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Roberto de Goes Ellery Jr.
Universidade de Brasília

Mirta Noemi Sataka Bugarin
Universidade de Brasília

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Roberto de G. Ellery Jr.
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UNIVERSIDADE DE BRASÍLIA
DEPARTAMENTO DE ECONOMIA
Campus Universitário Darcy Ribeiro
Instituto Central de Ciências
Caixa Postal 04302, 70910-900 Brasília, DF, Brasil
Tel.: (55-61) 3072498, 2723548
Fax: (55-61) 3402311
E-mail: econ@unb.br
http://www.unb.br/ih/eco

SÉRIE DE TEXTOS PARA DISCUSSÃO

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Welfare Implications of the Brazilian Social Security System

Roberto Ellery Junior
Departamento de Economia
Universidade de Brasília
Campus Universitário – ICC Norte
Brasília – DF , 70910-900

Mirta N. S. Bugarin
Departamento de Economia
Universidade de Brasília
Campus Universitário – ICC Norte
Brasília – DF, 70910-900

Abstract

This paper aims to evaluate the impact of the Brazilian Social Security General System (RGPS - Regime Geral de Previdência Social) on social welfare as well as its effects on some selected macroeconomic variables. To this end, a model economy of overlapping generations, calibrated to reproduce the main facts of the Brazilian economy, will be numerically simulated. The model economy introduces two idiosyncratic shocks to the agents. The shocks try to capture the uncertainties related to the life span of the agents and to their next period income, given the probability of the agent being employed or unemployed during that next period and the hypothesis of credit restriction into their per period budget constraint. The results obtained suggest that the pay-as-you-go system of social insurance, which guarantees only a fraction of the individual's working period income, results in improved social welfare, when compared to a system in which per period aggregate benefits are funded by accumulated savings.

1. Introduction

In any contemporaneous economic analysis issues on social security and on its financing mechanism arise naturally. From an applied economics point of view, in particular focusing on public policies, this institution constitutes itself a matter of extreme relevance. The distribution mechanism of social security benefits possesses an undeniable social welfare impact. The related issues range from inter-generation solidarity to income distribution considerations. On the other hand, the social cost of financing the social security scheme turns out to be a major public finance issue for the majority of the countries, as recent demographic changes increasingly threaten the financing capacity of the system all around the world.

Some studies indicate that from 2030 on the U.S. social security system will present a fiscal deficit[1], as it will also be the case of many European countries and Japan. In Brazil, the inability to finance the expenses associated to the Social Security System is already apparent. In 1998 the social security deficit was the main source of the Federal government's primary deficit[2] and, in 1999, despite strong fiscal efforts, the RGPS showed a deficit of approximately R$ 30 billions or 3.1% of the country's GDP.

Chile was one of the first countries that tried to solve the fiscal imbalance by changing the social security system itself. The Chilean proposal consisted of transforming the former pay-as-you-go system into a funded system or a system of individual accounts where each (future) benefit would be related to the associated contribution in order to face the changes in the Chilean demographic structure, which threaten the financial balance of the system. This reform proposal was based on the main existing theoretical literature, which argued that the change to a funded system would lead to increases in the saving rate of the population and, hence, to an increasing supply of capital. This increase would allow in turn a faster capital accumulation, thus leading to a faster output and consumption growth or, equivalently, to higher levels of social welfare. The cost of the transition from the former pay-as-you-go to the funded system was regarded worth bearing, in view of to

[1] See Feldstein & Samwick (1997).
[2] Data from the National Treasure Office (STN)

the future social welfare benefits. Such a confidently expected result turned the discussion on the ways to finance this transition cost, regarded as the sole obstacle to achieve the social benefits of the funded system. This country's experience was often taken as a benchmark case for analyzing alternative proposals[3].

As time went by, some new issues have been raised. In particular, it was noted that the funded system could transfer risks to the insured, especially those related to specific individual risks. An example would occur when an individual is dismissed and is not able to contribute for its personal account. This problem is more serious in countries where agents cannot count with a financial system that allows them to (optimally) smooth-out consumption during the economic cycle. This point is one of extreme relevance for Brazil, since most of the families in the country do not in fact have access to the credit market[4].

Another aspect is related to the question of dynamic inefficiency. Studies based on dynamic models suggest that if the economy presents dynamic inefficiency, an increase of capital accumulation does not imply an increase in welfare. Along this line of argument, for this type of economy, when capital supply increases due to the introduction of the funded social security system, social welfare can be in fact reduced in spite of a higher capital accumulation.

Some authors, using overlapping generation (OLG) models, recently studied problems of the Brazilian General Social Security System (RGPS)[5]. The present study aims to contribute to this line of research. We extend the standard OLG model by including some special features so as to incorporate into the analysis some of the above raised questions. In particular, credit restrictions will be introduced into the agent's per period budget constraint to capture this feature of the Brazilian economy, and idiosyncratic shocks will be incorporated, namely unemployment and uncertainty about the agent's life span.

The article is organized as follows. Section 2 presents the extended OLG model and defines the equilibrium that it should be numerically solved for. Section 3 explains the calibration of the model based on Brazilian data. Section 4 shows the results of the

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[3] See Barreto (1997).

[4] See Reis, Issler, Blanco & Carvalho (1998)

[5] See Barreto & Oliveira (1995), Barreto (1997) and Lannes Junior (1999).

simulations and, finally, Section 5 concludes introducing some suggestions for future research.

