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Personal Pension Plans and Stockmarket Volatility

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Abstract

One of the strongest objections against personal pension plans is that they transfer the investment risk to individual workers, who are then exposed to the vagaries of equity and bond markets. Using U.S. historical data, this paper investigates the impact of the volatility of investment returns on replacement rates in the context of personal pension plans. We find large fluctuations in replacement rates across different cohorts of workers, if undiversified portfolios are used.

We then explore a number of simple financial strategies to cope with this problem. These strategies include: portfolio diversification, a late gradual shift to bonds, a gradual purchase of nominal or real annuities, and a purchase of variable annuities. The first three of these strategies lower the volatility of replacement rates but at a significant cost in terms of lower replacement rates. But purchase of variable annuities reduces the dispersion of replacement rates across generations without lowering their level. This result is due to the persistence of the equity premium and the fact that the volatility of equity returns is lower, the longer the holding period.

Sophisticated financial engineering promises more efficient solutions to this problem; however, its applicability in developing countries (and financial markets) may not be feasible. It is worth noting that neither our approach nor the more sophisticated financial engineering solutions would be able to deal effectively with persistent deviations of investment returns from long-term trends. Nevertheless, our findings suggest that excessive concern about the impact of short-term volatility in stock markets on replacement rates may not be warranted.

Introduction[1]

Since the early 1980s there has been a veritable explosion in the spread of what may generically be called personal pension plans. These are arrangements that involve the accumulation of balances in individual accounts and their use for the generation of retirement income.

Following the example of Chile, which pioneered systemic pension reform in developing countries in 1981, several other Latin American implemented similar reforms in the 1990s. The list of countries includes Argentina (1994), Bolivia (1995), Colombia (1994), El Salvador (1998), Mexico (1997), Peru (1993) and Uruguay (1996). Although the scope and details of the reform programs vary considerably among these countries, they entail in all cases the use of fully funded personal pension plans as one of the main components of their new pension systems. More recently, several transitioning countries, including Croatia, Hungary, Latvia and Poland in Eastern Europe as well as Kazakhstan in Central Asia, passed legislation that involves the compulsory use of personal pension plans as part of their national pension systems.

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At the same time, there has been a growing use of defined-contribution and personal pension plans in various OECD countries. In the United States, the spread of personal pension plans was stimulated by the authorization of individual retirement arrangements (IRAs) by the Employee Retirement Income Security Act (ERISA) of 1974. A major boost was provided in 1978 when employer-sponsored 401(k) plans were authorized and especially in the early 1980s when the tax treatment of these plans was clarified. A further important development occurred in 1986, when the Thrift Savings Plan (TSP) for federal government employees was introduced. Although employer-sponsored DC plans existed before the mid-1970s, such plans are now dominated by 401(k) plans. In the United States, an early and highly successful example of personal pension plans is the system run by TIAA-CREF for college professors and teaching staff.

In the United Kingdom (as in other Anglo-American countries), defined-contribution plans, traditionally known as money-purchase schemes, used to be offered to workers of some industries. Their use declined drastically after the high inflation of the 1960s. Defined-contribution plans continued to be used on a small scale, especially in the form of additional voluntary contribution (AVC) plans and pension plans for self-employed people. But their use became more widespread after 1988, when employees were given the right to opt out of both the earnings-related component of the state pension system and employer-sponsored pension plans. At the same time, companies in the United Kingdom as well as Australia, New Zealand and South Africa started to convert their defined benefit plans into defined-contribution ones, especially for new employees.

Among OECD countries, Australia and Switzerland stand out because they are the only ones that have imposed on employers the mandatory offer of pension plans to all their employees. Although employers are free to offer defined-benefit plans, the minimum legal requirements are set out in terms of defined-contribution plans and this has given a boost to the offer of DC plans in these countries.

Finally, mention should be made of countries such as Malaysia and Singapore that have long operated national provident funds based on individual accounts and defined-contribution plans. Provident funds were also established in several other developing countries, especially in Africa and Asia.

The growth of personal pension plans has taken place despite the persistence of two major policy concerns regarding their ability to offer stable and adequate retirement benefits to covered workers. The first emanates from the transfer of the investment risk of pension funds to participating workers and their exposure to the volatility of financial returns. The second relates to the underdevelopment and apparent inefficiency of private annuity markets, even in the most advanced industrial countries, let alone in the developing world.

Traditional critics of pension reform have argued that because of the volatility of both equity and bond markets, personal pension plans would be unable to provide a satisfactory pension to all retiring workers. In fact, in countries such as Greece and Hungary that have suffered from repeated episodes of hyperinflation, there is widespread concern that a catastrophic collapse of capital markets might wipe out completely the real value of accumulated balances and thus leave retiring workers without any income at all. High inflation would also

exact a heavy price from the annuity market. Hyperinflation would either erode the value of nominal annuities or lead to the insolvency of insurance companies. In either case, pensioners would be deprived of their regular income.

This last point emphasizes the importance of maintaining low inflation and a stable macroeconomic environment for the successful operation of pension systems that rely on personal pension plans. But even with reasonable price stability, fluctuations in equity and bond returns could cause large differences in replacement rates for different cohorts of workers. Historical data from the United States show that replacement rates would have been highly volatile if extreme investment strategies involving undiversified portfolios (all equities or all bonds) were followed (see below).

This paper, using the longest available data for the U.S. markets[2], focuses on the impact of market volatility on investment returns and replacement ratios under various stylized scenarios.[3] It does not discuss the problems facing annuity markets.[4] There are three aspects of the volatility of investment returns as it affects the replacement rates offered by personal pension

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2 While the U.S. experience reflects the prevalence of a large equity premium over the past 120 years, its experience is not unique. Several other developed countries, that have followed relatively stable and sound financial policies, have also experienced large and persistent equity premiums since the 1920s. The European Commission (1999) reports that, since the 1920s, equity premia in countries such as Australia, Canada, Denmark, Sweden, Switzerland, and the U.K. have been between 4 % and 8.5 %. Developing countries could benefit from similar equity premia in the future if they were to pursue policies that promote sound and stable financial systems.

3 Burtless (1998) also uses historical U.S. equity returns to discuss the impact of volatile equity returns on replacement rates and on the internal rates of return earned by different cohorts. His objective is to critique proposals to privatize social security in the United States that overlook the impact of stock market volatility. Our objective is to discuss simple but feasible solutions to this problem.

4 For a review of the policy issues and likely causes for the underdevelopment of annuity markets, see James and Vittas (1999). There is a fast growing literature on annuity markets in the United States, led by academic researchers at MIT and Wharton, while a research project sponsored by the World Bank is focusing on annuity markets in a number of countries.

plans. The first concerns the fluctuations in annual returns and their impact on the replacement rates of different cohorts of workers. The second concerns the complete collapse of markets as a result of hyperinflation or other catastrophes. And the third concerns the occurrence of persistent deviations from trend that is half way between the first two. A basic point made in this paper is that there are relatively easy solutions to the first aspect of volatility problem (short-term fluctuations with quick reversion to the mean), while the second and third aspects present more daunting and persistent problems that are not amenable to easy solutions.

Without corrective measures, there can be very large fluctuations in replacement rates between retiring workers of different cohorts. Workers retiring in a year when equity and bond markets are booming would obtain a much higher pension than workers retiring when markets are stagnating. For instance, assuming that an all domestic equity strategy was followed, American workers who had invested their balances in a personal plan and retired in 1999 would have achieved a replacement rate that would have been higher by over 180% than workers who retired in 1995. This is because US equities had a cumulative total return of over 180% between 1994 and 1998. In contrast, workers who retired in 1975 would have received a replacement rate that would have been nearly 50% lower than that obtainable in 1973, since the total real return on equities was -21% in 1973 and -34% in 1974. Similarly, Japanese workers that had invested in an all domestic equity personal pension plan would have achieved a much lower replacement ratio in 1990 compared to 1989 since equity prices in Tokyo fell by 60% in 1990.

