returns due to the relative economic stability that followed the two World Wars from the first half of the century. The returns on bonds around the world for the same countries are presented in Figure 2.

Figure 2: Annualized returns on bonds internationally, 1900-2004



Clearly, equities have outperformed the bonds everywhere. If we look at the US markets, over the last 70 years the US Treasury bills averaged an annual nominal return of just over 3%. At the same time the S&P 500 averaged around 11%.

In view of all this data it seems almost absurd that the US Social Security system finds itself in the difficult position of today. The OASDI trust fund is projected to be depleted by 2042, and in 2018 Social Security payroll tax income is estimated to be less than the annual benefits and expenses. Of course, there are many reasons why the system is in this position. Some of them are economic, some of them (most of them) are political, but we will try to focus our attention on solutions to the problem.

As we mentioned before, the US Social Security System was envisioned initially to be pre-funded, but this idea was pushed into the future more and more and eventually was abandoned altogether. So, we were left with a pay-as-you-go system that cannot deal with problems such as the baby-boom generation. There are simply not enough young people to pay the Social Security taxes to fund the huge number of baby-boomers.

The other major problem is the retirement age. When the system was set up in the 1930s the expected lifetime for people in the US was around 50 years. The retirement age was set up at 65. Today's expected lifetime for people living in the US is approaching 80 years. The retirement age got pushed up to 67. Again, this is a major problem for a pay-as-you-go system. People simply retire and live a lot longer than expected and, in retirement, they get paid a lot more than what they paid into the system.

So, then, we have a system that clearly favors one generation over the next one, and that is not what a system for old age security is supposed to do.

How do we solve these problems? Individual Accounts seem like an easy answer. But, we have to be careful about many things, because many things can go wrong with individual accounts as well.

In view of the data presented earlier, it is only natural to try to devise a social security system that takes advantage of the equity returns over long periods of time. And, while 10% annual return in the past 100 years does not guarantee a 10% return for the next 100 years, we can assume safely that the return on equity will at least beat inflation and bonds over long periods.

Since they were first introduced in 1995, equity-indexed annuities have generated a great deal of attention and excitement in the investment world. They are basically, equity-linked deferred annuities whose returns are based on the performance of an equity mutual fund or a stock index. Usually a well-known index such as S&P 500 is used. The equity-indexed annuities have some very attractive features for both investors and, as we shall see, somebody using them for retirement plans. First, you have the chance to participate in the equity market. Second, there is a minimum guaranteed rate of return, so if the markets turn south, you are still protected. Third, some EIA designs allow for locking in of the credited interest rates.

A key concept for the EIA is the participation rate. This is set by the company selling these products in order to achieve certain economic purposes (profit, break-even, etc.). The way it works for a typical "point-to-point" EIA design is a s follows: if S&P 500 has a realized 5-year return of 8% and the participation rate is set at 90%, then the actual interest rate credited to the policy will be 8% x 90% = 7.2% if this is bigger than the minimum guaranteed rate (usually set around 3%).

As somebody is preparing for their retirement, they would probably like to have an assurance that, no matter what happens with the markets, they will always be guaranteed a rate of return that is just above inflation. Note that investing in the US Treasury bills would only result in a rate of return just above the inflation anyways.

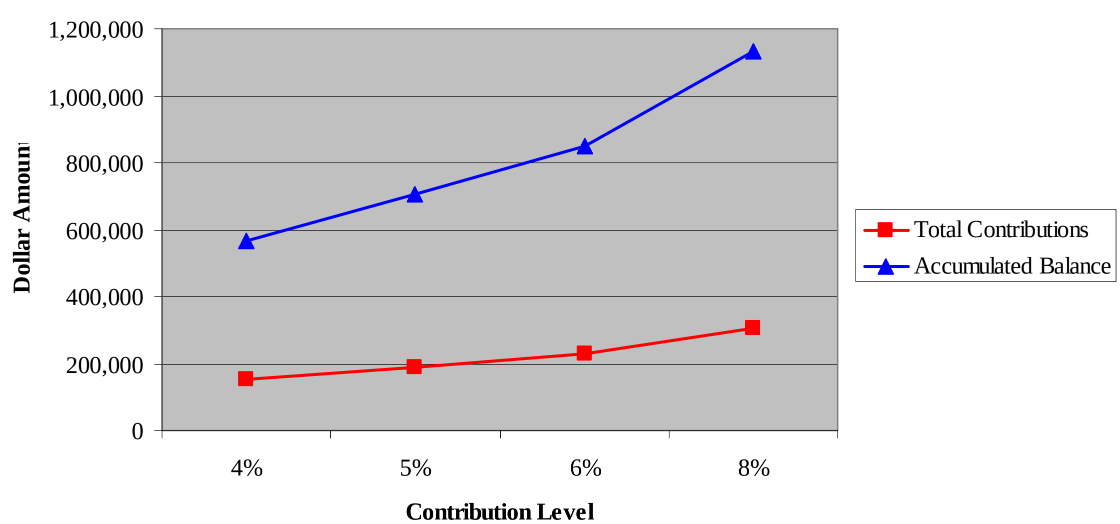
So, our idea is to construct a new US social security system that is based on these equity-indexed ideas, and then discuss its strengths and weaknesses and ways of implementing it. For the rest of this paper we will assume that the normal retirement age is 70. We will also assume a 4% salary scale and an inflation rate of 3%.

