Retirement Provision: Accumulations, Security, and Insurance

Sachi Purcal and John Piggott*

September 2000

Revised January 2003

Abstract

In this paper we explore the implications of adopting a DC based social security system in Japan. We ask the following hypothetical question: if instead of social security contributions, the same contributions had been invested in Japanese securities, what would the outcome have been? By considering different time periods and a small menu of alternative investment strategies, the importance of risk in choosing investment strategies is demonstrated. We then present simple stochastic simulations of employment based contributions and investments to show the impact of alternative strategies on lifetime accumulations and retirement income.

* Purcal is Lecturer in Actuarial Studies, University of New South Wales; Piggott is Professor of Economics, and Director of the Centre for Pensions and Superannuation, University of New South Wales. This is a revised version of a paper presented at the First International Forum of the Collaboration Projects, Osaka, Japan, September 2000. The authors gratefully acknowledge financial support for this research provided by the Economic and Social Research Institute, Cabinet Office, Government of Japan, and the Australian Research Council. Without implicating them we acknowledge helpful comments and suggestions from Forum participants and (especially) Geoffrey Kingston. We would like to thank Gary Burtless for help with data sources. Matt Williams provided excellent research assistance, along with Kevin Cheng, Jason Gordon and Richard Kouch. Opinions and conclusions are solely those of the authors.

Retirement Provision: Accumulations, Security, and Insurance

1 Introduction

Throughout the 20th century, governments increasingly have taken responsibility for financial provision of the elderly. At the end of the century, however, a steady retreat from this position can be observed throughout the world. Population aging, combined with electoral pressure for smaller government, has led to lower benefit entitlements for those relying on publicly funded social security; this is sometimes accompanied by calls for mandated retirement financing to (at least partly) replace public provision.

Retirement provision is an active policy issue in almost every developed country, and in many cases, reforms have already been enacted. Some of these are parametric, involving changes to the parameters of traditional social security systems: increases in contribution rates, benefit cuts, changes in the retirement age, or in survivorship provisions. Others, however, involve structural reform.

Structural reform, as the name implies, involves more fundamental policy change, for example, the privatization of social security (debated, but not enacted, in the US), or the development of a mandated employer or employee contribution to a pension fund, as in Australia and Chile. The UK reforms might be seen as combining elements of both. The US, while fighting shy of structural reform of Social Security, has nevertheless moved to encourage greater private participation in retirement financing through tax concessions to 401(k) pension plans, which are essentially defined contribution (DC) partially preserved retirement saving plans.

The advent of 401(k)s has dramatically changed the structure of retirement provision in that country.

Similar reforms are under consideration in Japan. In recent times, there has been active debate surrounding the introduction of tax preference for DC 401(k) type plans, which may or may not involve employee contributions. The critical features of these plans are that to qualify for tax preference, accumulations must be at least partially preserved until late in the life cycle; and that the beneficiary bears investment risk.

In one or another of its many guises, the most fundamental question in DC based retirement provision is: How much is enough for adequate retirement financing? In any predominantly accumulation-based scheme, the contribution rate required to produce an adequate retirement income stream is a central continuing issue. It will depend on many factors, including the length and nature of participation in the workforce, the pattern and size of earnings on accumulated funds, taxation of retirement saving, choice of retirement benefit, target replacement rate, longevity, and operation of government transfer and subsidy systems. The problem is distinct from the more conventional financial problem of stochastic returns over time of a once-for-all stake, because the nature of pension accumulations is that the investor's contribution is made through time, and may itself be subject to stochastic variation from labour market fluctuations.

Germane to this is the question of how funds should be invested and how they should be protected. Attention should also be paid to the question of life insurance and to the portfolio choice which might underlie income streams purchased to finance the post-retirement years. In a DC environment, the choice of investment strategy can be critical in determining the outcome of an accumulation program. Financial engineering of various kinds can have an impact on the rate of contribution required for a given specification of retirement accumulation distribution. Techniques such as age-phasing and portfolio insurance can help mould the nature of the financial risk confronted by the worker, and can help to make the most of a given contributions plan.

These strategies have considerable potential for benefiting individuals in all retirement saving frameworks where investment risk is borne by the worker. They may, however, be of special importance in Japan, where traditionally savers have operated within a highly capital-protected environment. All have the effect of modifying the distribution of outcomes that can be anticipated under given assumptions about the investment innovations process. They may therefore have a role to play in persuading life cycle savers in Japan to invest in risky assets.

In common with most other developed economies, Japan has a comprehensive social security system which provides Japanese workers with some financial security in old age. We ask the following hypothetical question: if instead of social security contributions, the same contributions had been invested in Japanese securities, what would the outcome have been? By considering different time periods and a small menu of alternative strategies, the importance of risk in choosing investment strategies is demonstrated.

The above exercise is of course carried out with the benefit of hindsight. We therefore go on to ask the following question: suppose the year was 1970, and we had no certain knowledge of the future. All we had was expectations about returns and volatilities of different asset classes. What would the expected distribution of outcomes at the end of 1999 look like under alternative strategies, viewed from 1970, given that these parameters are set to reflect the actual (but then unknown) outcome?

In this way, we try to take some preliminary steps towards understanding how Japanese retirement provision works, and how the performance of the Japanese economy and financial system over the last 30 years might impact on perceptions of investment risk in the context of lifelong financial security. Of course, current pension reform proposals in Japan do not envisage “privatization” of social security, and our analysis should not be seen as taking a position on any such proposal. Nor do we take account of the widespread defined benefit (DB) occupational pension plans in Japan. But in thinking about DC based retirement saving, it is convenient to take the existing retirement provision system as an initial benchmark.