2. The Model Economy

This section presents the OLG model developed in Imrohoroglu, Imrohoroglu and Jones (1995)[6], which will be used to quantitatively assess the implications of the social security system on social welfare. The basic structure of the model is a combination of two types of models. The first type, studied by Kotlikoff (1996), is given by a structure of overlapping generations such that, in any period, many different generations can coexist. The second type, named Bewley Models[7] by Sargent and Ljungqvist (2000), and used by Imrohoroglu (1989) and Hugget (1993), is characterized by an economy in which agents are subjected to idiosyncratic shocks but do not possess any means to perfectly insure themselves against such shocks.

According to these models, the life span of an individual is given by a probability distribution, for the individual knows the maximum time he/she can live but does not know in which period he/she is going to die. This assumption will allow us to study a more realistic demographic dynamics than the ones present in traditional overlapping generation models[8]. To formalize this demographic process, it is assumed that agents who are alive in the period *j-1* will also be alive in period *j* with a probability $\psi_j \in (0,1)$. It is also possible that some agents reach the maximum age *J* and, in this case, the probability of living until *J+1* is assumed to be zero. In each period the number of births grows at a ratio given by *n*. To analyze the steady state it is necessary to get a limit distribution for the demographic structure, in which the fraction of each generation, $\{\mu_j\}_{j=1}^{J}$, is computed according to the

[6] Imrohoroglu, Imrohoroglu and Jones (1998) present an expanded version of the model where land is included as a production factor.
[7] Named after Truman Bewley's (1977, 1980, 1983, 1986) pioneering articles
[8] See Kotlikoff (1996).

rules $\mu_j = \frac{\psi_j \mu_{j-1}}{1+n}$ and $\sum_{j=1}^{J} \mu_j = 1$. These values will be required, in turn, when aggregate amounts are calculated.

Furthermore, it is also assumed that agents in this model economy can face a stochastic income stream during his/her lifetime, for he/she could be dismissed in any active period. Denoting by $s \in S = \{e,u\}$ the states on the job condition, where *e* stands for employed and *u* for unemployed, the two-state Markov process and the associated transition probability matrix can fully describe the transition between the states, $\Pi(s',s) = [\pi_{ij}],\ i,j = e,u$ where $\pi_{ij} = \Pr\{s_{t+1} = j \mid s_t = i\}$. In case an individual is dismissed, it is assumed that he/she receives an income from the unemployment insurance program equivalent to $\phi\omega\varepsilon_j$. Once retired, the individual receives a benefit *b* from the social security system and consumes his stock of assets. The computation of the social security program benefit, $b_j,\ j = 1,2,\ldots,J$, is done according to the following equation:

$$b = \begin{cases} 0 & j = 1,2,\ldots,j_R - 1 \\ \theta \dfrac{\sum_{i=1}^{j_R-1} \omega_i^e}{j_R - 1} & j = j_R, j_R + 1,\ldots,J \end{cases} \tag{1}$$

where *R* represents the mandatory retirement age. Accordingly, the per period individual income is given by:

$$q_j = \begin{cases} (1-\tau_s-\tau_u)\omega\hat{h}\varepsilon_j & j \in [1, j_R), s = e \\ \phi\omega\hat{h} & j \in [1, j_R),\ s = u \\ b & j \in [j_R, J] \end{cases} \tag{2}$$

Another feature of the model consists of introducing an assumption according to which no individual in the model economy may become indebted, in other words, he/she faces constrained liquidity. This hypothesis is clearly relevant, for, without access to the credit market, the individual reduces the possibility of insuring himself/herself against the possible loss of his/her income, particularly after a certain age. In this case, the social security system works as insurance, noting that from equation (1) above, the social security

benefit does not depend on the agent's job history. Moreover, this assumption is even more relevant for the Brazilian economy, as can be inferred from empirical studies, such as Reis et alli (1998), among others, which show that about 80% of Brazilian consumers are constrained to consuming their entire per period income within every period.

Also, since the date of death is uncertain, there exists the possibility that an individual can hold a positive net supply of assets in the period of death. Should this be the case, it is assumed that the involuntary bequest will be equally distributed among all remaining agents. Denoting by $a_t \geq 0$ the supply of assets in period *t*, and ξ the received bequest, the consumer's budget constraint will be given by the following expression:

$$a_j = (1+r)a_{j-1} + q_j - c_j + \xi, \quad j = 1,2,\ldots,J \tag{3}$$

The lifetime utility of each individual is assumed to possess the following functional form:

$$E_0 \sum_{j=1}^{J} \beta^{j-1} \left[\prod_{k=1}^{j} \psi_k \right] \frac{c_j^{1-\gamma}}{1-\gamma}, \tag{4}$$

which he/she maximizes subject to the per period budget constraint (3).

