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# Ageing populations and intergenerational risk-sharing in payg pension schemes

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**JEL classification:** D30; H55; J14; J26;

## Abstract

The purpose of this paper is to compare pension schemes with respect to their intergenerational redistributive effects caused by economic and demographic changes. It is shown how these effects depend on the specific design of the pension scheme, with special attention devoted to the indexation problem. There is a potential trade-off between financial stability of the pension system and a “desired” distribution between generations. A buffer fund is often seen as the remedy to demographic strain and potential conflict. Therefore, the possibility of accumulating (and de-cumulating) a buffer fund is included.

A lifecycle perspective is applied and the risk-sharing is measured by different generations’ rate of return.

The analysis is carried out within the framework of an over-lapping generation model in the setting of a stylised economy.

# Ageing populations and intergenerational risk-sharing in payg pension schemes.<sup>1</sup>

## 1. Introduction

Most public pension systems in the industrialised world are defined benefit pay-as-you-go (payg) systems. Forecasts show them to be more or less unsustainable, due, among other things, to expected demographic development with ageing populations. Transition to a funded system has been analysed in a number of papers (see for example Campbell & Feldstein, 2001, Feldstein, 1996, Kruse, Porta & Saraceno, 1997, Raffelhüschen & Risa, 1995) as have changes in the benefit formula and indexing method (see Kruse, 2000, for an overview). A few countries, among them Italy and Sweden, have chosen to reform their systems in a way that has come to be known as a *notional defined contribution payg-system* (NDC) indexed by growth.<sup>2</sup>

In the 1990s the Swedish pension system was transformed from a defined-benefit (DB), price-indexed payg system into a defined-contribution system.<sup>3</sup> The major part (86%) is kept payg and is growth-indexed, and a minor part (14%) is transformed into a funded system. A number of goals were attached to the new Swedish pension system. As the old one had been shown to be unsustainable and very sensitive to economic growth, an aim with the new one was to make it sustainable and robust to economic and demographic changes.

The purpose of this paper is to analyse how different designs of pension systems affect redistribution between generations. One aspect of distribution between generations is risk-sharing, the risks being economic and demographic changes. This aspect includes how the

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<sup>1</sup> Different versions of this paper have been presented at the LSE conference “Modelling policy in an ageing Europe” in Jan. 2002, at the IAES, March 2002, at the “baby-boom”-symposium at the Dept of Economics, Uppsala in April 2002 and at the ESPE conference in June 2002. Comments from participants in these conferences are gratefully acknowledged.

<sup>2</sup> There is a persistent misunderstanding of pension system design suggesting that defined-benefit (DB) systems are public and payg while defined-contribution (DC) systems are private and funded. Kruse, Porta & Saraceno (1997) argue against this and the introduction of public notional defined contribution systems (NDC) should be argument enough.

<sup>3</sup> In 1992 a parliamentary committee on pension reform was set up. In that same year a report with the outlines of the design was presented. In 1994 the new design was passed in the Parliament (in principle; some details remained to be laid down) and in 1999 the new system was put into operation. An outline of the system is given in Kruse (2002) where intra-generational aspects of the design as well as effects on distortions in the labour market are briefly commented on.

system copes with income fluctuations, cyclical or a long-term trend, and how it copes with an ageing population with fewer children born and more pensioners due to increased life expectancy. If we assume risk-aversion, a pension system that entails risk-sharing will be utility-increasing. In Gordon & Varian (1988), and Thøgersen (1998), among others, risk-sharing between generation is analysed. They conclude that public payg, growth-indexed systems indeed do the trick. According to the results in this paper, this does not hold as a general result. The focus in this paper will be on the indexation method in connection with the DC, payg design. The purpose is to investigate the intergenerational risk-sharing following from different designs, and by the same token investigate whether the chosen method in the Swedish system fulfils one of the main goals of the reform, that of financial stability in combination with a certain or predetermined income distribution between generations.<sup>4</sup> The results are derived within a simulation model using a four-period, over-lapping generation model in a stylised economy.

The paper is organised as follows. The analysis of financial stability and intergenerational effects starts in the next section with an introductory examination of risk and distribution in a simple payg model. In section 3 the general NDC model is described. Here, indexes are also discussed. In section 4 the overlapping generation model and the simulations are presented and section 5 concludes the paper.

## **2. Design and risk in a simple payg pension model**

Pension systems are exposed to three kinds of risks: economic, demographic and political. The *economic risk* is the risk of a low or even negative rate of return. In a funded system the rate of return is that of the capital market, whereas in a pure payg-system it is the growth rate in the economy, i.e. changes in productivity and demography (Samuelson, 1958, Aaron, 1966). Thus, a funded system is exposed to capital market risks, a payg-system to growth risks. Both kinds of systems are exposed to *political risks*, that is, the risks of more or less abrupt changes in the design caused by political decisions.<sup>5</sup>

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<sup>4</sup> As mentioned above, in the Swedish system there is a payg part and a funded part. The latter is excluded from the analysis in this paper. It should, however, be pointed out that the split of the system into one part where the system is 'guaranteed' by future production possibilities – the payg-part where the rate of return is determined by future GDP – and one part placed in the capital market, is per se a risk diversification.

