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Pension financing and macroeconomic equilibrium

by

Enrico D'Elia

ISAE, Institute for Studies and Economic Analyses,
Piazza dell'Indipendenza, 4, 00185, Rome, Italy
email: delia.enrico@gmail.com

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ISAE - Piazza dell'Indipendenza, 4 – 00185 Roma
Tel. +39-06444821; www.isae.it

ABSTRACT

Financing pension systems necessitates that actual output is redistributed from workers and entrepreneurs actually in activity in favour of retirees. Therefore, in a closed economy, the return on accrued pension funds, to be distributed to pensioners, is ceiled by the real growth of income, unless the share of income levied on active workers increases indefinitely. Only possible revenues from past foreign investment can increase the overall resources available to pay domestic pensions. Thus, an efficient pre funded pension system inevitably stimulates large international capital movements. The paper sheds some light on an issue often overlooked in the debate on the merits and drawbacks of different systems, i.e. their possible consequences on interest and exchange rates. In order to provide an explicit solution for the dynamics of the relevant variables, the paper adopts an analytical approach more simple than the usual overlapping generation models. In particular, the paper confirms that in an aging society, with a fully indexed PAYG system, a constant contribution rate would make the public debt and related interest rates explode. On the other hand, in a pre-funded system, interest rates should be set below the national growth rates, and exchange rates must be ready to accommodate to large deficit of the balance of payment for many decades after the switch from a PAYG system, and later to large surplus.

Keywords: Aging society, Capital movements, Monetary policy, Pensions

JEL CODE: E43, F21, F32, H55, J32

CONTENTS

1 Introduction [(*)]

The debate on the relative merits and drawbacks of different pension systems is huge and some conclusions are still controversial, as shown by Barr and Diamond (2006) even recently, although many "myths" have been disproved, as noticed by Orszag and Stiglitz (2001). According to the mainstream literature, the "pay as you go" (PAYG) schemas, prevailing in most countries in the past decades, make retirees benefit directly from general economic growth, but also more exposed to the risk of demographic, regulatory and political changes. In addition, the pension system may face problems of financial sustainability. On the other hand, a capitalized funded system should rise saving and possibly investment, speeding up growth. Furthermore, it should be less sensitive to adverse demographic dynamics, although a pre funded system shares the general risks of financial market, possibly related also to demographic unbalances, and tends to widen inequality. The aim of this paper is to shed some light on an issue often overlooked in the current debate, that is the possible consequences of both systems on interest and exchange rates.

Indeed, whatever pension system necessitates that a fraction of good and services produced by productive units (i.e.: the employees, the entrepreneurs and the owners of the means of production) is appropriated by non active people. The redistribution of resources from active to non active units may happen either through a PAYG, a pre funded pension scheme, or a mix between the two. In fact, the System of National Accounts (United Nations *et al*., 1994, ch. 8 and 9) recognises pensions, related contributions, and possible capital gains on pension funds as a form of secondary distribution of income. As a matter of fact, in a closed economy, pensions and other allowances earned by non-active people necessarily reduce the real resources directly commanded by the rest of the population. In addition, the rate of return on pension funds cannot exceed the real growth rate of output, unless an increasing share of income produced by active workers and entrepreneurs is distributed to retirees.

Only possible transfers from abroad can increase the actual amount of resources available for domestic uses. In particular, additional resources may derive from the return on foreign investment of national pension funds. Nevertheless, the flow of foreign investment, on the one hand, and revenues from abroad, on the other, necessarily put some constraints to the macroeconomic equilibrium. In particular, continuing transfer from abroad, related to revenues and possible withdrawals from past investment, and current investment of pension funds affect the balance of payment. For a long while after the swing from a PAYG system to a pre funded system, the balance

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between inflow and outflow related to pensions likely shows a deficit. Later, in an aging society, the balance should turn in a surplus, since the number of retirees receiving a pension grows faster than the active population saving for future pensions.

Models based on overlapping generations introduced by Buiter (1981) and further developed by Börsch-Supan, *et al*. (2002), INGENUE (2002), and Fehr *et al*. (2003), predict a similar outcome, but relate it to the fact that the propensity to save decreases with age, according to the life cycle hypothesis of Ando and Modigliani (1963). Conversely, in this paper, the sign and dynamics of capital flow depends only on the investment policy of pension funds. In addition, the analytical approach adopted here provides explicit closed form expression for the dynamics of the relevant variables that would be almost impossible in the framework of the overlapping generation models.

In any case, the existing literature seems to overlook that international capital movements related to pre-funded pension systems initially put a downward pressure on exchange rates in aging countries, and an upward pressure in younger countries, receiving the investment of pension funds. Later the exchange rate tends to appreciate in aging societies and to depreciate elsewhere. On the other hand, under a fixed exchange rate regime, the capital flows generated by pension funding initially require increasing interest rates in elder countries, in order to keep the balance of payment in equilibrium, although the monetary policy may ease in the long run.

