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**OPTIMAL ACTUARIAL FAIRNESS IN
PENSION SYSTEM - a Note**

by

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Optimal Actuarial Fairness in Pension Systems

– a Note

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Preliminary

Abstract

A rationale for a compulsory pension system is that the government wants to correct supposedly myopic behavior by the individuals. Given such a system, we calculate the optimal relation between marginal contributions and benefits, i.e., the optimal degree of marginal actuarial fairness, for the individuals or for the government. We show that the optimal degree of marginal actuarial fairness increases in the rate of return in the social security system and decreases in the government's rate of time preference. It is also shown that labor supply always increases when the link between marginal contributions and benefits is strengthened.

JEL Classification Code: H55, H5, H2

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1. Introduction

There are many rationales for compulsory pension systems. In this paper we confine ourselves to pension systems as a device for life-cycle redistribution. Thus, we emphasize the paternalistic argument for compulsory systems; that is, the government is assumed to correct asserted myopic behavior of the individuals. Most of the literature on pension systems analyzes the consequences of heterogeneity, adverse selection problems or uncertainty. See for example Eckstein et al. (1985) and Abel (1986). Due to the much narrower scope of this note, we will disregard all such complications, despite their obvious importance.

Compulsory pension systems are bound to influence the lifetime consumption profile if the individual is credit-constrained, as then he cannot (fully) offset the compulsory intertemporal redistribution by reducing financial balances or borrowing. It is well-known that compulsory pension systems under such circumstances distort individual behavior and reduce individual utility, as evaluated by the individual's own preferences. We may identify three types of distortions:

(i) The most obvious from the point of view of the individual's own preferences is that a compulsory change of the consumption profile violates the intertemporal preferences of the individual. The individual is forced into a consumption behavior that may be optimal under the discount rate of the government but reduces the lifetime utility of the individual when measured with his own discount rate.

(ii) A compulsory pension system also distorts labor supply. If households are credit constrained, they value the future benefits they receive less than their contributions, even if the implicit rate of return on social security contributions be the same as the market return, so that the present discounted value of benefits equals the value of the contributions. Hence, actuarial fairness would not generally be enough to eliminate the effect of a compulsory social security fee on labor supply .

(iii) An additional distortion arises if the system is not actuarially fair with respect to marginal contributions, i.e., if a marginal increase in the contributions generates an increase in benefits with a lower market value to the individual than the value of the contribution. In

the real world, the pension fee is usually levied in proportion to the individual's wage income and the link between marginal benefits and contributions is typically not perfect; hence actually existing compulsory pension systems are usually not actuarially fair. In particular, the implicit rate of return in non-funded systems is typically lower than the return on a market portfolio (Feldstein, 1996 and Auerbach & Kotlikoff, 1987)¹. Such a discrepancy can arise also if there is no redistribution between individuals, that is, also in models with a representative individual.

Due to these three types of distortions, it may not be possible to construct a fiscally neutral pension system in which the individual values his *total* contributions the same as his total future benefits. However, it is natural to assume that the labor market distortion depends on the degree of *marginal* actuarial fairness, i.e., on the relation between marginal contributions and marginal benefits. This is the background for the analysis in this paper. More specifically, what happens with labor supply and individual utility when a compulsory pension system is made more actuarially fair on the margin? Moreover, given that individual utility varies with the degree of actuarial fairness – what is the optimal link between marginal contributions and benefits, as seen from the point of view of the individual as well as the government?²

One would perhaps expect that the distortionary effect on labor supply could be mitigated by making the present value of the marginal benefit higher than the marginal contribution, and finance the difference by a lump sum tax. As we will see, this turns out to be incorrect. Although such marginal “overcompensation” always increases labor supply, it does not raise individual utility. If, however, the government discount the future at a lower rate than the individuals, such marginal overcompensation will increase the welfare of the *government*.

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¹ However, the initial old generation generally gains when a pay-as-you-go system is introduced.