These would be very large fluctuations in replacement rates that could justify the concerns expressed by critics of personal pension plans. As developing countries have shallower markets, the volatility of returns could be even higher, thus weakening further the case for systemic pension reform. However, various alternative strategies could be followed to mitigate the impact of high volatility in annual investment returns and by extension in the replacement rates of successive cohorts of retiring workers.[5] Some of these strategies are simple and can be implemented in any market environment. Others are more complex and require well-developed derivatives markets, the use of synthetic products, and highly sophisticated investment techniques. The simpler strategies, some of which are already practiced in a number of countries, include the following:

Balanced Portfolios

The first and foremost strategy would be portfolio diversification. By investing in balanced portfolios of equities, bonds and money market instruments, the volatility of returns during the accumulation period can be substantially reduced. This is common practice in most employer-sponsored private pension funds, especially in the United States where government regulations linked to the guarantee of pension benefits impose minimum funding requirements and force sponsoring employers to adopt conservative investment policies or to make up any shortfalls in pension reserves that would result from large fluctuations in asset prices. In several continental European countries, including Germany, the Netherlands, and Switzerland, government regulations impose quantitative limits on investment allocations that aim to reduce

[5] These alternative strategies do not address the problems caused by catastrophic collapses of markets

volatility (even though in most cases employers operate defined-benefit plans and absorb the investment risk).[6] In Latin America, most countries have followed the example of Chile and have imposed upper limits on different classes of assets.

There is a trade-off between volatility (risk) and return. A less volatile portfolio would normally imply a lower return and thus a lower replacement rate and pension. The cost of lowering portfolio volatility can be quite significant if the equity premium is high, as has been the case in the United States and some European countries.[7] Volatility may also be reduced by investing in overseas assets and thus diversifying country risk.

Gradual Late Shift To Bonds

A second strategy could involve switching gradually and progressively from an all equity portfolio to a bond portfolio a few years before reaching retirement age. In this case the cost of lower volatility, measured in terms of lower average lifetime returns, can be minimized compared to the first option. This option could avoid exposure to serious equity market downturns at the end of the active life, when most of the pension fund has been accumulated and the worker does not have a great deal of time to make up any losses. The solution proposed here consists basically of having age-specific pension funds: those for younger workers investing mostly in

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or by persistent deviations from trend.

6 Notably, most of these quantitative limits have not been binding, although fund managers, especially in the Netherlands, have been pressing for their removal or relaxation.

7 Goetzmann and Jorion (1997) report data for equity returns in a large number of countries. These show that real equity returns were low in many countries that suffered from very high inflation or from interruptions caused by war or financial crises. But a few European countries, such as the United Kingdom, Denmark, Sweden, and Switzerland as well as the United States, reported uninterrupted real equity returns ranging between 5% and 8% (Table 3 of their paper).

equity and those for older workers investing a high proportion of their assets in government bonds. Both Chile and Mexico are contemplating the use of age-specific pension funds.[8]

Gradual Purchase Of Fixed (Nominal Or Real) Annuities

A third strategy could entail the gradual purchase over a number of years (say five years before retirement) of several fixed (nominal or real) annuities. The annuities would start making payments as of the date of retirement. If five installments were used, four of the annuity contracts would be deferred annuities, starting to make payments not immediately after purchase but some time later. A gradual purchase of fixed annuities is already allowed in the United Kingdom.[9]

Use Of Phased Withdrawals Or Purchase Of Variable Annuities

A fourth solution could involve the use of phased withdrawals and/or purchase of variable annuities. Several countries, especially in the British Commonwealth, allow workers to withdraw in one lump sum the accumulated balances in their individual accounts. But in the mandatory systems of Chile, Argentina and other Latin American countries workers do not have the option of withdrawing a lump sum (except for balances that exceed targeted pension levels). In these countries retiring workers can either purchase a fixed annuity (real in the case of Chile but nominal in the case of Argentina) from an insurance company or can start a series of phased withdrawals from their pension fund accounts. Phased withdrawals take account of the life

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8 The arguments for age-specific investment policies are reviewed in Jagannathan and Kocherlakota (1996) and Bodie (1998).

9 A similar proposal is made by Burtless (1998). He even goes further and suggests 10 installment annuities, starting 5 years before retirement and continuing until 5 years after retirement.

expectancy of retiring workers and their dependents but do not provide longevity insurance. Under the phased withdrawal option workers obtain a market-related return on their declining balances. They are protected from low asset prices and low returns that might prevail at the time of their retirement and also benefit during their retirement from the higher returns offered by fund managers compared to providers of fixed annuities (perhaps because of a continuing equity premium). Variable annuities operate like phased withdrawals but they also provide longevity insurance. Both phased withdrawals and variable annuities expose workers to the volatility of investment returns during their retirement years. Combining either of these approaches with the purchase of fixed annuities or investments in less risky assets would mitigate this risk. Combining them with purchase of a deferred fixed annuity that becomes effective at age 75 or 80 would probably provide a more economical solution with longevity insurance.

Use Of Derivatives And Synthetic Products

In addition to these solutions that can be implemented without relying on sophisticated financial engineering, there are two other possibilities that would involve the use of synthetic products and derivative financial contracts. Bodie and Crane (1998) and Bodie (1998) have analyzed the use of investment instruments that provide a floor on the value of a worker's assets over some period of time and also provide some share of the upside potential of the equity market as a means of protecting workers from the volatility of stock market returns.

An even more intriguing possibility is to use portfolio insurance, such as through the purchase of European put options, to protect the value of the balances of all workers who would be retiring within the next, say, five years. The exercise price for these options could be

equal to the current level of stock market prices or to a level that is lower by 5% or even 10% than the current level. Thus, a floor would be set on the impact of any market downturn.

The counterparts to the put options contracts could well be the very same pension fund management companies, but acting on behalf of their younger cohorts. That is to say, the put option contracts could be based on an intergenerational contract that would be similar in some respects to the contract that exists for social security systems, albeit with a very big difference. The put option contracts would be executed through the markets and their terms and conditions would be adjusted continuously in response to changing demand and supply factors. Such a solution would not be subject to the political pressures that cause a financial imbalance to arise, persist and worsen before corrective action is taken as has historically been the case with social security systems.[10]

It is of course unrealistic to suggest the use of put options and synthetic products in countries where capital markets are thin and underdeveloped. However, the growth of pension funds is likely to have a major positive impact on the development of capital markets. Thus, when the need to purchase portfolio insurance through put options is felt more strongly, which is likely to happen when pension funds reach a stage of maturity, the capital markets could have developed sufficient size and depth to be able to offer such sophisticated products.

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[10] It is perhaps worth adding a footnote on this point. In private annuity markets, insurance companies try hard to forecast improvements in longevity and adjust their life tables and annuity prices accordingly. In France, the normal retirement age in the social security system was lowered from 65 to 60 in the early 1980s, even though it was well known that French society was aging fast, like the rest of Europe.

Another way of providing a floor to the replacement rate is for the government to offer a minimum pension guarantee. This tends to be offered in countries, such as Chile, that have decided to close down the unfunded public pillar. It is not offered in countries that continue to operate a first pillar, such as Argentina, since the public pension would provide a floor to the replacement rate. However, even in the former countries, the minimum pension guarantee is expressed either in absolute terms and adjusted on an ad hoc basis or in relation to average earnings. The minimum replacement rate that is guaranteed for high-income workers is much lower than for low-income ones. The guarantee is offered free of charge and is available to workers with a minimum period of contributions (20 years in the case of Chile). It is financed from general revenue taxes.

These state guarantees protect low-income workers from the volatility of investment returns but offer limited protection to high-income workers. They are not, therefore, a substitute to the alternative approaches mentioned above. Like all state guarantees, they are exposed to serious problems of moral hazard.

Methodology

Despite the growing interest and attractiveness of DC pension plans, there is not much empirical evidence to allow a systematic exploration of the impact of stock market volatility on replacement rates. As already noted, the Chilean system has been in existence for some 18 years. This covers less than a third of the 60-year span of the underlying pension contract. Despite the high and volatile investment returns of the first 18 years, the Chilean experience is still too short for drawing firm empirical conclusions on the problems that might be caused by

the volatility of investment returns (the average rate of return amounted to more than 10% per year in real terms on pension fund assets, though to less than 8% on average on individual account balances after expenses are deducted). Moreover, the number of old age pensioners is still very small. In the United States, DC plans have grown at a dramatic rate over the past 15 years or so, but their experience is again too short to allow an empirical investigation of this issue.

