SOCIAL SECURITY REFORM AND ITS MEDIUM AND LONG-TERM MACROECONOMIC IMPACTS: AN OVERLAPPING GENERATION MODEL APPROACH FOR BRAZILIAN CASE[1]

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This paper presents an economic simulation assessing the medium and long-term impacts of the social security reform outlined in Constitutional Amendment (EC) No. 103/2019. To conduct this analysis, we employed an overlapping generations (OLG) model spanning 57 generations, which incorporates the transitional provisions. The results indicate that while EC No. 103/2019 may not offer a definitive solution to Brazil's pension challenges, it does provide a temporary respite. Specifically, it offers a window of approximately 10 to 15 years during which the social security deficit stabilizes. However, it's crucial to acknowledge that beyond this period, the situation is expected to deteriorate once more, with social security returning to an unsustainable trajectory. As a policy suggestion, it will be important to have another pension reform in the near future.

Keywords: demographic change; social security reform; overlapping generation models.

REFORMA DA PREVIDÊNCIA SOCIAL E SEUS IMPACTOS MACROECONÔMICOS DE MÉDIO E LONGO PRAZO: UMA ABORDAGEM DE MODELO DE GERAÇÃO SOBREPOSTA PARA O CASO BRASILEIRO

Este artigo apresenta uma simulação econômica avaliando os impactos de médio e longo prazo da reforma previdenciária delineada na Emenda Constitucional (EC) nº 103/2019. Para realizar esta análise, foi utilizado um modelo de gerações sobrepostas (OLG) abrangendo 57 gerações, que incorpora as disposições transitórias da reforma. Os resultados indicam que, embora a EC nº 103/2019 possa não oferecer uma solução definitiva para os desafios previdenciários do Brasil, ela proporciona uma janela temporária. Especificamente, oferece um período de aproximadamente 10 a 15 anos durante o qual o déficit da seguridade social se estabiliza. No entanto, é crucial reconhecer que, para além deste período, a situação deverá deteriorar-se mais uma vez, com a previdência social retornando a uma trajetória insustentável. Como sugestão política, será importante realizar outra reforma previdenciária em um futuro próximo.

Palavras-chave: mudança demográfica; reforma da previdência social; modelo de geração sobreposta.

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LA REFORMA DE LA SEGURIDAD SOCIAL Y SUS IMPACTOS MACROECONÓMICOS DE MEDIANO Y LARGO PLAZO: UN ENFOQUE DE MODELO DE GENERACIÓN SUPERPUESTA PARA EL CASO BRASILEÑO

Este artículo presenta una simulación económica que evalúa los impactos a mediano y largo plazo de la reforma de las pensiones descrita en la Enmienda Constitucional (CE) nº 103/2019. Para realizar este análisis se utilizó un modelo de superposición de generaciones (OLG) que abarca 57 generaciones y que incorpora las disposiciones transitorias de la reforma. Los resultados indican que, aunque la CE nº 103/2019 puede no ofrecer una solución definitiva a los desafíos de las pensiones de Brasil, sí proporciona una ventana temporal. En concreto, prevé un período de aproximadamente 10 a 15 años durante el cual se estabiliza el déficit de la Seguridad Social. Sin embargo, es fundamental reconocer que, más allá de este período, es probable que la situación se deteriore nuevamente y que la seguridad social retome una trayectoria insostenible. Como sugerencia política, será importante llevar a cabo otra reforma de las pensiones en un futuro próximo.

Palabras clave: cambio demográfico; reforma de la seguridad social; modelos de generaciones superpuestas.

JEL: J11; H20; H77.

1 INTRODUCTION

One of the foremost economic challenges facing Brazil is its Social Security system. In 2022, the General Social Security System (RGPS) reported a staggering deficit of R$ 270 billion. Simultaneously, the Social Welfare Regime (RPPS) for civil and military servants also registered a deficit of R$ 105 billion in the same year, further exacerbating the country's fiscal difficulties. In total, the Brazilian social security deficit reached R$ 375 billion in 2022.

Brazil is experiencing a rapid demographic transformation that could render its social security system unsustainable in the long term. Data from the Social Security Forum (Brasil, 2016a) reveals a significant decline in the birth rate, projected to drop to 1.3 children per woman by 2034. In parallel, life expectancy is expected to increase to 80.1 years by 2042. As a result, a Brazilian individual reaching 60 years of age will have an expected survival period of 25.2 years by 2060. Conversely, the IBGE's 2014 projections anticipate a reduction in the economically active population from 140.9 million in 2015 to 131.4 million by 2060, accompanied by a surge in the elderly population over 65 years, projected to increase from 16.1 million to 58.4 million during the same period.

This demographic shift is poised to widen the social security deficit unless changes are implemented. The Ministry of Finance estimates a significant surge in the social security deficit, which is expected to rise from the current 4% of GDP (2017) to a daunting 11.1% of GDP by 2060 (Brasil, 2017). Such a deficit would severely impede the government's ability to fulfill its fundamental obligations, including education, healthcare, and public safety.

Against this background, the Brazilian National Congress passed Constitutional Amendment (EC) No. 103/2019, which introduces significant reforms affecting both the General Social Security System (RGPS) and the Social Welfare Regime (RPPS) for federal civil servants. The key provision of this amendment establishes a minimum retirement age of 65 for men and 62 for women, with a 15 to 20-year transition period. A study conducted by the Ministry of Finance suggests that these measures should effectively curb the explosive growth of the social security deficit, at least until 2060 (Brasil, 2017).

The Brazilian economic literature has alerted on the problems of the country's social security system. Barreto (1997) was an early proponent of the idea that the Brazilian social security system was financially unsustainable, proposing a shift from the distribution system to a capitalization regime. In his research, he constructed an overlapping generations (OLG) model to evaluate the economic effects of this transition. While the impacts were positive, Barreto (1997) also emphasized the substantial fiscal costs that would arise during the shift from the distribution system to the capitalization system.