The results are preliminary in at least three significant ways. Japanese institutional features, such as taxation, prudential supervision, and other regulation are largely ignored; the simulation methodology is based on the simplest possible financial markets innovations processes; and labour market volatility is ignored except to the extent that we incorporate Japanese wages history.

2 Aging, social security, and financial markets in Japan

In what follows, we consider a hypothetical experiment in which employer and employee social security contributions made by or on behalf a Japanese worker on average earnings are invested in Japanese securities. The economic and financial data required for this exercise are summarized in Table 1; further details also appear in Annex 1. Average growth, volatility, and the range of extreme year on year changes are reported. The data that we use are all monthly series. Wages, prices, and the bill rate are not very volatile, but the Nikkei index is. In this example, we ignore the potential benefits from international diversification.

Table 1: Summary of Japanese Economic and Financial Market Experience, 1970-2000 (Continuously Compounding Rates)

	Wages[1]	**Prices[2]**	**Nikkei(Real)[3]**	**Nikkei(Nom)[4]**	**Bill Rate[5]**
Mean	5.9%	3.9%	4.1%	8.2%	4.7%
Volatility	2.2%	2.5%	26.5%	25.4%	0.9%
Range	(-1.9%, 29.1%)	(-1.1%, 24.7%)	(-40.9%, 95.1%)	(-38.6%, 106.6%)	(0.5%, 12.2%)

Sources:
1. CEIC database, Japanese Nominal Wage Index, All Industries, Monthly, Jan.1970-Jun.2000.
2. CEIC database, Japanese Consumer Price Index, Monthly, Jan.1970-Jun.2000.
3. Gary Burtless, The Brookings Institution, Washington, DC (2001), Real Total Return of Japan Stock, 1970-2000.
4. Gary Burtless, The Brookings Institution, Washington, DC (2001), Real Total Return of Japan Stock, 1970-2000.
5. CEIC database, Japanese Three Month Bank of Japan Bill Rate, Monthly, Jan.1970-Jun.2000.

In Figure 1, we chart the Nikkei's history in the last 30 years. The lower of the two lines is the Nikkei index, while the upper line is the Nikkei Accumulation Index, which adjustments for dividend reinvestment. The figure reveals the dramatic shifts in trend that have occurred through sub-periods of the 30 year span we examine. In particular, the index climbed dramatically through the 80s, and fell just as dramatically through the 90s. Its current value is still less than half its peak a decade earlier. The importance of this is demonstrated in the counterfactual analysis to follow.

We model four alternative investment strategies. The first is an all-equities strategy – all contributions are invested in the Nikkei. The second involves a "balanced" portfolio, in which contributions are split evenly between stocks and bonds, and the accumulation is rebalanced each period to maintain the constant proportion in risky. The third is an "age-phased" strategy, in which the proportion of the portfolio invested in stocks is gradually reduced over the life cycle. Personal finance experts frequently urge their clients to decrease their exposure to risky assets as they age, although financial economists have a hard time coming up with a theoretical justification for this advice.[1] Finally, in the "safe" strategy, all contributions and earnings are held in short term bills. All these four strategies are illustrative, and none would be followed by an optimizing investor.

Figure 1 The Nikkei Index 1970-2000

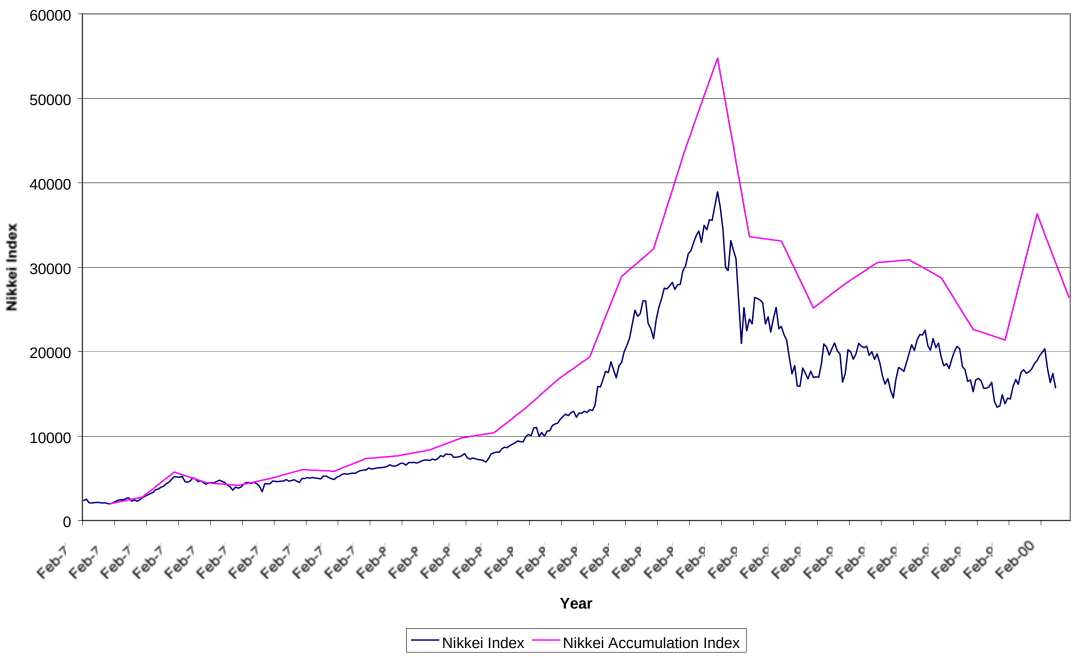


Table 2 reports the outcomes for selected 20 and 25 year horizons, as well as the full 30 year investment span which our data permits. Means and coefficients of

---

[1] MacNaughton et al. (2000) develop this point, and cite a number of sources advocating this strategy.

variation are reported for all 20 and 25 year horizons encompassed by the data; all prices are in ¥(2000).

