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Reformof the Brazilian RGPS Pensions System

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Abstract

In the last thirty years, the Old-Age Dependency Ratio increased nearly seven points in Brazil, from 7.0 in 1990 to 13.8 in 2020. Projections estimate it will rise to 36.2 in 2050.

Furthermore, the condition of the Brazilian public finance is very serious: in 2019 and for the sixth consecutive year, it was in a deficit. The imbalance was mainly caused by social security, in particular by the RGPS (*Regime Geral de Previdência Social*) pensions system. A reform was approved and started to be implemented this same year, but doubts persist about it being deep enough to guarantee the looked-for equilibrium.

Given this situation, the purpose of our work is to provide new insights on the very long run survival of the Brazilian public pensions, under alternative change scenarios, for instance, the shift to a Defined Contribution system. Transition costs and the costs related to the existing minimum guaranteed pension, are accounted for.

Findings prove that the reform started in 2019 will decrease the large deficit for the next ten years, but after this an increase will be observed, although smaller than the one in a pre-2019 reform setting. Therefore, the sustainability of the system will remain a critical issue and further and more effective actions will have to be put into practice as soon as possible.

Keywords: Brazil; Pensions Reform; Defined Benefit; Defined Contribution; Notional Defined Contribution.

1. Introducing the problem

(OECD, 2018) reminds that pensions are intended to offer adequate financial security to people who can no longer make a living. They could be financed by the State from general revenues, or through payroll taxes, on a Pay-As-You-Go (PAYG) system, or they could be fully funded through individual contributions and accumulated assets. As population ageing is speeding up in most OECD countries (OECD, 2019), growing difficulties to preserve pensions emerge. In 1980, there were two people older than 65 years for every ten people of working age in the OECD space; by the end of 2020 this number

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is close to three and expected to be almost six by 2060. The working age population is expected to have reduced by more than one-third in 2060, in several countries.

There is a consensus (Acosta-Ormaechea, Espinosa-Vega, & Wachs, 2017) about the demographic evolution having a very negative impact on the PAYG systems, as expenditure grows and revenue declines. It is necessary to prevent expenses from being too burdensome for future generations. For instance, Spain (Díaz-Giménez & Díaz-Saavedra, 2016) and Greece (Symeonidis, 2017), which presented severe fiscal imbalances, made radical reforms in their pension systems.

The existing public pension system in Brazil is a Defined Benefit (DB) PAYG system. This is the type of pension arrangement currently prevailing in Latin America. Despite being the most widespread in the region, it is also the most exposed to potential demographic disequilibrium, which has led to sustainability concerns (Holzmann, Palmer, & Robalino, 2013). In Brazil, one of the main issues is the fact that last decades have been characterized by declining fertility and increasing longevity, which led to a quick ageing of the total population, expressed in an increase of almost seven points in the Old-Age Dependency Ratio, from 7.0 in 1990 to 13.8 in 2020, cf. (OECD, 2019). Recent projections from the same source show a steep increase in the Old-Age Dependency Ratio to 36.2 in 2050. This means that there will be approximately 36 individuals aged 65 and over per 100 individuals of working age.

Also (United Nations, 2019 a) provide evidence that both longevity and the number of people over 65 are on a firm growth: 13.3 million in 2010, 20.4 million in 2020 and 30.4 million in 2030 (projection). The corresponding evolution of life expectancy at birth is 74.3 years, 76.6 years and 78.5 years (projection). Additionally, life expectancy at retirement age (62 for women and 65 for men) is 22.7 years for women and 17.1 years for men, based on the most recent life table in Brazil (Instituto Brasileiro de Geografia e Estatística, 2018).

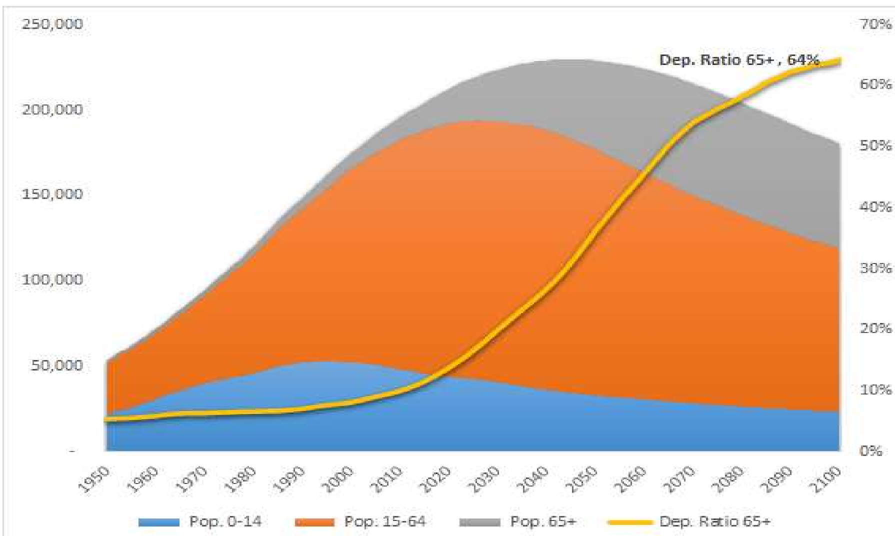
Along with mortality, fertility is an element of population growth, reflecting both the causes and effects of economic and social developments. In 2020 the fertility rate in Brazil is only 1.7. Following (OECD, 2019), the causes for the steady deterioration in birth rates during the past decades include postponed family formation and child-bearing and a decrease in desired family sizes, see ***Table 1*** and ***Figure 1***.

Table 1: Brazil demographic indicators 1990-2050

	1990	2000	2010	2020	2030	2040	2050
Population ($\mathbf{10^6}$)	149.0	174.8	195.7	212.6	223.9	229.1	229.0
Fertility rate	2.7	2.1	1.8	1.7	1.6	1.6	1.6
Young age pop. (≤ 15yo $\mathbf{10^6}$)	52.4	52.3	48.6	44.0	40.9	36.4	33.1
Young age pop. (≤ 15yo %)	35.2	29.9	24.8	20.7	18.3	15.9	14.5
Working age pop. (15 to 64yo $\mathbf{10^6}$)	90.3	113.3	133.8	148.2	152.6	152.1	143.8
Working age pop. (15 to 64yo %)	60.6	64.8	68.4	69.7	68.2	66.4	62.8
Old age pop. (≥ 65yo $\mathbf{10^6}$)	6.4	9.2	13.3	20.4	30.4	40.6	52.0
Old age pop. (≥ 65yo %)	4.3	5.2	6.8	9.6	13.6	17.7	22.7
Dep. Ratio (old / working age %)	7.0	8.1	10.0	13.8	19.9	26.7	36.2
Dep. Ratio (old / young age %)	12.1	17.5	27.5	46.3	74.4	111.6	157.0
Life expectancy at birth (total)	67.3	71.0	74.3	76.6	78.5	80.3	82.1
Life expectancy at 60 (total)	18.0	19.8	21.4	22.7	23.7	24.7	25.8

Source: Authors, based on UN (United Nations, 2019 a) data.

Figure 1: Evolution of the Brazilian population



Source: Authors, based on UN (United Nations, 2019 a) data.

To make the situation more difficult, is the fact that this demographic condition is only one side of the problem. The other side is that in 2019 the Brazilian public finance was in a deficit for the sixth consecutive year (Tribunal de Contas da União, 2019). The imbalance was mainly caused by expenses with pensions, which increased considerably in recent years. (The World Bank, 2017) estimated that, with no reform, the deficit of RGPS (Regime Geral de Previdência Social), which covers the private sector workforce, would reach 16% of the GDP, by 2066. If this is to be prevented, without changing the pension benefits, the contribution rate would have to double by 2035, to around 60% of gross wages. By 2065, when there will be two pensioners per contributor, the same source estimates the contribution rate would have to double again.

We must remark that the RGPS is not the only regime in Brazil. In fact, there are very complex pension systems in the country, comprising more than 2000 different rules (Secretaria de Previdência, 2018), which makes the Brazilian case maybe one of the most intricate in the world. The system is divided into sections and sub-sections: a general compulsory scheme for private workers, multiple special compulsory schemes for civil servants, at different levels of government, and a voluntary complementary scheme, available to all workers (see ***Table 2*** for a summary; for more details, cf. https://www.gov.br/previdencia/pt-br).

