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GUILHERME SILVA CARDOSO

Labor and Pension in an Ageing Society

A Computable General Equilibrium Approach for Brazilian Economy

BELO HORIZONTE

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A Computable General Equilibrium Approach for Brazilian Economy

Submitted to the Postgraduate Program in Economics of the Centre for Regional Development and Planning (CEDEPLAR/UFMG) in fulfillment of the requirements for the Doctor of Philosophy degree in Economics.

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LABOR AND PENSION IN AN AGEING SOCIETY: A COMPUTABLE GENERAL EQUILIBRIUM APPROACH FOR BRAZILIAN ECONOMY

GUILHERME SILVA CARDOSO

Tese de Doutorado defendida e aprovada, no dia 26 de fevereiro de 2024, pela Banca Examinadora designada pelo Colegiado do Programa de Pós-Graduação em Economia da Universidade Federal de Minas Gerais constituída pelos seguintes professores:

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Abstract

The National Pension Scheme (RGPS) 2019 reform (Constitutional Amendment Nº 103/2019) aimed at enhancing the PAYG scheme's sustainability by introducing the parameter of minimum age of retirement as the one criterion to get access to the benefit, as well as changing the benefit formula. The transition phase of the reform holds the new eligible pensioners growth rate as it reaches the new minimum age of retirement, simultaneously inflating the workforce. After the transition phase, set to last until 2033, RGPS deficit as well as Government savings go downhill. The "Policy with Budget Relief" scenario delivers better fiscal results (R$ 562 billion savings to Government and R$ 944 billion savings in the RGPS, compared to the baseline scenario in 2100 prices level). On the other hand, the "Policy with Tax Relief" scenario delivers better economic outputs, equalizing the deficit ratio to GDP results of both experiments. Thus, while the scenario with no reform projects a ratio of 21% of the RGPS deficit to GDP and 32.7% of the Government savings deficit to GDP in 2100, the policy scenarios with budget and tax relief present, respectively, 16.97% and 29.44%, and 17.03% and 29.7%. Modelling the pension reform through the BRIGHT model also allows us to see a distributional worsening of households' income, for the retirement benefit of the scheme is an important source of income of the poorer households, amongst other indirect effects derived from the scenario with tax relief. This Thesis also prospects about labor productivity and the RGPS enrollment. It showed that the number of workers unprotected by law and unenrolled in pension schemes has increased in the period of 2015-2022, when not only the pension but other labor reforms towards general flexibilization were approved. That became known as the *precarization* of the labor force, characterized by the increase of self-employed workers, often irregulars to the nature of their jobs and unprotected by labor rights. Two different experiments have shown that pension coverage is an important foundation for the scheme's performance, in a way that labor formality (as well as higher wage levels) should be pursued; alternatively, by encouraging labor flexibilization, policymakers discourage pension's active enrollment, potentially undermining the scheme as whole.

Keywords: Demographic Dividend, Social Security; Fiscal Adjustment; Economic Growth; Households; Labor Market; Productivity; Computable General Equilibrium.

JEL Codes: J11, H55, C68.