In fact, the empirical evidence already presented by Higgins (1998) shows the relevance of capital movements related to pensions. While Pemberton (1999) highlights the positive consequences on the international level of interest rates of such reallocation of assets, Poterba (2001) and Abel (2003) are quite pessimistic about the ultimate result of the required adjustment process, and fear an "asset market meltdown" as the baby boomers will stop to work and save and begin decumulating their pension funds. Nevertheless, Brooks (2002) highlights that the effect on asset earnings should compensate, or even overcompensate, the possible negative influence on the asset prices, assuming a "putty-putty" investment technology.

If the amount of pensions is set in accordance with some regulation or contractual agreement, the dynamics of the real rate of return on accrued pension funds (both if they are national or not) is also predetermined. Thus, either the monetary policy should accommodate to the required interest rate level, or the amount of pensions should vary in accordance with the actual monetary policy. In other words, the return on pension funds, and the amount of per capita pensions, cannot be set in advance arbitrarily, regardless to the underlying pension scheme.

This paper consists of five sections, other than this introduction. The next paragraph introduces the notation and highlights some well known aspects of a PAYG system, that is its intrinsic sensitivity to demographic dynamics. In addition, the possible consequences on interest rates of financing very

generous pension schemas with public debt are pointed out. Section 3 focuses on the constraints on the real return on pension funds implicit in a pre-funded system acting in a closed economy. The consequences of these constraints on interest rates and exchange rates in an open economy are discussed in Section 4. Furthermore, the dynamics of per-capita pensions and of the possible indexation of pensions are considered in Section 5. Few conclusive remarks close the paper.

2 Some implications of a PAYG system

Let assume that the domestic real income Y_t at time t is distributed between workers in activity who contribute directly to the production process, on the one hand, and retirees, on the other. In particular, if A_t is the amount of real resources appropriated by L_t workers in activity, each earning the per capita real income v_t; P_t is distributed to N_t pensioners, who benefit from the per capita pension p_t, the following accounting relations hold:

$$Y_t = A_t + P_t \qquad [1]$$

where

$$A_t = v_t L_t \qquad [2]$$

and

$$P_t = p_t N_t \qquad [3]$$

It is worth noticing that equations [1] - [3] are very general, since they are also capable to describe the redistribution of resources between current productive factors, including also entrepreneurs and capital owners, to non working people, including also children, students, jobless, disable persons, etc. Consequently, most of the conclusions of this paper also apply to a generic social security system.

In a PAYG system, the pensions P_t are funded by the contribution paid by the productive factors (mainly levied on the compensation of employees), that is

$$P_t = c_t A_t = c_t v_t L_t \qquad [4]$$

where c_t is the contribution rate. Assuming that that c_t, v_t, p_t, L_t, N_t and Y_t grow at the continuous rates $\dot{c}$, $\dot{v}$, $\dot{p}$, $\dot{L}$, $\dot{N}$ and $\dot{g}$ respectively, and that workers in activity fully benefit from the improvement of their productivity, so that $\dot{v} + \dot{L} = \dot{g}$, [3] and [4] imply that

$$p_0 N_0 e^{(\dot{p}+\dot{N})t} = c_0 v_0 L_0 e^{(\dot{c}+\dot{g})t} \qquad [5]$$

where the subscript 0 indicates the initial value of the variables at the time in which the pension system is established. Equation [5] entails that

$$\dot{c} + \dot{g} - \dot{N} - \dot{p} = \frac{\ln(R_0) + \ln(L_0/N_0) - \ln(c_0)}{t} \qquad [6]$$

where $R_0 = \frac{p_0}{v_0}$ is the initial value of the average replacement rate between per capita pension and per capita compensation of workers still in activity. A large R_0 ratio denotes a system very "generous" towards the pensioners, at least in the beginning.

In the long run, the right hand side of [6] goes to zero, so that it reads

$$\dot{p} = \dot{v} + \dot{c} - (\dot{N} - \dot{L}) \qquad [7]$$

Equation [7] states that, in a PAYG system, per capita pensions may increase at a rate which equals the growth rate of per capita income of workers in activity, plus the possible change of the contribution rate, minus the growth rate of the ratio of retirees to workers in activity. It follows from [7] that, in a aging society, where $\dot{N} > \dot{L}$, it is impossible to finance a PAYG system where pension are fully indexed to productivity (i.e.: $\dot{p} = \dot{v}$) and, at the same time, the contribution rate is kept constant over time. Conversely, the indexation requires that the contribution rate rises at the pace

$$\dot{c}^* = \dot{N} - \dot{L} \qquad [8]$$

It is worth noticing that the results [7] and [8] do not depend on the initial conditions and, in particular, R_0, c_0 and the initial ratio between pensioners and workers in activity. In particular, [8] shows that, in a sustainable PAYG scheme, the dynamics of the contribution rate is not affected by the generosity of the system, related to R_0, but only by demographic factors, that is the ratio $\frac{N_t}{L_t}$.

Furthermore, $\dot{c}^*$ cannot be reduced simply by once and for all measures, such as prolonging the working period or stimulating the participation to the labour market, but it is necessary to increase permanently the growth rate of workers in activity and reducing the increase of retirees as well.