Table 2: Brazilian pension regimes

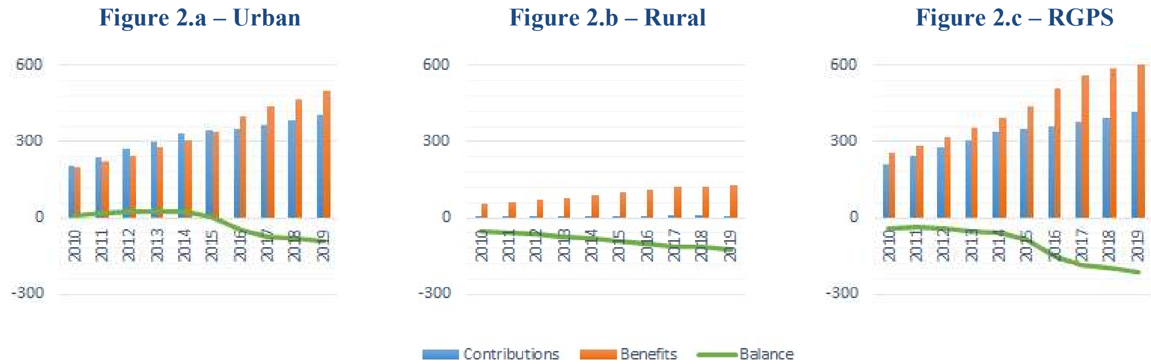
	RGPS	RPPS	State-level schemes	Complementary system
Coverage	Private sector	Civil servants	Civil servants	All workers
Nature	Mandatory	Mandatory	Mandatory	Optional
Scope	National	Federal, state or local	Federal or state	Open or closed
Management	Public	Public	Mixed	Private or independent
Funding	PAYG	PAYG	Pre-funding	Fully funded

Source: Authors, based on Ministry of Finance (https://www.gov.br/previdencia/pt-br).

RGPS is financed through payroll taxes, made by employers and employees. It is composed of the urban and rural subsystems, where the first is contributory and the second is only partially contributory. The '*Regime Próprio de Previdência Social*' (RPPS), for civil servants, exists at different levels of government. Some degree of pre-funding has been introduced at state level, as a few states have reformed their pension schemes. The complementary system is available to all workers as an option, being privately managed and fully funded. This system consists of either occupational or personal plans.

In 2018, the combined deficit in the pension system was 5.9% of the GDP. The share of RGPS was almost half of it (2.9%), see (Secretaria de Previdência, 2019; Secretaria de Previdência, 2018). ***Figure 2*** shows the financial result in the RGPS (urban, rural and total) from 2010 to 2018. The rural area has been in the red since 2003 and the deficit has increased ever since. In 2019, it contributed to 57% of the RGPS deficit, even though having a much smaller number of beneficiaries. Moreover, ***Figure 2.b*** shows that the rural regime has never been in equilibrium, mainly because it seems to be more like a welfare program than a pension system - there is no minimum requirement of contributions for a rural worker to retire.

Figure 2: Contributions and Benefits (109 R$) (a) Urban, (b) Rural & (c) RGPS

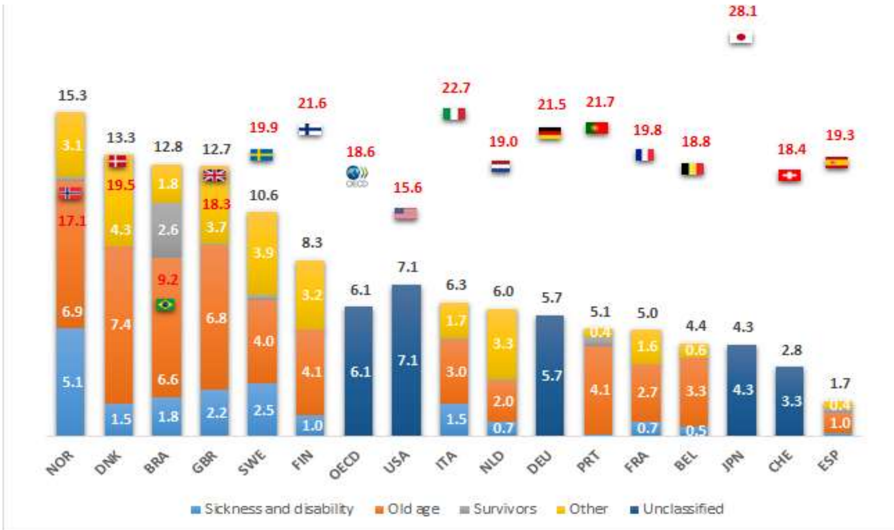


Source: Authors, based on Ministry of Finance (Secretaria de Previdência, 2019)

Following the Chilean experience, cf. (Bonasia & Napolitano, 2006), some Latin American countries decided to adopt a Funded Defined Contribution (FDC) system. Brazil is not one of them, due to the concern about the fiscal imbalance and the high transition cost (Caetano, 2014). Additionally, the actuarial-finance imbalance puts pressure over the system and makes it more difficult to solve existing problems of inequality and poverty. This is aligned with (Wang, Williamson, & Cansoy, 2016) who argue that the full or partial change from PAYG to FDC did not solve low pension coverage issues in developing countries They consider this change turns out to be a "triple burden" for contributors: financing PAYG for existing pensioners, paying the normal contribution and supporting low-income elderly relatives.

Even though the FDC way has not been chosen, expenditure in social protection of the Brazilian central government is 13% of GDP, above the OECD average and close to some Nordic countries, such as Norway and Denmark. ***Figure 3*** relates social protection expenses of the central government in OECD countries, in percentage of GDP, and population over 65, in 2018. We can see that only 9.2% of the Brazilian population was over 65, a low percentage in comparison to other countries, but the expenditure with old age benefits was high.

Figure 3: Social protection (% GDP) vs. 65+ old-age (% pop) in 2018



Source: Authors, based on (Tesouro Nacional, 2020; OECD, 2019).

Putting together the two sides of the problem, the conclusion is that the survival of the pension system is at risk and further reform is inevitable. This has been a recurrent topic of dispute in the Brazilian public sphere and in the academia. At present the debate is heated and there are a few important contributions. The most recent study (Afonso & Carvalho, 2019) was based on the proposal of reform initially presented by the government in 2019. Although the Congress has later altered many parts of the text, the study remains valid in many aspects. Results show that the proposal will reduce inequalities and the RGPS deficit, even if it is not very efficient from a fiscal perspective. Another conclusion is that the reform makes the deficit less unsustainable, but fails to eradicate it, implying that additional measures are necessary.

This study aims to project revenue and expenses for the RGPS until 2100, with the sustainability of the system in view. Eighty years may seem a too long horizon, but not when the topic is the provision of old age pensions. For this purpose, a simple integrated methodology to project public pension cash flows over the long term will be applied. Particular attention is given to the items where spending pressures are expected to increase most due to demographic trends. The ultimate goal is to simulate the effects of alternative additional reforms, including the transition from PAYG to FDC, in spite of the shortcomings, or to a Notional Defined Contribution (NDC) solution. The paper is divided in four sections. ***Section 2*** contains the model. ***Section 3*** covers the different proposed scenarios. ***Section 4*** concludes.

2. Modelling a PAYG DB pensions system – the Baseline Scenario

The International Monetary Fund (Acosta-Ormaechea, Espinosa-Vega, & Wachs, 2017) created a consistent method to analyze pensions inflows and outflows, which will be implemented in this work through Microsoft Excel (Microsoft 365 MSO), using the most recent data available for Brazil. It is important to point out that the focus is on the long-term projections, which explains the variables, assumptions and relationships included in the model, described in the next paragraphs (Goldstein & Gigerenzer, 2009; Miller & Castanheira, 2013). Although sometimes the model is approximate, relying on assumptions and relationships not entirely straightforward, cf. the Appendix for further detail, it gives a good insight to the problem and allows to undertake it with the available data. The starting point is a Baseline scenario, set by the 2019 reform.

