Social Security reform and its medium and long-term macroeconomic impacts: An overlapping generation model approach

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ABSTRACT

This paper presents a simulation of the economic impacts of medium and long term the proposed social security reform contained in the Proposal for Constitutional Amendment (PEC) nº 287/2016. For that, an overlapping generations (OLG) model with 57 generations was built, including the transition rule. The results suggest feasible the pension reform, since, the fiscal situation becomes unsustainable. Combining the expansion of social security expenditures with a reduction in the labor supply, it leads the country to a scenario a sharp fall in consumption and output per capita. The simulation with PEC nº 287/2016 indicates that, although it is not the definitive solution to the Brazilian pension issue, it allows a window of about 10 to 15 years in which the social security deficit stabilizes. After this period, the situation worsens once again with social security returning to an explosive trajectory. As a policy suggestion, although PEC nº 287/2016 has not even been voted, the recommendation is that it represents a minimum level for the next pension reform.

Keywords: Demographic Change; Social Security Reform; Overlapping Generation Models.

Reforma previdenciária e seus impactos macroeconômicos de médio e longo prazo: Uma aproximação pelo modelo de gerações sobrepostas

RESUMO

A presente pesquisa tem o intuito de simular os impactos econômicos de médio e longo prazo dos elementos principais da reforma previdenciária contida na Proposta de Emenda Constitucional (PEC) nº 287/2016. Para isso, o método parte de um modelo de gerações sobrepostas (OLG) com 57 gerações que inclui a regra de transição entre o regime atual e a proposta. Os resultados sugerem factível a reforma da previdência, uma vez que, situação fiscal torna-se insustentável. Combinando a ampliação das despesas previdenciárias com redução da oferta de trabalho, acaba por levar o país para um cenário de queda do produto e consumo per capita. A simulação com a PEC nº 287/2016 indica que ela não é a solução definitiva para a questão previdenciária brasileira, mas que permite uma janela de cerca de 10 a 15 anos em que o déficit previdenciário se estabiliza. Depois desse período a situação se agrava novamente com a previdência social voltando para uma trajetória explosiva. Como sugestão de política, apesar da PEC nº 287/2016 não ter sido sequer votada, a recomendação é que ela represente um patamar mínimo para a reforma da previdência.

Palavras-chave: Mudança Demográfica; Reforma da Previdência; Modelos de Gerações Sobrepostas.

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INTRODUCTION

The main economic challenge for Brazil today is undoubtedly Social Security. The General Social Security System (RGPS)[4] presented a deficit of R $ 182 billion and R $ 195 billion, 2017 and 2018, respectively. Likewise, the Social Welfare Regime (RPPS)[5] of union and military servants also presented a deficit of R $ 86 billion (2017) and R $ 95 billion (2018), which increases the fiscal difficulties of the country. In total, the Brazilian social security deficit reached R $ 268 billion in 2017 and R $ 290 billion in 2018.

The Brazilian demographic change occurs rapidly, which can lead to an unsustainable social security situation in the long term. Data from the Social Security Forum (2016) indicate that the Brazilian birth rate will decrease to 1.3 children per woman in 2034. In parallel, life expectancy is expected to rise to 80.1 years in 2042. Thus, a Brazilian reaching 60 years will have a 25.2 year survival expectation in 2060. On the other hand, the IBGE (2014) projects a reduction of the economically active population from 140.9 million in 2015 to 131.4 million in 2060, with an increase in number of elderly over 65 years from 16.1 million to 58.4 million in the same period.

The result of this process is the widening of the social security deficit if no change occurs. The Ministério da Fazenda (2017) estimates a sharp increase in the social security deficit, which is expected to jump from the current 4% of GDP to above 11.1% of GDP by 2060. A deficit would make most of the government's most fundamental tasks such as education, health and security.