The pension system faces an unbalance if a couple of conditions occurs at the same time, that is: (1) pensions are fully indexed to current income, and (2) the contribution rate is adjusted at the pace $\bar{c} < \dot{c}^*$, even though the dynamics of $\dot{N} - \dot{L}$ requires that it should change according to [8]. The ensuing deficit must be financed either by taxes or by public debt. In this framework, taxation can be regarded as a simple substitute for compulsory social contribution, possibly levied on income

other than the compensation of employees. On the other hand, the debt D_t accrued by setting c_t to c*, would be

$$D_t = v_0 \int_0^t \left(N_0 e^{(\dot{N}+\dot{v})\tau} - c^* L_0 e^{\dot{g}\tau} \right) d\tau =$$

$$= \frac{v_0 N_0 \left(e^{(\dot{N}+\dot{v})t} - 1 \right)}{\dot{N} + \dot{v}} - \frac{c^* v_0 L_0 \left(e^{\dot{g}t} - 1 \right)}{\dot{g}} \qquad [9]$$

Therefore, in the long run, the ratio of public debt to output would increase at the pace

$$\dot{D} - \dot{g} = \dot{N} - \dot{L} \qquad [10]$$

Hence, the number of workers in activity growing at the same pace of retirees is a necessary condition for the stabilisation of the ratio $\frac{D_t}{Y_t}$ in a PAYG scheme where: pensions are fully indexed, the contribution rate is set below the required level [8], and the system is partially financed by public debt. In practice, equation [10] means that, in an aging society, a pension system with the aforementioned characteristics cannot be financed by public debt, otherwise the interest rates on public bonds should raise indefinitely over time, in order to place on the market an exploding mass of debt.

3 The return on pension funds

In a pre funded pension system, the domestic resources assigned to pensioners are determined by the return on a pension fund F_t. For the sake of simplicity, fixed administrative costs are neglected in what follows, and pensioners are supposed to earn the whole return on F_t, so that

$$P_t = r_t F_t \qquad [11]$$

where r_t is the net rate of return on pension funds, i.e. it includes capital gains or losses on the fund and possible public subsidies, but excludes taxes levied directly on funds an their return, administrative costs proportional to F_t, etc. Thus [1] reads

$$r_t = \frac{Y_t - v_t L_t}{F_t} \qquad [12]$$

Since, according to the definition of r_t embodied in [11], the return on fund do not capitalize, the pension fund increases every year only because of the investment of workers in activity, who are

supposed to save in the fund a fraction of their income, say s_t. Assuming further that s_t grows at the continuous rate $\dot{s}$, it reads

$$F_t = F_0 + S_0 \int_0^t e^{(\dot{g}+\dot{s})\tau} d\tau = F_0 + S_0 \frac{e^{(\dot{g}+\dot{s})t} - 1}{\dot{g} + \dot{s}} \qquad [13]$$

where F_0 is the initial endowment of the pension fund at the time of the swing from a PAYG scheme to a fully pre-funded system, and $S_0 = s_0 v_0 L_0$ is the initial investment in the fund. Substituting [13] in [12], it reads

$$r_t = \frac{r_0 (\dot{g} + \dot{s}) e^{\dot{g}t}}{\dot{g} + \dot{s} + \frac{S_0}{F_0}\left(e^{(\dot{g}+\dot{s})t} - 1\right)} \qquad [14]$$

Equation [14] implies that in the long run r_t tends to zero if the saving ratio increases continuously over time, i.e. if $\dot{s} > 0$, and goes to infinity if $\dot{s} < 0$. It is worth noticing that s_t is supposed to decline over time in an aging society, according to the models incorporating the life cycle hypothesis of Ando and Modigliani (1963). Thus, according to [14], r_t should increase indefinitely as the percentage of elder people, saving less than middle age workers, increases.

In any case, equation [14] shows that the dynamics and the level of r_t, depend on a couple of initial conditions, since r_t is higher as its initial value r_0 is larger and the initial ratio of yearly pension saving to the pension fund $\frac{S_0}{F_0}$ is lower. In particular, some assumption on r_0 is needed to determine the long run value of r_t. A reasonable assumption derives almost directly from the long run sustainability of a pre-funded system. In fact, the payment of pensions should be assumed not to dip into the fund, that is F_t can never decrease over time, otherwise, the fund would be unable to pay the increasing amount of pensions required by an aging society. Since the latter condition must hold also at the time of the swing from a PAYG scheme to a pre-funded system, the pension paid by the fund F_0 should be less than the investment in the fund itself. Thus, a sustainability condition for a pre-funded system is that

$$P_0 = r_0 F_0 \leq S_0 \qquad [15]$$

The latter condition also means that nobody would invest in a fund which promises an yearly return r_0F_0 permanently larger than the corresponding yearly investment S_0, since such a pension scheme necessarily is going to erode the initial fund to pay pensions, and therefore is destined to go bankrupt in the long run.

