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Abstract

This paper explores the causes of the social security financial crises. We indicate that the financial crisis might be endogenous to the social security system. The main idea is that the PAYG social security system might affect fertility and human capital's decisions and therefore, may negatively impact the aggregated growth rate of the economy. These effects lead to an endogenous erosion of the financial basis of the PAYG social security program so that, as a consequence, the PAYG system is not sustainable and it requires continuous increases in the social security tax rate.

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Abstract

This paper explores the causes of the social security financial crises. We indicate that the financial crisis might be endogenous to the social security system. The main idea is that the PAYG social security system might affect fertility and human capital's decisions and therefore, may negatively impact the aggregated growth rate of the economy. These effects lead to an endogenous erosion of the financial basis of the PAYG social security program so that, as a consequence, the PAYG system is not sustainable and it requires continuous increases in the social security tax rate.

1 Introduction

Most social security systems established by governments in the past were financed by payroll taxes on a pay-as-you-go basis (PAYG). Thus, contributions paid by current workers are used to pay the pensions of those already retired. However, those systems have faced large financial problems due to the change in the age distribution and on life expectancy which have increased the fraction of population receiving benefits through time.

More retirees, fewer workers, and longer life expectancy are a combination that requires increments in payroll taxation to avoid the bankruptcy of the system. An example of this trend on payroll taxation is the U.S. social security payroll tax which increased from 2 percent in 1940 to 6 per cent in 1960 and 12 per cent in 1990.

Another example is the case of Chile. Chile had a PAYG system from 1925 until 1981. The system resulted in fiscal problems as the number of elderly individuals receiving benefits increased from 581,000 in 1970 to over one million in 1979. During the same period, the number of individuals paying social security taxes increased from

2.2 million to only 2.4 million [1]. As a consequence, the government continuously increased the social security tax rate reaching levels exceeding 50 per cent during the 1970s. Chile replaced its PAYG system by an individual account system in 1981.

This paper argues that this phenomenon, at least a part of it, is endogenous to the system. To do so, we follow the literature relating social security, fertility and endogenous growth -see Cigno (1992, 1995), Erlich and Zhong (1998), Nishimura and Zhang(1992), Veall(1986), Zhang (1995), Zhang and Zhang (1995,1998), Wigger (1998)- by extending the model developed by Becker, Murphy and Tamura (1990). This model provides similar conclusions to the model considered by Jie Zhang (1995), as the PAYG social security system might decrease fertility rate. However, the novelty of the paper is that we argue that the interactions between the family and the government lead to an endogenous erosion of the financial basis of the PAYG social security program so that, as a consequence, the PAYG system is not sustainable and it requires continuous increases in the social security tax rate.

We will focus in a small open economy facing factor prices. This is a simplifying assumption that allows us to focus in the demographic transition phenomena rather than in physical capital accumulation. We will show that the aggregated growth rate of the economy is partially determined by the PAYG system, because the system affects fertility and human capital's decisions. The negative impact on the aggregated growth rate of the economy produces the financial crisis of the social security system and the increments in the social security payroll tax rate. Section 2 will describe the family's problem and indicates how the fiscal variables affect the family's decisions while section 3 includes the government's reaction and focuses on the endogenous financial crisis.

[1] See Godoy and Valdes (1993)

2 The environment

We will suppose that in this economy people live for three periods of time. In the first of them, people are born and receive education from their parents while, in the second and third periods, they obtain utility from consumption flows. We will assume that the utility function is separable through time, and has the CRRA form, e.g. $u(c) = \frac{c^{1-\sigma}}{1-\sigma}$, with parameter $\sigma > 0$. Each individual has a discount factor $\beta < 1$.

Parents are altruistic as they care about the utility of their children. Following Becker, Murphy and Tamura (1990) we will assume that parent discount their children's utility by the factor $\alpha(n_t)^{-\epsilon}$, where n_t is the number of children parents choose to bear, while $\alpha > 0$ and $1 > \epsilon > 0$ are constant parameters. The last restriction assures concavity on the children's utility discount function.