Against this background, the federal government presented the Constitutional Amendment Proposal (PEC) nº 287/2016 that establishes a minimum age with transition rules and covers both the RGPS and the RPPS of the federal servers. The minimum retirement age will be 65 for men and 62 for women with a transition rule of 20 years. According to a study by the Ministry of Finance (2017) such measures would be sufficient to contain the social security deficit until at least 2060.

The national economic literature has alerted to the Brazilian social security issue. Barreto (1997) already argued that the Brazilian social security system was insolvent and suggested a change from the distribution system to the capitalization regime. The author builds a model of overlapping generations - OLG to evaluate the effects on the economy of change in the social security regime. The impacts are positive, but there is a heavy fiscal cost that must be borne during the transition from the allocation system to the capitalization system.

The change in the social security regime of capitalization distribution was very present in the Brazilian literature. Ferreira (2004) uses a OLG model to calculate the short-term and long-term effects of various pension reforms, with changes in the choice of a distribution system, capitalization or intermediate situations. The author concludes that partial reforms that reduce the replacement rate or shift the tax base from work to consumption produce positive long-term effects, but a high fiscal cost remains in the transition.

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

Concern about the drop-in fertility and the increase in life expectancy already appeared in the text by Oliveira, Beltrão and Ferreira (1997). The authors highlighted the legislative difficulties to approve a social security reform that was necessary at the time.

The first major change in social security since the approval of the Federal Constitution in 1988 was the approval of Constitutional Amendment 20/1998. The new legislation established the minimum contribution time of 35 years for men and 30 years for women and determined minimum retirement age in

[4] It is the social security system that applies to private sector employees, employers, salaried employees, domestic workers, self-employed persons, individual taxpayers, rural workers, occupiers of positions of trust in public administration and public servants of municipalities that do not have their own social security system.

[5] It is the regime applied to public servants of the Union, the States and the Federal District and also to 2,052 Brazilian municipalities.

the federal public service of 60 years for men and 55 years for women. Constitutional Amendment No. 20/1998 created the social security factor, together with the infraconstitutional legislation (Law 9.876 / 99), which made it possible to reduce the benefits amounts in the RGPS.

According to Giambiagi and Estermínio (2006) and Marques, Batich and Mendes (2003), EC 20/98 was only able to reduce the short-term deficit, but it did not represent a definitive solution for the Brazilian pension system.

The second social security reform was Constitutional Amendment No. 41 of 2003. EC 41/03 created the social security contribution of the inactive of the RPPS. Federal retirees with income above the RGPS benefit ceiling started to pay the same social security contribution as the assets. New limitations were also established within the RPPS, such as reducing the value of the benefit for employees retiring before the age of 60 (male) and 55 (female).

For Souza et al. (2006), the impact of EC 41/2003 was very limited, focusing only on RPPS whose implied debt fell by 20% and almost nil on the RGPS. Many authors begin to question the solvency of the Brazilian pension system. For Rocha and Caetano (2008) the regime presents very high expenditures in comparison with other countries, with a high number of beneficiaries, so that Brazilian social security expenditures already seemed excessive in 2006. Matos, Melo and Simonassi (2013) also question the solvency of RGPS in Brazil, but argue that reforms with the establishment of a minimum age would be able to reverse the trajectory of the social security deficit.

As a way of balancing the social security regime, Giambiagi et al. (2007) proposed the establishment of a minimum age of 60 years (male) and 55 years (female) with contribution time of 35 years (male) and 31 years (female) for those already in the labor market. For new entrants, establishment of minimum age of 65 for men and 64 for women, with contribution time of 40 years. The authors calculate that with these measures the implicit debt of the Brazilian social security system could fall between 40% and 60%.

Caetano et al. (2016) analyze the social security changes in Dilma Roussef's government, especially the end of the social security factor. The authors conclude that the social security factor was able to generate savings of 2.2% of GDP per year, while the new rules will increase RGPS spending by 0.4% per year. It recommends the adoption of a reform with the establishment of a minimum age of 65 for men and 60 for women.