In any case, according to [14], the evolution of r_t over time follows the path

$$r_t \leq (\dot{g} + \dot{s}) \frac{e^{\dot{g}t}}{e^{(\dot{g}+\dot{s})\ t} + \frac{F_0}{S_0}(\dot{g} + \dot{s}) - 1} \qquad [16]$$

Assuming further that s_t cannot rise indefinitely over time, [16] shows that the rate of return on pension funds goes from $r_0 \leq \frac{S_0}{F_0}$, and goes to the long run value

$$r \leq \dot{g} \qquad [17]$$

According to [16], r_0 is as smaller as the initial endowment of the fund is more generous, and raises with the saving propensity, thus, in principle, r_0 may be either higher or lower than the corresponding long run limiting value. However, even assuming the weaker condition [15], equation [16] gives

$$\left.\frac{dr_t}{dt}\right|_{\dot{s}=0} \leq \frac{\dot{g}^2\left(\frac{F_0}{S_0}\dot{g} - 1\right)e^{\dot{g}t}}{\left(e^{\dot{g}t} + \left(\frac{F_0}{S_0}\dot{g} - 1\right)\right)^2} \qquad [18]$$

The right hand side of [18] can be either positive or negative, depending on the sign of $(F_0\,\dot{g} - S_0)$, but tends always to zero as t goes to infinity. Thus, equations [16] and [18] imply that the rate of return on pension funds certainly converges to its long run ceiling established by [17], but the adjustment process may start either form a higher or a lower value and is possibly oscillating over time, since [18] puts only a ceiling, but not a floor, on $\left.\frac{dr_t}{dt}\right|_{\dot{s}=0}$.

4 Some consequences for the monetary policy

Equations [16] – [18] carry a number of interesting consequences. First of all, the rate of return on pension funds which can be granted on the long run is necessarily lower or equal to the real growth rate, that is the real growth rate is a ceiling for the return on pension funds. Thus, any announced higher return is not sustainable, unless the share of income of workers in activity destined to pension fund (i.e.: s_t) rises indefinitely over time, or they renounce to increase their income at the

same pace of total product Y_t. Nevertheless, [16] does not provide any floor for r_t, so that the return on pension fund could even be null or negative.

The second consequence, strictly related to the previous one, is that, the monetary authorities must keep the real interest rate at a level satisfying [17], in order to ensure the equilibrium on the domestic fund market. Otherwise, if market interest rate was lower than r_t, the pension funds would be unable to grant the payment of pensions in the long run, while if interest rate was higher than r_t, workers in activity would have a very little incentive to invest in pension funds instead of in the capital market individually.

Thirdly, according to [17], the real interest rates should differ among countries in order to adapt to the national real growth rates. Therefore, within a monetary union, with a centralised monetary policy, also pension systems should be harmonised, in order to grant a return on pension funds consistent with the interest rate set for the union.

Furthermore, equations [16] and [17] demonstrate that both the return on pension funds and its dynamics over time do not depend on the saving rate s_t. Nevertheless, the total amount of pensions, given by [13], is directly proportional to s_t, because the stock of pension fund, given by [11], is a multiple of s_t.

If pension funds were allowed to invest only on the domestic market, the constraint imposed to monetary policy by [17] carries some consequences on the exchange rate policy as well. In fact, the exchange rate must adapt to the required equilibrium value of r, so that the deficit or surplus in foreign trade associated to the current exchange rate has to compensate exactly the capital flows generated by the possible difference between r and international interest rates.

The consequences for monetary policy could be even larger if pension funds are allowed to invest also abroad, so that the total amount of pensions is

$$P_t^T = \mathrm{P_t} + P_t^E \qquad [19]$$

where P_t^E is the revenue from foreign investment of domestic pension funds. If workers in activity had invested abroad a share s_t^E of their income, increasing at the pace $\dot{s}^E$, the total foreign fund at time t is

$$F_t^E = S_0^E \int_0^t e^{\left(\dot{g}+\dot{s}^E\right)\tau} d\tau = S_0^E \frac{e^{\left(\dot{g}+\dot{s}^E\right)t} - 1}{\dot{g} + \dot{s}^E} \qquad [20]$$

where, $S_0^E = s_0^E v_0 L_0$ is the initial investment in foreign funds. According to [13] and [20], the dynamics of F_t^E is almost the same as the domestic fund: the intuition behind this result is that both the funds are fed by the income of workers in activity, which grows at the rate $\dot{g}$.

Given that the foreign fund grants a rate of return r_t^E (hopefully higher than r), it generates every year a capital inflow $r_t^E F_t^E$. Furthermore, assuming that the saving propensity of workers in activity does not change over time, that is $\dot{s}^E = \dot{s} = 0$, the net capital inflow related to pensions is

$$P_t^E - s_0^E v_t L_t = S_0^E \left(\frac{r_t^E}{\dot{g}} \left(e^{\dot{g}t} - 1 \right) - e^{\dot{g}t} \right) \qquad [21]$$

According to the right hand side of [21], the capital movement related to pensions does not affect the overall balance of payment, only if

$$r_t^E = \frac{\dot{g} e^{\dot{g}t}}{e^{\dot{g}t} - 1} \qquad [22]$$

that is if, in the long run, r_t^E reaches exactly the ceiling of r given by [17], but in this case workers in activity would have a very little incentive to invest abroad.

