IS THE BRAZILIAN SOCIAL SECURITY REFORM EC-103/19 SUFFICIENT IN THE LONG RUN? AN OLG MODEL ANALYSIS.

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Área 4: Macroeconomia, Economia Monetária e Finanças

Abstract

This research focuses on the analysis of the impacts of the current social security reform (EC 103/19), as well as some alternative proposals, such as the change to the fully funded and the multi-pillar regimes, on macroeconomic variables such as consumption, social security benefit and level of welfare of individuals, using a 68-generation Overlapping Generations model calibrated for Brazil and which considers projected demographic changes. These results contribute to the literature by showing evidence that EC 103/19 is not enough to solve the problems of the social security deficit, requiring reforms soon. As for the multi-pillar and fully funded systems, there are indications that these provide better fiscal results than the current reform in the social security system, as well as in the welfare state of the population.

Keywords: Overlapping Generations, Social Security, Pension Reforms and Fully funded system.
JEL Code: E21, H30, H55.

Resumo

Esta pesquisa se concentra na análise dos impactos da atual reforma previdenciária (EC 103/19), bem como algumas propostas alternativas, como a mudança para os regimes de capitalização e o multipilar, sobre variáveis macroeconômicas como consumo, benefício previdenciário e nível de bem-estar dos indivíduos, usando um modelo de Gerações Sobrepostas de 68 gerações calibrado para o Brasil e que considera as mudanças demográficas projetadas. Estes resultados contribuem com a literatura ao mostrar indícios de que a EC 103/19 não é suficiente para solucionar os problemas do deficit previdenciário, sendo necessário reformas num futuro próximo. Já para os regimes multipilar e de capitalização, há indícios de que estes proporcionam melhores resultados fiscais do que a atual reforma no sistema previdenciário, bem como, no bem-estar da população.

Keywords: Gerações Sobrepostas, Previdência Social, Reformas previdenciárias e Sistema de capitalização.

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1 Introduction

Constant focus of studies, Gelles (1945), Swan (1947), Rezende (1976), Schwarzer (2000) and Holzmann (2013) point out that social security must be systematized to all individuals in a way that ensures everyone in a way the minimum level of economic existence and that the stable prosperity of this system depends on coverage, conditions of eligibility, how the system is financed and benefits so that the relationship between social security benefits and income must be such that it equals the application of the social security contract.

Therefore, the aging of societies - which transform in the age pyramid - becomes an important factor to be considered when assessing the structures of social security systems, since ONU (2017) estimates that in 2017 there were approximately 1 billion people who were 60 years of age or older worldwide, something around 13% of the world population, already, when projecting for the year 2050, this number should more than double, reaching 2,1 billion inhabitants over 60 years old, about 20% of the world population. Which, according to Holzmann et al. (2005), will cause - together with retirement rules currently inadequate to the socioeconomic context - the problem in the social security system of several countries.

Similarly, Auerbach e Lee (2009) points out that worldwide public pension programs based on the *Pay-As-You-Go* system (PAYG) are facing serious long-term fiscal problems due to the projected aging of the population of several countries so that most seem unsustainable according to the current structure. These long-term fiscal problems are related to a misalignment between low but viable rates of return and promised rates of return that were viable in the past but are no longer.

In Brazil, according to Giambiagi et al. (2007), the impact of this phenomenon is exacerbated by the low average growth of the Gross Domestic Product (GDP) since the stabilization of inflation and economic activity in 1994 and the social security legislature that allows early retirements, burdening the public accounts, allowing individuals of working age to leave the labor market and become eligible to receive the social security benefit. What has been causing since 1998, according to data from the National Treasury, recurrent and growing deficits in the social security system. These demographic changes can have significant fiscal and economic consequences and pose important public policy challenges for the countries involved.

In this context, social security reform gains an important prominence within public finances, since, in a society in which the number of elderly people increases compared to the total population, expenditures with retirees tend to increase, if constant reforms and significant changes in the social security system do not occur.

Thus, in order to maintain a social security system with more stable results, Galasso (2008) highlights the need for additional efforts to be made constantly to limit the evolution of social security benefits per inhabitant. However, it points out the difficulty of being practised for having characteristics of containment of social welfare, in addition to political pressure from unions and electoral concerns, since it would be necessary to implement the minimum retirement age, as well as changes in the minimum contribution time and benefit calculation rule. In Brazil, the last effort to solve the pension deficit problem occurred in 2019, through Constitutional Amendment 103/19 (EC-103/19), modifying some rules, such as the implementation of a minimum age to become eligible for retirement.

This paper seeks to answer the long-term impacts of the last social security reform (EC-103/19), observing whether this policy will be sufficient to solve the problem of social security deficits. Besides, other alternative reforms will be analyzed, considering additional efforts in the current rule, as well as the modification of the financing scheme, considering a Fully Funded scheme - which applies social security contributions and redirects them to various investments, working as a kind of compulsory savings - and also the implementation of a multi-pillar scheme, which aggregates characteristics of the current distribution system and the fully financed regime,

as a way of obtaining the pension benefit of retirees.

For this, an Overlapping Generations Model (*OLG*) will be used, formed by agents representing 68 age groups - representing individuals aged 23 who offer labor in exchange for wages, and finally, with 90-year-old individuals representing the last age of retirement - the firm sector, which operates in a competitive market, and the government (responsible for the Social Security system), comparing variables such as aggregate consumption, social security benefit, investment level and the welfare of families after each one of reforms compared to the initial state that uses 2017 as the base year.

Thus, the main objective of this work is to analyzed the long-term impacts caused by several reforms in the Social Security rule on macroeconomic variables, such as those mentioned above, developing an OLG model that considers the population aging that will occur in Brazil between the years 2017 and 2060 that, if there is no pension reform, it will put further pressure on the already deficient Brazilian pension system.

