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OPTIMAL SOCIAL SECURITY DESIGN

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ABSTRACT

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This Paper considers the optimal design of public pension provision for the retired and income support for those of working age. We consider social security systems that differ in terms of the level of benefits, degree of means testing and the nature of contributions. We aim to find which system maximizes the expected utility of agents behind an initial veil of ignorance about their future labour productivity. We also explore whether systems which differ from the (*ex-ante*) optimal one could be reformed. We ask whether agents who already know what their productivity is would vote for a move towards a system that they would have found optimal from behind a veil of ignorance about their own position on the wages ladder. We also consider which systems could be sustained in an economy where reform is decided by majority voting. We find a substantial role for means testing in optimal welfare systems. We also find the possibility of multiple equilibria in welfare systems.

JEL Classification: H10, H20 and H30
Keywords: optimal taxes, pensions and social security

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Optimal Social Security Design

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Abstract:

This paper considers the optimal design of public pension provision for the retired and of income support for those of working age. We consider social security systems that differ in terms of the level of benefits, degree of means testing and the nature of contributions. We aim to find which system maximises the expected utility of agents behind an initial veil of ignorance about their future labor productivity. We also explore whether systems which differ from the (ex-ante) optimal one could be reformed. We ask whether agents who already know what their productivity is would vote for a move towards a system that they would have found optimal from behind a veil of ignorance about their own position on the wages ladder. We also consider which systems could be sustained in an economy where reform is decided by majority voting. We find a substantial role for means testing in optimal welfare systems. We also find the possibility of multiple equilbria in welfare systems.

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I Introduction:

The central aim of the paper is to evaluate the tradeoffs between the costs of the distortions created by linking receipt of welfare payments to incomes and wealth, and the benefits such linkage brings from redistribution and the provision of insurance. This is one of the key questions about the structure of social security programmes. How such programmes should be designed is a public policy issue of profound importance. It has generated a huge literature. (For a comprehensive, recent account see Feldstein (2001)). One aspect of design is the relative merits of universal programmes and means tested programmes. Moffitt (2002) shows that means tested transfer payments in the US have become very significant – expenditure in 1997 on the ten largest means tested transfer programmes was in

[1] Imperial College, London and CEPR. Miles acknowledges the receipt of a grant from the Banque de France which helped finance this research (CEPR administered grant FEPPR).

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excess of \$320 billion. The simulation results of Hubbard, Zeldes and Skinner (1995) suggest that means testing has significant effects upon consumption and saving. How far means testing should go is a question that divides political parties; it has also caused rifts within parties[3].

Another key issue in social security design is the relative importance of funded and pay-as-you-go benefits. A third, and in some senses more fundamental, issue is the relative importance of private insurance, mediated through markets, and public insurance, provided through social security. These are issues both of the overall size of social security programmes and of their design – that is the detailed rules governing benefits and contributions. This paper considers these issues; it analyses the optimal design of public pension provision for the retired and of income support for those of working age. We consider social security systems that differ in terms of the level of benefits, degree of means testing and the nature of contributions. We aim to find which system maximises the expected utility of agents behind an initial veil of ignorance about their future labor productivity. We also explore whether systems which differ from the (ex-ante) optimal one could be reformed. We ask whether agents who already know what their productivity is would vote for a move towards a system that they would have found optimal from behind a veil of ignorance about their own position on the wages ladder. We also consider which systems could be sustained in an economy where reform is decided by majority voting.

The paper adds to a literature on optimal pension design (for different aspects of this literature see Merton (1983); Feldstein, Ranguelova, and Samwick (1999); Bohn (1999) and Campbell and Feldstein (2001)). By focusing on the significance of the degree of means testing, or targeting, it also adds to a literature on the impact of means testing. Several papers have focused on the effect of means testing on saving (see for example Hubbard, Skinner and Zeldes (1995), Feldstein (1995), Gruber (1997), Powers (1998) and Neumark and Powers (1998)). Other papers have focused on the trade-offs between the advantages that universal, often flat-rate, benefit programmes generate (eg.minimising distortions at the margin and possibly getting better coverage amongst the poor) and their disadvantages of higher aggregate cost and the need for higher average tax rates. (See, for example, Feldstein (1987), Besley (1990), Creedy (1998)).

In this paper we use a stylised, calibrated overlapping generations model and look for optimal social security systems by varying: the generosity of benefits (both income support and social security pensions); the way they are financed (by compulsory saving or by payroll taxes); the qualification rules for receipt of benefits and the nature of means testing (by varying asset and income limits and taper, or benefit withdrawal, rates). We investigate the sensitivity of optimal design to key features of the economy – the degree of dispersion of individual productivities, labor supply elasticities, risk aversion, rates of return and productivity growth rates. We do this in a context of significant heterogeneity in labor productivity. We pay particular attention to optimal pension design. But optimal pension design

[3] In the late 1990's the UK labour party politician Frank Field resigned from his role as the architect of the government's pension reform strategy largely because he saw the system being steered by his government towards greater use of means testing.

is not independent of how the low paid are helped by social security systems during working years. So we also allow for an income support, or top up, system and investigate its optimal design. The contribution of this paper is to show under which conditions, if any, the merits of different social security systems outweigh their costs. We also consider how voting behaviour determines which systems are chosen. To analyse the issue we consider overlapping generations economies with constant demographic structure. We compute tax and benefit rates that are sustainable. We allow for endogenous choice over labour supply. By assuming that labor productivity within a cohort follows a log normal distribution we are able to compute lifetime profiles for consumption, labour supply and utility for all agents. We compute expected utility for an agent that understands the economic structure and the distribution of earnings but has yet to find out where they lie on the income distribution; we also compute that agent's utility after they discover their productivity. We use a model where agents live for 3 periods - in the first 2 periods agents are part of the labor force. This allows us to distinguish between labor supply in the first and second half of the working life enabling us to analyse the incentives that different pension and income support systems generate for labor supply at different points in the life cycle.

In the next section we first describe various types of social security system, focusing initially on pension design. We then describe the model in detail and consider how social security systems across the developed economies can be interpreted in it. In section III we describe the results on optimal social security systems. Section IV focuses on voting and how welfare systems evolve in a democracy. Conclusions are drawn in section V.

II.

II.i Modelling Alternative Social Security Pension Arrangements:

There are two kinds of social security programmes we consider – pension benefits for the retired and income support for those of pre-retirement age with low (or no) labor income. Benefits may be means tested or be flat rate and financed from payroll taxes but also, to some extent, from compulsory saving, in which case there is a link between contributions and benefits.

With a pure means-tested state pension with no flat rate element and no compulsory saving those whose retirement resources are above a certain level receive no state pension. Beneath that level pensions are dependent upon resources; those with fewer resources (ie savings) receive a larger pension. The compulsory savings system we consider links benefits to past contributions but allows for a state top-up. Under this system, individuals are forced to set aside a certain proportion of their earnings during their working years. If because of low earnings the resulting pot of savings falls short of a certain level, the state tops-up the savings pot. The way we will model the compulsory savings scheme is that the government pays a market rate of interest on forced contributions. The compulsory savings scheme, with a top-up, means that for those whose desired savings is above the compulsory level there are no distortions. The system also requires that those on low earnings make some contribution toward their own pension, albeit one that is topped-up by the state. This system has the merit over a means-tested system where the means testing is based on assets in retirement that there is no disincentive to save, even for the less well off. But because it typically forces saving out of some of the less well off it can be less redistributive than means tested, or even flat rate, pensions.

We consider the affects that these different systems have upon labour supply, savings and expected utility in a stylised three period model of the economy. Agents choose how much labour to supply in the first two periods of their lives. They also choose how much to save. In the third period agents are retired and consume their accumulated savings and receive benefits either in the form of means tested pensions, flat rate pensions or the value of the compulsory saving they made earlier in life (which for the low earners may have been topped up by the state). As well as running a pension system, the state also runs an income support system so that those whose incomes in work fall beneath a given level receive some state benefits. The income support system may also be means tested, but the level of income beneath which support is received, and the rate at which support is reduced as labor income rises, could be set so that the system effectively gives everyone the same level of “state income”.

We use as one welfare criteria the expected utility of an individual born into an economy where labor productivity is log-normally distributed; for this ex-ante measure expectations are taken before the initial level of labor productivity is known. We assume identical preferences across agents and so there is a unique level of expected utility for any given economy with a particular set of rules of the welfare programmes. Rawls (1971) provides a detailed argument for considering the choices made by agents behind a veil of ignorance are a basis for just decisions. Vickrey (1960) and Harsanyi (1955) provide an argument more firmly based on utility maximisation to justify the use of the expected utility of an agent behind a veil of ignorance as a social welfare function.

Different tax and benefit systems have various affects upon expected utility. Tax and benefit systems that generate very high marginal tax rates for certain individuals create distortions which in themselves are costly and reduce expected utility. But those systems might also generate substantial redistribution and for risk averse agents behind a veil of ignorance, who do not know whether they will be rich or poor, such redistribution can be valuable. Flat rate benefits avoid the problem with highly targeted benefits (that is means tested benefits) of generating very high marginal tax rates for specific, but perhaps small, groups of people. However, they require higher average levels of taxation for a given level of benefit for the less well off than with targeting. The trade-off here is between targeted benefits, which score highly in terms of redistribution, do not need to generate high average levels of taxation, but can generate highly distortionary marginal tax rates for particular groups, as against flat rate benefits which, while not creating extremely high marginal tax rates for specific groups, nonetheless generate moderately high tax rates for everyone.

Which of these social security systems turns out to generate higher expected utility, for agents who are behind an initial veil of ignorance, turns out to depend on a range of parameters reflecting both preferences (intertemporal substitutability, risk aversion and substitutability between consumption and leisure) and prices (the growth of wages over time and rates of return); it also depends upon the dispersion of productivity across agents.

II.ii The model:

Agents maximise a utility function that depends only upon the discounted value of the utility they receive from consumption of goods and of leisure in each of the three periods of their lives; this is a “pure” life-cycle model and there are no bequests. We assume agents have a within period, constant elasticity of substitution utility function defined in terms of consumption and of leisure. Choices depend on the intertemporal elasticity of substitution of consumption and leisure, as well as the within period degree of substitutability. Agents are assumed to be unable to borrow against future labor income or against receipt of future pension benefits or of income support.

We assume that agents chose how much labor to supply in the first 2 periods of their lives. In the third period agents are retired. We can think of a period as lasting 20 years. The first period then corresponds to the first half of the working life (running typically from early 20's to early 40's); the second period is the later half of the working life (running from early 40's to early 60's) and the third period is retirement. Agents have heterogenous productivity levels that are assumed to be log-normally distributed. Earnings depend upon the product of productivity and hours worked. Productivity in the second period of life is simply first period productivity multiplied by a common percentage increase in wages per hour. Thus all differences in productivity across agents are permanent.

We assume an additively separable form of the agent’s utility function so that lifetime utility for agent i , denoted U_i , is:

$$U_i = \sum_{t=1}^{t=3} \{ [u(c_{it},(1-l_{it}))]^{1-1/\zeta} / (1-1/\zeta) \} / (1+\rho)^{t-1} \qquad (1)$$

where ρ is the rate of time preference; c_{it} is consumption in period t; l_{it} is the proportion of available time devoted to paid work for t=1,2; $1-l_{it}$ is consumption of leisure ($0 <= l_{it} <= 1$). We assume some loss in effective units of time in old age (due to illness) so that the endowment of time falls by 30% at t=3 from 1 to 0.7. (This has the same effect on utility as if l_{i3} =0.3 for all i). The parameter ζ determines the degree of intertemporal substitutability of consumption and leisure. It also reflects risk aversion.

The within period utility functions, $u(c_{it},(1-l_{it}))$, are assumed to be of the constant elasticity of substitution type:

$$u(c_{it},(1-l_{it})) = [c_{it}^{(1-1/\varepsilon)} + \alpha(1-l_{it})^{(1-1/\varepsilon)}]^{(1/(1-1/\varepsilon))} \qquad (2)$$

α is a parameter which determines the intensity of preference for leisure relative to consumption; ε determines the substitutability of consumption and leisure.