More generally, investing in foreign funds generates a net capital outflow, mainly related to initial investment as long as $r_t^E > \frac{\dot{g} e^{\dot{g}t}}{e^{\dot{g}t} - 1}$, that is until

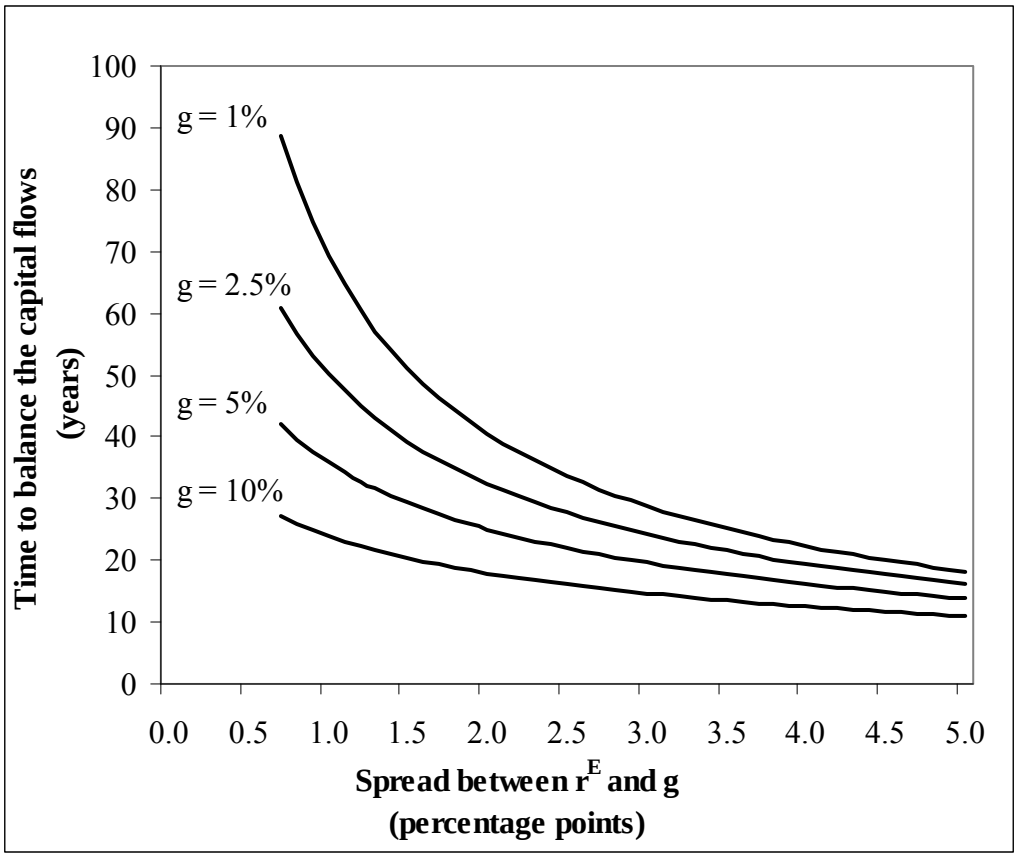
$$t < t^* = \frac{1}{\dot{g}} \ln \left(\frac{r_t^E}{r_t^E - \dot{g}} \right) \qquad [23]$$

and only later it produces a net inflow, mainly related to the payment of pensions. Assuming that $r_t^E > \dot{g} \geq r$, and r_t^E is large compared to the spread $r_t^E - r$, then the threshold t* established by [23] is positive, thus investing abroad initially implies a net capital outflow almost certainly. Furthermore, [23] shows that t* is lower as r_t^E is larger and $\dot{g}$ is smaller, since $\frac{dt^*}{dr_t^E} = \frac{\dot{g}}{r_t^E (\dot{g} - r_t^E)} < 0$, and $\frac{dt^*}{d\dot{g}} = \frac{1}{r_t^E - \dot{g}} > 0$. In particular, an extended period of capital outflow

should be expected in slow growing economies and when the foreign investment policy of pension funds is hopefully very prudential, so that r_t^E is not so large.

Figure 1 shows the time needed to reach the balance of capital flows for different combination of the domestic growth and the spread between r_t^E and $\dot{g}$. For instance, according to [23], if $\dot{g}$ = 2.5%, as in high developed countries during the last decades, and r_t^E = 4%, that is a large real return rate for a safe investment, t* turns out almost to reach 40 years. In addition, no reasonable combination of r_t^E and $\dot{g}$ grants the balance of capital flows before a couple of decades.

Figure 1 - Return on pension funds and balance of capital flows



The prolonged initial capital outflow related to pensions worsens the balance of payment and amplifies the flow of other investment attracted by the spread $r_t^E - r_t$. This fact likely backs the depreciation of national currencies of aging countries, where the real growth is slower and the investment of pension funds is larger. Only in the very long run, i.e. for t > t*, net capital flows related to pensions will be positive, partially compensating the other capital movements generated by the spread $r_t^E - r_t$.