Resumo

A Reforma da Previdência de 2019 (Emenda Constitucional nº 103/2019) teve como objetivo melhorar a sustentabilidade do regime de repartição RGPS – Regime Geral de Previdência Social ao estabelecer o parâmetro de idade mínima de aposentadoria como critério único para a garantia do benefício, bem como alterar a fórmula do benefício. O período de transição da reforma retém a taxa de crescimento de novos aposentados na medida em que se atinge a nova idade mínima estabelecida, aumentando, por consequência, o tamanho da força de trabalho. Após o período de transição, programado para durar até 2033, o déficit do RGPS, assim como o da poupança do Governo, cresce de forma abrupta. Ao testar diferentes fechamentos de condição fiscal, foi possível projetar um cenário de política com "alívio orçamentário", que apresenta melhores resultados fiscais (R$562 bilhões de poupança do Governo e R$944 bilhões de economia para o RGPS, em relação ao cenário sem reforma, ao nível de preços de 2100) e um cenário de "alívio tributário", que projeta maior crescimento econômico, equalizando os resultados de déficit em relação ao PIB em ambos os experimentos de política. Assim, enquanto o cenário sem a reforma projeta uma razão de 21% do déficit do RGPS sobre o PIB e de 32,7% do déficit da poupança do Governo sobre o PIB em 2100, os cenários de política com alívio orçamentário e com alívio tributário apresentam, respectivamente, 16,97% e 29,44%, e 17,03% e 29,7%. Modelar a reforma com o modelo BRIGHT também nos permitiu observar uma piora distributiva da renda das famílias, tendo em vista a importância do benefício de aposentadoria do regime como fonte de renda das famílias mais pobres, entre outros efeitos indiretos intrínsecos ao cenário de alívio tributário. Esta tese também prospecta sobre a produtividade do trabalho e a adesão de contribuintes ao RGPS. Ela mostra que o número de trabalhadores desprotegidos por lei (CLT) e pela previdência social cresceu no período de 2015 a 2022, quando não somente a reforma da previdência, mas outras reformas trabalhistas em direção à flexibilização generalizada foram aprovadas. Aquilo ficou caracterizado como a precarização da força de trabalho, caracterizada pelo aumento de trabalhadores conta-própria, frequentemente irregulares à natureza do trabalho exercido e desprotegidos por direitos trabalhistas. Dois diferentes experimentos mostraram que a cobertura previdenciária é um alicerce para o bom desempenho do regime de previdência, de modo que a formalização do trabalho (assim como uma maior massa salarial) deveria ser objetivada; alternativamente, ao incentivarem a flexibilização excessiva do trabalho, formuladores de política

desencorajam a adesão e permanência de contribuintes ativos, minando, em potencial, o regime como um todo.

Palavras-chave: Dividendo demográfico, Seguridade Social; Ajuste Fiscal; Crescimento Econômico; Famílias; Mercado de trabalho; Produtividade; Equilíbrio Geral Computável

Códigos JEL: J11, H55, C68.

List of Acronyms

AEPS – Statistical Yearbook of Social Security (Anuário Estatístico da Previdência Social)

BEPS – Social Security Statistical Bulletins (*Boletins Estatístico da Previdência Social*)

BPC – Continuous Cash Benefit (*Benefício de Prestação Continuada*)

BRIGHT – Brazilian Social Accounting – General Equilibrium Model for Income Generation, Households and Transfers

CES – Constant Elasticity of Substitution

CGE – Computable General Equilibrium

CLT – Consolidation of the Labor Laws (*Consolidação das Leis do Trabalho*)

CPI – Consumer Price Index

DPSV – Dixon, Parmenter, Sutton and Vincent

FGTS – Severance Fund Contribution (*Fundo de Garantia por Tempo de Serviço*)

GDP – Gross Domestic Product

GOS – Gross Operating Surplus

IBGE – Brazilian Institute for Geography and Statistics (*Instituto Brasileiro de Geografia e Estatística*)

ILO – International Labor Organization

INSS – National Institute for Social Security (*Instituto Nacional de Seguridade Social*)

LES – Linear Expenditure Substitution

MDS – Ministry of Development and Social Assistance, Family and Fight Against Hunger (*Ministério do Desenvolvimento e Assistência Social, Família e Combate à Fome*)

MEI – Individual Micro-Entrepreneur (*Micro Empreendedor Individual*)

NTA – National Transfer Accounts

OECD – Organization for Economic Co-operation and Development

PAYG – Pay-As-You-Go

PBF – *Programa Bolsa Família*

PNADC – (*Pesquisa Nacional por Amostra de Domincílio Contínua*)

POF – Consumer Expenditure Survey (*Pesquisa de Orçamentos Familiares*)

RGPS – National Pension Scheme (*Regime Geral de Previdência Social*)

ROW – Rest of the World

RPPS – Civil Service Pension Plan (*Regime Próprio de Previdência Social*)

SAM – Social Accounting Matrix

SNA – System of National Accounts

UN – United Nations

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Summary

General Introduction

Brazilian population is ageing fast due to a lower fertility rate and a higher life expectancy. The demographic transition that happens because of the population ageing has deep and lasting impacts in a country's economy. It normally implies stagnancy or even shrinkage of the working age population, raising labor costs as well as the risk of pension schemes unsustainability.