The period to period budget constraint is:

$$w_{it} = (1+r_t)w_{i\,t-1} + y_{it} - c_{it} + p_{it} + b_{it} - s_{it} \tag{3}$$

$$w_{it} \geq 0 \text{ for all } t$$

where w_{it} is the financial wealth of agent i at time t after the agent has received income and benefits and made consumption decisions; r_t is the interest rate earned on wealth held between period t-1 and period t. y_{it} is post tax labour income. p_{it} is the level of state pension received by agent i; it is zero for the first 2 periods of an agent's life. The pension is only paid in the third period of life and is given by

$$p_{i3} = \max(p - \lambda(1+r)w_{i2}, 0)$$

p is the state pension received by someone with no assets. λ is the taper rate on the pension - the reduction in pension for every $ of private resources.

b_{it} is net income support which is only paid to agents in periods 1 and 2, and then only if their earned income is below some threshold. Agents may be required to make compulsory savings to accounts held by the state and which pay the market rate r. The level of such compulsory savings is denoted s_{it}. Gross income is the product of the wage per unit time (π_{it}) and time devoted to work (l_{it}). There are two taxes on labor incomes; income tax (t_y) and social security tax (t_s). Both are proportional taxes. Thus:

$$y_{it} = \pi_{it}\, l_{it}\,(1 - t_y - t_s) \tag{4}$$

$l_{i3} = 0$ so that $y_{i3} = 0$. Compulsory saving is only made during the working period so s_3 is zero. Since we assume no bequest the optimal strategy for all agent is that $w_3 = 0$ which implies that

$$c_{i3} = (1+r_3)w_{i2} + p_{i3}$$

so agents consume all their resources in retirement. Income support payments are made to top people's income up to a minimum level of y_{min} and with a taper rate on earned income of τ. So long as $\tau > 0$ only someone with zero earned income would receive a benefit payment of y_{min}. Benefits are taxed[4]. Thus net benefits are

$$b_{it} = (1 - t_y - t_s)\,[\,\max(y_{min} - \tau\, y_{it}, 0)\,] \qquad \text{for } t = 1,2 \tag{5}$$

[4] We could just as well set up the income support system so that benefits are not taxed and scale down the benefit payments by the factor $1-t_y-t_s$

A mass of one agents is born each period and they have wages (or productivity) which in the first period of their life are lognormally distributed with a mean of unity[5]. Thus

$Ln(\pi) \sim N(-\sigma^2/2, \sigma^2)$

In the second period each agent's wage is (1+g) times the first period wage. g is the common rate of productivity growth.

Balancing the social security system

The rate of social security taxes (t_s) is set so that the present value of total revenue raised from a generation equals the present value of all income support benefits plus pensions paid to that generation net of any compulsory saving they have made. Therefore the present value of net transfers to a generation from the government over the period of its life - often defined as the 'generational account' of that cohort - is zero. This condition ensures long-run fiscal sustainability. It does not imply that there is no redistribution within a generation, simply that there are no transfers or redistribution between generations. It is necessary to set taxes to clear the generational account, rather than the government budget account, so as to be able to compare the outcome of different policy arrangements. In this framework, no generation is better off under a given policy simply because it receives more or gives less to another generation. It is only better off from a given policy because of an improved distribution of resources across the generation and over the lifetime of its members. If we did not impose this condition and simply looked at the impact of existing schemes on a typical generation we risk ignoring any net benefits (or costs) to earlier generations from the establishment of the scheme. Unfunded, PAYG pensions schemes generate benefits to the first generation of old who receive pensions, but make no contributions, when the scheme is established. Part of any apparent welfare losses created by such schemes to later generations (stemming from implicit PAYG returns being below the rate of return on capital) may largely reflect redistribution towards the first generation. To make welfare comparisons between social security systems we need to put all systems on a common footing.

With a zero generational account, and for the special case where there is a flat rate pension and no compulsory saving, the social security tax rate is set so that:

$$t_s \int \{ f_1(\pi).\pi + [\max(y_{min} - \tau f_1(\pi).\pi , 0)] \} dF(\pi) +$$

$$t_s /(1+r) \int \{ f_2(\pi).\pi(1+g) + [\max(y_{min} - \tau f_2(\pi).\pi(1+g) , 0)] \} dF(\pi) = p /(1+r)^2$$

$$+ \int [\max(y_{min} - \tau f_1(\pi).\pi , 0)] dF(\pi) + 1/(1+r) \int [\max(y_{min} - \tau f_2(\pi).\pi(1+g) , 0)] dF(\pi) \qquad (6)$$

[5] We do *not* require that the population is constant but for ease of exposition we ignore population growth in what follows.

where $F(\pi)$ is the probability distribution function of wages, or productivity. As noted we assume $Ln(\pi) \sim N(-\sigma^2/2, \sigma^2)$ which ensures that the mean wage across first period workers is unity. $f_1(\pi)$ is optimal labor supply in the first period for an agent with wage rate π. $f_2(\pi)$ is optimal labor supply in the second period for an agent who had productivity of π and whose wage is now $(1+g)\pi$. $f_1(\ )$ and $f_2(\ )$ are the levels of l_1 and l_2 that solves the agent optimisation problem. Clearly l is a function of the tax and benefit regime and of interest rates and of the growth of wages; we suppress the other arguments of the $f_1(\ )$ and $f_2(\ )$ functions for ease of exposition.

The first term on the left hand side of (6) is total receipts of social security contributions from young workers; the second term is the present value of total receipts from those workers when they are old. The right hand side is the sum of the present value to the generation of pensions paid (which is simply $p/(1+r)^2$ since the mass of agents in retirement is one and here we are assuming that state pensions are paid at the flat rate p to everyone) plus the level of income support benefits paid to young workers and old workers[6].

[6] One way to ensure generational neutrality is that there be a trust fund, set up with zero assets on the day the new policy is implemented. If F is the level of that fund then equilibrium level of F (reached after two periods of our model) is the level that satisfies the following condition:

$$r F + t_s \int \{ f_1(\pi).\pi + [\max(y_{min} - \tau f_1(\pi).\pi , 0)] \} dF(\pi) +$$

$$t_s \int \{ f_2(\pi).\pi(1+g) + [\max(y_{min} - \tau f_2(\pi).\pi(1+g) , 0)] \} dF(\pi) = p + \int [\max(y_{min} - \tau f_1(\pi).\pi , 0)] dF(\pi)$$

$$+ \int [\max(y_{min} - \tau f_2(\pi).\pi(1+g) , 0)] dF(\pi) \qquad (7)$$

This condition ensures that in each period the government social security accounts balance. Receipts of social security contributions from young and old workers plus interest on the trust fund (the left hand side of (7)) must equal the sum of pensions, p, plus payment of income support benefits to young and old workers.

Generational neutrality ensures the long run fiscal sustainability of the social security system. We assume that the income tax rate in our model, t_y, is fixed at the level to ensure long run sustainability of all other government expenditures. We simplify our model, by assuming that this tax rate is independent of the social security system used. This is a simplification, as the social security system effects labour supply and therefore income tax revenues. We are therefore implicitly assuming that government expenditures are scaled up or down so as to match revenues. As government expenditures do not enter the utility function of our workers, we are omitting some of the welfare costs or benefits of the different social security systems.

It is worth noting, that effects of economic history are subsumed into the tax rate t_y. If a generous, and partly unpaid for, social security arrangement had been in place before the new social security system is adopted, then government debt would be high and hence the tax rate to ensure long run government fiscal sustainability would be high, ceteris paribus. Therefore we can study some of the impacts of historical social security arrangements on the current social security system by investigating the sensitivity of our worker's welfare to changes in the tax rate t_y.

It may be that because of the way a social security system became established in the past that there is no trust fund, or one with assets less than the level F defined by condition (7). In that case there will be a deficit on the social security system if the system is generationally neutral. We would require revenues from other taxes to be higher to keep the system sustainable. One way to interpret the level of

Once we allow for there to be means testing of state pensions (λ>0) the condition for a balanced budget is a generalisation of (6):

$$t_s \int \{ f_1(\pi).\pi + [\max(y_{min} - \tau f_1(\pi).\pi , 0)] \} dF(\pi) +$$

$$t_s /(1+r) \int \{ f_2(\pi).\pi(1+g) + [\max(y_{min} - \tau f_2(\pi).\pi(1+g) , 0)] \} dF(\pi) =$$

$$= 1/(1+r)^2 \int [\max(p - \lambda (1+r)h(\pi) , 0)] dF(\pi) + \int [\max(y_{min} - \tau f_1(\pi).\pi , 0)] dF(\pi) +$$

$$1/ (1+r) \int [\max(y_{min} - \tau f_2(\pi).\pi(1+g) , 0)] dF(\pi) \quad (8)$$

Where $h(\pi)$ is the optimal value of w_{i2} for an agent as a function of their productivity, or wage, (π) in the first period of work. Clearly optimal retirement financial assets depend upon the tax and benefit system, the interest rate, the growth of wages between the first and second half of the working life and upon several distinct parameters of the utility function. We suppress all these dependencies upon factors which are common across agents and express assets held at the end of work by $h(\pi)$, ie. purely as a function of the agent-specific factor, their wage (π). The left hand side of (8) is the present value of aggregate social security contributions paid by a generation. The first term on the right hand side of (8) is the present value of total pension payments in the means tested regime. The other terms are the present value of aggregate income support received by this generation.

Compulsory saving towards retirement in notional accounts.

In this regime agents are required to make contributions to the government towards their future state pension which are held in virtual accounts. Those accounts pay a market rate. Although the government uses contributions to pay current benefits (ie the system is really a PAYG scheme) the agents receive a return of r on contributions. Contribution rates are set so that for someone who receives no top up the notional value of the fund at retirement equals p, the state pension they will receive. Someone whose earnings are so low that paying the standard rate of contributions would not generate a large enough notional fund at retirement to pay p will have their fund topped up and will still receive the pension p from the government. So the system works by having all those with lifetime earnings above some threshold accumulate savings in notional accounts with a value of p. The less well off make compulsory savings to these accounts at the same rate (as a fraction of labor income) as all others but

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the income tax rate in our model (t_y) is that it is the rate needed to cover other government spending *plus* any shortfall on the social security system if trust fund assets are less than F. If there is no trust fund, general tax revenues would have to contribute rF each period to the social security system, where rF is defined by equation (7).

the value of their saving is less than p. Since everyone receives the same pension it is as if the less well off have their contributions topped up by the state.

For individual i contributions paid in the first and second periods at work (s_{i1} and s_{i2}) are calculated thus:

$$s_{i1} = \min(comp.(y_{i1} + b_{i1}),\ p/(1+r)^2) \qquad (9)$$

$$s_{i2} = \min(comp.(y_{i2} + b_{i2}),\ p/(1+r) - s_{i1}(1+r)) \qquad (10)$$

All agents receive a state pension of p.

The contribution rate is set at level *comp* (for compulsory saving). Someone who has a relatively high income in the first period will find the min condition for s_{i1} in equation (9) kicks in and they pay $p/(1+r)^2$ in the first period and make no further contributions. Someone who has low income in both periods pays contributions that are a constant proportion *comp* of what they earn but effectively has their notional fund topped up so that they receive p in retirement. Note again that all agents receive p, as with the flat rate system, but that because contributions are in a notional account earning the market rate of return the impact of the system is neutral on those who would have aimed for retirement consumption greater than or equal to p. This is not true with the other schemes.