The debate over transitioning to a capitalization-based social security regime has been a recurring theme in Brazilian literature. Ferreira (2004) utilized an OLG model to assess the short-term and long-term consequences of various pension reforms, considering options such as the distribution system, full capitalization, or intermediate solutions. His findings indicated that partial reforms, such as those reducing the replacement rate or shifting the tax base from labor to consumption, could yield positive long-term results. However, he also highlighted the significant fiscal costs associated with the transition.

Ellery Junior and Bugarin (2003) apply an OLG model to determine the optimal balance between distribution and capitalization systems, measured by the replacement rate. The authors conclude, for reasonable parameters, that the capitalization system is always preferable instead of an distribution system.

The concerns regarding declining fertility rates and increasing life expectancy were highlighted in the work of Oliveira, Beltrão and Ferreira (1997). They underscored the legislative challenges involved in approving a necessary social security reform at the time.

The first significant change to Brazil's social security system since the approval of the Federal Constitution in 1988 was the enactment of Constitutional Amendment 20/1998. This legislation introduced a minimum contribution time of 35 years for men and 30 years for women, along with stipulating a minimum retirement age of 60 for men and 55 for women in the federal public civil service. Constitutional Amendment No. 20/1998 also introduced the concept of the social security factor, in conjunction with Law No. 9.876/1999, which enabled the adjustment of benefits within the General Social Security System (RGPS).

However, as noted by Giambiagi and Estermínio (2006) and Marques, Batich and Mendes (2003), EC 20/98 primarily addressed the short-term deficit, falling short of providing a definitive solution for the Brazilian pension system.

The second major reform was the Constitutional Amendment No. 41 of 2003 (EC 41/03). This amendment introduced social security contributions from inactive members of the Social Welfare Regime (RPPS). It mandated that federal retirees with incomes exceeding the RGPS benefit ceiling contribute to social security in the same way as active employees. Furthermore, EC 41/03 imposed additional restrictions within the RPPS, including reducing the benefit amounts for civil employees who retired before the age of 60 (males) and 55 (females).

In the evaluation by Souza et al. (2006), the impact of EC 41/2003 was notably limited, primarily affecting the Social Welfare Regime (RPPS) with a reduction in implied debt by approximately 20%, while its influence on the General Social Security System (RGPS) was minimal. This led many authors to raise questions about the sustainability of the Brazilian pension system. Rocha and Caetano (2008) observed that the system carried remarkably high expenditures compared to other nations, along with a substantial number of beneficiaries, so that Brazilian social security expenditures already seemed excessive in 2006.

Matos, Melo, and Simonassi (2013) also cast doubt on the solvency of the RGPS in Brazil, emphasizing that reforms involving the implementation of a minimum retirement age could potentially reverse the trajectory of the social security deficit.

In an attempt to restore balance to the social security regime, Giambiagi et al. (2007) proposed the introduction of a minimum retirement age of 60 for men and 55 for women, accompanied by a minimum contribution period of 35 years for men and 31 years for women already in the labor market. New entrants, they suggested, should face even higher requirements, with a minimum age of 65 for men and 64 for women, alongside a contribution time of 40 years. The authors estimated that implementing these measures could potentially reduce the implicit debt of the Brazilian social security system by as much as 40% to 60%.

Caetano et al. (2016) examined the social security policy changes during Dilma Rousseff's government, especially the end of the social security factor. Their analysis concluded that the social security factor was able to generate savings amounting to 2.2% of GDP per year, whereas the new rules would increase RGPS spending by 0.4% per year. Consequently, they recommended the adoption of a reform that establishes a minimum retirement age of 65 for men and 60 for women as a viable solution.

This paper contributes to the existing literature by simulating the economic impacts of Constitutional Amendment (EC) No. 103/2019. To achieve this,

we employ an overlapping generations (OLG) model spanning 57 generations, incorporating the transition rule. While this methodology is common in international literature, its application in Brazil has been limited.[4]

The findings of our study indicate that EC No. 103/2019 has significant effects on the economy. A comparison between the scenario with and without the reform reveals notable improvements in key macroeconomic variables. Output, consumption, and employment levels all show positive trends with the reform in place. However, the total social security deficit, which encompasses both RGPS and RPPS, increases from approximately 4.59% of GDP to 13.10% of GDP with the reform, whereas it would rise to 21.65% of GDP without the reform. These results lead to the conclusion that, according to our model, while the EC 103/2019 reform may offer some relief, it falls short of completely solving the social security deficit issue.

Beyond this introductory section, the article comprises five additional sections. Section 2 outlines the methodology used, Section 3 presents the data and calibration processes, Section 4 provides a detailed overview of Constitutional Amendment No. 103/2019, and Section 5 discusses the simulation results. Finally, Section 6 offers concluding remarks.

2 METHODOLOGY

This article uses a model of overlapping generations with greater detail on the fiscal side, approaching the real situation of the Brazilian economy.

2.1 Households

Households comprehend 57 overlapping generations of adults. With each period of time, there is an exit and an entrance of individuals. The entry happens at the age of 23, and the exit, happens with an expected age of death of 80 years. The assumption is that individuals start working at age 23 (when $j = 1$, where j is the generation), retire exactly at the moment that he or she complete 58 years old[5] ($j = 35$) and die when he or she completed 80 years old ($j = 57$). Life uncertainty was considered in this model when introducing the mortality rate of each family.

For each family, we assume preferences represented by a utility function with the current and future values of consumption and leisure. Leisure is measured as the difference between the fraction of the maximum amount of time that an individual could work in the reference week having values between zero and one.

4. See: Auerbach and Kotlikoff (1987), Lisenkova, Mérette and Wright (2012), Conesa and Krüger (1999), Choi and Shin (2015), İmrohoroglu, İmrohoroglu and Joines (1995), Heer and Irmen (2014) and Fredriksen et al. (2019).