Education determines the level of human capital, H_t, used during the second period of life (young adult). At this moment, the young adult obtains income from two sources. The first source is inheritance from parents, b_t, while the second is labor income, that depends on her human capital and on the time devoted to the labor market. We will suppose that the agent has a unit of time that must be distributed between labor supply and time dedicated to raising children. Thus, the agent must decide whichever children to raise and the amount of time dedicated to each one of them, y_t. It follows that labor income is $w_t H_t(1 - n_t y_t)(1 - \tau_t)$, where w_t is the wage rate per unit of human capital and τ_t is the tax rate levied by the government to collect revenues. Total income is distributed between consumption c_t^y and saving, s_t, for the third and last period of life.

During the last period of life (old adult), the individual obtains income from the return of her savings, $(1 + r_{t+1})s_t$, as well as a transference from the public funded social security, which is a proportion Φ of the individual's contribution during her second period of life. The parameter Φ is constant through time. Income is used as consumption, c^o_{t+1}, and as inheritances for children, $n_t b_{t+1}$. Finally, the human capital evolves according to the functional form $H_{t+1} = A y_t H_t$, where H_{t+1} is the son's human capital stock while H_t is the one corresponding to the parent. This scheme is transformed in the following recursive problem:

$$\begin{aligned}
V(b_t, H_t) &= max \quad u(c^y_t) + \beta u(c^o_{t+1}) + \beta \alpha n_t^{1-\epsilon} V(b_{t+1}, H_{t+1}) && (1)\\
s.t. & \\
c^y_t &= b_t + w_t H_t (1 - n_t y_t)(1 - \tau_t) - s_t && (2)\\
c^0_{t+1} &= (1 + r_{t+1}) s_t + \Phi w_t H_t (1 - n_t y_t) \tau_t && (3)\\
H_{t+1} &= A y_t H_t && (4)
\end{aligned}$$

Where $V(b_t, H_t)$ is an individual's value function. Before characterizing the problem, we will indicate certain restrictions that we will impose in the parameters of the problem. In the first place, we will restrict the tax rate, τ_t to lie in the interval $[0, 1]$, $\forall t$. Obviously, a tax rate smaller than zero would not produce collection of revenues, (in fact it would produce subsidies), and therefore the government would not be able to pay the promised benefits to the retirees in the systems. Similarly, a rate superior to a 100 percent is discarded because the individual would not have incentives work and hence, this is another scenario in which there is no collection of taxes. Secondly, we will assume that the rate of return of the social security system, Φ, is smaller than the one of the financial system, e.g. $1 + r_{t+1} > \Phi$. Although this might be seen as an arbitrary assumption, the evidence provided by Song (2000) indicates that, in general, the rate of return of the PAYG social security systems through the world is smaller to the one obtained from the financial system and even in some cases is negative.

Thirdly, we will assume that our economy is a small economy facing stationary factor prices, e.g. $w_t = w, r_t = r$, $\forall$ t. Finally, it is important to notice that given the time restriction, it follows that $0 < n_t y_t < 1$, $\forall$ t.

The first order conditions with respect to y_t, s_t, plus the envelope condition on human capital[2] determine the following condition:

$$R_H = A(1 - n_{t+1}y_{t+1})\frac{w_{t+1}}{w_t}\frac{1 - \tau_{t+1}(1 - \frac{\Phi}{1+r_{t+2}})}{1 - \tau_t(1 - \frac{\Phi}{1+r_{t+1}})} = 1 + r_{t+1} = R_k \tag{5}$$

Where R_H, R_k are the rate of return of human capital and financial sector, respectively. Note that the numerator of R_H is the rate of return of current human capital investment, which depends on the parameter A (the productivity of the human capital technology) and son's labor supply decision. Hence the numerator of R_H is the return of increasing marginally time spent on human capital per capita. The denominator is the opportunity cost of dedicating time to human capital accumulation. The intuition of the condition (5) is that, at the margin, the return of the two forms of inheritances (human capital and bequests) must be equal.

An additional condition is obtained from the bequests' first order and envelope conditions:

$$\frac{u_c(c_t^y)}{u_c(c_{t+1}^y)} = (\frac{c_{t+1}^y}{c_t^y})^\sigma \quad = \quad (Ay_t)^\sigma = \beta\alpha(1 + r_{t+1})n_t^{-\epsilon} \tag{6}$$

The equality uses the the property of a stable growth path, e.g. $\frac{c_{t+1}^y}{c_t^y} = Ay_t$. This equation indicates that the growth rate of consumption across generations depends on a traditional Euler equation, where the discount factor is function of the number of children, n_t.