The budget balance condition for the compulsory saving system is:

$$t_s \int \{ f_1(\pi).\pi + [\max(y_{min} - \tau f_1(\pi).\pi, 0)] \} dF(\pi) +$$

$$t_s/(1+r) \int \{ f_2(\pi).\pi(1+g) + [\max(y_{min} - \tau f_2(\pi).\pi(1+g), 0)] \} dF(\pi) +$$

$$+ \int s_1(\pi) dF(\pi) + 1/(1+r) \int s_2(\pi) dF(\pi) = p/(1+r)^2 + \int [\max(y_{min} - \tau f_1(\pi).\pi), 0)] dF(\pi) +$$

$$1/(1+r) \int [\max(y_{min} - \tau f_2(\pi).\pi(1+g)), 0)] dF(\pi) \qquad (11)$$

This condition is similar to (6) but we add to the payroll tax contributions to the social security budget the inflows to the notional savings accounts of all workers. Those inflows are the result of aggregating the individual compulsory savings functions given by equations (9) and (10) across all agents. We write the compulsory savings of a young worker as a function of the wage - $s_1(\pi)$. From equation (9) it is clear that s_1 is a non-linear function of first period earnings, which themselves are a function of π and are given by $f_1(\pi).\pi + [\max(y_{min} - \tau f_1(\pi).\pi, 0)]$. Thus s_1 is a complicated function of all the parameters in the model; as before we suppress all the common parameters and write the form of s_1 as $s_1(\pi)$. A similar notation is used for second period saving, which at the individual level is given by equation (10) and which we write as $s_2(\pi)$.

II.ii Matching the model to actual systems:

In our modelling of retirement benefits, we have assumed that the primary aim of social security provision is to provide a minimum level of income for all. In this respect we are true to the first and third of Beveridge's (1942) three guiding principles to social security design; that the aim of a social security system is to provide a universal (Principle 1) minimum income level (Principle 3). Indeed these principles were quantified in 1952, by the 141 members of the International Labour Organisation (1952), who agreed that the minimum income in retirement of a couple should be fixed at 40% of an 'ordinary adult male labourer'[7].

All our three stylised pension system arrangements – flat rate pensions, means tested pensions, compulsory savings with a state top-up - guarantee a minimum level of income in retirement. (We will, however, look at systems where this minimum income level is well above and well below 40% of average earnings). Given that a central aim of a social security system is to provide a minimum income level, the question becomes what is the 'best' way to fund these retirement benefits. In this section we shall briefly summarise how this has been done in different OECD countries and show how the different arrangements fit into our model.

The approaches can be roughly broken down into two broad categories, labelled here as the Beveridge and Bismarkian approaches. Within these broad categories there are a plethora of variations. Yet recently there has been a gentle convergence in the design of the various social security systems to a system that could be described as a synthesis or hybrid of these two categories, (ILO, 1984).

Influenced heavily by Beveridge's principle of universality, the Nordic countries, Netherlands, and most Anglo-Saxon countries (Australia, Canada, New Zealand, United Kingdom) - but excluding the United States - set up a system of universal flat retirement benefits. These benefits were financed either from general tax revenue, as in the case of Australia, Canada, Denmark and New Zealand, or more directly from payroll contributions. However as universal retirement benefits became progressively more expensive to fund, because both their generosity and life expectancy increased, most of these countries have since adjusted their pension arrangements. At presently only the Netherlands and New Zealand still retain a fundamentally universal flat rate retirement system. Our flat-rate social security system can be regarded as a stylised model of the pension system of these countries.

One approach adopted by may countries, either to reduce the cost of their social security system or to target more resources at the poorer section of the retired population, was to introduce some form of means-testing of retirement benefits. The most dramatic change was in Australia in 1983, where the then Treasurer Paul Keating said that unless something was done to reduce the burden of the social

[7] The Convention did not actually require strict universality. If the retirement benefits were calculated with reference to the earnings of the beneficiary, then the beneficiary might also be required to pass a qualifying criterion for a full pension which was usually fixed to be 30 years of paid contributions.

security system, Australia would 'end up being just a third rate economy.... a banana republic'. His government introduced a means-test on the entire amount of the basic pension[8]. In contrast Canada, Sweden and the United Kingdom have frozen, or only marginally increased, the generosity of the basic pension in real terms and supplemented this universal pension by introducing a means-tested income support benefit targeted at poorer pensioners. All these means-tests are both income and asset based and allow for a variety of exclusions to increase coverage. The taper rates, the proportion of supplementary income lost per unit of private income, are generally between 40 and 50%. The UK is an outlier with a taper rate that has been 100%[9].

The key feature of a means-tested retirement benefits that we wish to model is that it is equivalent to a system that has a universal pension system funded partly from general taxation and partly funded by levying a proportional tax on assets up to some given level. It is therefore redistributive in the sense that it partly funds a universal pension by taxation of those that have savings. In our model the means-tested pension system is closest in spirit to the Australian model where the entire basic pension is means tested.

The Beveridge approach to social security can be contrasted to the earnings related social insurance model first pioneered by Bismark in Germany in 1889 and subsequently adopted in Austria, Belgium, France, Italy, Spain and the United States. Retirement benefits in these countries are related to past earnings and are financed by a mixture of mandatory employer and employee contributions. These schemes generally have some earnings ceiling above which further contributions to pension schemes are voluntary. The formula that relates past earning contributions to final retirement benefits varies dramatically across countries.

The central feature of this system is that all those with a full work history[10] are guaranteed a minimum level of income financed by a proportional payroll tax on labor income, sometimes only levied on income up to a specified maximal level. These systems are usually less redistributive than a means-tested system as they are often financed by a proportional labour tax on all income below a given maximal level. Our ‘compulsory savings’ system is an extreme example of this type of pension system as we assume that those above an income limit receive a pension equal in present value terms to their contributions. In practise the value of the pension is usually less that the present value of the contributions and so there is an element of redistribution built into these systems.

There has been a convergence in pension system arrangements across countries. Most of the countries that started with a universal pension system funded from general tax revenues have introduced ‘second tiers’ of earning related schemes - Sweden, Canada and the UK being examples. Other countries with

[8] The means test was an income and asset based test that effectively introduced a marginal tax rate or taper rate of 50% on private income. Further Australia in 1983 introduced mandatory earnings related pension, the income from which is not included in the means-test for the basic pension. (CHECK)
[9] In April 2002 this taper rate was reduced to 40% with the introduction of the Pension Credit.
[10] There are usually credits for periods of unemployment and child-rearing.

an earnings related scheme have introduced a means-tested supplementary benefit system, such as the SSI benefit in the US, to ensure that every individual gets a minimum income level. Therefore our three stylised pension systems must be seen as the generic types, with most country's pension system being a mix of these basic types.

II.iii Solving the Model:

Agents maximise the lifetime utility function defined by (1) and (2) subject to the constraint given by (3) and the net income and benefit equations (4) and (5). The borrowing constraints and the non-linearities generated by the tax and benefit rules make it impossible to generate an explicit closed form solution. We use numerical methods to find optimal levels of labor supply, consumption and saving over the 3 periods for agents. We use the constrained optimisation routine in GAUSS to solve the individual problem for given rules of the tax and benefit system. We then seek values for the social security contribution rate to generate a balanced budget. The procedure is straightforward. For a given social security system take an initial guess at the value of the social security tax rate (t_s) that balances the system. Then use numerical methods to solve the individual optimisation problem at this set of taxes and benefits for a large set of agents with different levels of π. Use the resulting values of optimal labor supply, consumption, benefit receipts, asset accumulation and pension entitlements for agents with different π's to estimate the corresponding whole economy aggregates using numerical integration. Finally check to see if the budget restriction ((6), (8) or (11) holds. Update the estimate of t_s if the budget is not balanced and continue the iterations.

II.iv Calibration:

In the base case simulations we set the discount rate equal to 0.02 a year (our periods are of 20 years so the 20 year discount rate is about 48%). We consider two values for the intertemporal elasticity of substitution (ζ), the inverse of the coefficient of relative risk aversion, setting it either equal to 0.5 or 0.25. The magnitude of the intertermporal elasticity of substitution is controversial; Cooley and Prescott (1995) use unity for their simulations whereas Auerbach and Kotlikoff (1987) use a coefficient of relative risk aversion of 4, implying the elasticity is only 0.25. Empirical work by Hansen and Singleton (1983) and Mankiw, Rotemberg and Summers (1985) suggest values a little over unity for the intertemporal elasticity of substitution while Grossman and Shiller (1981), Mankiw (1985) and Hall (1980) found values between 0 and 0.4. Blundell et al (1994) present evidence consistent with a choice of 0.75 for the intertemporal elasticity. Values of the coefficient of relative risk aversion (the inverse of the interetemporal elasticity of substitution) required to explain the equity premium puzzle first posed by Mehra and Prescott (1985) are very much higher than the values of 2 and 4 consistent with interetemporal elasticity of 0.5 and 0.25 respectively; but those very high values are implausible. Survey evidence on attitudes to risk suggest that coefficients of relative aversion greater than 5 are unlikely . (See Barsky, Kimball, Juster and Shapiro (1997)).

We set α, the relative weight attached to leisure against consumption, to a value which generates a plausible optimal labor supply over the working life for the base case social security system which we consider below. We took a plausible average labor supply over the working life to imply that around 0.3 of the available endowment of time during the working years is spent at work. Assuming 8 hours a day spent asleep gives a total time endowment over a year of 5840 hours. Assuming a typical working year of 46 weeks and a working week of 38 hours would make the average level of l equal to 0.3. We set the parameter determining substitutability between consumption and leisure (ε) equal to either 0.5 or 0.9. [See Auerbach and Kotklikoff (1987) for a justification of a value of around 0.8].

We consider two values for the real interest rate: 3% a year or 5% a year. These rates of return are exogenous. 3% as a real rate of return , net of all transactions costs and on an asset without risk, seems a central estimate. In the UK inflation proof (index linked) bonds trade in deep, liquid markets and generate a close to known real return; they have yielded between 2% and 3% for most of the 20 year period that they have been traded. In the US inflation proof government bonds are a more recent phenomenon. Since launched in the mid 1990's they have generally yielded between 3% and 4%. We consider 5% a relatively optimistic estimate of the likely net real return on financial assets. We assume a global capital market, so that while the ratio of aggregate financial assets to national income changes as social security rules are altered this does not affect the rate of return. We set the growth of productivity at 1.5% a year but also consider the impact of higher growth.

We set the standard deviation of log productivity to 0.6. This generates a cross section distribution of incomes that roughly matches US and UK data. Hubbard, Skinner and Zeldes (1995) use a model of income dynamics to simulate the impact of social security which is based on characteristics of US household income data. Their model of individual income, unlike our more stylised version, allows for some element of the differences in income in cross section to be transitory. The unconditional standard deviation of incomes using their parameters and calibration is around 0.56[11] . Dutta, Sefton and Weale (2001), focusing on the spread of incomes in the UK, approximate the distribution by a log normal with a standard deviation of around 0.55. We also consider a case with much lower dispersion of log productivities with a standard deviation of 0.4 (which Miles and Cerny (2002) suggest is relevant to

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[11] Their model for the log income of household k at time t is:

$y_{kt} = f(age_{kt}) + u_{kt} + w_{kt}$

$u_{kt} = \rho u_{kt-1} + v_{kt}$

where v and w are iid shocks that are not correlated and $f(age_{kt})$ is a deterministic function.

A measure of the unconditional variance of log income, which is the relevant moment for our purposes, is: $\sigma^2_w + \sigma^2_v / (1 - \rho^2)$

Typical values for ρ, σ_w and σ_v used by Hubbard et al are 0.955, 0.158 and 0.158, although there are clear differences across employment sectors. These values imply that some income shocks are highly persistent. With these values their measure of the unconditional standard deviation of the shock to log income is 0.56. In fact Hubbard et al set different values of ρ, σ_w and σ_v for those with no high school, high school and College education. The implied unconditional standard deviation of log income for these three groups are 0.64, 0.51 and 0.44 respectively.

Japan) and much higher dispersion, a standard deviation in the cross section of log productivity for one cohort of 0.8.