5. Average age of retirement in Brazil according to data from the Social Security Forum (2016a).

For preferences, we use the constant elasticity of substitution function (CES). We can represent the intertemporal utility function as follows:

$$U_t = \frac{1}{1-\frac{1}{\gamma}} \sum_{j=1}^{57} (1+\beta)^{-(t-1)} p_j u_{j,t}^{\left(1-\frac{1}{\gamma}\right)} \tag{1}$$

$$u_{j,t}(c_{j,t}, l_{j,t}) = \left(c_{j,t}^{\left(1-\frac{1}{\rho}\right)} + \alpha l_{j,t}^{\left(1-\frac{1}{\rho}\right)}\right)^{\frac{1}{\left(1-\frac{1}{\rho}\right)}} \tag{2}$$

In which γ is the intertemporal substitution elasticity, β is the discount rate, p_j is the survival probability of the individual of family j (IBGE, 2017). For simplicity, the accidental inheritances left by individuals are not used by the model. The variables $c_{j,t}$ and $l_{j,t}$ represent consumption and leisure with age j at time t. The parameter ρ represents the intratemporal substitution elasticity between consumption and leisure and α is the weight of leisure in relation to the consumption in the preferences of the families.

Given this, we have that families maximize their intertemporal utility based on their income expectations throughout the life cycle, represented by the equation below:

$$\sum_{j=1}^{35} \prod_{m=1}^{t} \left(\frac{W_t e_j (1-l_{j,t})(1-\tau_{lt}-\tau_{st})}{[1+r_m(1-\tau_{kt})]}\right) + \sum_{j=36}^{57} \prod_{m=36}^{t} \left(\frac{b_t}{[1+r_m(1-\tau_{kt})]}\right) + Tr_t \geq \sum_{j=1}^{57} \prod_{m=1}^{t} \left(\frac{(1+\tau_{ct})c_{j,t}}{[1+r_m(1-\tau_{kt})]}\right) \tag{3}$$

The equation ensures that the present value of consumption over the life cycle is less than or equal to the present value of the income of individuals during the finite period of life of families. Leisure $l_{j,t}$ assumes values less than 1, for j between 1 and 35; and values equal to 1 for j from 36 to 57. This is due to the fact that retirees do not offer work (generation between 36 and 57). The wage in year t is given by W_t, $(1-l_{j,t})$ are hours worked and e_j is an exogenous adjustment factor to capture differences in skill levels between families of different ages.

The tax rates are: τ_{lt} – tax rate on labor income, τ_{kt} – rate on capital income, τ_{ct} – tax rate on consumption and τ_{st} rate of social security contributions, and Tr_t are transfers from government to families.

The variable r_t is the real interest rate, while b_t represents transfers to families as social security. Thus, the value of the benefit salary will be:[6]

6. According to Law No. 9.876 of 1999, retirees by contribution time and by age will have their benefit salaries as a simple arithmetic mean of the highest contribution wages corresponding to eighty percent (0.8) of the entire contributory period.

$$b_t = 0{,}8 \sum_{j=1}^{35} \left(\frac{W_{t-j} e_j (1 - l_{j,t-j})}{35}\right) \tag{4}$$

Finally, solving for $j = 1, \ldots, 35$ the maximization of the utility function subject to budget constraint, we obtain the intertemporal trajectories and the intratemporal relation of consumption and leisure, equations (5), (6) and (7), respectively:

$$c_{j,t} = c_{j-1,t-1} \cdot \left(\frac{(1+\beta)^{t-2}}{(1+\beta)^{t-1}}\right)^{\gamma} \cdot ([1 + r_t(1 - \tau_{kt})])^{\gamma} \cdot \left(\frac{p_j}{p_{j-1}}\right)^{\gamma} \cdot \left(\frac{1+\tau_{ct-1}}{1+\tau_{ct}}\right)^{\gamma} \cdot \left(\frac{1 + \alpha^{\rho}(w^*_{j-1,t-1})^{(1-\rho)}}{1 + \alpha^{\rho}(w^*_{j,t})^{(1-\rho)}}\right)^{\frac{\rho-\gamma}{\rho-1}} \tag{5}$$

$$l_{j,t} = l_{j-1,t-1} \left(\frac{(1+\beta)^{t-2}}{(1+\beta)^{t-1}}\right)^{\gamma} \cdot ([1 + r_t(1 - \tau_{kt})])^{\gamma} \cdot \left(\frac{p_j}{p_{j-1}}\right)^{\gamma} \cdot \left(\frac{1+\tau_{ct-1}}{1+\tau_{ct}}\right)^{\gamma} \cdot \left(\frac{1 + \alpha^{1+\rho} w^{*}_{j-1,t-1}{}^{(1-\rho)}}{1 + \alpha^{1+\rho} w^{*}_{j,t}{}^{(1-\rho)}}\right)^{\frac{\rho-\gamma}{\rho-1}} \cdot \left(\frac{w^*_{j-1,t-1}}{w^*_{j,t}}\right)^{\rho} \tag{6}$$

$$l_{j,t} = c_{j,t} \alpha^{\rho} w^{*(-\rho)}_{j,t} \tag{7}$$

$$w^*_{j,t} = \frac{W_t e_j (1 - \tau_{lt} - \tau_{st}) + \mu_{j,t}}{(1 + \tau_{ct})} \tag{8}$$

The parameter $\mu_{j,t}$ would be the shadow wage of family j in year t which is equal to zero if the individual offers some labor and is not equal to zero if he decides not to work in year t. $\frac{p_{j-1,t-1}}{p_{j,t}}$ is the conditional probability of a family of generation j living plus one unit of time.