The main results obtained with the simulations indicate that any reform will provide better financial results for the government compared to the scenario where there is no type of reform. The change to the fully funded financing regime provides relevant improvements in public finances, as well as a higher level of savings for individuals. Parametric reforms, on the other hand, are not able to contain the advance of the deficit in the social security system, requiring additional government resources to finance social security benefits. The multi-pillar regime, on the other hand, appears as a middle ground between fully funded and parametric reforms, and the reform proposal that provides a better level of welfare for society. These and other results obtained will be commented on in the results section.

In addition to this introductory section, this survey has 5 more sections. The second section presents the main social security numbers in Brazil, from the institution of the General Social Security Regime (in Portuguese, Regime Geral de Previdência Social - RGPS) to the present. The following section presents the model of overlapping generations used to simulate an economy with characteristics of the Brazilian economy. Subsequently, the parameters used in the model described in the third section will be calibrated. The fifth section will be responsible for presenting the results obtained in the simulations performed. The last section highlights the main contributions of this research alluding to social security and public finances in Brazil.

2 Brazilian Social Security

Created on June 27, 1990, through Decree nº 99.350, the National Institute of Social Security (INSS) emerged from the merger of two existing social security institutes, the Institute of Financial Administration for Social Security and Social Assistance (IAPAS) and the National Institute of Social Security (INPS) and today is responsible for administering the benefits of the General Social Security Regime (RGPS) and the Own Social Security Regime (RPPS).

The first regime covers workers in the private sector, plus public sector workers who work under the Consolidation of labor Laws (CLT), rules that govern individual and collective labor relations. The second regime, on the other hand, is composed exclusively of public sector workers holding effective positions, so that these regimes are maintained by the public entities of the Federation (Union, States, Federal District and Municipalities) responsible for covering public agent.

According to Banks e Emmerson (2000), the types of financing of the pension system can be divided into: i) fully funded system in which the contributions of an individual or generation go for a fund that is invested, it accumulates and subsequently finances the benefits received by that same individual or generation when they retire; ii) Pay-as-you-go system (*PAYG*), which is characterized by contributions from current job generations that directly pay the social security benefits of those who are currently retired while the benefit of current workers will depend on

the generation thus, this system as a whole is financed year by year; and iii) multi-pillar system, which is a combination of previous financing approaches, in which part of the system follows the pay-as-you-go system and the other part uses the fully funded system.

The RGPS, the main social security system in the country, follows a simple PAYG system, so there is no formation of reserves so that the deficits arising from this system are financed by the Government with collections from other taxes. According to data from SPREV (2018), this scheme is responsible for benefiting, almost 20 million retirees in 2017, about 84% of this year's active benefits. The main contributors to the RGPS are companies, domestic employers, workers, and individual and optional taxpayers who represent around 87% of the entire Brazilian social security system.

An important factor in the dynamics of the social security system, the demographic issue in Brazil is undergoing a transition with population aging, with life expectancy at birth going from 52.5 years in 1960 to 76 years in 2017. The change caused by better sanitary conditions, improvements in the health, education and security services of the population, which caused a decrease in the level of mortality and fertility rate, still having a difference between the life expectations of men and women due to violence - in the form of murders - which mostly affects young men and adults between the ages of 15 and 30 and risk factors linked to heart problems in the 40 to 60 age group according to Giambiagi, Além e Pinto (2015).

So, estimates from IBGE (2018) indicate that in 2050 Brazil will have a larger number of its population in high age groups, above 65 years, providing the flattening of the base of the age pyramid. Considering this demographic factor, the relationship between income and expenses of the social security system is observed with greater concern, since the ratio between inactive and active people will be lower than currently in a scenario that Brazil already presents a high level of expenditure on social security benefits in relation to its current demographic structure, according to Rocha e Caetano (2008), Giambiagi e Tafner (2011) and Tafner, Botelho e Erbisti (2015).

Otherwise, the average replacement rate for early retirements in Brazil is equivalent to the maximum replacement rates for retirements in OECD countries, thus, in Brazil, a higher value is received in relative terms and for a longer time. Table 1 also shows the evolution of the RGPS cash deficit as a proportion of GDP for each year, pointing out the negative balance of this system since 1997, and it is important to highlight the high growth rate of social security expenses, from 4.94% of GDP at the beginning of the historical series to 7.61% in 2018.

Table 1 – RGPS Income and Expenses 1997/2018 - % GDP

	1997	2000	2003	2006	2009	2012	2015	2018
Income	4,65	4,65	4,70	5,13	5,46	5,73	5,84	4,90
Expenses	4,94	5,49	6,24	6,87	6,75	6,58	7,27	7,61
Balance	-0,29	-0,84	-1,54	-1,75	-1,29	-0,85	-1,43	-2,70

Source: STN (2019). Authors' elaboration.

Matos, Melo e Simonassi (2013) and Giambiagi, Além e Pinto (2015) point out that the causes for this fiscal pressure are, i) the low average growth - since a greater dynamism of the economy would have mitigated the increase in the spending/GDP ratio; ii) the benevolence of the legislation or the Constitution itself, which includes several possibilities for early retirements; and iii) the cumulative effect of successive real increases in the minimum wage, particularly since the stabilization of 1994, since there is a link between the minimum wage and the social security floor, so that the real increase in the minimum wage causes an increase in the amount of benefits.