This paper contributes in the literature by simulating the economic impacts of the Proposal for Constitutional Amendment (PEC) nº 287/2016. In order to do so, an overlapping generations (OLG) model with 57 generations will be constructed and will include the transition rule. The methodology used, although very common in the international literature[6], is little used in Brazil.

The results suggest that PEC No. 287/2016 has relevant effects on the economy. Comparing the situation without reform with the reform proposed by PEC 287/2016, it can be observed that the macroeconomic variables perform better with the reform, with the product, consumption and employment reaching higher levels throughout the trajectory. However, the total social security deficit, which includes RGPS and RPPS, jumps from around 4.59% of GDP to 13.10% of GDP with reform and 21.65% of GDP without reform. The conclusion is that, from the perspective of the model, the reform of PEC 287/2016 may help, but it is far from solving the social security deficit.

Besides this introduction, the work counts on 5 more sections. Section 2 outlines the methodology, section 3 presents the data and the calibration, section 4 details the Proposals of Constitutional Amendment No. 287/2016 and section 5 discusses the results. Section 6 presents the final comments.

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.

[6] Auerbach and Kotlikoff (1987), Lisenkova et. al. (2012), Conesa and Krüger (1999), Choi and Shin (2015), İmrohoroglu et.al. (1995), Heer and Irmen (2014) and Fredriksen et. al. (2019).

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 at 58[7] ($j = 35$) and die at age 80 (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. For preferences, we use the constant elasticity of substitution function (CES). We can represent the intertemporal utility function as follows:

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

Where:

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

Where 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:

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

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[8]:

[7] Average age of retirement in Brazil according to data from the Social Security Forum (2016).

[8] 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.

$$b_t = 0{,}8 \sum_{j=1}^{45} \left(\frac{W_{t-j} e_j (1 - l_{j,t-j})}{45} \right) \quad (4)$$

Finally, solving for j = 1, ..., 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

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

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

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

where,

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

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, ..., 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:

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

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:

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

Where 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:

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

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

Where δ represents the rate of capital depreciation.

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.

$$G_t = T_t - S_t^B - Tr_t \quad (13)$$

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:

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

At where S_t^A is the collection of social security 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:

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

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

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

2.5 Marketplace balance

The balance in the labor market requires:

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

The balance in the capital market is given by:

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

The equality between supply and aggregate demand is represented by equation 19:

$$Y_t = C_t + I_t + G_t \quad (19)$$

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

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 Federal Revenue Secretariat of 2017. For simplicity, the product of the economy for 2015 was set at 1.

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.

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

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

$$\delta = \frac{I/Y}{\bar{K}} \quad (23)$$

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

Descrição	Parâmetros	Valor	Fonte
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

Source: Elaboration of the authors. Note: 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, $A = {}^{Y}/_{K^{\theta} \cdot L^{1-\theta}}$, where 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 10.17% based on the broad consumer price index (IPCA), so that the real interest rate was 3.98% 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:

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

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 (RFB, 2017) and social security expenditure was obtained through the Statistical Yearbook of Social Security (PREVIDÊNCIA SOCIAL, 2015).

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

Table 2 - Economic Aggregates (2015).

	Brazil 2015 in% 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	3,97	3,97
Wages rate	62,23	62,23
Government revenue	31,23	31,23
Social Security revenue	7,15	7,15
Expenses on Social Security	10,92	10,92

Source: National Accounts (2015), Ipeadata (2017), Previdência Social(2015) and Elaboration of the authors.

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 (2017). 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%

Source: Elaboration of the authors

4. A PROPOSED CONSTITUTIONAL AMENDMENT Nº 287/2016

The Constitutional Amendment Proposal (PEC) nº 287/2016 presented in its initial version 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 20 years of transition rule. A minimum age of 25 years old of contribution to the right to retirement was suggested. The calculation of the benefit was modified, so that it would only receive the full amount of the pension, who would contribute for 40 years for Social Security. For rural workers it was proposed to establish a minimum period of 15 years of contribution. Another proposal was to increase the age for granting the benefits to the elderly from 65 to 68 years old. Finally, the government proposed the untying of the social security floor of the minimum wage.