We will show results for several values of the maximum level of pensions (p) and different levels of the taper rate. How the actual pension received by an agent relates to p, the level of the full state pension, depends on the taper rate and on whether there is a compulsory saving system. In the flat rate pension regime every agent receives p; with means testing only those with zero assets at retirement receive p and the taper rate determines how much less than p other agents receive; in the compulsory saving regime all agents receive p - some have made compulsory past savings equal in present value to p while the less well off have saved less than p.

We undertake a search over all the parameters of the social security system to find the ideal system. The "ideal" system is the one that generates the highest expected utility for an agent behind a veil of ignorance on their own productivity and at the start of their life. A system here is defined as a set of levels for the key parameters of the social security system - levels of pension, values of taper rates, income support payment rules, settings for asset levels at which benefits cease and the level of any compulsory saving rates.

In the base case we assume that income taxes required to finance other types of government spending (t_y) are levied at a constant rate of 20%. Auerbach, using the NBER TAXSIM model, estimates that the average marginal tax rate on wages in the US in the mid 1990's was 0.217 (see Altig et al (2001)). Prescott (2002) reports an average marginal federal income tax rate in the US in 1997 of 19.5%. In the UK in 2001 the ratio of total income tax receipts to household wages and salaries plus distributed income of corporations was 0.214 (National Income accounts, Office for National Statistics). In many Continental European countries average income rates have tended to be somewhat higher. (Prescott, (2002), for example, estimates the overall marginal tax rate on labor income, which adds social security taxes to income taxes, to be 0.32 and 0.31 in the US and UK respectively but to be 0.49 in France). We investigate later the impact of higher levels of t_y.

III: Simulation Results:

III.i The ex ante optimal system

We search over 4 parameters to find the system that maximises expected utility: the level of the full state pension (p) ; the taper rate on wealth of the state pension (λ – the rate at which the state pension received falls as financial assets at retirement rise ie. the degree of means testing of pensions); the level of the maximum income support (ymin); the taper rate on income support – ie. the rate at which receipt of income support falls as earned income rises (τ - the degree of means testing of income support). We search over a wide range of values of these four parameters including, as special cases: a flat rate pension system (λ=0); a non-means tested social income system for the working population (τ=0); no state pensions (p=0); no income support for those with low productivity (y_{min} =0). We also search over systems with compulsory saving. In each case we calculate the contribution rate required to balance the system.

We began with a search over a coarse grid in the four-dimensional parameter space. We then conducted a search over a much finer grid on the relevant part of the coarser grid. For a given set of preference parameters and assumptions about rates of return we ran around 30,000 simulations to find the optimal four parameters to 3 decimal places.

The social security systems that maximised expected utility at different values for the key exogenous economic parameters – rates of return, degree of variability in productivity (or incomes), background income tax rate – are shown in Table 1. The first column shows the optimal system for what we consider to be the central (or base) values for the key parameters. Here we set the rate of return to 3%; the background income tax rate to 20% and the standard deviation of log productivity to 0.6. We take a rate of intertemporal substitutablity of 0.5 (implying a coefficient of relative risk aversion of 2); we set the elasticity of substitution between leisure and consumption at 0.9; productivity growth is set at 1.5%. In this environment the optimal system has the following characteristics: The full state pension is worth about 57% of the second period, post-tax salary of someone with average productivity working 0.3 of available time[12]. The taper rate on financial assets at retirement is 0.2. The optimal level of maximum income support is approximately 32% of the first period earnings of someone with average productivity who works 0.3 of available time. The taper rate on income support is 0.25. This implies that all workers on beneath typical earnings (what someone with average productivity earns with labor supply at 0.3) receive some benefit, at least in the first half of their working life. The social security contribution rate that balances this system is close to 15%; this implies that with $t_y = 0.2$ the overall tax on wage income is about 35%.

With this "optimal" system the state pension generates a fairly high replacement rate for the majority of workers. Furthermore the taper rate is set at a level such that only those with substantial wealth receive significantly less than the full pension. The ratio of the average state pension received to the full sate pension (only received by those with no retirement saving) is just under 90%. The limited degree of means testing of the state pension system (the low taper rate and the fairly generous overall level) is not matched by the features of the income support system. The maximum level of income support is only 32% of typical wages and the taper rate is higher than for the state pension; the optimal income support scheme is very much a safety net for the least well off.

The social security contribution rate required to balance this system (15.3%) implies a high overall tax rate on earned income. What is happening here is that risk averse agents attach a high weight to the insurance role of a relatively generous level of state pensions and a substantial safety net for very low

[12] We will consistently describe the levels of state pensions and of income support as the maximum level of benefits relative to the income of a typical worker, who we take to be a worker with average productivity who supplies 30% of time to paid work.

productivity workers. Taper rates are fairly low, pushing the system some way along the spectrum towards a universal, flat rate system. High taper rates would mean that the overall contribution rate could be much lower than 15%, but they would generate two sorts of costs: first, they create obvious distortions for the less well off by creating high effective tax rates on marginal income and marginal saving. Second, high tapers mean that insurance would only be provided for those at the bottom of the earnings distribution. A low taper means that state pensions and at least some income support are paid to those with incomes only a little under the average.

Table 2 provides much more insight into the workings of the optimal system at the base values of the parameters. Here we look at the impact of the "optimal" social security system (summarised in the first column of table 1) on agents at different points on the income distribution. The table shows that the state pension provides the larger part of retirement resources for the great majority of agents. Someone with average productivity (normalised to unity) finds it optimal to have the state pension finance about 65% of retirement consumption. Someone with 75% of average productivity finds it hardly worth saving and covers approximately 99% of retirement consumption from the state pension. No-one with less than 75% of average productivity finds it optimal to save anything for retirement. This is the major factor behind the low aggregate wealth to income ratio in the "optimal" system of 1.42. As a point of comparison Poterba, Venti and Wise (2001) report a ratio of total retirement assets to aggregate wage and salary earnings in the US of around 2.5 in 1999[13]. That figure is a relevant one for our stylised model where saving for retirement is the overwhelming motive for asset accumulation; in our model we assume productivity differences are permanent so once agents start working there are no stochastic elements to future earnings and there is no precautionary saving. In the UK the net equity of households in pension funds and with life assurance companies corresponds roughly to savings that are explicitly for retirement. The ratio of the stock of such assets to wages and salaries in the second half of 2001 was approximately 2.6 (UK Economic Accounts 2001, Tables A37 and A64). So if the ex-ante optimal social security system generates a wealth to income ratio of under 1.5 it is generating an incentive to save for retirement which is apparently much lower than exists in the US and UK. We shall see below that with much lower public pensions – nearer those that exist in the US and UK – the model generates wealth to income ratios at, or slightly above, the levels seen in the US and UK.

Table 2 shows that amongst those with very low wages incentives both to save and to work are seriously affected by the optimal (ex-ante) social security system. Even though the maximum income support level is set at a fairly low level (only worth 32% of the earnings of a typical worker in the first half of their working life) and the taper rate is only 25%, those with productivity under 50% of the average supply substantially less labor than those of average productivity. The agent with average productivity devotes about 27% of their time in the first half of their working life to paid employment and about 36% in the second half. The worker with only 50% of average productivity supplies 22% and 24% of their time to work in the first and second half of their working life. But those with productivity of only 20% or less of the average supply very little labor. From behind the veil of ignorance, the risk averse agent sees these disincentive affects – both on saving and labor supply - as a price worth paying for the substantial insurance against bad outcomes (very low productivity) that the social security system brings.

The distortions to saving are lower with a compulsory saving system to notional accounts earning the market rate of return. But we find that any compulsory saving generates a lower level of ex-ante welfare than a well-designed system with means tested benefits. The results in the first column of Table 1 show that taper rates are a long way from zero so means testing is an important part of the optimal system. Figure 1 illustrates the value of means testing and its superiority to a compulsory saving system. The figure shows the expected utility, at birth and from behind a veil of ignorance about productivity, of an agent as a function of the type of social security system in place. In this figure we take given levels of the pension and vary the degree of means testing. We show expected utility as a function of the taper rate for two values of the full sate pension – 40% and 50% of the average second period (after tax) income of the worker with average productivity who works 30% of their time. (Table 1 shows that the optimal system, which involves means testing, has a maximum pension worth rather more than 50% for the base case parameters). A taper rate of zero is a non-means tested system with flat rate benefits. As the taper rises the degree of means testing increases and the behavior of all agents adjusts accordingly.

The figure also shows expected utility for a compulsory saving system with the same two levels of the full state pensions (worth 40% and 50% of typical second period earnings). With the compulsory saving system everyone receives the same state pension, but we vary the level of compulsory saving rate from zero (which is simply a flat rate pension system financed purely from social security payroll contributions) to a forced saving rate of 15%. The compulsory saving rate is shown on the lower x axis. The means tested system with a zero taper is the same system as a flat rate system with a zero compulsory saving rate so the lines coincide at zero.

Three things are revealed by the figure. First, a compulsory saving system is rarely as good as a means tested system; only when the taper rate on the means tested system rises above about 45% does expected utility fall to the level of the best compulsory saving system. Second, if one does abandon means testing and also considers financing some part of benefits payments from compulsory savings then the best one can do is have a simple flat rate system with a level of compulsory savings that is virtually zero. Third, some form of means testing is optimal; expected utility increases as the taper rate on the state pension rises from zero (flat rate pensions) to a taper rate of around 20% for a full pension of 40% of typical wages. The optimal taper rate when the full pension is higher, at 50% of typical second period wages, is higher again at around 25%. Beyond that the distortions created by higher taper rates outweigh the benefits.

[13] Altig et al (2001) estimate the capital output ratio for the US in the mid 1990's to be 2.66.

It is useful to put the differences in expected utility in a metric that reveals their economic significance. Taking as the base case a completely flat rate system (the left most points in the figure) we can calculate for different systems the lump sum, flat rate amount we would need to give, or take from, all agents at retirement to give the same expected utility as the base case. With the optimal amount of means testing and a full pension worth 40% of typical second period wages agents are better off than with flat rate pensions by the equivalent of a lump sum at retirement of about 28% of typical second period annual earnings. But with a compulsory saving rate of 10% agents are worse off by the equivalent of a lump sum of 200% of typical annual second period earnings. The cost of having too much means testing (relative again to a base of flat rate pensions) is also significant. A taper rate of 70% generates a loss equivalent to a lump sum of about 50% of typical annual earnings. So getting the taper rate right is important.

Why does compulsory saving do so badly? A compulsory saving system is a form of self-insurance that forces those with low productivity to make some contribution to their own retirement resources. For a given level of the full state pension, a means tested or flat rate system with no compulsory saving will require a smaller contribution from the least well off, many of whom find it optimal to make no saving for retirement. With risk averse agents, judging which system to support from behind a veil of ignorance about their own productivity, a compulsory saving system was always dominated by some form of means tested system.

Even if we rule out means testing we still find that compulsory saving is not desirable so long as we take as out welfare criterion ex ante expected utility. The second column of Table 1 shows the system that is optimal if we chose between alternative systems with no means testing (ie. we constrain λ to be 0). We allow both the level of the pension and the extent to which it is financed from compulsory saving (ie the level of the parameter *comp*) to be chosen. We find that it is optimal to set the level of *comp* to zero – there is no compulsory saving and the flat rate, non-means tested pension is financed completely out of social security contributions. The equilibrium social security contribution rate is 16.2% and the level of the state pension is lower than the maximum level of pension when we allow means testing – the full state pension with optimal means testing is worth 57% of the earnings of the typical worker in the second period of work while with flat rate pensions it is worth 52%. This non means-tested system is strictly dominated by the system in column 1, which has means tested pensions and also has no compulsory saving. So from the perspective of agents behind an initial veil of ignorance on their productivity, a compulsory saving system would not be chosen but neither would a system with universal (flat rate) pensions. But the wealth to income ratio would be higher with flat rate pensions – column 2 of Table 1 shows that the optimal flat rate system generates a wealth income ratio of 1.61 against a value of 1.42 for the global optimal social security system; aggregate labor supply would also be slightly greater with no means testing. But the *overall* tax rate on labor income would be marginally *higher* without means testing (at 36.2% against 35.3%) and welfare is lower. The money value of having the optimal means tested system (column1) rather than the optimal flat rate system (column 2) is not small – it is the equivalent of a lump sum bonus at retirement for all agents of around 28% of typical second period annual earnings.