² A compulsory pension system may change the consumption profile of an individual, even without credit constraints, if the implicit rate of return in the compulsory system is different than the return on the capital market. The reason is that the system in this case will change the lifetime income of the individual for any level of his labor supply. Such an income change can, however, hardly be a rationale for a compulsory system even if it would in fact induce the individual to rearrange his intertemporal consumption profile.

We want to emphasize that our analysis depends crucially on the assumption that the individual is credit constrained. There is empirical support for this assumption. For instance, the median financial holdings of US households with heads between 55 and 65 years old was only \$8,300 in 1991 (Feldstein, 1996); the corresponding figure for Sweden in 1990 was \$17,600 (expressed in 1992 consumer prices) and the assets of the first quartile was as low as \$5,400 (Ekman, 1996). These figures indicate that most households in these age groups have financial holdings enough for only a few months consumption. These financial holdings, and the amount of savings that generated them, are quite small as compared to annual pension fees of some 15-25% of income.³ How pervasive liquidity constraints are in the economy is, however, certainly not a settled issue. In this paper, we simply assume that the share of liquidity constrained households is large enough for an analysis of how they react to compulsory pension systems to be valuable.

2. The model

Consider a consumer who solves the following two period problem

$$\begin{aligned}
 U = \max_{c_1, c_2, l_1, l_2} & \quad u(c_1, -l_1) + (1+\theta)^{-1} u(c_2, -l_2) \\
 \text{s.t.} \quad & w_1 l_1 (1-t) - c_1 \geq 0 \\
 & w_1 l_1 (1-t) + \frac{w_2 l_2}{1+r} + \alpha w_1 l_1 + \frac{T}{1+r} - c_1 - \frac{c_2}{1+r} \geq 0
 \end{aligned} \tag{1}$$

u is a standard utility function with strictly positive first derivatives, negative second own-derivatives and non-negative cross-derivatives. Consumption, labor supply and wage rates in the two periods are denoted c_i , l_i and w_i , respectively. The compulsory social security fee is levied at rate t on wage income in the first period, $w_1 l_1$. The fees finance the benefit (pension) in the second period. The benefit is paid in two parts. One part depends on previously paid fees and it equals $(1+r)\alpha w_1 l_1$; r is the market rate of return, α is the link between a marginal contribution and the present discounted value of the marginal benefit. We will label a system as fully actuarially fair when α is unity. In an actuarially fair system,

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³ See also Zeldes (1989) for an empirical estimation of the proportion of liquidity constrained households

one dollar of extra contributions generate an extra pension benefit that has a present discounted value of one dollar, discounted at the *market* discount rate. The other part of the benefits, T , is a lump-sum which is set so that the government's budget constraint is respected. θ is the rate of time preference. For the limited purpose of this note, we abstain from considering general equilibrium effects on wages and interest rates, so these are assumed to be fixed exogenously.

The first restriction in (1) is a liquidity constraint and the second restriction is the intertemporal budget constraint. The associated shadow values are denoted λ_1 and λ_2 . We assume that both these constraint are binding, so that both shadow values are strictly positive. The assumption that the liquidity constraint is binding is crucial for all following results. The exact form of the liquidity constraint is, however, not important. We may, for instance, allow the agent to borrow some fraction of his net income in period 1, or a fixed sum, without any important consequences for the analysis.

As the government adjusts the transfer T to satisfy budget balance,

$$tw_1l_1(1+r_G) = (1+r)\alpha tw_1l_1 + T. \quad (2)$$

The right-hand side of (2) is the benefits paid to the currently old. r_G is the implicit rate of return in the pension system. If the system is pay-as-you-go, r_G is the rate of growth of the tax-base, which is determined by the sum of the growth rate of productivity and population. The left-hand side is, with this interpretation, equal to the government receipts of pension fees from the currently young. We may alternatively interpret (2) as a budget constraint in a fully-funded system. Then r_G is the return on government investments and the left-hand side is now the government receipts from those who were young in the previous period, multiplied by the gross return obtained by the government. From (2) we see that the lump sum transfer T , is positive (negative) if α is smaller (larger) than $(1+r_G)/(1+r)$.

