NOTES ON USING THE HIDDEN ASSET OR THE CONTRIBUTION ASSET TO COMPILE THE ACTUARIAL BALANCE FOR PAY-AS- YOU-GO PENSION SYSTEMS

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NOTES ON USING THE HIDDEN ASSET OR THE CONTRIBUTION ASSET TO COMPILE THE ACTUARIAL BALANCE FOR PAY-AS-YOU-GO PENSION SYSTEMS[*]

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ABSTRACT

The aim of this paper is twofold: to determine the connection between the "contribution asset" and the "hidden asset" and to discover whether using either of them to compile the actuarial balance in Swedish-type pay-as-you-go pension systems will provide a reliable solvency indicator. We develop an overlapping generations model and apply it to the defined benefit pay-as-you-go system, although it would be just as valid for defined contribution systems. On the theoretical side the main conclusion is that, despite their very different natures, in a simplified scenario the hidden asset and the contribution asset may nearly coincide under the assumption that, at the limit, r (the interest rate of the financial market) tends upwards towards G (the growth of the covered wage bill). On the applied side there are three main reasons why it would be better to use the contribution asset to calculate the Swedish-type actuarial balance as a solvency indicator: it has a financial-actuarial basics in the pay-as-you-go pension system as there is no need to use the real rate of interest; it is simple to calculate as there is no need for projections to be made; and it is clear in diagnosing solvency, whereas the hidden asset supplies a solvency indicator which is not always consistent with the system's financial health.

Keywords: Actuarial Balance, Public Pensions, Retirement, Sustainability, Transparency.
JEL classification: H55, H83, J26, M49

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1.-Introduction

The growing social demand for transparency in the financial management of public mandatory systems, the advantages of immunizing the pay-as-you-go (PAYG) system against some of the political risk it faces, and the desire to gain credibility among participants (contributors and pensioners) by reconciling their expectations to the economic realities of the pension plan all call for new management tools to be applied to the PAYG pension system.

The actuarial balance (AB), notional defined-contribution accounts (NDCs) [1] and automatic balance mechanisms (ABMs)[2] provide a suitable answer to all these three issues and also supply a positive incentive to improve financial management by eliminating or at least minimizing the traditional mismatch between the planning horizons of electors, politicians and the system.

Following Boado-Penas et al. (2009), there are basically two methodologies that can be used to compile an actuarial balance for the PAYG system: the "US" and the "Swedish" models. The "US" AB, published by the US Social Security Administration (SSA), belongs to the aggregate or growth accounting models and measures the difference in present value - discounted by the projected yield on trust fund assets – between spending on pensions and income from contributions, expressed as a percentage of the present value of the contribution bases for a period of 75 years, taking into account that the level of financial reserves (trust fund) at the end of the time horizon reaches a magnitude of one year's expenditure. The "US" AB, Plamondon et al. (2002), similar to those published by the authorities in Japan every five years and in Canada every three years, is not a balance sheet in the traditional accounting sense of the term, with a list of assets and liabilities that exist at the valuation point.

The AB for the PAYG pension system as compiled in Sweden does not fit into any of the classical methods such as aggregate or growth accounting, micro-simulation, general equilibrium or indirect models. It can be described as a financial statement listing the pension system's obligations towards contributors and pensioners at a particular date, with the amounts of the various assets (financial and through contributions) which back up those commitments. It has the traditional structure of an accounting balance sheet, with a list of assets and liabilities[3].

Particular reference is made in this paper to the "Swedish" model and, unless otherwise stated, the term 'actuarial balance' will refer to that model.

The entry on the PAYG balance sheet known as the "contribution asset" by Settergren (2001, 2003), Settergren and Mikula (2005), Boado-Penas et al. (2008) and in the literature spawned by the Swedish Social Insurance Agency is called the "hidden asset" by Valdés-Prieto (2002, 2005), who is alone in suggesting its possible theoretical application to the actuarial

[1] See the papers by Palmer (2002), Sunden (2006) or Holzmann and Palmer (2006) amongst many others.
[2] See the papers by Vidal-Meliá et al. (2009, 2010) on this aspect.
[3] See the paper by Boado-Penas et al (2009) for the main differences and similarities between both types of AB with regard to objectives, information provided, structure, projections, valuation of assets/revenues, discount rate, effects on contributors/pensioners, solvency/sustainability indicators, transparency and applicability.

balance. This concept coincides with what has been called the "hidden tax", the "implicit tax on pensions" and the "PAYG asset" by other researchers[4]. It seems clear that the contribution asset (CA) and the hidden asset (HA) cannot appear on the actuarial balance sheet of the PAYG system at the same time. They occupy the same place on the balance sheet and are both based on an assessment of the expected contribution flow. However, as will be seen later, for its calculation the CA uses only factors that have an impact on the cash flows of the PAYGO system and therefore needs no recourse to the interest rate of the financial market, whereas the HA, despite being applied to the PAYG system, must use the discount rate observed in the financial markets, so it can only be determined in dynamically efficient economies[5].

The aim of this paper is twofold: to determine the connection between the contribution asset and the hidden asset and to discover whether using either of them to compile the actuarial balance in PAYG pension systems will provide a reliable solvency indicator. As far as we are aware, there is a large gap in the literature which we are attempting fill with this paper because, until now, this area of study has not been looked at from the perspective of the hidden asset as an entry to be included in the actuarial balance sheet.

Following this brief introduction, in Section 2 we analytically develop both the contribution asset and the hidden asset and obtain the connection between the two. In Section 3 the concepts developed in Section 2 are applied to a complex example representative of the PAYG pension system using a number of reasonable hypotheses. This enables us to assess the reliability of the solvency indicator that appears when the actuarial balance is compiled. Section 4 lists the main conclusions reached. The paper ends with three appendices in which we develop the turnover duration in defined benefit PAYG pension systems, with the assumption that the population increases or decreases over time, we determine the internal rate of return (IRR) of the PAYG system for those generations fully affected by the stationary state. We also present a sensitivity analysis of the numerical results shown in appendix 3.

2.-The contribution asset and the hidden asset.

2.1.- The contribution asset in DB PAYG systems.

The contribution asset (CA) can be interpreted intuitively as the maximum level of liabilities that can be financed by the existing contribution rate (stable income from contributions, increasing or decreasing over time depending on assumptions regarding population growth and earnings growth), without periodic supplements from the sponsor, if the conditions prevailing at the time of valuation remain constant. The value of the CA is the product of the turnover duration (TD) and the value of the contributions made in that period. The TD is the time expected to elapse from when a monetary unit enters the system as a contribution until it leaves in the form

[4] See the papers by Lüdecke (1988), Sinn (2000), Geanakoplos et al. (1998), Beckmann (2000), Thogersen (2001), Lindbeck & Persson (2003), Fenge & Werding (2003, 2004), Disney (2004), Krieger (2005), Cigno (2008) and Robalino & Bodor (2009) among others.

[5] An economy will suffer from dynamic inefficiency when the growth rate of GDP is equal to or greater than the risk-adjusted, long-term real rate of interest in the financial markets.

of a pension, assuming economic, demographic and legal conditions to be constant. This concept is based on population data obtained from a cross-section, not a projection.

To obtain the TD[6], the total expected liabilities are divided by the annual contribution flow, and the interest rate for discounting future pensions and contributions in the financially sustainable PAYG system is taken to be the IRR, i.e. the real growth in wages plus the real growth in the contributing population. Therefore, the TD can be expressed as:

$$TD_t = \overbrace{\underbrace{\frac{\sum_{k=0}^{w-x_e-A-1} N_{(x_e+A+k,1)}\, \ddot{a}^{\lambda}_{x_e+A+k} \left[\frac{1+\lambda}{1+G}\right]^k}{N_{(x_e+A,1)}\, \ddot{a}^{\lambda}_{x_e+A}}}_{pt_r^t}}^{\text{Pay-out duration}} + A - \underbrace{\overbrace{\frac{\sum_{k=0}^{A-1} N_{(x_e+k,1)}\, y_{(x_e+k,1)}\,(k+1)}{\sum_{k=0}^{A-1} y_{(x_e+k,1)}\, N_{(x_e+k,1)}}}^{pt_c^t}}_{\text{Pay-in duration}} \qquad [1.]$$

Being:

$N_{(x_e+k,1)}$: Number of contributors by age at time 1, $N_{(x_e+A+k,1)}$: Number of pensioners by age at time 1, $y_{(x_e+k,1)}$: Average contribution base by age at time 1, A: Years of contribution, x_e: Age of entering at the labor market, x_e+A: Age of retirement, λ: Growth rate of pensions in payment, G: growth of the covered wage bill and $\ddot{a}^{\lambda}_{x_e+A+k}$ being the present value of a lifetime annuity of 1 per year payable in advance growing at real rate λ, valued at age "x_e+A+k" years, with a technical interest rate equal to $d = G$.

where the TD_t can also be calculated as[7]:

$$TD_t = \overbrace{\underbrace{\frac{\sum_{k=0}^{w-x_e-A-1} N_{(x_e+A+k,1)}\, \overbrace{(k+1)}^{(x_e+A+k-(x_e+A-1))} \left[\frac{1+\lambda}{1+G}\right]^k}{\sum_{k=0}^{w-x_e-A-1} N_{(x_e+A+k,1)} \left[\frac{1+\lambda}{1+G}\right]^k}}_{pt_r^t}}^{\text{Pay-out duration}} + \underbrace{\overbrace{\frac{\sum_{k=0}^{A-1} y_{(x_e+k,1)}\, N_{(x_e+k,1)}\, \overbrace{(A-(k+1))}^{(x_e+A-1-(x_e+k))}}{\sum_{k=0}^{A-1} y_{(x_e+k,1)}\, N_{(x_e+k,1)}}}^{pt_c^t}}_{\text{Pay-in duration}} \qquad [2.]$$

where the pay-in duration (see Figure 1) - or on the analogy of Ortin and Prior's (1992) ideas, the average length of stay in the entry flow - is the average time in years that the monetary unit is expected to form part of the liability to contributors before it becomes part of the liability to

6 See Appendix 1.
7 This is similar to the formula used in the report by the Swedish authorities to calculate the real balance. See the Orange Annual Report 2008.

pensioners. The pay-out duration or average length of stay in the exit flow is the number of years that the monetary unit is expected to form part of the liability to pensioners before leaving in the form of benefit payments.