In Brazil, the public transfers to households in both individual and aggregate perspective show an important share of public education and services in the younger ages; cash benefits in the working-age; and, in the last third of the life-cycle, an abrupt share of public health, social security and cash benefits, highlighting the country's characteristic of "elderly-biased public transfers" (Turra, 2011), that so far helped to avoid increasing poverty amongst that age group compared to the rest.

Along with this challenging demographic scenario, Brazil has just crossed a long period of economic stagnation and have been guided by fiscal consolidation policies as well as by reforms towards liberalization. In fact, Brazilian labor market has been marked by significant and persistent inequalities, strongly related to social exclusion that originate and reproduce poverty. The economic opening of the 1980s and 1990s has changed the path of the country's labor market up to this date, that still suffers from the main symptoms of the early deindustrialization.

That makes the challenges inherent to the demographic transition even more complex in Brazil. Thus, to provide support to policymakers that deal with this problem, the main contribution of the Thesis is to developed a robust tool for modelling Brazilian social security, from a national perspective, considering its economic and welfare linkages altogether, and evaluate the impacts of the minimal age introduction of the Brazilian National Pension Scheme (RGPS) 2019 reform. Additionally, it also aims to evaluate the interdependence between social security dynamics and those related to the labor market, considering that, for a pension scheme's performance, more than the working age population, what matters is the active workforce, and especially its degree of formality and under occupation (Neri et al, 2007; Jung and Tran, 2012) as well as wage levels and pension enrollment.

This Thesis is not alone in the hall of attempts to model Brazilian RGPS through Computable General Equilibrium models. It has an intimate connection with the results of Silva (2018), that analyzes the impact of the demographic transition on the fiscal balance of the RGPS in the coming decades. Storto and Afonso (2018) and Afonso and Carvalho (2021) also cover the fiscal and economic impacts of the last attempts of reforms of the Brazilian National Pension Scheme with other empirical methodologies. It is also connected to the researches that handle with poverty and distributional aspects of the scheme such as Souza *et al*. (2021), Rangel and Saboia (2015), Silveira *et al.* (2020) and Freire Cardoso *et al*. (2024). Other countries' experiences on the same subject are found in Sánchez-Romero *et al.* (2013), Barrientos (2005), Dethier *et al*. (2011), Cammeraat (2020), Wang *et al.* (2017) and Zuo *et al*. (2020).

Methodologically, this Thesis provides several modelling contributions. To begin with, it updated BRIGHT (Freire Cardoso, 2020) with a new Social Accounting Matrix (SAM) data considering a new disaggregation and a new set of variables and equations to model a Pension Module. This allows the modeler to treat Government transfers to households, as well as its income from them, separately by scheme, i.e. the RGPS, the Civil Service Pension Plan (RPPS), the Military's, and the Continuous Cash Benefit (BPC) flows, accruing from household income class. An entire set of fiscal results from this module is available in the model.

In second place, it considers different ways of evaluating the effects of the 2019 Pension Reform by setting different closures of fiscal adjustment, conversing with the works that aim to incorporate fiscal consolidation allocative responses in a CGE framework, like Cardoso (2019) and Freire Cardoso *et al.* (2024).

Thirdly, it successfully integrates demographic projections over a CGE structure through shocks and a quite well specified set of equations that transmit them to the rest of the economy (the whole system of equations of BRIGHT) in a dynamic way, enhancing a bridge between the two areas of modelling.

The Thesis is structed in four main parts. There are also three auxiliary sections – appendixes – that contribute to understand the different methodological approaches of this work.

Chapter 1, “Theoretical Referential”, presents the foundations of the Thesis starting from the economic life-cycle theory of saving and consumption, the demand for wealth and the derived inequalities of the ageing societies up to the state of art of this kind of modelling. In addition, it shows how the imminent demographic transition of Brazilian population shapes a scenario of acute economic challenges by pressuring Government’s budget. It consists on a general exhibition of elements that mark the Thesis perspective, for specific literature reviews makes up each chapter separately. Essentially, it shows how Brazilian aggregate working-age population struggles to accumulate the enough surplus to finance youth and, mainly, the elderly consumption.

Chapter 2, “Methodology and Database”, presents the adaptations implemented on BRIGHT (Brazilian Social Accounting – General Equilibrium Model for Income Generation, Households and Transfers) to achieve the Thesis’ main goal. It details the model’s database and equations for pensions, presenting the schemes’ accounts from within the Brazilian System of National Accounts (SNA) and households class structure; as well as its fiscal module and additional aspects.