Figure 1

The two interpretations of equation (2) are given a graphical representation in Figure 1. In a fully funded system, the young born in time period s pay tw_1l_1 when they are young. This grows by the factor $(1+r_G)$ until they are old (arrow F) and must then equal their total pension benefits. If the system instead is pay-as-you-go, the pension benefits paid to the old who were born in s is financed by the young generation born in $s+1$ (arrow B). Since the tax-base is supposed to increase by a factor $(1+r_G)$ between two periods, their contributions equal $tw_1l_1(1+r_G)$.

The relation between total pensions and labor supply in the first period for different values of α depicted in Figure 2. Higher α increases the slope of the relation between first period labor supply and pensions. This, however, is balanced by a lower intercept, i.e., by a lower base pension. The relation in Figure 2 is as seen from the point of view of the individual. Of course, by changing his labor supply, the individual changes government revenues in the system, which will influence the value of T necessary to give budget balance, unless $\alpha = (1+r_G)/(1+r)$. However, since the individual is assumed to be small relative to the total economy, this effect on T is realistically assumed not to be internalized by the individual. The budget constraint for the government implies that the *actual* relation between first-period labor supply and pensions, including the externality, is given by the ray through the origin with slope $tw_1(1+r_G)$.

Figure 2

Now turn to the individual's optimization problem. The first order conditions for maximum utility are

$$\begin{aligned} u_{c_1} &= \lambda_1 + \lambda_2, \\ u_{-l_1} &= (\lambda_1 + \lambda_2)w_1(1-t) + \lambda_2\alpha tw_1, \\ u_{c_2} &= \frac{1+\theta}{1+r}\lambda_2, \\ u_{-l_2} &= \frac{1+\theta}{1+r}w_2\lambda_2. \end{aligned} \quad (3)$$

Since both constraints in (1) bind, consumption in the two periods are given by

$$\begin{aligned} c_1 &= w_1l_1(1-t) \\ c_2 &= (1+r)\alpha tw_1l_1 + T + w_2l_2 \\ &= (1+r_G)tw_1l_1 + w_2l_2, \end{aligned} \quad (4)$$

where the government's budget constraint has been used to derive the last equality. From (4) we note two things. First, the budget set in the second period increases in l_1 : a higher labor income in the first period increases the amount of benefits received in the second period. Second, the budget sets are not *directly* affected by changes in α . The second period budget set is affected only to the extent that changes in α also change hours worked in the first period. Increased labor supply in the first period will increase the benefits received in the second, and vice versa.

Proposition 1. *When t is positive a rise in α increases labor supply in the first period.*

Proof: Assume the opposite – that labor supply is non-increasing in α . From (4) we know that the budget set would then shrink and consumption of goods and/or leisure in the second period must be non-increasing. Thus, marginal utility is non-decreasing. From the last two equations of (3), λ_2 would then be non-decreasing. In the first period the liquidity constraint is unchanged so non-increasing labor supply implies non-increasing c_1 , which from (3) implies that $\lambda_1 + \lambda_2$ is non-decreasing. Now use the second first order condition

$$u_{-l_1} = (\lambda_1 + \lambda_2)w_1(1-t) + \lambda_2\alpha w_1.$$

Since $\lambda_1 + \lambda_2$ and λ_2 are non-decreasing and α increases strictly, this implies that the marginal utility of leisure must increase strictly. But this contradicts the initial assumption of non-increasing labor supply and consumption, which require non-increasing marginal utility of leisure. Thus, the initial assumption that that labor supply decreases weakly as α increases is false.

Intuition. When the liquidity constraint is strictly binding, the two-period problem becomes two separate one-period problems with one single link: increased labor supply in the first period increases the amount of resources to be spent in the second. With this single link between the sub-problems of the two periods we can express the problem in the first period as in the left panel of *Figure 3*, with standard indifference curves and a budget restriction. With $\alpha = 0$ the problem in the first period is a standard tax problem, and the optimum for the individual is where an indifference curve is tangent to the liquidity constraint. If instead $\alpha > 0$, the slope of the liquidity constraint does not fully describe the actual trade-off faced by the agent. The slope of the budget restriction (the liquidity constraint), $-w_1(1-t)$, has to be adjusted by the relative marginal effect on welfare in the next period by working one more unit of time in the first period. This is given by $\lambda_2\alpha w_1/(\lambda_1 + \lambda_2)$. The optimal choice of work is where an indifference curve is tangent to this trade-off on the liquidity constraint. This optimality condition can be written:

$$\frac{u_{-l_1}}{u_{c_1}} = w_1(1-t) + \frac{\lambda_2}{\lambda_1 + \lambda_2}\alpha w_1. \quad (5)$$