Once the description of the consumers is presented, the next step will be devoted to characterize the firms of the model economy. The numerous identical and competitive firms are introduced according to the traditional hypothesis that allows for the use of the aggregate production function $Q = BK^{1-\alpha}N^{\alpha}$, where Q is output, K is capital and N is labor. Thus, as usual, the first order conditions of the firms' profit maximization problem determine the respective prices of capital *r*, and labor ω, as given by the expressions below.

$$r = (1-\alpha)B\left(\frac{K}{N}\right)^{-\alpha} - \delta$$
$$\omega = \alpha B\left(\frac{K}{N}\right)^{(1-\alpha)} \tag{5}$$

In order to describe the stationary equilibrium of this economy, it will be necessary to write the consumers' problem as a dynamic programming problem (DPP) and then to define, for each age, the limiting measure that describes the distribution of the asset supply among the agents of the economy. The value function that describes the DPP problem of an age *j* individual can be written as below:

$$V_j(a,s) = \max_{c,a'}\left\{u(c) + \beta\psi_{j+1}E_{s'}V_{j+1}(a',s')\right\}, \quad j = 1,2,\ldots,J \tag{6}$$

with the optimization subjected to (3) and $a' \geq 0$. The associated limiting distribution of assets is found in a recursive way as follows:

Given the decision rules A_j, $j = 1,2,\ldots,J$ and the wealth distribution λ_1, the limiting measure can be obtained according to the following rule:

$$\lambda_j(a',s') = \sum_s \sum_{a:a' \in A_j(a,s)} \Pi(s',s)\lambda_{j-1}(a,s) \tag{7}$$

Then, with the above definitions in hand it is possible to define the stationary equilibrium of the model, which will next be numerically solved.

Definition: A stationary equilibrium for a given set of policy arrangements $\{\theta,\phi,\tau_s,\tau_u\}$ is a collection of value functions $V_j(a,s)$; individual policy rules A_j e C_j; age-

dependent, but time invariant, measures of agent types λ_j; relative prices of labor and capital $\{\omega,r\}$; and involuntary bequest ξ, such that:

1. individual and aggregate behaviors are consistent:

$$K = \sum_j \sum_a \sum_s \mu_j \lambda_j(a,s) a_{j-1} \quad \text{e} \quad N = \sum_{j=1}^{j_R-1} \sum_a \mu_j \lambda_j(a, s=e) \varepsilon_j \tag{8},$$

2. factor prices $\{\omega,r\}$ are given by (5),

3. given $\{\omega,r\}$, $\{\theta,\phi,\tau_s,\tau_u\}$ and ξ, the individual policy functions $C_j(a,s)$ and $A_j(a,s)$ solve the dynamic problem in (6),

4. commodity markets clear:

$$\sum_j \sum_a \sum_s \mu_j \lambda_j(a,s) \left\{ C_j(a,s) + \left[A_j(a,s) - (1-\delta) A_{j-1}(a,s) \right] \right\} = Q \tag{9},$$

5. the collection of time invariant measures $\lambda_j(a,s)$ for $j = 1,2,\ldots,J$ satisfies:

$$\lambda_j(a',s') = \sum_s \sum_{a:a' \in A_j(a,s)} \Pi(s',s) \lambda_{j-1}(a,s),$$

6. the social security system is self-financing:

$$\tau_s = \frac{\sum_{j=j_R}^{J} \sum_a \mu_j \lambda_j(a,s) b}{\sum_{j=1}^{j_R-1} \sum_a \mu_j \lambda_j(a, s=e) \omega \varepsilon_j} \tag{10},$$

7. the unemployment benefit insurance program is self-financing:

$$\tau_u = \frac{\sum_{j=1}^{j_R-1} \sum_a \mu_j \lambda_j(a, s=u) \phi \omega \varepsilon_j}{\sum_{j=1}^{j_R-1} \sum_a \mu_j \lambda_j(a, s=e) \omega \varepsilon_j} \tag{11} \text{ and,}$$

8. the involuntary bequests are given by:

$$\xi = \sum_j \sum_a \sum_s \mu_j \lambda_j(a,s) (1 - \psi_{j+1}) A_j(a,s)$$

Given this definition of equilibrium, we turn in the next section to describe the calibration procedure, which assigns values to the parameters of the model economy so as to render the above artificial economy consistent with the Brazilian economy.

3. Calibration

The main objective of this section is to provide a set of values for the parameters of the model economy such that it can properly represent the Brazilian economy through the process known as calibration. Gomes, Ellery Jr. and Sachsida (2000) list some of the basic problems associated with the calibration of dynamic models for Brazil and also suggest several solutions to deal with them. Some of the questions pointed out by the authors apply to the model presented in the previous section, but other questions are specific for the model they were using[9].

Herein, whenever the calibration problem coincides with one of the listed by the above authors, their suggested solution will be used. Also, the calibration procedure for a specific parameter will be different from the one proposed by Imrohoroglu, Imrohoroglu and Jones (1995, 1998, 1999). Such divergences result from a specific problem related to the available Brazilian data. Whenever those cases occur, the two calibration procedures and the related implications will be discussed as well.

Beforehand, it is possible to classify the set of parameters according to their specific roles in the model economy, as it is shown by the different types of parameters listed below.

- Demographic: describes the age structure of the population.
- Preference: characterizes the utility function of the consumers.
- Technological: describes the production process.

[9] Gomes, Ellery Jr., & Sachsida (2000) analyze a class of infinite-lived representative agents models, so that questions as life expectancy and social security are excluded. However some questions such as consumption and capital accumulation may have a similar treatment.

- Policy: describes the social security system and the unemployment insurance program.
- Parameters of the random process that characterize the per period condition of being employed or unemployed.