The accumulations reported in Table 2 illustrate several points. First, the return on equity investment in Japan over the last 30 years has varied enormously by

Table 2 The DC Alternative: the last 30 years, ¥ (2000)

		Equities	Balanced	Age-phased	Safe
20 year Horizon	1970-89	23,899,896	13,520,922	16,514,962	7,374,332
	1972-91	13,315,942	11,142,481	12,655,449	8,538,752
	1974-93	11,308,942	10,793,803	12,338,478	9,367,838
	1976-95	12,080,003	11,497,653	12,718,262	10,074,697
	1978-97	8,507,964	9,784,437	11,512,188	10,374,622
	1980-99	13,648,401	12,996,352	12,802,555	10,883,199
	Mean	12,557,979	11,174,800	12,664,142	9,475,246
	Coefficient of variation	0.34	0.11	0.11	0.12
25 year Horizon	1970-94	14,813,552	11,892,208	14,855,748	11,025,382
	1972-96	14,003,261	12,777,422	14,953,609	11,935,211
	1974-98	10,764,980	12,169,019	14,505,206	12,602,783
	1975-99	18,315,367	16,660,259	16,667,415	13,072,635
	Mean	14,018,026	13,005,961	15,091,500	12,069,918
	Coefficient of variation	0.20	0.14	0.05	0.06
30 year Horizon	1970-99	21,587,358	19,112,955	18,205,550	14,397,945

Sources: CEIC database, and authors' calculations; see Annex 1 for definitions.

sub-period. Consider first the 20 year spans. They reveal massive accumulations between 1970 and 1990, nearly twice that experienced from 1980 and 2000. Second, a balanced portfolio, while offering a more modest average accumulation and volatility, nevertheless realizes a wide range of accumulations over a 20 year horizon. Third, the longer, 25 year span sharply reduces the variation in returns in all strategies, except for the balanced strategy. For example, the coefficient of variation on equity accumulations is 0.34 for 20 year time spans, but only 0.20 for 25 year spans.

Fourth, had protection against calamitous returns been available, the returns on equity investment would have been much higher. (In one year, equities lost nearly half their value – see Table 1.) Finally, the age-phased strategy does best in six of the eleven cases reported.

Table 3 compares social security with the outcomes of securities-based accumulations for a worker on average earnings over 20 and 25 year spans to the end of 1999. To do this, price indexed annuity factors were calculated for couples, encompassing one worker retiring at age 65, with 75% survivor benefits.[2] These calculations yielded factors of 19.47 for a husband and wife both aged 65, and 21.36 for a husband aged 65 with a wife aged 5 years younger.

The life annuities assumed here are valued on a population mortality basis, in line with the idea that, consistent with social security, annuity purchase is mandatory. The difference between the Social Security benefits reported and the estimated annuity payments provides one possible measure of the government

[2] Annuity factors were calculated using Japanese Life Table 18 (population mortality), assuming a 1% rate of interest and continuous payments.

subsidy to retirement provision on the assumptions used here, over and above social security tax revenue.

Table 3 Comparison of Social Security with Defined Contribution Benefits

¥(2000)

	Social Security Benefits		**Benefits under DC system**			
	EPI	EPF	Equities	Balanced	Age-phased	Safe
20 years	1,101,974	1,207,515	702,378	668,822	658,849	560,074
25 years	1,226,680	1,358,606	942,550	857,375	857,743	672,748
30 years	1,418,403	1,576,714	1,108,750	981,662	935,056	739,494

Sources: CEIC database, and authors' calculations; see Annex 1 for definitions.
Note: Calculations assume that individual is exempt from contributions to NPS before employment begins. Time period is 1970 to 1999 for 30 years, 1975 to 1999 for 25 years, and 1980 to 1999 for 20 years. Contributions adjusted to earn interest during part of year in which contribution made. Couple assumed to be same age, retiring at 65.
Annuity factor: 19.47 (see text).
Age-phasing patterns:
30 years - 8 yrs 80/20, 7 yrs 60/40, 7 yrs 40/60, 7 yrs 20/80
25 years - 6 yrs 80/20, 6 yrs 60/40, 6 yrs 40/60, 6 yrs 20/80
20 years - 5 yrs 80/20, 5 yrs 60/40, 5 yrs 40/60, 4 yrs 20/80

Our results suggest that whatever investment strategy were adopted, a 30 year history of social security contributions would not be sufficient to deliver adequate retirement income from a DC plan. They also point to the riskiness of financial markets – accumulations vary significantly with the chosen strategy, and with the time period considered.

Of course, the calculations presented here benefit from hindsight. In 1970, the realized wage and price changes, changes in social security contributions and benefits, and movements in the Nikkei, used in the above analysis, were not known. Although suggestive in a number of respects, this analysis cannot offer a rigorous guide to the future. For this, a framework encompassing uncertainty is required, and outcomes presented in probabilistic terms. To make progress in this direction, we begin with a review of relevant theory.