As a way of trying to contain this increasingly sharp growth in the RGPS deficit, described in Table 1, some policies were already implemented in 1998, in 2015 and the last in 2019. The

first of the reforms implemented the Social Security Factor, a coefficient proportional to the years of contribution and age at the time of retirement that multiplied the contributory average of the individual's active phase and aimed to inhibit the practice of granting especially early pensions as occurred at the time. Another measure, still in 1998, was Constitutional Amendment (in Portuguese, Emenda Constitucional - EC) EC 20/1998, which increased the age for granting pensions in the RGPS for young individuals who had not yet entered in the labor market.

Giambiagi et al. (2007), Rocha e Caetano (2008) and Giambiagi, Além e Pinto (2015) analyzed that these changes were correct to move the system closer to an actuarial balance, although these measures were not sufficient given the magnitude of the imbalances. In other words, even with the reformist efforts, the changes promoted in the design of the social security system were only able to reduce the expansionary trajectory of social security expenditure without inhibiting its upward movement. Also, according to data from SPREV (2018), even in 1998, there was a *boom* in pensions as many individuals chose to anticipate retirement because they feared a change in the rules, resulting in reforms with considerably lesser impacts than expected in the original proposition.

In 2015, a new rule was implemented that required, to obtain full retirement, a sum between age and contribution time of 85 points for women and 95 points for men, and after 2017 this sum would be increased by 1 until 2022, reaching 90/100 points for women/men. If the worker decides to retire earlier, the benefit would be reduced by the Social Security Factor.

In 2019, the latest reform, based on the Constitutional Amendment - EC 103/19 there was the implementation of minimum retirement age so that the general rule pass to require 62 years of age and at least 15 years of contributions for women and 65 years of age and at least 20 years contribution for men, as well as a change in the calculation of the benefit, becoming 60% of the average of all contributions plus 1 p.p. for each additional year of contribution, reaching up to 100%. However, due to the transition rules, the minimum retirement ages and the change in the benefit calculation will only be achieved in the social security system between the years 2028 and 2033.

These pension reform processes, focused on the financial sustainability of the system, are not exclusive to Brazil, according to Aglietta et al. (2007) and Tafner e Giambiagi (2011) countries that have faced or are facing a demographic transition and have structured pension systems under the PAYG scheme - a regime strongly subject to population dynamics - put pressure on the finances of pension systems in European and Latin American countries and in Japan.

According to Mesa-Lago e Müller (2002), Hujo (2009), Börsch-Supan (2012), Forteza (2014), in Latin America, reforms began in the 1980s with Chile - implementing the fully funded system and a greater preponderance of the private sector, leaving the government with a mostly regulatory role - and more strongly in the 1990s, with reforms in Bolivia, El Salvador and Mexico (replacing the public system with the private system, financed by the fully funded regime), in Argentina and Uruguay (implementing multi-pillar models) and in Colombia and Peru (creating a system that allows the coexistence and competition of the public and private systems). In 2008, Chile started to use a multi-pillar system, which proved to be more effective than those of other Latin American countries in combating inequality and poverty in old age.

Olivera (2016) studies the potential effects of a hypothetical multi-pillar pension system on Peru's inequality and well-being, comparing it with the current Peruvian system that can lead to high levels of inequality in that system's pensions and debts. The results show that in a multi-pillar pension system, pension inequality can be reduced with social security policies that preserve the welfare of society. Regarding the fully funded system, Miles et al. (1999) point out that the costs of transition to this system are high and - unless they are financed by debt - these costs will fall on current generations that are likely to oppose the reform. In addition, the higher potential returns of this system are accompanied by a significantly greater risk, making the multi-pillar system a more attractive proposition in democratic countries.

3 Methodology

Developed from the seminal work of Samuelson (1958) and complemented by the work of Diamond (1965), the Overlapping Generations (OLG) models has microeconomics foundations and makes it possible to analyzed the implications of individual decisions on aggregate variables. So, the life span of individuals is finite, and, in each period, a new generation is born, and the older generation dies, making it possible to divide the population into members of the same age.

One of the seminal models in the study of the quantitative effects of economic policies was developed by Auerbach, Kotlikoff et al. (1987) making it possible to study large-scale OLG models, in which cohorts are usually identified as members of the population of the same age, enabling the study of tax reforms and their impacts, as done in Altig et al. (1997) and Altig et al. (2001) simulating these reforms for the United States.

In the same way, Heer e Trede (2003) study the quantitative effects of two revenue-neutral income tax reform proposals in a general equilibrium model with elastic labor supply and progressive income taxation calibrated for the German economy, showing that these reforms result in a sharp increase in the aggregate savings and significant welfare gains.

In this way, Aglietta et al. (2007) and Martín e SánchezMarcos (2010) analyzed the impacts of social security reforms in several European countries in a population aging scenario, concluding that the social security systems of the time proved to be unsustainable in the long run. With this, models of overlapping generations are useful in the study of social security reforms and population aging.

For Brazil, Lledo (2005) observes the simulated short- and long-term macroeconomic effects for replacing indirect taxes on private sector operating revenues with a new value-added tax, finding lifetime welfare gains in most generations. When using the OLG model to analyzed the impact on the economy of changing the minimum retirement age, Freitas e Paes (2019) finds that very low minimum retirement ages are fiscally unsustainable.

Thus, the model of overlapping generations used in this research uses an economy represented by three sectors, they are: the household sector, the production sector, and the government sector, the latter responsible for social security, presented below.

3.1 Households

In the family sector, 68 generations are considered representing individuals who offer labor to companies in exchange for remuneration and individuals representing the elderly, retirees who receive a social security benefit, choosing consumption and leisure levels according to Modigliani e Brumberg (1954), in the present and future, considering their income expectations throughout their life. Therefore, at each point *t* in time, 68 generations live together and the differences in individual preferences will be due to the generation that each belongs to. Therefore, it is considered that only a single member will represent each generation.