<sup>5</sup> In the childhood of public pension systems the political risk warned against was the expansion of the system beyond an optimal level (Browning, 1975). Today the concern is rather reductions in such a non-transparent way that the public is confused (Disney, 1996).

The design of the system also determines how these risks are shared between generations. Kruse (2000) analyses the effects of changes in demography and growth on the working generation and retirees. It is shown that the redistribution and risk-sharing caused by various shocks depend on the design of the system. The budget restriction of a pure payg pension model makes it easy to intuitively grasp how the risks and risk-sharing between generations depend on the design.

$$q w L = b R \quad (1)$$

$$q = b/w R/L \quad (1')$$

$$b/w = q L/R \quad (1'')$$

where  $q$  is the tax or contribution rate,  $w$  average wage,  $L$  labour force,  $b$  average benefit level,  $R$  number of pensioners,  $b/w$  replacement ratio and  $R/L$  the dependency ratio. In a simple overlapping two-generation model today's retirees are yesterday's workers, i.e.  $R_t = L_{t-1}$ . It is assumed that the whole labour force is covered by the pension system. Thus,  $L$  is also the number of contributors and  $R$  is those who were contributors during their working lives.

The implicit – and sometimes explicit – rate of return in such a model is the rate of growth in the tax base, i.e. the wage sum, i.e. changes in  $L$  and in  $w$ , but it also depends on the number of retirees that are alive to share the proceeds of the system. The rate of growth is defined as

$$g = (1+\lambda)(1+z); \quad \lambda = (L_t - L_{t-1})/L_{t-1} = \Delta(L/R) \quad (2)$$

where  $z$  is productivity change and  $\lambda$  population change.

In a DB system,  $b$  or even more often  $b/w$ , is fixed. To keep the budget restriction in the face of economic and demographic changes the contribution rate,  $q$ , has to be changed, which follows from eq. 1. Thus, with such a design all adaptation costs are borne by the working generation.<sup>6</sup> In a DC system the contribution rate,  $q$ , is fixed. The pension benefit then follows from eq. 1', where the level of the system is determined and from the growth rate as defined in eq. 2. With a constant population structure the pension benefit changes with changes in the wage sum; workers and pensioners take part in the same economic changes.

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<sup>6</sup> Actual reforms of DB systems show, however, a diversity of adjustments where benefits turned out not to be defined when the systems were exposed to stress. The changes range from increases in retirement age to plain cuts in benefits. This is an example of the political risk pension systems are exposed to (Kruse 2000).

In a DC system each pensioner gets  $b = (q * w_t * L_t) / R_t$ . As those who were pensioners in year  $t$ ,  $R_t$  paid  $q * w_{t-1} * R_t$ ,<sup>7</sup> the rate of return in the system is

$$\frac{q * w_t * L_t}{q * w_{t-1} * R_t}$$

This of course is the growth rate of the economy (assuming a constant capital /labour share) as defined in eq. 2. Thus, the rate of return,  $\rho$ , is determined by  $w$ ,  $L$  and  $R$ :

$$\rho = f(w, L, R)$$

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the signs being those of partial derivatives.

#### $\Delta w$

In a DC payg system, an increase in  $w$  means increased consumption possibilities for all, both the working generation and the retired, and vice versa with a decrease in  $w$ . Thus, a change in  $w$  has a symmetric effect on the distribution.

#### $\Delta L$

An increase in  $L$ , cet.par., means an increase in the contribution base, giving an increase in  $b$ . However, the per capita income of the working generation is not increasing, thus changing the distribution between generations. A decrease in  $L$ , cet.par. will decrease total income (the contribution base) and  $b$  but not per capita  $w$ . Thus a change in  $L$  has an asymmetric effect on the distribution.

#### $\Delta R$

An increase in  $R$  decreases  $b$  (not through the indexing method but due to the budget restriction) but does not affect  $w$ , thus changing the per capita distribution in favour of the working generation.

Thus,  $\Delta w$  has a symmetric effect on the distribution while  $\Delta L$  and  $\Delta R$  have asymmetric effects. So, assuming the pension system is designed to give (what is perceived as) an optimal life-time distribution, the use of the index  $\rho$  will change this distribution as well as the distribution between generations.