For retirees who correspond to the generations $j = 36, \ldots, 57$, the leisure trajectory is unitary, then, from the process of maximizing the utility function subject to the budget constraint, we have the following consumption equation:

$$\left(\frac{c_{j,t}}{c_{j-1,t-1}}\right)^{-\left(\frac{1}{\rho}\right)} \cdot \frac{\left(c_{j,t}^{\left(1-\frac{1}{\rho}\right)} + \alpha l_{j,t}^{\left(1-\frac{1}{\rho}\right)}\right)^{\frac{\frac{1}{\rho}-\frac{1}{\gamma}}{1-\frac{1}{\rho}}}}{\left(c_{j-1,t-1}^{\left(1-\frac{1}{\rho}\right)} + \alpha l_{j-1,t-1}^{\left(1-\frac{1}{\rho}\right)}\right)} = \left(\frac{(1+\beta)^{-(t-2)}}{[1 + r_t(1 - \tau_{kt})](1+\beta)^{-(t-1)}}\right) \cdot \left(\frac{p_{j-1,t-1}}{p_{j,t}}\right) \cdot \left(\frac{1+\tau_{ct}}{1+\tau_{ct-1}}\right) \tag{9}$$

2.2 Production

The production function has as input capital and labor and a Cobb-Douglas technology. Capital is homogeneous, while labor is expanded by the level of efficiency (e_j), that is, people of different ages provide different amounts of labor per leisure unit. Thus, the production function is given by:

$$Y_t = F(K_t, L_t) = A_t(K_t^{\theta} L_t^{1-\theta}) \tag{10}$$

In which Y_t is the aggregate product, K_t and L_t represent capital and aggregate labor, respectively. The term θ is the share of capital in the production function and, finally, A_t represents the total factor productivity. Thus, from the process optimization of production function (10), we have the following equations of wage and interest rate:

$$W_t = (1-\theta)A_t \left(\frac{K_t}{L_t}\right)^{\theta} \tag{11}$$

$$r_t = \theta A_t \left(\frac{K_t}{L_t}\right)^{\theta-1} \tag{12}$$

2.3 Government

The government keeps the budget balanced, so that the revenues are exactly equal to the sum of government consumption with the social security deficit and transfers.

$$G_t = T_t - S_t^B - Tr_t \tag{13}$$

G_t is government consumption of goods and services, S_t^B are the benefits of social security and Tr_t are government transfers. For the tax collection T_t, we have:

$$T_t = \sum_{j=1}^{35} N_{j,t}\,\tau_{lt} W_t e_j (1 - l_{j,t}) + \sum_{j=1}^{57} N_{j,t} c_{j,t}\,\tau_{ct} + \tau_{kt}(r_t + \delta)K_t + S_t^A \tag{14}$$

In which S_t^A is the collection of social security, δ represents the rate of capital depreciation and $N_{j,t}$ is the population of age j in t periods.

2.4 Social Security

In Brazil the social security system uses the simple distribution system (PAYG), where the benefits received from retirement extend until the death of the individual. Following the Brazilian reality, in the model the retirement occurs in $j = 37$, equivalent to 58 years of age, and the benefit value is calculated by the equation (4). The total annual social security expenditure can be represented by the following equation:

$$S_t^B = \sum_{j=36}^{57} N_{j,t} b_t \tag{15}$$

The annual income of the social security comes from the contribution of the employees on the payroll:

$$S_t^A = \sum_{j=1}^{35} N_{j,t} W_t e_j (1 - l_j, t)\, \tau_{st} \tag{16}$$

2.5 Marketplace balance

The balance in the labor market requires:

$$L_t = \sum_{j=1}^{35} N_{j,t} e_j (1 - l_{t,j}) \tag{17}$$

The balance in the capital market is given by:

$$K_{t+1} = Y_t + (1 - \delta) K_t - G_t - C_t \tag{18}$$

The equality between supply and aggregate demand is represented by:

$$Y_t = C_t + I_t + G_t \tag{19}$$

$$C_t = \sum_{j=1}^{57} c_{j,t} N_{j,t} \tag{20}$$

2.6 Solution of the model

For the solution of the equilibrium trajectory of the economy, we used the algorithm of Broyden (1965) that numerically solves the system of nonlinear equations composed of equations (5) to (9) and (11) to (20). The program code was written in Python 3.

3 DATA AND CALIBRATION

The calibration was done with data from the National Accounts of the IBGE of 2017 and data from the Secretaria da Receita Federal do Brasil – RFB (Brasil, 2016b). For simplicity, the product of the economy for 2015 was set at 100.

Table 1 presents the model parameters. For the calculation of participation of capital income in the product, θ, the gross operating surplus value was divided in relation to the sum of the salaries of employees and self-employed with the gross operating surplus itself.

$$\theta = \frac{1.925.415}{(1.925.415 + 2.673.347 + 499.417)} = 0.3776 \tag{21}$$

The population parameter (N_{jt}) was collected through projection of the population by age up to 2060 (IBGE, 2014). The probability of death (p_j) was obtained from the complete mortality table provided by IBGE-COPIS (IBGE, 2015). The other parameters were calculated endogenously or collected in the national literature.

TABLE 1
Model parameters

Description	Parameters	Values	Source
Intertemporal substitution elasticity	γ	0.700	Cavalcanti e Silva (2010)
Intratemporal substitution elasticity	ρ	1.135	Ferreira (2004)
Preference for leisure in utility function	α	0.250	Cavalcanti e Silva (2010)
Preference for the present	β	0.025	Cavalcanti e Silva (2010)
Total factor productivity	A	0.9719	Model
Capital participation in the production function	θ	0.378	IBGE (2017)
Capital depreciation rate	δ	0.035	Model
$e^{(a+bj+cj^2)}$	e_j	$a = -0.94410$ $b = .043836$ $c = -.000671$	Model

Authors' elaboration.
Obs.: The parameters related to e_j were calculated endogenously from the steady-state equilibrium equations using the Broyden algorithm (1965) as the solution. The parameter A comes from the steady-state equation, $A = {}^{Y}/_{K^{\theta} \cdot L^{1-\theta}}$, in which Y is equal to one.