Example 1 Let us first look at a person that is 21 years old now with an annual salary of $25,000. We assume that he will invest 4% (we call this the contribution level) of his salary every year and we also assume a 6% investment return. Then, by the time he is 70 years old, he will have contributed $152,667. This can be calculated using the formula:

$$1 + x + x^2 + ... + x^n = \frac{x^{n+1} - 1}{x - 1} \qquad (1)$$

Using the same formula we determine that his accumulated balance at age 70, using the 6% rate of return, will be $565,674. In Figure 3 we can see the total contributions and accumulated balances at age 70 for various contributions levels. Obviously, the more you contribute, the greater the accumulated balance at age 70.

Figure 3: Total Contributions And Accumulated Balances



The first conclusion we can draw is that pre-funding your retirement benefit is a good idea. The contributions made by this hypothetical person during his working years represent only 27% of the accumulated balance at age 70. The rest is made up by the interest accumulated over a long period of time.

Note that the interest rate of 6% is a nominal rate of return, so, in terms of real return that would only be a 3%. Going back to our data regarding returns on equity over the last century, the 3% real rate of return does not seem very difficult to reach under most circumstances.

The salary this person would earn at age 70 is equal to $25{,}000 \times 1.04^{49} = 170{,}834$.

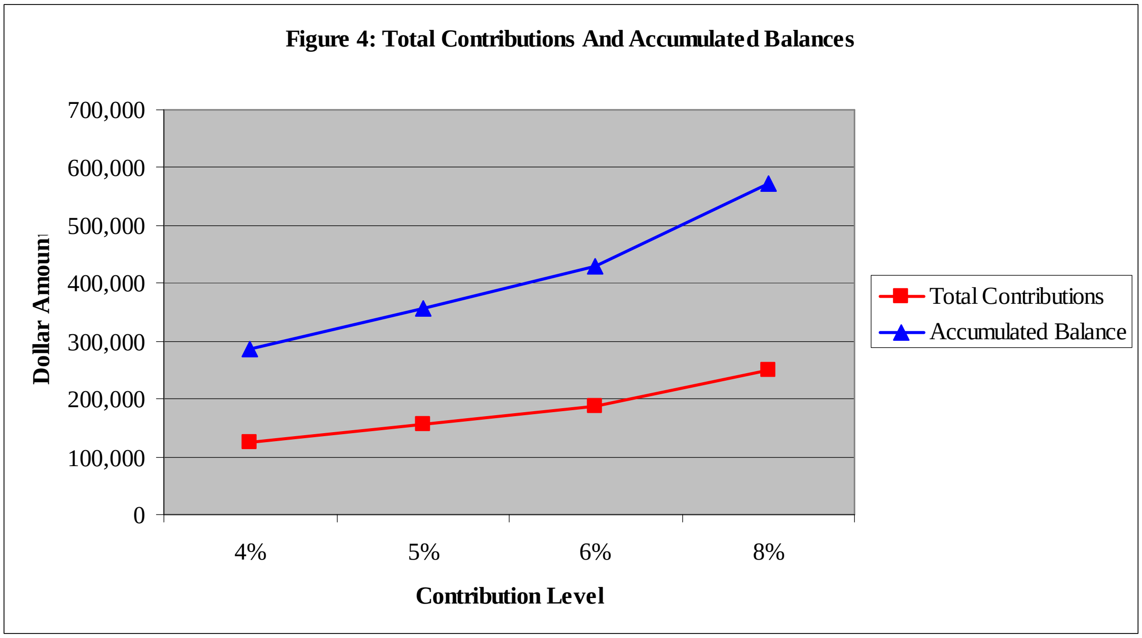
The annual retirement benefit based on his accumulated balance at age 70, using an annuity factor based on a 6% interest rate and a generic mortality table, will be (for the 4% contribution level scenario) $565{,}674 / 9.5 = 59{,}545$. This represents a 35% replacement ratio (his annual retirement benefit divided by the salary just before he retires). However, the replacement ratio can get as high as 70% in the scenario of 8% contribution level. If we think of the retirement benefits being based on the three big legs: government benefit, private employer benefit, and individual savings, 35% to 70% is a very good start. Most research indicates that an 80% replacement ratio is actually what people need in order to remain at the same pre-retirement life standard.

Example 2 If we take the same person from Example 1 and project him forward to age 40, we will have a person with an annual salary of $52,671. Let us assume that he starts saving at age 40 at a contribution level of 4%, and let us investigate what that means in terms of replacement ratio and contributions made.

