Old Age Pension Systems: A Theoretical Evaluation

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Abstract: The paper evaluates the theoretical literature on public pension schemes. First, the terms pay-as-you-go and capital reserve are made precise. These two systems are then compared, followed by a consideration of their efficiency properties. Thereafter conversion policies are discussed.

JEL-Classification: H21, H55

1 Introduction

Since the end of World War II, many countries have introduced public pension systems. Other countries, where such systems already existed, have expanded them considerably. The sheer size of these systems is startling. Germany, for example, spent over 300 billion marks on public pensions in 1992, that is nearly 15 per cent of its national income[1].

Not surprisingly, this development has stimulated a large scientific literature. In this paper, I do not want to give a complete account of that literature. Rather, I want to focus on some specific problems of social security that are directly related to prospects for reform. The main question discussed in the following is if it is possible to convert pay-as-go-systems into capital-reserve systems in a Pareto-improving fashion.

The paper is organised as follows. In section A several types of pension systems are discussed and the terms pay-as-you-go and capital reserve are made precise. These two systems are compared in section B. Section C considers the efficiency properties of pay-as-you-go systems. Thereafter, conversion policies are discussed in section D. Section E offers some concluding remarks.

2 A Typology of Pension Schemes

For the time being, the existence of a given *retirement period*, i.e. a time span where old people consume but do not work anymore, is taken for granted. The need for a pension scheme follows directly from this assumption. I use the term *pension scheme* in a very broad sense: Such a scheme may be *public* or *private*; it may be *mandatory* or *voluntary*; it may be intragenerationally *fair* or *redistributive*. Most importantly, the pension scheme may be contrived as a *pay-as-you-go system* (PAYG), or as a *capital reserve system* (CR). Finally, a pension scheme may or may not entail *risk-pooling*. The issue of risk-pooling, however, is analytically simple and well understood and will be neglected in the following.

A *public* pension scheme is operated by the state whereas *private* schemes are handled by insurance companies or take place within the family. A *mandatory* pension scheme, where individuals are forced by the law to provide for their old-age, can be either public or private. The latter case is similar to compulsory car insurance: every car owner has to find some insurance company, but insurance is not provided by the state itself. A private pension scheme is *intragenerationally fair*, whereas a public scheme can entail *intragenerational redistribution*. Examples of intragenerational redistribution are discussed later on. It should be clear that redistributive schemes must be mandatory.

A PAYG is characterised by the fact that the system does not accumulate any financial reserves for future pensioners. All premium payments made by the young are more or less immediately distributed to the old. A CR, on the other hand, is similar to private savings. The premium payments of the young are accumulated, and these payments plus interest will be paid back to them when they are old. Both PAYG and CR can be either public or

[1] Source: Statistisches Bundesamt (1994) Table 19.4. Pensions to civil servants (*Beamte*) are not included in this figure.

private, at least in principle. Under realistic assumptions, however, a public PAYG must be mandatory whereas a CR could also be voluntary. This will become clear in the next section.

Most public pension schemes we encounter today are mandatory pay-as-you-go systems; some of them entail intragenerational redistribution, others are intragenerationally fair. Recent reform proposals have suggested to making the systems voluntary, or to changing the degree of redistribution, but most have aimed at converting PAYG into CR. To see why, an analytical characterisation of these two systems is provided in the next section.

3 Comparing PAYG and CR

A convenient framework for analysing pension issues is the standard overlapping generations model. There are discrete time periods t=1,2, ... up to infinity[2]. In each period, which lasts some thirty years, N_t identical households (or individuals, if you prefer) are born. Every household born in period t lives during periods t and t+1. In period t, the household is „young" and consumes the quantity c_t^1; in period t+1, the household is „old" and consumes the quantity c_{t+1}^2. A younger household's labour supply is normalised to one. Therefore, wage income just amounts to w_t, where w_t denotes the gross real wage rate in period t. Neglecting taxes and social security for the moment, w_t is also the household's net income, which can be distributed freely on consumption and savings, s_t. As the elderly do not work by assumption, principal and interest are their only income source. Consumption during period t+1 is thus given by $R_{t+1}\cdot s_t$, where $R_{t+1}=1+r_{t+1}$ denotes the real interest factor and r_{t+1} is the compound real interest rate. To summarise, the younger households solve