For that, the individual works T years and is compulsorily retired after this period remaining so for T^r years, so that $T + T^r = 68$. The life cycle of a generation begins when it enters the job market, at the age of 23 and lives until the age of 90, the age when the individual leaves the model.

For each family, preferences are represented by a utility function with current and future consumption and leisure values. In which leisure is measured as the difference between the fraction of the maximum amount of time that an individual could work in the reference week with values between zero and one. Thus, the intertemporal utility function is represented by:

$$U^t = \sum_{j=1}^{68} (1+\beta)^{-(j-1)} p_{j,t} u(c_{j,t+j-1}, l_{j,t+j-1}) \tag{1}$$

The variable ($c_{j,t}$) represents the consumption of the generation j born in the year t and ($l_{j,t}$) is the leisure in each period of life, being $l_{j,t} < 1$ for working generations and $l_{j,t} = 1$ for retired generations. The subscript *j* and the subscript *t* refer to the individual's jth period of life and the period t is the year which the young individual entered the model, respectively. The parameter β is the discount factor. Where $u(c, l)$ is a CRRA (Constant Relative Risk Aversion) function of consumption and leisure, so that:

$$u(c,l) = \frac{((c+\psi)l^{\gamma})^{1-\eta} - 1}{1-\eta} \tag{2}$$

The constant ψ is used to ensure that utility is finite, even if consumption is zero, in the case of no income, the parameter γ represents the factor of disutility provided by the work and η represents the coefficient risk aversion.

The budget constraint for the worker is given by:

$$k_{j+1,t+1} = [1 + r_t(1-\tau_k)]k_{j,t} + (1 - \tau_n - \tau_{ns})w_t n_{j,t} - (1 + \tau_c + \tau_{cs})c_{j,t} \qquad \forall j = 1, ..., T \tag{3}$$

For retired agents, the budget constraint is given by:

$$k_{j+1,t+1} = [1 + r_t(1-\tau_k)]k_{j,t} + b_t - (1 + \tau_c + \tau_{cs})c_{j,t} \qquad \forall j = T+1, ..., 68 \tag{4}$$

Where, $k_{j+1,t+1}$ are the assets accumulated at the end of period t to period $t+1$, $k_{1,t} = k_{69,t} = 0$ and the leisure of retired individuals are equal to one so that the total time allocation for each individual is distributed between leisure (l_t) and work (n_t), this means that $l_t + n_t = 1$. The variable r_t represents the real interest rate of the economy, w_t is the wage in year t, τ_{ns} and τ_{cs} are labor and consumption taxes intended for social security for the payment of social security benefits, so that:

$$S_t^A = \tau_{cs} \sum_{j=1}^{68} \mu_j c_{j,t} + \tau_{ns} \sum_{j=1}^{T} \mu_j w_t n_{j,t} \tag{5}$$

Where μ_j is the age j population for the year 2017. The other rates τ_k, τ_n, τ_c, are taxes on capital, labor and consumption, respectively, for other government expenditures. And b_t represents the social security benefit, given by:

$$b_t = 0,8 \sum_{j=1}^{T} \left(\frac{w_{t-j} n_{j,t-j}}{T} \right) \tag{6}$$

This rule is in complies with 1999 law nº 9,876, which retirees by contribution time and age will receive the arithmetic average of the highest salaries corresponding to 80 % of the entire contribution period.

3.2 Firms

Firms are identical and act competitively on the market. The representative firm uses the following factors of production: physical capital and labor provided by generations active in the labor market to produce a homogeneous output Y_t with the use of the technology represented by the following constant-returns-to-scale Cobb–Douglas production function:

$$Y_t = F(K_t, N_t) = K_t^{\alpha} N_t^{1-\alpha} \tag{7}$$

where K_t and N_t represent aggregate capital and aggregate labor, respectively, and Y_t is the aggregate product. The parameter α is the share of capital in the production function.

Thus, from the optimization process of the firms' production function (equation 7), the equations of real interest rate and wages are obtained, as described below:

$$r_t = \alpha \frac{Y_t}{K_t} - \delta \tag{8}$$

$$w_t = (1-\alpha) \frac{Y_t}{N_t} \tag{9}$$

where δ represents the capital's depreciation rate. These conditions state that firms hire capital and labor until the marginal products are equal to the factor prices.

3.3 Government and Social Security System

The government's budget constraint is a function of tax revenues from consumption, capital and labor taxes and social security contributions on consumption and labor, as well as the social security benefits paid to retirees. So that:

$$G_t = T_t + S_t^A - S_t^B \tag{10}$$

G_t is government spending, while T_t is tax revenue, S_t^B is the expense of the Social Security System and S_t^A is the total revenue raised from the labor and consumption taxes to social security. So that:

$$T_t = \tau_c \sum_{j=1}^{68} \mu_j c_{j,t} + \tau_n \sum_{j=1}^{T} \mu_j w_t n_{j,t} + \tau_k r_t K_t \tag{11}$$

$$S_t^B = \sum_{j=T+1}^{68} \mu_j b_t \tag{12}$$

Pensions are financed according to a pay-as-you-go system, so there is an intergenerational transfer from young people to the elderly. All pension benefits in a given period are financed by the total amount of social security contributions paid, if this amount is insufficient, it will be necessary for the government to finance this deficit.