Thus, the calibration process of the model economy parameters is described below following the above classification.

3.1 Demographic

The demographic structure in the model is characterized by two sets of parameters. The first one consists of the survival probabilities or the probability that an individual that reached age *j-1* comes to reach age *j*, denoted by ψ_j in the model. The second one represents the ratio between the size of each age cohort *j*, j = 1,2,..., J, and the total population or, in other words, the age structure of the population.

Once the values of ψ_j, for j= 1,2,...J, the fraction of agents of each age in the total population, are known, the measure of the each set of age j, j = 1,2,...J, agents defined as μ_j can be determined in turn. As the measure of the total population is one, μ_j can be interpreted as the probability of a randomly chosen individual being of age *j*. To derive the value of μ_j from ψ_j, the rule $\mu_{j+1} = \frac{\psi_{j+1}}{1+n}\mu_j$ and the requirement $\sum_{j=1}^{J}\mu_j = 1$ are used, where n denotes the growth rate of the population. According to the available data from IBGE[10], the average rate of growth of the Brazilian population is approximately 2% per year[11].

Therefore, the problem associated with the characterization of the demographic structure of the model is reduced to find the value of the survival probability for each age *j* individual, ψ_j. To this end, the Mortality Table (IBGE) for to the year 1998 will be used to obtain the probabilities that age *j* individual could die between ages *j-1* and *j*.

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[10] Instituto Brasileiro de Geografia e Estatística.

[11] Data from IBGE covering the period between 1970 and 1998.

However, some caveats apply when IBGE' table is used for calibration purposes. The first one is related to the fact that the model economy includes agents from 21 up to 85 year old only [12], while the IBGE data encompass individuals from zero to 80 year old. The problem can be easily solved for less than 21 year old agents, taking into account only the data related to older ages, and assuming the additional hypothesis that $\psi_1 = 1$, which is equivalent to assume that all agents reach the first age of the model economy. To solve the problem related to the 21-85 year old agents, a linear extrapolation of the series was implemented.

3.2 Preferences

Two parameters are related to the description of the preferences; the first one describes the individual's degree of risk aversion, γ, and the second characterizes the subjective discount factor, β. The calibration of both parameters are troublesome for the Brazilian economy in particular, as very few good estimates are available for the former and, for the later, there exists a problem in the estimation of the wealth supply of the country.

One of the traditional ways to calibrate the value of the risk aversion parameter is to use the estimates of its reverse, namely the intertemporal elasticity of substitution defined as $\nu = 1/\gamma$. The estimation procedure of this parameter is a sufficiently complex task, as pointed out by Reis, Issler, Blanco and Carvalho (1998). Moreover, the procedure appears to be difficult even for countries with a good tradition in providing accurate databases. For instance, in the United States, Mehra and Prescott (1985) argue that reasons exist to believe that the intertemporal elasticity of substitution would be between zero and one[13]. In turn, Imrohoroglu (1989) suggests that in the majority of studied cases the value of this parameter would be between half and one and a half. On the other hand, to study the costs of real business cycles in the United States, Lucas (1987) uses a value close to 0.16 for the

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[12] The authors plan a future extension where agents may enter the workforce at ages below 21 years, even though Barreto(1995) and Lannes Jr. (1999) have also assumed 21 as the age that the agents enter the labor market.

[13] These values are associated with values ranging from one and twenty for the risk aversion coeficient.

same parameter ν[14], while Hall (1978), from annual data, suggests that this value can be a negative one. The great disparity between the estimated values made some authors assume that the intertemporal elasticity was equal to one, as a way of getting the operational advantages associated to the logarithmic specification of the utility function[15].

For the Brazilian case, the estimates also present a great disparity among them. Estimating the Euler equations, Cavalcanti (1993) concludes that the intertemporal elasticity of substitution would be smaller than one, near zero, the same result obtained by Gleizer (1991). On the other side, Reis et alli (1998) suggest that, since by construction the ratio includes the credit-unconstrained population and since the elasticity of intertemporal substitution is statistically zero, there is a clear indication that the value of the intertemporal elasticity of substitution is greater than one[16]. Also in studies on the Brazilian cycle, Issler and Rocha (1999) use values between zero and one for the elasticity of intertemporal substitution, ν.

These estimates for the Brazilian economy could be regarded as an indication of the relevance of the credit restriction faced by Brazilian consumers. Most of these estimates use the sensitivity of the consumption to the interest rate to estimate this elasticity. If the population is constrained to consume all its income, consumption must present a negligible sensitivity with respect to variations of the interest rate. So, the low sensitivity of consumption to interest rates would not be reflecting a low elasticity of substitution but rather the existence of binding liquidity constraints faced by the consumers.

Due to the great disparity between the estimates for the intertemporal elasticity of substitution, the value of this parameter was drawn from other simulation studies about the Brazilian Social Security System. Barreto (1997) and Lannes Jr (1999) use the estimates given by Cifuentes and Valdés-Pietro (1993) [17] for developing countries. Barreto (1997) uses a value of 0.7 for the intertemporal elasticity of substitution , so this will be the value used in the numerical simulations below.

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[14] A value of 6 for γ.
[15] See Prescott (1986).
[16] They estimate that the share of non-restricted agents is 0.2.
[17] The same reference is used in Barreto & Oliveira (1995).