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<sup>7</sup> For simplicity, it is assumed that all workers become pensioners. It would be easy to include mortality in the

### 3. The notional defined-contribution system

In the NDC system each year's contributions are registered in an individual pension account. The rate of return on the account is the growth rate of the wage sum (the 'interest' on the account). The pension benefit, the annuity, is determined by the accumulated contributions, i.e. the (notional) capital, incl. the compound interest that has accrued in the account, at the date of retirement, divided by the expected remaining years of life. The benefits in the following years are determined by this first annuity being indexed by the growth rate of the wage sum. This is close to the design following from Samuelson (1958), which can be interpreted as solving the 'pension problem' by a DC, growth indexed payg system.

The *DC-element* means that all income during all years count, and count on an equal footing in a way that makes different life cycle earnings' profiles equal from the pension point of view.<sup>8</sup> The *notional element*, that the deposits in the account are fictitious, means that the system still is an unfunded one, i.e. the capital market can be assumed to be unaffected compared to the payg state. Furthermore, the rate of return is determined by the growth rate, not by the interest in the capital market.

Organised in this way, the pension system is (almost!) financially stable; the accrual of pension rights as well as outgoing pensions follow the changes in the wage sum, which is also the contribution base. However, the notional element means that the indexing introduces a financial instability, which will be shown in the sections to follow.

In the NDC system pension rights accrue in an individual (notional) account. Each year's contributions ( $q \cdot w_t$ ) are added to the account and indexed by the indexation number. If the working period is from year  $e$  to year  $x$ , the  $k$ :th individual's accrued pension rights are

$$NW_k = q \sum_{t=e}^x w_t \prod_{j=t+1}^{x+1} (1 + \lambda_j)(1+z_j) \quad (3)$$

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model, for example by letting  $R_t = (1-s_t)L_{t-1}$ ,  $s$  being survival probability.

<sup>8</sup> Assuming that there is no floor and no ceiling on the pension-carrying income.

where  $NW$  is notional pension wealth and  $w_t$  is the individual's wage income in the  $t$ :th year, determined by working hours as well as hourly wage, and the indexation is by  $(1 + \lambda_j)(1+z_j)$ , which is the interest on the account.

The yearly pension benefit – the annuity – is determined at the date of retirement as

$$b_{k, x+1} = NW_k / \eta_K \quad (4)$$

and the benefit during the following years as

$$b_{k, x+i} = b_{k, x+i-1} (1+\lambda_{x+i-1})(1+z_{x+i-1}) \quad i = 2 \dots D \quad (5)$$

where  $\eta_K$  is life expectancy estimated for  $k$ 's cohort  $K$  at the date of retirement.<sup>9, 10</sup>  $D$  is the year of death. Thus  $b$  is an actuarially calculated annuity (possibly apart from the risk difference between sexes and socio-economic groups), which in the NDC system will be indexed by the same factor as the accrued contributions. The discounted value of contributions equals the discounted value of benefits and the individual's rate of return is the economy's growth rate. Thus, the options open to an individual to affect his or her pension benefit are through  $e$ ,  $w$  and  $x$  while  $\lambda$  and  $z$  obviously are exogenously determined. With an ageing population,  $\lambda < 1$ , the rate of return – and  $b$  – is reduced compared to a situation with a stable population.

With a design of the NDC system as in eq. 3-5, the pension system is not used for redistribution except, possibly, for the differences in life expectancy within a cohort. There is

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<sup>9</sup> In an obligatory system  $\eta$  can be pooled between men and women and between socio-economic groups, thus giving rise to redistribution between these risk groups, or, to put it in another way, making it possible to use a broader base for risk pooling than a voluntary system would allow.

<sup>10</sup> The formula for the division number in the Swedish system, including the discounting factor of 1.6%, the so called adaptation index, is

$$\eta_n = 1/12 * 1/L_n \sum_k \sum_x (1.016)^{-(k-n)} * [L_k + (L_{k+1} - L_k) * x/12] * (1.016)^{-x/2}$$

where

$\eta_n$  is the division number when the benefit is claimed at the age of  $n$  years

$n = 61, 62, \dots$

$k = n, n+1, n+2, \dots$

$x = 0, 1, 2, \dots 11$

$L_k$  = number of survivors in the age of  $k$ . The number of survivors in a certain age is determined by using the official statistics on life expectancy in a birth cohort.

Thus, in the Swedish system,  $\eta$  is based on historical life tables, not on forecasts. So far there has been increasing life expectancy, which means a risk that the system will be under-financed. See also section 3.1 below.



a perfect connection between an individual's contributions and benefits, reducing tax wedges and excess burden. Redistribution, if wanted, has to be carried out outside the pension system.<sup>11</sup>

When indexed by growth in the wage sum (the tax base) as in equations 3-5,  $b$  is adjusted through the index. In the NDC system a time lag is introduced through the indexing. The time lag gives rise to a violation of the familiar budget restriction in payg systems:

$$\sum_{h=e}^x q w_h L_h = \sum_{h=x+1}^D b_h R_h \quad (6)$$

where  $h$  are cohorts,  $h = e \dots x$  are working cohorts,  $x+1 \dots D$  retired cohorts. With a satisfied budget restriction, as in a "pure" payg system, the system is financially stable and the adaptation is either through the contribution rate (a DB-system) or through the benefit level / replacement rate (a DC-system). However, with the NDC there is a possibility of financial instability.