Faced with a lack of directly relevant data, we use in this paper historical US data to illustrate the effects of the solutions proposed above. First, we present simulations of what the performance of a DC FF pension scheme would have been over the past 126 years in the United States. The simulations assume that workers contribute 10% of their income for 40 years and live in retirement for 20 years. We calculate the capital accumulation ratios (the total accumulated capital divided by the final wage) and the replacement rates (the pension divided by the final wage) by using 2 basic types of annuities: real annuities, where the discount rate is equal to 2.5 percent[11]; and nominal annuities where the discount rate is the 15-year bond yield prevailing at the time of retirement. In the case of nominal annuities we report both the first-year and average replacement rates, since inflation erodes the real value of nominal annuity payouts. We abstract from all the complexities caused by differences in life expectancies, while for the sake of additional simplicity and because they are not the focus of the paper, we do not take

[11] Most countries do not offer real annuities so that workers have to assume the inflation risk during their life in retirement. Variable annuities as well as escalating annuities provide a partial (but complex) answer to this problem.

account of the operating fees and commissions charged by insurance companies and pension fund managers.[12]

Because the accumulation lasts for 40 years, we effectively have replacement rates for 86 cohorts. The results are compared with the hypothetical case (baseline) in which the return on pension fund investments is constant over time. The aim of this simulation is to analyze the deviations of actual returns from the baseline case, their magnitude, frequency and persistence. Then the various solutions discussed above are evaluated using the same approach.

In a DC pension plan the value of the accumulated capital of workers is determined by three factors: the length of active life, the level of contributions (which in turn depends on the contribution rate and the wage level), and the net returns on pension fund investments. The capital accumulation ratio is invariant to the use of real or nominal returns. The annuity that retiring workers can purchase with their accumulated capital depends on their life expectancy at retirement and the rate of interest that is used to discount future payments. In the case of nominal annuities, the annual replacement rate is eroded by inflation and for this reason we focus on the average replacement rate over a worker's retirement life.

Workers usually have some control over the first two factors mentioned above. The law establishes a normal retirement age but does not preclude workers from working beyond that age or from retiring early. There is also a minimum contribution rate to the pension fund, but workers can contribute more or can build up additional voluntary savings outside their pension

[12] In the results presented below, the effect of these charges would be to proportionally scale down the level of replacement rates. We do not underestimate the impact of high fees on pensions. For a

account. On the other hand, workers have no control over the returns on financial assets or over interest rates. The solutions described above are intended to mitigate the impact of the factors not controlled by workers, but whose volatility can make an important difference in the replacement rate that different workers obtain. In the analysis that follows workers are assumed to adopt passive investment policies, investing in indexed funds for the three main types of instruments. No stock selection or market timing are considered, while the different asset allocation strategies are assumed to be set for life with no opportunistic changes at different points in time.

The simulations illustrate the replacement rate that workers would have obtained from their individual retirement accounts had they saved regularly during their active life a given percentage of their income and followed the investment strategy and purchased the annuity highlighted in each simulation. The simulations focus on the effects of the level and volatility of asset returns on pension fund performance and on the replacement rates that would be attainable under the specified terms. In order to isolate these effects, it is assumed that participating workers from each cohort have earnings that increase over their active life at the average rate of growth of wages. This is obtained from historical series of earnings in the manufacturing sector[13]. But to allow for the upward sloping career-earning profiles of most workers, a 1 percentage point is added to the each year's growth rate of wages. It is also

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discussion of arrangements that would aim to lower fees by constraining choice, see James and others (1999).

13 The use of earnings in the manufacturing sector to construct a real wage index is due to data availability reasons. See next section for more details on the construction of the index.

assumed that the number of participating workers is small enough as to have no effect on the level and volatility of market returns.

The 2 baseline cases for the real and nominal annuities use the weighted average real and nominal returns on equities, bonds and commercial paper with weights equal to 60%, 30% and 10% respectively. This is equal to 5.66% per annum in real terms and 7.69% in nominal terms.

Data

The historical series of financial assets returns were most kindly provided by R. Sylla and J. Wilson[14]. The database contains series for total nominal returns on S&P Stocks, 15-Year US Bonds, and Commercial Paper. It also has series for the yield on US Bonds and Commercial Paper. The database covers the period from 1871 to 1995. To obtain the ex-post total real returns on these assets, the data is deflated by the Consumer Price Index (CPI) in order.

The first three columns of tables 1-4 present some summary statistics of the inflation-adjusted Sylla-Wilson data for five 25-year sub-periods[15]. The last column in tables 1-3 represents the performance of an investment fund holding stocks, bonds and commercial paper in proportions 60%, 30% and 10%, respectively.

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[14] The data represent updated and revised estimates from previous research by: Wilson and Jones (1987a, 1987b, and 1997) and Sylla, Wilson and Jones (1990, 1994).

[15] All the input and output data and charts are available from the authors.

The geometric average real return on equities for the whole period amounted to 6.87% against 2.81% for bonds and 3.11% for commercial paper. The balanced portfolio consisting of 60% equities, 30% bonds and 10% commercial paper had an average return of 5.66%. Stocks were more volatile than the debt instruments or the balanced portfolio. The balanced portfolio had a lower return and lower volatility than equities, but a higher return and higher volatility than either of the debt instruments.

From an overall perspective commercial paper dominated bonds. For the whole period, the average return on commercial paper was higher, and the standard deviation lower, than for bonds. During the first sub-period 1871-1895, commercial paper also dominated stocks. This reflected the relative stage of development of US financial markets at the end of the last century. Returns on commercial paper declined drastically in the subsequent periods. During the last sub-period the variance of bond returns more than doubled compared to the earlier sub-period, reaching a level that was very close to the volatility of equity returns and more than four times the variance of commercial paper returns.

These data suggest that for the whole period under review commercial paper was safer than government bonds. Allowing for the premium for inflation risk, which is higher for non-indexed longer-term instruments, then the risk-adjusted real return on commercial paper was even higher than the risk-adjusted real return on bonds.

For most of the period, there was a persistent premium of equity over bond returns. The equity premium was particularly high during the 1946-70 25-year period (at over 9%) but fell to 2.6% in the sub-period 1971-95. Over the whole period the equity premium exceeded 4%.

The returns of the three classes of assets were positively correlated over the sample period. The correlation in the returns of equities and bonds was particularly high during the two sub-periods when the equity premium was relatively low, suggesting that the benefits of diversification and holding bonds in order to hedge the risk of equities were rather limited.

Historical real equity returns fluctuated widely. Although over 25-year sub-periods, the fluctuation in the average return was not very high – ranging between a low of 3.78% for the 1896-1920 sub-period and a high of 9.24% during the 1921-1945 sub-period, there were shorter periods during which cumulative returns were either highly negative or highly positive. They were highly negative between 1915 and 1920, when they registered a cumulative fall of 44%, between 1928 and 1931, when they fell by 57%, and between 1972 and 1974, when they declined by 48%. Periods during which positive cumulative returns were very large include 1921 and 1922 (+70%), 1924 to 1928 (+234%), 1949 to 1952 (+95%), 1954 and 1955 (+90%), 1963 to 1965 (+54%) and, of course, 1995 to 1998 (+183%). These large cumulative fluctuations have important implications for replacement rates achieved by defined-contribution personal pension plans.

The index of real wages was constructed using historical series on remuneration in the manufacturing sector deflated by the CPI. The historical series are three. First, from 1891 to 1900 the series is constructed using average weekly hours and average hourly earnings in the manufacturing sector. These two series are identified as 765 and 766 in US.DOC (1975). Secondly, from 1900 to 1948 the data corresponds to the average annual earnings per full time employee in the manufacturing sector (series 740 in US.DOC 1975). Finally, from 1949 to

1992 the data come from the National Income and Product Accounts; line Manufacturing in Tables 6.6b and 6.6C US.BEA (1993).

The last two series 1900-1948 and 1949-1992 are perfectly compatible, the first one is not. Thus the first period must be taken carefully. In order to have a series on real earnings covering the period 1871-1995, the values for 1871-1890 and 1993-1995 are obtained by extrapolating the overall average real growth rate of earnings (1.5% per annum) of the series 1891-1992.

Table 5 presents some summary statistics on the growth rate of real earnings 1871-1995 according to the index constructed with the data described above. This series is the one used in the simulations presented in this paper. As already noted, in our simulations we add 1 percentage point in each year to reflect the age-related growth of wages.

Simulations With Real Annuities

To facilitate the discussion of our results we first present our simulations using real annuities. As already noted these are based on a 2.5% real rate of discount and make no allowance for differences in life expectancy.[16] For each case we report the capital accumulation ratio and the replacement rates. We first present the results for undiversified and balanced portfolios and then discuss the impact of undertaking three alternative strategies: a gradual late

[16] In an earlier version of this paper, we assumed a 4% real annuity and also did not allow for the rising earnings profile of the average worker. Not surprisingly, we obtained very high replacement rates. At the suggestion of Estelle James we lowered the real annuity to 2.5% and allowed for a 1% additional growth in wages. The combined effect of these changes in assumptions was to lower replacement rates considerably to more realistic levels.

shift into bonds, a gradual purchase of annuities, and a purchase of variable annuities. The results using nominal annuities are reported in the following section.