For the subjective discount factor, β, the traditional way to calibrate it is to restrict the model to replicate the observed wealth/income relation in the economy. However, an important share of the wealth is given by the supply of durable goods, and this series is not available for Brazil. Given the lack of an appropriate series for wealth supply, it is possible to calibrate β alternatively from the interest rate of the economy[18]. To deal with this problem, two alternative procedures will be used to define the value for this parameter.

The first one replicates the wealth/income ratio suggested by the series of wealth published by IPEA[19], which reaches an average value of 2.7 for the period 1970-2000. According to this method, the value of β would equal 1.005. The alternative procedure, using the interest rate, the value of β would be approximately 0.96.

An important theoretical remark is due at this point. OLG models do not require the subjective discount factor to be smaller than one, due to the fact that the policy function and the value function are well defined for agents who reach the maximum age J[20]. Therefore, the solution of the DPP problem does not depend on fixed-point arguments and consequently the Bellman Equation does not need to be a contraction. Another important point is that the probability of death creates, in fact, an effective discount rate that differs from β[21], so that values smaller than one for this parameter do not imply negative interest rates either.

3.3 Technology

The parameters defining the available technology in the model economy are the ones related to the production function, B and α, and to the depreciation rate, δ. The parameter B is a multiplicative constant and will be defined so as to equate the output value to one in the basic model.

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[18] This procedure is used in Barreto & Oliveira (1995), Barreto (1997) and Lannes Junior (1999).
[19] This series may be found at IPEADATA (http://www.ipeadata.gov.br).
[20] The policy rule amounts to consuming all the assets previously accumulated, plus the current income. To find the value function, one should plug this policy function into the Bellman Equation.
[21] The effective discount factor is $\left\{\beta^{j-1}\prod_{k=1}^{j}\psi_k\right\}_{j=1}^{J}$ [see Imrohoroglu, Imrohoroglu e Jones (1998)].

For the labor share in aggregate income, data from the National Accounts (IBGE) were taken. This series also presents two main limitations. The first one is related to the calculation of labor and capital incomes in case of autonomous workers; the second one relates to the informal economy. These issues can lead to an over-estimated share of capital income in the official accounts. The correction of the official data by the labor and capital income shares in the informal sector could solve this problem. However, this alternative was not used in this study due to the low reliability, or even absence, of these estimates on the Brazilian informal sector.

To simplify things, the income of the autonomous workers was added to the official aggregate labor income in order to calibrate the parameter relative to the labor share in aggregate income. With this procedure, the labor income share was set to 0.53. Although this value is lower than the value usually used for the American economy (about 0.66), it is compatible with values used by other authors, as Barreto and Oliveira (1995), Barreto (1997), Lannes Jr (1999) and Ellery Jr, Gomes and Sachsida (2000), in studies for the Brazilian economy.

The calibration of the depreciation rate on the Brazilian capital stock also presents several shortcomings. First, the Brazilian National Account System does not publish the value of aggregate variables, such as output and investment, neither gross nor net. Second, there is no official capital stock series available, therefore no official estimate of the depreciation rate is feasible.

This lack of an official estimate for δ is circumvented by using different estimates for this parameter value. Barreto and Oliveira (1995), for instance, use a depreciation rate of 3.5% for the Brazilian capital stock when analyzing also the Brazilian Social Security System, justifying this value as being *"a usual value in this type of study"*. Kanczuck and Faria (2000), on the other hand, argue that there are no reasons for the Brazilian rate of depreciation to be different from the one used in the United States (a value from 4.5% to 10%).

Cooley and Prescott (1995) propose a standard way to calibrate the depreciation rate. Their method consists of defining it in such a way that the stability of the capital/output ratio in

the balanced growth path can be guaranteed. This calibration procedure can be described by the equation below, directly derived from the linear capital accumulation dynamics.

$$\delta = \frac{I}{K} + 1 - (1+x)(1+n)$$

where x represents the growth rate of *per-capita* GNP, n the population growth rate and, I/K the investment-capital ratio.

Since this method depends on the availability of a capital series data and given the lack of official data on the Brazilian capital stock, we decided to follow the suggestion given by Kanczuk and Faria (2000). The authors argue that durable and capital goods consumption in Brazil and in the United States are not significantly different, hence, a similar depreciation rate could be applied to both economies. Following this line of argument, the depreciation rate was set to 10% as suggested by Imrohoroglu, Imrohoroglu & Jones (1999) for the latter country.

3.4 Policy Parameters

A given policy in this model economy will be characterized by the values of the replacement rate to the pay-as-you-go social security system, θ, and of the benefit rate associated to the unemployment insurance program, ϕ. Given the values of these policy parameters, the value of the contribution rate to each one of the programs, τ_s e τ_u, respectively, will in turn be defined such that self-financing conditions (10) and (11) are satisfied.

The calibration of the above policy parameters is based on data from the Ministry of Labor (MTb). According to the available official data, the value of the unemployment insurance benefit corresponds, in average, to 40% of the employed individual's wage. Hence, this parameter is set to $\phi = 0.4$.

In the case of the replacement rate of the pay-as-you-go social security system, the average remuneration of the private sector employees from RAIS[22] and the legal RGPS regulatory information were taken into consideration.