$$\max! \quad U(c_t^1, c_{t+1}^2) \tag{1}$$

$$\text{s.t.} \quad c_t^1 + s_t = w_t \,,$$

$$c_{t+1}^2 = R_{t+1}\cdot s_t \,,$$

where the common utility function is smooth, strictly monotonically increasing, and strictly quasi-concave. The model could be closed by adding a standard production sector whose details should not detain us here. In this case, the sequences (w_t) and (R_t) represent a competitive equilibrium, and the outcome of the maximisation problem (1) can be considered as a private voluntary CR.

Let us now introduce a mandatory pension scheme. Such a scheme is generally characterised by sequences (τ_t) and (p_t) of *premium rates* τ_t and *pensions* p_t. Because households are obliged to make premium payments $\tau_t\cdot w_t$ when young and get pension payments p_{t+1} when old, the two budget constraints must be modified in the following manner:

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[2] The assumption of an infinite horizon is crucial and has sometimes been questioned. But to postulate a finite horizon with a given end of the world is problematic, too. In a recent paper, Schwager (1995) has shown that the infinite-horizon overlapping generations model is mathematically equivalent to a model where the world ends with positive probability after each period (and thus, ends with probability one in the limit).

$$c_t^1 + s_t = w_t \cdot (1-\tau_t) \,, \tag{2}$$

$$c_{t+1}^2 = R_{t+1} \cdot s_t + p_{t+1} \,.$$

Under the assumption of a perfect capital market, a CR without intragenerational redistribution is analytically indistinguishable from private savings. This is because premium payments yield the market interest rate, $p_{t+1}=R_{t+1} \cdot \tau_t \cdot w_t$, so that a household can offset any change in premium payments by a suitable adjustment of its savings.

Consider now a PAYG with a constant premium rate, τ. Aggregate pensions $p_{t+1} \cdot N_t$ equal aggregate premium payments $\tau \cdot w_{t+1} \cdot N_{t+1}$ in each period, the individual pension thus amounts to $p_{t+1}=\tau \cdot w_{t+1} \cdot N_{t+1}/N_t$, and every household faces the implicit return

$$\frac{p_{t+1}}{\tau \cdot w_t} = \frac{\tau \cdot w_{t+1} \cdot N_{t+1} / N_t}{\tau \cdot w_t} = \frac{W_{t+1}}{W_t} \equiv G_{t+1} \,, \tag{3}$$

where $W_t=w_t \cdot N_t$ denotes aggregate wage income. $G_{t+1}=1+g_{t+1}$ is the growth factor of wage income and g_{t+1} is the growth rate. We can state: *Under PAYG each generation obtains an implicit rate of return which equals the real rate of growth of wage income; under CR, the rate of return equals the real interest rate.* Therefore, an individual prefers PAYG to CR if the growth rate exceeds the interest rate, and it prefers CR to PAYG in the opposite case[3]. It is not surprising, then, that many democratic societies favoured PAYG during the immediate post-war years, when growth rates normally exceeded interest rates. This became completely different in the early 1970s when both birth rates and per-capita income growth declined. World-wide increases in real interest rates, which took place around 1980 and which last up to the present, reinforced the opposition to PAYG.

It is well known from the theory of intertemporal allocation that a growth path is *dynamically inefficient* when the interest rate falls short of the growth rate permanently. This means that it would be possible to make some generations better off without making others worse off. If such an inefficiency is *assumed,* the government can improve the allocation using public debt (Diamond, 1965) or by means of introducing PAYG (Samuelson, 1958, Aaron, 1966). In the present writer's opinion, however, such an assumption is pointless. As has been shown in the literature, the private sector can overcome a dynamically inefficient allocation without government assistance. One way would be to create asset bubbles (Tirole, 1985) which are compatible with perfect foresight if the original allocation were inefficient. Moreover, dynamically inefficient allocations are impossible if there exists a durable asset like land (Homburg, 1991) or if it is possible to speculate with Old Masters. Therefore, I assume

$$\liminf_{t\to\infty} \prod_{\tau=2}^{t} \frac{G_\tau}{R_\tau} = 0 \tag{4}$$

[3] Strictly speaking, this holds only for pay-as-you-go systems with a *constant* premium rate. The return of PAYG will be greater when the premium rate increases over time. The return cannot be greater *permanently*, however, if the premium rate is bounded from above.

in the following text. This condition rules out dynamic inefficiency (Homburg, 1992). It states that the compound interest rate exceeds the compound growth rate in the limit. A particularly simple special case would be a steady state where R exceeds G so that $(G/R)^t$ converges to zero.