Undiversified And Balanced Funds

This section explores the performance of pension funds under four alternative portfolio strategies. Under each strategy the portfolio composition is the same every year. In the first two strategies there is no portfolio diversification. The individual accounts hold only equities (100-0-0) or only bonds (0-100-0). The last two strategies consist of accounts with balanced portfolios, holding combinations of equities, bonds and commercial paper. The first combination is 60%, 30% and 10% (60-30-10) and the second is 30%, 60% and 10% (30-60-10), respectively. The last two strategies are part of the first type of corrective measures described in the introduction. In the US private pension funds have a portfolio composition similar to the 60-30-10 strategy, while in Chile the portfolio composition is closer to 30-60-10.

In the baseline case, where the accounts obtain a fixed return of 5.66% every period, the average capital accumulation ratio amounts to 7.52 and the average replacement rate across all cohorts is 48.21% with a standard deviation of 5.65%. The volatility in the baseline case arises from fluctuations in real earnings. The cohorts that obtain the highest replacement rates are those retiring in the 1910s and in the 1990s, with replacement rates ranging between 50% and 58%. On the other hand, the cohort retiring in 1945 is the one with the lowest replacement rate (39%). It is interesting to note that the max/min ratio (i.e. the ratio of the maximum to the minimum replacement rate) is only 1.46 in this case, while the coefficient of variation is 12%. These are the same for both the capital accumulation ratio and the replacement rates since the same annuity rate is used throughout.

If the fixed rate of return is set equal to 6.87%, the geometric average for the return on equities, and the rate of earnings growth is set equal to 2.51%, the replacement rate for a 10% contribution rate, a 40/20 ratio of active to passive life, and a 2.5% real annuity, would amount to 65%. This compares with 48% for the baseline case and reflects the strong performance of the US equity market over the past 120 years.

Tables 6-8 summarize the results, in terms of capital accumulation ratios and replacement rates, for the four portfolio strategies described above. The all-equity portfolio achieves the highest capital accumulation ratio (9.43) and highest average replacement (61%) but also has the highest volatility measured by the standard deviation, coefficient of variation, or max/min ratio. In more than 40% of cohorts, the replacement rate exceeds 60%, while only 1 cohort (that retiring in 1921) obtains a replacement rate of less than 30%.

The all-equity and all-bond strategies show higher volatility, measured either by the coefficient of variation or the max/min ratio, than the balanced portfolio strategies. Perhaps because of the persistence of the equity premium, the all-equity strategy produces a higher replacement rate than the all-bond strategy for every single cohort. The maximum replacement rate for the all-equity strategy amounts to 100% (1966) but to only 44% (1996) for the all-bond strategy. The historical weakness of the bond market relative to the equity market is underscored by the fact that the all-bond strategy always yields a lower replacement rate than any of the other three strategies. The replacement rate of this strategy is also lower for all cohorts than in the baseline case. Investing only in government bonds, even those of the United States, would indeed have amounted to “reckless conservatism”.

Among balanced portfolio strategies, the 60-30-10 strategy always results in a higher replacement rate than the 30-60-10 strategy. The 60-30-10 strategy performs better than holding an all-equity portfolio for only seven cohorts (1932, 1933, 1935, 1938, 1941, 1942, and 1943), but for the rest of the cohorts the all-equity strategy produces a higher replacement rate. In those years where the balanced portfolio strategy produces a higher replacement rate the difference is very small--less than 6 percentage points. The balanced portfolio strategies exhibit lower volatility, in terms of the coefficient of variation and the max/min ratio, than the other two strategies. But the price for the lower volatility is a much lower average capital accumulation ratio and replacement rate. For the 60-30-10 strategy these amount to 6.55 and 42% respectively (against 9.43 and 61% for the all-equity strategy). The lower level of volatility of the balanced strategies is achieved by pulling down the high replacement rates of many cohorts in the all-equity portfolio rather than by raising the cohorts with low replacement rates. Under the 60-30-10 strategy, only 10 percent of the cohorts obtain a replacement rate above 60%. The performance of the balanced 60-30-10 strategy is close to that of the all-equity strategy for most of the period between 1920 and 1950 but is substantially below it in the period between 1950 and 1973, though it narrows again in the more recent period between 1974 and 1995. Notice, however, the max/min ratio and coefficient of variation are much lower for the balanced portfolio.

If the four strategies are ranked by average capital accumulation ratio or replacement rate, the rank would be --in descending order: 100-0-0, 60-30-10, 30-60-10, and 0-100-0. The ranking according to volatility of outcomes is: 60-30-10, 30-60-10, 0-100-0, and 100-0-

0. If an investment strategy is defined as dominated if it yields a lower average level and a higher standard deviation of the replacement rate compared to another alternative strategy, then strategy 0-100-0 is dominated by both 60-30-10 and 30-60-10, while strategy 30-60-10 is dominated by 60-30-10.

In general, the lesson from the historical returns over the past 120 years is to stay away from bonds, which have provided little hedging protection against the volatility of returns in the equity market. This is particularly the case in the sub-periods when the equity premium is low but the correlation of returns between bonds and equities is quite high.

Gradual Late Shift To Bonds

The results of the first simulations, using US data, suggest that the relevant investment strategies are those of holding only stocks or a combination of 60% stocks, 30% bonds and 10% commercial paper. This section explores the effect of a gradual and progressive shift away from stocks toward bonds in the last five years of a person's working life. The objective of this strategy is to allow workers to benefit from the equity premium for most of their working lives but to gradually switch into the greater safety of bonds as they near retirement. If the equity market were to experience a major downturn close to their retirement, they would not have enough time to make up any large capital losses during their remaining working years. Tables 10-12 present the results of these simulations.

A gradual shift to bonds from an all-equity portfolio during the last five years of working life results in lower volatility, especially as measured by the max/min ratio but only a slight improvement in terms of the coefficient of variation. The gradual shift improves the replacement

rates of 24 cohorts and lowers that of all other cohorts. Cohorts retiring in the 1950s and 1960s obtain much lower replacement rates, while those retiring in the early 1930s obtain much higher replacement rates.

A similar approach from a 60-30-10 balanced portfolio would produce improved replacement rates for 22 cohorts and lower rates for all other cohorts. The positive or negative changes are, however, generally much smaller in magnitude. This is also reflected in the ambivalent improvement in overall measures of volatility. The max/min ratio falls from 3.15 to 2.77, but the coefficient of variation increases from 0.24 to 0.26.

The cost of the late switching to bonds from an all equity portfolio in terms of a lower average replacement rate obtained by all the cohorts is 7 percentage points. This compares with 19 percentage points in the case of holding a balanced portfolio for the whole of a worker's active life. In 37 percent of cohorts, the replacement rate is above 60%, while in only 6 percent it is below 30%.

Because of the generally weak relative performance of bonds in the United States during the period under review, a gradual late shift into bonds does not produce significant benefits in lower volatility, even though its costs in terms of lower average replacement rates is also low. It appears, however, to be superior than the strategy of always keeping a balanced portfolio in the sense that it achieves a higher average replacement rate with a lower max/min ratio and coefficient of variation. However, the "late balanced" strategy does not dominate the "always balanced" strategy because it reports a greater standard deviation (15% against 10%). For developing countries where the bond market may perform better relative to the equity

market, or where the equity premium may be less persistent, the results of the gradual shift to bonds could be more promising.

Gradual Purchase Of Annuities

The third solution mentioned in the introduction consists of allowing, encouraging or even requiring workers to start buying several fixed annuities during the last years of their active life, instead of only one fixed annuity at retirement. Under this scheme workers would diversify two risks, one related to the profitability of the pension fund and the other related to changes in the annuity rate. The simulations presented below assume a constant risk-free rate of interest of 2.5% and thus they only show the effect of lowering the risk of changes in the profitability of the pension fund.

Because life in retirement is set at 20 years, the purchase of a fixed annuity is equivalent to investing in an asset that yields 2.5%.[17] Thus, the gradual purchase of annuities is equivalent to a gradual shift in this fourth asset. The simulations are presented for the all-equity and 60-30-10 combination strategies. Five years before retirement workers start using 20% of their accumulated capital to buy an annuity every year.