Using the equation (1), the contributions he makes to his retirement account by age 70, are $124,995. The accumulated balance at age 70 is 286,000.

So, in this second example the contributions made during his working lifetime represent about 44% of the accumulated balance at age 70. This is due to the fact that this person started saving a lot later than the person in Example 1 and therefore there is less time for the interest to accumulate.

His annual retirement benefit would be $286{,}000 / 9.5 = 30{,}105$, which represents a replacement ratio of only 18%. This is very important to note in view of any change to a new system. Some people will have less time to accumulate their benefits, and we will have to find adjustments for that. The solutions for the person in Example 2 are either to contribute more or to get a rate of return on his investments higher than the person in Example 1 or to receive some benefit for his pre-40 contributions.



For various contribution levels we can see in Figure 4 the different outcomes for this particular person. We have to note that the replacement ratio in the 8% contribution level scenario is close to 35%, which means that somebody that started saving at age 40 needs to save twice as much as if that somebody had started saving at age 21.

3. NEW DESIGNS FOR US SOCIAL SECURITY

We will construct a system which will benefit everybody under the age of 40. That means that anybody over the age of 40 will still be covered under the old system. This is of course subject to discussion and we could look at a gradual approach with some people being covered by both systems (administratively difficult) or maybe give a choice to those people that are within 3-5 years of age 40. For simplification purposes and to make discussions and comparisons between systems easier we will assume that age 40 is the "cutoff" age.

From the current FICA taxes we will set aside 4% for everybody that will go in an individual account. We call these accounts "individual", but really the individual is not in control of the investments. An independent agency (or the government) will distribute this money among various investments companies with good credentials and will allow said companies to invest at their own discretion within certain regulations. By doing this we alleviate one of the two big problems related to individual accounts and 401(k) plans in particular – participants' lack of investing knowledge. The "certain regulations" mentioned above are to follow the regular equity-indexed annuities principles. The money invested in these "individual accounts" will earn a rate of return that is tied to the S&P 500 index (or Russell 2000 or Wilshire 5000). There will also be a minimum guaranteed rate of return of 3% on these investments. This minimum guaranteed rate solves the second big problem encountered in the defined contribution field – namely, that no benefits are ever guaranteed.

We will look at three types of designs based on three types of equity-indexed annuities. A first type of design will be a “point-to-point” design, where the index is surveyed over a period of time and only the value of the index at the two ends of the intervals is considered. A second design will be the “annual reset” design where the rate is locked in at the end of every year. A third type of design is the “continuous lookback” design where the rate will be based on the highest value reached by the index over a certain period of time.

In order to keep it simple from an administrative point of view we will consider that all the contributions made in any one year took place at the end of that year. In order to determine the rate of return of the index over a given period of time we will look at the value of the index at the end of the year when they started contributing and at the beginning of the year when they turn 70. For example, if somebody starts contributing on May 15, 2010 and he will turn 70 on September 1, 2055, we will look at the value of the index as of December 31, 2010 and the value as of January 1, 2055.

The following assumptions are made for all the pricing formulas found in this paper. We assume that the market is complete, and therefore that there exists a unique risk-neutral measure. The risky assets follow a standard geometric Brownian motion. We also assume that the risk-free force of interest is constant and that there are no transaction costs.

3.1 The Point-to-Point Design

Let $S(t) = S(0)e^{X(t)},\ t \geq 0$, be the value of a risky asset (the S&P 500 for example) at time t. Under the Black-Scholes model, $X(t)$ is a Brownian motion with drift u and diffusion σ^2. This means that for any $t \geq 0$, $X(t)$ follows a normal distribution with mean μt and variance $\sigma^2 t$. Let α be the participation rate, $\alpha > 0$, and let g be the minimum guaranteed rate of return.

At time $T, T \geq 0$, given an initial premium of \$1 the point-to-point design pays $e^{\alpha X(T)}$ or e^{gT}, whichever is higher. Therefore, at maturity, this policy earns a percentage of the realized return on the risky asset over T periods, with the provision of a minimum guaranteed return of g compounded continuously over time. The value of this policy can be computed as (see [1]):

$$P_{pp} = e^{[(\alpha-1)r+0.5\alpha(\alpha-1)\sigma^2]T}\Phi\left[\frac{(r-0.5\sigma^2+\alpha\sigma^2)T-\frac{gT}{\alpha}}{\sigma\sqrt{T}}\right]+ \\ +\mathrm{e}^{(\mathrm{g}-\mathrm{r})\mathrm{T}}\Phi\left[\frac{\frac{gT}{\alpha}-(r-0.5\sigma^2)T}{\sigma\sqrt{T}}\right] \tag{2}$$

where r is the constant risk-free force of interest and $\Phi(\cdot)$ denotes the cumulative distribution function of a standard normal random variable.

Due to the increased volatility exhibited by the markets in the early 2000s the prices for these equity-indexed annuities have increased and as a consequence the participation rates have dropped significantly.