Optimal Systems in alternative environments:

How does the optimal social security system changes with different rates of return, changes in the degree of cross-section dispersion in productivity and variations in the rate of income tax? Column 3 of Table 1 shows the optimal social security system when the rate of return on assets is 5% rather than 3%. The value of the full state pension is higher, relative to the wages of a typical worker in the second half of their working life, than in the base case. But the taper rate is slightly greater and the wealth to income ratio is much larger (at 2.18 relative to 1.42 for the optimal system in the base case). Furthermore the level of income support is significantly lower. Overall the social security system can be balanced with a contribution rate of 14.8% - slightly below the rate of 15.3% needed to balance the system that is optimal with a 3% rate of return. A key point is that means testing remains optimal - indeed the taper rate on the state pension is slightly higher (at 22% against 20%).

If the income tax rate required to finance other elements of government spending is higher - 30% as against 20% in the base case – the level of full pension and maximum income support benefits both fall and the taper rates rise (column 4 of table 1). This is a reflection of the non-linearities in the relation between the distortionary costs of the tax-benefit system and the overall contribution rate out of income. The optimal social security system with an income tax rate of 30% is balanced with a contribution rate of 10.3%. This means that the overall deductions from incomes to finance government spending (t_y+t_s) is 40.3%; in the base case that overall rate was 35.3%. So when the income tax rate is 10% higher the overall tax rate is only about 5% higher. If other elements of government spending are higher by 10% of labor earnings then the optimal full state pension should be cut from 57% of typical second period earnings to 52%; the taper rate should be increased from 20% to 26%; income support should also be reduced. Overall the welfare system is less generous and means testing is greater. This generates savings in the government budget worth about 5% of incomes and that offsets about half of the impact of higher non-welfare spending upon the average tax rate on incomes.

Column 5 of Table 1 shows the optimal social security system when the distribution of productivity across the population is less equal (the standard deviation of the log of productivity in cross section is 0.8 against 0.6 in the base case). The optimal level of the full state pension falls somewhat (relative to second period earnings of a typical worker). But the level of maximum income support is very much higher – around 55% of the typical wages of a worker in the first half of their working life as compared to about 32% in the base case. When there is much greater uncertainty about income, agents who do not know whether they will be highly productive or have low productivity opt for a system which gives them more insurance against bad outcomes – they prefer income support levels to be higher and for there to be more redistribution during their working lives. The equilibrium social security contribution rate is correspondingly much higher – 22.2% as compared with 15.3% in the base case. This generates an overall contribution rate out of income of 42.2%; in the base case the overall contribution rate is

35.3%. Labor supply is, on average, significantly lower with a much less equal distribution of productivity and a significantly higher overall tax rate on income. Once again there is a clear role for means testing; the taper rate on the state pension is 24%.

With less dispersion in productivity across the workforce many of these effects go into reverse. The final column of table 1 shows the optimal system when the standard deviation of log productivity is 0.4. Now while the optimal full state pension is higher than in the base case the level of maximum income support is very much lower. The supply of labor is, on average, significantly greater: agents supply an average of 32% of their time in the first half of their working life and 35% in the second. This compares with average supply of 26% and 31% in the base case (and only 20% and 25% when the standard deviation of log productivity is at 0.8). With more labor supply and lower levels of income support the contribution rate needed to balance the social security system is down to 9.8% generating an overall tax on income of under 30%. Taper rates on receipt of pensions and of income support are at around 20%.
Once again this significantly affects incentives for those with low productivity whose supply of labor and saving is very much less than with no welfare state.

III.ii Other Welfare Systems:
The ex ante optimal systems shown in Table 1 have high levels of the full state pension and significant means testing. They generate low overall savings and no savings for retirement from a substantial proportion of the population. A society may decide that having the great majority of those with below average earnings save nothing for old age is undesirable, even if such an outcome maximises ex ante utility. So it is interesting to consider other systems and investigate how different are their aggregate and distributional characteristics. Table 3 shows outcomes with means tested pensions of very different levels of generosity. Here we set the full state pension, the pension received by someone who has zero assets at retirement, at various proportions of typical second period net of income tax earnings. As before, we take typical second period earnings to be the earnings of an agent with average productivity who supplies 30% of their time to paid employment. There is a taper rate, or withdrawal rate, of 40% for every dollar of assets. This implies that if we set the full pension at 40% of typical net second period earnings then someone with a stock of assets at retirement equal to typical second period earnings will receive no state pension. There is no compulsory saving. Income support is set at a level so that someone with no labor earnings will receive benefits of around 17% of the first period earnings of a worker with average productivity who works 30% of their time[14]. Income support benefits are assumed to be withdrawn at a rate of 20% of earnings. With this system someone with earnings of around 85% of the typical worker in the first period of their life just fails to qualify for any benefit. We take these taper rates as given and then consider how outcomes vary as we alter the level of the full state pension. The taper rates we have chosen do not correspond precisely to rates set in a particular

[14] Hubbard et al (1995) assume a consumption floor, or safety net, of $7000 for the non-elderly in the US, where they estimate the median income at age 40 of households with high school education to be

economy and are largely illustrative. In fact matching up taper rates in actual social welfare systems with the two rates in out stylised model is rather hard. For example, there are over 80 means tested programmes in the US, providing, amongst other things, medical benefits, food stamps and tax credits (see Moffitt, 2002). Many poor households will claim several benefits so that amongst those claiming some means-tested benefits taper rates will vary. Moffitt reports that the taper rate on the earned income tax credit in the US in 1999 was 21%. The taper rate on the Food Stamp Programme was 30%, although that rate is also affected by the presence of deductions and exemptions. Overall we feel that a taper rate of between 20% and 40% for many benefits is not unrealistic.

Table 3 summarises the outcomes at what we consider to be central values of the key parameters. With this set of parameters and a maximum pension worth 40% of typical second period net of tax earnings, the ratio of aggregate private sector wealth to national income[15] is around 2.6 . As noted above, this roughly corresponds to recent values of the stock of retirement savings relative to incomes in the US and UK. Workers in the first period of their life, on average, allocate about 30% of their time to paid work; that fraction is higher in the second half of the work life when around 35% of time is, on average, spent working. The average state pension received is about 58% of the full pension; in other words the operation of the means testing system reduces aggregate state pension expenditure to just under 60% of its level under a flat-rate, universal system. The social security tax rate required to balance the system is 5.8%. With a value of t_s of 0.2 this implies an overall tax on labor income of 25.8%.

When the means tested pension is worth only 20% of typical after tax, second period earnings the saving rate is higher and the average wealth to income ratio is almost 3.7. With no state pensions, the aggregate wealth to national income ratio is close to 4, over 50% higher than with the full state pension worth 40% of the typical worker's second period after tax income. As the state pension becomes worth less labor supply in both the first and second periods of life rises for workers of different productivities, but the effect is greater for the least well off. Reliance upon the state pension for those on 50% of average wages falls from being worth virtually 100% of retirement consumption when the full pension is 40% of typical second period earnings to 71% when it is worth only 30% of typical earnings and to only 29% of retirement consumption when the full pension is worth 20% of typical final earnings. Clearly the generosity of the full state pension has a very significant impact on aggregate savings and, to a lesser extent, on labor supply.

The results are sensitive to growth, rates of return and to elasticities of substitution. Table 4 keeps the taper parameters of the social security system constant at their base case levels (as in table 3), and sets the full pension to 40% of typical second period net earnings, but varies preference parameters, rates of return and productivity growth.

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around $30,000. This gives a ratio of about 23%. In the UK income support payments in 2002 to someone with no income would be only about $3700 - around 17% of average UK earnings.

With rates of return at 5% the stock of wealth is substantially higher than with a 3% rate of return. The aggregate wealth to income ratio is 4.35 (as against 2.59 when r = 3%); reliance upon state pensions is much lower. The social security tax rate can fall from 5.8% at a 3% rate of return to around 3.0%. There is a substantial impact upon the pattern of labor supply over the life cycle: labor supply from those in the first part of their working life increases sharply (from an average of 30% of available time to around 35% of available time) while supply in the second half of the work life falls sharply (from 35% at a 3% rate of return to 29% at a 5% rate of return). The enhanced rate of return encourages more work earlier in the life cycle as savings are used to buy both consumption and leisure later in life.

Higher productivity growth has a fairly small impact on average labor supply over the life cycle and also on the aggregate wealth to national income ratio. With 2% a year productivity, rather than the base case of 1.5%, labor supply in the second half of the working life is slightly higher – on average 36% of available time is supplied as against 35% when productivity grows at 1.5%. Higher productivity growth makes the wage-age profile steeper and most agents respond by working slightly more later in the life cycle. The aggregate wealth to income ratio is lower with higher productivity – 2.34 against 2.59 when productivity grows at 1.5%. With wages more skewed towards later in life both work and savings are slightly lower earlier in the life cycle.

A reduction in the degree of intertemporal substitutability from 0.5 to 0.25 means that agents tend to save less as the gain in utility later in life from postponing consumption is reduced. The aggregate wealth to income ratio is about 2.4 at a value of 0.25 for the elasticity of substitution over time against a value of 2.6 at an elasticity of 0.5. Reducing the substitutability of leisure and consumption (with an offsetting change in the parameter alpha to stop overall labor supply falling significantly) tends to flatten out labor supply schedules over the life cycle; with the consumption–leisure substitutability parameter set at 0.5, as opposed to the "central" value of 0.9, labor supply is now slightly greater in the second half of the working life than in the first half.

Overall, table 4 shows that while results are sensitive to alternative assumptions about returns on assets they are rather less affected by changes in other parameters of a comparable magnitude.

How different are the results with flat rate pensions? Table 5 summarises the results for 5 different levels of a non-means tested state pension. With the full state pension worth 40% of second period, post income tax wages of someone with typical productivity and labor supply, the equilibrium contribution rate is 8.5%. This compares with a figure of 5.8% with means tested benefits and a taper rate of 40%. With this level of universal pensions savings is lower. The aggregate wealth to income ratio is 2.3 with universal pensions but 2.6 with means testing and a 40% taper. The income effect of

[15] National income is the sum of gross labor income plus interest on the aggregate stock of private sector financial assets; the latter is the sum of wealth held by all agents alive at each point.

higher average state pensions more than offsets the substitution (or price) effect of a zero benefits tax rate on financial assets.

The impact of a compulsory saving system for retirement pensions is summarised in Table 6. Again we consider various ratios between the state pension and the earnings of a worker with average productivity who allocates 30% of their time to work. In this system we set the compulsory contribution rate so that the worker with average productivity who works 30% of the time will have made compulsory saving equal to the present value of the pension they receive. Anyone with income below that level will get a pension with higher value than the present value of their compulsory saving. But no-one has a level of compulsory saving greater than the value of the state pension. The compulsory saving rate varies from 15% down to 5%. Relative to the means tested system, the compulsory saving system generates slightly larger labor supply, reflecting the reduced distortions from social security contributions. But the size of the difference is relatively small. More generally, the aggregate outcomes are not significantly different for the same level of pension whether we have means testing or compulsory saving (to nominal government accounts). But the disaggregated results are different and the impact upon the welfare of different agents is distinct because the compulsory saving scheme is less redistributive. The compulsory saving rate at a pension level of 40% typical second period earnings is around 10%. For the better off this is not a burden since they effectively only pay this on the first part of earnings and it is a perfect substitute for other saving. The least well off have to pay the rate on all their income and since their other saving is zero they generally end up paying more for their pension than with a flat rate scheme or a means tested scheme.