[2]The envelope condition, as in Stokey, Lucas and Prescott (1989), is $\frac{\partial V_t}{\partial H_t}$

Equations (5) and (6) determine a set of two implicit functions[3] as in $n_t = n_t(\tau_t, \tau_{t-1}), y_t = y_t(\tau_t, \tau_{t-1})$. An interesting property is obtained when we characterize the effect of an increase in the current tax rate.

An increase in the current tax rate is similar to a fall in the after tax-wage rate and therefore is associated with an income and a substitution effect. The income effect occurs because the rate of return of the social security system is smaller than the rate of return of the financial system and therefore, the present value of an increase in the tax rate is negative. The substitution effect is associated with the increase in the opportunity cost of labor supply. As we will see below, the income effect is larger than the substitution effect and, as a consequence, total time spent on children decreases which will produce an impact on fertility rate and time spent per child.

The next set of equations illustrates the effects of the increase in the current tax rate:

$$\frac{\partial n_t}{\partial \tau_t}\frac{1}{n_t} = -\frac{\sigma}{\sigma - \epsilon}\frac{(1-n_t y_t)}{n_t y_t}\frac{1-\frac{\Phi}{1+r_{t+1}}}{1-\tau_t(1-\frac{\Phi}{1+r_{t+1}})} \tag{7}$$

$$\frac{\partial y_t}{\partial \tau_t}\frac{1}{y_t} = -\frac{\epsilon}{\sigma}[\frac{\partial n_t}{\partial \tau_t}\frac{1}{n_t}] \tag{8}$$

$$\frac{\partial n_t y_t}{\partial \tau_t}\frac{1}{n_t y_t} = \frac{\sigma - \epsilon}{\sigma}[\frac{\partial n_t}{\partial \tau_t}\frac{1}{n_t}] \tag{9}$$

The results show that, in fact, when $\sigma > \epsilon$, fertility rate falls whereas the time dedicated to each son increases. Moreover the effect on fertility is greater, which produces the negative effect on total time dedicated to raising children. The intuition of the result is that the utility function on per capita consumption is more concave that the discount function (which depends on the rate of fertility). Hence, we try to diminish the variations in consumption (labor income), granting greater variation

[3]The implicit functions depends also on others parameters, such as β, A, Φ, etc.. These parameters have been omitted from the functional form because they are constant through time.

to the fertility rate. Conversely when $\sigma < \epsilon$, we grant less variation to the fertility rate and we diminish time spent per child while we increase fertility rate. Notice that for any value of σ and ϵ, total time dedicated to childbearing diminishes, while labor supply raises.

Similarly, the effects of an increase on the lagged tax rate are:

$$\begin{aligned}
\frac{\partial n_t}{\partial \tau_{t-1}} \frac{1}{n_t} &= \frac{\sigma}{\sigma - \epsilon} \frac{(1 - n_t y_t)}{n_t y_t} \frac{1 - \frac{\Phi}{1+r_t}}{1 - \tau_{t-1}(1 - \frac{\Phi}{1+r_t})} \\
\frac{\partial y_t}{\partial \tau_{t-1}} \frac{1}{y_t} &= -\frac{\epsilon}{\sigma}[\frac{\partial n_t}{\partial \tau_{t-1}} \frac{1}{n_t}], \qquad \frac{\partial n_t y_t}{\partial \tau_{t-1}} \frac{1}{n_t y_t} = \frac{\sigma - \epsilon}{\sigma}[\frac{\partial n_t}{\partial \tau_{t-1}} \frac{1}{n_t}]
\end{aligned}$$

The results in this case are exactly the contrary compared to the previous case. In the first place, for any value of σ and ϵ, the time dedicated to work diminishes, whereas the amount of time dedicated to raise children increases. The intuition is that the increase on the lagged tax rate was related to an increase in the tax rate faced by the parents of the current young adult generation, who reacted to this tax by increasing the time dedicated to their work, and diminished their total time dedicated to their children. In order to compensate to the present generation, the parents dedicated larger time per capita (as we saw above) to each child or left greater per capita inheritances. This is the reason why the resources of the present generation, at the per capita level increased. This positive per capita income effect stimulates each current young adult, who provides less work and spends more time (altogether) in her children. This is done by increasing the fertility rate while smoothly diminishing the time spent in each child, when $\sigma > \epsilon$. The opposite occurs when $\sigma < \epsilon$.