In order to improve the classic models and alleviate the increased volatility issues, different solutions were offered (see [1] and [2]) in the last few years.

The "barrier approach" seems like a fairly straight solution. This policy will pay the realized return on the index, with a participation rate α, as long as that is more the minimum guaranteed g, and it does so only if the index reached a certain barrier B. Hence, this policy will pay $\max(e^{gT}, e^{\alpha X(T)})$, if $\alpha X(T) \geq BT$, or just e^{gT}, if $\alpha X(T) < BT$. The price of this policy can be computed as (see [1]):

$$P_{bp} = e^{[(\alpha-1)r+0.5\alpha(\alpha-1)\sigma^2]T}\Phi\left[\frac{(r-0.5\sigma^2+\alpha\sigma^2)T-\frac{BT}{\alpha}}{\sigma\sqrt{T}}\right]+ \\ +e^{(g-r)T}\Phi\left[\frac{\frac{BT}{\alpha}-(r-0.5\sigma^2)T}{\sigma\sqrt{T}}\right] \qquad (3)$$

The advantage of this second policy is that the participation rates are higher for the same price. Using $T = 10$, $g = 3\%$, $\sigma = 20\%$, $r = 5\%$, $B = 7\%$, we obtain, for a break even price of $1, a participation rate of about 76% for the classic design and about 86% for the barrier design.

Equations (2) and (3) are valid for an annuity with one single payment of $1 at the beginning of the period $[0,T]$. In order to obtain a formula for the person in Example 1 we would need to add 49 equations of type (2) or (3) for $T = 1,\ldots,49$ and discount them accordingly.

Let us study the strengths and weaknesses of a social security system based on the above design.

From an administrative point of view it would not be too complicated to keep track of rates of return because we are dealing with end of year values for the given index every year.

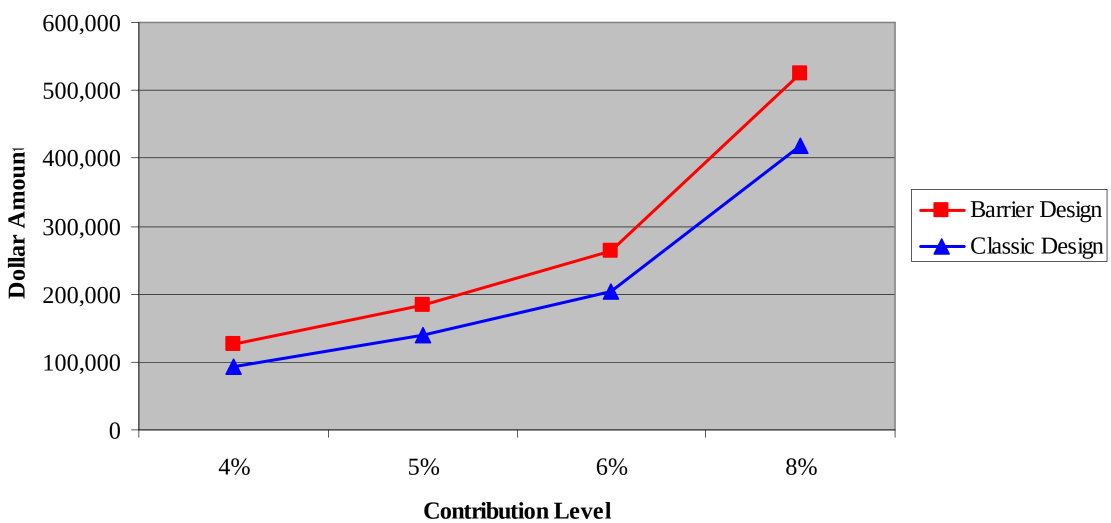
At the same time this may be a weakness, as there could be special pressures and risks associated with relating the rate of return to one singular value in any one particular day.

That particular day could be the worst day over the whole period the index was surveyed. To solve this problem, the value could be computed as an average of a few weeks before the end of the year. This is called an "Asian end" design. A little bit more work (and therefore more cumbersome) needs to be done in order to price this design accurately.

Of course, when somebody is investing for 40-50 years it is a little bit hard to make everything depend on any particular week or month or even year. The fact that somebody's retirement age happens to fall in the middle of the "Great Depression 2" should be accounted for and dealt with. The point-to-point design is not well suited to deal with such issues.