3.4 Marketplace balance

After all sectors have been detailed, there are the equilibrium conditions that must be met for each of the markets, namely: goods and services, capital, consumption, labor and investment. The following conditions are necessary for the numerical solution of the model. The balance between supply and aggregate demand is represented by:

$$Y_t = C_t + I_t + G_t \tag{13}$$

In the capital market, there are:

$$K_t = \sum_{j=1}^{68} \mu_j k_{j,t} \tag{14}$$

The aggregate consumption is such that:

$$C_t = \sum_{j=1}^{68} \mu_j c_{j,t} \tag{15}$$

In the labor market, the balance is in the equality between the demand (on the side of the firm) and the supply of labor (on the side of households).

$$N_t = \sum_{j=1}^{T} \mu_j n_{j,t} \tag{16}$$

3.5 Pension Reforms

One of the objectives of this work, as previously mentioned, is to evaluate the economic impacts of reforms in the social security system, observing variables such as consumption, the level of investments, the social security system and the welfare of families considered in the model. In addition to the baseline model (initial steady state), five more simulations will be studied, the first will observe how the economy would behave after the demographic change but without any change in the social security rules, in addition to this, four alternative policies proposed to reform the social security system will be simulated.

The first pension reform simulated follows the Constitutional Amendment - EC 103/19 which changed the minimum retirement age to 65 years, however, due to the transition rules this rule will only be implemented in fact between 2028 and 2033, this change will be considered in all other policies. The second reform will add to the first simulation a reduction in the rate of replacement of the social security benefits, simulating the European Union's replacement rate.

The third and fourth simulated policies will simulate alternative social security systems adding the fully funded regime to the current system. In one of them, there will be a multi-pillar system (pay-as-you-go plus fully funded regime) in which half of the amounts collected by social security taxes will be allocated to each of the regimes. The other policy will simulate the total shift to the fully funded regime. However, the transition costs of these policies will not be observed.

The analysis of this study will be done by comparing the initial steady state - before the demographic change - with the final steady states resulting from the five simulations described above. Where the initial steady state product will be normalized to 1.

4 Calibration

The economic environment described above allows us to simulate the steady-state growth and fiscal effects of various changes in the pension system. This simulation exercise requires

that we first parameterize and resolve the model so that it is possible to compare the long-term effects of policy changes. To solve the model and to perform our simulations, we choose the algorithm of Broyden (1965), an algorithm that numerically solves the system of nonlinear equations presented above.

The calibration of the model was carried out using data from the National Accounts System (in Portuguese, Sistema de Contas Nacionais - SCN) of the IBGE, the Social Security Statistical Yearbook (in Portuguese, Anuário Estatístico da Previdência Social - AEPS) of the Secretary of Social Security and the Tax Burden in Brazil (in Portuguese, Carga Tributária no Brasil - CTB) of the Federal Revenue for 2017, considered as the steady state of the economy. The Table 2 presents these values for the economic aggregates for the year 2017 and the model that will be the *baseline* of this study, as follows:

Table 2 – Economic Aggregates

	Brazil - 2017 (% of GDP)	Baseline Model
Consumption	0,64	0,64
Investment	0,15	0,14
Government Consumption	0,21	0,22
Capital	-	3,13
Social Security Revenue	0,05	0,05
Government Revenue	0,32	0,31
Social Security Expenses	0,08	0,08
Social Security Benefit	0,32	0,32
Interest Rate - SELIC	0,101	-
Real Interest Rate	0,07	0,08

Source: SPREV (2018), RFB (2018) and IBGE (2019). Authors' elaboration.

The basic interest rate of the economy, the SELIC, for the analyzed period was 10.1%, the inflation for the same period of the main Brazilian index (IPCA) was 2.95%, so that, the real interest rate (r) of the economy was 7.2% for 2017. In simulations involving the fully funded regime, the remuneration rate used was the CDI rate, a rate commonly used in fixed income securities issued by financial institutions and banks, equal to 6.89% in 2017.

Next, Table 3 presents the values of the parameters used in the model, as well as the values of the rates that make up the government's collection, as shown previously. The constant ψ is added to the model to ensure that the utility is finite, even for zero consumption, in the case of no income, so this constant must assume a low value ($\psi = 0.001$). Like this:

The share of capital in the product (α), was calculated with data from the System of National Accounts for the year 2017 and is the result of the ratio between the Gross Operating Surplus (EOB) and the sum of the EOB, with salaries of employees and freelancers. The capital depreciation rate (δ) is obtained endogenously from the steady state equilibrium equations. In order to obtain the tax rates, information from the Tax Charge in Brazil for 2017 was used. The preference parameter for the present was taken from Cavalcanti e Silva (2010).

5 Long Term Results

In this research, the initial steady state was simulated, with 2017 as the base year, as previously defined, and the final steady states for five scenarios, all considering the population by age group at the 2060 levels, using IBGE's data from population projection for the period. Observing variables such as GDP, aggregate consumption, investment, government consumption and social security collections and expenses.