3 The endogenous social security crisis

The previous section showed that the fiscal variables could affect the family' decisions, and particularly the fertility decisions. This section extends these results by allowing the interaction of the family' decisions with the reactions of the government. We will argue that this interaction produces a financial crisis in the PAYG social security system.

In our context, the government looks for keeping its promised benefits while maintaining the system working through time. Although the government could emit debt during certain periods, we will suppose that the PAYG social security program must stay financed, and therefore there is a balanced fiscal budget. This is a simplification that does not modify the analysis because debt emission, if it exists, must be financed in the future.

The following definition explains what we will understand as a social security financial crisis:

Definition: A PAYG social security financial crisis will be understood as a situation in which the government increases the social security tax rate in order to obtain sufficient revenue to pay social security benefits that have been promised.

In the definition we assume that to palliate any financing problem, the government must adequate its tax policy. Nevertheless, it must be indicated that alternatively the government could modify its expenditure policy (through Φ) or could modify the age of retirement of individuals to obtain larger revenues and to diminish its expenses. In our case, we centered the analysis in the tax policy because we considered that whatever is the alternative, the problem does not change: there is a financial crisis on the social security system. The instrument chosen to face this financial crisis is the payroll tax rate.

Next, we will explain how the interaction between the family and the government produces the financial problem. The government must satisfy the following budget constraint:

$$\tau_{t+1} n_t w_{t+1}(1 - n_{t+1} y_{t+1}) H_{t+1} = \Phi \tau_t w_t (1 - n_t y_t) H_t \tag{10}$$

The right hand side is total expenditure per old adult at t+1, which depends on her past contribution to the system, while the left hand side is total revenue collection from current young adults. This equation can be written as in:

$$\tau_{t+1} = \frac{\Phi}{n_t A y_t} \frac{w_t(1 - n_t y_t)}{w_{t+1}(1 - n_{t+1} y_{t+1})} \tau_t \tag{11}$$

At first sight, this equation indicates that the tax rate is not constant. In fact, the tax rate would be constant through time only when the rate of return of the social security system is equal to the aggregated growth rate of the economy ($n_t A y_t$) and when the per capita labor supply does not vary. The fulfillment of those conditions will happen only by chance. Therefore the stability of the system becomes fragile.

Further, the variables that affect the fragility of the social security system are determined by the family that reacts to the government policy, as indicated by the implicit functions of the previous section. The simple implementation of the system alters the family' decisions, which cause the government to react as well, to maintain in balance the fiscal budget. Therefore, an exogenous increase in the current tax rate impacts the future tax rate due to the family and governments reactions as in:

$$
\begin{aligned}
\frac{\partial \tau_{t+1}}{\partial \tau_t}\frac{\tau_t}{\tau_{t+1}} &= \frac{1}{[1-\Theta_{\tau_{t+1}}^{n_{t+1}y_{t+1}}\alpha_{n_{t+1}y_{t+1}}]} + \frac{-\Theta_{\tau_t}^{n_{t+1}y_{t+1}}}{[1-\Theta_{\tau_{t+1}}^{n_{t+1}y_{t+1}}\alpha_{n_{t+1}y_{t+1}}]} + ... \\
&+ \frac{-\Theta_{\tau_t}^{n_t y_t}\frac{1}{1-n_t y_t}}{[1-\Theta_{\tau_{t+1}}^{n_{t+1}y_{t+1}}\alpha_{n_{t+1}y_{t+1}}]} \qquad (12)
\end{aligned}
$$

Where

$$
\begin{aligned}
\Theta_{\tau_t}^{n_{t+1}y_{t+1}} &= -\frac{\partial n_{t+1}y_{t+1}}{\partial \tau_t}\frac{\tau_t}{n_{t+1}y_{t+1}} < 0, \quad \Theta_{\tau_t}^{n_t y_t} = \frac{\partial n_t y_t}{\partial \tau_t}\frac{\tau_t}{n_t y_t} < 0 \\
\Theta_{\tau_{t+1}}^{n_{t+1}y_{t+1}} &= \frac{\partial n_{t+1}y_{t+1}}{\partial \tau_{t+1}}\frac{\tau_{t+1}}{n_{t+1}y_{t+1}} < 0, \quad \alpha_{n_{t+1}y_{t+1}} = \frac{n_{t+1}y_{t+1}}{1-n_{t+1}y_{t+1}}
\end{aligned}
$$