2.1. Pensioners and pension payments

There are three groups receiving public pension benefits in the formal sector: retirees, survivors and permanently disabled. There is a fourth group, of non-contributory pensioners. Thus, the average number of pensioners receiving benefits in a certain year t is

$$Bnfp_t = PenPop_t \times lp \times fs + Bnfs_t + Bnfpd_t + Bnfnc_t, \qquad \text{Eq. 1}$$

where $Bnfp_t$ is the total number of pensioners, $PenPop_t$ is the population who have reached the average retirement age, lp is the labor force participation rate, fs is the share of the formal sector, $Bnfs_t$ is the number of survival pensioners, $Bnfpd_t$ is the number of permanently disabled pensioners and $Bnfnc_t$ is the number of non-contributory pensioners.

To compute the aggregate amount of pension payments, is necessary to estimate the average annual pension for the existing pensioners (who have retired before year t). The average pension for current pensioners, $AvPenCbdb_t$, is computed by 5-year cohorts and by indexing the previous year average pension to the inflation rate π_t, i.e., for each cohort,

$$AvPenCbdb_t = AvPenCbdb_{t-1}(1 + \pi_t). \qquad \text{Eq. 2}$$

The need to use 5-year cohorts results from the fact that the existing projections (United Nations, 2019 a) present data in this way. By law, pension benefits cannot be below the minimum wage (Cuevas, Karpowicz, Mulas-Granados, & Soto, 2017), but since the minimum wage also increases with inflation, it is adequate to use it to model $AvPenCbdb_t$.

Next, we calculate the average annual pension for pensioners who retire in year t, be

$$AvPendbnb_t = rrAvWage_t, \qquad \text{Eq. 3}$$

where rr is the replacement rate for new retirees (Bogomolova, Impavido, & Pallares-Miralles, 2007) and $AvWage_t$ is the average wage, calculated as

$$AvWage_t = \begin{cases} \dfrac{GDP_{n_t} \times ws}{Empl_t}, & t < 2021 \\ Av_{wage_{t-1}}(1 + g_{n_t}), & t \geq 2021 \end{cases}. \qquad \text{Eq. 4}$$

For $t < 2021$, GDP_{n_t} is the nominal GDP, ws is the share allocated to employees and $Empl_t$ is total employment, calculated as follows

$$Empl_t = (1 - u)lp \times WorkPop_t, \qquad \text{Eq. 5}$$

where u is the unemployment rate and $WorkPop_t$ is the working-age population, defined to be from 20 to 60 years old (men) and from 20 to 55 (women).

For $t \geq 2021$, the assumption is that the average annual wage grows each year according to the nominal GDP growth rate gn_t,

$$gn_t = (1 + gpc_t)(1 + gpop_t)(1 + \pi_t) - 1, \qquad \text{Eq. 6}$$

where gpc_t is the real per capita GDP growth rate and $gpop_t$ is the population growth rate.

The average pension per pensioner, including all beneficiaries, $AvPendb_t$ is computed as the weighted average of the current and new pensions, and their weights are established by the proportion of pensioners in each cohort as shown below.

$$AvPendb_t = \sum_{t=1}^{\infty} AvPenCbdb_t\, cb_t + AvPenNbdb_t nb_t, \qquad \text{Eq. 7}$$

where cb_t is the proportion of pensioners who have retired in the past and nb_t is the proportion of new pensioners (in the year).

Finally, $TotBenefdb_t$ denotes the total amount of benefits and is given by

$$TotBenefdb_t = AvPendb_t \times Bnfdb_t. \qquad \text{Eq. 8}$$

2.2. Active workers and contributions

$Contrdb_t$ denotes the number of workers who make contributions to the system,

$$Contrdb_t = WorkPop_t \times lp \times fs. \qquad \text{Eq. 9}$$

$AvContrdb_t$ denotes the average annual contribution per person,

$$AvContrdb_t = crdb_t AvWage_t, \qquad \text{Eq. 10}$$

where $crdb_t$ is the total contribution rate and equals the sum of three rates: the employee's, the employer's and the government's, denoted $crdb_{ee}, crdb_{er}$ and $crdb_g$, respectively. Then,

$$crdb_t = crdb_{ee} + crdb_{er} + crdb_g. \quad \text{Eq. 11}$$

Therefore, total contributions, denoted $TotContrdb_t$, are

$$TotContrdb_t = AvContrdb_t \times Contrdb_t. \quad \text{Eq. 12}$$

2.3. Net cash flows

Using ***Eq. 12*** and ***Eq. 8***, the net cash flow is

$$Ncfdb_t = TotContrdb_t - TotBenefdb_t. \quad \text{Eq. 13}$$

Next, we have the projections of contributions and benefits under the current rules, our Baseline scenario. In the following, results from all the other scenarios are compared with the results in this scenario. Using ***Eq. 1*** to ***Eq. 13***, results obtained are displayed in ***Table 3***. Remark that the evolution in the revenue is mainly due to the changing aspects of the working-age population shown in ***Figure 1***.

Table 3: Baseline Scenario - Contributions and Benefits (% GDP)

	2020	2030	2040	2050	2060	2070	2080	2090	2100
Contrib.	8.4	9.5	9.5	9.0	8.3	7.6	7.0	6.4	6.0
Male	4.4	4.9	4.9	4.7	4.4	4.0	3.7	3.4	3.2
Female	4.0	4.6	4.6	4.3	4.0	3.6	3.3	3.0	2.8
Benef.	14.7	13.5	16.5	20.9	24.2	26.2	26.4	26.0	24.9
Male	6.3	5.9	7.7	10.0	11.9	13.1	13.3	13.3	12.8
Female	8.4	7.6	8.8	10.9	12.4	13.0	13.1	12.8	12.1
Balance	**-6.3**	**-4.0**	**-7.0**	**-11.9**	**-15.9**	**-18.5**	**-19.3**	**-19.6**	**-18.9**
Male	-1.9	-1.0	-2.7	-5.3	-7.5	-9.1	-9.6	-9.8	-9.6
Female	-4.4	-3.0	-4.2	-6.6	-8.4	-9.4	-9.8	-9.7	-9.3

Source: Authors.

Table 3 shows that in the 2020-2100 period, after a slight recovery in the next ten years (due to the impact of the transition rule), the disequilibrium of the system is going to expand until 2100, when it starts to recover again. This is explained by the demographic pressure. Furthermore, regarding females, it performs worse than regarding males because of the difference in the retirement age and the fact that women live longer.

3. Reform scenarios

In this section we propose a few scenarios that may shed a light on possible ways to reform the system, in order to achieve its future sustainability and actuarial-financial equilibrium. We start by showing that the 2019 reform will be effective only to a certain extent, the reason why additional measures are required as soon as possible.

3.1. Scenario 1 *vs*. Baseline Scenario: assessing the 2019 reform

There are six transition rules associated with the enactment of this reform (Brazil Const. amend. 103, 2019), but its material impact comes from the establishment of a new minimum normal retirement age. In short, it imposes a yearly constant increase of six months in the retirement age, until it is equal to 65 for men and 62 for women (for further details cf. http://www.brasil.gov.br/novaprevidencia/#novas-regras).

We first assume a very unlikely 'scenario' (***Scn1***) modelling the pension system as it was before the reform, that is, retirement age is still 60 for men and 55 for women. ***Eq. 1*** will be replaced with ***Eq. 14*** and $WorkPop_t$ in ***Eq. 9*** will be replaced with the expression in ***Eq. 15***, as follows.

$$PenPopdb_t^{Scn1} = PenPopdb_t + RefAge_t \frac{varScn1_t}{5}, \qquad \text{Eq. 14}$$

$$WorkPopdb_t^{Scn1} = WorkPop_t - RefAge_t \frac{varScn1_t}{5}. \qquad \text{Eq. 15}$$

where $PenPopdb_t^{Sc}$ denotes the pension-age population in ***Scn1***, $WorkPopdb_t^{Scn1}$ denotes the working-age population in ***Scn1***, $RefAge_t$ is the cohort of the population that is affected by the reform; $varscn_1$ is

$$varScn_1 = ra_t - ra^{Scn1}, \qquad \text{Eq. 16}$$

where ra_t is the retirement age and ra^{Scn1} is the retirement age before reform.