3 Theoretical Considerations

The theoretical underpinnings of the analysis of strategies for lifelong financial security have been developed over the last half century. Beginning with the work of Markowitz (1959) and Tobin (1958), which considered portfolio selection over one period, economists have wrestled with the more general question of multiple period optimal consumption and investment. This brief review divides into three subsections: how to invest, how to protect your investments, and how to insure against non-financial life contingencies.

3.1 How to invest

The question of how best to invest your money over your lifetime has been addressed by the intertemporal consumption and portfolio choice literature. Early important papers include Samuelson (1969) and Merton (1969, 1971). Simply stated, the papers address the question of how an investor, wishing to maximize his lifetime utility, should invest his money as time passes, choosing between a risky and a safe asset at each instant. Merton's (1969) classic solution to the problem assumed stationary lognormal stock returns and constant interest rates. This work has provided a useful benchmark for later researchers, who have sought to add greater realism to these original assumptions.

One aspect of the Merton (1969) solution that has attracted attention is the result that for the family of constant relative risk aversion (CRRA) utility functions, investors will invest a constant proportion of their wealth in the risky asset. This result is in stark contrast to observed investor behaviour and the advice of financial planners (Jagannathan & Kocherlakota 1996). How can this result be reconciled with observation? Two approaches have been offered up, relating to time-varying investment opportunity (i.e., stock returns are no longer stationary lognormal) and accounting for labour market behaviour.

Merton (1971) himself considered the question of time-varying investment opportunities. In this more general framework the proportion invested in risky assets is no longer constant, and now depends on the investment horizon of the investor. Other authors have made important contributions to this aspect of the literature (Brennan, Schwartz & Lagnado 1997, Campbell & Viceira 1999, 2000, Kim & Omberg 1996). Of interest is also the work of Wachter (1999), which recognizes the presence of mean reversion and persistence in the returns process.

The papers by Liu (1998) and Detemple, Garcia & Rindisbacher (1999) extend this area of research by allowing for variability in the safe rate of interest. Researchers have also sought to address the question of market incompleteness (Chacko & Viceira 1999), the risk of bankruptcy (Sethi 1997), and borrowing constraints (Fleming & Zariphopoulou 1991).

The papers above largely ignore non-tradable assets, especially human capital, in their analysis. This issue was dealt with by Bodie, Merton & Samuelson (1992), who showed, for the case of certain future income, that if the value of human capital is added to wealth, then the constant proportion Merton rule has the appearance of a reducing proportion invested in risky assets over one's working life. That is, although the investor invests a constant proportion of his human capital augmented wealth over his lifetime, as a proportion of wealth (not augmented by human capital) his investment in risky falls over his working life. These authors also point out the importance of correlation between labour earnings and stock returns a positive correlation will lead to lower investment in risky assets. Viceira (2001) considers the case of risky labour income not perfectly correlated with stock returns, pointing out the effects of increasing labour income risk on savings and portfolio decisions.

In a general equilibrium setting Basak (1999) details how the presence of labour income can lead consumption to be smoother than the stock market, explaining an oft-quoted empirical observation.

Another aspect of the optimal consumption and investment literature is the question of how individual investors will behave if their investment in risky assets is affected by a deterioration in background (or undiversifiable) risk. Koo (1995) shows that an increase in the variance of permanent income shocks will reduce the amount invested in risky by CRRA utility investors. Later work by Elmendorf & Kimball (1999) confirms Koo's findings.

3.2 How to protect your assets

Investments made to DC plans which are invested in equities clearly have fluctuating final accumulations. DB plans, on the other hand, offer fixed promises, with plan sponsors assuming the investment risk. What, then, are some strategies available to add a degree of protection to DC final balances?

Turner (2000) surveys employer backed minimum guarantees for DC schemes. Here, the employer agrees to contribute more to the fund in difficult times, thus sharing in the investment risk. Khorasanee & Ng (2000) discuss hybrid plans, combining the desirable features of DC and DB plans. These plans also involve the employer sharing investment risk.

Rate of return guarantees can also be implemented for DC plans using derivatives. Bateman (1998) discusses the use of portfolio insurance techniques, such as protective puts and collars, to protect DC accumulations. Bodie & Crane (1999) discuss the use of call option strategies pioneered by Merton, Scholes & Gladstein (1978). Grossman & Zhou (1996) place portfolio insurance strategies in a general equilibrium setting.

Bodie & Crane also point to the developing market for innovative protective products in securities markets as a means of protecting employee balances. Equity indexed annuities have generated much interest in the US since their introduction in 1995, and improved versions of such products may make useful contributions to retirement saving programs.

3.3 Insurance

DB retirement plans often offer valuable ancillary benefits, such as life insurance, to protect a member's dependents. Within the economics literature the question of determining the optimal amount of life insurance within the framework of the intertemporal consumption and portfolio choice problem has been addressed by Richard (1975) and Purcal (1997). This model also includes the optimal purchase of annuities, and can inform the debate on optimal annuity design.

Most of the literature above is, as is much of this financial economics literature, framed in a single agent optimization setting. The papers by Basak (1999) and Grossman & Zhou (1996) are notable exceptions. While intertemporal general equilibrium models (Merton 1990, Chapter 16) have demonstrated the Merton (1969) results can carry over to this richer setting, in general, the formulation of these financial models in a general equilibrium setting is a difficult and unresolved issue. Recent work by Kogan & Uppal (1999) deals with solving consumption and portfolio problems in continuous time in both partial and general equilibrium formulations and may provide a way forward in this area.