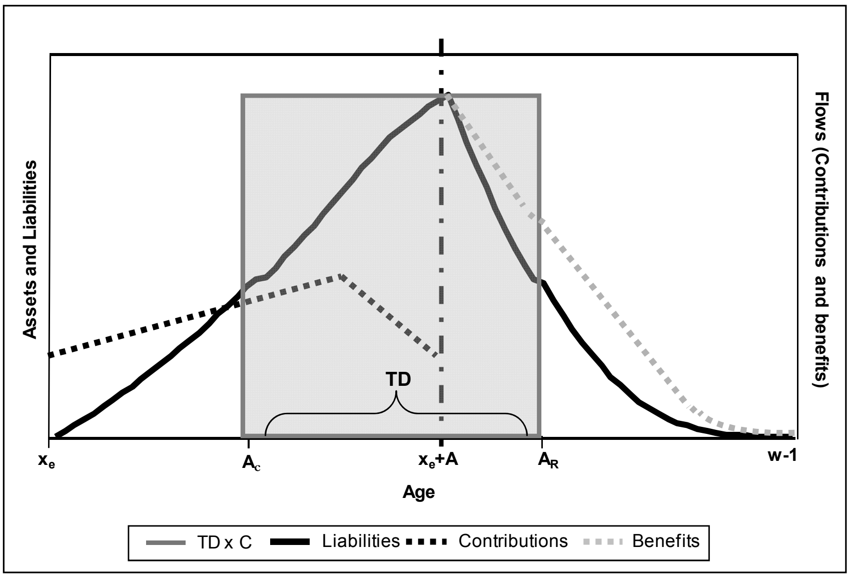

Figure 1: Assets and liabilities of the system and the flows of contributions and benefits.

Figure 1 clearly shows the size of the fund (the system's assets and liabilities) and the size of the flow (the continuous payment of contributions and the corresponding pensions). The assets and liabilities (fund magnitude) are measured on the first vertical axis while the flow of contributions and pensions by age are measured on the second, which for reasons of clarity does not have the same scale as the first. The value of the year's contributions are shown by the height of the rectangle with a base equal to TD_t, which coincides with the maximum value of the system's liabilities, i.e. the sum of all those individuals who reach retirement age x_e + A. In the steady state the amount of liabilities of the system (area below the liabilities function in figure 1) is equal to the product of the turnover duration (TD) and the value of the contributions made in that period (the rectangle in figure 1).

The TD is the time expected to elapse between a monetary unit entering the system as a contribution and leaving in the form of a pension, assuming economic, demographic and legal conditions to be constant, i.e. the time in years that is expected to elapse before all the system's liabilities are renewed or rotated.

$$\frac{V_t^T}{C_t} \equiv TD_t = pt_r^t + pt_c^t \qquad \textbf{[3.]}$$

If "x_e+A-1" years are added to and subtracted from the above expression, the TD is the difference in expected weighted average ages of pensioners and contributors:

$$TD_t = \overbrace{(x_e + A - 1) + pt_r^t}^{\text{Weighted average age for the pensioners}} - \underbrace{(x_e + A - 1 - pt_c^t)}_{\text{Weighted average age for the contributors}} =$$

$$= \overbrace{(x_e + A - 1) + \frac{\sum_{k=0}^{w-x_e-A-1} N_{(x_e+A+k,1)}\, \ddot{a}^{\lambda}_{x_e+A+k} \left[\frac{1+\lambda}{1+G}\right]^k}{\sum_{k=0}^{w-x_e-A-1} N_{(x_e+A+k,1)} \left[\frac{1+\lambda}{1+G}\right]^k}}^{\text{Weighted average age for the pensioners}} - \underbrace{\left(x_e + A - 1 - A + \frac{\sum_{k=0}^{A-1} y_{(x_e+k,1)} N_{(x_e+k,1)} (k+1)}{\sum_{k=0}^{A-1} y_{(x_e+k,1)} N_{(x_e+k,1)}} \right)}_{\text{Weighted average age for the contributors}} =$$

$$= \underbrace{\frac{\sum_{k=0}^{w-x_e-A-1} N_{(x_e+A+k,1)} (x_e + A + k) \left[\frac{1+\lambda}{1+G}\right]^k}{\sum_{k=0}^{w-x_e-A-1} N_{(x_e+A+k,1)} \left[\frac{1+\lambda}{1+G}\right]^k}}_{A_r^t} - \underbrace{\frac{\sum_{k=0}^{A-1} y_{(x_e+k,1)} N_{(x_e+k,1)} (x_e + k)}{\sum_{k=0}^{A-1} y_{(x_e+k,1)} N_{(x_e+k,1)}}}_{A_c^t} = A_r^t - A_c^t$$

[4.]

It must be stressed that the TD in this theoretical model, irrespective of the IRR used to discount the pensions and contributions, is always equal to the difference in expected weighted average ages of contributors A_c^t and pensioners A_r^t, which, in the case of a real pension system with its specific contributor-pensioner structure configuration, involves the additional difficulty of having to determine what IRR to apply.

As deduced from the process, the TD_t is interpreted as the number of years expected to elapse for the committed liabilities with contributors and pensioners to be completely renewed at the current level of contributions, since it is established that the system is in a stationary state and every year pension spending is paid for with the income from contributions.

As shown in Formula 2 and Figure 1, not all contributions are paid to pensioners aged "$x_e + A$" years because pensioners whose ages range from "$x_e + A$" years to "$w-1$" years coexist within the system. The contributions are also paid by a set of contributors ranging in age from "x_e" to "$x_e + A - 1$" years. Indeed the expression of the TD_t in Formula 4 attempts to include this fact. Each monetary unit enters the system as if it were paid by a contributor of "A_c" years and remains *within* the contribution liability until retirement age is reached (pay-in), and is received by the pensioner of "A_r" years after remaining *within* the liability to pensioners during the pay-out.

So as to avoid inexact interpretations[8] which distort the concept, the TD_t can also be expressed as:

$$TD_t = \overbrace{(x_e + A)}^{\text{Age of retirement}} - \underbrace{\frac{\overbrace{(A_c^t - pt_r^t + 1)}^{\text{Normalized weighted average age for the contributors}}}{A_c^*}} \quad \textbf{[5.]}$$

Hence the CA is the product of the system's TD for yearly contributions:

$$CA_t = \underbrace{C_t * \underbrace{(A_r^t - A_c^t)}_{TD_{t'}}}_{\text{Contribution asset}} = \overbrace{V_t}^{\text{Liabilities}} = C_t * (pt_r^t + pt_c^t) \quad \textbf{[6.]}$$

In a theoretical model such as the one suggested, actuarially balanced and in an initial stationary state, the value of the TD, under variations of the system's parameters, has the following properties in a new steady state:

1.-*For a value of* γ *(growth rate of population) constant, the TD remains constant as long as it is considered that* g *(growth rate of contribution base) is equal to* λ *(growth rate of pensions in payment), as can be seen in the first term (pay-out) of Expression 2*, *whereas the second term (pay-in) remains constant even though there are changes in the value of these parameters. It is important to stress that although the TD and the dependency rate do not change, there are changes in the amount of the pensions awarded by the system, in the contribution rate and, obviously, in the system's assets and liabilities in a balanced state.*

2.-The TD, for a value of γ *constant, depends on the difference* $g - \lambda$ *(decreasing as this difference grows), as can be deduced from the first term (pay-out) of Expression 2. In fact the TD increases or decreases because the expected weighted average age of the pensioners changes. The expected age of the contributors remains the same (second term of Expression 4).*

3.-The TD for a value of λ *and g without changes decreases as* γ *increases and vice versa and the expected weighted average age of the pensioners is reduced (or increased), although there are changes in the amount of the pensions awarded by the system, in the contribution rate and in the system's assets and liabilities in a balanced state.*

4.-For a value of $\lambda =$ *constant, the TD remains constant as long as* $\gamma + g$ = constant, *as can be deduced from the first term (pay-out) of Expression 2. In this assumption the contribution rate in a balanced state will also remain constant, although there will be variations in the*

[8] See the paper by Andrews (2008), page 70.

dependency rate (Expression 21) and in the system's average contribution-average pension ratio (Expressions 23 and 25).

5.-The TD decreases (increases) with increases (decreases) in the slope of the age-wage structure, as can be deduced from the second term (pay-in) of Expression 2. In fact the TD increases or decreases because the expected weighted average age of the contributors changes, while that of the pensioners remains the same (first term of Expression 2). In this assumption the dependency rate in a balanced state remains constant, although there will be variations in the contribution rate (Formula 20) and in the system's average contribution-average pension ratio.

6.-The TD increases (decreases) when there are increases (decreases) in longevity - as can be seen in Expression 2 - as there is an increase (decrease) in the pay-out. Clearly the increase (decrease) in longevity increases (decreases) the contribution rate for a balanced state and the system's assets and liabilities[9]*.*

7.-Variations in retirement age. An increase (decrease) in retirement age would be expected to increase (decrease) the expected weighted average age of pensioners and contributors (Expression 4). The combined effect on the TD would also depend on all the other parameters that affect the pension system, such as the salary profile and the mortality pattern.

8.-Variations in the number of generations of contributors for a particular retirement age. An increase (decrease) in the number of generations of contributors would be expected to increase (decrease) the TD because the weighted average age of the contributors would decrease (increase), although clearly both the contribution rate for a balanced state and the contributor-pensioner ratio would have to decrease (increase).

9.-Variations in the number of generations of pensioners for a particular retirement age. An increase (decrease) in the number of generations of pensioners would be expected to increase (decrease) the TD because the weighted average age of the pensioners would increase (decrease), although clearly both the contribution rate for a balanced state and the contributor-pensioner ratio would have to increase (decrease). Naturally this is similar to the variations in longevity.

2.2.-The hidden asset in DB PAYG systems.

According to Valdés-Prieto (2002), the hidden asset (HA) is the present expected value of the hidden taxes that the system will apply to its participants in the future, either in the form of excess contributions in relation to the pensions to be provided or in the form of insufficient

[9] This explains Robalino and Bodor's (2009) objections regarding the TD: "*the TD can increase as a result of an increase in life expectancy and that would be perceived as an increase in contribution assets when in fact that increase can reduce the pay-as-you-go asset as individuals receive pensions for longer".* The truth is that the TD is not an isolated element within the pension system. It is related to the other parameters too.

pensions in relation to the contributions paid. Hidden taxes are defined as contributions in excess of those that would be needed by a capitalized system to pay the same benefits. Their existence stems from the theoretical assumption that contributions should yield the interest rate of the financial market and that the economy suffers no dynamic inefficiency. Theoretical macroeconomic equilibrium stipulates that r > G, both in the specific cases of certainty as shown by Tirole (1985), and uncertainty, following Demange (2002) and Krueger & Kubler (2006).

An economy will suffer from dynamic inefficiency when the growth rate of GDP is equal to or greater than the risk-adjusted, long-term real rate of interest in the financial markets. It does not imply that the funded system is always preferable to the PAYG system. As Barr and Diamond (2009) point out: "*Since long-run rates of return exceed growth rates, the higher stock market return is sometimes presented as a pure gain. This argument is flawed because it does not compare like with like. A fuller analysis considers (a) the costs of the transition from PAYG to funding, (b) the relative risks of the two systems, and (c) their respective administrative costs*". Furthermore, for Matsen and Thogersen, (2004), a low-yielding PAYG system can benefit individuals if it contributes to hedging other risks to their lifetime resources. Likewise, De Menil et al. (2006), the really important thing is that the PAYG system (NDC or DB) can enhance welfare, even in dynamically efficient economies, because of the insurance it provides against otherwise uninsurable macroeconomic risk. Knell (2008) shows analytically that in an overlapping generations (OLG) model the optimal share of funding decreases with the strength of individuals' concern for relative standing.