Thus, if the pension funds are allowed to invest abroad, the most probable outcome is that, for a long while, the national exchange rate in developed countries will be lower than the one justified by the dynamics of the other components of the balance of payment. In turn, if the Marshall-Lerner conditions are satisfied, this fact generates larger export and less import, hopefully speeding up the overall domestic growth and reducing trade unbalance, in line with the standard conclusions of the Mundell – Fleming model. This fact would also raise the ceiling of r_t established by [17].

On the other hand, if the exchange rate between aging and fast growing countries is fixed, as happens within a monetary union, the discrepancy between r_t^E and r simply produces international capital movements that worsen the balance of payment of aging countries for many years. Therefore, for a long while, the monetary authorities should allow for an exchange rate adjustment, since the condition [17] makes impracticable to adapt r_t to r_t^E.

The aforementioned tendencies tend to revert in the very long run, since the amount of pensions paid by foreign funds likely dominates the flow of saving after the period t*. Thus after some decades, the exchange rates of aging countries tend to appreciate and the balance of payment to improve, with adverse effects also on the dynamics of exports and output in aging countries. What is more, in principle, the flow of pension from abroad could increase without any limit, putting the exchange rates system under permanent and increasing pressure.

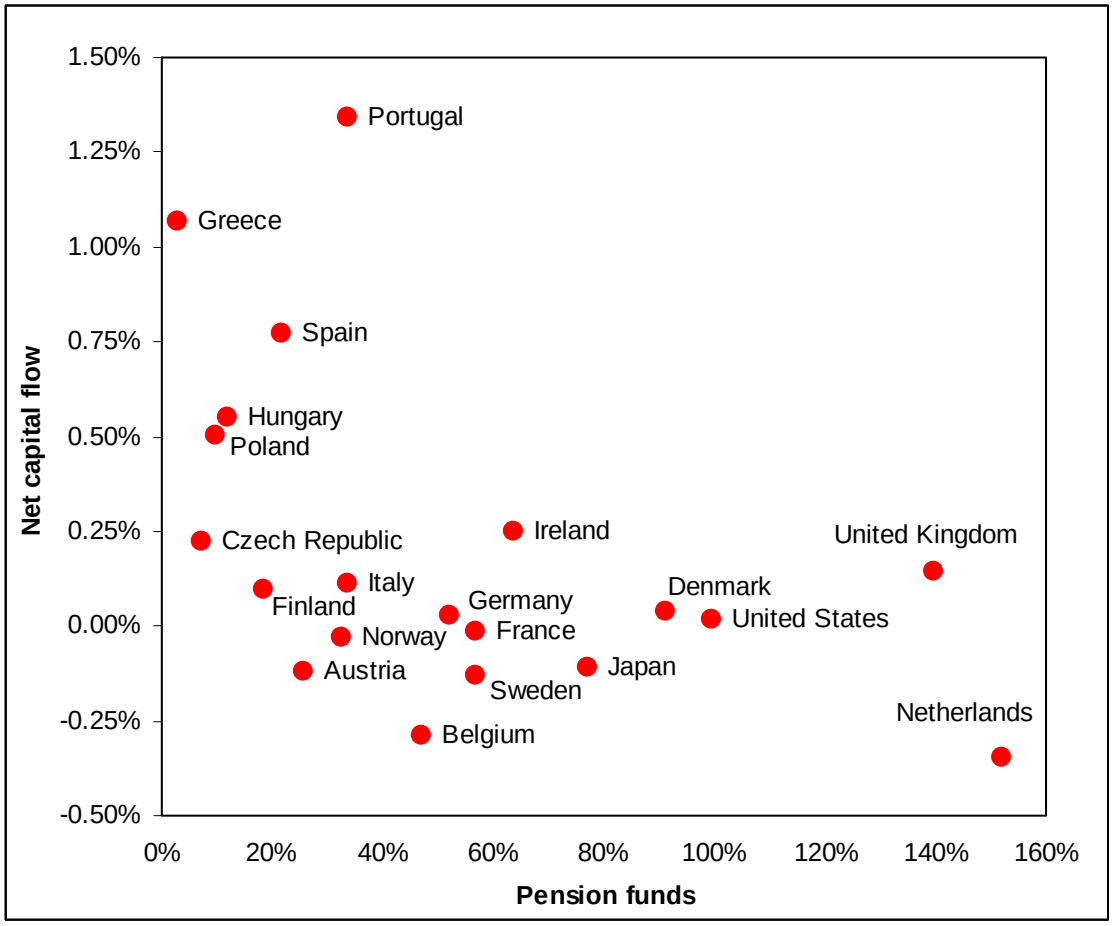
The financial accounts published by OECD and Eurostat provides some empirical support to the prediction that introducing a private funded pension system initially tends to worsen the capital account balance and is associated to an improvement of the balance only when the private funded systems reach their maturity.