The present study focuses on the analysis of the Brazilian General Social Security System (RGPS). This choice leaves the Brazilian federal public employees pension system (RJU) and other sub-national and public agencies' pension schemes out of the present study because of the specific legal rules that apply to the former and, in addition, the lack of trustworthy data for the latter systems. Other pension funds, as well as any private retirement programs, must also be excluded from the analysis due to the particular specification of the model economy. Namely, as introduced in the previous section, the model economy does not allow for more than one type of private asset, therefore, any contribution to a private retirement account is imputed in the individual's total saving in the artificial economy.

Finally, the mandatory retirement age, R, represents another parameter, which is indirectly associated to the retirement policy. Following previous studies on the Brazilian social security system, namely Oliveira & Barreto (1995), Barreto (1997) and Lannes Jr (1999), this age will be set as 65 years old.

3.5 Labor Market

The labor market considered in the model presents a rather simple structure. In each period an individual receives or not a job offer and, every time an offer is made, the individual always accepts it. In other words, it is assumed that the labor supply is inelastic.

Therefore, the calibration of the labor market boils down to the description of the stochastic process governing the job opportunities faced by each individual at every period. A discrete time 2-state-Markov process characterizes this process, hence, totally described by the following transition probability matrix.

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[22] Industry and Commerce Annual Report,

$$\Pi = \begin{bmatrix} \pi_{ee} & \pi_{eu} \\ \pi_{ue} & \pi_{uu} \end{bmatrix}$$

where each element represents the probability that an individual is at state *j* in time (*t+1*) given that in time *t* he was at the state *i*, i.e. $\pi_{ij} = \Pr\{s_{t+1} = j \mid s_t = i\}$ with $i, j = \{e, u\}$ where *e* and *u* represent the states where the individual is employed and unemployed respectively.

There are two alternative ways to calibrate the parameters of the above transition probability matrix *Π*. The first one consists of observing the duration time of each state and find the values of the π_{ij}'s consistent with the observed values, observing that a given state, *v*, will have its duration expressed by $D_v = (1 - \pi_{vv})^{-1}$. For this procedure, following Imrohoroglu (1989), given the observed duration of each state and using the fact that each line of the matrix *Π*, by definition, has to add one, the corresponding values of the elements of the transition matrix can be obtained. Even though this methods is more suitable for calibrating the above matrix, will not be implemented in this study due to the lack of trustworthy data on the persistence of employment/unemployment states for the Brazilian economy.

The implemented procedure to calibrate the transition matrix follows Imrohoroglu, Imrohoroglu & Jones (1999). This alternative method is based on the determination of the value of the elements of the matrix *Π* so as to replicate the observed unemployment rate in the economy. Brazilian data from the Monthly Employment Survey (PME) - IBGE indicate an unemployment rate of approximately 5.5%. This average unemployment rate could be partially induced by the following probability transition matrix.

$$\Pi = \begin{bmatrix} 0{,}945 & 0{,}055 \\ 0{,}945 & 0{,}055 \end{bmatrix}$$

Using the values of this array, the average duration of the unemployment in the artificial economy becomes $(1-0{,}055)^{-1} = 1{,}0582$ model periods, equivalent to approximately 55 weeks, which does not exactly reflect the duration of the unemployment in Brazil[23]. However, since the analysis will be focused on the steady state, the limiting invariant measure associated to the probability transition matrix is what really matters. Furthermore, since this measure will be the same, independently of the form taken in the calibration process, the above calibrated matrix will be used for describing the stochastic process that governs the per period individual's employment opportunities in the model economy.

The limitation associated to this procedure, however, is given by the fact that it cannot replicate the employment persistence effect. In this case, by construction, each of the probabilities $\Pi_{ij}(t+1)$, for $i, j = \{e, u\}$, does not depend on the employment situation in period t. This restriction would cause some side effects only when applied to a short run business cycle analysis, but again, the present study focuses on the steady state analysis.

Another factor indirectly related to the labor market is that the effective wage of each individual could be correlated with his/her age. The hypothesis that the productivity can vary according to the individual's age is well explored in the economic literature[24], however there is no consensual conclusion about the mechanism and the direction that this relationship could occur.

The present study does not aim to explore this controversy. In fact, what the model does is to assume that there exists such a relationship without assuming any hypothesis about its sign, or in other words, whether the wages tend to increase or decrease according to the individual's age. To calibrate this efficiency index, the data form the Brazilian Social Information Annual Report (RAIS) relative to 1998 was used.

The calibration procedure of the model economy is eventually complete with the above calibration of the labor market. The next step is to numerically compute the theoretically defined equilibrium and to implement alternative policy simulations, varying

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[23] Imrohoroglu, Imrohoroglu & Jones (1999) have alerted to the fact that this calibration procedure would overstimate the duration of the unemployment.
[24] See Jovanovic e Nyarko (1996).

the replacement rate of the social security system, in order to evaluate the welfare impacts of those policies.

4. Simulations Results

The objective of this section is to quantitatively assess the impact of alternative pay-as-you-go social security systems on social welfare. To this end, the implemented numerical simulations set the replacement rate policy parameter, θ, to vary from zero (0%) to one (100%).