As mentioned in the introduction, the definition given by Valdés-Prieto (2002, 2005) coincides with what has been called the "hidden tax", the "implicit tax on pensions"[10] and the "PAYG asset"[11] by other researchers such as Lüdecke (1988), Sinn (1990, 2000), Geanakoplos et al. (1998), Beckmann (2000), Lindbeck & Persson (2003), Fenge & Werding (2003 and 2004), Disney (2004), Krieger (2005), Cigno (2008) and Robalino & Bodor (2009).

If the concept of the HA is developed, when "$w-x_e-A=t$" years have passed since the inception of the system, the concept can be generalized and it can also be shown that the HA and the CA can coincide under certain circumstances.

It is assumed that the covered wage bill of the pension system grows at the real annual rate of G, where $G=(1+g)(1+\gamma)-1$, according to the notation used in the previous section.

This would give:

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[10] According to Cigno (2008), the difference between the present value of the contributions and the present value of the benefits for an individual constitutes an implicit tax. If this difference is negative, it constitutes an implicit subsidy.

[11] According to Robalino and Bodor (2009), the "PAYG Asset" is defined as "the present value of future contributions minus the present value of pensions ensuing from these contributions".

$$HA_t \equiv \sum_{i=0}^{\infty}\left[\sum_{k=0}^{A-1}\theta^{*}\cdot y_{(x_e+k,\,t)}\cdot N_{(x_e+k,\,t)}\right]\left[\frac{1+G}{1+r}\right]^{i} = \theta^{*}\sum_{k=0}^{A-1} y_{(x_e+k,\,t)}\cdot N_{(x_e+k,\,t)}\left[\frac{1+r}{r-G}\right] \quad \textbf{[7.]}$$

where $\theta^{*} = (\theta - \theta_f)$ is the excess contribution rate that the system has to apply in perpetuity to its contributors in order to remain financially solvent. In this formula it seems clear that the biggest difficulty is in setting the value of θ_f depending on the r considered.

Given that in a system in a stationary state, as shown earlier, the contribution asset is equal to the liability, the hidden asset must in the same way be equal to the system's total liability valued with discount rate r. The actuarially fair rate that makes $HA_t = V_t^{T\,(r>G)}$ is:

$$\theta_f = (\theta - \overbrace{\frac{V_t^{T\,(r>G)}\left[\frac{r-G}{1+r}\right]}{\sum_{k=0}^{A-1} y_{(x_e+k,\,t)}\cdot N_{(x_e+k,\,t)}}}^{\text{Perpetual excess contribution rate}}) \quad \textbf{[8.]}$$

It can immediately be seen that the excess contribution that has to be paid every year in perpetuity by all contributors is to cover that part of the liability[12] deriving from those affiliates who received payments without having made any contributions or without having paid them in full but who benefited from a higher IRR than other generations[13] (in the first year the system started there were already beneficiaries who had not paid contributions, and in the second year those who received a pension had only contributed for one year and received a full pension. Only when A years had passed would all beneficiaries have a full contribution record):

$$\overbrace{\theta^{*}\sum_{k=0}^{A-1} y_{(x_e+k,\,t)}\cdot N_{(x_e+k,\,t)}}^{\text{Excess yearly contributions}} = \underbrace{V_t^{T\,(r>G)}\left[\frac{r-G}{1+r}\right]}_{\text{Pepertual interest cost acrrued by actuarial liabilities}} \quad \textbf{[9.]}$$

It is therefore consistent that the excess contribution should be discounted from the contribution rate needed to balance the system in order to obtain the actuarially fair contribution rate in line with the performance of the financial market.

In the stationary state described, if it is considered that r > G, it can be stated that:

$$(CA_t = V_t^{T\,(r=G)}) > (HA_t = V_t^{T\,(r>G)}) \quad \textbf{[10.]}$$

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[12] Note that this part of the liability can be minimized if it is considered that during the first A years the affiliates who start to receive a pension receive only a fraction of the replacement rate $\beta\cdot$y(c, k-1))*(k/A) depending on the years contributed by their generation (k). Only those who contribute over their whole working life will receive the full amount.

[13] See this demonstrated in Appendix 2.

and it is also clear that as the difference r-G is reduced, the value of the HA will move closer towards the value of the CA; and at the limit where r tends upwards towards G[14], the difference between those values tends to zero given that the value of their liabilities becomes nearly equal:

$$\lim_{(r-G)\to 0^{+}}(CA_t - HA_t) = (V_t^{T\,(r=G)} - V_t^{T\,((r-G)\to 0^{+})}) \cong 0 \qquad \textbf{[11.]}$$

and, in this case, $\theta_{eq} = \theta \cong \theta_f$.

2.3.-The contribution asset and the hidden asset as items to be integrated into the "Swedish" actuarial balance.

This subsection summarizes the two previous ones by comparing the main elements that characterize the CA and the HA as items to be integrated into the "Swedish" actuarial balance. The main economic implications will then be discussed.

The CA is the maximum liability that can be financed in the long term by the present contribution rate (income from contributions that is stable, increasing or decreasing over time depending on assumptions regarding population growth) without requiring additional funding from the promoter, assuming a stationary state. The HA is defined as the present value of the hidden taxes or subsidies[15] that the system will have to apply to its contributors in the future, within legislated parameters and with trends known. These hidden taxes in turn are defined as the contributions in excess of those that would be needed by a capitalized system to pay the same benefits.

The basics of each concept is different. The CA is based on the turnover duration (TD) and is the product of the annual contributions multiplied by the difference between the expected weighted average age of pensioners, A_r^t, and contributors, A_c^t. The TD is the expected number of years needed for the complete rotation of the committed liabilities with contributors and pensioners under present legislation, including contribution levels, age-distributed income profiles and mortality rates. In practice, Boado-Penas et al (2009), if the population declines (increases), there is a risk that the accounts will (slightly) overstate (understate) the system's assets in relation to its liabilities, since in such a case the turnover duration is (slightly) overestimated (underestimated). However, as the balance sheet must be compiled every year according to verifiable events and transactions, it tends to provide a true and fair view. The stationary demographic and economic state is certainly not ex-post facto true, but because successive changes are included as they are registered in successive balance sheets, the solvency indicator remains reliable[16]. Another requirement for calculating the TD is that the only

[14] It should be remembered that the function of the "hidden asset" is discontinuous and indeterminate for r=G, and its value tends towards less than infinite when r tends towards G on the left.
[15] The subsidies could originate in the form of insufficient contributions in relation to the pensions to be received.
[16] See the papers by Auerbach and Lee (2009a and 2009b).

contingency assessed is retirement. Other contingencies such as invalidity or survivor benefit make it more difficult to define the TD in both theoretical and practical terms.

The HA is based on the theoretical assumption that contributions should yield a return at the interest rate of the financial market (relating the PAYG system to the capitalization system), that the economy does not suffer from dynamic inefficiency ($G \geq r$), and that the excess contribution to be paid every year in perpetuity by all contributors is allocated to cover that part of the liability deriving from those affiliates who received pensions without having made any contributions or without having paid them in full but who benefited from a greater IRR than all the other generations.

The relation that both these assets have with the system's liabilities is also different. In order for it to be consistent with the CA, the system's actuarial liability has to be calculated with the rate of return of the PAYG system, which is assumed to be $G = (1+g)(1+\gamma)-1$. The actuarial liability will be greater than that of the capitalization system if the hypothesis of dynamic efficiency is fulfilled. And on the practical side, Boado-Penas et al (2009), both the assets and the liabilities are valued on the basis of verifiable cross-section facts, i.e. no projections are made[17]. For example, current longevity is used even though it is expected to increase. If and when that expectation materializes in new mortality tables, this will be incorporated into the information on the balance sheet on a year-to-year basis.

In the case of the HA, for consistency the system's actuarial liability has to be calculated using the rate of return of the financial market, r. Unlike in the previous case, the actuarial liability would coincide with the liability there would be if the pension system were funded by capitalization. It seems clear that the liability calculated with either G or r answers two different questions: 'What is the value of the commitment to contributors and pensioners taken on by the system?', for the liability calculated with G, and 'How much would the system have to pay a third party if it decided to contract out or transfer its commitments to contributors and pensioners?', if the liability was calculated with r.

There are also differences in the practical application of both concepts. The CA, Försäkringskassan (2010), is applied in order to compile the actuarial balance for Swedish Social Security, which has a DC PAYG pension system (NDC), and is fairly straightforward to calculate as it needs no projections of economic, demographic or financial variables.

The HA, however, has only a theoretical application so far. Apart from the difficulty in setting the value of r, it needs projections of economic, demographic and financial variables in order to be calculated. Most authors that have used the concept have not suggested that it be used to compile actuarial balances. Disney (2004), for example, constructs indicators of the tax

[17] It would be necessary to make projections for the DB PAYG pension system as liabilities to contributors have to be calculated using the prospective method. See appendix 1

component of pension programmes, both between and within generations, across a range of OECD countries and time periods, and Fenge and Werding (2004) use the concept of the 'implicit tax rate" to measure intergenerational imbalances in unfunded public pension schemes.

A concept that brings to mind what Valdés-Prieto (2002) defined as the "hidden asset" is used in the extremely detailed report from which the "US" actuarial balance is compiled, BOT (2010). The US administration defines it as the system's "unfunded obligation" with a perpetual horizon. It is calculated by the "present value of future benefits less future contributions for current and future participants, considering that the reserve fund runs dry and legislation is constant"[18]. It is also assumed in the calculations that there is dynamic efficiency in the economy (r>G), which makes convergence and financial sense feasible.

The "hidden asset" and the "unfunded obligation" are clearly two different concepts because, although projections for a perpetual horizon are made and the interest rate of the financial market is used, the hidden asset is based on the concept of excess contributions in relation to the pensions to be received, while the "unfunded" liability considers the present value of all the system's contributions and benefits in the future. And in order to analyse the PAYG system's sustainability/viability, the value of the hidden asset would have to be related to the liabilities, and the value of the "unfunded liability" would in itself already be an indicator of the system's sustainability.

The positive amount of the "unfunded obligation" shows that the PAYG system in the USA is unsustainable because the participants should not have a realistic expectation of receiving the benefits that have been promised without the system's sponsor (the State) having to make periodic additional contributions. In other words, at some point in the future, unless the sponsor allocates extraordinary funds to cover the extra liability, the promises made to some participants will be partially broken.

However, although their analytical expressions appear to be somewhat different, their structures are based on the taxable wage bill, a financial and multiplying effect[19], and various contribution rates. For the CA:

[18] It should be pointed out that Table IV.B7 on page 66 of this report shows an "*unfunded obligation for all participants through the infinite horizon*" of $US 16.1 trillion at 1.1.10, which represents an annual 1.2% of the value of future GDPs or approximately 109% of the projected GDP for 2010. In other words if the projections for a perpetual horizon are accurate, the promoter will have to inject financial resources at a present value of $US 16.1 trillion into the system in order to fund all the scheduled benefits.