In the literature it has sometimes been asserted that CR is preferable to PAYG in the efficient case because, under CR, pensioners obtain the return R, whereas, under PAYG, they only get the return G<R. So Townley (1981) suggested to converting PAYG into CR, distributing the accruing profits to the elderly in order to compensate them for the abolition of PAYG. Similarly, Martin Feldstein (1974) favoured CR because this system entails a higher aggregate capital stock; he obviously presupposed a return to capital which exceeds the growth rate.

These arguments, however, though popular, are not convincing. Saying that it would be profitable to *have* more wealth is different from saying that it would be profitable to *form* more wealth. More technically, consider a steady state under PAYG with an exogenous interest factor R=3, with a constant population, N=1, and with constant per capita wages w. This is a Neoclassical growth model of a small open economy where equilibrium prices are given from the world markets. The annual real rate of interest comes to r=3.7% if a period length of 30 years is assumed. Each generation pays $\tau\cdot w$ when young and obtains the pension $p=\tau\cdot w$ when old; the implicit rate of return of PAYG is zero. Under a mandatory CR, the younger households would pay $\tau\cdot w$ while the elderly would obtain $p=R\cdot\tau\cdot w$. Hence, under PAYG, every generation incurs a loss $(R-1)\cdot\tau\cdot w$ or $r\cdot\tau\cdot w$, for short. The aggregate loss, also referred to as *implicit government debt* (D), is simply the sum of the present values of these losses from period one to infinity:

$$D = \frac{r\cdot\tau\cdot w}{R} + \frac{r\cdot\tau\cdot w}{R^2} + \ldots = \frac{r\cdot\tau\cdot w/R}{1-1/R} = \tau\cdot w\,. \tag{5}$$

Assume now that society decided to switch from PAYG to CR in period one. According to the above calculation, future generations' incomes will increase by $D=\tau\cdot w$. On the other hand, an abrupt switch from PAYG to CR means that the pensions of the currently living elderly, $p=w\cdot\tau$, must be set to zero. The loss of the elderly exactly equals the profit of the young. What has taken place has been a mere redistribution but not an improvement of the allocation. Without a specific value judgement it would be impossible to recommend a move from PAYG to CR under these circumstances.

This example is very special, of course, because it entails stationary state assumptions and assumes a sudden switch from PAYG to CR. In a classic paper, however, Breyer (1989) has shown that the main result carries over to more general economies. If you want to move from PAYG to CR, you cannot find a compensation scheme, however sophisticated, which leaves the elderly as well off as under PAYG and which yields a profit for the younger at the same time. It is only possible to convert the debt that is implicit in PAYG into regular government debt; but this would neither harm nor benefit anyone.

The deeper reason for Breyer's result is that PAYG does *not* induce capital market distortions. The decline in the aggregate capital stock that is normally supposed to follow the introduction of PAYG is an efficient reaction of the market; there is no dead-weight loss.

Note, however, that this is a preliminary result which holds only when an exogenous labour supply is assumed.

4 The Efficiency of Pay-as-you-go Schemes

I turn now to discussing some principal problems of PAYG. The issue that has received most attention in the literature becomes clear when one recognises that workers' labour supply is an endogenous variable which depends on the net wage rate. Hence, let us replace (1) by the following optimisation program:

$$\max! \quad U(c_t^1, c_{t+1}^2, 1-\ell_t) \tag{6}$$

$$\text{s.t.} \quad c_t^1 + s_t = w_t \cdot \ell_t \cdot (1-\tau),$$

$$c_{t+1}^2 = R_{t+1} \cdot s_t + p_{t+1},$$

where ℓ_t is the household's labour supply and $1-\ell_t$ denotes leisure (the household's disposable time has been normalised to one). Consider a PAYG with a constant premium rate, τ, and with pensions that are independent of individual premium payments. Such a pension scheme will be referred to as a *Dutch System*; it is similar to the US pension system. Under a Dutch System, each household perceives the premium payment as a *flat rate tax* on its labour income; and each household perceives the pension as a *lump-sum subsidy*. If U is smooth and strictly quasi-concave and if all goods are normal we can apply standard results from taxation theory to the problem at hand.