This equation indicates that the increase of the current tax rate, τ_t, produces an increase in the future tax rate, τ_{t+1}, due to the following effects. In the first place, an increase in τ_t produces an increase in contributions and thus in future benefits to be paid, for a given level labor supply. Secondly, current labor supply increases, which also increases future benefits to be paid and thirdly, the increase of current taxes is related to a fall in the future labor supply (children will work less, as seen in the previous section). These are the three effects that appear in the numerators of the right hand side of the equation (12). All these effects are related to greater future benefits to be paid whereas lower future revenues are collected, and therefore, require larger tax rates in the future. There is a fourth effect that goes in the opposite sense (the coefficient in the denominator, $\Theta_{\tau_{t+1}}^{n_{t+1}y_{t+1}}$). This is related to the fact that an increase in the future tax rate causes an increase in the future labor supply, which allows to lessen the effect of τ_t on τ_{t+1}. However, it is clear that the right hand side of (12) is positive, indicating that an increment in the current tax rate will cause an increase in the future tax rate. In other words, an exogenous increase in the current tax rate must be transferred to the future and produces an endogenous financial problem.

Notice that equation (12) can be written as in:

$$\frac{\partial\tau_{t+1}}{\partial\tau_t}\frac{\tau_t}{\tau_{t+1}} = \underbrace{[\frac{1+r_{t+1}}{A(1-n_{t+1}y_{t+1})}]}_{\substack{\text{finan.-human cap.}\\ \text{return ratio}}} \underbrace{[1+\frac{\tau_t}{n_t y_t}(1-\frac{\Phi}{1+r_{t+1}})]}_{\substack{\text{increase in}\\ \text{future benefits}}} \tag{13}$$

In this expression, the effect of τ_t on τ_{t+1} depends on two parts: (1) the ratio of the rate of return on the financial sector -$(1+r_{t+1})$- and the rate of return of the human capital technology and on (2) the increase in future benefits.

There are larger future benefits due to the larger current tax rate which (1) produces larger contributions to the PAYG system and, (2) increases labor supply. Both effects are associate with larger future financial requirements of the PAYG system. In fact, the first of them requires an increase in the future tax rate similar to the current increase.

It is interesting to notice that the term corresponding to the increase in future benefits is unambiguously greater than one and therefore, when $(1+r_{t+1}) > A(1-n_{t+1}y_{t+1})$, an increase of 1 percent on τ_t produces an increase superior to 1 percent on τ_{t+1}. This result has an important implication as it indicates that an exogenous increase in the tax rate will be amplified through time. In that sense, the tax rate follows a unit-root process and thus, any exogenous shock to the system creates an endogenous and explosive financial crisis in the PAYG social security system.

The condition $(1+r_{t+1}) > A(1-n_{t+1}y_{t+1})$ assures that the rate of return of human capital be smaller than the financial sector rate of return. This implies that the human capital growth rate does not provide enough funds to finance the system in the future, for any given level of future benefits. The condition depends on children's labor supply, $(1-n_{t+1}y_{t+1})$, indicating that even when the human capital technology might be very productive, $A \gg (1+r_{t+1})$, the government might not be able to collect enough revenue due to labor supply responses of the family.

Nevertheless, it is important to notice that the condition $(1 + r_{t+1}) > A(1 - n_{t+1}y_{t+1})$ is a sufficient condition, but not a necessary condition. In fact, a less demanding condition would also produce the result that the increase in the current tax rate requires a superior increase in the future tax rate. This condition is the result of considering the effect of the increase in future benefits, stated above, jointly with the ratio of rate of returns.

In summary, this document indicates that the social security system can suffer of an endogenous financial crisis. In fact, the family reacts to the system and those reactions cause a fall in the aggregated growth rate of the economy. The mechanism is the following. The increase in the tax rate produces an increase in the current labor supply, which diminishes time spent on children, $n_t y_t$, and directly impacts the aggregated growth rate of the economy as this last one is a linear function of $n_t y_t$, e.g. $n_t \frac{H_{t+1}}{H_t} = n_t A y_t$. This takes place through a demographic transition or a diminution in the growth of the human capital to per capita. In any case, as the aggregated growth rate is reduced, it is not possible to collect the necessary funds to pay promised benefits and increments in the tax rate through time are required.

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