[19] According to Settergren (2003), the TD can be interpreted as the value supplied by discounting a perpetual flow of contributions, where the discount factor is the inverse of the TD. For example, if the value of the TD is 33 years, the CA is calculated by discounting a perpetual (yearly) contribution with an interest rate of 3.03%.

$$CA_t = \left[\underbrace{\theta}_{\text{Rate of contribution}} \overbrace{(A_r^t - A_c^t)}^{\text{Financial factor}} \right] \left[\underbrace{\sum_{k=0}^{A-1} y_{(x_e+k,t)} N_{(x_e+k,\ t)}}_{\text{Aggregate contribution base}} \right] \quad \textbf{[12.]}$$

while for the HA it is:

$$HA_t = \left[\underbrace{\overbrace{\theta^*}^{(\theta-\theta_f)}}_{\text{Rate of contribution (excess)}} \overbrace{\left[\frac{1+r}{r-G}\right]}^{\text{Financial factor}} \right] \left[\underbrace{\sum_{k=0}^{A-1} y_{(x_e+k,\ t)} \cdot N_{(x_e+k,\ t)}}_{\text{Aggregate contribution base}} \right] \quad \textbf{[13.]}$$

and as we saw in the previous subsection, since the difference r-G is reduced, the value of the HA moves closer to the value of the CA, and at the limit when r tends towards G and upwards, the values of both coincide, and $\theta_{eq} = \theta = \theta_f$.

Finally, the AB of a balanced PAYG system with the CA will be:

Table 1: Actuarial Balance Sheet of a Balanced PAYG System with CA.	
ASSETS	**LIABILITIES**
Contribution Asset, CA_t (Formula 6 or 12, flow of contributions based on current contributors and the turnover duration if the conditions prevailing at the time of valuation remain constant.)	Liability to current pensioners, V_t^r (Formula 28, with d=G)
	Liability to current contributors V_t^c (Formula 29, with d=G)
Total Assets	**Total Liabilities**

Whereas with the HA it will be:

Table 2: Actuarial Balance Sheet of a Balanced PAYG System with HA.	
ASSETS	**LIABILITIES**
Hidden Asset, HA_t (Formula 7 or 13, flow of contributions based on the excess contribution rate that the system has to apply in perpetuity to its future contributors in order to remain financially solvent.)	Liability to current pensioners, V_t^r (Formula 28, with d=r)
	Liability to current contributors V_t^c (Formula 29, with d=r)
Total Assets	**Total Liabilities**

And in both cases the solvency ratio, $SR_t = \frac{\text{Assets}}{\text{Liabilities}}$, is equal to one in the case of a balanced pension system, but more items may appear when compiling an actuarial balance for an already-functioning defined-benefit pension system. These could be financial assets or liabilities that may have accumulated, and the system's deficit or surplus. As a result Tables 1 and 2 could become Tables 3 and 4 and the solvency indicator could be different to one. In the latter case, promises of pension payments would mean that the contribution rate would have to be either reduced or increased in order to re-establish balance to the system.

The accumulation of losses in each period determines the value of the accumulated deficit, and the "losses in each period" represents the difference between the increase in the value of actuarial liabilities and assets for the period. If the increase in assets were greater than the increase in liabilities, there would be ''actuarial profits'' in the period, and likewise, the accumulation of profits in each period determines the value of the accumulated deficit.

Table 3: Actuarial Balance Sheet of an already DB PAYG System with CA	
ASSETS	**LIABILITIES**
Financial Assets	Financial Liabilities (explicit debt, to finance treasury deficits)
	Liability to current pensioners
Contribution Asset	Liability to current contributors
Accumulated Deficit	Accumulated Surplus
Total Assets	**Total Liabilities**

The accumulated deficit in DB pension systems is due not only to demographic and economic factors but also to the phenomenon known as populism in pensions, which occurs more often in countries which do not periodically draw up an actuarial balance. For Vidal-Meliá et al (2009), *populism in pensions* can be defined as a form of competition between politicians in which voters are offered subsidies and benefits without the voters appreciating that it is they themselves who will pay through higher taxes, higher contributions, higher inflation or reduced economic growth. Populism manifests itself in higher spending on the pension system generated by unjustified increases in minimum pensions, the increase or extension of payments without the contributions to cover them, the awarding of disability pensions without rigour, and contribution subsidies. Populism in pensions is aggravated if a country suffers from a weak democratic structure.

In the case of the hidden asset, if the contribution rate really was lower than the actuarially fair rate ($\theta < \theta_f$), a negative asset (extra-liability) would be obtained. Boado-Penas et al. (2008) have described theoretical situations in which the HA would be negative, but when it comes to compiling the balance sheet for the pension system it would be difficult to apply.

Robalino and Bodor (2009) also justify a pension plan operating with a negative PAYG asset if the system is very generous, meaning it pays an IRR above market rates, but not forever.

Table 4: Actuarial Balance Sheet of an already DB PAYG System with HA	
ASSETS	**LIABILITIES**
Financial Assets	Financial Liabilities
	Liability to current pensioners
Hidden Asset, positive if $\theta > \theta_f$	Liability to current contributors
	Extra-liability = Negative Hidden Asset[20] if $\theta < \theta_f$
Accumulated Deficit	Accumulated Surplus
Total Assets	**Total Liabilities**

3.-Using the contribution asset and the hidden asset as solvency indicators: some numerical results.

In this section we show the results obtained for the actuarial balance when different contribution rates are applied, looking especially at the solvency ratio obtained when using the contribution asset and the hidden asset. Basically it is a question of analysing what would happen in a situation of insolvency. What values would the actuarial balance supply?

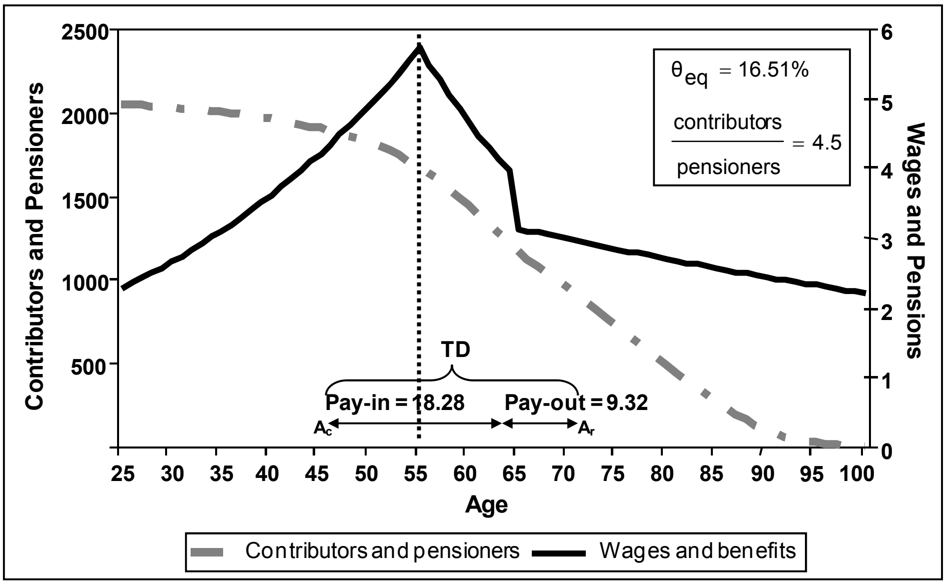

Figure 2: Contributors, pensioners, wages and pensions of the system.

Figure 2 shows contributors and pensioners by age and contribution (wage) and pension structure in a stationary state, 36 years after the inception of the system, assuming that g grows

[20] In practice, Robalino and Bogomolova (2006), the HA (or PAYG asset, in their terminology) tends to be negative in most DB PAYG systems.

at an annual accumulative rate of 1% and the population grows at an annual accumulative rate of 2%, and that the pension payable to pensioners at age 65 is 80% of the previous 40 years' contributions and constant in real terms ($\lambda = 0\%$).

Under these conditions the contribution rate for balance is 16.51%, the TD is 27.59 years (weighted average age of pensioners 73.32 years, weighted average age of contributors 45.72 years), which is distributed over 9.32 years for the pay-out and 18.28 years for the pay-in, and the contributor-pensioner ratio is 4.5.

BALANCED PENSION SYSTEM

In this case both the CA and the HA supply a 100% solvency ratio as the system is balanced in the stationary state. The value of its assets will therefore be the same as the value of its liabilities, although the composition of the liabilities may change. Tables 5a, 5b and 5c show the actuarial balance for the CA as well as the HA.

Table 5a: Balanced Pension System (estimated with CA).

ASSETS			**LIABILITIES**		
Item	Monetary units	%	%	Monetary units	Item
Contribution Asset	1,283,135.10	100	33.76	433,225.80	Liability to Pensioners
Accumulated Deficit	0	0	66.24	849,909.30	Liability to Contributors
Total Assets	1,283,135.10	**100**	**100**	1,283,135.10	**Total Liabilities**
G=(1.01)(1.02)-1=0.0302					

Table 5b: Balanced Pension System (estimated with HA).

ASSETS			**LIABILITIES**		
Item	Monetary units	%	%	Monetary units	Item
Hidden Asset	938,329.77	100	43.47	407,885.62	Liability to Pensioners
Accumulated Deficit	0	0	56.53	530,444.15	Liability to Contributors
Total Assets	938,329.77	**100**	**100**	938,329.77	**Total Liabilities**
G=0.0302; r=0.04					

Table 5c: Balanced Pension System (estimated with HA).

ASSETS			**LIABILITIES**		
Item	Monetary units	%	%	Monetary units	Item
Hidden Asset	693,241.55	100	55.51	384,839.69	Liability to Pensioners
Accumulated Deficit	0	0	44.49	308,401.86	Liability to Contributors
Total Assets	693,241.55	**100**	**100**	693,241.55	**Total Liabilities**
G=0.0302; r=0.05					

Naturally in the case where $r \cong G$, as shown earlier, the actuarial balance calculating with the contribution asset and the hidden asset will be similar.

UNBALANCED PENSION SYSTEM[21]

Instead of being balanced, the contribution rate (CR) is considered to be 14.94% (θ_{dq}), which is still greater than the fair contribution rate when r>G. The debt would also change because of this since the liability for future contributions would increase as these would be made at a lower rate (14.94%<16.51%) for benefit entitlement [22].

In this specific case the actuarial balance with the CA would supply a solvency indicator of 84.18%. The value of the accumulated deficit would therefore be the extra contribution the promoter would have to make in order to fulfil its commitments to all contributors and pensioners. This extra contribution could be offset if there had been an accumulated surplus in previous periods.