Table 3 (cf. ***Eq. 1*** to ***Eq. 16***) shows a steady deterioration in the balance in a pre-reform scenario, reaching its peak in 2080 as 24.3% of GDP.

Table 3: Scn1 - Contributions and Benefits (% GDP)

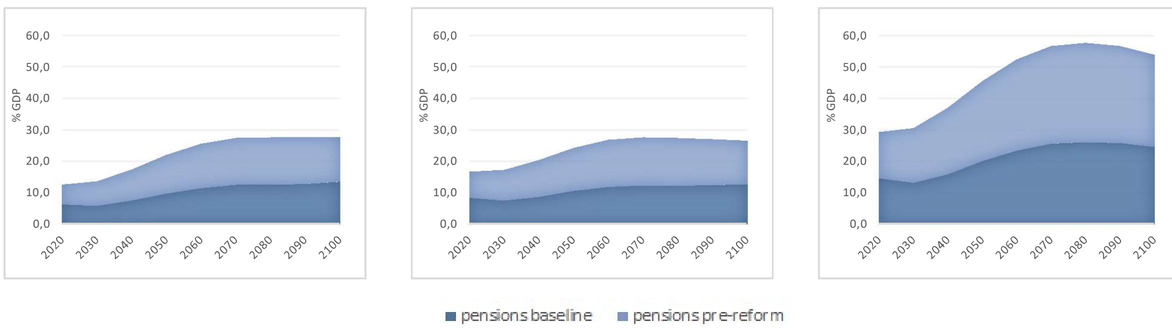
	2020	2030	2040	2050	2060	2070	2080	2090	2100
Contrib.	8.4	8.6	8.4	7.8	7.2	6.6	6.0	5.5	5.2
Male	4.4	4.5	4.5	4.2	3.9	3.6	3.3	3.0	2.8
Female	4.0	4.1	3.9	3.6	3.3	3.0	2.7	2.5	2.3
Benef.	14.7	17.6	21.7	26.0	29.1	30.3	30.4	29.5	28.0
Male	6.3	7.8	9.9	12.3	14.2	15.0	15.1	14.8	14.2
Female	8.4	9.8	11.8	13.7	15.0	15.3	15.2	14.7	13.8
Balance	**-6.3**	**-9.0**	**-13.3**	**-18.2**	**-22.0**	**-23.7**	**-24.3**	**-23.9**	**-22.9**
Male	-1.9	-3.3	-5.4	-8.1	-10.3	-11.4	-11.8	-11.8	-11.4
Female	-4.4	-5.7	-7.9	-10.1	-11.7	-12.3	-12.5	-12.1	-11.5

Source: Authors.

Figure 4 shows a comparison between the ***Scn1*** benefits and the benefits under the Baseline scenario, throughout the projection. It is clear that expenditure with benefits would be significantly higher if there was no reform (Brazil Const. amend. 103, 2019). Even if it does not eliminate the deficit, the reform has a clear positive impact on the fiscal burden.

Figure 4: Impact on benefits (a) Male, (b) Female and (c) Total

Figure 4.a – Male **Figure 4.b - Female** **Figure 4.c – Total**



Source: Authors.

3.2. Scenario 2: linking retirement age to longevity and equalizing retirement ages

The following scenario (***Scn2***) goes in the same direction as the 2019 reform and aims to proceed with the increase of the retirement age, by linking it to the increments in longevity of the whole Brazilian population, according to projections. The measure would be applicable only when the transition rules end up, in 2028 (men) and 2032 (women). The increase in the retirement age will be the same as the increment in life expectancy.

In order to suppress the inequality resulting from different retirement ages for men and women, another change is proposed. Starting in 2032, an additional increase of three months per year will be added to women's retirement age, so that from 2038 on retirement age will be the same for men and women. ***Eq. 1*** will be replaced with ***Eq. 17*** and $WorkPop_t$ in ***Eq. 9*** will be replaced with the expression in ***Eq. 18***.

$$PenPopdb_t^{Scn2} = PenPopdb_t - RefAge_t \frac{varScn2_t}{5} \qquad \textit{Eq. 17}$$

$$WorkPopdb_t^{Scn2} = WorkPopdb_t + RefAge_t \frac{varScn2_t}{5}, \qquad \textit{Eq. 18}$$

where

$$varScn2_t = ap_t - ap_{2028(2032)}, \qquad \textit{Eq. 19}$$

$RefAge_t = 65(62/62.25/62.5/\ldots/65)$, and ap_t is the life expectancy of the whole population in year t.

Increasing the entitlement age is possibly one of the most widespread solutions in the reform of PAYG systems. As people tend to understand the reasoning behind this measure, it is not bad also from a policymaker`s perspective. This scenario affects both sides, increasing the contributions (received longer) and decreasing the benefits (paid for shorter periods) as it affects the numbers of contributors and beneficiaries.

Table 4: Scn2 - Contributions and Benefits (% GDP)

	2020	2030	2040	2050	2060	2070	2080	2090	2100
Contrib.	8.4	9.5	10.0	10.2	9.9	9.5	8.9	8.3	7.7
Male	4.4	4.9	5.0	5.1	5.0	4.8	4.5	4.2	3.9
Female	4.0	4.6	5.0	5.1	4.9	4.7	4.4	4.1	3.8
Benef.	14.7	13.5	14.1	15.0	16.0	16.5	16.4	15.9	15.4
Male	6.3	5.9	7.1	7.6	8.2	8.5	8.5	8.2	8.0
Female	8.4	7.6	7.0	7.4	7.8	8.0	8.0	7.7	7.4
Balance	**-6.3**	**-4.0**	**-4.1**	**-4.8**	**-6.1**	**-7.0**	**-7.5**	**-7.5**	**-7.7**
Male	-1.9	-1.0	-2.1	-2.5	-3.2	-3.7	-3.9	-4.0	-4.1
Female	-4.4	-3.0	-1.9	-2.3	-2.9	-3.3	-3.6	-3.6	-3.6

Source: Authors.

Table 4 (cf. ***Eq. 1*** to ***Eq. 13*** and ***Eq. 17*** to ***Eq. 19***) shows a great positive impact on the balance. Indexing the retirement age to longevity after the transition rules end up is a possible path to the sustainability of the pension system. Additionally, in 2040 the deficit in balance is projected to be (- 4.1%) lower in comparison with the one in the Baseline setting (-7.0%).

Table 5 displays the average age of the population and the new retirement age by linking it to the average age of the population. $Avg.Age$ denotes the average age of the population and $Ret.Age$ denotes the new retirement age in this scenario. Furthermore, for the whole population it was calculated as the weighted average of males and females.

Table 5: Scn2 - average age and new retirement age

	2020	2030	2040	2050	2060	2070	2080	2090	2100
Avg. Age.	35.0	38.4	41.6	44.4	46.5	48.2	49.1	49.6	49.8
Male	34.0	37.2	40.3	43.0	45.2	46.8	47.9	48.5	48.8
Female	35.9	39.4	42.7	45.5	47.7	49.4	50.4	50.9	51.2
Ret. Age.	58.5	62.9	66.1	68.9	71.2	72.8	73.8	74.3	74.6
Male	61.0	65.0	66.1	68.9	71.2	72.8	73.8	74.3	74.6
Female	56.0	61.0	66.1	68.9	71.2	72.8	73.8	74.3	74.6

Source: Authors.

Although results show a significant improvement, this measure will not fully eliminate the deficit. Further, according to (Koutronas & Yew, 2017), in many cases such reforms have proved to be not so effective to pension systems after all, with an insufficient linkage among contributions and benefits. For these reasons, four new scenarios will be defined next. They result from a more extreme approach: to gradually replace the public PAYG with private FDC schemes (***Scn3*** and ***Scn4***) or with a public NDC system (***Scn5*** and ***Scn6***), considering all the costs involved, including the burden of a minimum guaranteed pension (MGP).

3.3. Scenarios 3 and 4: transition from PAYG DB to private FDC pension schemes

We will assume now that a transition from the PAYG Brazilian system to private FDC pension schemes will take place, starting in 2030. Under the DC scheme, people entering the labor market from 2030 on will receive their pension benefits as an annuity, the amount of payments depending on the accumulated balance in their respective accounts. Contributions will be calculated in the same way as in the 'old' DB system.