Let us revisit Example 1 and see what happens to that person in our various scenarios. We assume a 10% annual rate of return on the index over the 49 years he contributes to his individual account. According to equation (3) in order for the investment groups to break even, given one single payment of $1 at the beginning of a 10-year period, the participation rate would be 86%. For longer periods of time (which is the case in Example 1) the participation rates only grow higher (see [5])

Figure 5: Annual Benefit Payable at Age 70 under The Point-To-Point Design

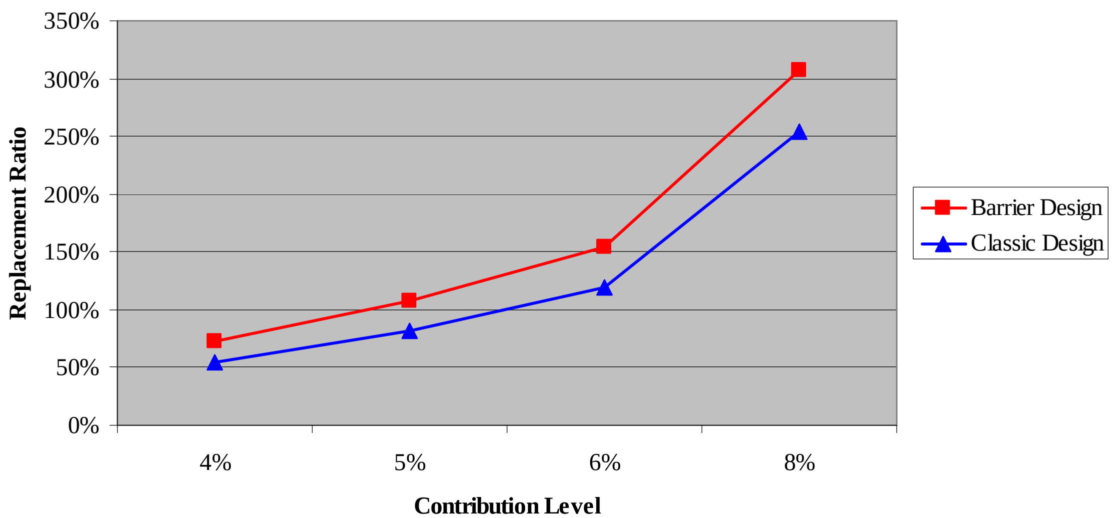


Keep in mind that most of his investments (38 of the 49 annual payments-taxes) will be accruing interest for more than 10 years. We will assume a conservative 86% participation rate for all his investments. This would be a fairly conservative assumption even for somebody age 40 – the "cutoff" age for the new system – as 20 out of the 30 annual payments-taxes would be accruing for more than 10 years. Then, the person in our Example 1 would be credited an annual interest rate of 8.6% under the barrier design, and, following a similar analysis, a 7.6% rate in the classic design. Therefore, using equation (1) again, we obtain the chart from Figure 5 for various contribution levels.

The first thing we notice is the fact that under the barrier design the annual benefit payable at age 70 is always greater than those in the classic design. This is of course due to the fact that we are able to provide a higher participation rate at the expense of an extra hurdle (barrier) the index has to pass. Also, as noticed earlier, the higher the contribution level, the higher the accumulated balance and consequently the annual benefit payable at age 70.

Another measure of the success of a retirement system is the replacement ratio. In Figure 6 we have the replacement ratios corresponding to the values from Figure 5:

Figure 6: Replacement Ratios under The Point-To-Point Design

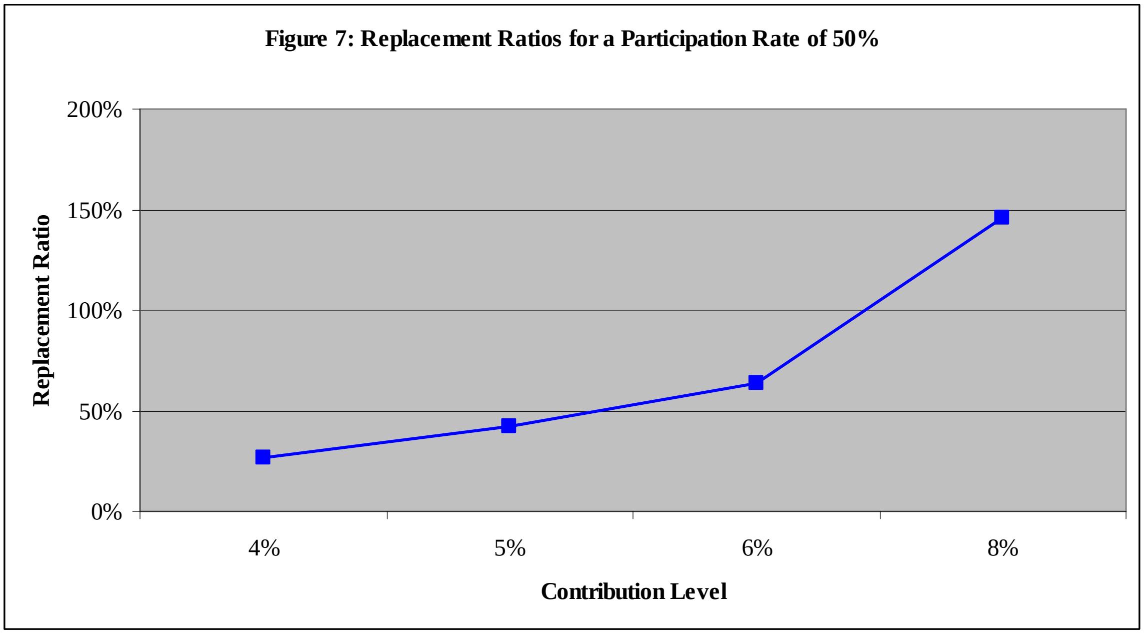


We notice that if a contribution rate of 5% (instead of 4%) is used for these individual accounts, the person from example 1 would have a replacement ratio in excess of 100% under the barrier design. This means that his annual benefit in retirement would be higher than his salary at just prior to age 70. That would qualify as a more than adequate Social Security system.