The results ate very close to those of a gradual late shift to bonds. The max/min ratio and coefficient of variation are a little lower but so is the average replacement rate.[18] 30 percent

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[17] As discussed in Brown (1999), annuity products benefit form the so-called mortality premium, although there is considerable debate about the nature and size of this premium. However, any fixed annuity can be perceived as a bond paying a fixed nominal or real return in an ex ante sense. This would be higher than the return of an ordinary bond by the amount of the mortality premium.

[18] The results for the capital accumulation ratio are not shown since the final year's capital is already depleted by the purchase of a series of deferred annuities.

of cohorts achieve a replacement rate above 60% while only 4 cohorts (out of 86) have replacement rates below 30%.

Compared to the 60-30-10 strategy, there is significant improvement in terms of both a lower max/min ratio and a smaller coefficient of variation. Moreover, this is achieved at a small reduction of the average replacement rate from 42% to 37%. However, combining a balanced portfolio with a gradual purchase of annuities reduces the average replacement rate by 24 percentage points compared to the pure all-equity strategy. The price of lower volatility is thus quite high. Moreover, as already remarked, the reduction in the max/min ratio is achieved by lowering the maximum replacement rate without any increase in the minimum replacement rate.

Purchasing Variable Annuities

The results of the preceding simulations are based on the assumption that, at retirement, workers use the accumulated capital in their pension plan to buy a fixed real annuity (at a 2.5% real interest rate and a fixed life in retirement of 20 years). This section explores the possibility that workers use part or all of their accumulated capital to purchase a variable annuity. The part of the accumulated capital that is not used to purchase a fixed real annuity stays invested in the pension fund, and earns the same return as the fund. Because we assume in this paper that workers live in retirement for 20 years, use of variable annuities is equivalent to use of phased withdrawals. The balance kept in the pension fund is withdrawn gradually from the pension account during retirement. Every period, retirees withdraw from their pension fund accounts a fraction of the remaining balance, which is equal to one divided by their remaining life. The amount withdrawn in each year varies in response to changes in investment returns.

In the simulations with phased withdrawals the last 20 observations are lost since each simulation requires data until workers die and not just until they retire. Thus, instead of 87 cases (those cohorts retiring from 1910 until 1996), the simulations in this section cover only 67 cases (those cohorts retiring from 1910 until 1977). In the case with phased withdrawals there is no unique replacement rate. This varies every year with the variations in asset returns. The results reported in tables 15 and 16 refer to the average replacement rate for individual cohorts (Again because it is unaffected by the decision of how much, and how, to annuitize, the data on the capital accumulation ratios are not reported.)

The simulations in this section explore two cases: when all the accumulated capital is used for phased withdrawals (PW 100) and when only 50% of the capital is used to purchase a fixed real annuity and the other 50% is used for phased withdrawals (PW 50). We limit our analysis to the all-equity strategy.

Table 15 shows that under the all-equity strategy, the higher the proportion of the pension fund used for phased-withdrawals, the higher the average replacement rate. Although the 50% phased withdrawal strategy has a smaller standard deviation, it is not a good strategy because for every single cohort it obtains a lower replacement. In fact, its average replacement rate is only marginally higher than the minimum replacement rate under the 100% phased withdrawal strategy. The impact of continuing to invest in equities even during a worker's retirement is exemplified by a comparison of the replacement rates for the cohort retiring in 1921. Under the all-equity strategy that invests everything in a 2.5% real annuity on retirement,

the replacement rate would be equal to 25%. But purchasing a variable annuity (100% phased withdrawal) would increase the replacement rate to 74%.[19]

Given the size and persistence of the equity premium over the past 120 years, it is not surprising that a strategy that focuses on holding equities, not only during the active life but also throughout the passive life of workers, would produce the best results in terms of replacement rates, even at the expense of a higher volatility. As shown in table 16, no cohort achieves a replacement rate of less than 60%, the average is 114% and the maximum is a staggering 165%. However, since it is not known if history will repeat itself, a more sanguine conclusion would, perhaps, be to advocate a 50% phased withdrawal strategy. Only 1 cohort obtains a replacement rate of less than 60% under this strategy, while the average replacement rate is 73% and the maximum reaches 104%.

Analysis by decades[20]

The use of a large number of cohorts in the previous analysis makes it difficult to disentangle short term fluctuations (high frequency) and persistent deviations (low frequency) in measures of volatility of replacement rates. Since interest in this paper is in solutions to high frequency movements in replacement rates, we present here an analysis on a decade by decade basis to reinforce our previous conclusions. As shown in table 17, in the only equity portfolio case the max/min ratio is higher than 4, however, on a decade by decade basis the highest ratios

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[19] The implied strong conclusion needs to be mitigated by the realization that the replacement rates reported for the variable annuity cases are averages over the whole of the retirement life. There could be individual years when the value of the paid annuity could be very low and others when it could be very high.

occur in the earlier years of the sample (1910s to 1930s) , while in the post war decades the max/min ratio remains below 2.1. Turning to the solutions proposed, this analysis allows us to better see how the strategy of purchasing variable annuities, not only increases the average replacement rate, but significantly reduces volatility by increasing the minimum replacement rates more than the maximum. In addition, under this strategy the max/min ratio remains below 1.6 in every single decade, with the 1930s having the highest ratio.

Simulations With Nominal Annuities

This part of the paper discusses replacement rates by using nominal rather than real annuities. As we do not have historical data on annuity rates we use the series of 15-year bond yields for calculating the annual payouts and comparing them to the final wage. We continue to abstract from operating fees and commissions as well as from the complexities caused by life expectancies.

As in the case of real annuities, we first present the results for strategies involving undiversified and balanced portfolios. But because the results of the simulations are broadly similar, we discuss briefly and in summary way the impact of undertaking the by now familiar three alternative strategies: a gradual late shift into bonds, a gradual purchase of annuities, and a purchase of variable annuities. Moreover, as the capital accumulation ratios are not affected by the use of nominal annuities we do not repeat them here. However, one complication that arises in the case of nominal annuities is that the real value of payouts is eroded by inflation. For this reason we report separately the first-year replacement rates and the average replacement rates.

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[20] We thank Roberto Rocha for suggesting to undertake some sub-sample analysis.

As in the case of variable annuities, we focus our analysis on the behavior of average replacement rates. But since we lose the last 19 observations, we report data for only 67 cohorts.

Before presenting the simulation results, we need to refer briefly to the behavior of nominal yields and inflation. Over the whole period under review, the 15-year bond yield averaged 4.72%. With inflation running at 2.03%, this implies a real rate of 2.64%, which is slightly higher than the 2.5% we used for real annuities in the preceding section. In the most recent period, nominal yields amounted on average to 8.72% against an inflation rate of 5.34%, giving a real rate of 3.21%. The real rate of interest was very high at the end of the last century and during the interwar period, but was very low between 1896 and 1920 and again in the period after World War II.

Undiversified And Balanced Portfolios

Because a different annuity rate is used for each cohort, there is greater variability in replacement rates now than with the constant 2.5 real annuity of the preceding section. For the all-equity case, the max/min ratio is equal to 4.36 for first-year replacement rates and 4.79 for average replacement rates against 4.06 under real annuities. The average replacement rate over the whole retirement life is slightly lower, amounting to 55% against 61%. The maximum reaches 108% (1929), while the minimum is as low as 22% (1942).

The all-bond portfolio continues to perform very badly with an overall average replacement rate of less than 20 percent, a maximum that is no higher than 30%, and a minimum that is as low as 11%.

The 60-30-10 strategy achieves a substantial reduction in volatility (the max/min ratio declines from 4.79 to 2.92) but at a high cost in terms of a lower replacement rate of 17 percentage points (from 55% down to 38%).

The Three Alternative Strategies

The gradual late shift into bonds and the gradual purchase of annuities have very similar effects. Volatility is reduced but a considerable cost in terms of lower replacement rates. The use of nominal annuities causes greater variability across cohorts and the max/min ratios are generally higher than with real annuities.

The use of variable annuities seems to achieve the best results, lowering volatility but without sacrificing much in replacement rates. In this case, more than two thirds of the average replacement rates are between 90% and 120%, and only one tenth of them are below 90%. This is clearly the result of the large and persistent equity premium of the past 100 years or so, and the reduction in stocks return volatility that can be achieved by participating for a longer period of time in the stock market. Table 27 presents volatility statistics for the average returns on stock held over different time spans. As it can be seen, the longer a stock portfolio is held, the higher the average return and the lower the volatility of the returns (measured by the standard deviation and the max/min ratio). Again an attractive compromise solution, given the great uncertainty about future returns, could well be the combination of variable and fixed annuities. In countries where social security offers real annuities, a combination of variable and nominal annuities would seem to make sense. But for workers for whom social security pensions are a small fraction of their income, a variable/real mix might be more appropriate.