Two scenarios will be considered: (i) ***Scn3***/partial shift option - 50% of the cohorts will contribute to the new system and the other 50% to the old system; ***Scn4***/full shift option - all new cohorts entering the labor market will contribute to the new system. Under ***Scn3***, new participants can choose the scheme where contributions go to. For instance, it was observed in Peru (1993), Argentina (1994), Colombia (1994) and Uruguay (1995) (Bonasia & Napolitano, 2006). Chile (1981) was the first country to implement ***Scn4***. Other examples are Mexico (1997), Bolivia (1997) and El Salvador (1998) (Bonasia & Napolitano, 2006). We start with the technical aspects specific to this approach.

3.3.1. Individual account balance under a FDC Scheme

In order to calculate the balance of the individual accounts, the working-age population was divided into quintiles according to income level for the MGP calculations basis and to estimate government responsibility, and into age cohorts of five years each. $AvContrdc_{t_q}$ denotes the contribution per capita of quintile q of cohort c in year t and is given by

$$AvContrdc_{t_q} = is_q \times Av_{wage_t} \times crdc, \qquad \text{Eq. 20}$$

where is_q is the income share of quintile q and $crdc$ is the contribution rate defined as the same contribution rate for the DB system. ***Eq. 21*** gives the amount in the account in year t for a worker in quintile q of cohort c ($AccBalfdc_q$),

$$AccBalfdc_{t_q} = AccBalfdc_{t-1_q}(1 + ifdc_t) + AvContrdc_{t_q}\frac{cy}{12}, \qquad \text{Eq. 21}$$

where $ifdc_t$ is the real rate of return (the nominal interest rate corrected from the effects of inflation), and cy is the average number of contributions to the individual account per year, to include unemployment periods and other events that result in temporary pauses in contributions. The account balance raises up each year until it reaches its maximum level the year before retirement.

At the time of retirement, a whole life annuity is purchased using the balance in the account. Each annual payment on retirement is of amount and it will consider the inflation along the years

$$RetAnnfdc_{t_{c_q}} = \frac{AccBalfdc_{t_{c_q}}}{a_{NRA}^{*(13)}}, \qquad \textit{Eq. 22}$$

where $a_{NRA}^{*(13)}$ denotes the expected present value of a whole life annuity that makes 13 payments per year in arrear (see Brazilian law 4,281/1963). Basis: the most recent mortality table for Brazil from the U (United Nations, 2019 a) N which accounts for updates until 2100 and the current structure of interest rates for a specific time calculation.

3.3.2. Social security expenditure under a FDC Scheme

Contributions made to the accounts of low-salary participants may not be enough to purchase a pension (at least) equal to the MGP. The government is responsible for paying the amount necessary to cover the difference. In order to evaluate this liability, the MGP is compared to the average annual pension of quintile q of cohort c in year t, to see whether it is necessary to cover a difference or not. $GovExpfdc_t$ denotes the total government expenditure in year t and is given by ***Eq. 23***.

$$GovExpfdc_t = \sum_{q=1}^{5} (MGP_t - RetAnnfdc_{t_q}) I_{t_q} \times Bnfpdc_{t_q}, \qquad \textit{Eq. 23}$$

where $I_{t_q} = 1$, if $RetAnnfdc_{t_q} < \mathrm{MGP_t}$, and $I_{t_q} = 0$ otherwise; $Bnfpdc_{t_q}$ is the number of beneficiaries of quintile q and cohort c in year t. Thus, total benefits, $TotBeneffdc_t$, and total contributions, $TotContrfdc_t$, are given by:

$$TotBeneffdc_t = GovExpfdc_t, \qquad \textit{Eq. 24}$$

$$TotContrfdc_t = 0. \qquad \textit{Eq. 25}$$

Using ***Eq. 24*** and ***Eq. 25***, the net cash flow is

$$Ncfdc_t = TotContrfdc_t - TotBeneffdc_t. \qquad \textit{Eq. 26}$$

While the two systems coexist, the total expenditure is $TotBenefdbfdc_t$ and the total of revenue is $TotContrdbfdc_t$ and may be calculated as

$$TotBenefdbfdc_t = TotBenefdb_t + TotBeneffdc_t, \qquad \text{Eq. 27}$$

$$TotContrdbfdc_t = TotContrdb_t + TotContrfdc_t, \qquad \text{Eq. 28}$$

Using ***Eq. 27*** and ***Eq. 28***, the net cash flow is

$$Ncfdbfdc_t = TotContrdbfdc_t - TotBenefdbfdc_t. \qquad \text{Eq. 29}$$

Numeric results follow for each of ***Scn3*** and ***Scn4***.

3.3.3. Scenario 3: Transition from a PAYG to a private FDC scheme in partial shift

Using ***Eq. 1*** to ***Eq. 6*** and ***Eq. 20*** to ***Eq. 29***, we obtain the projections in ***Table 6***.

Table 6: Scn3 - Contributions and Benefits (% GDP)

	2020	2030	2040	2050	2060	2070	2080	2090	2100
Contrib.	8.4	9.4	8.4	7.0	5.5	4.1	3.5	3.2	3.0
Male	4.4	4.8	4.3	3.7	2.9	2.2	1.9	1.7	1.6
Female	4.0	4.5	4.1	3.3	2.6	1.9	1.7	1.5	1.4
Benef.	14.7	13.5	16.5	20.9	24.2	26.0	22.3	17.5	13.9
Male	6.3	5.9	7.7	10.0	11.9	13.1	11.4	8.9	7.0
Female	8.4	7.6	8.8	10.9	12.4	12.9	10.9	8.6	6.9
Balance	**-6.3**	**-4.1**	**-8.1**	**-13.9**	**-18.8**	**-21.9**	**-18.8**	**-14.3**	**-10.9**
Male	-1.9	-1.1	-3.3	-6.3	-9.0	-10.9	-9.6	-7.2	-5.5
Female	-4.4	-3.1	-4.8	-7.6	-9.8	-11.0	-9.2	-7.1	-5.5

Source: Authors.

Besides the initial balance improvement, ***Scn3*** causes also a substantial increment in private savings, cf. ***Table 7***.

$IATS$ denotes the total stock generated by the individual accounts in the new pension scheme (see ***Eq. 21***), $TCost$ is the transition cost of switching from a DB system to a DC system, calculated as the difference between the contributions before and after implementing the DC system, and MGP is the cost of the minimum guaranteed pension (see ***Eq. 23***).

Table 7: Scn3 – other CFs (% GDP)

	2020	2030	2040	2050	2060	2070	2080	2090	2100
Tcost	0.0	0.0	0.6	1.6	2.5	3.2	3.7	3.4	3.1
Male	0.0	0.0	0.3	0.8	1.3	1.6	1.9	1.8	1.6
Female	0.0	0.0	0.3	0.8	1.2	1.6	1.7	1.6	1.5
IATS	0.0	0.1	3.5	12.4	26.8	46.5	66.4	76.8	82.3
Male	0.0	0.0	1.8	6.3	13.7	23.7	34.4	39.8	42.3
Female	0.0	0.0	1.7	6.1	13.1	22.8	32.0	37.1	40.0
MGP	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1
Male	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Female	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1

Source: Authors.

3.3.4. Scenario 4: Transition from a PAYG to a private FDC scheme in full shift

Table 8 (cf. ***Eq. 1*** to ***Eq. 6*** and ***Eq. 20*** to ***Eq. 29***) shows that with ***Scn4*** there is a negative temporary effect over the sustainability of the system in the short term, followed by a positive impact in the long term. As expected, the transition cost in this scenario (see ***Table 9***, ***Eq. 21*** and ***Eq. 23***) is greater than the one in the partial shift case (see ***Table 7***) and savings generated are greater, due to the full shift.