3.4 Summary

Recent economic theory has done much to increase our understanding of how individuals might optimally invest their assets over their lifetimes, how they should protect their investments, and how much life insurance and annuities they should buy at different stages of their lives. These disparate strands in the literature provide the theoretical underpinnings of our research, which can be seen as focussing on household retirement in an environment of increasing reliance on self-provision. This work will investigate the role of alternative financial strategies and policy settings.

4 Investing for lifetime security: stochastic counterfactuals

While elegant results have been obtained in the finance literature which point to optimal lifetime financial investment strategies, added doses of realism typically render theoretical analysis intractable, and numerical simulation must be used to make further headway. In this paper we model a simple innovations process over only one stochastic variable – investment returns. The assumed stochastic process follows geometric Brownian motion. The index grows at a trend rate which is continuously disturbed by random shocks. This "proportional random walk" implies that the volatility of the time path is proportional to the level of the associated index.

Formally, the process can be represented by

$$\frac{dX}{X} = \mu dt + \sigma dW \qquad (1)$$

where X is the value of the real risky accumulation index, μ is the mean rate of change, and σ^2 is the corresponding variance.

The return index is generated by discrete approximations to the above processes. Drawing on a standard result in mathematical finance, it can be shown that valid approximations to (1) are given by:

$$\frac{\Delta X_t}{X_t} = \mu \Delta t + \sigma \sqrt{\Delta t}\ \varepsilon_t \qquad (2)$$

where $\varepsilon_t \sim N(0,1)$ and independent, and we measure time units in fortnights ($\Delta t = 1/26$ of a year) so that for an accumulation of 30 years we have 780 periods.

The Merton (1969) result, that standard preference maximization yields a constant proportion in risky rule, provides a starting point for designing investment strategies over the life cycle. Three of the four strategies we model here flow from the simplest possible constant proportions rules: all in risky, all in safe, and a 50-50 split.

The intuition underlying risk constancy is that we seek to optimize by trading off risk at the margin much as we trade off other commodities. We drive slower in wet weather to expose ourselves to constant risk while driving. Equally, so long as risky does not change its riskiness, we should not alter our portfolios.

Our fourth strategy involves age-phasing, which may be thought of as a simple illustration of a sophisticated strategy for lifelong financial security. Superficially, risk constancy would appear inconsistent with the flavour of much popular financial advice, which suggests that exposure to risky assets should decrease with age. It is, however, possible to reconcile the risk constancy result with age-phasing advice.[3]

The two most convincing arguments for age-phasing are well articulated by Bodie et al. (1992). The first essentially extends the risk constancy proposition to include human as well as non-human capital. If human capital is relatively safe, then as the stock of human capital depletes with age, a compensating financial portfolio adjustment should take place to preserve constant exposure to risk overall. This will have the effect of increasing the proportion of safe assets in a financial portfolio with age.

The second argument, less analytically crisp but perhaps more robust, is that people's ability to adjust their behaviour to accommodate the consequences of bad luck decreases with age. A family that takes a hit when the household head is in his 30s, or even 40s, has more margins on which to adjust than one whose head is approaching retirement. Work effort (including secondary labour force participation), job retraining, even family size, are all examples of adjustments that are much more feasible earlier rather than later in the life cycle.

---

[3] Kingston et al. (1992) use stochastic simulation to illustrate the efficacy of age-phasing in the Australian context.

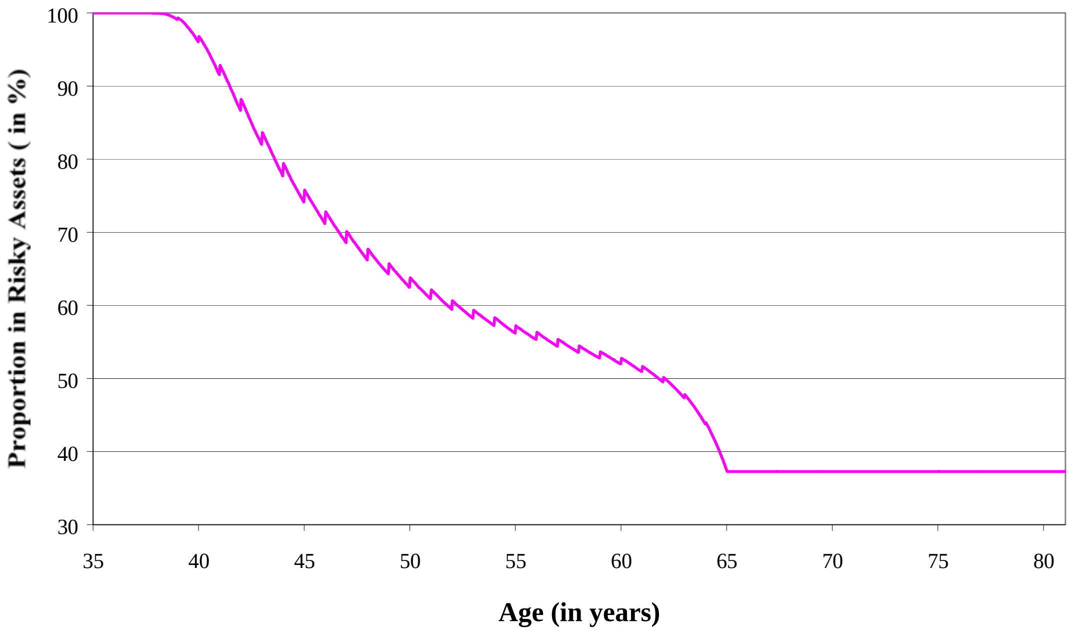
Figure 2 maps out the proportion of a gradually accumulating financial portfolio which should be held in risky over time by an exemplar individual, given safe human capital.[4] In the early years, until about age 40, the entire portfolio is in risky. Were borrowing permitted, the optimizing investor would borrow against his human capital to increase exposure to risky assets. As his financial portfolio increases in size, and his human capital depletes, safe assets enter into his financial portfolio, until at retirement, he holds between 35% and 40% of his portfolio in risky assets.