The results of the analysis on a decade by decade basis using nominal annuities are similar to the ones described above, confirming the results discussed in the previous paragraph.

Financial Engineering and Synthetic Products

As already noted, this paper makes no attempt to assess the use of portfolio insurance and European put options to hedge the value of balances of workers who are near their retirement nor the use of synthetic products that provide a floor on the value of balances over some period of time while also allowing some sharing in the upside potential of the equity market. Bodie and Crane (1998) provide an interesting example of the potential use of financial engineering and synthetic products. Bodie and Crane first establish that with a real rate of interest of 3% during both the accumulation and decumulation periods and a constant real wage, workers contributing for 40 years and living in retirement for 20 years would need a contribution rate of 11.84% to attain a targeted replacement rate of 60%. (This corresponds to a 51% replacement rate with a 10% contribution rate). They then assume that the S&P index has an average nominal return of 10%, a standard deviation of 20%, and a dividend yield of 3% and that inflation also is uncertain with an average rate of 4% and a standard deviation of 0.5%. The simulated inflation reverts to the mean at a rate of 0.2, while there is positive correlation of 0.5 between the S&P index and inflation. On the basis of these assumptions, Bodie and Crane run 100,000 simulations of an all-equity portfolio that produce an average replacement rate of 115% (implying an average real rate of return of 5%). However, in 34% of the cases the replacement rate is below the targeted 60% level. Bodie and Crane also use a 60-40 allocation

in equities and 3% inflation-indexed bonds (treasury inflation protected securities or TIPS) and find that the average replacement rate is then lower at 88% (implied average real return of 4.2%). In this case, 29% of cases are below the targeted replacement rate. They also consider age-linked portfolios that invest a proportion equal to the age of the worker in TIPS and the rest in equities. This produces a lower average replacement rate of 83% (implied average rate of return of 4%) with 27% of cases below target. Finally, Bodie and Crane run two simulations where portfolio protection is offered on an annual or five-year basis. They find that the annual protection is not efficient but the five-year protection products achieve an average replacement rate of 128% with only 12% of cases below the target of 60%.

The simulations of Bodie and Crane show the potential benefits that may be produced by financial engineering. However, they involve the purchase of indexed bonds and call options on equities. This would require a high level of sophistication in terms of using hedging products as well as regulating and supervising the financial institutions offering such products. This sophistication is not currently available, not only developing countries but even in the most advanced of the developed countries. Moreover, use of these financial engineering techniques implies either that the government issues an immense amount of indexed bonds, which goes against the idea of containing government debts or that other borrowers (corporations or mortgages for households) step up to fill the gap. The simpler approaches discussed in this paper appear more feasible, although in the longer run they could be replaced by the more sophisticated techniques discussed by Bodie and Crane, while the development of a true

intergenerational marketable contract, as described in the introductory section of this paper, may also benefit from the growth of financial engineering.

Concluding Remarks

This paper explores simple financial strategies that can mitigate the impact of short-term volatility on personal pension plans. Sophisticated financial engineering promises more efficient solutions to this problem; however, its applicability in developing countries (and financial markets) may not be possible until, among others, important regulatory issues are resolved. It is worth noting that neither approach may be able to deal effectively with persistent deviations from the long-term trend. The use of a multi-pillar system may mitigate the impact of such deviations.

The preceding analysis has shown that on the basis of historical US returns on equities, investing all their contributions in an all-equity index fund and buying on retirement either a nominal annuity or a 2.5% real annuity would have exposed workers of different cohorts to large fluctuations in replacement rates. While the average replacement rate would have amounted to around 60%, which is remarkably high with only a 10% contribution rate, the standard deviation would have been of the order of 20%, implying that one-fifth of workers would have either a pension higher than 80% or lower than 40%. The maximum replacement rate would have ranged between 100% and 110% (depending on the type of annuity used) and the minimum replacement rate between 23% and 25%, resulting in a max/min ratio of between 4 and 4.8.

Investing everything in bonds on the basis of their historical returns would have suffered from the same volatility and high max/min ratio but with much lower replacement rates. This would have been a consequence of the large and persistent equity premiums that has characterized US financial markets over the past 100 years or so.

Employing a more balanced portfolio, consisting of 60% in equities, 30% in bonds and 10% in commercial paper would have reduced the volatility of returns and the fluctuations in replacement rates. But the price of reduced volatility would have been a substantial reduction in the average replacement rate. Most of the improvement in the max/min ratio would have been obtained by reducing high replacement rates rather than by raising low ones.

Instead of using a balanced portfolio strategy throughout a worker's career, an alternative approach would have been to use an all-equity portfolio for most of the active life and adopt either a gradual late shift into bonds or a gradual purchase of annuities. Both of these alternative strategies would have achieved equivalent reductions in volatility and the max/min ratio but at a significantly lower cost in terms of lower replacement rates.

However, in view of the persistence of the equity premium, the best approach would have been to buy a variable annuity either for the whole or for half of the accumulated capital. Using half the accumulated capital to purchase a fixed annuity (real or nominal) and the other half for phased withdrawals (which under the assumptions used in this paper are equivalent to purchasing a variable annuity) would have achieved an average replacement rate of nearly 75% with a low max/min ratio of around 2.5. Of greater interest is that both the maximum and

minimum replacement rates would have been much higher than under all the other strategies that do not use variable annuities.

The results would have been even better if all the capital was used for phased withdrawals, but this would have implied a huge exposure to the volatility of equity returns. Such an extreme approach would not have been advisable, especially if account is taken of the fact that the reported replacement rate for each cohort would have been an average of the variable annual replacement rates over a worker's retirement life.

Finally, use of synthetic products that provide portfolio protection would have achieved broadly similar results. While in the long-run financial engineering and more sophisticated strategies may be more appropriate, in developing countries the simpler solutions presented in this paper would appear more feasible and probably equally effective.

Gary Burtless in his 1998 paper reaches similar conclusions. He suggests that workers could diversify their investment portfolios and place a portion of their retirement savings in bonds. He does not, however, recommend a late shift into bonds. He also suggests the use of installment annuities and even proposes using 10 installments that would straddle the retirement year—5 installment annuities before and 5 after they retire. Finally, he suggests that some of the accumulated capital could continue to be invested in equities, a proposal that is analogous to the use of variable annuities.

In this paper, we have tried to show that excessive concern about the impact of short-term volatility in stock markets may not be warranted. We are fully aware that annuity markets are very underdeveloped in most countries and that, once such markets develop, annuity prices

are likely to fluctuate on a daily basis in response to changes in interest rates. We are also aware that the greater problem facing annuity markets is a sensible and realistic prediction of improvements in longevity. In fact, the biggest challenge facing annuity providers is the development of portable variable annuities along the lines suggested by Salvador Valdes-Prieto and his colleagues (Valdes-Prieto and Edwards 1997, Valdes-Prieto 1998). Nevertheless, we believe that annuity markets will become more sophisticated in response to the greater demand for annuities that will be generated by maturing pension systems based on individual accounts. The growth of financial engineering will also help in this process.

What is more difficult to see right now is how to overcome the problems caused by what may be described as persistent deviations from trend, when whole generations of workers may retire with either too high or too low pensions. The establishment of multi-pillar systems, comprising a public pillar based on the principles of redistribution and social insurance and a private pillar that has a symbiotic relationship with private capital and annuity markets, may provide an effective solution to this problem, although this remains to be proved.

Table 1: Real Total Returns (%) - Geometric Average
1871 - 1995

	S&P Stocks	15 Year US Bonds	Commercial Paper	Combination 60-30-10
1871-1895	6.84	6.89	7.69	7.15
1896-1920	3.78	-0.20	1.79	2.72
1921-1945	9.24	4.92	2.86	8.06
1946-1970	8.01	-1.25	0.45	4.79
1971-1995	6.55	3.93	2.90	5.67
Overall	6.87	2.81	3.11	5.66

Source: Authors' calculations based on revised and updated data from Wilson and Jones (1987, 1997) and Sylla, Wilson and Jones (1990, 1994). Data kindly provided by R. Sylla and J. Wilson.