Table 6a: Unbalanced Pension System (estimated with CA).					
ASSETS			**LIABILITIES**		
Item	Monetary units	%	%	Monetary units	Item
Contribution Asset	1,161,026.73	**84.18**	31.41	433,225.80	Liability to Pensioners
Accumulated Deficit	218,250.33	15.82	68.59	946,051.27	Liability to Contributors
Total Assets	1,379,277.06	**100**	**100**	1,379,277.06	**Total Liabilities**
G=0.0302; θ = 16.51%; θ_{dq}=14.94%					

The actuarial balance compiled using the HA will supply a very different solvency indicator. Before the imbalance the excess contribution was $\theta - \theta_f = \theta^*$, where is what contributors really pay in a balanced system and θ_f is what they should pay (depending on the market interest rate). *With a situation of imbalance the excess contribution is* $\theta_{dq} - \theta_f = \theta^*_{dq}$

The difference between the two HAs for both situations, before and after imbalance, is:

$$(\theta^* - \theta^*_{dq})\sum_{k=0}^{A-1} y_{(x_e+k,\,t)} \cdot N_{(x_e+k,\,t)} \left[\frac{1+r}{r-G}\right] = HA_t - HA^*_t \qquad \textbf{[14.]}$$

[21] For simplicity, the numerical results in the tables are shown for the unbalanced contribution rates that follow the formulae θ_{eq}-(θ_{eq}-θ_f)/2 and θ_{eq}+(θ_{eq}-θ_f)/2 respectively, where θ_f, in this case, corresponds to the lower r considered in each example.

[22] A problem appears in the unbalanced system when it comes to valuing the liability with contributors because it will not coincide using the prospective or retrospective methods. The liability to contributors will be greater (real) if it is valued with the prospective method rather than the retrospective. The system is unbalanced in favour of the contributors and this is reflected in the calculation.

where HA_t is the HA in a balanced situation (equal to the liability) and HA_t^* is the HA in an unbalanced situation. If we calculate:

$$HA_t - (\theta^* - \theta^*_{dq}) \sum_{k=0}^{A-1} y_{(x_e+k,\,t)} \cdot N_{(x_e+k,\,t)} \left[\frac{1+r}{r-G} \right] = HA_t^* \qquad \textbf{[15.]}$$

or as:

$$\sum_{k=0}^{A-1} y_{(x_e+k,\,t)} \cdot N_{(x_e+k,\,t)} \left[\frac{1+r}{r-G} \right] = \frac{HA_t}{\theta^*} \qquad \textbf{[16.]}$$

substituting in the previous formula:

$$HA_t\left(\frac{\theta^*_{dq}}{\theta^*}\right) = HA_t^* = HA_t\left(\frac{\theta_{dq} - \theta_f}{\theta - \theta_f}\right) \qquad \textbf{[17.]}$$

the results for assets, liabilities and solvency ratio are:

Table 6b: Unbalanced Pension System (estimated with HA).					
ASSETS			**LIABILITIES**		
Item	Monetary units	%	%	Monetary units	Item
Hidden Asset (Equation 17)	468,677.44	**45.78**	39.85	407,885.62	Liability to Pensioners
Accumulated Deficit	554,996.81	54.22	60.15	615,788.63	Liability to Contributors
Total Assets	1,023,674.25	**100**	**100**	1,023,674.25	**Total Liabilities**
G=0.0302; r=0.04; θ = 16.51%; θ_{dq}=14.94%; θ_f =13.37%					

Table 6c: Unbalanced Pension System (estimated with HA).					
ASSETS			**LIABILITIES**		
Item	Monetary units	%	%	Monetary units	Item
Hidden Asset	458,552.23	**59.59**	50.01	384,839.69	Liability to Pensioners
Accumulated Deficit	310,915.69	40.41	49.99	384,628.23	Liability to Contributors
Total Assets	769,467.92	**100**	**100**	769,467.92	**Total Liabilities**
G=0.0302; r=0.05; θ = 16.51%; θ_{dq}=14.94%; θ_f =11.87%					

If the imbalance were due to a real contribution rate, θ_{dq}, of 18.08%, table 7a, the actuarial balance with the CA supplies a solvency ratio of 118.35% (contribution asset/(liability to pensioners + liability to contributors)):

Table 7a: Unbalanced Pension System (estimated with CA).					
ASSETS			**LIABILITIES**		
Item	Monetary units	%	%	Monetary units	Item
Contribution Asset	1,405,044.39	**100**	30.83	433,225.80	Liability to Pensioners
			53.66	753,924.08	Liability to Contributors
			15.51	217,894.51	Accumulated surplus
Total Assets	1,405,044.39	**100**	**100**	1,405,044.39	**Total Liabilities**
G=0.0302; θ = 16.51%; θ_{dq} =18.08%; SR= 118.35%					

Table 7b: Unbalanced Pension System (estimated with HA).					
ASSETS			**LIABILITIES**		
Item	Monetary units	%	%	Monetary units	Item
Hidden Asset	1,407,216.41	**100**	28.99	407,885.62	Liability to Pensioners
			31.64	445,238.82	Liability to Contributors
			39.38	554,091.97	Accumulated surplus
Total Assets	1,407,216.41	**100**	**100**	1,407,216.41	**Total Liabilities**
G=0.0302; r=0.04; θ = 16.51%; θ_{dq} =18.08%; θ_f =13.37%; SR= 164.95%					

Table 7c: Unbalanced Pension System (estimated with HA).					
ASSETS			**LIABILITIES**		
Item	Monetary units	%	%	Monetary units	Item
Hidden Asset	927,548.25	**100**	41.49	384,839.69	Liability to Pensioners
			25.04	232,299.77	Liability to Contributors
			33.47	310,408.79	Accumulated surplus
Total Assets	927,548.25	**100**	**100**	927,548.25	**Total Liabilities**
G=0.0302; r=0.05; θ = 16.51%; θ_{dq} =18.08%; θ_f =11.87% SR= 150.30%					

It can be seen how the solvency ratio in the case of the HA is highly volatile when there is a change in the market interest rate (which has no effect on the PAYG pension system)[23]. The results that appear are clearly inconsistent from the point of view of the system's solvency. For example, as shown in the tables above, for a contribution rate of 14.94 (18.08) % and a market

[23] Using historical data from 1981 to 2006, D'Abbio et al. (2009) attempt to measure the degree of uncertainty in investment returns. The results show a median real return of 7.3% a year on a portfolio equally weighted between equities and bonds (averaged across the countries studied). The degree of uncertainty, even with the relatively long investment horizons of pensions, is found to be large. In 10% of cases, an annual return of less than 5.5% would be expected, while in 10% of cases this would exceed 9.0%.

interest rate of 4%, the solvency ratio (SR) would barely reach 45.78 (164.95) % as opposed to 84.18 (118.35) % if the CA were used. The fact that the system's solvency ratio is affected by an assumption on a variable that has no impact on either the flow of contributions or the flow of benefits is, if not proof, a strong indicator of the theoretical weakness of the "hidden asset" as a measure of solvency in a PAYG pension system.

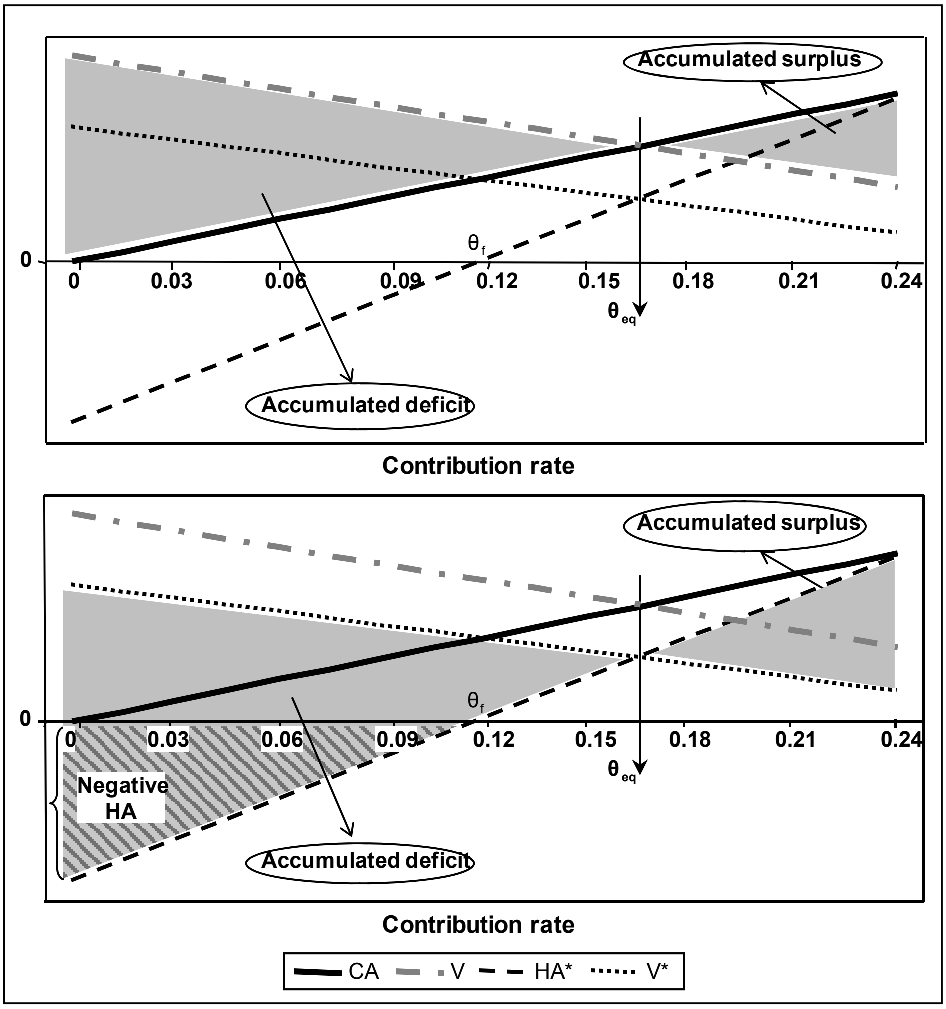

Figure 3: CA versus HA, r=0.05, g=0.01, $\gamma = 0.02$

The results for the accumulated deficit or surplus for various contribution rates and a market interest rate of 5% are shown in Figure 3. It can be seen that for θ_{eq} = 16.51%, the assets and liabilities coincide and the accumulated deficit is zero. For lower (higher) contribution rates the assets are lower (higher) than the liabilities, therefore the accumulated deficit (surplus) is positive and the solvency ratio worsens (improves).

Figure 4 shows solvency levels using the CA and the HA for different contribution rates and market interest rates.