It is noteworthy that exposure to risky is still significant, even after retirement. This suggests that annuity designs should perhaps include some degree of exposure to risk, as is the case with the variable annuity.

In Figure 3, we reproduce the distributions of outcomes in the portfolios where there is some degree of exposure to risk, and point to the safe return as a comparator. Returns and volatilities were set consistent with Japan’s experience over the last 30 years. The safe rate of return was set at 4.6%, the risky rate at 8.2%, and volatility at 25.4%. These are the continuously compounding rates of return matching those given in Table 1. The contribution rate was set at 15.33%. This is the value that, invested in safe, gives the accumulation at age 65 that would actually have been realized (see Table 2).

[4] This assumes an individual maximizing standard power utility function $U=C^{1-\gamma}/(1-)$, where =1.5, and follows Merton (1969) and Bodie et al. (1992).

Figure 2 Age-Phasing: Variation in optimal exposure to risky assets with age (safe human capital)

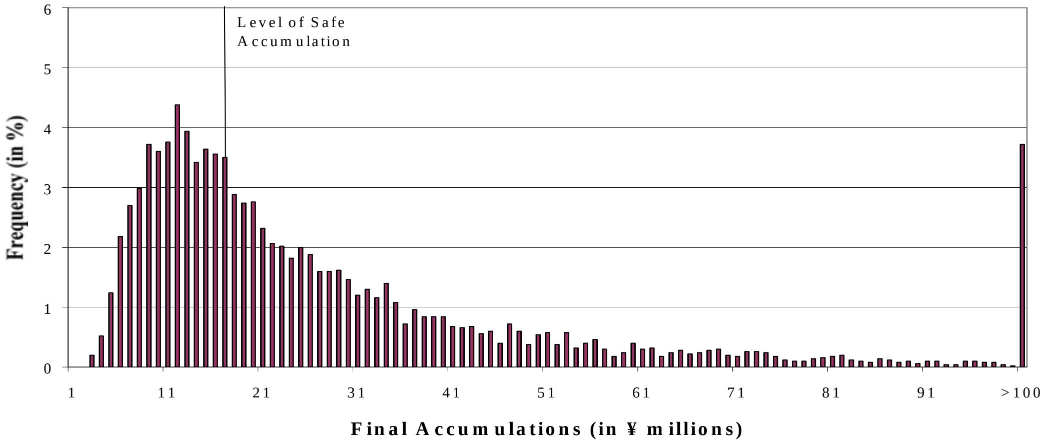


The mean accumulation under the all equities regime is highest, at ¥29.83 million; next comes the age-phased portfolio, with ¥22.98 million. The balanced case generates a mean accumulation of ¥22.17 million, with the safe strategy returning ¥17.01 million with certainty.

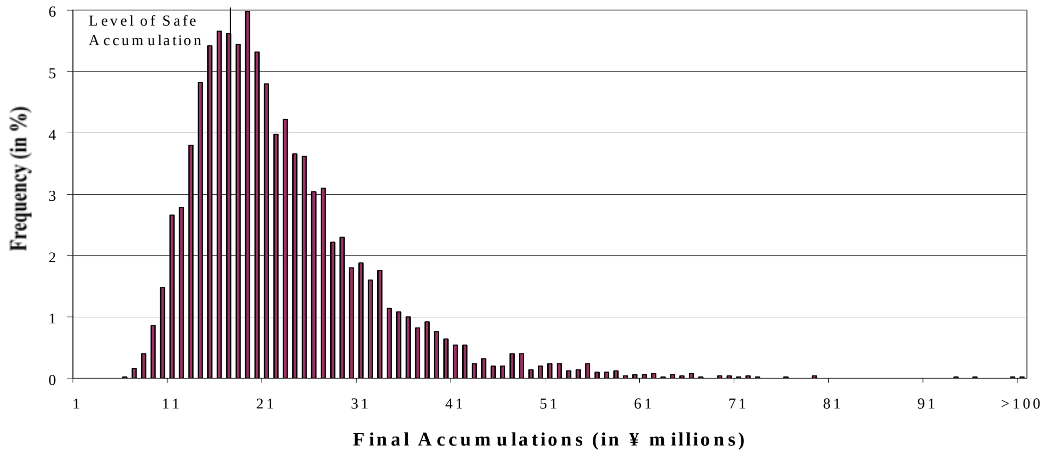
The standard deviations in each case indicate a clean trade-off between risk and return in the four cases we examine, with coefficients of variation of 1.21 for the all-equities portfolio, 0.45 for the age-phased portfolio, and 0.44 for the balanced portfolio.