Consumption in proportion to GDP reached 62.50% in 2015. Government consumption and investments reached 19.77% and 17.71% respectively in relation to GDP.

The basic interest rate of the economy (SELIC) for the period was 14.15%, inflation in 2015 was 10.67% based on the broad consumer price index (IPCA), so that the real interest rate was 3.48% per year.

For steady state capital, we use the investment value as a proportion of GDP, the real interest rate and the value of θ:

$$\bar{K} = \frac{(\theta - \frac{I}{Y})}{r} \tag{22}$$

Given the investments in relation to GDP and steady state capital, we can calculate the capital depreciation rate (δ) as:

$$\delta = \frac{{}^{I}/_{Y}}{\bar{K}} \tag{23}$$

To calculate the hours worked (L), we use the working hours available for the market activity. Thus, from the 168 hours per week, 56 hours of sleep per week are withdrawn, and considering a working day of 44 hours per week, $L = 44/112 = 0.3928$.

The values for the collection were taken from the study of the Brazilian tax burden (Brasil, 2016b) and social security expenditure was obtained through the Statistical Yearbook of Social Security.[7]

Table 2 presents the values of economic aggregates. The steady state is considered the real economy of 2015.

TABLE 2
Economic aggregates (2015)

	Brazil (% GDP)	Model
Consumption	62.50	62.50
Government consumption	19.77	19.77
Capital	-	504.07
Investment	17.71	17.71
Selic interest rate	14.15	-
Real interest rate	3.48	3.48
Wages rate	62.23	62.23
Government revenue	31.23	31.23
Social Security revenue	6.43	6.43
Expenses on Social Security	11.02	11.02

Source: National Accounts (IBGE, 2017), Ipeadata (available at: https://biblioteca.ibge.gov.br/index.php/biblioteca-catalogo?view=detalhes&id=2101289; accessed on: May 14, 2022) and Ministry of Social Security (available at: https://www.gov.br/previdencia/pt-br/assuntos/previdencia-social/aeps-2013).
Authors' elaboration.

To compute the tax rates of the model: capital income tax (τ_k), labor income tax (τ_l), social security tax (τ_s) and consumption tax (τ_c) were calculated on the basis of RFB (Brasil, 2016b). Table 3 summarizes the values found for the tax rates.

TABLE 3
Tax rates

	Description	Value (%)
τ_k	Tax rate on capital income	12.47
τ_l	Tax rate on labor income	10.66
τ_s	Tax rate on social security	10.33
τ_c	Tax rate on consumption	21.51

Authors' elaboration.

7. Available at: https://www.gov.br/previdencia/pt-br/assuntos/previdencia-social/aeps-2013.

4 THE CONSTITUTIONAL AMENDMENT NO. 103/2019

The Constitutional Amendment No. 103/2019 presented a series of changes not only in Social Security, but also in Social Assistance. At this time, it was proposed to establish a minimum age for both RGPS and RPPS of 65 years old for men and 62 years old for women with a transition rule. A minimum of 15 years of contribution is required to retirement for men or 15 years for women. The calculation of the benefit was modified, so that it would only receive the full amount of the pension, individuals who contribute for 40 years for Social Security. For rural workers it was established a minimum period of 15 years of contribution and the minimum age for retirement of 55 and 60 years old for women and men, respectively. The table below details the main points of the EC 103/2019.

TABLE 4
Main changes of EC 103/2019

Proposals	General Social Security System (RGPS)	Regime of Social Security (RPPS) – Federal
Minimum age – Urban	Men – 65 years. Women – 62 years. Contribution time – 20 years (Men); 15 years (Women).	
Amount of benefit	60% of the average of all contributions considering the minimum years of contribution; plus 2% for each year beyond the minimum years of contribution until reaching 100%.	
Increase of the minimum age	The law will establish the correction of the minimum age due to the increase in the expectation of survival.	
Transition rule	Increase of minimum age from 56 years (woman) and 61 years (man) from 6 months every year from 01/01/2020.	
Value of the benefit in the transition (servers that entered before Constitutional Amendment No. 41/2003)	Not applicable.	For those who retire at age 60 (woman) or 65 (man) receive integrality and parity. If you retire before, 100% of the average of the contribution's wages.
Pensions	Family quota of 50% plus 10% per dependent.	

Authors' elaboration.

For the purposes of the simulations of EC 103/2019, a minimum retirement age of 63 years was adopted, equivalent to the proposal of 65 years for men and 62 years for women. The transition rule, which provides for the minimum age to increase by 1 year every two years from 2020, as well as the recalculation of benefit, have also been incorporated into the simulation.

Brazil must pass in the coming years from the demographic bonus situation, in which population growth drives the economy, to a situation of demographic "burden" in which the distribution of the population has a negative effect on economic growth. It is estimated that the demographic "bonus" will extend until around 2040, when the share of the economically active population starts to decrease.

The transition rule of EC 103/2019 attenuates the demographic "burden" by gradually raising the minimum retirement age, stabilizing the working age population and, consequently, keeping the number of retirees relatively constant, as observed in table 5.

TABLE 5
Retired population in the transition with pension reform

Period in model (t)	Age retired	Population (%)	Period in the model (t)	Age retired	Population (%)
0	58-80	18.68	6	61-80	18.56
1	58-80	19.43	7	61-80	19.32
2	59-80	18.67	8	62-80	18.47
3	59-80	19.43	9	62-80	19.23
4	60-80	18.64	10	63-80	18.34
5	60-80	19.39	11	63-80	19.10

Source: IBGE (2014).
Authors' elaboration.