To bring out more clearly the degree of redistribution inherent in the ex-ante optimal social security system Figure 2 shows the distribution of lifetime income under three social security systems: the optimal system at the base case parameters (shown in column 1 of Table 1); the system with a pension worth 40%, and maximum income support worth 17%, of typical second period earnings and taper rates of 40% and 20% (shown in column 3 of Table 3); the compulsory saving system of table 6, also with a state pension worth 40% of typical second period earnings and maximum income support of 17% of typical first period earnings (shown in the third column of Table 6). The (ex-ante) optimal system generates the most equal distribution of lifetime income; the Gini coefficient is 0.298. The compulsory saving system generates the least equal distribution of income, with a Gini coefficient of 0.327. The means tested system of column 3 of table 3 has a degree of lifetime income inequality half way between the other two, with a Gini coefficient of 0.315. (Atkinson (1995, Table 2.10, p 60) reports estimates of Gini coefficients for developed countries in the early 1990's. The (unweighted) average across 9 developed economies is around 0.29. But the range is substantial. At one end is the US and UK (0.43 and 0.33) and at the other is Sweden (0.25) and Finland (0.20)).

IV Voting on Social Security Systems:

If agents voted on the structure of social security systems from behind an initial veil of ignorance about their productivity then assuming common utility functions there would be unanimity – everyone would favor what we have called the optimal system: the system that maximises expected utility. But no political decisions are made that way. Only adults, who are all too aware of their current (and probably likely future) position on the income and wealth distributions, get to vote. In this section we ask a simple question. We assume that agents stand at the start of their life but are aware of their productivity. We then ask how agents would vote in a straight choice between two social security systems. We consider a wide range of different social security systems and calculate for each possible pair the proportion of agents who would vote for one over the other. We allow the current generation of agents about to start work to choose between different systems. Only young agents vote because we assume they are being asked to consider an alternative social security system that will only affect them. Agents in the second half of their working life and in retirement carry on with whatever is the current social security system. *Because all the systems we consider are inter-generationally neutral it is possible to look at reforms that only affect the young.*

In a comparison of any two systems we always found that there is a key voter – someone who is just indifferent between the schemes. Every agent with lower productivity than this agent prefers one system. Every agent with higher productivity prefers the other (less redistributive) system. This "single peakness" condition seemed to be universal, even though the different systems differed in several dimensions. If this characteristic was indeed true for all possible systems then the social security system that maximised the welfare of the agent that knew they had median productivity would win a vote against any other system. One of the systems we compare against the others is that which maximises welfare for someone with median productivity and it does indeed dominate every other system.

So we begin in Table 7 by describing the system that is optimal for the person with median productivity. This agent has a level of income below the mean because productivity is log-normally distributed. Table 7 shows that this key agent consistently favors a relatively high state pension and *no* income support. The agent who knows they have median productivity would gain little from income support unless it was set at a very generous level; but that would prove costly. So for this agent providing zero supplements to income for low earners is optimal – they have an income which takes them out of bottom of the earnings pile. Comparing the system that is optimal for the median productivity worker (table 7) with the ex-ante optimal system (table 1) shows that pension generosity is much greater when the median productivity agent gets the system of their choice. In the base case (with a 3% rate of return, 0.6 standard deviation of log productivity and a 20% income tax rate) the replacement rate of the median voter's optimal scheme is 80% compared with 57% for the ex ante optimal scheme. At different rates of return, income dispersions and with different income tax rates the median voter consistently prefers higher maximum pensions than the ex ante optimal level. But the overall contribution rate to social security is consistently lower when the median voters picks the optimal scheme – the cost saving from abolition of income support and having a higher taper rate on state pensions more than compensates for significantly higher full state pensions. But the impact upon private aggregate wealth accumulation of adopting the median voter's preferred system is substantially negative. The wealth to income ratio is about 50% lower with the median voter system than with the ex-ante efficient system.

These results appear to confirm the results in Browning (1975) who finds that democratic voting may lead to an over-provision of social security. (See also Myles (1995) and Breyer (1994)). But because we allow for quite detailed social security systems – involving choices over taper rates and methods of financing and with both retirement benefits and in work benefits – the result is not quite so straightforward. The system that is optimal for the median voter does indeed have higher state pensions than the ex-ante optimal system, but it also has higher taper rates and lower overall contribution rates. So in a model with a quite detailed specification of the social security system the median voter finds that there are many aspects of the system he favors which are less generous than the ex ante optimal system.

Table 8 is a voting matrix that allows us to assess how a straight vote on any 2 social security systems would go. Each cell in the matrix shows the proportion of voters who would prefer the system corresponding to the row heading over the system corresponding to the column heading. In all cases we take what we have called the base case parameters – a rate of return of 3%, a standard deviation of log productivity of 0.6, productivity growth of 1.5% and a 20% income tax rate.

We consider 16 social security systems. The first block of 4 systems are compulsory saving schemes with a compulsory saving rate of 9.5% and various levels of the state pension (20%, 40%, 60% and 90% of the earnings of the typical worker in the second period of their working life). The second block of five systems are flat rate systems with no means testing of the pension. The first of these systems is the special case of zero pensions; the others have replacement rates for the typical second period worker of 20%, 40%, 60% and 90%. The third block has 4 social security systems with a 40% taper rate and different levels for the full state pension. In all these systems (the compulsory saving cases; the flat rate systems and the systems with means tested pensions) we have an income support system that pays a maximum level of support of 17% of typical first period earnings and has a taper rate of 20%.

The final three systems are the optimal system that maximises ex-ante utility (shown in the first column of Table 1); that flat rate system (no taper of the state pension) that the person with median productivity would prefer; and finally the globally preferred system for the agent with median productivity (the system shown in the first column of table 7). As expected this last system always gains a majority of support over any other system.

Several features stand out from the table.

1. Compulsory savings systems do very poorly. A majority of voters prefers almost any other system to any form of compulsory saving.

2. Flat rate (non-means tested) pension systems are preferred to many other systems. In particular they consistently get a majority against the system that maximises ex-ante utility.
3. The optimal system (which maximises ex-ante utility) never wins in a head to head vote against any of the means tested systems or any of the flat rate pension systems. Systems that have much lower pensions than the optimal one, but also those with much higher pensions than the optimal system, are preferred to it by a majority.
4. The system that is optimal for the median voter wins a fairly clear majority in a head to head vote against all other systems, generally getting more than 60% of the vote.

What is clear is that it is very unlikely that a majority of people who already knew their position on the income distribution would vote for a move to the ex-ante optimal system. Ex post, the ex-ante ideal system really benefits those at the bottom of the income distribution. But many of those earning below average wages would prefer a less redistributive system once they know that they are not at the bottom of the pile. Indeed many prefer a system with virtually no welfare state to the ex-ante optimal system. Just over 53% of voters would prefer a system with no state pension at all to the ex-ante optimal system where the full state pension is worth 57% of typical second period earnings. The key voter is the worker with median wages. This is someone with significantly less than average productivity (with a standard deviation of 0.6 for log productivity the person who is at 50th percentile has a level of productivity about 16.5% less than the average). This illustrates rather clearly that the ex-ante optimal system is so redistributive that it takes resources not just from those with above average productivity to give to those with below average productivity – it redirects resources from those quite significantly beneath average productivity to those *very* far beneath average productivity. Although this is optimal in an ex ante sense it is often rejected by a majority of a population that knows its productivity.

Although it is clear that the ex-ante system is unlikely to emerge from any voting system, it is less obvious what will emerge. Suppose, for example, that we start from a position with low, flat rate state pensions – much beneath the level that the median voter would find optimal (which table 7 shows is a means-tested system with a full state pension worth 80% of typical second period earnings). Suppose also that voters are presented with a choice between two parties where one party offers the status quo and the other offers a system with higher state pensions but which are means tested. Table 8 shows that in this head to head choice whether the system that is nearer that which the median voter prefers will win depends on *how* near it is. Suppose, for example, that the choice is between a flat rate system with a 20% replacement rate and a system with the full state pension worth 40% of typical earnings but with a 40% taper rate. Moving towards a system with a full pension twice as high and a 40% taper rate seems clearly to be a move nearer to a system that the median voter finds optimal – the optimal system for the median voter has a taper rate of 35% and a full state pension worth 80% of typical second period earnings. Yet 55.6% of the voters would chose to stay with a low level, flat rate state pension system. But if there was a choice between the status quo and a *much* more generous means tested system – with a full state pension worth 90% of typical second period wages – the more generous system would win 55.5% of the vote.

What is happening here is that making a not very generous system a bit more generous is, from the point of view of the median voter, a very bad outcome. They fail to get significantly more benefits since the means testing ensures that the higher pensions go predominantly to those less well off than the median voter while the costs are borne largely by those who do not gain much. Making the system a *lot* more generous would, however, benefit the agent with median productivity.

This suggests that there can be multiple equilibria in social security systems: countries that begin with a very small social security system and consider incremental changes to that system which the electorate vote on may find that the democratic process preserves a limited welfare state. Democratic countries that have a large welfare state may also be in an equilibrium; any system that started out near the system favoured by the median voter (an 80% replacement rate for the state pension with substantial means testing) would not vote for a party that suggested significant change to the social security programmes. .

V. Conclusions:

If we take as our welfare criterion the expected utility of an agent at the start of their life, and from behind a veil of ignorance about their own position in the distribution of productivity for their cohort, then the social security system that is optimal is one that provides a relatively generous state pension with a significant element of means testing. It is optimal that there is an income support system paying benefits to those of working age with low incomes; but the scale of benefits is relatively low. Just how generous state pensions are in the optimal system, and what the contribution rate needed to balance the system is, are sensitive to the rate of return on assets, the dispersion of productivity and, crucially, to the level of other taxes levied on agents to cover other types of government spending. But we never find that the level of the optimal state pension falls below 50% of typical second period wages. This overall level of pension benefits that the calibrated model suggests is optimal does not look out of line with that seen in many Continental European systems and in Japan where replacement rates for state pensions have often been well over 50%, and in many cases over 70%. But the much lower levels of state benefits typical in recent decades in the US and in the UK do look very much below what the calibrated model suggests might be chosen by agents before they recognised where they stood on the income distribution. In fact even the comparison with Continental European and Japanese systems overstates their proximity to the ex ante “optimal” system. In many economies where government pensions are generous there is a close link between lifetime earnings and the state pension that an agent receives – in Germany and Japan, for example, there is a strong positive correlation between a worker’s lifetime earnings and the level of the state pension that they receive. In the optimal system analysed here there is instead a strong *negative* link between the pension received and income from work; means testing of pensions, rather than linkage to final salary, is what risk averse agents would chose before they knew their productivity. They would not chose compulsory saving.

To a large extent the fact that most countries do not have a social security system that is as redistributive as the ex ante optimal one analysed here is that agents are obviously not behind a veil of ignorance when they vote. Yet the system that the median voter would prefer, and which one might expect to emerge in a democracy, is itself significantly redistributive. It has no income support but it does have a large state pension which is mean tested and which redistributes resources from those with well above average productivity to those of below average productivity – a group that includes the person with median productivity. But we have seen that one reason why we do not see many social security systems with highly redistriubutive and relatively generous (to those below average earnings) state pensions is that any political system that considers reform in a gradualist fashion may remain in an equilibrium a long way from the globally optimal system for the median voter.

One feature of the system that the median voter favours that we do see in may countries is that benefit support for poor workers is low relative to benefit payments to the retired. In most countries replacement rates for the unemployed, for example, are lower than the typical replacement rate of the state pension. Our results suggest that a system that voters will find attractive may be too generous towards the old and not generous enough towards the working-age poor.

Finally, our results suggest that compulsory saving systems have drawbacks. Neither the optimal system nor the system that the median voter favors is a compulsory saving system. With the optimal system – that which maximises ex-ante utility – a substantial proportion of the population (everyone with less than 80% of the average level of productivity using our base case parameters) save nothing for old age. The system favoured by the median voter would make not saving for retirement the optimal strategy for an even higher proportion of the population. This suggests that a compulsory saving system is unlikely to prove popular. With a welfare system whose structure is decided by the political process in a country with democratic institutions saving for old age may remain a minority activity.