Table 2: Real Total Returns (%) - Arithmetic Average
1871 - 1995

	S&P Stocks	15 Year US Bonds	Commercial Paper	Combination 60-30-10
1871-1895	7.72	6.93	7.73	7.48
1896-1920	5.60	0.01	1.95	3.56
1921-1945	12.15	5.28	3.10	9.18
1946-1970	9.33	-1.04	0.54	5.34
1971-1995	7.92	4.70	2.94	6.45
Overall	8.54	3.18	3.25	6.40

Source: Authors' calculations based on revised and updated data from Wilson and Jones (1987, 1997) and Sylla, Wilson and Jones (1990, 1994). Data kindly provided by R. Sylla and J. Wilson.

Table 3: Real Total Returns - Standard Deviation
1871 - 1995

	S&P Stocks	15 Year US Bonds	Commercial Paper	Combination 60-30-10
1871-1895	0.1430	0.0311	0.0290	0.0875
1896-1920	0.1982	0.0640	0.0568	0.1337
1921-1945	0.2451	0.0904	0.0722	0.1539
1946-1970	0.1759	0.0658	0.0417	0.1096
1971-1995	0.1666	0.1328	0.0305	0.1289
Overall	0.1871	0.0883	0.0539	0.1242

Source: Authors' calculations based on revised and updated data from Wilson and Jones (1987, 1997) and Sylla, Wilson and Jones (1990, 1994). Data kindly provided by R. Sylla and J. Wilson.

Table 4: Real Total Returns - Correlations
1871 - 1995

	Stocks - Bonds	Stocks - Comm. Papers	Bonds - Comm. P.
1871-1895	0.2106	-0.3512	0.5614
1896-1920	0.5964	0.2939	0.8886
1921-1945	0.1333	-0.0599	0.8501
1946-1970	0.0233	0.2949	0.6792
1971-1995	0.5848	0.3506	0.6076
Overall	0.3006	0.0862	0.6879

Source: Authors' calculations based on revised and updated data from Wilson and Jones (1987, 1997) and Sylla, Wilson and Jones (1990, 1994). Data kindly provided by R. Sylla and J. Wilson.

Table 5: Real Earnings Growth Rate (%)
1871-1995

	Arithmetic Average	Geometric Average	Standard Deviation
1871-1895	1.49	1.49	0.56
1896-1920	1.73	1.61	5.13
1921-1945	2.11	2.00	4.78
1946-1970	1.84	1.75	4.21
1971-1995	0.73	0.72	1.74
Overall	1.58	1.51	3.75

Source: Authors' calculations based on U.S. DOC (1975) series 765, 766, and 740.

Table 6:
Capital Accumulation Ratio for Alternative Portfolios
Summary Statistics
(ratio to last wage)

2.5% Real Annuities	**100-0-0**	**0-100-0**	**60-30-10**	**30-60-10**	**Baseline**
Average	9.43	3.53	6.55	4.85	7.52
Standard deviation	3.02	1.33	1.55	1.44	0.88
Maximum	15.55	6.81	10.80	8.16	8.98
Minimum	3.83	1.80	3.43	2.76	6.14
Coefficient of variation	0.32	0.38	0.24	0.30	0.12
Max/Min ratio	4.06	3.78	3.15	2.96	1.46

Source: Authors' calculations.

Table 7:
Replacement Rates for Alternative Portfolios
Summary Statistics
(as a percentage of last wage)

2.5% Real Annuities	100-0-0	0-100-0	60-30-10	30-60-10	Baseline
Average	60.51	22.61	42.02	31.10	48.21
Standard deviation	19.34	8.56	9.93	9.21	5.65
Maximum	99.73	43.71	69.28	52.32	57.58
Minimum	24.59	11.57	21.99	17.68	39.36
Coefficient of variation	0.32	0.38	0.24	0.30	0.12
Max/Min ratio	4.06	3.78	3.15	2.96	1.46

Source: Authors' calculations.

Table 8:
Distribution of Replacement Rates
Summary Statistics
(in percent)

2.5% Real Annuities	100-0-0	0-100-0	60-30-10	30-60-10	Baseline
0 to 30	1.1	73.6	11.5	56.3	0.0
30 to 60	56.3	26.4	85.1	43.7	100.0
Higher than 60	42.5	0.0	3.4	0.0	0.0

Source: Authors' calculations.

Table 9:
Portfolio Compositions for the Gradual and Progressive Shift to Bonds
Last Five Working Years
(portfolio allocations as a % of the total fund)

	100-0-0			60-30-10		
	Stocks	Bonds	Comm. P.	Stocks	Bonds	Comm. P.
Ret – 6	100	0	0	60	30	10
Ret – 5	80	20	0	48	42	10
Ret – 4	60	40	0	36	54	10
Ret – 3	40	60	0	24	66	10
Ret – 2	20	80	0	12	78	10
Ret – 1	0	100	0	0	90	10

Note: Ret - i means i years before retirement age.

Table 10:
Capital Accumulation Ratios - Switching to Bonds
Summary Statistics
(ratio to last wage)

2.5% Real Annuities	All Equity case		60-30-10 case	
	No Switch	Switch	No Switch	Switch
Average	9.43	8.32	6.55	6.04
Standard deviation	3.02	2.42	1.55	1.55
Maximum	15.55	12.73	10.80	9.48
Minimum	3.83	4.14	3.43	3.42
Coefficient of variation	0.32	0.29	0.24	0.26
Max/Min ratio	4.06	3.08	3.15	2.77

Source: Authors' calculations.

Table 11:
Replacement Rates – Switching to Bonds
Summary Statistics
(as a percentage of last wage)

2.5% Real Annuities	All Equity case		60-30-10 case	
	No Switch	Switch	No Switch	Switch
Average	60.51	53.37	42.02	38.71
Standard deviation	19.34	15.53	9.93	9.95
Maximum	99.73	81.66	69.28	60.79
Minimum	24.59	26.54	21.99	21.95
Coefficient of variation	0.32	0.29	0.24	0.26
Max/Min ratio	4.06	3.08	3.15	2.77

Source: Authors' calculations.

Table 12:
Distribution of Replacement Rates - Switching to Bonds
Summary Statistics
(as a percentage of last wage)

2.5% Real Annuities	All Equity case		60-30-10 case	
	No Switch	Switch	No Switch	Switch
0 to 30	1.1	5.7	11.5	24.1
30 to 60	56.3	57.5	85.1	74.7
Higher than 60	42.5	36.8	3.4	1.1

Source: Authors' calculations.

Table 13:
Replacement Rates – Gradual Purchase of Annuities
Summary Statistics
(as a percentage of last wage)

2.5% Real Annuities	All Equity case		60-30-10 case	
	1 Annuity	5 Annuities	1 Annuity	5 Annuities
Average	60.51	51.98	42.02	36.88
Standard deviation	19.34	14.30	9.93	7.49
Maximum	99.73	82.97	69.28	57.67
Minimum	24.59	27.80	21.99	24.40
Coefficient of variation	0.32	0.28	0.24	0.20
Max/Min ratio	4.06	2.98	3.15	2.36

Source: Authors' calculations.

Table 14:
Distribution of Replacement Rates – Gradual Purchase of Annuities
Summary Statistics
(as a percentage of last wage)

2.5% Real Annuities	**All Equity case**		**60-30-10 case**	
	1 Annuity	5 Annuities	1 Annuity	5 Annuities
0 to 30	1.1	4.6	11.5	18.4
30 to 60	56.3	65.5	85.1	81.6
Higher than 60	42.5	29.9	3.4	0.0

Source: Authors' calculations.

Table 15:
Average Replacement Rates for All Equity and Phased Withdrawal Strategies
Summary Statistics
(as a percentage of last wage)

2.5% Real Annuities	No PW	PW 50	PW 100
Average	61.85	72.36	113.79
Standard deviation	21.11	15.65	25.45
Maximum	99.73	104.10	165.13
Minimum	24.59	43.09	70.39
Coefficient of variation	0.34	0.22	0.22
Max/Min ratio	4.06	2.42	2.35

Source: Authors' calculations.

Table 16:
Distribution of Replacement Rates
For All-Equity and Phased Withdrawal Strategies
Summary Statistics
(as a percentage of last wage)

2.5% Real Annuities	No PW	PW 50	PW 100
0 to 30	1.5	0.0	0.0
30 to 60	52.2	1.5	0.0
Higher than 60	46.3	98.5	100.0

Source: Authors' calculations.