Moreover, two alternative values for the subjective discount factor, β, were considered for simulation purposes. The first value for this parameter was chosen such that the wealth-output ratio of 2.7 could be derived for the Brazilian economy. In this first case, taking the replacement rate of the social security system between 90% and 100%, the subjective discount factor corresponds to $\beta = 1.005$. The social security system in Brazil refunds in full the wage of all the workers of the system earning up to 10 minimum wages. Taking into consideration that the average wage is approximately 5.1 minimum wages, according to the 1998 RAIS, and given the well known high income concentration in the country, the alternative policies were simulated by varying the replacement rate of the model's social security system, θ, between 0.9 (90%) and 1 (100%).

Alternatively, a value of $\beta = 0.96$ for the subjective discount rate was used. This value is compatible with the one used by Oliveira, Beltrão and Maniero (1997) and also with the wealth/income ratio value suggested by Gomes, Ellery Jr & Sachsida (2000).

The values for the remaining parameters were set according to the procedure described in the previous section. Thus, the labor income share in aggregate income was set to $\alpha = 0.53$; the depreciation rate to $\delta = 10\%$; the per capita GNP growth rate to $x = 2.6\%$; the population growth rate to $n = 2\%$; the risk aversion parameter to $\gamma = 1.4285$ and, the compulsory retirement age to $R = 57$ which corresponds to 37 model periods. The probability transition matrix describing the employment opportunities was calibrated as:

$$\Pi = \begin{bmatrix} 0{,}945 & 0{,}055 \\ 0{,}945 & 0{,}055 \end{bmatrix}$$

The results of the first set of simulations are shown in Table 1 below.

Table 1. Welfare Impacts of the Social Security System (β = 1.005)

θ	τ_s	ω	r	Aggregate Consumption	Wealth/ Output	Welfare
0	0	2,31	0,0463	0,6308	3,21	-121,72
0,1	0,0153	2,28	0,0490	0,6306	3,15	-121,46
0,2	0,0307	2,23	0,0525	0,6298	3,08	-121,32
0,3	**0,0461**	**2,19**	**0,0554**	**0,6288**	**3,02**	**-121,30**
0,4	0,0615	2,16	0,0582	0,6277	2,97	-121,33
0,5	0,0769	2,12	0,0610	0,6261	2,92	-121,48
0,6	0,0923	2,09	0,0637	0,6245	2,87	-121,68
0,7	0,1076	2,06	0,0666	0,6227	2,82	-121,96
0,8	0,1230	2,03	0,0693	0,6207	2,77	-122,26
0,9	0,1384	2,01	0,0716	0,6188	2,73	-122,61
1	0,1537	1,99	0,0735	0,6173	2,70	-122,98

The obtained simulation results show that in this case, the OG model economy with a subjective discount factor of β = 1.005 reaches its maximum welfare when there exists a pay-as-you-go system that (partially) restitutes 30%, i.e. $\theta = 0.3$, of the individual's working age income[25].

Another interesting result points out that above 60% replacement rates are all of them associated with lower welfare levels than the ones derived from a pure funded system, i.e. $\theta = 0$. This result strongly suggests that guaranteeing an integral (100%) income for the

[25] This result is similar to the one found by Imrohoroglu, Imrohoroglu and Jones (1995, 1998 and 1999) for the American economy, and also to the conclusions obtained by Oliveira, Beltrão and Ferreira (1997) for the Brazilian economy.

retirement period by means of a pay-as-you-go system does not guarantee the maximum social welfare in the presence of individual risks. In other words, at the steady state equilibrium, such a system is Pareto-dominated by any other partial restitution pay-as-you-go system or even by a funded system.

Table 2 below shows in turn the simulation results when setting the subjective discount factor to $\beta = 0.96$.

Table 2. Welfare Impacts of the Social Security System ($\beta = 0.96$)

θ	τ_s	ω	r	Aggregate Consumption	Wealth/ Output	Welfare
0	**0**	**1,76**	**0,0983**	**0,5934**	**2,38**	**-54,06**
0,1	0,0153	1,74	0,1018	0,5890	2,32	-54,54
0,2	0,0307	1,72	0,1046	0,5860	2,29	-54,97
0,3	0,0461	1,69	0,1076	0,5827	2,26	-55,43
0,4	0,0615	1,68	0,1100	0,5802	2,23	-55,88
0,5	0,0768	1,66	0,1130	0,5766	2,20	-56,37
0,6	0,0922	1,64	0,1160	0,5733	2,17	-56,87
0,7	0,1076	1,62	0,1185	0,5704	2,14	-57,35
0,8	0,1230	1,60	0,1209	0,5677	2,12	-57,83
0,9	0,1384	1,59	0,1234	0,5650	2,10	-58,33
1	0,1537	1,57	0,1257	0,5625	2,08	-58,82

In this case, a pure funded system, i.e. $\theta = 0$, Pareto-dominates all alternative pay-as-you-go social security systems.

Cross-comparing the results of Table 1 with the ones of Table 2, it is apparent that the value chosen for the subjective discount factor β is of crucial importance in order to assess the welfare effect of the social security system introduced into the OG model economy.

One of the possible theoretical explanations to justify this high sensitivity of the results obtained to the value of β is based on the presence of dynamic inefficiency. According to this line of argument, the reduction in accumulation driven by the introduction of a pay-as-you-go system can lead to a welfare improvement. Although empirical evidences do not support the dynamic inefficiency argument for the Brazilian

economy, Table 1 results, with $\beta = 1.005$, show that this calibration can better mimic the wealth/output ratio observed in the Brazilian economy (2.7) than the second set of simulations shown in Table 2. These results suggest that higher values of the subjective discount factor β could be producing some dynamic inefficiency in the OG artificial economy.