The second term is positive if α and t are both positive. The ratio of the marginal utilities in (5) is thus larger than $w_1(1-t)$, and the relevant indifference curve must therefore be steeper than the budget constraint at the optimum. Say that this optimum point is at A for some set of parameters. Now consider the effects of increasing α . First we know that this has no effect on the budget set in the first period. The new optimum must, therefore, lie on the old budget line. Second, the first-order effect of increased α implies that the right-hand side of (5) increases. To accommodate this, also the left hand side must increase. This can only happen if we move in the direction of the arrow, i.e., by consuming less leisure and working more.⁴ The new optimum is thus to the north-west of A at, say B or C. The effect of the increased labor supply on the second-period problem is more traditional; it shifts the budget line upwards as depicted in the right panel of the figure. If both leisure and consumption are normal goods, consumption will increase and labor supply fall.

In *Figure 3* we also see that increasing α only has a substitution effect in the first period, in the sense that the budget set is unchanged while the marginal value of an extra hours work is increased. In the second period, the higher pension benefits resulting from more work in the first period generates a pure income effect.

That B and C lies on lower indifference curves than A does not mean that overall utility is lower; only that first-period utility is lower. As we will see in the following proposition, overall utility of the individual in fact increases by greater actuarial fairness.

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⁴ In general, this will change the values of λ_1 and λ_2 , but this only has second order effects.

Figure 3 Effects of Increasing Actuarial Fairness

Proposition 2. Overall utility for the individual increases with α if $0 < \alpha < (1+r_G)/(1+r)$ and $t > 0$. A necessary condition for maximum individual welfare is that $\alpha = (1+r_G)/(1+r)$, which is consistent with budget balance and a zero lump-sum transfer.

Proof: Substituting from (4) into the maximand and differentiating we get

$$U = u(w_1(1-t)l_1, -l_1) + (1+\theta)^{-1} \left[u((1+r_G)tw_1l_1 + w_2l_2, -l_2) \right]$$

$$\frac{dU}{d\alpha} = u_{c_1} w_1 (1-t) \frac{\partial l_1}{\partial \alpha} - u_{-l_1} \frac{\partial l_1}{\partial \alpha} + (1+\theta)^{-1} \left[u_{c_2} (1+r_G)tw_1 \frac{\partial l_1}{\partial \alpha} + \overbrace{(u_{c_2} w_2 - u_{-l_2})}^A \frac{\partial l_2}{\partial \alpha} \right] \quad (6)$$

From the first order conditions for l_2 and c_2 – the last two equations of (3) – follows that $u_{c_2} w_2 = u_{-l_2}$. Thus, $A \equiv 0$ in (6). Using this and the other first order conditions, and substituting the marginal utilities for the shadow values λ_1 and λ_2 we get

$$\frac{dU}{d\alpha} = \left((\lambda_1 + \lambda_2)w_1(1-t) - (\lambda_1 + \lambda_2)w_1(1-t) - \lambda_2 \alpha tw_1 + \lambda_2 \frac{1+r_G}{1+r} tw_1 \right) \frac{\partial l_1}{\partial \alpha}$$

$$= \lambda_2 tw_1 \left(\frac{1+r_G}{1+r} - \alpha \right) \frac{\partial l_1}{\partial \alpha}. \quad (7)$$

This is clearly positive when $\alpha < (1+r_G)/(1+r)$ and zero when $\alpha = (1+r_G)/(1+r)$, which is then a necessary first-order condition for maximizing individual welfare over α