Table 3 – Model Parameters

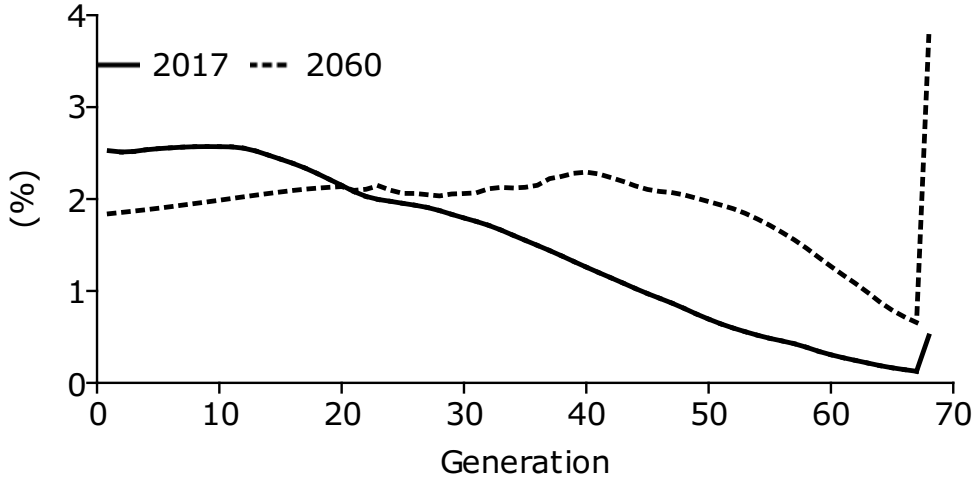
Description	Parameter	Value	Source
Preference for the present	β	0,025	Cavalcanti e Silva (2010)
Work disutility	γ	2	Calibration
Risk aversion coefficient	η	2	Calibration
Capital depreciation rate	δ	0,048	Model
Capital share in the production	α	0,381	IBGE (2019)
Tax on consumption	τ_c	0,236	RFB (2018)
Social security tax on consumption	τ_{cs}	0,013	RFB (2018)
Tax on capital	τ_k	0,164	RFB (2018)
Tax on work	τ_n	0,09	RFB (2018)
Social security tax on work	τ_{ns}	0,078	RFB (2018)

Source: Authors' elaboration.

The first simulation considers that there was no reform in the social security system, maintaining the average retirement age of the baseline model (55 years). The second scenario consists of changing the retirement age to 65 years of age similar to EC 103/19 and the third scenario adds to the second a change in the replacement rate for the average level of European Union countries (57%), below the current 80% practised in Brazil.

As previously mentioned Brazil is going through a population aging process and in 2060 this population will be 30% larger than the current one, with a greater number of elderly people compared to 2017, as it can be observed in Figure 1, which shows the populations of the 68 generations used in this research. The peak observed in the last generation of each information is because this generation considers all individuals aged 90 or over.

Figure 1 – Population in the initial and final Steady States



Source: Authors' elaboration.

In 2017, approximately 74% of the population of the generations analyzed in this study were between 23 and 55 years old ($j = 1$ to $j = 33$), in 2060 the projection is that this percentage will reduce to 51% of the population. This is a good representation of the population change that will occur in just over 40 years, with the relevant increase in people over 55 and, consequently,

a reduction in the number of individuals of working age and the ratio of retirees/economically active population.

For these simulations, the main variables to be analyzed were aggregate consumption, capital stock, investments, GDP, tax collection, social security expenditure and revenue, the government consumption and the welfare level of individuals calculated from the utility function.

Thus, initially, the results of the baseline model and the first simulation will be compared, which considers only changes in the sizes of the age groups and no changes in Social Security. Table 4 summarizes this information, presenting the values for the baseline model, for the first proposed scenario and the percentage variation of the variables between these two scenarios.

Table 4 – Long-Term Macroeconomic Effects - No reforms

Description	Variable	Baseline	No reform	Var. %
GDP	Y	1	1,26	26,05
Population	L	1	1,30	30
GDP per capita	$\frac{Y}{L}$	1	0,97	-3,04
Consumption	$\frac{C}{Y}$	0,64	0,73	15,11
Investment	$\frac{I}{Y}$	0,14	0,18	19,31
Government Consumption	$\frac{G}{Y}$	0,22	0,10	-56,44
Capital	$\frac{K}{Y}$	3,13	3,72	18,96
Government Revenue	$\frac{T}{Y}$	0,31	0,30	-2,04
Social Security Revenue	$\frac{S^A}{Y}$	0,05	0,04	-23,54
Social Security Expenses	$\frac{S^b}{Y}$	0,08	0,21	142,19
Social Security System	$S^A - S^b$	-0,03	-0,17	435,74
Social Security Benefits	b	0,32	0,33	0,22
Wages	w	1,17	1,17	0,13

Source: Authors' elaboration.

The results of Table 4 identify that the aging of society and the lack of reforms in the social security system will lead to a reduction in GDP *per capita* since population growth will be greater than that of the GDP of the economy. It is also noticed the decrease in government consumption caused mostly by the financing of Social Security expenses, which go from the current 8% to 21% of GDP, considering that the number of people over 55 years old (retirement age) increase from 26% to more than 60% of the population in 2060 and the social security revenue is not able to neutralize this expenditure, causing a deficit of the social security system relative to the GDP five times greater than in the base year.

Barrell et al. (2009) and Matos, Melo e Simonassi (2013) mention that the decrease in government spending reduces the Government's power to cut taxes, pay debts and improve services. They also point out that raising the minimum retirement age allows governments to reduce taxes.

In the same way, Orszag e Stiglitz (2001) highlight that a greater deficit in social security causes a considerable cost to society since it is this deficit that is financed by the Government, representing the non-application of resources in necessary investments in education, health and infrastructure. This makes it essential to formulate a balanced system on its own or less dependent on the state, otherwise avoiding a crisis, in the long run, will not be so simple.

Once the scenario in which retirement in the pension system is not considered, its impacts on the economy and the comparison with the baseline model is observed, reform scenarios in the current pension system were simulated, as already highlighted. Table 5 shows the values of these simulations.