In its present state, January 2018, and in the face of difficulties in approving the original version of the reform, PEC 287/2016 was considerably reduced. The proposal was limited to setting a minimum age for urban workers only, with a transition rule, 15 years of contribution for the RGPS and 25 years for the RPPS, and re-calculation of the retirement value, based on the percentage of 60% for those who contributed for 15 years up to 100% for those with 40 years of contribution.

The table below details the main points of the proposal.

Table 4 - Main Proposals of PEC 287/2016

Proposals	**General Social Security System (RGPS)**	**Regime of Social Security (RPPS) - Federal**
Minimum age – Urban	Men - 65 years Women - 62 years Contribution time - 25 years	
Amount of Benefit	60% of the average of all contributions (minimum of 15 years of contribution); plus 1% for each year that exceeds 15 years of contribution time; 1.5% for each year beyond 25 years; 2% for each year beyond 30 years; and 2.5% for each year beyond 35 years 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 53 years (woman) and 55 years (man) from 1 year every two years from 01/01/2020. 30% toll on what will fail to fulfill 30 years (woman) and 35 years (man)	
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.
Accommodation	Family quota of 50% plus 10% per dependent	

Source: Elaboration of the authors.

For the purposes of the simulations of PEC 287/2016, 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 PEC 287/2016 attenuates the demographic "burden" by gradually raising the minimum retirement age, stabilizing the working age population and, as a consequence, 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

Fonte: Elaboration of the authors based on IBGE (2014).

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 - Without Reform.

	Initial Stationary State	Change (%) * Without pension reform	Change (%) * With PEC 287/2016
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

Source: Elaboration of the authors. * 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 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 PEC 287/2016. 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. In addition, as retirement time is shorter with retirement, the number of retirees is lower, so that unemployment is also reduced compared to the unreformed scenario.

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 PEC 287/2016, raising the minimum age more than compensates for the demographic transition so that labor supply grows.

The aggregate product increases with PEC 287/2016, avoiding an even greater economic recession. 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 PEC 287/2016.