### 3.1. Life expectancy – the division number

The annuity is determined as in eq. 4, i.e. by dividing the accumulated notional wealth by the expected remaining years of life ( $\eta$ ). The design of the system determines who bears the risk of changing life expectancy. In a DB system the risk is totally borne by the working generation, in a DC system by the pensioners. As changes in life expectancy, to a large degree, are foreseen, there are many ways for a person to adapt while still working, for example by longer working hours, private savings, and deferred retirement, to mention the most obvious.

A gradual, ongoing increase in life expectancy may be a "risk" shared between generations, depending on the specific design of the system. If the division number is determined on the date of retirement and constant thereafter as in the Swedish system, the pensioners are protected against decreasing consumption possibilities caused by continuous increases in life

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<sup>11</sup> Redistribution is as easy to achieve in a NDC system as in a DB system. Let the benefit be as in eq. 4 if  $b_{k, x+1} > b_{\min}$ , otherwise  $b_{\min}$ . The minimum pension can be financed over the state budget, like the Swedish 'guarantee pension'. The tight connection between contributions and benefits will, however, be broken. Also, an individual's risk of a temporary loss of income due to illness or unemployment can be insured against in the pension system by including remuneration from social insurance in the pension-carrying income,  $w_t$ .

expectancy after the date of retirement. In a DC system indexed by wages this will create a deficit as contributions cannot be raised in order to cover the extra costs. Either a deficit is accumulated (a debt), or it is financed through taxes, or a previously built up fund is decumulated.

### *3.2. Conflict between financial stability and a distribution goal; sum index vs. average wage index*

The growth index shown previously is based on changes in the wage sum with changes in  $L_t/L_{t-1}$  taken into consideration. A wage sum index may in a sense be the “natural” choice of index since the wage sum is the tax or contribution base. However, with a sum index the accrual rate and the outgoing benefits would not follow the standard of living of the working generation.<sup>12</sup> An index based on changes in average wage,  $\chi = \Delta(\Sigma w * L / L)$ , like the indexing in the Swedish system, remedies this flaw.<sup>13</sup>

However, an average index introduces the possibility of financial instability as the benefits no longer follow the changes in the wage sum. For example, with an increase in  $w$ , a decrease in  $L$  and a constant  $\Sigma w * L$ , a sum index is constant while an average index is positive, thus giving benefits that cannot be covered by the contributions.

In section 4 where the simulations are presented, it will become evident that the budget restriction (as in eq. 1 and 2) will be violated in an NDC system, be it indexed by the wage sum or by average wages. This occurs whenever demographic changes change the index or the sum of contributions and benefits. A buffer fund and/or a balance mechanism is necessary to keep the system in balance. It is a matter of taste whether to bring this about by discrete

<sup>12</sup> The effects of using  $\rho$  as an index in combination with the foreseen demographic changes in industrialised countries, decreasing  $L$  and increasing  $R$ , both twisting the distribution to the disadvantage of the pensioners, may be another reason for not choosing such an index.

<sup>13</sup> In the Swedish system, the index during the accrual period is changes in average wage [ $\Delta(\Sigma \text{wages} / (\text{number of people with pension-carrying income, incl. disability pensioners}))$ ]:

$$\chi_t = (Y_{t-1} / Y_{t-4}) \chi_{t-1}$$

where  $Y$  is average income calculated as a three year moving average of average real income;  $\chi_{1999} = 100$ . To be more precise, income is defined as

$$Y = \frac{\text{py}_{(16-64)} + (\text{py}_{(16-64)} > 7,5 \text{ income base amounts}) + \text{public exp. on disability pensions}}{\text{Number of persons having income specified in the nominator}} * \frac{1}{\text{CPI}}$$

where  $\text{py}$  is pension-carrying income and  $\text{CPI}$  is consumer price index.

The annuity from the NDC system is indexed by  $(\chi_t - 1.6)$ , an indexation that has been called ‘adaptation index’. In both cases this holds as long as the automatic stabiliser is inactive.

political decisions, i.e. leaving it to the political process whenever benefits and the accrual rate need to be changed due to demographic or economic changes, or to use an automatic stabiliser.<sup>14</sup>

### *3.3. The index and rate of return in a DC system and NDC system*

There is a fundamental difference between these two designs. In a DC payg system, the rate of return will only be known afterwards, when the worker actually retires. The sum of contributions on that date will be divided by the number of pensioners, determining the pension benefit; and the actual rate of return can be determined. There is no indexation during the accrual / working period, i.e. no “interest” is allotted to the account. The contributions a person has made entitle him to a certain share of the sum of contributions ( $q w L$ ) as a pensioner. In the NDC system, as we have seen in eqs. 3-5, each year’s growth rate affects the notional pension account and so the pension benefit.