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Table 1: The Ex ante Optimal Social Security System and Aggregate Outcomes:

Scenarios	1	2	3	4	5	6
Full state pension (as ratio of post income tax second period wage of typical worker)	0.570	0.521	0.913	0.521	0.533	0.632
Withdrawal rate of pension as wealth increases	0.202	0.000	0.217	0.263	0.239	0.212
Maximum Income support (as ratio of first period gross wage of typical worker)	0.320	0.321	0.259	0.251	0.550	0.123
Withdrawal rate of income support as earnings rise	0.253	0.218	0.209	0.250	0.259	0.190
Intertemporal Elasticity of substitution	0.5	0.5	0.5	0.5	0.5	0.5
Elasticity of substitution between labor and leisure	0.9	0.9	0.9	0.9	0.9	0.9
Real rate of return	3.0%	3.0%	5.0%	3.0%	3.0%	3.0%
Growth of productivity per annum	1.5%	1.5%	1.5%	1.5%	1.5%	1.5%
Volatility of Incomes – yvol	0.6	0.6	0.6	0.6	0.8	0.4
Aggregate Wealth to Income ratio	1.42	1.61	2.18	1.50	1.40	1.26
Average wealth for first period workers	0.002	0.002	0.035	0.003	0.004	0.001
Average wealth for second period workers	0.057	0.066	0.056	0.061	0.055	0.053
Average labor supply for first period	0.26	0.26	0.30	0.28	0.20	0.32
Average labor supply for second period	0.31	0.32	0.24	0.33	0.25	0.35
Equilibrium social security tax rate	15.3%	16.2%	14.8%	10.3%	22.2%	9.8%
Average state pension received as a percent of full pension	88.9%	100.0%	89.4%	81.5%	87.6%	90.1%
Overall tax and contribution rate on earned income	35.3%	36.2%	34.8%	40.3%	42.2%	29.8%
State pension as percent of retirement consumption for person with 50% (150%) average productivity	100% (37%)	98% (39%)	100% (37%)	100% (38%)	100% (38%)	100% (38%)

Notes

1st Column : optimal system given base parameters

2nd Column: base parameters but system is the optimal flat rate system; λ constrained to be 0. Here we search over values for the pension and for "comp" - the compulsory saving rate. The optimum is where comp = 0

3rd Column: base parameters except interest Rate 5%

4th Column: base parameters except income tax rate 30%

5th Column: base parameters except yvol = 0.8 increase inequality

6th Column: base parameters except yvol = 0.4 decrease inequality

Table 2: The Distribution of Outcomes across income groups for the "optimal" social security

Social security system parameters and other details are as in the first column of table 1. Average productivity amongst young workers is 1; full state pension is worth 57% of post income tax *second* period earnings of worker with average productivity working 0.3 of time (ie $0.57 \times 1 \times 0.3 \times (1+0.015)^{20} \times (1-0.2) = 0.184$)

Productivity Level	Income t=1	Income Support t=1	Labor Supply t=1	Income t=2	Income Support t=2	Labor Supply t=2	Consumption t=1	Consumption t=2	Consumption t=3	Wealth t=1	Wealth t=2	Wealth t=3	State Pension
0.1	0.083	0.083	0.000	0.083	0.083	0.000	0.051	0.058	0.184	0.003	0.000	0.000	0.184
0.15	0.083	0.083	0.000	0.084	0.082	0.010	0.051	0.059	0.184	0.002	0.000	0.000	0.184
0.2	0.088	0.081	0.034	0.105	0.075	0.113	0.057	0.068	0.184	0.000	0.000	0.000	0.184
0.25	0.101	0.077	0.095	0.122	0.069	0.158	0.065	0.079	0.184	0.000	0.000	0.000	0.184
0.3	0.113	0.072	0.136	0.139	0.064	0.187	0.073	0.090	0.184	0.000	0.000	0.000	0.184
0.35	0.126	0.068	0.164	0.156	0.058	0.208	0.081	0.101	0.184	0.000	0.000	0.000	0.184
0.4	0.138	0.064	0.186	0.172	0.052	0.223	0.089	0.112	0.184	0.000	0.000	0.000	0.184
0.45	0.151	0.060	0.202	0.189	0.047	0.234	0.097	0.122	0.184	0.000	0.000	0.000	0.184
0.5	0.163	0.056	0.215	0.205	0.041	0.243	0.105	0.133	0.184	0.000	0.000	0.000	0.184
0.55	0.175	0.051	0.225	0.221	0.036	0.251	0.113	0.143	0.184	0.000	0.000	0.000	0.184
0.6	0.187	0.047	0.233	0.238	0.030	0.257	0.121	0.154	0.184	0.000	0.000	0.000	0.184
0.65	0.200	0.043	0.241	0.254	0.025	0.261	0.129	0.164	0.184	0.000	0.000	0.000	0.184
0.7	0.212	0.039	0.246	0.270	0.019	0.265	0.137	0.175	0.184	0.000	0.000	0.000	0.184
0.75	0.224	0.035	0.252	0.286	0.014	0.269	0.145	0.185	0.184	0.000	0.000	0.000	0.184
0.8	0.236	0.031	0.256	0.307	0.007	0.278	0.153	0.193	0.192	0.000	0.005	0.009	0.182
0.85	0.248	0.027	0.260	0.408	0.000	0.357	0.160	0.237	0.224	0.000	0.027	0.050	0.174
0.9	0.260	0.023	0.263	0.436	0.000	0.360	0.168	0.248	0.234	0.000	0.034	0.062	0.172
0.95	0.271	0.019	0.266	0.464	0.000	0.363	0.176	0.259	0.244	0.000	0.041	0.075	0.169
1	0.283	0.015	0.268	0.492	0.000	0.365	0.183	0.270	0.254	0.000	0.048	0.087	0.166
1.1	0.366	0.000	0.333	0.548	0.000	0.370	0.237	0.293	0.274	0.000	0.062	0.112	0.161
1.2	0.397	0.000	0.331	0.603	0.000	0.373	0.257	0.315	0.294	0.000	0.076	0.137	0.156
1.4	0.458	0.000	0.327	0.714	0.000	0.378	0.297	0.358	0.333	0.000	0.103	0.187	0.146
1.6	0.519	0.000	0.324	0.823	0.000	0.382	0.336	0.402	0.373	0.000	0.131	0.236	0.136
1.8	0.584	0.000	0.324	0.926	0.000	0.382	0.374	0.447	0.414	0.004	0.160	0.288	0.126
2	0.648	0.000	0.324	1.028	0.000	0.382	0.411	0.492	0.456	0.008	0.188	0.340	0.115
2.5	0.807	0.000	0.323	1.280	0.000	0.380	0.503	0.603	0.559	0.019	0.260	0.469	0.089
3	0.964	0.000	0.321	1.529	0.000	0.378	0.595	0.712	0.661	0.029	0.331	0.597	0.064
4	1.302	0.000	0.325	2.057	0.000	0.382	0.766	0.917	0.999	0.077	0.553	0.999	0.000
10	3.054	0.000	0.305	4.876	0.000	0.362	1.798	2.159	2.386	0.179	1.321	2.386	0.000

Table 3: Alternative Social Security Systems and Aggregate Outcomes:

Full state pension (as ratio of post income tax second period wage of typical worker)	0.6	0.5	0.4	0.3	0.2	0
Withdrawal rate of pension as wealth increases	40%	40%	40%	40%	40%	-
Maximum Income support (as ratio of first period gross wage of typical worker)	17%	17%	17%	17%	17%	17%
Withdrawal rate of income support as earnings rise	20%	20%	20%	20%	20%	20%
Intertemporal Elasticity of substitution	0.5	0.5	0.5	0.5	0.5	0.5
Elasticity of substitution between labor and leisure	0.9	0.9	0.9	0.9	0.9	0.9
Real rate of return	3%	3%	3%	3%	3%	3%
Growth of productivity per annum	1.5%	1.5%	1.5%	1.5%	1.5%	1.5%
Aggregate Wealth to Income ratio	1.48	2.00	2.59	3.22	3.67	3.94
Average wealth for first period workers	0.004	0.007	0.011	0.016	0.020	0.023
Average wealth for second period workers	0.058	0.081	0.107	0.136	0.161	0.174
Average labor supply for first period	0.30	0.30	0.30	0.31	0.31	0.32
Average labor supply for second period	0.33	0.34	0.35	0.37	0.39	0.40
Equilibrium social security tax rate	10.4%	8.0%	5.8%	3.8%	2.4%	1.6%
Average state pension received as a percent of full pension	81.8%	71.8%	57.8%	38.8%	17.6%	Na
Overall tax and contribution rate on earned income	30.4%	28.0%	25.8%	23.8%	22.4%	21.6%
State pension as percent of retirement consumption for person with 50% (150%) average productivity	100% (36%)	100% (19%)	100% (0%)	71% (0%)	29% (0%)	0% (0%)

Table 4: Aggregate Outcomes in Alternatoive Econom,ic Environemnets

Maximum, means-tested pension worth 40% of typical second period net earnings

Taper rate on pensions = 40%; max income support is 17% of typical first period earnings with a taper rate of 20%

Interest rate per annum	Growth rate in Wages per annum	Elasticity of Leisure / Consumption	Elasticity of Intertemporal Substitution	Average pension	Average Labor Supply t=1	Average Labor Supply t=2	Average Wealth 1	Average Wealth 2	Social Security Tax Level	Wealth to Income Ratio
0.03	0.015	0.9	0.5	0.07	0.30	0.35	0.01	0.11	0.058	2.59
0.05	0.015	0.9	0.5	0.04	0.35	0.29	0.06	0.16	0.030	4.35
0.03	0.02	0.9	0.5	0.08	0.30	0.36	0.00	0.11	0.059	2.34
0.05	0.02	0.9	0.5	0.05	0.33	0.32	0.04	0.16	0.032	3.79
0.03	0.015	0.9	0.25	0.07	0.30	0.35	0.01	0.10	0.059	2.36
0.05	0.015	0.9	0.25	0.05	0.32	0.33	0.03	0.12	0.035	3.06
0.03	0.02	0.9	0.25	0.08	0.30	0.36	0.00	0.10	0.059	2.20
0.05	0.02	0.9	0.25	0.06	0.31	0.35	0.02	0.12	0.037	2.65
0.03	0.015	0.5	0.5	0.08	0.30	0.32	0.00	0.07	0.068	2.05
0.05	0.015	0.5	0.5	0.05	0.34	0.24	0.05	0.10	0.034	3.94
0.03	0.02	0.5	0.5	0.09	0.30	0.31	0.00	0.07	0.072	1.92
0.05	0.02	0.5	0.5	0.06	0.32	0.27	0.03	0.10	0.038	3.22
0.03	0.015	0.5	0.25	0.08	0.30	0.32	0.00	0.08	0.066	2.20
0.05	0.015	0.5	0.25	0.06	0.31	0.29	0.03	0.09	0.038	2.98
0.03	0.02	0.5	0.25	0.09	0.30	0.31	0.00	0.08	0.071	2.00
0.05	0.02	0.5	0.25	0.07	0.30	0.30	0.01	0.09	0.042	2.50

Table 5: Flat rate Pension systems:

Full state pension (as ratio of post income tax second period wage of typical worker)	0.6	0.5	0.4	0.3	0.2
Maximum Income support (as ratio of first period gross wage of average worker)	17%	17%	17%	17%	17%
Withdrawal rate of income support as earnings rise	20%	20%	20%	20%	20%
Aggregate Wealth to Income ratio	1.61	1.94	2.31	2.71	3.12
Average wealth for first period workers	0.002	0.004	0.006	0.009	0.013
Average wealth for second period workers	0.067	0.082	0.098	0.116	0.135
Average labor supply for first period	0.30	0.30	0.30	0.30	0.31
Average labor supply for second period	0.34	0.35	0.36	0.37	0.38
Equilibrium social security tax rate	12.1%	10.3%	8.5%	6.7%	5.0%
Overall tax and contribution rate on earned income	32.1%	30.3%	28.5%	26.7%	25.0%
State pension as percent of retirement consumption for person with 50% (150%) average productivity	100% (45%)	99% (37%)	81% (29%)	62% (21%)	42% (14%)