5 RESULTS

5.1 Long term results

Table 6 presents the results of the long-term simulations. Two simulations were carried out, the first considering the minimum retirement age of 58 years (without social security policy) and the second with the minimum age of 63 years, with transition rule increasing by 1 year every two years until reaching 63 years (with social security policy).

TABLE 6
Long-term macroeconomic effects

	Initial stationary state	Change without pension reform (%)[1]	Change with EC 103/2019 (%)[1]
Consumption	62.50	21.28	27.20
Government	19.77	-72.53	-22.45
Capital	504.07	-7.94	7.46
Labor	0.3928	-2.60	5.66
GDP	100.00	-1.63	9.15
Wages	62.23	-2.10	6.40
Soc. Sec. expenses	11.02	153.81	82.48
Soc. Sec. revenue	6.43	-1.71	9.02
Tax revenues	31.23	6.29	15.00
Consumption per capita	100.00	-1.58	2.89
Product per capita	100.00	-22.68	-13.79

Authors' elaboration.
Note: [1] Percentage change from initial steady state.

In all simulations, the demographic change was estimated as estimated by the IBGE (2014) with the projection of the population by age in 2060. The IBGE (2014) made projections for the Brazilian population up to 2060, estimating a population growth of almost 27% between 2015 and 2060, but that this growth will occur disproportionately among the age groups. The number of people up to 58 years old will have decreased by 5.35%, while the number of people over 58 will have grown by 182%.

The demographic transition supplemented by the increase in life expectancy of Brazilians substantially affected the social security equilibrium. Social security expenditures go from 11.02% of GDP in the initial steady state to 27.97% (without reform) or 20.11% of GDP (with retirement) in the final steady state. On the side of social security revenues, there is a negative variation, from 6.43% of GDP in initial equilibrium to 6.32% of GDP (without reform) or 7.01% of GDP (with reform) in the new long-term equilibrium. As a result, the social security deficit increases from 4.59% of GDP to 21.65% of GDP (without reform) or 13.10% of GDP (with retirement).

Since transfers from the public sector to households are assumed to be constant, the social security deficit leads to a sharp reduction in public spending, which falls from 19.77% of GDP in the initial steady state to only 5.43% of GDP (without reform) or 15.33% of GDP (with reform).

A second factor that affects outcomes is population growth. IBGE (2014) made projections for the Brazilian population until 2059, estimating a growth of almost 27%, but disproportionately among the age groups. For simulation purposes, it was assumed that the population distribution remains the same from the 45 period.

By the theory of the cycle of life, with an older population, the aggregate consumption tends to increase. This growth is boosted by population growth and occupies the space in the aggregate demand previously destined to the consumption of the public sector. Still, in per capita terms, simulation without pension reform suggests a decline in per capita consumption, while with retirement this variable remains practically at the same level as the initial steady state.

Capital stock increases in the long term with EC 103/2019. The explanation of this behavior is due to the demographic change, accompanied by the increase of the minimum age, which stimulates the accumulation of capital for more time by the workers.

Regarding the labor supply, the results directly reflect the demographic change and the increase of the time for the retirement. In the case without reform, only the demographic change acts, so that there is a fall in the labor supply in the long term.

In the simulation with EC 103/2019, raising the minimum age more than compensates for the demographic transition so that labor supply grows.

In any case, the Brazilian social security deficit charges a high price of per capita product, which falls 22.5% in the scenario without reform and 14% in the scenario with EC 103/2019.

5.2 Transition path and medium-term results

Figure 1 shows the transition path of social security expenditure and income, as well as other macroeconomic variables.

Aggregate consumption begins its accelerated growth, reflecting the increase in population, and reaches the maximum around the 30th period. The differentiation in the trajectories with and without reform stems from the fact that the increase in the minimum age for retirement makes the period is higher, providing a higher income over the life cycle with higher consumption.

As for the capital stock, the presence of the pension reform substantially affects the trajectory. EC 103/2019, by maintaining a greater number of active workers, encourages capital investment during the transition. However, as the population ages, investment tends to decline, albeit with a higher level of capital accumulated during the transition, and necessary to accommodate higher output with increased labor supply.

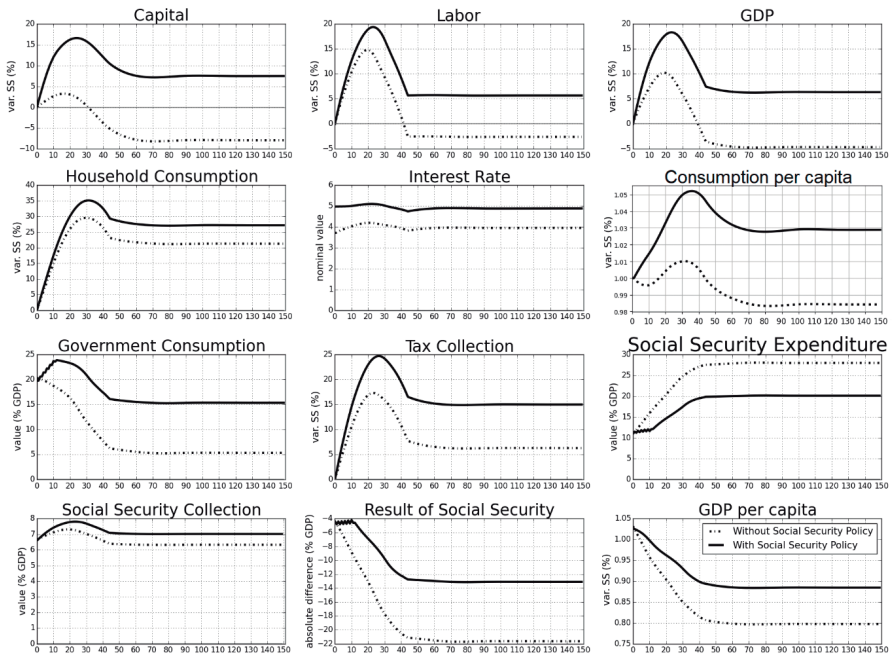
The number of workers grows up around the period 20, following a favorable demography. However, from this point on, without the reform, demographic change is reversed, and the number of workers decreases year by year. The difference in the trajectories of the labor supply with and without reform stems directly from the increase in the minimum age proposed by EC 103/2019.