Figure 3 Accumulation Distributions under Alternative Investment Strategies

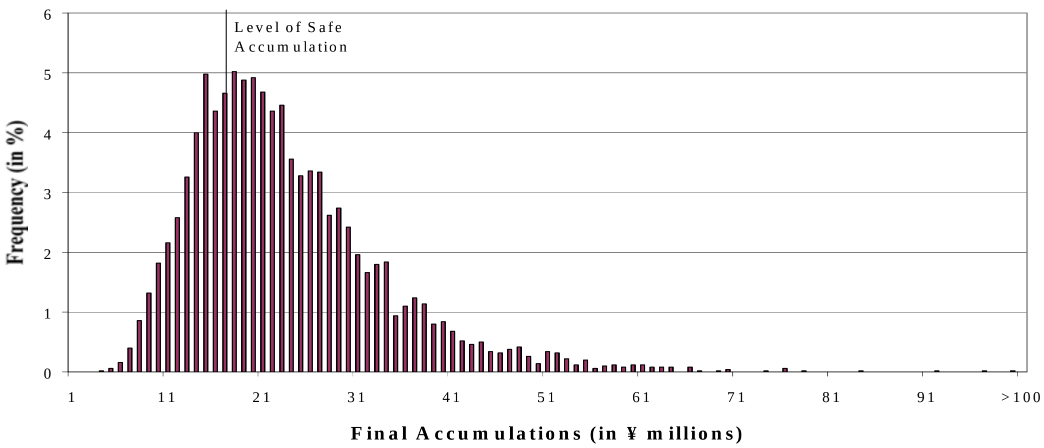
Risky Strategy



Balanced Strategy



Age-Phased Strategy



Inspection of Figure 3 suggests that by age-phasing, it is possible to narrow the distribution of outcomes - and thus reduce uncertainty without a large sacrifice in mean expected return. By contrast, the all-equities portfolio offers the possibility of considerable upside, but at the cost of a high probability of indifferent outcomes.

The role of investment strategies of the age-phased type, and financial engineering more generally, is to shape the distribution of outcomes to more closely fit the preferences of the life cycle investor than would be possible with unsophisticated strategies.

Table 4 reports the percentile outcomes from these simulations. Note that while the mean return of the all-equities portfolio is significantly greater than any other, the median is little greater than the safe return. The age-phased strategy offers the highest median return[5].

Table 4 Percentile accumulations for alternative investment strategies

(¥ Millions)

Percentile	Equities	Balanced	Age-Phased	Safe
90%	59.791	34.404	36.375	17.009
75%	33.933	26.379	27.968	17.009
50%	19.383	19.940	20.989	17.009
25%	11.942	15.459	15.764	17.009
10%	8.090	12.442	12.236	17.009

[5] This result is of course independent of the historical path of the Nikkei Index over the past 30 years, unlike the strong performance of the age-phased strategy in Table 2.

5 Conclusion

This paper canvasses questions raised by the world-wide trend towards increased individual responsibility for lifelong financial security, and specifically focuses on the implications for Japan. Publicly provided Social Security, and many occupationally based DB plans have traditionally provided insurance against longevity, investment, and inflation risk, and have also offered life insurance to support dependants. As individuals increasingly rely on their own resources and decision-making to insure against demographic and financial risks, privately based delivery of the underlying investment and insurance services will become critically important.

In this paper we use Japanese data and social security structures to compare market based outcomes with public outcomes, using time-spans covering the past 30 years. We use a simple stochastic model of investment returns innovations to generate distributions of outcomes under alternative investment strategies. We find that increasing the sophistication of the investment strategy generates outcomes, or distributions of outcomes, which dominate those implied by simple constant-proportions positions.

References

Basak, Suleyman, 1999. “On the fluctuations in consumption and market returns in the presence of labor and human capital: An equilibrium analysis”, *Journal of Economic Dynamics and Control* 23, 1029-1064.

Bateman, Hazel, 1998. “Risk management issues for mandatory private retirement provision: roles for options”, *Australian Journal of Management*, 22, 175-97.

Bodie, Zvi, and Dwight B. Crane, 1999. “The Design and Production of New Retirement Saving Products”, *Journal of Portfolio Management*, 1999 (Winter issue) 77-82.

Bodie, Zvi, Robert C. Merton, and William F. Samuelson, 1992. “Labor Supply Flexibility and Portfolio Choice in a Life Cycle Model”, *Journal of Economic Dynamics and Control* 16, 427-449.

Brennan, Michael J., Eduardo S. Schwartz, and Ronald Lagnado, 1997. “Strategic asset allocation”, *Journal of Economic Dynamics and Control* 21, 1377-1403.

Campbell, John Y. and Luis M. Viceira, 1999. “Consumption and portfolio decisions when expected returns are time varying”, *Quarterly Journal of Economics* 114, 433-495.

Campbell, John Y. and Luis Viceira, 2001. “Who should buy long-term bonds?”, *American Economic Review* 91, 99-127

CEIC Database, DX Data, Sydney, 2000.

Chacko, George and Luis Viceira, 1999. “Dynamic consumption and portfolio choice with stochastic volatility in incomplete markets”, Working paper, Harvard Business School.

Clark, Robert L., 1991. *Retirement Systems in Japan*, Pension Research Council, Irwin, Boston MA.

Detemple, Jerome, Rene Garcia, and Marcel Rindisbacher, 1999. “A Monte Carlo Method for Optimal Portfolios”, Working Paper, Rotman School of Management, University of Toronto, Canada.

Elmendorf, Douglas W. and Miles S. Kimball, 2000. “Taxation of labor income and the demand for risky assets”, *International Economic Review* 41, 801-33

Fleming, Wendell H., and Thaleia Zariphopoulou, 1991. “An Optimal Investment/Consumption Model with Borrowing”, *Mathematics of Operation Research* 16, 802-822.

Grossman, Sanford and Zhongquan Zhou, 1996. “Equilibrium analysis of portfolio insurance”, *Journal of Finance* 51, 1379-1403.