The Dutch System induces a dead-weight loss *in the labour market* because it distorts the labour-leisure decision. Reducing a household's pension from p_{t+1} to zero and reducing τ such that the household's life-time income remains unchanged will certainly make that household better off. Due to the premise of an unchanged life-time income, other generations remain unaffected. Reducing *every* generation's pension to zero and changing the premium rates appropriately will make *all* generations better off—except the currently living elderly, of course, who are as well off as before.

Therefore, abolishing a Dutch System yields a true Pareto-improvement. This has been demonstrated for small open economies (Homburg, 1990) and for closed economies (Breyer and Straub, 1993)[4]. Note that the policy described above does not entail the use of lump-sum taxation which is often considered to be practically impossible. In order to asses the size of the excess burden caused by PAYG, consider the following formula from taxation theory[5]:

$$DWL = \tfrac{1}{2} \cdot \varepsilon \cdot (\theta + \tau) \cdot W \,. \tag{7}$$

[4] The issue is less clear-cut when one considers a large open economy which is able to influence the intertemporal terms of trade to its advantage. The results then generally depend on whether the country is a net lender or a net borrower; confer Breyer and Wildasin (1993).

[5] This calculation has been adopted from Homburg and Richter (1989).

Again, W is total wage income, ε is the compensated elasticity of labour supply[6], and DWL is the dead-weight loss. τ denotes the premium rate of the Dutch System whereas θ is the marginal rate of other taxes on labour income. Assuming θ=0.25 , τ=0.2, and ε=1 (these values are plausible at least for European countries) yields DWL/W=22.5 per cent. Setting τ to zero would yield DWL/W=12.5 per cent. Hence, the welfare loss induced by the Dutch Systems amounts to 10 per cent of total gross wage income, or roughly 7 per cent of national income.

The Dutch System analysed so far entails intragenerational redistribution because premium payments depend on wage income whereas pensions are lump-sum. By contrast, a PAYG is intragenerationally fair if it links individual pensions to individual premium payments. Such a pension scheme will be called a *German System* because it comes close to the German *Gesetzliche Rentenversicherung*. With a German System, individual pensions are directly proportional to individual premium payments so that a household's perceived budget constraint reads

$$c_t^1 + s_t = w_t \cdot \ell_t \cdot (1-\tau), \tag{8}$$

$$c_{t+1}^2 = R_{t+1} \cdot s_t + G_{t+1} \cdot \tau \cdot w_t \cdot \ell_t .$$

The individual pension p_{t+1} has been substituted by the expression $G_t \cdot \tau \cdot w_t \cdot \ell_t$ which is simply the product of the household's premium payments and the implicit rate of return of PAYG, the growth rate of wage income. Under these circumstances the household considers only a fraction of its premium payments as a tax on wage income. This fraction can be calculated easily from the household's combined budget constraint:

$$\textit{Implicit tax rate} = \tau \cdot \frac{r_{t+1} - g_{t+1}}{R_{t+1}} \quad . \tag{9}$$

The implicit tax rate depends on the difference between the interest rate, r, and the growth rate of wage income, g. If this difference is zero, the implicit tax rate is zero, too, because the household is indifferent between buying assets in the capital market or paying into the pension system. As an example of the dynamically efficient case, where the interest rate must exceed the growth rate, assume r=2 and g=0.81. In other words, the annual interest rate equals 3.7 per cent, and the annual growth rate of wage income equals 2 per cent. From equation (9) it follows that the implicit tax rate, which was τ under the Dutch System, falls to $0.4 \cdot \tau$ under the German System. The household perceives 40 per cent of its premium payments as an income tax and the remaining 60 per cent as „savings“. To summarise, the German System redistributes income only between but not within generations. Other things equal, the resulting dead-weight loss is lower than under the Dutch

[6] Note that the uncompensated elasticity of labour supply may well be zero, as many empirical studies suggest. What counts here is the mere substitution effect, not the sum of substitution and income effects. The substitution effect is different from zero as long as U is smooth and strictly quasi-concave.