As there is path dependency in the economy, the sum of contributions that will be shared in the DC system is, of course, dependent on the economic performance of earlier years – thus, the rates of return in the two systems are intimately connected, but as we will see in the next section, not the same.

## **4. Simulations in a stylized economy**

In analysing the distribution effects of economic and demographic changes and how these effects depend on design and index method chosen, an overlapping generations model is used.

The model set up is as follows:

There are 4 contemporaneously living generations, 3 of working age,  $L_y$ ,  $L_m$  and  $L_o$  where  $y$ ,  $m$  and  $o$  stand for young, middle-aged and old, and 1 generation retirees,  $R = L_o(t-1)$ . A new period starts with a new cohort of  $L_y$  workers entering the labour force, the other cohorts moving one step forward in the life cycle and the last period’s  $R$  die. From a life cycle perspective, assuming each age is of equal length, this setting corresponds to a working life of 45 years, for example 20 – 64, and a retirement period of 15 years, from 65 to 80.

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<sup>14</sup> In the Swedish system an automatic balance mechanism, a so called break, is used. In the former system discrete decisions were taken. The experience of that coping mechanism is that since the late 1960s more than 50 changes have occurred in less than 30 years.

Assume steady-state until period 1. The values in period 0 and before are shown in table 1.

*Table 1. Steady-state values of the economy. Period 0.*

	Ly	Lm	Lo	R	R/L	Total
R, L	10	10	10	10	0.33	
Income, per capita (w)	1	1	1	0		
Cohort income	10	10	10			30
Contribution, 20% (q*w*L)	2	2	2			6
Benefit, per capita (b)				0.6		

This set up, with a dependency ratio of 0.33 – or equivalently a life consisting of 45 working years and 15 years as a pensioner – yields a pension benefit of 60% of the wage at a contribution rate of 20%. In steady-state, a DB system gives the same result as a DC system.

### *Scenarios*

The scenarios are chosen to picture how demographic changes work their way through the system. They are also chosen so as to illustrate the effects of commonly assumed or forecasted demographic events.

### *Changing population structure:*

1. A temporary drop in the cohort entering the labour force, cet.par.;  $Ly(1)=8$ ,  $Ly(2)=10$
2. A permanent drop in the cohort entering the labour force;  
 Period 1:  $Ly(1)=8$ ,  $Lm=10$ ,  $Lo=10$   
 Period 2:  $Ly(2)=8$ ,  $Lm(2)=8$ ,  $Lo(2)=10$ , and so forth
3. Varying cohort sizes:  
 $Ly(1)=8$ ,  $Ly(2)=10$ ,  $Ly(3)=8$ ,  $Ly(4)=10$ , and so on.
4. A baby-boom generation enters the labour force;  
 $Ly(1)=12$ ,  $Ly(2)=10$ ,  $Ly(3)=10$ , and so on.
5. Increase in life expectancy, i.e.  $\eta \uparrow 10\%$

### *Changes in labour supply<sup>15</sup>*

6. A decrease in labour supply in a way that neutralises productivity growth, i.e. all growth is consumed as leisure time. Labour supply down by 20%, causing a drop in registered income but leaving virtual income during working years unaffected, i.e.  $(1 + \lambda)(1+z) = 1$ .
7. Early retirement, decreasing  $L_0$  by a third, increasing  $R$  to the same extent.

### *Results*

Using equations 3 – 5 and the starting values in table 1, the scenarios give the following results. Notations:  $R(1)$  = pensioners in period 1,  $R(2) = L_0(1)$  = pensioners in period 2, i.e. older workers in period 1, and so on.

#### Scenario 1: temporary drop in the labour force; sum index

The cohort entering the labour force in period 1 is only 80% of the preceding as well as of the following cohorts. The index is less than 1 in period 1, 1 in period 2 and 3, and greater than 1 in period 4 ( $z$  is assumed to be 0). Figure 1 shows the effects on benefits.

$R(1)$ : becoming pensioners in the same period as the small cohorts enter the labour market.

$b(R(1))$  drops by the full decrease in  $\lambda$ .

$R(2) = L_0(1)$ : get a decrease in the rate of return on the accrued pension rights from all 3 working periods.  $b(R(2))$  drops by the full decrease in  $\lambda$ .

$R(3) = L_m(1)$ : get a decrease in the rate of return on the accrued pension rights from 2 working periods.

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<sup>15</sup> Note: The system is actuarially designed, i.e. a decrease/increase in a person's labour supply or wage means a decrease/increase in the pension benefit. Thus, there is no economic incentive in advanced or deferred retirement.