Table 8: Scn4 - Contributions and Benefits (% GDP)

	2020	2030	2040	2050	2060	2070	2080	2090	2100
Contrib.	8.4	9.2	7.3	4.9	2.6	0.5	0.0	0.0	0.0
Male	4.4	4.8	3.8	2.6	1.5	0.4	0.0	0.0	0.0
Female	4.0	4.5	3.5	2.3	1.2	0.2	0.0	0.0	0.0
Benef.	14.7	13.5	16.5	20.9	24.2	25.9	18.2	9.0	2.9
Male	6.3	5.9	7.7	10.0	11.9	13.1	9.5	4.5	1.3
Female	8.4	7.6	8.8	10.9	12.4	12.8	8.7	4.5	1.6
Balance	**-6.3**	**-4.3**	**-9.2**	**-15.9**	**-21.6**	**-25.4**	**-18.2**	**-9.0**	**-2.9**
Male	-1.9	-1.1	-3.9	-7.4	-10.4	-12.7	-9.5	-4.5	-1.3
Female	-4.4	-3.1	-5.3	-8.6	-11.2	-12.6	-8.7	-4.5	-1.6

Source: Authors.

Table 9: Scn4 - other CFs (% GDP)

	2020	2030	2040	2050	2060	2070	2080	2090	2100
Tcost	0.0	0.0	1.2	3.2	4.9	6.4	7.3	6.7	6.2
Male	0.0	0.0	0.6	1.6	2.5	3.3	3.9	3.6	3.3
Female	0.0	0.0	0.6	1.6	2.4	3.2	3.5	3.2	2.9
IATS	0.0	0.1	7.0	24.8	53.5	93.1	132.9	153.7	164.7
Male	0.0	0.1	3.6	12.7	27.3	47.5	68.9	79.5	84.7
Female	0.0	0.1	3.4	12.2	26.2	45.6	64.0	74.1	80.0
MGP	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.2
Male	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1
Female	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1

Source: Authors.

3.4. Scenarios 5 and 6: Transition from a PAYG to a public NDC pension scheme

We will assume now that a transition from the PAYG Brazilian system to a public NDC pension scheme will take place, starting in 2030. According to (Holzmann, Palmer, & Robalino, 2013), the NDC may be viewed as a middle ground between PAYG and FDC. (Simonovits, 2006) point out that NDC schemes have most of the advantages of the FDC design (for instance, the robust connection among formal market, individual savings and pension benefits) and also present other advantageous features, for instance, they deal with the longevity risk by linking the pension benefits to whole life annuities, and are sometimes a less costly way to move to a DC scheme (Brooks & Weaver, 2005).

Basically, the two main issues when shifting from PAYG DB to NDC are: (i) how to transform rights of workers in the old scheme into rights in the new NDC scheme; (ii) how to quantify the unfinanced legacy from the old scheme, which should be financed by general revenues (Palmer, 2006).

Additionally, a NDC scheme provides no direct contribution to national saving during the build-up phase to maturity. Unlike in the FDC scheme, where the cash in the accounts is invested in market assets and participants earn a market rate of return, in the NDC scheme, by definition, the individual account is a notional DC scheme and participants earn an internal rate of return, determined by economy development (Holzmann & Palmer, 2006). Furthermore, current contributions are used to pay current pensions, as in PAYG scheme, and individual account values represent only a claim on a future pension (Directorate-General for Economic and Financial Affairs, 2007)

Again, two scenarios will be considered: (i) ***Scn5***/partial shift option - 50% of the cohorts will contribute to the new system and the other 50% to the old system; ***Scn6***/full shift option - all new cohorts entering the labor market will contribute to the new system. Partial Shift was observed in Greece (2012) (Actuarial Association of Europe, 2019). Sweden (1991-1998) was the first country to shift from a public PAYG to a public NDC. Other examples of full shift are Italy (1995), Norway (2009), Poland (1997-1998) and Latvia (1996) (Guardiancich, Weaver, Demarco, & Dorfman, 2019). This option for a full shift to a scheme based on notional individual accounts has the advantages of avoiding the transition costs and risk shifting that occur in a switch to a FDC scheme (Holzmann, Palmer, & Robalino, 2013).

3.4.1. Individual notional account balance under a NDC Scheme

This part follows closely ***section 3.3.1***, as the main differences result from the fact that the individual accounts are not funded and the rate of return is based on the average wage growth rate rather than on a market rate of return. Hence, the account value at the end of each year consists of contributions accumulated during the year plus the accumulated value from the previous years, which is indexed by the average rate of growth of earnings per contributor (Directorate-General for Economic and Financial Affairs, 2007). Therefore, $\mathrm{AccBalndc}_{\mathrm{t_q}}$, the balance in the notional account of quintile q and cohort c in year t, is calculated as follows:

$$AccBalndc_{t_q} = AccBalndc_{t-1_q} \times (1 + indc_t) + AvContrdc_{t_q} \frac{cy}{12}, \qquad \textit{Eq. 30}$$

where $indc_t$ is the financial rate based on the average wage growth.

Dividing $AccBalndc_{t_q}$by $a_{NRA}^{*(13)}$, then the annual payment at year t is

$$RetAnnndc_{t_q} = \frac{AccBalndc_{t_q}}{a_{NRA}^{*(13)}}. \quad \text{Eq. 31}$$

3.4.2. Expenditure, revenue and net cash flow under a public NDC scheme

Unlike in the case of private FDC schemes, where the public pension expenditure is the amount to cover the MGP, in the case of a public NDC scheme pension expenditure consists of total pensions. Thus, the government collects all the contributions, and it is in charge of paying the pension benefits.

By the same idea of ***Eq. 23***, $GovExpndc_t$ denotes the total government expenditure in year t.

$$GovExpndc_t = \sum_{q=1}^{5} (MGP_t - RetAnnndc_{t_q}) I_{t_q} \times Bnfpdc_{t_q}, \quad \text{Eq. 32}$$

$TotBenefndc_t$ denotes the total benefits, $TotContrndc_t$ denotes the total contributions and are given by

$$TotBenefndc_t = \sum_{q=1}^{5} RetAnnndc_{t_q} \times Bnfpdc_{t_q} + GovExpndc_t) \quad \text{Eq. 33}$$

$$TotContrndc_t = \sum_{q=1}^{5} AvContrdc_{t_q} \times WorkPopdb_{t_q}. \quad \text{Eq. 34}$$

Using ***Eq. 33*** and ***Eq. 34***, the net cash flow is

$$Ncfndc_t = TotContrndc_t - TotBenefndc_t. \quad \text{Eq. 35}$$

While the two systems coexist, the total expenditure and the total contributions are

$$TotBenefdbndc_t = TotBenefdb_t + TotBenefndc_t, \quad \text{Eq. 36}$$

$$TotContrdbndc_t = TotContrdb_t + TotContrndc_t. \quad \text{Eq. 37}$$

Using now ***Eq. 36*** and ***Eq. 37*** the net cash flow is

$$Ncfdbndc_t = TotContrdbndc_t - TotBenefdbndc_t. \quad \text{Eq. 38}$$

Numeric results follow for each of ***Scn5*** and ***Scn6***.

3.4.3. Scenario 5: Transition from a PAYG to a public NDC scheme in partial shift

A material effect is observed (see ***Table 10*** and cf. ***Eq. 1*** to ***Eq. 6***, ***Eq. 20***, ***Eq. 23*** and ***Eq. 30*** to ***Eq. 38***). Revenue is the same as in the Baseline scenario because the same contribution rate was assumed.

Table 10: Scn5 - Contributions and Benefits (% GDP)

	2020	2030	2040	2050	2060	2070	2080	2090	2100
Contrib.	8.4	9.5	9.5	9.0	8.3	7.6	7.0	6.4	6.0
Male	4.4	4.9	4.9	4.7	4.4	4.0	3.7	3.4	3.2
Female	4.0	4.6	4.6	4.3	4.0	3.6	3.3	3.0	2.8
Benef.	14.7	13.5	16.5	20.9	24.2	26.0	22.7	18.3	14.9
Male	6.3	5.9	7.7	10.0	11.9	13.1	11.6	9.3	7.6
Female	8.4	7.6	8.8	10.9	12.4	12.9	11.1	9.0	7.3
Balance	**-6.3**	**-4.0**	**-7.0**	**-11.9**	**-15.9**	**-18.4**	**-15.7**	**-11.9**	**-8.9**
Male	-1.9	-1.0	-2.7	-5.3	-7.5	-9.1	-7.9	-5.9	-4.4
Female	-4.4	-3.0	-4.2	-6.6	-8.4	-9.3	-7.8	-6.0	-4.5

Source: Authors.