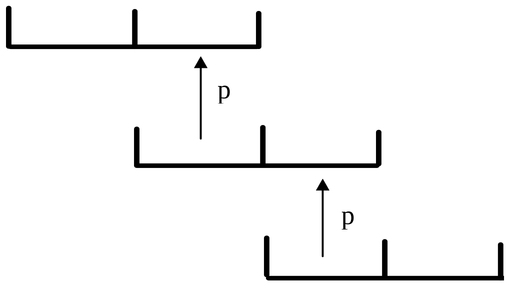
System. Indeed, the dead-weight loss is so low that, starting from a German System, the Pareto-improvement discussed above cannot be reached[7]. Therefore, the German System is second best in the sense that a Pareto-improvement cannot be achieved without lump-sum taxation.

The Dutch System *may* be second best in this sense, too, as has been pointed out by Brunner (1994). Brunner considered a setting with two household types in each generation. The two types differ with respect to their labour productivity. In equilibrium, one household type is „rich“ while the other is „poor“. Because the Dutch System entails intragenerational redistribution from the rich to the poor, reducing the uniform pension payment to zero does not necessarily make the poor household better off. The dead-weight loss is reduced, as shown above, but the redistribution constitutes a countervailing effect. In a recent paper, Fenge and Schwager (1995) have shown that a Pareto improvement can only be achieved if the income differential between the two household types is small enough or if the compensated elasticity of labour supply is large enough.

5 Converting PAYG into CR

When pensions are fully funded at the outset, it is easy for society to switch to PAYG. The currently living elderly make a windfall profit, and a corresponding burden is placed upon the subsequent generations. A more complicated issue is whether it is possible to convert a pay-as-you-go system into a capital reserve system without hurting anyone. The answer to this question depends on whether the original allocation is first best or at least second best in the sense defined above.

Fig. 1. The Original Pay-as-you-go Scheme.



Rather than repeating the more general analysis that can be found in the literature (Homburg, 1990), I want to simplify the exposition by taking a specific example. I consider a PAYG of the Dutch type in an economy with a constant population, N=1, constant wage rates, w, and an exogenous positive interest rate, r. Households are all identical, and the labour supply is endogenous. In this setting, each household makes the premium payment $\tau \cdot w \cdot \ell$ when young and gets the pension $p = \tau \cdot w \cdot \ell$ when old. Under CR, every household

[7] This has been shown by Fenge (1995).

would get the pension R·p instead, so there is in *implicit tax* r·p. The system also entails *implicit government debt* which equals D=p. All this has already been shown in the preceding sections. Figure 1 illustrates the operation of PAYG. Each line represents a generation which makes the payment p when young and receives the payment p when old. The system is now converted into a fully funded system in two steps.

Step 1: A trivial conversion is enacted which involves converting the implicit debt of PAYG into regular government debt. The pension payments to the old are made out of the general budget. Hence the government must borrow the amount D=p. The younger generations are taxed explicitly rather than implicitly: Every following generation has to pay an income tax T=r·p at the end of its first life period or, what amounts to the same, at the beginning of its second life period. Because these generations do not make premium payments p and do not get pensions p, their life-time income remains unchanged.

Fig. 2. Conversion Policy, First Step.

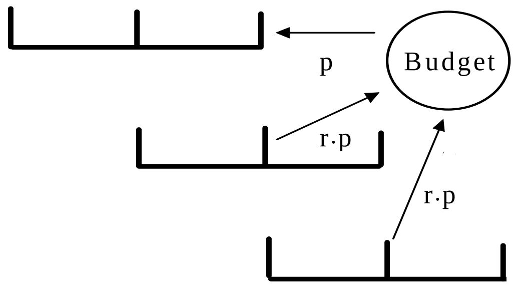
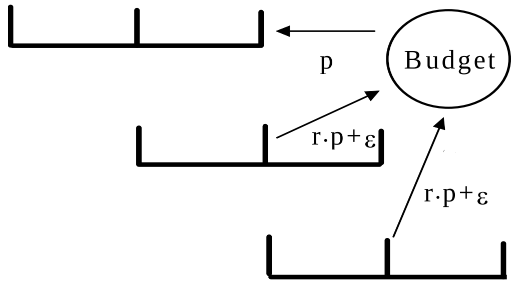


