Increasing Life Expectancy

and Reforms in Pension Plans

by

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Abstract

We compare the different possibilities to reform a funded pension plan, whose balance is threatened by the decrease in mortality. Since the plan is mandatory, the welfare of workers might be depleted if contributions increase or if retirement age is raised.

The empirical study of the Israeli data shows that a reform which decreases the pension's benefits is the optimal scenario, when compared with the options of increasing the retirement age or increasing pension fund contributions. We also show that giving workers the freedom to choose the retirement age and the induced pension benefits is the optimal policy and increases the welfare of workers.

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1. Introduction

Workers all over the world are concerned with securing their old age income. Governments together with financial institutions try to meet this concern by managing mandatory pension plan. Dissatisfaction is felt by the two sides: workers and pension plan managers. Some suggestions to improve existing plans are discussed in a publication edited by Bodie et al. (1996). My paper adds another aspect to the already complex subject, as it describes a simplified model of a plan where the individual worker cannot choose the age of retirement or the size of the pension. This mandatory pension plan which is funded by the contributions of its members should be actuarially balanced. This means that the present value of its assets must be greater than the present value of its liabilities. When life expectancy of retirees increases, the fund has to pay pensions for longer periods. This demographic process threatens the actuarial balance of the fund and it has to accordingly, change the regulations of the pension plan.

The impact of a decrease in the mortality rate is common to all funded pension plans around the world. To counteract this impact, regulators of such pension plans will most likely consider taking one or more of the following steps:

(1) Increasing the contributions of the members while they are working.

(2) Raising the retirement age.

(3) Decreasing the benefits given to pensioners.

This paper will now compare the three suggested alternatives of pension reform from the workers' point of view.

This study includes an analysis based on Israeli data, which shows the theoretical applications of the three suggested reforms. An additional analysis showing the dominant role of age and wage dependent pension is presented at a later stage.

2. The Pension

The pension plan given to workers by the government or employers is an annuity that secures future consumption under an uncertain lifetime period. Since pension funds are subsidized by the government, most worker's contributions exceed the sum of the optimal pension, chosen without a subsidy. There is a limit to the subsidy given and we expect workers to choose the mandatory pension as their optimal corner solution. Our model applies to workers who feel that the annuity given to them by their employers is more then enough and they do not have the desire to purchase any additional annuities in the financial markets. While contributing to the mandatory pension plan workers may incur other debts. When retiring, many of the pensioners, who are allowed to cash part of the present value of their pensions, take the money and thus choose to decrease the value of their annuities. This situation allows us to see at least part of the pension plan as a financial asset, and to ignore the change in the insurance of the uncertain future consumption, associated with small changes in the value of the annuities. This paper therefore analyses the welfare of workers who believe that while holding their mandatory pension plan, they do not need any additional annuities to insure their future consumption.

For the simplicity of the model, we focus only on the old age pension plan and ignore benefits to young successors and the spouse of workers who die before retirement age. We also ignore the pension given to the spouse of a pensioner who passed away. These properties of existing plans can be added at a later stage to the model without changing the main results. The pension described here is thus paid as a function of age only.

A young worker is considering his future welfare while examining a retirement plan. The pension plan will mature once the worker reaches the age of z. At age z, the worker's present value of his pension will depend on his life expectancy. A death at age t gives a person with a present value of x(t):

$$x(t) = \int_{0}^{t-z} Se^{-Ry} dy - C \quad (1)$$

where:

S- the annual pension benefits

R- the rate of return

C- the value of the accumulated contributions up to retirement which is certain in our simplified model. -C is the minimum value of x(t).

Thus, a worker who retires at age z has a pension plan described by the vector (z,S,C). The pension fund has to keep the expected present value of benefits minus contributions, denoted by Ex(t), negative.

$$Ex(t) = \int_{z}^{\infty} g(t) \int_{0}^{t-z} Se^{-Ry} dy dt - C \quad (2)$$

g(t) is the probability to die at age t ,contingent on the possibility that age z is reached.

It holds true that $\int_{z}^{\infty} g(t) dt = 1$

Let us assume that a 'representative' member of the fund believes that his risk to die at some future time t, is described by the density probability function g(t). The probability function g(t), is estimated by the general mortality rates published annually by the bureau of statistics. We also assume that members are risk averse and follow either the Expected Utility Theory (EU) introduced by von Neumann and Morgenstern (1947) or Yaari's Dual Theory of choice under risk (DT, (1987)). The change in mortality risk is expressed by a shift of the function g(t) to another function f(t). The empirical estimations point to the statistical properties of these shifts and experts give their forecasts for future changes.