Jagannathan, Ravi and Narayana R. Kocherlakota, 1996. “Why Should Older People Invest Less in Stocks Than Younger People?” *Federal Reserve Bank of Minneapolis, Quarterly Review* 20, 11-23.

Khorasanee, M. Saki and Ho Kuen Ng, 2000. “A retirement plan based on fixed accumulation and variable accrual”, *North American Actuarial Journal* 4, 63-79.

Kim, Tong Suk and Edward Omberg, 1996. “Dynamic nonmyopic portfolio behavior”, *Review of Financial Studies* 9, 141-161.

Kingston, Geoffrey, John Piggott, and Hazel Bateman, 1992. "Customized Investment Strategies for Accumulation Superannuation", in Davis, Kevin and Ian Harper (eds), *Superannuation and the Australian Financial System*, Allen and Unwin, 139-156.

Kogan, Leonid and Raman Uppal, 1999. “Risk aversion and optimal portfolio policies in partial and general equilibrium economies”, Working paper, Sloan School of Management, MIT.

Koo, Hyeng-Keun, 1995. “Consumption and portfolio selection with labor income I: Evaluation of human capital”, Unpublished paper, Washington University.

Liu, Jin, 1998. “Portfolio selection in stochastic environments”, Working paper, Graduate School of Business, Stanford University.

MacNaughton, Tracey, John Piggott and Sachi Purcal, 2000. “Growing Old Gracefully: Age-phasing, Targets, and Saving Rules”, *Journal of Private Portfolio Management* 2, 20-24.

Markowitz, Harry M., 1959. *Portfolio Selection: Efficient Diversification of Investment*, John Wiley & Sons.

Merton, Robert. C., 1969. “Lifetime portfolio selection under uncertainty: the continuous-time case.” *Review of Economics and Statistics* 51, 247-257.

Merton, Robert. C., 1971. “Optimal consumption and portfolio rules in a continuous-time model.” *Journal of Economic Theory* 3, 373-413.

Merton, Robert. C., 1990. *Continuous-time Finance*, Basil Blackwell.

Merton, Robert C., Myron S. Scholes, and Matthew L. Gladstein, 1978. “The returns and risks of alternative call option portfolio investment strategies”, *Journal of Business* 51, 183-242.

Purcal, Sachi, 1997. “Optimal portfolio selection and financial planning”, Working paper, The University of New South Wales.

Richard, Scott F., 1975. “Optimal consumption, portfolio and life insurance rules for an uncertain lived individual in a continuous time model.” *Journal of Financial Economics* 2, 187-203.

Samuelson, Paul A., 1969. "Lifetime portfolio selection by dynamic stochastic programming." *Review of Economics and Statistics* 51, 239-246.

Sethi, Suresh P., 1997. *Optimal Consumption and Investment with Bankruptcy*, Kluwer Academic.

Takayama, Noriyuki, 1998. *The Morning After in Japan: Its Declining Population, Too Generous Pensions and a Weakened Economy*, Maruzen Co. Ltd., Tokyo.

Tobin, James, 1958. "Liquidity preference as behavior towards risk", *Review of Economic Studies* XXV, February, 68-85.

Turner, John, 2000. "The best of both worlds?", *The Actuary*, August, 20-21.

Viceira, Luis M., 2001. "Optimal portfolio choice for long-horizon investors with nontradeable labor income", *Journal of Finance* 56(2), April, 433-70.

Wachter, Jessica, 1999. "Portfolio and consumption decisions under mean-reverting returns: An exact solution for complete markets", Working paper, Harvard University.

Annex 1

Data sources for economic and financial data series used in Japan social security and investment calculations

Prices and nominal wages series Taken from the CEIC database. Figures are for December each year and are the change on the previous December figure. The nominal wage series is seasonally adjusted by averaging the values of the preceding twelve months.

Monthly wages Average monthly cash earnings of regular employees figures taken from Japan Institute of Labour webpage, (http://www.jil.go.jp/estatis/e0301.htm). The figures for 1994-98 were each taken back to December 1970 using the nominal wages series, and the average of the five figures was around ¥67,000 (the exact figures were: 66,581 based on the 1998 series; 66,649, 97 series; 66,879, 96 series; 67,325, 95 series; 67,752, 94 series). The series was then constructed using the nominal wages series to get the time series. The estimated figure for December 1999 is ¥364,638.

Bonuses Data from the Ministry of Labour's Monthly Labour Survey on their webpage (http://www.mol.go.jp/info/toukei/english/index.htm) has figures on contractual cash earnings (regular salary) and special cash earnings (bonuses). Analysis of the data shows that bonuses account for just over 20 per cent of total average monthly earnings (data for June 1999 to June 2000). So for the model we have estimated regular salary (i.e. used as basis for pension contributions and benefits) is 80 per cent of average total monthly earnings, and bonuses are 20 per cent of total earnings. Thus, in December 1999, average regular monthly salary was ¥291,710 and average monthly bonuses were ¥72,928.

EPI contribution rate Taken from Social Security Programs Throughout the World, Takayama (1998) and Clark (1991). The series is 12.4% up to 1989, 14.5% 1990-93, 16.5% 1994-5, 17.35% 1996 onwards. Also one per cent of bonus is contributed.

Rates of return Taken from CEIC databases and data supplied by Gary Burtless. The risky rate of return is the change in Nikkei accumulation index over previous December's figure. The safe rate of return is the Bank of Japan bill rate series with estimates calculated for missing values.