Intertemporal Elasticity of substitution =0.5; Elasticity of substitution between labor and leisure =0.9;
Rate of return = **3** %; Productivity growth = **1.5%**

Table 6: Compulsory saving system:

Full state pension (as ratio of post income tax second period wage of typical worker)	0.6	0.5	0.4	0.3	0.2
Maximum Income support (as ratio of first period gross wage of average worker)	17%	17%	17%	17%	17%
Withdrawal rate of income support as earnings rise	20%	20%	20%	20%	20%
Aggregate Wealth to Income ratio	1.80	2.03	2.30	2.59	2.88
Average wealth for first period workers	0.000	0.000	0.000	0.000	0.000
Average wealth for second period workers	0.086	0.098	0.113	0.130	0.147
Average labor supply for first period	0.32	0.32	0.32	0.31	0.31
Average labor supply for second period	0.35	0.36	0.37	0.38	0.40
Equilibrium social security tax rate	3.1%	2.8%	2.6%	2.3%	2.0%
Compulsory saving rate	15.0%	12.5%	10.0%	7.5%	5.0%
Total tax and contribution rate on earned income plus compulsory saving	38.1%	35.3%	32.6%	29.8%	27.0%
State pension as percent of retirement consumption for person with 50% (150%) average productivity	100% (40%)	100% (34%)	84% (27%)	60% (21%)	40% (14%)

Intertemporal Elasticity of substitution =0.5; Elasticity of substitution between labor and leisure =0.9; Rate of return = **3%** ; Productivity growth = **1.5%**

Table 7: The Optimal Medium Voter Social Security System and Aggregate Outcomes:

	1	2	3	4	5	6
Full state pension (as ratio of post income tax second period wage of average worker)	0.802	0.864	1.284	0.790	0.786	0.811
Withdrawal rate of pension as wealth increases	0.352	0.000	0.365	0.370	0.450	0.273
Maximum Income support (as ratio of first period gross wage of average worker)	0.000	0.000	0.000	0.000	0.000	0.000
Withdrawal rate of income support as earnings rise	0.000	0.000	0.000	0.000	0.000	0.000
Intertemporal Elasticity of substitution	0.5	0.5	0.5	0.5	0.5	0.5
Elasticity of substitution between labor and leisure	0.9	0.9	0.9	0.9	0.9	0.9
Real rate of return	3.0%	3.0%	5.0%	3.0%	3.0%	3.0%
Growth of productivity per annum	1.5%	1.5%	1.5%	1.5%	1.5%	1.5%
Volatility of Incomes – yvol	0.6	0.6	0.6	0.6	0.8	0.4
Aggregate Wealth to Income ratio	0.83	0.98	1.54	0.78	1.30	0.59
Average wealth for first period workers	0.001	0.001	0.030	0.001	0.005	0.000
Average wealth for second period workers	0.033	0.040	0.033	0.031	0.050	0.024
Average labor supply for first period	0.34	0.34	0.36	0.34	0.34	0.34
Average labor supply for second period	0.34	0.35	0.29	0.35	0.35	0.34
Equilibrium social security tax rate	12.4%	14.4%	10.8%	10.5%	11.6%	13.0%
Average state pension received as a percent of full pension	92.3%	100.0%	92.9%	91.5%	88.6%	95.5%
Overall tax and contribution rate on earned income	32.4%	34.4%	30.8%	40.5%	31.6%	33.0%
State pension as percent of retirement consumption for person with 50% (150%) average productivity	100% (59%)	100% (64%)	100% (70%)	100% (63%)	100% (68%)	100% (63%)

Note

1st Column : Medium Voter Preferred system given base parameters

2nd Column: Medium Voter Preferred system (Flat Rate System) base parameters

3rd Column: Interest Rate 5%

4th Column: Base Tax Rate 30%

5th Column: yvol = 0.8 increase inequality

6th Column: yvol = 0.4 decrease inequality

Table 8: Voting on alternative social security systems

Each cell shows the proportion of the population that prefer the pension system corresponding to the row heading to the pension system corresponding to the column heading.

		Compulsory Pension Contrib.				Flat Rate Pension System					Means Tested Pensions				Optimal Pension	Flat Rate Median Voter	Means-Tested Median Voter
		Income Support level = 17%, Income Support taper = 0.20															
		p=0.2	p=0.4	p=0.6	p=0.9	p=0	p=0.2	p=0.4	p=0.6	p=0.9	p=0.2	p=0.4	p=0.6	p=0.9			
Compulsory Pension Contributions. Income Support level 17%, taper 0.20	p=0.2, comp =9.5%		74.2	72.9	93.2	29.6	34.8	40.5	42.3	44.5	79.9	49.5	43.2	42.3	52.0	41.0	39.6
	p=0.4, comp =9.5%	25.8		76.2	100.0	27.9	39.1	34.0	38.2	41.7	32.5	45.5	40.5	39.7	50.2	42.2	41.0
	p=0.6, comp =9.5%	27.1	23.8		100.0	27.5	32.7	25.7	32.1	37.4	29.6	39.9	36.6	35.8	48.1	39.3	39.0
	p=0.9, comp =9.5%	6.8	0.0	0.0		20.0	2.7	16.1	23.8	30.0	0.0	29.8	29.3	29.8	42.6	28.6	29.7
Flat Rate Pension System. Income Support level 17%, taper 0.20	p=0	70.4	72.1	72.5	80.0		45.1	45.1	45.5	47.1	75.4	52.7	45.5	44.5	53.4	39.6	37.4
	p=0.2	65.2	61.0	67.3	97.3	54.9		45.5	46.1	47.4	67.4	55.6	45.5	44.5	54.9	43.0	41.1
	p=0.4	59.5	66.0	74.3	83.9	54.9	54.5		46.4	48.6	62.6	60.7	45.5	44.2	56.8	44.6	44.5
	p=0.6	57.7	61.8	67.9	76.2	54.5	53.9	53.6		68.6	59.2	79.4	45.1	50.4	58.3	36.1	43.8
	p=0.9	55.5	58.3	62.6	70.0	52.9	52.6	51.4	31.4		56.8	58.0	0.0	27.9	59.4	28.3	25.0
Means Tested Pension System. Income Support level 17%, taper 0.20	p=0.2, τ =0.4	20.1	67.5	70.4	100.0	24.6	32.6	37.4	40.8	43.2		48.1	42.3	41.4	51.2	40.6	39.3
	p=0.4, τ =0.4	50.5	54.5	60.1	70.2	47.3	44.4	39.3	20.6	42.0	51.9		28.7	36.3	54.5	37.5	39.6
	p=0.6, τ =0.4	56.8	59.5	63.4	70.7	54.5	54.5	54.5	54.9	100.0	57.7	71.3		79.4	63.0	35.2	33.7
	p=0.9, τ =0.4	57.7	60.4	64.2	70.2	55.5	55.5	55.8	49.7	72.1	58.6	63.7	20.6		55.6	30.4	27.1
Optimal Means-Tested Pension System		48.1	49.8	51.9	57.4	46.6	45.1	43.2	41.7	40.6	48.8	45.5	37.0	44.4		35.8	33.7
Flat Rate System Preferred by Median Voter		59.0	57.8	60.7	71.4	60.5	57.0	55.4	63.9	71.7	59.4	62.5	64.9	69.6	64.3		30.4
Means-Tested Pension Preferred by Median Voter		60.5	59.0	61.1	70.3	62.6	59.0	55.5	56.2	75.0	60.7	60.4	66.3	72.9	66.3	69.6	

Figure 1: Expected Utility under different pension arrangements:

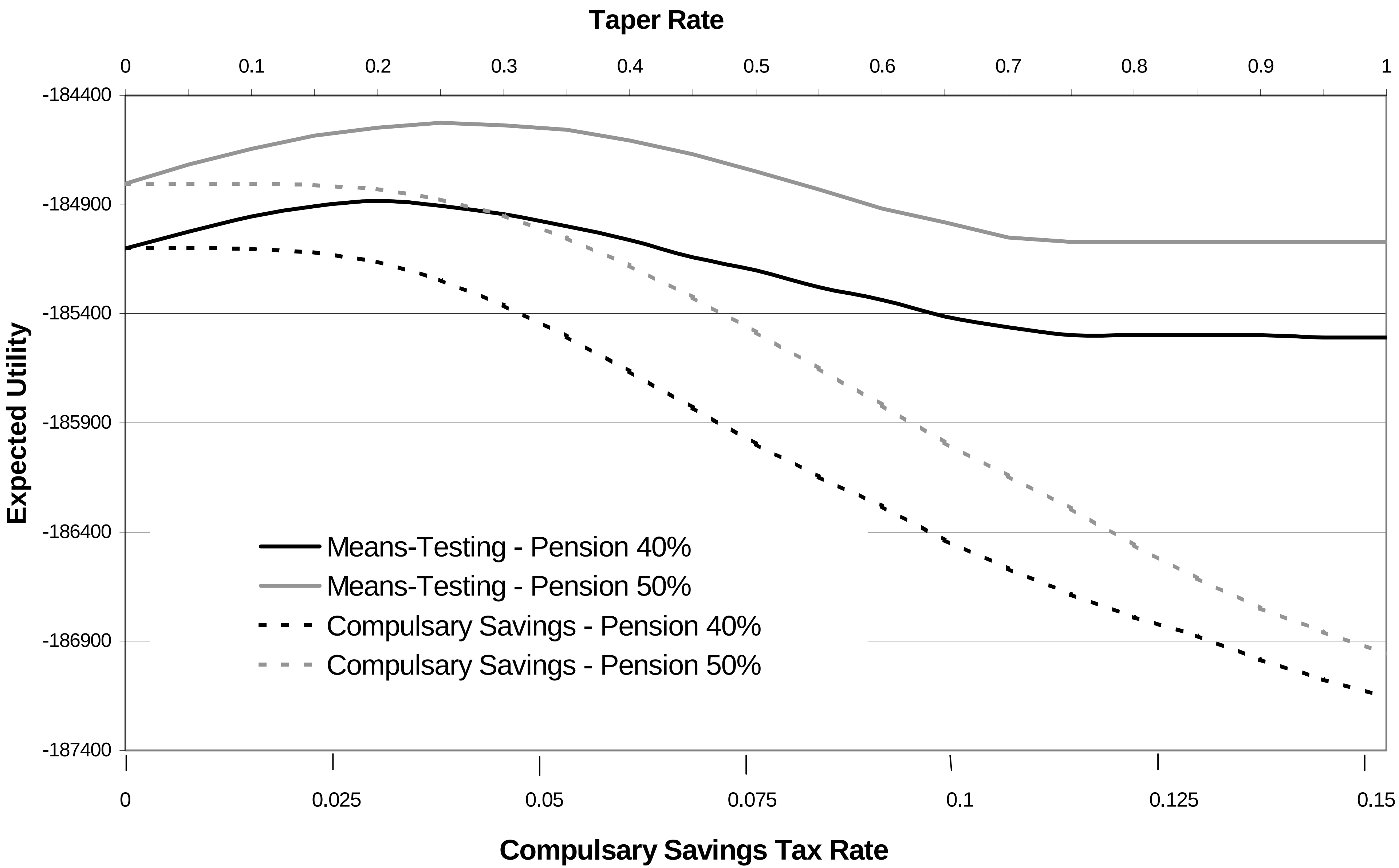

Figure 2: Lorenz Curves of alternate pension arrangements

Chart shows the Lorenz curves corresponding to distribution of lifetime resources of a generation under three alternative pension regimes: the optimal means tested system as in column 1 of Table 1, the means-tested regime with a 40% full state pension (as in table 3) and the compulsory saving pension system as in table 6 where the full state pension (as ratio of post income tax second period wage of average worker) is 0.4.