Intuition. When the consumer chooses labor supply in the first period he does not internalize all the positive effects of working unless $\alpha = (1+r_G)/(1+r)$. There is an external effect as the transfer T increases in his labor supply. If, however, $\alpha = (1+r_G)/(1+r)$, we see

from (2) that the transfer is zero. The individual is in this case internalizing all the effects of working an extra hour. We can think of $\alpha = (1+r_G)/(1+r)$ as the *constrained first best* solution for the individual. In Figure 2 we saw that the actual trade-off between labor supply in the first period and pensions is given by the ray through the origin. Here we find that the pension system should be constructed so that this is also the perceived trade-off facing the individual. It is important to note that the optimal α is independent of the utility function and, in particular, of the labor supply elasticity. This is why we interpret the optimal α as a constrained first best rather than a second best. Finding the second best would have involved trading of different distortions where the labor supply elasticity would have played a critical role.

We thus find that the optimal value of α is unity if the rate of return in the social security system equals the market rate. It is below (above) unity if the rate of return in the social security system is below (above) the market rate. Thus, an optimal pension system should in this case under(over)-compensate the individuals, i.e., pay less (more) than one dollar in benefits per dollar of fees paid.

Now consider the case of differences in rates of time preference between the government and the public. As discussed in the introduction, such a difference seems to be a fundamental reason for having a compulsory system in the first place. The next proposition states the optimal level of α in this case.

Proposition 3. *A government that maximizes a welfare function U^G equal to (1), but with a lower discount rate θ_G , gains more than the individuals by increasing α , given the assumptions in Proposition 2. The necessary condition for maximum government welfare in this case implies that $\alpha = ((1+r_G)/(1+\theta_G))/((1+r)/(1+\theta)) \equiv \alpha^*$*

Proof: This follows directly by substituting θ_G for θ in (6). The government marginal gain is then given by

$$\begin{aligned} \frac{dU^G}{d\alpha} &= u_{c_1} w_1 (1-t) \frac{\partial l_1}{\partial \alpha} - u_{-l_1} \frac{\partial l_1}{\partial \alpha} + (1+\theta_G)^{-1} u_{c_2} (1+r_G) t w_1 \frac{\partial l_1}{\partial \alpha} \\ &= \lambda_2 t w_1 (\alpha^* - \alpha) \frac{\partial l_1}{\partial \alpha} \end{aligned} \quad (8)$$

Thus, the optimal pension system should in this case overcompensate individuals on the margin in the sense that the benefits generated by an extra hours work should have higher present value than what the government receives in fees. This overcompensation should be financed by a lump-sum tax. The intuition is that setting to α to α^* assures that the individual's valuation of an extra hours work coincides with the government's valuation.

So far, we have studied the optimal value of α , for the government and for the individual respectively, when t is given. Now let us look at the optimal value of t itself, from the point of view of the government. This is studied by totally differentiating the government objective function, where c_1 and c_2 are substituted, using (4), as in (6).

$$\begin{aligned} \frac{dU^G}{dt} = & u_{c_1} w_1 (1-t) \frac{\partial l_1}{\partial t} - u_{c_1} w_1 l_1 + u_{-l_1} \frac{\partial l_1}{\partial t} \\ & + (1+\theta_G)^{-1} \left[u_{c_2} (1+r_G) t w_1 \frac{\partial l_1}{\partial t} + u_{c_2} (1+r_G) l_1 w_1 + \overbrace{(u_{c_2} w_2 - u_{1-l_2})}^{=0} \frac{\partial l_2}{\partial \alpha} \right] \end{aligned} \quad (9)$$

By substituting the shadow values for the marginal utilities from the first order conditions (3) we get

$$\frac{dU^G}{dt} = \lambda_2 t w_1 (\alpha^* - \alpha) \frac{\partial l_1}{\partial t} + w_1 l_1 [\alpha^* \lambda_2 - (\lambda_1 + \lambda_2)]. \quad (10)$$

From proposition 3 we already know that the government should set $\alpha = \alpha^*$, which makes the first term of (10) zero. We can then write (10) as

$$\left. \frac{dU^G}{dt} \right|_{\alpha=\alpha^*} = w_1 l_1 [-\lambda_1 + (\alpha^* - 1) \lambda_2]. \quad (11)$$