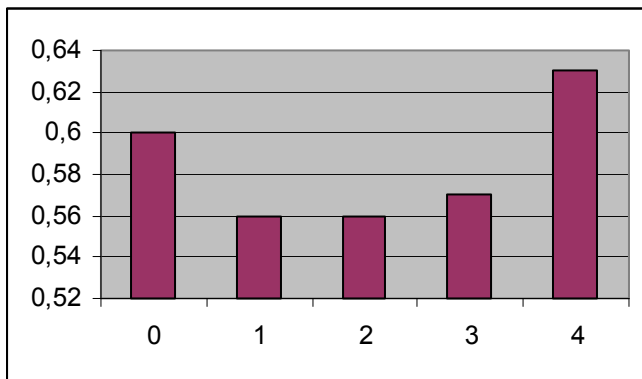


Figure 1. Benefits of different generations after a temporary drop in the labour force.

$R(4) = Ly(1)$ : Get a decrease in the rate of return on the accrued pension rights from their first working period. When they retire the labour force increases and  $b(R(4))$  is indexed by the increase in  $\lambda$ .

In the NDC system indexed by the wage sum, a small cohort surrounded by larger cohorts, in this example  $R(4)=Ly(1)$ , gets a higher benefit than the steady state benefit ( $=0.6$ ). The generations coming out badly due to the drop in labour force are those who retire or are close to retirement when the drop occurs. The generation that is middle-aged when the drop occurs almost regains the steady-state value of the benefit. In period 3, when this generation retires, the financial stability of the system is violated (in eq. 6  $LS < RS$ ). Pension payments exceed the sum of contributions by slightly more than 20%.

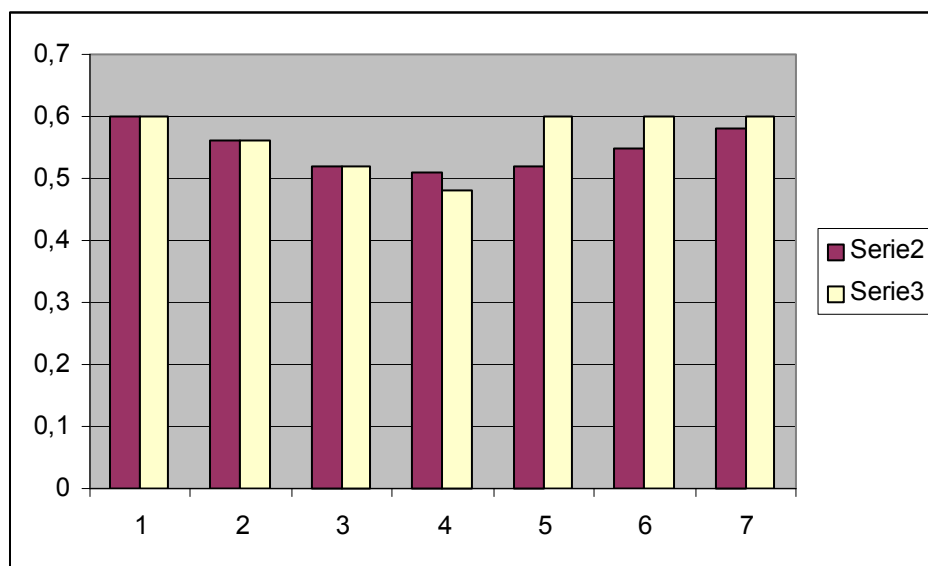
In a DC system, where  $b = q w L/R$  holds strictly for each period, the redistribution between generations is even more accentuated:  $R(1)$  to  $R(3)$  get a benefit of 0.56, while the small generation  $R(4)$  gets a benefit of 0.75.

#### Scenario 2: a permanent drop in the labour force; sum index

The drop in the labour force means a drop in the index. It takes four periods/generations before the index recovers and is back at 1 again.

The results are shown in figure 2. The NDC system is compared with the results in a DC system.

Figure 2. Different generations' benefits after a permanent drop in the labour force. Serie 2 shows the benefit in a NDC system, serie 3 in a DC system.



Notation: 1 = period 0, and so forth

In the NDC system it takes 6 generations of pensioners before the system recovers from a permanent drop in the labour force (or population decline). As can be seen, a DC system has more pronounced fluctuations in benefits than the NDC system, but returns more quickly to the equilibrium level. For some of the generations during the transition period the NDC system gives lower benefits than a DC system.

Scenario 3: varying cohort sizes.

There is a transition period when total population drops, from 40 in period 0 to 38 in period 1 and 2, and to 36 in period 3 and onwards. From period 3 and onwards the population is stable. However, the age structure varies and causes the rate of return to differ between generations. The results are shown in table 2.

Table 2. Results with varying cohort sizes.