As for the aggregate product, on the supply side, the reform allows the increase in time following the positive trajectories of capital and labor inputs. The opposite occurs in the situation without reform, in which the product falls along with the fall in inputs. On the demand side, the result of the Brazilian social security without reform reduces government spending by almost 5% of GDP, which is not offset by the increase in private consumption, so that without reform, aggregate demand decreases. With reform, the decline in public consumption is lower, going from 19.77% to 15.33% of GDP, easily offset by the increase in private consumption, so that aggregate demand increases with the reform.

The pension deficit is contained in the short term by the reform proposed by EC 103/2019. It is observed that the increase in the minimum age is able to keep the social security deficit relatively constant for about 20 periods. After that, the demographic transition becomes more pronounced, and the reform proves incapable

of containing the growth of the pension deficit. Without reform, social security expenditures are growing in the short term, in an explosive trajectory, causing a sharp contraction of government consumption and leading to an unsustainable fiscal situation in the medium term.

FIGURE 1
Transition trajectory for selected variables
(In %)



Authors' elaboration.
Obs.: Figure whose layout and texts could not be formatted due to the technical characteristics of the original files (Publisher's note).

The per capita variables that show the real effect on the economy. In 2059, the population will have grown almost 27%, but disproportionately. The number of people up to 58 years old will have decreased by 5.4%, while the number of people over 58 will have grown by 182%. The consequence is shrinkage of output and consumption per capita as shown in the graphs. The growing deficit of social security makes the Brazilian population poorer. EC 103/2019 softens the problem, but does not prevent the impoverishment of the population, with a drop in the per capita product of around 22.68% without politics and 13.79% with social security policy.

5.3 Sensitivity analysis

To test the sensitivity of the results in relation to the parameters, the intertemporal substitution elasticity, γ, and the preference for leisure in the utility function, α, were chosen. Both were chosen because they were not calibrated and their values in the simulation base scenario were taken from literature. Thus, the simulations were repeated for different values of these two parameters. Tables 7 and 8 present the results. Only the results referring to the adjustment of government expenditures were presented.

In relation to the elasticity of intertemporal substitution, Havranek et al. (2015) present estimates for 104 countries based on 169 studies published in different periods. The average found for all studies was 0.5. However, half the published work refers to the United States. When the average between countries is considered, the elasticity value rises to 0.7. Interestingly, that for Brazil, the estimate was 0.107 with a standard deviation of 0.093. As the baseline scenario, given by the calibration, already contemplates $\gamma = 0.7$, the sensitivity analysis tested the other two values - 0.2 and 0.5.

Regarding leisure preference, national literature presents different values for this parameter. For example, Paes (2011) uses 2.02, while Araújo and Ferreira (1999) use 1,4; Paes and Bugarin (2006), 1.94 and Pereira and Ferreira (2010), 0.94. In the sensitivity analysis, values between 0.5 and 2.0 were considered, within the range adopted by the Brazilian literature.

TABLE 7
Sensitivity analysis – no reform with adjustment in government expenditures

γ	α	K	L	Y	C	G	Sb	Sa
0.2	*0.25*	-32.34	-22.32	-26.27	-5.83	-85.17	103.30	-26.27
0.5	*0.25*	-23.48	-21.31	-22.14	-3.11	-81.01	105.85	-22.14
0.7	*0.25*	*-7.94*	*-2.6*	*-4.62*	*21.28*	*-72.98*	*153.75*	*-1.63*
0.7	0.5	-20.01	-38.13	-31.83	-15.15	-94.94	100.51	-31.83
0.7	1.0	-11.44	-59.05	-45.20	-32.14	-100.00	97.01	-45.20
0.7	1.5	10.77	-68.93	-49.78	-41.74	-100.00	101.53	-49.78
0.7	2.0	336.98	-55.16	5.94	-52.37	-100.00	142.59	5.94

Authors' elaboration.

The base scenario, given by the calibration, appears in italic in the table. Economic theory suggests that the lower the elasticity of intertemporal substitution, the lower the household savings, so that they begin to value the present consumption more to the detriment of future consumption. This actually did appear in the results, with the economy moving into a long-run equilibrium with a sharp drop in capital stock, which is reflected in reduced output and aggregate consumption.

Therefore, if families are more impatient about the future, the economic consequences of population aging will be worse.

Regarding changes in preference for leisure, it is expected that the increase in the values of this parameter has quite negative effects on labor supply, accompanied by a reduction in private consumption. The results confirm this behavior; however, government spending becomes zero from $\alpha = 1$. This implies the complete collapse of government, so that the results no longer have economic sense.

As in the sensitivity analysis of the scenario without reform, with the change in the minimum age, the pattern was exactly the same: lower savings for lower values of intertemporal substitution elasticity and lower labor supply and private consumption for higher values of preference for leisure, α.

TABLE 8
Sensitivity analysis – minimum age and adjustment in government expenditures

γ	α	K	L	Y	C	G	Sb	Sa
0.2	*0.25*	6.31	-4.30	-3.42	-8.47	-45.97	60.84	-4.02
0.5	*0.25*	7.00	-4.02	-1.79	-3.44	-38.06	61.20	-1.79
0.7	*0.25*	*7.46*	*5.66*	*9.15*	*27.20*	*-22.33*	*82.47*	*9.15*
0.7	0.5	6.77	-20.84	-11.37	-20.12	-33.71	77.59	-11.36
0.7	1.5	62.30	-48.33	-20.39	-50.34	-100.00	167.51	-20.39
0.7	2.0	117.16	-51.83	-14.93	-57.18	-100.00	263.50	-14.93

Authors' elaboration.