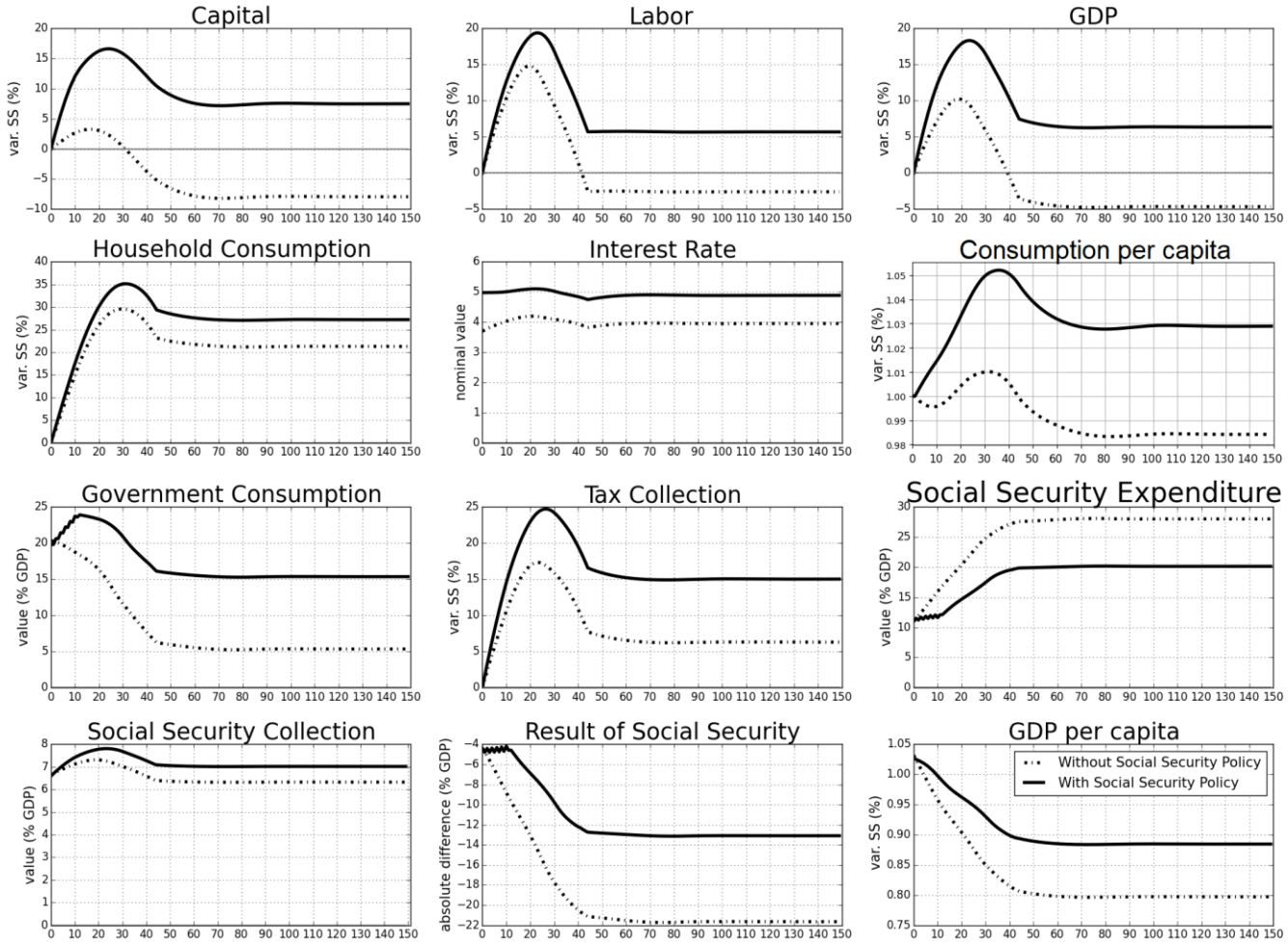
5.2 Transition path and medium-term results

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. PEC 287/2016, 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.

Figure 1 - Transition trajectory for selected variables (var.% Steady state Initial and% GDP).



Source: Elaboration of the authors.

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 PEC 287/2016.

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 PEC 287/2016. 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.

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. PEC No. 287/2016 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 9 and 10 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 γ = 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 9 – 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

Source: Authors' elaboration

The base scenario, given by the calibration, appears in bold 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 α = 1. This implies the complete collapse of government, so that the results no longer have economic sense.

Table 10 - 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	1,0	28,20	-39,61	-19,75	-39,63	-43,60	93,77	-19,75
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

Source: Authors' elaboration

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.

6. FINAL COMMENTS

With a model of overlapping generations, this study analyzed the impact of population aging on social security and the Brazilian economy. There is a strong increase in the social security deficit, which is expected to jump from the current 4% of GDP to above 11.1% of GDP in 2060. A second scenario in which the Proposed Constitutional Amendment No. 287/2016 would be approved. This proposal basically establishes a minimum age for retirement in Brazil.

The results suggest that not doing retirement is a very bad choice for society. The fiscal situation becomes unsustainable, and the expansion of social security expenditures in combination with the reduction of labor supply end up leading the country to a scenario of a sharp fall in per capita consumption and consumption.

On the other hand, the simulations indicate that PEC 287/2016 is not the definitive solution to the Brazilian social security issue, but that it allows a window of about 10 to 15 years in which the social security deficit stabilizes. After this period, the situation worsens once again with social security returning to an explosive trajectory.

As a policy suggestion, although PEC No. 287/2016 has not even been voted on, the recommendation is that it represent a minimum level of pension reform, and it is desirable that a more restrictive reform, which will raise the retirement age even further, is proposed to have a longer lasting effect on the economy.

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