Table 5 – Long-Term Macroeconomic Effects - With reforms

Description	Baseline	EC 103/19	Policy 2	Fully Funded	Multi-pillar
		% var. of init. S.S	% var. of init. S.S	% var. of init. S.S	% var. of init. S.S
GDP	1	36,43	41,49	80,39	57,37
GDP per Capita	1	4,95	8,84	38,76	21,05
Consumption	0,64	5,10	-0,78	-18,58	-7,86
Investment	0,14	16,11	23,74	72,64	50,21
Government Consumption	0,22	-25,59	-13,96	3,69	-11,74
Capital	3,13	15,77	23,38	72,14	49,78
Government Revenue	0,31	-4,42	-6,78	-26,42	-16,66
Social Security Revenue	0,05	-13,27	-12,56	-100	-63,25
Social Security Expenses	0,08	54,48	16,16	-100	-25,23
Social Security System	-0,03	174,49	67,03	-100	42,12
Social Security Benefit	0,32	-1,51	-25,94	23,55	10,58
Wages	1,17	3,47	5,96	1,03	2,24

Source: Authors' elaboration.

The increase in the minimum retirement age to 65 years - following the EC (103/19) - provides, unlike the simulation without reform, an increase in GDP *per capita* compared to 2017 by up to 8.84%. In the scenario without pension reform, the evolution of the sum of all goods produced by society would be less than its growth rate.

From this, the reforms presented allow for smaller fiscal adjustments than those observed in Table 4. On the collection side, the values obtained are higher - without reform, a decrease of almost 24%, with reforms, decreases between 12% and 13% - compared to the simulation without changes in social security, since there is an increase 17% in the workforce provided by the increase in the minimum retirement age.

Already observing the expenses with payment of benefits are 13% and 10% of GDP for policies that simulate the Constitutional Amendment and the change in the rate of replacement of the benefit, respectively. Higher results than those experienced in 2017, but substantially lower than the 21% relative to the GDP of the simulation without reform, so that the lower financing of the social security deficit provides smaller contractions in government consumption.

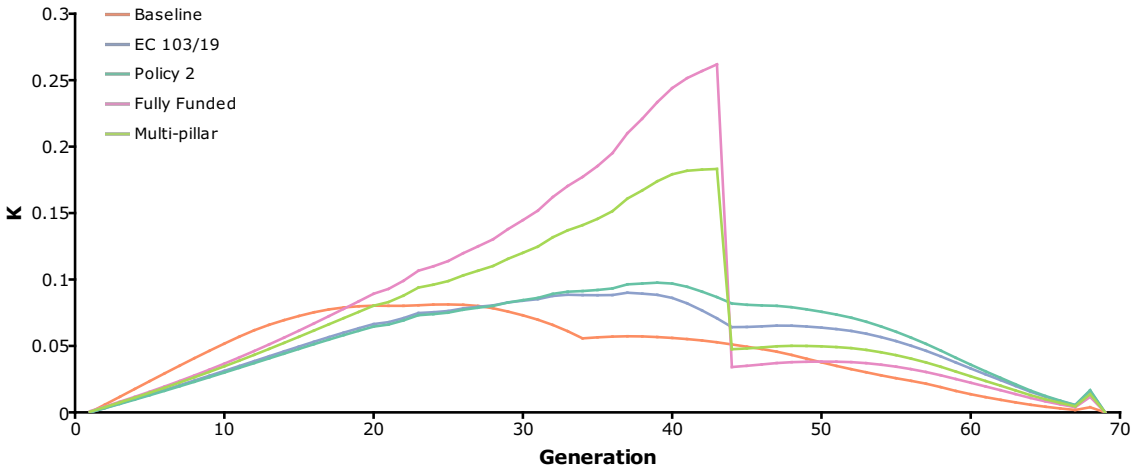
With the change of regime, moving from PAYG to fully funded, it is noteworthy that, unlike simulations that only modify the distribution system, the proposed fully funded system neutralizes the balance of the social security system, in addition to presenting a greater benefit received by retirees at if a rate of return equal to the CDI is used. As well as, it presents the highest increase in the product *per capita* and expansion of savings, which goes from 15% of GDP in 2017 to about 26% of GDP in 2060.

When considering the multi-pillar regime, which includes, in the calculation of the social security benefit, a pillar with the characteristics of the pay-as-you-go scheme and another pillar with the characteristics of the fully funded regime, the results obtained present a combination of the results previously observed for the parametric reforms and the change to the fully funded regime.

There is a significant increase in the level of investments, as well as in the fully funded regime, however, even with a reduction in the expenses of the social security system, there will still be a deficit, 4% of GDP, slightly higher than that observed in the baseline model. This is because, while there is a decrease in social security expenses, there is a reduction in social security contributions, both due to the pillar of the fully funded regime.

As reported by Kotlikoff (1996), Feldstein (1997) and Mesa-Lago (2006), the results in Figure 2 show that capital accumulation is more intense when the reform modifies the social security system to fully funded, the same is true for the Multi-pillar system but to a lesser extent. This happens due to the addition of the amounts collected, by the rates related to the social security of labor and consumption, to the savings of each year, since the PAYG system classifies

Figure 2 – Capital Accumulation by Generation ($k_{j+1,t+1}$)



Source: Authors' elaboration.