5.4 Welfare analysis

Figure 2 presents the results for intergenerational welfare from the pension reform. The curve with the minimum age of 58 years corresponds to the case without the pension reform and the curve with the minimum age of 63 years is the simulation with the pension reform.

In order to estimate the impact of pension reform in welfare, we follow the traditional methodology in the literature, those of Auerbach and Kotlikoff (1987), Pereira and Ferreira (2010; 2011) and Ileri and Derin-Gure (2014). This estimation begins by measuring the variation in the utility of individuals under the new policy, which provides the same level of satisfaction that they enjoyed before the pension reform. This variation in the portion of gain or loss that arises from the solution in d of the following equation (adapted for the model proposed in this work):

$$(1+d_j)^{\frac{1}{1-\frac{1}{\gamma}}}U_{j,0} = \frac{1}{1-\frac{1}{\gamma}}\sum_{j=1}^{57}(1 + \beta)^{-(t-1)}p_j\left(\left(c_{j,t}(1+d_j)^{(1-\frac{1}{\rho})} + \alpha l_{j,t}(1+d_j)^{(1-\frac{1}{\rho})}\right)^{\frac{1}{1-\frac{1}{\rho}}}\right)^{(1-\frac{1}{\gamma})} \quad (24)$$

In which $U_{j,0}$ are the steady-state utility levels; and $c_{j,t}$ and $l_{j,t}$ are the consumption and leisure of family j at time t under the new policy. Given the utility ($U_{j,t}$) after the social security policy, the variation in welfare can be measured as:

$$d_j = \left(\frac{U_{j,t}}{U_{j,0}}\right)^{\frac{1}{1-\frac{1}{\gamma}}} - 1 \quad (25)$$

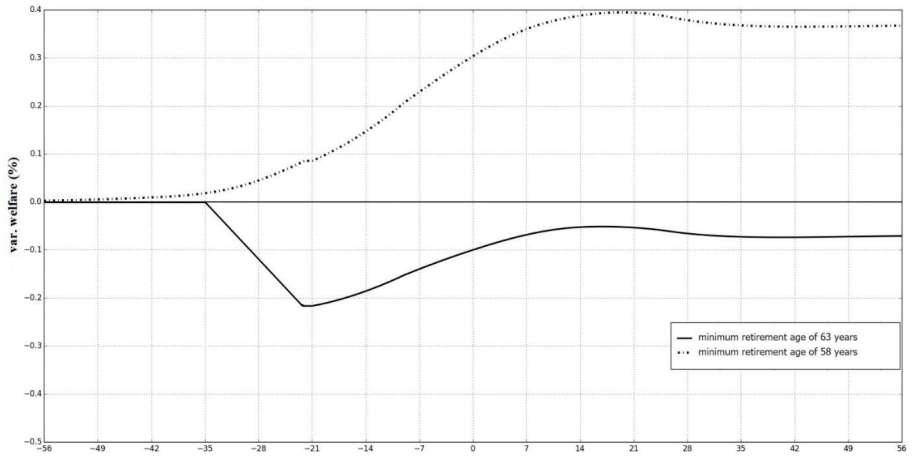
The horizontal axis of figure 2 represents the generations. From -56 to -36 are the individuals who are retired at the time of the simulations, where between -1 and -35 are the families that are in the job market. Generation 0 onwards are the generations born after the start of the simulations.

The effects on welfare are modest. It is observed that in both cases, retirees do not have their welfare altered at all, whether there is a change in retirement rules or not, since they are not affected by the reform.

In the case without pension reform, welfare tends to increase due to the reduction in working hours, which decreases more than per capita consumption. The economy moves to an equilibrium where there is a drop in production, and consequently, lowering demand for work, but also reflecting lower per capita consumption. This decrease, however, is more pronounced in the demand for work than in consumption, resulting in a positive effect on welfare.

For the simulation with pension reform, there is a loss of welfare in the first periods after the reform, which mainly affects those who have been in the job market for longer. The need to work longer increases the supply of work, expanding production and consumption per capita. However, the supply of labor grows more than per capita consumption, resulting in a loss of welfare. The effect of the greater labor supply diminishes over time, leading to an inflection in their behavior from generation -22 onwards (figure 1). From this point, the supply of labor starts to decrease, reversing the downward trend in welfare, although it remains negative throughout the trajectory with pension reform.

FIGURE 2
Effects on intergenerational welfare
(In %)



Authors' elaboration.
Obs.: Figure whose layout and texts could not be formatted due to the technical characteristics of the original files (Publisher's note).

6 CONCLUSIONS

This study utilizes an overlapping generations model to assess the impact of population aging on social security and the Brazilian economy. The findings reveal a significant rise in the social security deficit, projected to surge from the current 4% of GDP to over 11.1% of GDP by 2060. A second simulated scenario involves the implementation of Constitutional Amendment No. 103/2019, which establishes a minimum retirement age in Brazil.

The results underscore the detrimental consequences of avoiding such reforms, emphasizing that the fiscal situation becomes unsustainable. The expansion of social security expenditures, coupled with a reduction in the labor supply, leads to a sharp decline in per capita consumption.

Conversely, the simulations indicate that EC 103/2019, while not providing a definitive solution to Brazil's social security challenges, offers a temporary respite, stabilizing the social security deficit for approximately 10 to 15 years. However, beyond this period, the situation worsens, with social security returning to an explosive trajectory.

As a policy recommendation, even though EC 103/2019 has been in effect for almost four years since its approval, it is advisable to consider a new pension reform in the near future. This reform should potentially raise the retirement age even further, ensuring a longer lasting and more positive impact on the economy.

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