As the individual accounts are notional in the NDC scheme, the country cannot benefit from the savings generated (see ***Table 11***, ***Eq. 30*** and ***Eq. 32***). The transition cost is the same as the one in Scn3.

Table 11: Scn5 - other CFs (% GDP)

	2020	2030	2040	2050	2060	2070	2080	2090	2100
Tcost	0.0	0.0	0.6	1.6	2.5	3.2	3.7	3.4	3.1
Male	0.0	0.0	0.3	0.8	1.3	1.6	1.9	1.8	1.6
Female	0.0	0.0	0.3	0.8	1.2	1.6	1.7	1.6	1.5
IATS	-	-	-	-	-	-	-	-	-
Male	-	-	-	-	-	-	-	-	-
Female	-	-	-	-	-	-	-	-	-
MGP	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.2	0.2
Male	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1
Female	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1

Source: Authors.

3.4.4. Scenario 6: Transition from a PAYG to a public NDC scheme in fully shift

Table 12: Scn6 - Contributions and Benefits (% GDP)

	2020	2030	2040	2050	2060	2070	2080	2090	2100
Contrib.	8.4	9.5	9.5	9.0	8.3	7.6	7.0	6.4	6.0
Male	4.4	4.9	4.9	4.7	4.4	4.0	3.7	3.4	3.2
Female	4.0	4.6	4.6	4.3	4.0	3.6	3.3	3.0	2.8
Benef.	14.7	13.5	16.5	20.9	24.2	25.9	19.1	10.7	4.9
Male	6.3	5.9	7.7	10.0	11.9	13.1	10.0	5.4	2.3
Female	8.4	7.6	8.8	10.9	12.4	12.8	9.1	5.3	2.6
Balance	**-6.3**	**-4.0**	**-7.0**	**-11.9**	**-15.9**	**-18.3**	**-12.0**	**-4.2**	**1.1**
Male	-1.9	-1.0	-2.7	-5.3	-7.5	-9.1	-6.3	-2.0	0.8
Female	-4.4	-3.0	-4.2	-6.6	-8.4	-9.2	-5.8	-2.3	0.2

Source: Authors

Table 12 (cf. ***Eq. 1*** to ***Eq. 6***, ***Eq. 20***, ***Eq. 23***, ***Eq. 30*** to ***Eq. 38***) shows a positive impact in the long term. In fact, it is the 'best scenario' in the sense that there is even a surplus in 2100. The surplus outcomes from the fact that contributions are made at the same level of the Baseline scenario (see ***Table 3***) and benefits are now “less expensive”, as they are provided by a whole life annuity purchased using the balance in the notional account immediately before retirement (subject to MGP criterion). As expected, the transition cost in this scenario (see ***Table 13***, ***Eq. 30*** and ***Eq. 32***) is greater than the one in the partial shift case (see ***Table 11***) and equal to the FDC full shift case (see ***Table 9***).

Table 13: Scn6 - other CFs (% GDP)

	2020	2030	2040	2050	2060	2070	2080	2090	2100
Tcost	0.0	0.0	1.2	3.2	4.9	6.4	7.3	6.7	6.2
Male	0.0	0.0	0.6	1.6	2.5	3.3	3.9	3.6	3.3
Female	0.0	0.0	0.6	1.6	2.4	3.2	3.5	3.2	2.9
IATS	-	-	-	-	-	-	-	-	-
Male	-	-	-	-	-	-	-	-	-
Female	-	-	-	-	-	-	-	-	-
MGP	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.3	0.5
Male	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.2	0.2
Female	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.2	0.2

Source: Authors.

Summarizing, results show that, if no additional measures are taken, the deficit will decrease over roughly the next ten years, then an increase will be observed from that time on - although of a reduced amount, in comparison with a pre-2019 reform scenario (***Scn1***). Indexing the retirement age to longevity (***Scn2***) showed a way to achieve sustainability. ***Scn3*** and ***Scn4*** correspond to substantial increments in private savings and support the sustainability of the pension system in the long run. ***Scn5*** and ***Scn6*** also have a very positive response in terms of the long run sustainability, in particular ***Scn6***.

4. Conclusion

The aim of this paper is to examine the Brazilian pension system, which has incurred in a deficit for a long time, to project its cash flows until 2100, following the 2019 reform, and to present parametric and systematic scenarios with additional changes, still required to guarantee the sustainability of the system in the long run.

For this purpose, all relevant concepts and methodologies were detailed in Section 2 (the work followed closely the methodology established in (Acosta-Ormaechea, Espinosa-Vega, & Wachs, 2017)). After setting the framework, several different proposals (scenarios) to help solving the deficit problem have been suggested.

Findings proved that the 2019 reform (***Baseline***) improves the balance and allows the huge deficit in RGPS to decrease, but not as much as required. Therefore, it is very likely that the discussion about the sustainability of the system will again be the order of the day in a few years. Figures show that the deficit will decrease over the next 10 years, then an increase will be observed from that time on -

although of a much smaller amount than that in a pre-reform scenario (***Scenario 1***). In fact, the 2019 reform is a good starting point to fight the existing disequilibrium.

Various recommendations for action can now be suggested. Linking retirement age to longevity is a way to address the sustainability problem properly. Moving into DC may be a fair option, in the sense that benefits are fully linked to contributions, not to mention that there is a possible boost in economic growth through the accrued savings. However, it is important to emphasize that this is not an easy transition and most of the risks may fall entirely on pensioners. In Brazil, this can be in some way mitigated, as pension benefits cannot be below the minimum wage by law. The full shift to public NDC (***Scenario 6***) appears to be the most effective strategy in the long run, but a decision must fit in the short and medium terms.

The limitations come mostly from the lack of data. For instance, the constraint that pension benefits cannot be below the minimum wage was proxied by assuming that they will increase according to the CPI – an assumption about the income distribution by cohorts of pensioners would be necessary and there is not enough information. Another issue is that the forecast of the population that is available was made taking five-year age groups, but it would be desirable to have information per age. There is also lack of data by gender, for instance concerning the unemployment rate, the labor force participation rate and the size of the informal sector.

Future research on the topic is linked to the limitations described before. The essential point is to complete data, so that the analysis can be more accurate and extended to the other regimes. The pension system in the country is so complex that many different studies can be conducted. Last but not least, to study the possible effects of the current pandemic on the projections is also another important matter these days. Performing a sensitivity analysis assessing such effects on each of the alternative scenarios is relevant, since it is quite obvious that the alterations in the projections resulting from this crisis will convey additional issues to the problem

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Appendix - Assumptions

We detail here the demographic, macroeconomic and pension assumptions used in the paper, the source and a brief description of each one.

A. Demographic assumptions

The *population* is the existing data throughout the projected horizon, it is on an annual basis divided by five-year age groups and for the analysis is the medium fertility variant.

The *population growth rate* is assumed to be calculated as the ratio of total *population* and its previous value minus one.

The *labor force participation rate* is the available data until its last available value (2030), thereafter it is assumed to stay constant at the average of the last 5 available values (2026-2030) throughout the projected horizon and it is a percentage of total population ages 15-64.

Table A1 – Description of demographic parameters

	Male	Female	Total	Source
Population (10^6)	104.4	108.1	212.6	United Nations[4] (United Nations, 2019 a)
Population growth rate	0.7%	0.8%	0.7%	Author calculations
Labor force participation rate	80.1%	61.1%	70.5%	International Labour Organization[5] (International Labour Organization, 2017)

Source: Author.

B. Macroeconomic assumptions

The *unemployment rate* is assumed from the available data until its last available value (2024), thereafter it is assumed to stay constant at the average of the last 5 available values (2020-2024) throughout the projected horizon and it is a percentage of total youth adults ages 25+.

The *size of formal sector* is assumed is the existing data until its last available value (2015), thereafter it is assumed to stay constant at the average of the last 5 available values (2011-2015) throughout the projected horizon and it is a percentage of non-agriculture employment of a harmonized series.

The *GDP deflator* is the existing data until the last available value (2024), thereafter is assumed to be the multiplication of its previous value and the factor of *inflation rate* throughout the projected horizon.