Looking at the formulas we can see that the first reform increases C, the second one raises the minimal age of retirement z and the third reform decreases S.

3. Israeli Data

The Israeli data is reported in Tables 1 and 2. These tables refer only to the Jewish population whose mortality rates are lower than those of the minorities. The Jewish population is more relevant to our problem as relative small portions of the minorities are members of the pension funds. The tables show estimations of mortality risk in several age groups during different periods.

Insert Tables 1 & 2

The Statistical Yearbooks show that during the period 1975-1993, life expectancy of retirees increased by more than 12%. While looking at the tables, we see that mortality of the age groups 60-70 went down by more than 20% in 14 years and that this ratio decreases when the age of the group increases. In Tables 1 and 2 we measure the probability of death estimated when the worker reaches his retirement age. This ratio differs from the age specific mortality rates reported annually by the Central Bureau of Statistics (CBS) and the World Tables (1995). The probability to die at age 85+ as estimated at the ages 60 or 65 increased, since all human beings will eventually pass away. The shift in the probability distribution from g(t) in the period 1975-1979 to f(t) in the period 1989-1993, is presented in Tables 1 and 2. The shift is in accordance with the Monotone Likelihood Ratio (MLR) property defined by Lehmann (1959) and applied to the decision taking under uncertainty by Landsberger and Meilijson (1990) and Ormiston and Schlee (1993). MLR requires that the ratio g(t)/f(t) is non-increasing with t. These four authors showed in their theoretical contributions that the main property of the MLR shift under EU is certainty equivalence. MLR is a private case of the First Order Stochastic Dominance (FSD) applied to mortality risk by Paroush and Silber (1980). In fact, while looking at changes in age specific mortality of the retired population in other industrialized countries, we observe MLR shift of mortality rates along time. The ratio of the change in mortality along time declines as age increases (for mortality rates, see UN Demographic Yearbooks, 1972, 1992 and for estimation, see Machnes (1998)).

We now estimate the financial application of the changes in the mortality rates. We see that the decrease in mortality that occurred in Israel during the years 1975-1993 increased the present value of the pensions by 6.9% for men and by 6.4% for women. These figures shown in Tables 1 and 2 are based on real interest rate of 4.8% (since indexed bonds are sold in Israel we can ignore inflation).

4. The Financial Application

We now consider the way a risk-averse individual with full information about age specific mortality risk, compares the three alternative reforms in the pension plan induced by the increase of his life expectancy.

The target of the pension fund is to choose a reform that maximizes the utility of workers under the exogenous shift of g(t), subject to the constraint Ex(t) equal to zero. We are therefore searching for a shift of x(t) that fulfills the Second order Stochastic Dominance (SSD) criteria (introduced by Hadar and Russel (1969) and Hanoch and Levy (1969)). These authors showed that risk-averse individuals are better off if their risky asset is changed according to the SSD criteria. Wang and Young (1998) showed the same for agents whose preference order fulfills the DT axioms.

The asset x(t) defined in (1) denotes the present value of the pension, which is a random variable whose value depends on the age at death and its minimum value is denoted here by the letter a. During the initial period, the minimum value of x was $-C$ but the first two reforms suggest to lower this value.

The SSD criteria hold true if and only if:

$$\int_a^b \{\int_a^v [\bar{g}(x) - \bar{f}(x)]dx\}dv \geq 0 \quad a \leq x < \infty \quad \text{for every b} \tag{3}$$

The probability distribution functions of x are denoted by $\bar{g}$ and $\bar{f}$, whereby $\bar{g}$ prevails in the initial period and $\bar{f}$ takes care both of the change in mortality and the reform. Since x is strictly increasing with t, the probability distribution function of age at death can be transformed to a function of the present value of the pension.

We can see that the first two suggested reforms cannot fulfill the SSD criterion, while the third reform follows this criterion as seen in the Israeli case study.

Insert Figures 1 and 2

The first two reforms cannot satisfy the SSD criterion since they suggest a greater probability of receiving a pension that is lower or equal to -C, (this being the minimum value of the pension originally received during 1975-1979). This situation contradicts the last inequality (3) whereby the pensioner dies shortly after his retirement.