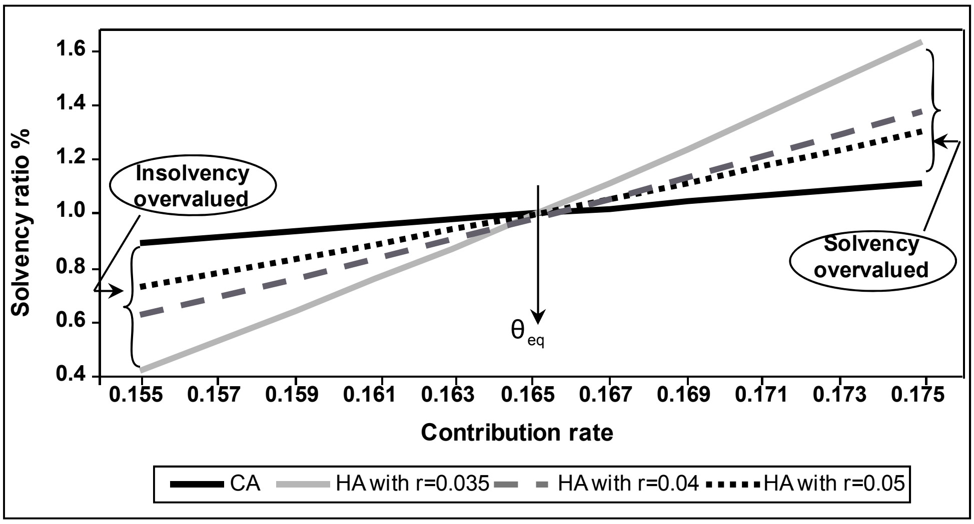

Figure 4: Solvency ratio using CA and HA

It can be seen how the situation of solvency is overvalued compared to that calculated under the contribution asset in those cases where contribution rates are above the balanced rates, and this overvaluation is greater the smaller the difference between G and r. Similarly there appears an overvaluation of the situation of insolvency in those cases where the contribution rates are lower than those for a balanced state, and this overvaluation is greater the smaller the difference between G and r.

The results (consistency and inconsistency) are robust to changes in population growth rate, mortality tables, the age-wage structure, the growth rate of pensions in payment, etc. See Appendix 3.

4.-Concluding comments

When compiling the official actuarial balance for the PAYG system, public social security administrations basically use two approaches: the so-called “Swedish” and “US” models. The “Swedish” model is a very recent one as it has only been carried out officially since 2001 and is innovative in that it adopts the typical structure of accounting balance sheets by having a list of assets and liabilities. The main methodological innovation enabling the actuarial balance to be compiled is what is known as the contribution asset, although its theoretical basis needs to be further analysed in the literature. Only the papers by Settergren & Mikula (2005) and Boado-Penas et al (2008) have looked at it in any detail. At the same time some authors have questioned the validity of the concept, Andrews (2008), or have expressed doubts about it, Robalino & Bodor (2009), suggesting that the contribution asset should be replaced by the “PAYG asset”, which is another name for what other authors mentioned in this paper call the “hidden asset”, the “hidden tax” or the “implicit tax on pensions”.

In order to shed some light on the basic theory behind the contribution asset and its connection with the possible alternative known as the hidden asset, this paper has developed an overlapping generations model and applied it to the defined-benefit PAYG system, though it would be equally valid for NDC systems. We deduced both assets from this model and derived the basic properties of the turnover duration, which is a necessary element for enabling the contribution asset to be calculated. The main theoretical conclusion is that despite their very different natures, in a simplified scenario the hidden asset and the contribution asset may nearly coincide under the assumption that, at the limit, r (the interest rate of the financial market) tends upwards towards G (the growth of the covered wage bill).

In the applied section, in order to compile the actuarial balance as a solvency indicator for the “Swedish” model, there are three main reasons as to why it is better to use the contribution asset:

(1) its financial-actuarial basics in the PAYG system, which makes it unnecessary to use the interest rate of the financial market to answer the questions: 'What is the value of the commitment to contributors and pensioners taken on by the system?' and 'What are the assets that back up this commitment?';

(2) it is easy to calculate as there is no need to make projections; and

(3) it is clear in diagnosing insolvency because, as shown in the previous section, the use of the hidden asset supplies a solvency indicator which is not always consistent with the financial health of the system - the solvency indicator supplied by the HA is highly volatile when there is a change in the market interest rate (which has no effect on the PAYG pension system).

The fact that the solvency ratio of the system is affected by an assumption on a variable that has no impact on either the flow of contributions or the flow of benefits is, if not proof, a strong indicator of the theoretical weakness of the “hidden asset” as a measure of solvency in a PAYG pension system. However, there is an important limitation regarding the use of the CA to compile the actuarial balance insofar as, in order to calculate the TD, the only contingency taken into account is retirement. Other contingencies such as disability or survivor benefits make it more difficult to define the TD in both theoretical and practical terms.

Another important question deriving directly from the model developed is that the TD, regardless of the IRR (G) used to discount pensions and contributions, is always equal to the difference in the expected weighted average age of contributors and pensioners. In the case of a real pension system which has its contributor-pensioner structure set up in a particular way, this brings the added difficulty of determing the IRR (G) to be applied. Therefore, when compiling an actuarial balance for an already-functioning defined-benefit pension system, two options can be considered:

1.-Assume that the pensioners-pensions and contributors-contributions structure remains constant in real terms in the future as in the case of Sweden, or use an estimated value for G based on the most recently observed data (the previous 3 or 5 years). Clearly the position of solvency that the balance shows will vary depending on which choice is made. On the practical side, too, as a sensitivity analysis, it could be suggested what the level of contribution should be with the TD and the committed liability in order for the system to be solvent.

2.- Assume that the pensioners-pensions and contributors-contributions structure remains constant in real terms in the future, and look for the G that would make the assets and liabilities equal. This would show how much the system would need to grow in the future in order for it to remain solvent, should the initial calculation show that this was not the case.

Finally, the use of the philosophy described in the hidden asset makes more sense when a “US” type actuarial balance is compiled, although the meaning could refer to assets or liabilities given that the SSA calculates it in such a way that it is known as the “unfunded liability” and is equivalent to the amount that would need to be contributed at the time of valuation, with legislation constant, in order to cover all the projected financial obligations of the system with a perpetual time horizon. However, this liability makes no actuarial sense as it represents the value of the treasury deficit. If, following the way the SSA calculates it, the result were negative, what this would really be indicating would be the amount represented at the present moment by the treasury surplus with a perpetual time horizon and no changes in legislation.

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Appendix 1.-The Turnover duration in DB PAYG pension system.

In this appendix we develop the concept of the CA for the case where participants' lives last (w-1-x_e) periods, where (w-1) is the highest age to which it is possible to survive and x_e is the age of entry into the system. In this case, A generations of contributors and (w-1-(x_e+A)) generations of pensioners coexist at each moment in time.

We build on the case developed by Boado-Penas et al. (2008), where the contribution base (coinciding with earnings) grows at an annual rate of g, i.e. there are wage gains in real terms if g > 0 and losses if g < 0, but with the additional assumptions that the population increases or decreases over time[24] at an annual accumulative rate of γ, affecting all groups of contributors equally, which means it must be assumed that real GDP and the system's income from contributions (the wage bill) also grows (decreases) at rate G = (1+g)(1+ γ)-1, and pensions in payment increase or decrease at an annual rate of λ.

The parameters of the pension system are considered to be in a stationary state (fixed over time), and as it is PAYG, the collective is open. Both the age giving entitlement to a retirement pension, "x_e+A", and the formula used for calculating the pension are constant, leading to a fixed replacement rate of size β.

The demographic-financial structure at any moment "t" from the start of the system is given by:

1.-Age:

$$\overbrace{x_e,\ x_e+1,\ x_e+2,.............x_e+A-1,}^{\text{Contributors' ages}}\ \underbrace{x_e+A, x_e+A+1,...........\ w-1}_{\text{Pensioners' ages}} \qquad \textbf{[18.]}$$

2.-Number of contributors by age at time t:

$$N_{(x_e,t)}=N_{(x_e,1)}(1+\gamma)^{t-1},\ N_{(x_e+1,t)}=N_{(x_e+1,1)}(1+\gamma)^{t-1},.......,N_{(x_e+A-1,t)}=N_{(x_e+A-1,1)}(1+\gamma)^{t-1} \qquad \textbf{[19.]}$$

where $N_{(x_e+k,1)}=N_{(x_e,1)\,k}R_{x_e}$, with ${}_kR_{x_e}$ being the stable-in-time ratio between the number of individuals of age x_e y x_e+k years, which can be increasing or decreasing and can also be expressed by means of probabilities ${}_kp_{x_e}$.

3.-Average wage (average contribution base) by age at time t:

[24] The Swedish legislation implicitly assumes that population growth is 0 (γ = 0). Boado-Penas et al. (2008) use the same hypothesis. Here, as well as in Settergren and Mikula (2005), both positive and negative population growth are allowed in the model.

$$y_{(x_e,t)} = y_{(x_e,1)}(1+g)^{t-1},\ y_{(x_e+1,t)} = y_{(x_e+1,1)}(1+g)^{t-1},\ \ldots\ldots\ldots\ldots,\ y_{(x_e+A-1,t)} = y_{(x_e+A-1,1)}(1+g)^{t-1} \qquad \textbf{[20.]}$$

The demographic structure above means that the age-wage structure (contribution bases) only undergoes proportional changes. The slope of the age-wage structure is constant.

The annual retirement pension is $\beta \cdot Y_{C,0}$, which is calculated as a set percentage â of average wages taking into account all the years (A) contributed, $Y_{C,0} = \frac{\sum_{k=0}^{A-1} y_{(x_e+k,-A+k+1)}}{A}$, and pensions in payment increase (decrease) at an accumulative annual rate of ë. It will also be assumed that payment of both contributions and benefits is distributed uniformly over time.

In this scenario, the contribution rate (è) in a stationary state depends on the stability of the dependency ratio (dr). The contribution rate from year "w-x_e-A=t" counting from the start of the system can be considered constant from the actuarial point of view because from that moment the ratio between the number of pensioners and the number of contributors - (dr) - stabilizes:

$$dr_t = \frac{\overbrace{\sum_{k=0}^{w-x_e-A-1} N_{(x_e+A+k,1)}\,(1+\gamma)^{t-k}}^{\text{Pensioners}=R_t}}{\underbrace{(1+\gamma)^{t-1}\sum_{k=0}^{A-1} N_{(x_e+k,1)}}_{\text{Contributors}=C_t}} = \frac{\sum_{k=0}^{w-x_e-A-1} N_{(x_e+A+k,1)}\,(1+\gamma)^{-k}}{\sum_{k=0}^{A-1} N_{(x_e+k,1)}} = dr_{t+1} = \ldots\ldots = dr = \frac{R}{C} \qquad \textbf{[21.]}$$

because both groups evolve (increase or decrease) exactly equal to rate γ. From this year the system is in a stationary state and the contribution rate will be:

$$\theta_t = \frac{\overbrace{\beta Y_{C,0} \sum_{k=0}^{w-x_e-A-1} N_{(x_e+A+k,1)}\,(1+G)^{t-1-k}\,(1+\lambda)^k}^{\text{Expenditure on pensions}=\text{aggregate benefit expendidure}}}{\underbrace{(1+G)^{t-1}\sum_{k=0}^{A-1} y_{(x_e+k,1)} N_{(x_e+k,1)}}_{\text{Aggregate (pensionable earnings}=\text{contribution base)}}} = \frac{P_{(x_e+A,t)} \sum_{k=0}^{w-x_e-A-1} N_{(x_e+A+k,t)} \left[\frac{1+\lambda}{1+G}\right]^k}{\sum_{k=0}^{A-1} y_{(x_e+k,t)} N_{(x_e+k,t)}} = \theta_{t+1} = .. = \theta$$

[22.]