The *inflation rate* (*GDP deflator growth rate*) is assumed to be calculated as the ratio of the *GDP deflator* and its previous value minus one until the last available value (2024) and thereafter it is assumed to stay constant at the average of the last 5 available values (2020-2024) throughout the projected horizon.

The *GDP deflator index* is assumed to be calculated as the ratio of the *GDP deflator* and its value in 2020 minus one until the last available value (2024).

The *GDP (current prices)* is the existing data until its last available value (2024) and thereafter will be calculated as a multiplication of the factor of the *nominal GDP (current prices) growth rate* and its previous value throughout the projected horizon.

[4] Available at: https://population.un.org/wpp/Download/Standard/CSV/

[5] Available at: https://www.ilo.org/shinyapps/bulkexplorer9/?lang=en&segment=&id=EAP_2WAP_SEX_AGE_RT_A

The *nominal GDP (current prices) growth rate* is assumed to be calculated as the ratio of *GDP (current prices)* and its previous value minus one until the last available value (2024), thereafter is assumed to be calculated as a multiplication of the factors of *real GDP per capita growth rate*, *population growth rate* and *inflation rate* minus one.
The *real GDP (current prices) growth rate* is assumed to be calculated as the ratio of the division of the *GDP (current prices)* for its previous value and the division of the *GDP deflator* and its previous value minus one throughout the projected horizon.
The *GDP (constant prices)* is assumed to be calculated as the ratio of the *GDP (current prices)* and the *GDP deflator index* until the last available value (2024).
The *real GDP (current prices) per capita* is assumed to be calculated as the ratio of the *GDP (constant prices)* and the total *population* until the last available value (2024).
The *real GDP (current prices) per capita growth rate* is assumed to be calculated as the ratio of the *real GDP (current prices) per capita* and its previous value minus one until the end of the last data available (2024), thereafter it is assumed to stay constant at the average of the last 5 available values (2020-2024) throughout the projected horizon.
The *compensation of employees* is the existing data until its last available value (2017) weighted by the average of the last 5 available values (2009-2014) of the *wage gap gender*.
The *wage gap gender* is the existing data until the last available value (2014), thereafter it is assumed to stay constant at the average of the last 5 available values (2009-2014) throughout the projected horizon.
The *wage share* is assumed to stay constant at the average of the ratio of the *compensation of employees* and *GDP (current price)* of the last 5 available values (2013-2017) until its last available value (2024), thereafter is obtained on the basis of the aggregate wages in the economy and *GDP*.
The *real wage growth rate* is assumed to stay constant at the ratio of the factor of the average of the last 5 available values (2020-2024) of the *GDP (current prices) growth rate* and the factor of the average of the last 5 available values (2020-2024) of the *inflation rate* throughout the projected horizon.
The *discount rate*[6] is assumed to be a division of the *real interest rate* minus the *real GDP (current prices) growth rate* over the *real GDP (current prices) growth rate* plus one and it was set to be 1% throughout the projected horizon.
The *real interest rate* is assumed to be the multiplication of the *discount rate* and the factor of the *real GDP (current prices) growth rate* plus the *real GDP (current prices) growth rate* throughout the projected horizon.
The *financial rate of return* is assumed to be the multiplication of the factor of the *real interest rate* and the factor of the *inflation rate* minus one throughout the projected horizon.
The *income share held by the lowest 20%* is the existing data until the last available value (2018), thereafter it is assumed to stay constant at the average of the last 5 available values (2014-2018) throughout the projected horizon.

[6] The rational is the interest paid in year t as a ratio to debt outstanding at the end of year $t-1$, which constitutes a safe proxy for the interest rate, roughly equal 1%, and it is equivalent to the average interest rate-growth differential (Escolano, 2010; Kogan, Stone, DaSilva, & Rejeski, 2015).

Table A2 - Description of macroeconomic parameters

	Male	Female	Total	Source
Unemployment rate	7.3%	10.8%	8.8%	International Labour Organization[7] (Internation Labour Organization, 2019)
Size of formal sector	61.5%	62.7%	62.0%	International Labour Organization[8] (International Labour Organization, 2018)
GDP deflator	631	631	631	International Monetary Fund[9] (International Monetary Fund, 2019)
Inflation rate	4.2%	4.2%	4.2%	Author calculations
GDP deflator index	100	100	100	Author calculations
GDP (current prices) (10^9)	7,650	7,650	7,650	International Monetary Fund[9] (International Monetary Fund, 2019)
Nominal GDP (current prices) growth rate	6.3%	6.3%	6.3%	Author calculations
Real GDP (current prices) growth rate	2.0%	2.0%	2.0%	Author calculations
GDP (constant prices) (10^9)	7,650	7,650	7,650	Author calculations
Real GDP (current prices) per capita	73,248	70,750	35,989	Author calculations
Real GDP (current prices) per capita growth rate	1.4%	1.3%	1.3%	Author calculations
Compensation of employees (10^9)	1,507	1,296	2,802	United Nations[10] (United Nations, 2019 b)
Wage gap gender	16.0%	16.0%	16.0%	International Labour Organization[11] (International Labour Organization, 2018)
Wage share	23.5%	20.2%	43.8%	Author calculations
Real wage growth rate	2.3%	2.3%	2.3%	Author calculations
Discount Rate	1.0%	1.0%	1.0%	Author calculations
Real interest rate	3.1%	3.1%	3.1%	Author calculations
Financial rate of return	7.4%	7.4%	7.4%	Author calculations
Income share held by the lowest 20%	3.10%	3.10%	3.10%	World Bank[12]

Source: Author.

C. Pension assumptions

The *replacement rate* is assumed to stay constant at the average between the available values (2014 & 2018).
The *contribution rate* is assumed to stay constant at the level of the last available value (2020).
The *retirement age (after transition)* is assumed to stay constant at the level of the last available value (2020).

[7] Available at: https://www.ilo.org/shinyapps/bulkexplorer49/?lang=en&segment=&id=UNE_2EAP_SEX_AGE_RT_A
[8] Available at: https://www.ilo.org/shinyapps/bulkexplorer37/?lang=en&segment=&id=IFL_4IEM_SEX_ECO_IFL_RT_A
[9] Available at: https://www.imf.org/en/Publications/WEO/weo-database/2019/October/download-entire-database
[10] Available at: http://data.un.org/Data.aspx?q=Compensation+of+employees&d=SNA&f=group_code%3a401%3bitem_code%3a20
[11] Available at: https://www.ilo.org/shinyapps/bulkexplorer37/?lang=en&segment=&id=IFL_4IEM_SEX_ECO_IFL_RT_A
[12] Available at: https://data.worldbank.org/indicator/SI.DST.FRST.20

The *retirement age (initial)* is assumed to stay constant at the level of the last available value (2020).
The *minimum pension* is assumed to stay constant at the level of the last available value (2020).
The *average number of contributions per year* to stay constant at the latest available value (2009) in Chile.
The *life expectancy (after retirement)* is assumed to stay constant at the latest available value (2018).

Table A3 - Description of pension parameters

	Male	Female	Total	Source
Replacement rate	61.20%	52.50%	56.78%	OECD[13] (United Nations, 2019 a)
Contribution rate	28.00%	28.00%	28.00%	USA Social Security administration[14] (Social Security Administration, 2019)
Retirement age (after transition)	65.0	62.0	63.5	Ministry of Finance
Retirement age (initial)	61.0	56.0	58.5	Ministry of Finance
Minimum pension	13,585	13,585	13,585	Ministry of Finance[15]
Average months of contributions per year	6.0	6.0	6.0	Ministry of Finance[16] (Chile)
Life expectancy (after retirement)	22.7	27.4	25.0	UN mortality table (United Nations, 2019 a)

Source: Author.

[13] Available at: https://data.oecd.org/pension/gross-pension-replacement-rates.htm
[14] Available at: https://www.ssa.gov/policy/docs/progdesc/ssptw/2018-2019/americas/brazil.pdf
[15] For more details, https://www.gov.br/economia/pt-br/assuntos/noticias/2020/02/novas-aliquotas-da-previdencia-entram-em-vigor-em-1o-de-marco
[16] Available at: https://www.dipres.gob.cl/598/articles-58451_doc_pdf.pdf