Let us consider the first alternative reform and ask workers to increase their contributions to the fund. When considering equation (1), we see that contributions are increasing and therefore under $\bar{f}$, there is a positive probability for an interval of pensions lower than -C. Workers who contributed a greater sum of money to the fund and who subsequently passed away at age of z , just after retirement, lost more money than before the reform. As a worst case scenario, the present value of their pension is decreasing where b<-C.

For this interval the integral $\int_a^{-C} \bar{g}$ gets a value of 0 while the integral $\int_a^{-C} \bar{f}$ is positive. So the integral in (3) is negative for b<-C and the condition for SSD shift is abolished.

The same argument is true when we consider the second suggested reform. Raising the retirement age increases the probability of a minimal value for the pension plan denoted by -C. If the pension fund follows the present reform in the USA's Social Security plan, and increases the retirement age by five years, then workers who pass away between the ages z to z+5 will receive a present value of -C or less. (To obtain a present value of less than -C would depend on regulations requiring contributions to the fund along these additional five years). By increasing the probability of getting -C or less, we abolish the SSD criteria described in inequality

(3).

The third reform can fulfill the SSD criteria. Figures 1 and 2 show the shift of the cumulative distribution function of the pension, which is based on a reduction of the pension benefits by 6.8% (this is the weighted average of the changes for the two genders). Under this reform, when a member dies at age z just after retirement, the random value of asset does not change and is equal to -C. For pensions lower than the mean Ex(t)+C, the effect of decreasing benefits is smaller than the effect of the decrease in mortality rates, but for pensions larger than Ex(t)+C, the opposite is true. Figures 1 and 2 demonstrate this result which is induced by the MLR criteria of the probability shift. We compare the pension given during the period 1975-1979, to the pension given during the period 1989-1993, after decreasing the benefits by 6.8% whereby pensioners receive a benefit of only 0.932S. We observe in these estimations a single crossing of the cumulative probability curves for two genders, as shown in Figures 1 and 2. Since the expected value of the two random pension plans, $\overline{g}(x)$ and $\overline{\mathrm{f}}(\mathrm{x})$ are equal, we can conclude that the single crossing assures that the SSD criterion holds true. The SSD shift of the random asset increases the welfare of all risk-averse workers. The workers who feel that after the reform they need a greater pension can always purchase additional annuities in the financial markets and will not be hurt by the reform.

5. Wage Dependent Pension

Despite our theoretical conclusion that raising the age of retirement does not fulfill the SSD criteria and may deteriorate the utility of the members, this strategy was chosen by several pension plans that followed the USA's Social Security reform.

Looking carefully at the regulations of the USA's Social Security plan, we find that the change of the retirement age from 65 to 70 is followed by an additional criteria: a pension will be given at the ages 65-70, only in the case of having no other wage income. Those who prefer to work lose their pension during these ages. This additional criterion brings an additional aspect to the model and changes our conclusion. It is assumed that the young members who join the fund know that life expectancy is increasing and that the expected value of their pension is kept constant. They now consider three possible states of nature during the age period 65-70: Working (W) Retiring (S) and Death (0). However the incomes contingent on wage and age dependent reform are respectfully: W,S,O. The wage income W fulfills W>S, and the young member attaches to each possible state of nature the appropriate probability. Let us use the traditional symbols and denote the probability to die at the age k as estimated by a member whose age is 30 according to mortality rates of 1993 by ${}_{k}|q_{30}^{1993}$ and the probability to work at the age k, by p. For 65<k<70, we denote $q = {}_{k}|q_{30}^{1993}$. We assume that p is known to the fund and the new retirement age set by the reform is based on this probability. It therefore holds true that ES=(1-p)S . We can sum up the future possibilities in the following table:

State of nature (during the age of 65-70)	Income (reform no. 3)	Income (wage dependent reform)	Probability
Working	W+ES	W	p(1-q)
Retiring (without wage)	ES	S	(1-p)(1-q)
Death	0	0	Q

We see that both EU and DT risk-averse members, will prefer the higher age *and* wage dependent pension to a lower pension, which is only age dependent. We have here a binomial probability distribution of the future streams, contingent on living at ages 65-70. One can see that the age and wage dependent reform is SSD to reform number 3, which keeps the pension only age dependent.