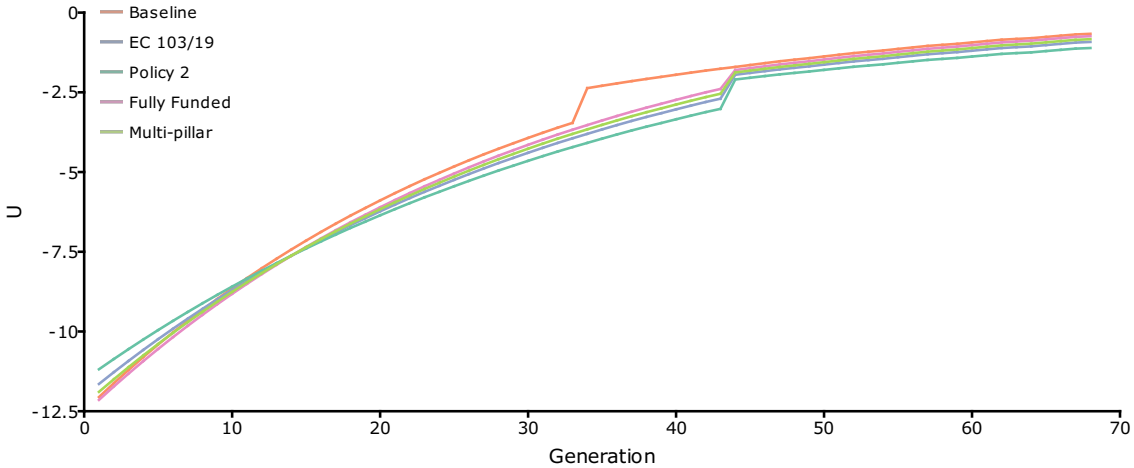
the contributions as taxes.

Still from Figure 2, it can be seen that the fully funded and multi-pillar regimes have greater capital accumulation at the ages when individuals work, while the PAYG regimes when compared with the proposed reforms in the fully funded system, present a greater accumulation of capital among retirees.

Thus, considering the impossibility of maintaining the current rule of the Brazilian social security system and also the current change in the minimum retirement age to 65 years (from EC 103/19 onwards, which, due to the transition rules, will only come into force between the years 2028 and 2033), the main changes in the macroeconomic variables of five proposals were addressed.

In addition to these observations, it is necessary to analyze how these changes affect the level of individuals' welfare in the proposed scenarios, a situation that is observed in Figure 3[3].

Figure 3 – Welfare State of Individuals by Generation



Source: Authors' elaboration.

From this analysis, the reason why pension reforms are difficult to apply is highlighted. Since, after the reforms, the utility levels of individuals will be lower than in the base scenario - which

[3] The observed values are negative due to the utility function used to be a CRRA function where the variables used (consumption and leisure) have values less than or equal to 1.

has tax complications in the social security system - mainly from the 12th generation. Among the proposed simulations, the reforms that implement the fully funded and multi-pillar regimes in Social Security are the policies that present the highest levels of welfare in society, whereas parametric reforms are the ones that most reduce the levels of family satisfaction.

What it explains, as discussed in Giambiagi et al. (2007) and Galasso (2008), that regardless of the country, the reforms aimed at reducing the deficit of this system are hampered because they have characteristics of containment of welfare, with political pressure and electoral concerns.

6 Concluding Remarks

The main motivation of this research was to verify the effects of the most recent pension reform (EC 103/19) and some alternative proposals on the economy as a whole, analyzing in more detail variables such as consumption, investment and level of social welfare, considering the demographic change projected for Brazil between 2017 and 2060, caused by an aging population, which will put pressure on the already deficient social security system.

For this analysis, five scenarios were compared with the baseline model, considering from no reform in the system to partial changes (multi-pillar scheme) or complete changes (fully funded scheme) of the type of system funding. Two parametric reforms are studied, which would only change the values of the current rule (EC 103/19), as well as a scenario that analyzed the impacts on the economy if there is no reform in the system.

For this purpose, an overlapping generations model was used, structured in a way that can capture the life cycles of individuals of 68 generations, a representative firm, and the Government. The simulation found that in a horizon without reforms, the results of the social security system will deteriorate further, requiring a greater portion of public revenue to finance the system. The results observed give some evidences that the most recent pension reform reduces the growth dynamics of social security deficit, however, additional efforts will be necessary to solve the Social Security problem.

The simulations of partial change - the multi-pillar scheme - in the financing regime, implementing the fully funded regime in addition to the pay-as-you-go, find that this proposal is responsible for producing a deficit similar to the current one, but provides a significant increase in the level of investment and income in the economy. When considering the total change of the regime - only the fully funded scheme - the end of the deficit in the system is identified, as well as a significant increase in capital accumulation, characteristic of this regime.

When analyzing the change in welfare, considering only consumption and leisure levels of individuals, we identify the reason why social security reforms are so discussed but difficult to implement, since any reform will leave individuals at a lower level of welfare, highlighting that the change to the fully funded regime has higher transition costs, but provides an end to the pension deficit, which causes individuals less loss of welfare concerning the baseline model.

Parametric reforms, which have a lower transition cost, but require greater government funding, are the ones that provide the greatest loss of welfare for the population. The proposal for a Multi-pillar system, which should have a transition cost that is among those of the reforms mentioned above, is capable of providing levels of welfare similar to the fully funded regime and should be a considerable hypothesis among formulators of Brazilian public policies.

By simulating only the initial steady state, which uses 2017 as the base year, and the final steady states for 2060, the study does not include an analysis of the transition cost for each of the proposed reforms, a variable that deserves great importance in the choice for the most viable policy. However, the results of this study prove to be useful, too, in long-term analyzed, as well as in the choice of a proposal that provides better fiscal results or less impact on the welfare state of the population or even a policy that can mix both.

This study does not exhaust the analyzed question, pointing as possible future analyzed related issues, as already mentioned above, of the transition cost of each of these reforms, as well short-term impacts of these changes. Besides, the simulation of other alternative proposals, which can consider other variables such as, for example, the growth in worker productivity and other social security schemes.

However, this study proves to be efficient because it shows that the current Brazilian reform is not able to completely solve the deficit problem in social security, providing, as happened in previous reforms, a smoothing of the current deficit growth, concluding that new reforms will be necessary. Highlighting that regimes such as Fully Funded and multi-pillar should be considered, even with higher transition costs, as proposals to balance the Social Security System, allowing the Government to use resources in other areas such as infrastructure and education.

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