However, since we are looking for solution to real world problems let us look a little bit deeper. The participation rate would have to be set lower than 86% because *there are* administrative costs and other issues to be dealt with. Some of these other issues relate to ways to pay for people with disabilities that cannot work anymore, ways to pay the beneficiaries of people that die before they reach retirement age and also how to deal with lifelong poverty.

By lowering the 86% participation rate to about 50% we think there would be enough savings to provide everybody with a minimum benefit regardless of how much they contributed, as well as all the other costs associated with the pre-retirement survivorship and disability benefits. In the current US Social Security system the costs associated with the above issues are approaching 25% of the overall cost. In the new Social Security system the adjustment in the participation rates from 86% to 50% should more than cover for them.

Figure 7 below shows the updated replacement ratios for the 21-year old from our Example 1, using a 50% participation rate.



The replacement ratios drop as expected, but, the new Social Security design would still be more than adequate, as it provides at least a third of the retirement income in most cases.

So, one of the main strengths of this system based on this particular design is that given the assumption of a healthy economy and solid returns (not spectacular) the new design would help make in most cases more than one third of the replacement ratio needed in retirement to maintain pre-retirement life standards.

3.2 The Annual Reset Design

This is also called the "ratchet design" or the "cliquet design" and is the most common type of equity-indexed annuity in the markets. This policy will earn, at the end of every period, the return on the asset $S(t)$ over that period with a participation rate $\alpha \geq 0$, or the minimum guaranteed return g, whichever is higher. Once interest is credited, the earnings are locked in and will never decrease, regardless of future performance of the market.

This is clearly a big improvement over the point-to-point design, since we are now splitting the long period of time before people retire into many smaller ones. Therefore, one can take full advantage of a good run in the markets and still get a minimum return in years when the markets are not performing well.

The price for this type of policy is given by (see [1]):

$$P_{ar} = \left[e^{(\alpha-1)r+0.5\alpha(\alpha-1)\sigma^2} \Phi\left(\frac{r - 0.5\sigma^2 + \alpha\sigma^2 - \frac{g}{\alpha}}{\sigma} \right) + \mathrm{e}^{\mathrm{g-r}} \Phi\left(\frac{\frac{g}{\alpha} - r + 0.5\sigma^2}{\sigma} \right) \right]^n , \qquad (4)$$

where n is the number of years the policy goes over.

The big problem with this design is the cost. For the same market setting we used previously ($T = 10$, $g = 3\%$, $\sigma = 20\%$, $r = 5\%$) we obtain, for a break even price of $1, a participation rate of about 35%. To improve the participation rates the same barrier approach works here as well. The formula for the barrier design can be found in [1] and will not be reproduced in here as it is rather lengthy. The improvements brought by the barrier design are smaller than in the point to point design case. Depending on how aggressively the barriers are set, we can increase the participation rate to about 40%.

The worst case scenario for this annual reset design is the case when every year the markets are not performing well and therefore the rate that will be credited to the account is the minimum guaranteed rate of 3%. Note that this is also the worst case scenario for the point-to-point design. Then, given a contribution level of 4%, the person in our Example 1 would have an accumulated balance at age 70 of $272,278. This would lead to a low 17% replacement ratio. This is expected due to the costly annual "lock" feature. However, if we increase the contribution level to 5% the replacement ratio becomes a respectable 27%.

This type of policy also solves the problem we mentioned earlier regarding somebody retiring in the middle of a depression. Since the rate of return gets locked in every year, a few bad years at the end of his working lifetime will not affect too much his retirement benefit.

Of course the administration of this system will be more cumbersome, since we would have to recalculate everybody's benefit every year.