	Sum index	Benefit (b)	Surplus/ Deficit
Period 1	0.933	0.56	0
2	0.933	0.56	0
3	0.929	0.53	-0.12
4	1.077	0.59	+1.09
5	0.929	0.57	-0.5
6	1.077	0.62	+0.68
7	0.929	0.59	-0.66
8	1.077	0.62	+0.68

The “worst” outcome (the lowest benefits) is in period 3, when there are two small cohorts in the labour force. In period 4, there is a small cohort retiring, with 2 large cohorts and 1 small in the labour force. In period 5 a large cohort retires, and there are 2 small cohorts and 1 large one in the labour force. These two situations are then repeated.

Using a clear-cut sum index in an NDC system means that small cohorts are ‘favoured’, i.e. get a higher benefit than large cohorts. From period 3 and onwards, the economy is back in a sort of steady-state with a constant population and with regular variations in cohort sizes, and regular variations in benefits.

This scenario clearly shows, that with a changing demographic structure, a Samuelsonian pension system, where each generation gets a rate of return on their contributions equal to the growth rate, does not fulfil the request on either financial stability, or on risk sharing. Thus, benefits vary with cohort size, and the budget restriction (eq. 6) is violated as is shown in the table. The violation of the budget restriction shows alternate surpluses and deficits. Thus, there is a smoothing possibility. Whether voting in a system with a majority rule would yield such a result is a question left for future research.

#### Scenario 4: a baby-boom generation

All generations ahead of a baby-boom generation get a higher benefit than the steady-state case, while the baby-boomers themselves get a lower benefit. Also, the generations coming after a big one get lower benefits due to the decrease in the index when the baby-boom



generation retires. If generations 4 to 7 had a vote in period 0 or 1 they would probably vote in favour of keeping the benefits at the steady-state level, using the surplus to create a buffer fund. However, with a sum index, there is a surplus in all periods but the one when the baby-boomers are pensioners. Thus, there is an option to use these surpluses to even out the consumption possibilities between generations.

*Table 3.*

	Sum index	Benefit (b)	Surplus/ Deficit
Period 0	1	0.6	0
1	1.067	0.64	0
2	1	0.64	0
3	1	0.63	+0.13
4	0.938	0.58	-0.9
5	1	0.56	+0.37
6	1	0.58	+0.25
7	1	0.59	+0.12
8	1	0.6	0

Scenario 5.  $\eta \uparrow 10\%$

$$b(R(0)) = 0,6, b(R(1)) = 0,55, b(R(2)) = 0,5 \dots$$

The accrued pension benefits, the NWs, are unaffected. Due to the design the “burden” of a longer life is entirely borne by the pensioners.

Scenario 6.  $(1 + \Delta\lambda)(1 + \Delta z) = 1$ . A productivity increase is consumed as increases in leisure time.

The sum of income and income per capita are unchanged. Thus contributions as well benefits are unchanged. Virtual income, incl. the value of leisure time, has increased – the sum of contributions is 6, but the sum of contributions out of virtual income is 7.2. The pensioners get 60% of measured or registered income, but only 50% of virtual income.

Scenario 7. A decrease in retirement age.

Lo(1) decides to retire earlier, a pattern preserved by the following generations.  $(1+\lambda_1) = 0,89$ ,  $(1+\lambda_i) = 1$ ;  $i \neq 1$ .  $\eta_1 = 1$ ,  $\eta_i = 1.3$ ,  $i = 2, 3 \dots$

R's benefit:

R(1)'s entire working period was in the steady-state period. Thus, NW is 0.6, which, when they retire, is indexed with  $(1+\lambda_1) = 0.89$ .  $\eta = 1$  gives a benefit of 0.53.

$b(R(2)) = 0,37$ . The reduction in  $b$  compared to the original state is due to three factors. As they retire early, their contributions are reduced (NW is smaller). The earlier retirement of the previous generation caused a reduction in the rate of growth; thus during their last working period their NW gets a negative rate of return. Finally,  $\eta$  is increased due to the earlier retirement.

The benefits of R(3) to R(5) are similarly calculated. The results are shown in table 4.

*Table 4.* Early retirement from period 1 and onwards. Effects on benefits ( $b$ ) in DC-systems and on contributions ( $q$ ) in a DB-system.

	b – NDC	b – DC	q – DB
R <sub>0</sub>	0.60	0.60	0.20
R <sub>1</sub>	0.53	0.54	0.22
R <sub>2</sub>	0.37	0.42	0.29
R <sub>3</sub>	0.38	0.42	0.29
R <sub>4</sub>	0.40	0.42	0.29
R <sub>5</sub>	0.42	0.42	0.29

The system is actuarial. Early retirement reduces contributions; thus the reduction in benefits. A main point here, however, is that other generations will also have to pay for this generation's reduction in work supply (increase in leisure time). Auerbach & Hassett (2001) discuss fiscal policy and risk-sharing between generations. They use a two-period overlapping generations model and show that when the relative risk aversion of the two generations is equal the risk-sharing should be complete. They do not, however, discuss the possibility that the actions of one generation may be the very cause of the productivity change, thereby changing the rate of return for other generations.