Figure 2 depicts the trivial conversion. Two important aspects of this conversion should be noted. First, the sequence **p**=(p, p, ...) of implicit government debt under PAYG has been replaced by the sequence **D**=(D, D, ...) of explicit government debt, where D=p. Therefore, the conversion is not a Ponzi-game which shifts a burden into the future. Second, every generation has been made strictly better off except the first one which is as well off as before. This is due to the fact that the distortionary premium payment p has been substituted by an income tax whose present value is just r·p/R<p. So the dead-weight loss has been reduced.

Step 2: As we have just observed, the trivial conversion entails an increase in each younger household's utility because the household must pay only the income tax T=r·p. If the aim of the policy is to reach a true conversion—i.e. to run down the implicit debt of PAYG in finite time—a natural idea would be to tax the following generations a bit *harder*. So let them pay T=r·p+ε instead. From the continuity of the utility function it follows directly that there exists ε>0 such that each generation is at least as well off as under PAYG. The number ε must only be chosen such that the corresponding decrease in utility exactly counterbalances the gain from the reduced dead-weight loss.

The sequence of explicit government debt now becomes **D**=(D-ε, D-2·ε, D-3·ε, ...) and it should be obvious that the debt becomes zero after some period T, where T is the integer value of D/ε. Figure 3 illustrates.

Fig. 3. Conversion Policy, Second Step



It has thus been demonstrated that it is possible, at least in principle, to convert a pay-as-you-go pension scheme into a fully funded system without hurting anyone—especially without hurting the presently living elderly. This result contrasts sharply with the common belief that a PAYG, once introduced, can *never* be removed without placing a „double burden" upon some generation. With a German System, or with a Dutch System and large income differentials between households of the same generation, it may be impossible to carry out the second step, i.e. to run down the system's implicit debt in finite time. The trivial conversion, however, can be accomplished in any case.

6 Conclusion

The issue of public pension schemes is a complicated one. In this paper, I have sketched but a small number of problems and I want to take the opportunity to point out some others briefly. First, the efficiency analysis carried out above shows *possibilities* which are open to a benevolent dictator only. In reality, the median voter must agree to any policy measure taken, but the median voter is of middle age and will vote for an extension of the public pension scheme in most cases. This is the main reason why public pension systems have a tendency to encroach, a point which has been made first by Browning (1973). Yet, this issue should not be overstated. The strength of the Pareto criterion employed above is that if the possibility of a Pareto-improvement exists, voters should agree *unanimously*.

A second qualification concerns the assumption of a perfect capital market which rules out many potential inefficiencies. In a world with imperfect capital markets, where consumption loans are severely restricted, any *mandatory* pension scheme causes a dead-weight loss irrespective of whether it is PAYG or CR. Think of a twenty-year-old couple with young children that is forced by the mandatory pension system to put aside twenty per cent of gross income every month—even if they would find it optimal to provide for their old age later.

More generally, there are many sources of dead-weight losses which have not received due attention in the literature. I only want to mention shifts to the shadow economy or „spurious self-employment" or other measures which are taken by individuals in order to avoid the public pension system. In an integrated labour market, such as in the European

Union, migration may become an important means to evade high social security payments if national PAYG systems are not harmonized.[8]

The most important, and at the same time most difficult, problem of pay-as-you-go systems, however, is their political instability. As we have seen above, any introduction of PAYG entails placing a burden on future generations. At present it is uncertain whether the next generations will be co-operative or whether they will resist the entire system. In this sense, forming PAYG induces what I call *social speculation*. Especially in countries with a declining population, the younger individuals face an extremely uncertain yield, and therefore it is almost impossible to say which part of the premium payment they consider as taxation; but this information, in turn, is crucial for assessing the efficiency properties of PAYG.

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[8] More material on this issue may be found in Homburg and Richter (1993), or in Breyer and Kolmar (1994).

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