3.3 The Continuous Lookback Design

The third and last classic design we will be discussing is the continuous lookback design, It is also called the "high-water mark" design. The basic concept of this type of policy is that, at maturity, the interest rate earned will be based on the growth rate of the highest index value attained during the life of the policy over the value of the index at the start of the term. Let

$$M(T) = \max_{0 \le t \le T} X(t) \qquad (5)$$

be the maximum rate of return on the index attained over the time interval $[0,T]$. At time T the policy pays $e^{\alpha M(T)}$, α being the participation rate, or e^{gT}, whichever is higher. We denoted the minimum guaranteed rate by g. The price of this policy can be computed as (see [1]):

$$P_{cl} = e^{[(\alpha-1)r+0.5\alpha(\alpha-1)\sigma^2]T}\Phi\left[\frac{(r-0.5\sigma^2+\alpha\sigma^2)T-\frac{gT}{\alpha}}{\sigma\sqrt{T}}\right]+$$
$$+\frac{\alpha}{a(\alpha)}e^{[-(a(\alpha)+1)r+0.5a(\alpha)(a(\alpha)-1)\sigma^2]T}\Phi\left[\frac{(-r+0.5\sigma^2+a(\alpha)\sigma^2)T-\frac{gT}{\alpha}}{\sigma\sqrt{T}}\right] \qquad (6)$$
$$-\frac{\alpha}{a(\alpha)}e^{\left[\frac{a(\alpha)g}{\alpha}-r\right]T}\Phi\left[\frac{-\frac{gT}{\alpha}-(r-0.5\sigma^2)T}{\sigma\sqrt{T}}\right]+\mathrm{e}^{(\mathrm{g}-\mathrm{r})\mathrm{T}}\Phi\left[\frac{\frac{gT}{\alpha}-(r-0.5\sigma^2)T}{\sigma\sqrt{T}}\right]$$

where $a(\alpha)=\alpha+\dfrac{2r}{\sigma^2}-1$.

It may come as a surprise that, for the break even price of $1, and for the same market setting as before ($T=10$, $g=3\%$, $\sigma=20\%$, $r=5\%$), the participation rate available on this classic continuous lookback design is about 75% which is just shy of the participation rate for the classic point-to-point design. This is due to the fact that the cumulative distribution function for the maximum value, over a certain time interval, for a process following a Brownian motion, depends *only* on the value of this process at the ends of the time interval.

The continuous lookback design is very attractive to customers, because they do not depend on the value of the market on any one day, rather the maximum value over the whole period is considered. And this is done without sacrificing the participation rates as is the case with the annual reset design.

This continuous lookback design has been improved (see [1]) using the same “barrier approach” we talked about earlier. The formulas get a little bit more complicated but the participation rates jump into the 85%+ range.

Administratively, this would be more complicated than the simpler point-to-point design but the people benefiting from it would be better off.

4. ANALYSIS OF THE NEW SYSTEM

In Table 1 below we summarize the benefits that the 21 year old from our Example 1 would get under the three new Social Security designs introduced in this paper. The participation rates given in the table are the ones obtained for the break even price of $1. The market setting is the aforementioned one: $g = 3\%$, $\sigma = 20\%$ and $r = 5\%$.

Table 1: Comparison of the New Social Security Designs at a Contribuiton Level of 4%

	Point-To-Point		Annual Reset		Lookback	
	Classic Design	Barrier Design	Classic Design	Barrier Design	Classic Design	Barrier Design
Participation Rate	76%	86%	35%	40%	75%	85%
Accumulated Balance at age 70	$ 884,801	$ 1,190,541	$ 304,351	$ 341,667	$ 859,516	$ 1,155,103
Annual Benefit Payable at age 70	$ 93,137	$ 125,320	$ 32,037	$ 35,965	$ 90,475	$ 121,590
Replacement Ratio	55%	73%	19%	21%	53%	71%

In Table 2 we summarize the same information for a contribution level of 5%.

Table 2: Comparison of the New Social Security Designs at a Contribuiton Level of 5%

	Point-To-Point		Annual Reset		Lookback	
	Classic Design	Barrier Design	Classic Design	Barrier Design	Classic Design	Barrier Design
Participation Rate	76%	86%	35%	40%	75%	85%
Accumulated Balance at age 70	$ 1,321,736	$ 1,750,145	$ 490,206	$ 545,090	$ 1,286,117	$ 1,700,676
Annual Benefit Payable at age 70	$ 139,130	$ 184,226	$ 51,601	$ 57,378	$ 135,381	$ 179,018
Replacement Ratio	81%	108%	30%	34%	79%	105%

The barrier designs provide higher participation rates and therefore are more useful for the new social security system. Let us not forget that we want to adjust downward these participation rates in order to pay for benefits for the pre-retirement survivorship and disability benefits, as well as for the welfare aspect of the social security. The participation rates used in the above tables are already set at conservative levels, following the same analysis as we did in Section 3.1. We could determine the exact numbers to use for the participation rate for anybody in the system, but that might be a little bit too difficult from an administrative point of view, and, probably the savings gained from this, would not be worth the costs.

One of the big weaknesses of the individual accounts idea is the fact that any set tax or contribution would provide the same average replacement income percentage to everyone, regardless of income. This means that by substituting the current system with the individual accounts system we would be redistributing retirement benefits from the poor to everybody else. At the same time the salary growth for the poor over their careers is lower than the salary growth for the rich, and, as a result, the individual account for the poor will amount to a higher replacement ratio. And, as we said before there will be a minimum guaranteed benefit for everybody regardless of how much they contributed into the system.