If the system's average pension is considered to be:

$$\overline{P}_t = \frac{\overbrace{\beta Y_{C,0} \sum_{k=0}^{w-x_e-A-1} N_{(x_e+A+k,1)} (1+g)^{t-1-k} (1+\gamma)^{t-1-k} (1+\lambda)^{k}}^{\text{Expenditure on pensions}}}{\underbrace{\sum_{k=0}^{w-x_e-A-1} N_{(x_e+A+k,1)} (1+\gamma)^{t-1-k}}_{\text{Pensioners}=R_t}} = \frac{P_{(x_e+A,t)} \sum_{k=0}^{w-x_e-A-1} N_{(x_e+A+k,t)} \left[\frac{1+\lambda}{1+G}\right]^{k}}{\sum_{k=0}^{w-x_e-A-1} N_{(x_e+A+k,t} (1+\gamma)^{-k}}$$

[23.]

with:

$$P_{(x_e+A,t)} = \beta Y_{C,0} \; (1+g)^{t-1} \qquad \textbf{[24.]}$$

and the average contribution base being:

$$\overline{W}_t = \frac{\overbrace{(1+G)^{t-1} \sum_{k=0}^{A-1} y_{(x_e+k,1)} N_{(x_e+k,1)}}^{\text{Aggregate contribution base}}}{\underbrace{(1+\gamma)^{t-1} \sum_{k=0}^{A-1} N_{(x_e+k,1)}}_{\text{Contributors}=C_t}} = \frac{\sum_{k=0}^{A-1} y_{(x_e+k,t)} N_{(x_e+k,t)}}{\sum_{k=0}^{A-1} N_{(x_e+k,t)}} \qquad \textbf{[25.]}$$

in the stationary state reached, the average pension-average contribution base quotient is already constant due to the fact that the numerator and denominator evolve equally (at the rate of variation in wages):

$$\frac{\overline{P}_t}{\overline{W}_t} = \frac{\overline{P}_{t+1}}{\overline{W}_{t+1}} = ... = \frac{\overline{P}}{\overline{W}} \qquad \textbf{[26.]}$$

Therefore the contribution rate is the product of the demographic dependency ratio and the financial ratio (average replacement rate of the system):

$$\theta = \frac{\overline{P}}{\overline{W}} dr = \overbrace{\frac{\overline{P}}{\overline{W}}}^{\text{Financial ratio}} \underbrace{\frac{R}{C}}_{\text{Demographic ratio}} \qquad \textbf{[27.]}$$

The system's liabilities, V^T, have two components: (i) liabilities to current pensioners V^r, and (ii) liabilities to current contributors V^c. Actuaries use the terms “technical provisions for pensions in payment” and “technical provisions for rights being acquired” for (i) and (ii) respectively.

The first component - liabilities to current pensioners - in the stationary state is equal to:

$$V_t^r = \beta\, Y_{C,0} \sum_{k=0}^{w-xe-A-1} N_{(x_e+A+k,1)}\, \ddot{a}^{\lambda}_{x_e+A+k}\, (1+G)^{t-1-k}(1+\lambda)^k$$

$$= \qquad \textbf{[28.]}$$

$$P_{(x_e+A,t)} \sum_{k=0}^{w-xe-A-1} N_{(x_e+A+k,t)}\, \ddot{a}^{\lambda}_{x_e+A+k} \left[\frac{1+\lambda}{1+G}\right]^k$$

with $\ddot{a}^{\lambda}_{x_e+A+k}$ being the present value of a lifetime annuity due of 1 per year payable in advance growing at real rate λ, valued at age "x_e+A+k" years, with a technical interest rate equal to d=G.

The second component is the liability to current contributors, payments to whom have still not begun but for which a commitment has been made by virtue of the contributions already paid. This second component of the liabilities is calculated by the prospective method[25] and will be the *difference* between the present value of future pensions and the present value of future contributions. The definition of these liabilities is that of the "closed group".

Liabilities to contributors will be constant and equal to:

$$V_t^c = \overbrace{\beta\, Y_{C,0} N_{(Xe+A,1)}\, \ddot{a}^{\lambda}_{Xe+A} \sum_{h=1}^{A} (1+G)^{t+h-1}(1+d)^{-h}}^{\text{Future pensions}} - \underbrace{\theta \sum_{k=0}^{A-1}\sum_{h=0}^{k} N_{(Xe+k,1)}\, y_{(Xe+k,1)} (1+G)^{t+h-1}(1+d)^{-h}}_{\text{Future contributions}}$$

$$= \qquad \textbf{[29.]}$$

$$\overbrace{P_{(x_e+A,t)} N_{(Xe+A,t)}\, \ddot{a}^{\lambda}_{Xe+A} \sum_{h=1}^{A} \left[\frac{1+G}{1+d}\right]^{h}}^{\text{Future pensions}} - \underbrace{\theta \sum_{k=0}^{A-1}\sum_{h=0}^{k} N_{(Xe+k,t)}\, y_{(Xe+k,t)} \left[\frac{1+G}{1+d}\right]^{h}}_{\text{Future contributions}}$$

To obtain the TD, the total liabilities are divided by the annual contribution flow, and the interest rate for discounting future pensions and contributions in the financially sustainable PAYG system is taken to be the IRR, i.e. the real growth in wages plus the real growth in the contributing population - which is actually G= $(1+g)(1+\gamma)-1)$[26] - and therefore:

[25] The calculation is much more simple in the notional accounts system and the logical thing is to use the retrospective system, the value of which coincides with the sum of the notional capital accumulated by the contributors as a whole.

[26] See Appendix 2. Gronchi and Nisticò (2008) present a reformulation of the Samuelson–Aaron theorem that recognized the wage bill growth rate as the IRR on contributions and the 'sustainable return' of PAYG defined-benefit schemes in a steady growing economy. Knell's papers (2005a, 2005b) are also very useful.

$$TD_t = \underbrace{\frac{\overbrace{\sum_{k=0}^{w-x_e-A-1} N_{(x_e+A+k,1)}\, \ddot{a}^{\lambda}_{x_e+A+k} \left[\frac{1+\lambda}{1+G}\right]^k}^{\text{Pay-out duration}}}{N_{(x_e+A,1)}\, \ddot{a}^{\lambda}_{x_e+A}}}_{pt^t_r} + A - \underbrace{\overbrace{\frac{\sum_{k=0}^{A-1} N_{(x_e+k,1)}\, y_{(x_e+k,1)}\,(k+1)}{\sum_{k=0}^{A-1} y_{(x_e+k,1)}\, N_{(x_e+k,1)}}}^{pt^t_c}}_{\text{Pay-in duration}} \quad \textbf{[30.]}$$

Appendix 2.-The internal rate of return of the PAYG pension system.

The IRR is defined as the value of parameter “irr” of the law of compound interest, which sets equal to zero the present value of the cash-flows constituted by the aggregate yearly contributions paid by a cohort and the aggregate yearly pension benefits received by the same cohort.

In order to determine the IRR of any generation once the stationary state has been reached, the contributions made by all members of that generation will need to be determined:

$$\theta \sum_{k=0}^{A-1} y_{(x_e+k,\,t+k)}\, N_{(x_e+k,\,t+k)} = \underbrace{(1+G)^{t-1}\theta \sum_{k=0}^{A-1} y_{(x_e+k,\,1)}\, N_{(x_e+k,\,1)}\,(1+G)^k}_{\text{Contributions}} \quad \textbf{[31.]}$$

along with the benefits received by all the members of a generation:

$$\sum_{k=A}^{w-x_e-1} P_{(x_e+k,\,t+k)}\, N_{(x_e+k,\,t+k)} = \underbrace{(1+G)^{t-1}\beta\, Y_{C,0} \sum_{k=A}^{w-x_e-1} N_{(x_e+k,\,1)}\,(1+G)^k}_{\text{Benefits}} \quad \textbf{[32.]}$$

and their discounted values will have to be made equal:

$$\left[\theta \sum_{k=0}^{A-1} y_{(x_e+k,\,1)}\, N_{(x_e+k,\,1)}\,(1+G)^k - \beta\, Y_{C,0} \sum_{k=A}^{w-x_e-1} N_{(x_e+k,\,1)}\,(1+G)^k\right](1+irr)^{-k} = 0 \quad \textbf{[33.]}$$

if we prefer to make the main relations which are the basis of the system's financial balance clear:

$$\left[\frac{\overline{P}}{\overline{\overline{W}}}\frac{R}{C} \sum_{k=0}^{A-1} y_{(x_e+k,\,1)}\, N_{(x_e+k,\,1)}\,(1+G)^k - \beta\, Y_{C,0} \sum_{k=0}^{w-x_e-A-1} N_{(x_e+A+k,\,1)}\,(1+G)^k\right](1+irr)^{-k} = 0 \quad \textbf{[34.]}$$

It is easy to test that IRR=G for a generation. In fact, if IRR=G is substituted in either of the two expressions above, it is verified - given the stable structure of the population for the cross-section and the previously defined relations - that:

$$\left[\underbrace{\theta\sum_{k=0}^{A-1} y_{(x_e+k,1)}\,N_{(x_e+k,1)}}_{\text{Contributions}} - \overbrace{\beta\,Y_{C,0}\sum_{k=0}^{w-x_e-A-1} N_{(x_e+A+k,1)}}^{\text{Benefits}}\right] = 0 \qquad \textbf{[35.]}$$

Based on a development carried out by Devesa-Carpio et al. (2002), an approximate expression can be obtained for the IRR for a particular generation which comes from satisfying the restriction of the life-cycle and equalling the contributions and the pensions projected, as shown in the following integral equation:

$$\overbrace{\theta\int_{x_e}^{x_e+A} \underbrace{N_{(x,x+1-x_e)}}_{\text{contributors}}\; y_{(x,x+1-x_e)}\; \underbrace{e^{-ix}}_{\text{Discount factor}}\,dx}^{\text{Contributions}} = \overbrace{\int_{x_e+A}^{w} \underbrace{N_{(x,x+1-x_e)}}_{\text{pensioners}}\; P_{(x,x+1-x_e)}\; \underbrace{e^{-ix}}_{\text{Discount factor}}\,dx}^{\text{Benefits}} \qquad \textbf{[36.]}$$

Because the functions involved in Expression 36 are exponential and therefore continuous and smooth, without an excessive margin of error, the integral can be taken as close to the value of the function, integrating for the weighted average age, separately, for length of working life and length of retirement;

$$\text{if } \bar{x} \in [a,b] \rightarrow \int_a^b f(x)\,dx \approx f(\bar{x})\,[b-a] \qquad \textbf{[37.]}$$

that is, A_c for the integral of the first member of Equation 36 and A_r for the second.