### *Average wage index*

In all scenarios, except scenario 6, per capita wage is unchanged. Thus, using an average wage index instead of the sum index used in the examples above, will leave the index unchanged, and, consequently, also the per capita benefit.

*Table 4.*

	Scenario 1		Scenario 2		Scenario 3		Scenario 4	
	$\Sigma q$	$\Sigma b$	$\Sigma q$	$\Sigma b$	$\Sigma q$	$\Sigma b$	$\Sigma q$	$\Sigma b$
Period 1	5.6	6	5.6	6	5.6	6	6.4	6
2	5.6	6	5.2	6	5.6	6	6.4	6
3	5.6	6	4.8	6	5.2	6	6.4	6
4	6	4.8	4.8	4.8	5.6	4.8	6	7.2
5	6	6			5.2	6	6	6
6	6	6			5.6	4.8	6	6

### Scenario 1; a temporary drop in $L_y$

As per capita income does not change, the index is unaffected by this demographic event. Thus, per capita benefits are unchanged. However, a small cohort entering the labour market reduces the sum of contributions. There will be a deficit in the 3 periods during which the small cohort belongs to the labour market, a deficit that will turn into a surplus, offsetting the deficit in period 4 when the small cohort retires. (n.b. no interest rate in the model). To run a system like this, either a possibility of borrowing between generations (a demographic fund) can be organised, or a balancing mechanism has to be introduced.

### Scenario 2; a permanent drop in the labour force entering the labour market

With a sum index the benefits are affected, decreasing to 0.56 for the generation retiring when the drop first occurs, to 0.52 for the next two generations, and to 0.51 for the fourth generation. Thereafter it turns and starts increasing again. With an average index nothing of the sort happens. Average wage is not affected, so the index and benefits are not affected either. Again a deficit accrues in the system.

The accumulated deficit amounts to 75% of the pension system account in the new steady-state. From period 5 and onwards the deficit will not increase. But, unless there is an increase in the number of people belonging to the labour force as in scenario 1, the deficit will not turn into a surplus with the prospect of repaying the deficit and smoothing consumption possibilities. Of course, the debt will have to be managed and financed.

One solution is to create a demographic reserve which can be drawn on when big generations retire, big generations that are followed by small ones. Other solutions are to deviate from the index either by discrete political decisions or by some sort of automatic stabiliser.

#### Scenario 3; varying cohort sizes

Varying cohort sizes, starting with a small cohort entering the labour market, give rise to deficits during the first 3 periods, with a surplus not emerging until the first small cohort retires in period 4. After that surpluses and deficits arise interchangeably.

#### Scenario 4; a baby-boom generation

This is a scenario without problems! 3 periods with surpluses enough to cover the deficit when the big cohort retires in the 4<sup>th</sup> period. There is of course a political risk that the surpluses will be spent under way, as concluded in Browning (1975).

### **5. Conclusions, discussion**

As pointed out in section 4, the scenarios are chosen to picture how demographic changes work their way through the system. They are also chosen so as to illustrate the effects of assumed or forecasted events. The scenario with increased life expectancy depicts, for example, more or less the expected future according to Statistics Sweden's forecasts. In Sweden life expectancy at the age of 65 has increased by 17% for men and 30% for women since 1960, a pattern similar to that in other countries. The scenario with early retirement is highly relevant. The participation rate for men aged 60-64 has fallen from around 70% in the early 1960s to 20-30% in the 1990s. Gruber & Wise (1999, 2001) show convincingly that the design of pension systems per se contributes substantially to this outcome. However, there is nothing in the design of the NDC system that encourages (or punishes) early (delayed) retirement. Therefore, this is how the scenario is set up. Those retiring early are treated actuarially "fair": with early retirement the accrued pension wealth is smaller and is to be divided by an increased number of years compared to a situation with deferred retirement.

The payg DB price-indexed pension systems so common in industrialised countries have been shown to be unsustainable, due, among other things, to ageing populations. The burden of deteriorating economies and population structure is borne by the working generations unless discrete political decisions are taken. The NDC system has many advantages over a DB system, one being transparency. The individual account in which contributions grow with compound interest is easy to follow. Also, tax wedges are reduced as an individual's contributions are registered in her own account, presumably reducing distortions in the labour market.

One purpose of reforming the old pension systems has been to make them financially stable and robust to economic and demographic changes, the latter also achieving a risk-sharing between generations. It has been maintained by many researchers, among others by me!, that with a growth index the fruits of good years and the burden of lean years are shared between the working generations and the pensioners. This paper shows a more complex picture. It shows that an NDC system, whether indexed by the sum of wages or by average wages, does not fulfil these aims when exposed to demographic changes.

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