Any of the three designs would have no problem in dealing with a social problem such as the “baby boom generation”. Everybody gets the fruits of their lifetime work, rather than hoping there would be enough young workers paying into the system to support them as is the case with the current pay-as-you-go system.

Another problem that could appear with the individual accounts is the annuity factors used in annualizing the accumulated balance into a retirement benefit. Depending on the economic situation in a given period, there could be very favorable factors used for certain people and very unfavorable factors used for some other people. This problem can be regulated with a provision to use a certain 30 or 40-year average interest rate and a generic mortality table. This will help smooth out any of the extreme factors.

One of the biggest issues in a defined contribution plan is the fact that the investment responsibility is shifted from the employer to the employee. The employer is absolved of any financial responsibility and, if the employee is not investment savvy (most people are not), or, if simply the markets don’t perform well for a few years (see early 2000s), we would have lots of people depending only on social security and government help. As a government you are probably trying to avoid these types of social problems. By setting up a social security system with individual account with minimum guaranteed rate and investments responsibilities shifted to people or businesses that have the necessary knowledge, you are solving all these issues.

The “cutoff” age of 40 is not ideal, but it can be amended. We saw that somebody starting saving at age 21 has a big advantage over somebody starting at age 40. In order to solve this problem we could use again our trusty participation rate and grade it. For example, for people in the 30-40 years old range we would provide higher participation rates. For those younger than 30 we would provide lower participation rates.

The individual accounts system as we presented it here is clearly a better system than the current one. It will never have the intra-generational conflict. It can deal just fine with baby-boom type generations. Over the long run the system will not run into any solvency problems. It is fair to everybody contributing. It is flexible enough to adjust for various causes (just play with the participation rates).

Of course then, the next logical question is why we don’t have this system up and running yet? The quick answer is that we already have a system in place. Trying to switch to a new system requires an enormous effort and good will from the part of all parts involved. The cost associated with such a switch is the subject of heated debates everywhere. The current administration puts the price of a transition to an individual account system with 4% contributions at around $2 trillion. Other experts estimate that as high as $5 trillion. The costs are high, the current economic situation is uniquely bad with record federal deficits. Yet, we have to do something now because we have already waited far too long and the price of doing nothing is too high.

All this leads to a discussion about ways of implementing a new system. We believe that due to the flexibility nature of an equity-indexed approach, this can go a lot smoother than people would think. The current FICA taxes will still be paid to help keep the promise made to the older generation. But 4% to 8% of them will be shifted to the new system. The government will have to pay the difference. The way we see it, is either pay now or pay later. A government will eventually have to pay a huge bill anyway. We could also try to get the older generation involved by offering them a combination of benefits from the two systems and this would help lower the costs.

5. CONCLUSIONS AND FINAL COMMENTS

We constructed a new Social Security System based on designs from the equity-indexed annuity markets. The three design presented are the point-to-point, the annual reset, and the continuous lookback. They are all well suited to deal with issues such as the baby-boom generation and by adjusting the participation rates the system can provide for welfare benefits, pre-retirement survivorship and disability benefits. The fact that we call them "individual accounts" does not mean that the individual is in charge of investments. The government will be in charge of designating who is investing the money and there will be rules and regulations set in place just for this. And then there is always the minimum guaranteed rate of return, providing people with the assurance that a few bad years in the markets will not ruin their retirement plans. There is no doubt that the costs of implementing this new system will be high, but the costs of doing nothing will be a lot higher.

We also need to mention that the international experience with public pension plans is not all positive, but most of the funds with problems are in the developing world. There are some good examples of well-performing funds in countries such as Denmark and Norway.

We should also be aware of the fact that when valuing long-term options the results are very sensitive to the assumptions. So, carefully setting the assumptions is a must for this new system. More research needs to be done to develop proper hedging strategies, as well as formulas that allow for varying interest rates (non-constant force of interest). The reserving practices and regulations for the equity-indexed annuity market can be described at best as not clear and, therefore, there would probably be a great need for a PBGC equivalent institution.

BIBLIOGRAPHY

[1] Sachelarie, V. *Improvements 0n The Equity Indexed Annuity Market*, 2002, PhD Thesis – The Ohio State University
[2] Lee, H. *Pricing Exotic Options with Applications to Equity Indexed Annuities,* 2002, PhD Thesis, University of Iowa
[3] Gerber, H.U. and Shiu, E.S.W. *Option Pricing by Esscher Transforms*, 1994, Transactions of the Society of Actuaries 46: 99-140
[4] ABN AMRO, *The Global Investment Returns Yearbook*, 2005
[5] Tiong, S. *Valuing Equity-Indexed Annuities,* North American Actuarial Journal, Volume 4, Number 4: 149-170
[6] Schieber, S. and Graig, L.A. *US Retirement Policy: The Sleeping Giant Awakens,* 1994, The Wyatt Company