This analysis yields the following proposition about the optimal size of compulsory pension system:

Proposition 4. *If the market return is at least as large as the implicit rate of return in the social security system, there exists a strictly positive ε such that a compulsory pension system reduces government welfare unless the difference in the rates of time preference between the individual and the government is strictly larger than ε .*

This is seen immediately from (11). Since both λ_1 and λ_2 are positive, $\alpha^* \equiv ((1+r_G)/(1+\theta_G))/((1+r)/(1+\theta))$, must be strictly larger than unity for (11) to be positive.

$\alpha^* > 1$ is a necessary, but not sufficient condition for (11) to be positive. If the derivative is negative when t is zero, increasing t , i.e., introducing compulsory pension plans, reduces the welfare of the government and, of course, of the individuals.

Compulsory pensions involve redistribution of consumption opportunities from the first to second period. We can view the relative rate of return in the pension system, i.e., $(1+r_G)/(1+r)$ as the efficiency of this transfer. Given that the individual's liquidity constraint is binding, a transfer of consumption opportunities from the first to the second period is strictly against the individual's preferences. The government, however, values second period consumption higher than the individual does, if $\theta_G < \theta$. So, the government may want such a transfer to take place, but only if θ_G is sufficiently small and the efficiency sufficiently high.

We also see that a lower λ_1 , or a higher λ_2 , gives stronger incentives to raise t . Such a change could be caused by capital market liberalization that reduces the impact of the liquidity constraint. This would happen, for example, if the individuals could borrow some limited amount on his future income. This would reduce the shadow value of the liquidity constraint, hence reduce λ_1 . By shifting consumption from the future to the present, it would also increase the marginal utility of consumption in the future, and thus increase λ_2 .

3. Summary of Conclusions

The results in the previous section may be summarized as follows:

1. Increasing the degree of marginal actuarial fairness, α , will always increase labor supply in the first period. This holds also when α is above unity, that is when the system overcompensates the individual's marginal pension fees.
2. If the government and the individual rates of time preference are equal, and the market rate of return equals the return in the social security system, the optimal level of α is unity. The system should then be fully actuarially fair, regardless of the size of the payroll fee t .
3. The system should under-compensate the individuals if the rate of return in the social security system is lower than the market return. The optimal level of α is in this case

$(1+r_G)/(1+r)$, where r is the market rate of return and r_G is the implicit return in the social security system.

4. If the government uses a lower discount rate than the individuals, this tends to make the optimal α higher. The system should then overcompensate the individuals and finance this with a negative base-pension. The optimal level of α is in this case $((1+r_G)(1+\theta))/((1+r)(1+\theta_G))$, where r is the market rate of return and r_G is the implicit return in the social security system.
5. Optimal marginal actuarial fairness is independent of the labor supply elasticity.
6. When the market return is at least as large as the implicit return in the social security system, a compulsory pension system reduces government welfare unless the government's rate of time preference is more than marginally smaller than the individual's rate of time preference. That the government's discount rate is lower than the individual's is a necessary but not sufficient condition for improved government welfare. In terms of the individual's preferences, individual welfare is always reduced by the compulsory pension system. This, of course, abstracts from other rationales for compulsory pension systems than pure life-cycle transferring.
7. Reductions in the impact of the first period liquidity constraint, for example due to capital market liberalization, raise the optimum rate of compulsory social security fees, as seen from the government's point of view.

Compulsory pension systems, in which fees are paid in proportion to wage income, are prevalent in the modern society. In this note, we have taken the existence of these systems as given rather than compared them to alternatives. This is not to say that better alternatives could not exist. To subsidize savings may, for example, be preferable both from the government's and the individual's point of view.

We have also taken as given that individuals, at least some of them, are liquidity constrained. A broader analysis of optimal pension systems would require that the mechanism responsible for the liquidity constraint is modeled explicitly since changes in the system may interact with borrowing possibilities, for example via general equilibrium effects on factor prices.

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