Expression 36 can be expressed as:

$$\underbrace{\overbrace{\theta\; y_{((A_c,A_c+1-x_e)}}^{\text{Contribution}}\; \underbrace{N_{(A_c,A_c+1-x_e)}}_{\text{contributors}}\; \overbrace{(x_e+A)-(A_c+1)}^{\text{Pay-in}}\; \underbrace{e^{-i(A_c-x_e)}}_{\text{Discount factor}}}_{\text{Present value of contributions}} \approx \underbrace{\overbrace{P_{(A_r,A_r+1-x_e)}}^{\text{Benefit}}\; \underbrace{N_{(A_r,A_r+1-x_e)}}_{\text{pensioners}}\; \overbrace{(A_r+1)-(x_e+A)}^{\text{Pay-out}}\; \underbrace{e^{-i(A_r-x_e)}}_{\text{Discount factor}}}_{\text{Present value of benefits}} \qquad \textbf{[38.]}$$

giving us a very enlightening approximate expression which is based on the average turnover duration in the stationary state described:

$$i \approx \frac{1}{\underbrace{A_r - A_c}_{\text{TD}}}\left[\underbrace{\ln\frac{\overbrace{P_{(A_r,A_r+1-x_e)}}^{\text{Benefit}}}{\underbrace{\theta\; y_{((A_c,A_c+1-x_e)}}_{\text{Contribution}}}}_{1} + \overbrace{\ln\frac{\overbrace{N_{(A_r,A_r+1-x_e)}}^{\text{Pensioners}}}{\underbrace{N_{(A_c,A_c+1-x_e)}}_{\text{Contributors}}}}^{2} + \underbrace{\ln\frac{\overbrace{(A_r+1)-(x_e+A)}^{\text{Pay-out}}}{\underbrace{(x_e+A)-(A_c+1)}_{\text{Pay-in}}}}_{3}\right] \qquad \textbf{[39.]}$$

where:

1 is the neper of the ratio between the pension and the contribution associated with the weighted average ages related with the turnover duration.

2 is the neper of the dependency ratio associated with the weighted average ages related with the average period of contribution.

3 is the neper of the ratio between the time one monetary unit is in period of payment (pay-out) and contribution (pay-in).

Clearly Expression 39 could be developed as many times as needed in order for it to show other elements that may be of interest. If it is considered that:

$$N_{(A_c, A_c+1-x_e)} = N_{(A_c,1)}(1+\gamma)^{A_c-x_e} \quad , \quad y_{(A_c, A_c+1-x_e)} = y_{(A_c,1)}(1+g)^{A_c-x_e}$$

$$P_{(A_r, A_r+1-x_e)} = \beta\, Y_{(C,0)}(1+g)^{A_r-x_e} \text{ and } N_{(A_r, A_r+1-x_e)} = N_{(A_r,1)}(1+\gamma)^{A_r-x_e}$$

then,

$$i \approx \frac{1}{\underbrace{A_r - A_c}_{TD}}\left[\ln\frac{\beta\, Y_{(C,0)}(1+g)^{A_r-A_c}}{\theta\, y(A_c,1)} + \ln\frac{N_{(A_r,1)}(1+\gamma)^{A_r-A_c}}{N_{(A_c,1)}} + \ln\frac{(A_r+1)-(x_e+A)}{(x_e+A)-(A_c+1)}\right] \quad \textbf{[40.]}$$

Substituting θ leaves an extremely interesting expression:

$$i \approx \frac{1}{\underbrace{A_r - A_c}_{TD}}\left[\underbrace{\ln\frac{\beta\, Y_{(C,0)}(1+g)^{A_r-A_c}}{y_{(A_c,1)}}}_{a} + \underbrace{\ln\frac{N_{(A_r,1)}(1+\gamma)^{A_r-A_c}}{N_{(A_c,1)}}}_{b} + \underbrace{\ln\frac{(A_r+1)-(x_e+A)}{(x_e+A)-(A_c+1)}}_{c} - \underbrace{\ln\frac{R}{C}}_{d} - \underbrace{\ln\frac{\overline{P}}{\overline{W}}}_{e}\right] \quad \textbf{[41.]}$$

in which there is an explicit appearance of the system's dependency ratio (d), the ratio between the system's pension and average wage (e), in which the revaluation of the pension in payment is included within the formula for the average pension, the effect of the increase or decrease in wages on pensions in payment (a), the effect of the increase or decrease in population on the generation of pensioners (b), and finally the ratio between the pay-out and the pay-in, which is affected by all the previous parameters (c).

Expressions 39, 40, 41 or any other equivalent can be used to obtain the IRR, with: $IRR \approx e^{i} - 1$

It should be stressed that the IRR for the generations of affiliates that received payment having paid no contributions or without having paid them in full is considerably higher than that for the generations once the stationary state is reached. The generation of affiliates who received a pension without having contributed anything has an IRR ∞, and the following generations have a decreasing IRR which tends towards G as the system matures and the stationary state is reached.

For the generation that has only contributed one year, the IRR would be determined by:

$$\left[\theta\sum_{k=A-1}^{A-1} y_{(x_e+k,1)}\,N_{(x_e+A-1,1)} - \beta\,Y_{C,0}\sum_{k=A}^{w-x_e-1} N_{(x_e+k,1)}\,(1+G)^{k+1-A}\right](1+irr)^{-(k-(A-1))} = 0 \qquad \textbf{[42.]}$$

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.

while for the generation that has contributed A-1 years:

$$\left[\theta\sum_{k=1}^{A-1} y_{(x_e+k,1)}\,N_{(x_e+A-1,1)}\,(1+G)^{k-1} - \beta\,Y_{C,0}\sum_{k=A}^{w-x_e-1} N_{(x_e+k,1)}\,(1+G)^{k-1}\right](1+irr)^{-(k-1))} = 0 \qquad \textbf{[43.]}$$

Clearly in these cases IRR> G, given that the growth of the covered wage bill during these years was also higher than G. In addition, the generation that joined the system the first year as pensioners without having contributed anything would benefit from an IRR= ∞

Appendix 3.- Sensitivity analysis of the numerical results showed in section 3.

Figure 5 and Table 8 show the main results for the system under different assumptions of population growth, pension growth, different salary profile and a different mortality table respectively.

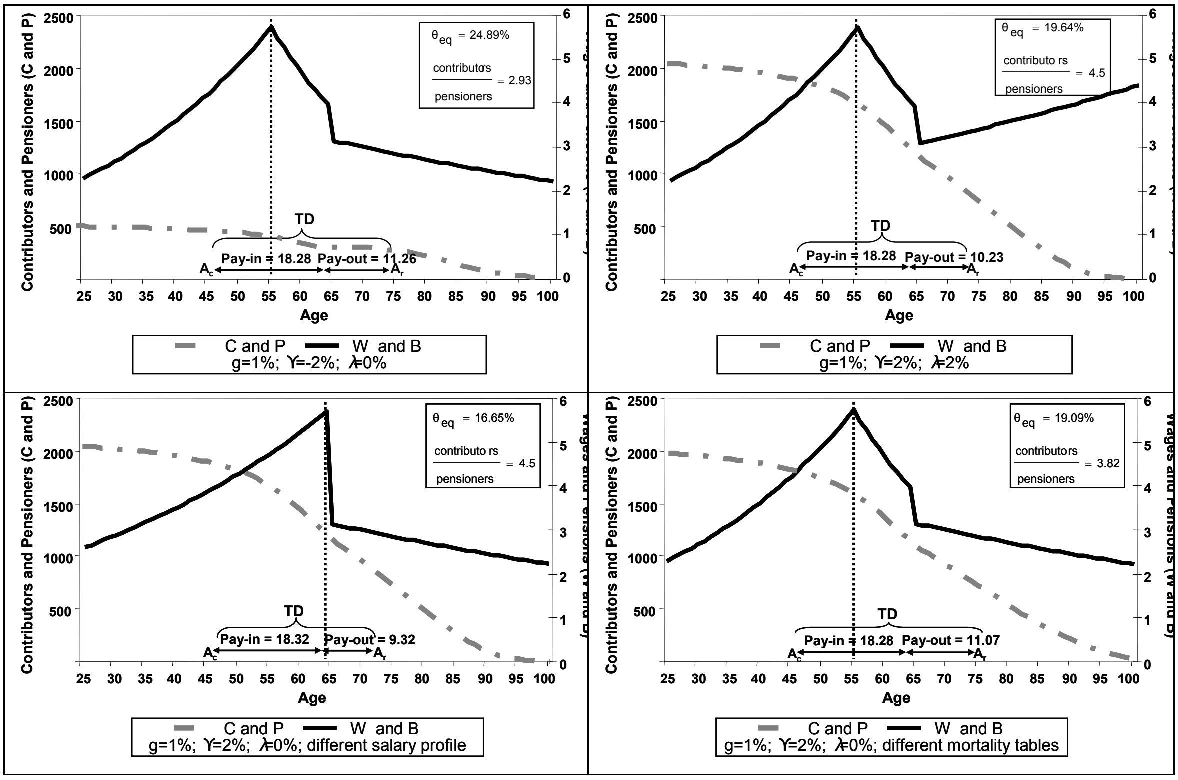

Figure 5: The system's contributors, pensioners, wages and pensions undet different assumptions

Table 8: Unbalanced pension system depending on different assumptions. Solvency ratios (%)[27]

	CA	HA		CA	HA	
	θ_{dq}	θ_{dq}, r (%)	θ_{dq}, r (%)	θ_{dq}	θ_{dq}, r (%)	θ_{dq}, r (%)
g=1%; Y=-2%; λ=0%	θ_{dq}=22.25 **82.90**	θ_{dq}=22.25; r=0 **45.54**	θ_{dq}=22.25; r=1 **57.82**	θ_{dq}=27.54 **120.02**	θ_{dq}=27.54; r=0 **166.32**	θ_{dq}=27.54; r=1 **153.74**
g=1%; Y=2%; λ=2%	θ_{dq}=17.72 **83.96**	θ_{dq}=17.72; r=4 **45.78**	θ_{dq}=17.72; r=5 **59.42**	θ_{dq}=21.56 **118.60**	θ_{dq}=21.56; r=4 **164.97**	θ_{dq}=21.56; r=5 **150.58**
g=1%; Y=2%; λ=0%; different salary profile	θ_{dq}=15.06 **84.14**	θ_{dq}=15.06; r=4 **45.82**	θ_{dq}=15.06; r=5 **59.74**	θ_{dq}=18.24 **118.42**	θ_{dq}=18.24; r=4 **164.95**	θ_{dq}=18.24; r=5 **150.08**
g=1%; Y=2%; λ=0%; different mortality table[28]	θ_{dq}=17.72 **88.12**	θ_{dq}=17.72; r=4 **45.84**	θ_{dq}=17.72; r=5 **58.77**	θ_{dq}=20.47 **113.22**	θ_{dq}=20.47; r=4 **165.04**	θ_{dq}=20.47; r=5 **151.72**

[27] For simplicity, the r's are considered to be one and two points above the G for each example. The unbalanced contribution rates shown in the tables follow the formulae described in the text.

[28] In this case, the life expectancy of a person of 65 is 19.63, higher than the result obtained without changing the mortality table (15.61).

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