6. Continuous Adjustment

Past demographic changes call for pension fund reforms, however we have to consider future trends. There are forecasts that mortality will continue to decrease in the future as the standard of living increases and that better education will encourage more people to enjoy a healthier lifestyle. Thus, introducing a dynamic plan that will adjust the pension benefits to the changes in life expectancy is very important. When young members are informed about the effect of life expectancy and the possible changes in the benefits or the retirement age that will take place in the future, there will be no need for drastic reform to pension regulations. The decreasing mortality rates in Israel during the years 1975-1993, induces a constant annual decrease of about 0.047% $(1.068^{1/14} = 1.0047)$ on the pension benefits. We also believe that a dynamic gradual adjustment will be accepted more easily by the fund members than a dramatic reform.

7. Conclusion

We measure the impact of the demographic changes that occurred in Israel on the actuarial balance of the pension funds. Since pension is mandatory, increasing contributions or raising the age of retirement may decrease the welfare of workers. This decrease in welfare may however occur despite the subsidy given to pension plans. We also find that decreasing benefits according to longevity does not decrease the welfare of workers. We later show that by giving workers the choice of their retirement age and the size of the pension benefits implied, we increase their utility. In order to prevent dramatic changes in the pension plans, a dynamic continuous change of the pension benefits is recommended.

Table 1: Distribution of Age at Death of Retired Israeli Males

Ratio A/D	D	C	B	A	
	1989-1993	**1985-1989**	**1980-1984**	**1975-1979**	**Age**
1.24	11.73	12.07	13.22	14.56	65-69
1.24	15.54	16.98	18.07	19.33	70-74
1.10	19.98	20.67	21.54	21.92	75-79
0.96	21.40	21.82	21.33	20.49	80-84
0.76	31.34	28.47	25.85	23.71	85+
	100.00	100.00	100.00	100.00	**SUM**

Table 2: Distribution of Age at Death of Retired Israeli Females

Ratio A/D	D	C	B	A	
	1989-1993	**1985-1989**	**1980-1984**	**1975-1979**	**Age**
1.39	4.65	5.00	5.75	6.49	60-64
1.39	7.18	8.28	9.19	9.98	65-69
1.26	11.84	12.78	13.87	14.93	70-74
1.18	16.52	18.18	18.82	19.48	75-79
1.00	20.79	21.22	22.19	20.86	80-84
0.72	39.01	34.54	30.18	28.26	85+
	100.00	100.00	100.00	100.00	**SUM**

References

Bodie, Zvi; Mitchell, Olivia-S.; Turner,-John-A. (eds),1996. Securing employer based pensions: An international perspective: Wharton School, University of Philadelphia Press.

Israel, Central Bureau of Statistics, Statistical Yearbooks, 1995-1998.

Hadar, J. and Russel, W.R., 1969, Rules for Ordering Uncertain Prospects, *American Economic Review* 59, 25-34.

Hanoch, G. and Levy, H., 1969, The Efficiency Analysis of Choices Involving Risk, *Review of Economic Studies* 36, 335-346.

Landsberger, M. and Meilijson, I., 1990, Demand for Risky Financial Assets: A Portfolio Analysis 1990, *Journal of Economic Theory*, February 50, 204-213.

Lehmann, E.L., 1959, Testing Statistical Hypotheses, New York: Wiley.

Machnes, Y. 1998, Changes In Age Specific Mortality Rates: An Economist's Perspective. Mimeo. Bar-Ilan University.

Ormiston, M.B. and Schlee, E.E., 1993, Comparative Statistics Under Uncertainty for a Class of Economic Agents, *Journal of Economic Theory* 61, 412-422.

Paroush, J. and Silber, J., 1980, The Stochastic Dominance Criteria, Mortality Risk and Investment in Education: A Cross-Country Comparison, *Research in Finance* 2, 111-120.

United Nations, 1972 and 1992, Demographic Yearbooks.

von Neumann J. and Morgenstern, O., 1947, Theory of Games and Economic Behavior, Princeton University Press, Princeton New Jersey.

Wang, S.S., and Young, V.R., 1998, Ordering Risks: Expected Utility Theory Versus Yaari's Dual Theory of Risk, *Insurance: Mathematics and Economics* 22, 145-161.

World Tables, 1995, A World Bank Book, Baltimore and London: The Johns Hopkins University Press.

Yaari, M., 1987, The Dual Theory of Choice Under Risk, *Econometrica* 55, 95-116.