Another possible interpretation of the high sensitivity of the results to the alternative values of β is based on the definition of the subjective discount factor itself. The smaller this factor, the less the individual values future consumption and, therefore, the weaker the incentives to reduce his/her present consumption to guarantee a better future income. Hence, a pay-as-you-go social security system that implies discounting on current income would not lead, in this case, to any welfare gains.

Another interesting point derived from Tables 1 and 2 is that the rate of the contribution to the social security system able to finance a full retirement benefit would be approximately 15% on the payroll. The average contribution to the RGPS system in the Brazilian economy amounts to a remarkably high contribution of 33% on the payroll (an average contribution of 22% on the payroll from the employers plus 11% percent from the employees), but still the RGPS shows a considerable deficit.

In particular, two possible reasons could justify such a discrepancy between the self-financing contribution rates derived from the model and the observed in the Brazilian economy. The first one refers to the incorporations of typical social assistance programs into the social security account, as the rural pension program and until recently the Brazilian public health care system. The second is derived from the existence of disability retirements due to (a permanent disability caused by a disease or an accident) and early retirements (earned after fulfilling the mandatory working life requirements), cases that are not considered in the OLG artificial economy. The pay-as-you-go system's self-financing contribution rate of 15% does not match the findings of Oliveira, Beltrão and Maniero (1997) either. These authors introduce into the model some additional variables such as administrative costs, contribution and benefits caps, and age-independent retirements, that are not included in the present OLG model economy and that could lead to differences in the model's contribution rates at the steady state equilibrium.

Moreover, those divergences do not invalidate the main basic conclusion suggested in Table 1, very similar to the obtained by Oliveira, Beltrão and Ferreira (1997). Both their study and the results reported above, clearly indicate that the Pareto-superior way to organize the social security in a model economy calibrated for the Brazilian economy is based on a pay-as-you-go system, with only a partial refund. Moreover, if agents in such an economy want to further increase their retirement period income, they would be better off in a pure funded system.

As a shortcoming of the present analysis, the inability to explicitly identify the analytical mechanism behind the welfare gains of the pay-as-you-go system introduced into the OG model economy remains an open question. As discussed above, the possible dynamic inefficiency generated by the artificial model economy at hand stands as one possible transmission mechanism. This argument is strengthened by the observed alteration in the simulation results when the value of β is reduced to 0.96. Another alternative explanation, according to Lannes Jr. (1999), is based on the credit constraint imposed to the agents in the model economy, for in this case the social security system might be correcting for this market failure, thus generating social welfare gains. Finally, the explanation can also reside in the presence of idiosyncratic shocks faced by the agents in the model economy. Jobless agents unable to contribute to their respective accounts in a funded system could be better off in a pay-as-you-go scheme, for this system could work as an insurance mechanism for them.

Dealing with the same question, Imrohoroglu, Imrohoroglu and Jones (1998), elaborate a model including a fixed factor, land, such that the presence of dynamic inefficiency can be avoided. Whenever agents start to accumulate too much capital, the price of the fixed factor (land) would increase, forcing them to substitute capital for land. Thus, the fixed amount of land would limit the accumulation of capital. Once the dynamic efficiency is precluded in the model economy, the obtained results are similar to other OLG based studies'. Namely, the maximum welfare is always associated to a pure funded system.

Testing for the impacts of the introduction of this factor into an OLG model calibrated for the Brazilian economy is left as a topic for a future extension.

In summary, the simulation results obtained in this section clearly showed that the welfare maximizing social security system is characterized by a pay-as-you-go scheme with a 30% partial restitution in an OG model in which agents face idiosyncratic shocks, calibrated for the Brazilian economy. Moreover, the current Brazilian RGPS system, which refunds between 90% and 100% of the wage income, could be inducing a lower social welfare level compared to a possible welfare attainable through a pure funded scheme, regardless of the value assigned to the subjective discount factor β.

5. Conclusion

The present study discussed the welfare implications of alternative social security schemes by numerically simulating an extended OG model calibrated for the Brazilian economy. Therefore, the analysis contributes to the line of research previously explored by Barreto and Oliveira (1995), Barreto (1997) and, Lannes Jr (1999). The present analysis extends these previous studies by assuming the presence of idiosyncratic shocks to the agents, thus allowing for a more realistic setting, while keeping the credit constrained hypothesis suggested by the later author.

The main results strongly suggest that both the welfare maximizing pay-as-you-go system partially that refunds 30% of the wage income and the one with full refund for the retirement period are clearly Pareto-dominated by a pure funded system in such a model economy.

For public policy purposes, this conclusion suggests that the Brazilian RGPS social security reform should not be directed towards a complete elimination of the current pay-as-you-go system, as it happened in Chile. The results obtained point out to a reform towards a pay-as-you-go scheme with a partial refund only, and where the agents would be allowed to individually add to their retirement income through/from a complementary funded system. This arrangement seems the best among the reform alternatives from a welfare point of view.

Some possible further extensions, in particular the use of different mortality tables for calibrating the demographic parameters and the introduction of other retirement channels

(e.g. a disability retirement plan) into the model economy will be left as a list of challenges for future research.

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