Table 17:
Replacement Rates by Decades
Summary Statistics
(as a percentage of last wage)

	1910-19	1920-29	1930-39	1940-49	1950-59	1960-69	1970-79 1/	1980-89	1990-96	1910-76	1910-96
All Equity Portfolio and a Fixed 2.5% Real Annuity											
Average	63.82	48.53	53.71	41.36	68.69	91.75	60.70	50.12	68.22	61.85	60.51
Standard deviation	16.38	19.73	14.99	7.24	17.41	6.63	16.67	5.92	6.25	21.11	19.34
Maximum	90.90	90.71	76.87	53.06	93.55	99.73	80.98	58.12	79.57	99.73	99.73
Minimum	37.16	24.59	31.58	31.92	44.92	81.00	40.21	41.98	59.76	24.59	24.59
Coefficient of variation	0.26	0.41	0.28	0.17	0.25	0.07	0.27	0.12	0.09	0.34	0.32
Max/Min ratio	2.45	3.69	2.43	1.66	2.08	1.23	2.01	1.38	1.33	4.06	4.06
All Equitty Portfolio and Variable Annuity											
Average	104.33	88.16	93.27	119.83	159.46	124.31	104.37	…	…	113.79	…
Standard deviation	9.92	8.08	13.21	19.82	5.59	11.11	5.37	…	…	25.45	…
Maximum	122.75	101.77	109.90	149.42	165.13	146.67	110.54	…	…	165.13	…
Minimum	89.91	74.17	70.39	101.50	149.32	110.86	94.80	…	…	70.39	…
Coefficient of variation	0.10	0.09	0.14	0.17	0.04	0.09	0.05	…	…	0.22	…
Max/Min ratio	1.37	1.37	1.56	1.47	1.11	1.32	1.17	…	…	2.35	…

1/ In the variable annuity case covers only 1970-76.

Source: Author's calculations.

Table 18: Nominal Yields and Inflation, 1871-1995

Period		15-Year Bonds	Comm Paper	CPI Inflation
1871-1895	**Average**	4.09%	6.03%	-1.61%
	Std. Dev.	0.0069	0.0182	0.0151
1896-1920	**Average**	3.84%	5.13%	3.34%
	Std. Dev.	0.0058	0.0128	0.0611
1921-1945	**Average**	3.10%	2.40%	0.02%
	Std. Dev.	0.0080	0.0190	0.0539
1946-1970	**Average**	3.86%	3.57%	3.08%
	Std. Dev.	0.0147	0.0195	0.0390
1971-1995	**Average**	8.72%	7.69%	5.34%
	Std. Dev.	0.0213	0.0297	0.0281
Overall	**Average**	4.72%	4.96%	2.03%
	Std. Dev.	0.0239	0.0275	0.0490

Source: Authors' calculations based on revised and updated data from Wilson and Jones (1987, 1997) and Sylla, Wilson and Jones (1990, 1994). Data kindly provided by R. Sylla and J. Wilson.

Table 19:
First Replacement Rates for Alternative Portfolio Strategies
Summary Statistics
(as a percentage of last wage)

Nominal Annuities	**100-0-0**	**0-100-0**	**60-30-10**	**30-60-10**	**Baseline**
Average	76.75	28.14	52.61	38.75	55.85
Standard deviation	27.32	10.99	13.82	11.97	15.16
Maximum	137.30	58.41	84.17	69.91	101.87
Minimum	31.47	15.66	28.45	23.98	40.87
Coefficient of variation	0.36	0.39	0.26	0.31	0.27
Max/Min ratio	4.36	3.73	2.96	2.91	2.49

Source: Authors' calculations.

Table 20:
Average Replacement Rates for Alternative Portfolio Strategies 1/
Summary Statistics
(as a percentage of last wage)

Nominal Annuities	**100-0-0**	**0-100-0**	**60-30-10**	**30-60-10**	**Baseline**
Average	55.03	19.67	37.80	27.60	45.40
Standard deviation	19.29	6.68	9.06	7.58	13.95
Maximum	107.62	29.60	66.56	43.51	71.69
Minimum	22.48	10.99	22.78	17.49	27.05
Coefficient of variation	0.35	0.34	0.24	0.27	0.31
Max/Min ratio	4.79	2.69	2.92	2.49	2.65

1/ In the calculation of the average replacement rate 20 observations are lost, therefore the statistics above cover only generations retiring between 1910 and 1976.

Source: Authors' calculations.

Table 21:
First Replacement Rates - Switching to Bonds
Summary Statistics
(as a percentage of last wage)

Nominal Annuities	All Equity case		60-30-10 case	
	No Switch	Switch	No Switch	Switch
Average	76.75	68.18	52.61	48.70
Standard deviation	27.32	24.10	13.82	14.29
Maximum	137.30	113.08	84.17	79.46
Minimum	31.47	26.27	28.45	26.55
Coefficient of variation	0.36	0.35	0.26	0.29
Max/Min ratio	4.36	4.30	2.96	2.99

Source: Authors' calculations.

Table 22:
Average Replacement Rates – Switching to Bonds Case 1/
Summary Statistics
(as a percentage of last wage)

Nominal Annuities	All Equity case		60-30-10 case	
	No Switch	Switch	No Switch	Switch
Average	55.03	47.59	37.80	34.39
Standard deviation	19.29	13.66	9.06	8.02
Maximum	107.62	72.92	66.56	51.22
Minimum	22.48	18.47	22.78	18.66
Coefficient of variation	0.35	0.29	0.24	0.23
Max/Min ratio	4.79	3.95	2.92	2.75

1/ In the calculation of the average replacement rate 20 observations are lost, therefore
The statistics above cover only generations retiring between 1910 and 1976.

Source: Authors' calculations.

Table 23:
First Replacement Rates – Gradual Purchase of Annuities
Summary Statistics
(as a percentage of last wage)

Nominal Annuities	All Equity case		60-30-10 case	
	1 Annuity	5 Annuities	1 Annuity	5 Annuities
Average	76.75	65.41	52.61	45.86
Standard deviation	27.32	22.14	13.82	12.62
Maximum	137.30	106.49	84.17	74.54
Minimum	31.47	26.83	28.45	26.01
Coefficient of variation	0.36	0.34	0.26	0.28
Max/Min ratio	4.36	3.97	2.96	2.87

Source: Authors' calculations.

Table 24:
Average Replacement Rates – Gradual Purchase of Annuities 1/
Summary Statistics
(as a percentage of last wage)

	All Equity case		60-30-10 case	
	1 Annuity	5 Annuities	1 Annuity	5 Annuities
Average	55.03	46.30	37.80	32.65
Standard deviation	19.29	13.41	9.06	7.23
Maximum	107.62	71.58	66.56	49.69
Minimum	22.48	18.91	22.78	18.28
Coefficient of variation	0.35	0.29	0.24	0.22
Max/Min ratio	4.79	3.78	2.92	2.72

Source: Authors' calculations.

Table 25:
Average First Replacement Rates
for All Equity and Phased Withdrawal Strategies
Summary Statistics
(as a percentage of last wage)

Nominal Annuities	**No PW**	**PW 50**	**PW 100**
Average	61.85	96.71	157.75
Standard deviation	21.11	26.40	43.85
Maximum	99.73	140.77	214.01
Minimum	24.59	41.10	66.29
Coefficient of variation	0.34	0.27	0.28
Max/Min ratio	4.06	3.43	3.23

Source: Authors' calculations.

Table 26:
Average Replacement Rates for All Equity and Phased Withdrawal Strategies 1/
Summary Statistics
(as a percentage of last wage)

	No PW	PW 50	PW 100
Average	55.03	70.08	112.64
Standard deviation	19.29	14.37	24.60
Maximum	107.62	100.51	165.29
Minimum	22.48	44.05	72.39
Coefficient of variation	0.35	0.21	0.22
Max/Min ratio	4.79	2.28	2.28

1/ In the calculation of the average replacement rate 20 observations are lost, therefore the statistics above cover only generations retiring between 1910 and 1976.

Source: Authors' calculations.

Table 27: Average Returns on Stock Over Different Time Spans
(In percent)

	20 Years	40 Years	60 Years
Average	9.06	10.05	10.56
Standard Deviation	2.14	1.87	1.46
Max.	14.95	13.86	13.48
Min.	5.88	6.66	7.30
Max/Min ratio	2.54	2.08	1.85

Source: Authors' calculations based on revised and updated data from Wilson and Jones (1987, 1997) and Sylla, Wilson and Jones (1990, 1994). Data kindly provided by R. Sylla and J. Wilson.

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