In the last few decades, almost every country has reduced the importance of public pension systems based on the PAYG schemas, introducing or promoting pre funded systems. As a consequence, the net equity of households in life insurance and pension funds reserves increased compared to GDP, especially in countries where public systems were substantial during the seventies and eighties. In fact, it is apparent from Figure 2 that, until the amount of the pension saving does not exceed 50-60% of GDP, a larger share of pension funds owned by households is also associated to a smaller net balance of international capital flow. Beyond this threshold, the capital inflow related to the withdrawals from previous foreign investment of pension funds possibly dominates over the new investment, so that the national capital account balance tends to improve slightly, as in the case of Japan, Denmark, US, and UK, where the pension funds accrued until now about equal or even exceed the corresponding GDP. Within this framework, the Dutch case is an exception, being characterized by relatively large deficit in capital flow and huge assets invested by households in pension funds.

In any case, it is worth noticing that the net capital balance worsening likely induced by the investment policy of pension funds in the short and medium run seems more evident that the possible later improvement, as predicted by the model. In fact, the pensions funded by previous foreign investment hardly balance the new current pension saving of workers in activity, unless the ratio of contributors to pensioners deteriorates dramatically.

Figure 2 – Households pension saving and capital account balance

(Percentage of GDP, average 2000-2008)



Source: Elaboration on Eurostat and OECD data.

5 Per capita pensions and indexation in a pre funded system

According to [13], [19] and [20], and assuming that the foreign interest rate is exogenously set to r^E, the total amount of pensions is

$$P_t^T = r_t F_0 + \left(r_t S_0 + r^E S_0^E\right) \frac{e^{\dot{g}t} - 1}{\dot{g}} \qquad [24]$$

and per capita pension $p_t^T = \frac{P_t^T}{N_t}$ is

$$p_t^T = \frac{r_t \dot{g} F_0 + \left(r_t S_0 + r^E S_0^E \right)\left(e^{\dot{g}t} - 1 \right)}{\dot{g} N_0 e^{\dot{N}t}} \qquad [25]$$

Equation [25] implies that, in the long run, the growth rate of per capita pension is

$$\dot{p}^T = \dot{g} - \dot{N} = \dot{v} + (\dot{L} - \dot{N}) \qquad [26]$$

which depends only on the real growth rate of domestic economy and demographic factors, i.e. the difference between the growth rate of active and non active population. Furthermore, [26] shows that $\dot{p}^T$ is unrelated to the rate of return of both domestic and foreign pension funds, even though the amount of per capita pension, given by [25], depends both on the composition of the portfolio of pension funds and its overall return. It follows that portfolio selection and monetary policies possibly affect only the absolute level, but not the long run dynamics of per capita pensions. This result comes out directly from the assumption that pension funds are financed every year by a constant share of the income of workers in activity, which, in turn, rises at the pace $\dot{g}$, regardless to the return of funds.

According to [25], the average replacement rate is

$$\mathrm{R_t} = \frac{p_t^T}{v_t} = \frac{r_t \dot{g} v_0 F_0 + \left(r_t s_0 + r^E s_0^E \right) L_0 \left(e^{\dot{g}t} - 1 \right)}{\dot{g} N_0 e^{\left(\dot{N} + \dot{v}\right) t}} \qquad [27]$$

Equation [27] implies that in the long run

$$\dot{R} = \dot{L} - \dot{N} \qquad [28]$$

Therefore, the long run dynamics of $\mathrm{R_t}$ depends only on demographic factors, but not on productivity and financial factors (i.e.: the composition of the portfolio of funds and its return).

Equations [26] and [28] carry a number of interesting consequences. First of all, any private agreement or institutional rule is neither sustainable in the long run nor credible if it promises that per capita pensions will grow at a rate higher than $\dot{v} - (\dot{L} - \dot{N})$, and, at the same time, keeps the pension saving propensity $s_t + s_t^E$ constant over time, and the real growth rate of per capita income to $\dot{v}$. Secondly, the rate of return on pension funds is not essential in determining the evolution of per capita pensions, also with reference to the revenues of workers in activity. More precisely, in the long run, the ratio between per capita pensions and income of productive workers tracks exactly

the dynamics of the ratio of the number of active to non active people. It follows that, in an aging society, where $\dot{L} < \dot{N}$, any sustainable pension scheme, with constant contribution ratio, necessarily must foresee a deterioration of the revenues and purchasing power of pensioners, compared to workers in activity. Nevertheless, equation [27] shows that the ratio between p_t^T and v_t is also related to the composition and return of the portfolio of pension funds.