Chapter 3, “Modelling the Economic Impacts of the Minimal Age Introduction of the Brazilian Pension Reform of 2019”, presents the very first experiment with the new modules of BRIGHT. Divided in three main sections, the chapter contextualizes the recent history of the National Pension Scheme and presents the main aspects of 2019’s reform, the trigger for this Thesis’ development. After formulating a synthesis of the reform, it finally presents the demographic projections inputs for the experiment. The results section details all the transmission mechanisms of the simulation within the model that led to the fiscal results. It shows that, because of its transition phase design, the reform holds the schemes’ deficit constant until 2035. After that, it goes downhill up to the end of the projection, in 2100. Government saving deficit goes in the same way.

Finally, Chapter 4, “Understanding Brazilian Workforce: Prospects about Productivity and the Social Security Enrollment”, dissertates about Brazilian persistent structure of inequalities and social exclusion in the labor market. As previously mentioned, it is one of the Thesis’ main goals to include the labor market discussion in the social security agenda. Chapter 4 then brings a workforce stratification of the recent years in the Brazilian economy and shows that the number of workers unprotected by law and unenrolled in the social security has increased. It proposes then two alternatives

forecast scenarios: a short-run recovery and a long-run experiment of precarization. The first one could assist the 2019's reform, improving the schemes' deficit position. The second, on the other hand, indicates poverty and, to a certain extent, a serious threat to the RGPS.

Chapter 1 - Theoretical Referential

> "I intend living as long as possible . . . and so I need every farthing, and the longer I live, the more I shall need.
>
> I can still pass for a man of five and fifty, but I want to pass for one for another twenty years. So I am saving up more and more, simply for myself, my dear son".
>
> (*The Brothers Karamazov*, by Fiodór Dostoievski, first published in 1880)

When Franco Modigliani published his famous contribution to the economic science in 1966, he seemed to have little acquaintance of the centenary words of Fiodór Dostoievski. It is true that the now impending demographic trend patterns of the various nations of the world were not yet so evident at that time, for his "ten years of retired life"[1] suggestion did not age well before the persistent phenomenon in the modern societies: the elderly as a longevous and active economic agent – and self-loved being.

This Chapter contextualizes the Thesis' theoretical ground by delivering the main theory of how individuals behavior in face of the increasing life expectancy, such as the life-cycle decision of saving and consumption, aggregates into a country's macro picture – influencing the overall economy, especially its fiscal side. Additionally, because of the increasing demand for health and social security, the sectoral picture is also subject to changes. Under those circumstances, the Government tends to be an important intermediate agent.

[1] "Thus, for an earning span of, say, forty years, and a life span of fifty years (from the date of entering the labor force), aggregate wealth in our stationary society would come to five times annual income." (Modigliani, 1966, p. 165).

1.1 The Life-Cycle of the Economics of Ageing

The work of Modigliani (1966) successfully integrated the demographic aspects of ageing to the economic field through the life-cycle hypothesis of saving and consumption, the demand for wealth and the supply of capital. His contributions converse directly with the Growth Theory (Solow, 1956) and its consequences for income and wealth inequality (Piketty, 2014), opening the frontiers to the demographic perspective of the National Transfers Accounts (NTA).

As Modigliani (1966) initially describes, the starting point of the life-cycle model is the hypothesis that consumption and saving decisions of households at each point of time reflect an approximate conscious attempt at achieving the preferred distribution of consumption throughout the life cycle, considering the constraint imposed by the resources accruing to the household over its lifetime. Variations regarding zero net individual (consumption exhausts resources and no planned bequests) and aggregate saving; as well as to population and productivity growth are also available in his famous model.

If under the individual perspective it looks like a private "fully-funded" scheme for retiring, letting income grow as a result of population growth or of growth in income per worker, Modigliani's life-cycle model approximates more or less the effects of the demographic bonus in the economy – detailed in Bloom *et al.* (2001) and Mason (1981) – an increase of the ratio of younger households in their accumulation phase to older households in their dissaving phase (a positive net flow of savings). That is the basis of the so-called Pay-As-You-Go (PAYG) scheme of social security, central object of this Thesis. Naturally, the older the society gets, the higher is the need for finding adjustments and alternative sources for financing the dissaving phase.