If a pension scheme grants individual pensions indexed to the income of workers in activity, and that the return on foreign assets is given, equation [24] implies that

$$\left(r_0 S_0 + r^E S_0^E\right) e^{\left(\dot{v}+\dot{N}\right) t} = r_t F_0 + \frac{\left(r_t S_0 + r^E S_0^E\right)\left(e^{\dot{g}t} - 1\right)}{\dot{g}} \qquad [29]$$

that is

$$r_t = \frac{\dot{g}\left(r_0 S_0 + r^E S_0^E\right)}{S_0\left(e^{\dot{g}t} - 1\right) + \dot{g}F_0} e^{\left(\dot{v}+\dot{N}\right) t} - \frac{\dot{g} r^E S_0^E}{S_0 + \dot{g}F_0\left(e^{\dot{g}t} - 1\right)^{-1}} \qquad [30]$$

As a consequence, r_t should be adjusted over time in order to grant the indexation of individual pensions, no matter if its level exceeds $\dot{g}$, breaking the sustainability condition [17]. In addition, in an aging society, where $\dot{L} < \dot{N}$, [30] implies that the return on domestic funds should rise monotonically at the rate $\dot{N} - \dot{L}$, without any upper limit, regardless to the real growth rate, the return on foreign funds and the initial conditions given by S_0, S_0^E and F_0. Under such conditions, the dynamics of r_t is clearly unsustainable in the long run, therefore the only possible conclusion is that no pension scheme can grant a full indexation of pensions, unless the pension fund increases at a pace faster than the income of workers in activity, that is if larger and larger resources are diverted from the compensation of productive factors in favour of pensions. This redistribution of income may occur by increasing contribution rate or the saving propensity of workers in activity.

6 Concluding remarks

Whatever pension system foresees that a significant share of the output produced by workers in activity is distributed to pensioners. Previous individual payments of social contributions or investment in pension funds only represent claims on future output, since it is almost impossible to store for decades the goods and particularly services that workers in activity will possibly consume after their retirement. Indeed, the only practicable forms of storing consists of investing in

dwellings, infrastructures and the human capital of the workers who likely will provide the pensioners with goods and services in the future. Therefore, an aging society faces only two alternatives: either to increase the share of the income of workers in activity distributed to pensioners, or to reduce the resources available for retirees. A further possibility would be adopting the practice of some primitive tribes, reported by Caffè (1986) paradoxically, where "when elders became unable to give even the least contribution to the community, were brought to the bank of a deep river and pushed with long perches, gently but firmly, toward the no return point".

This paper supports the view that a generous pension scheme is inconsistent both with light social contributions and low investment in a voluntary pension fund. In particular, in a PAYG system, the contribution rate cannot be kept constant simply by stimulating the participation to the labour market once and for all, but it is necessary to increase permanently the growth rate of workers in activity and reducing the increase of pensioners as well, possibly without making use of perches. A PAYG that grants generous pensions and inadequate contribution rates would make the public debt and related interest rates explode over time.

On the other hand, a pre-funded system promising large returns on the saving of workers in activity nowadays would be unsustainable in the long run as well. In particular, if the saving ratio is kept constant over time, the return on pension funds cannot exceed the real growth rate of output, so that, in an aging society, the pre-capita pensions must necessarily increase at a rate lower than other incomes. If pension funds had invested in fast growing countries, in order to overcome the ceiling put on the return of domestic investment, the monetary authorities should be geared up to face a prolonged deficit of foreign balance of payment, or to depreciate the national currency, or to adjust interest rates upward, even if the latter solution would discourage pension saving in favour of individual financial investment. Some back of the envelope calculations show that only after several decades, the international capital flows related to the payment of pensions may contribute to improve the balance of payment. Nevertheless, the consequences on monetary variables of switching to a fully pre-funded system have been often overlooked in the literature. In particular, only few studies (such as Jousten and Legros, 2002), investigate the opportunity that a centralised monetary policy, within a monetary union, requires also harmonised pension systems to avoid an undesirable reallocation of resources among different countries.

This paper strengthens the view that the best way to finance a generous pension system without overloading the working generation is to accelerate the growth, notably investing in technology, infrastructures, and the formation of human capital. However, in an aging society, workers in activity should accept to renounce to a large share of the output they produce, and pensioners should acknowledge that their purchasing power cannot grow at the same pace of output.

Otherwise, the economy should live with large and prolonged changes in interest and exchange rates, and a huge international reallocation of funds. The reform of pension systems may attenuate the drawbacks and costs of the transition to the equilibrium path, but cannot elude the constrains put by aging and slow growth of developed economies.

Although the results of this paper hold formally for whatever notion of real growth, pensioners and workers in activity, the conclusions turn out to be more or less binding depending on the definitions adopted. As long as the sustainability of a pension system ultimately depends on the ratio between the number of pensioners and workers, it makes a difference to consider the role actually played by each individual within the economic and social system. More precisely, the capacity of some people to contribute to real growth matters, as well as their eligibility to fund the pension system through even virtual payment. In fact, many pensioners are very productive, in particular in child care, house keeping and protection of the environment, e.g.: maintaining little towns otherwise abandoned, improving the security of the districts where they live, etc. Hence, in most cases pensions should be correctly considered as the compensation for useful social work (net of corresponding social contribution). Nevertheless, the current statistics do not include such activities within the GDP. Contrarily, many people classified as workers by the official statistics give only a negligible contribution to the growth, and their wages should be regarded more properly as social benefits rather than as compensation of productive factors. As a consequence, a careful reclassification of productive activities within the system of official statistics might change the picture of the sustainability of actual pension schemas, in particular of PAYG systems.

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