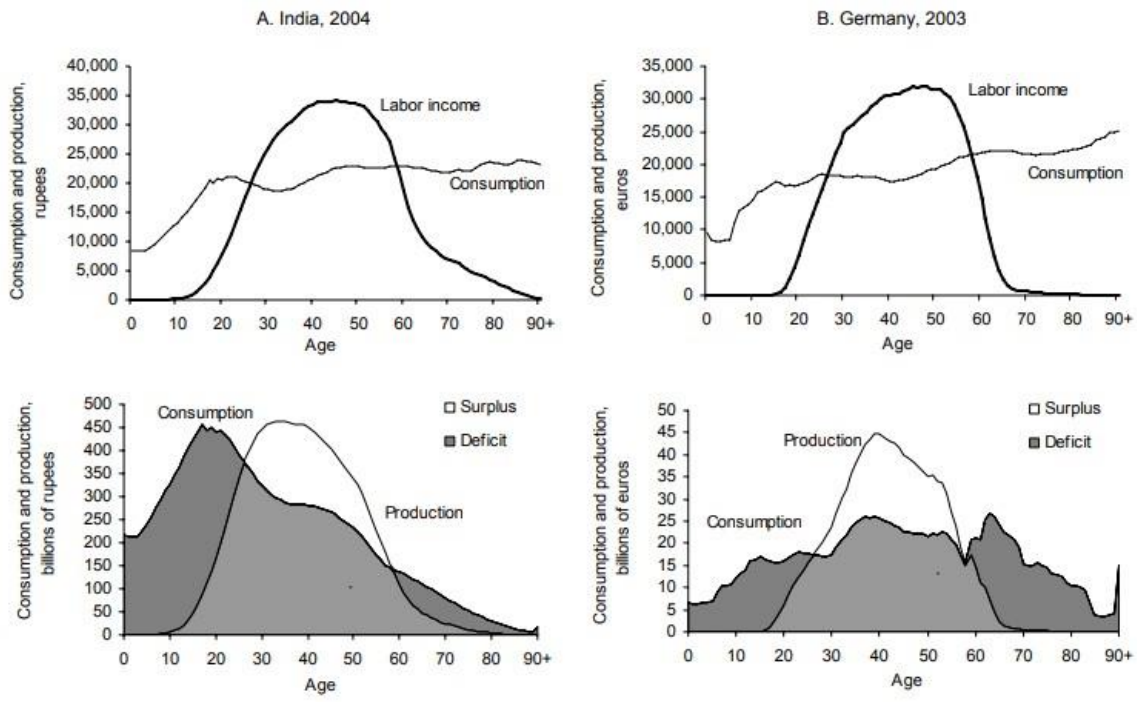
Before heading into the National Transfers Accounts matter, it is worth it to describe the role of populational and economic growth in the income and wealth inequality. When Piketty (2014) described "the fundamental force for divergence: $r > g$" (in which *r* stands for the average annual rate of return on all sorts of capital, and *g* for the rate of growth of the economy) he mentioned a positive correlation between demographic and economic growth in some societies over the history, and concerned about the contrary. In other words, a society where output per capita grows tenfold every

generation, he explained, it is better to count on what one can earn and save from one's own labor, for the income of previous generations would be too small compared to the potential income from bequests. On the other hand, a stagnant or decreasing population increases the influence of capital accumulated in previous generations – forcing the r > g condition thus strengthening inequality. It is true that in many developed societies both r and g are low. In this case, Piketty (2014, p. 376) emphasizes the role of the increasing sophistication of the global capital market: "meaning that the return on capital will become increasingly disconnected from the individual characteristics of the owner. . . reinforcing the logic of r > g". Lee (2003) brings a cross-cultural perspective on intergenerational transfers and the economic life cycle.

1.2 Demographic Transition and the National Account Transfers

As Figure 1.1 shows, the costumery curves of the individual Life-Cycle of saving and consumption can hide opposite momentums in the aggregated form due to the demographic characteristics of a society. As the various individual life-cycle of consumption and saving aggregates a country's national consumption and saving, that is also true within the popular national accounts.

Figure 1.1 – Individual and Aggregated Life-Cycle curves according to a society's ageing structure

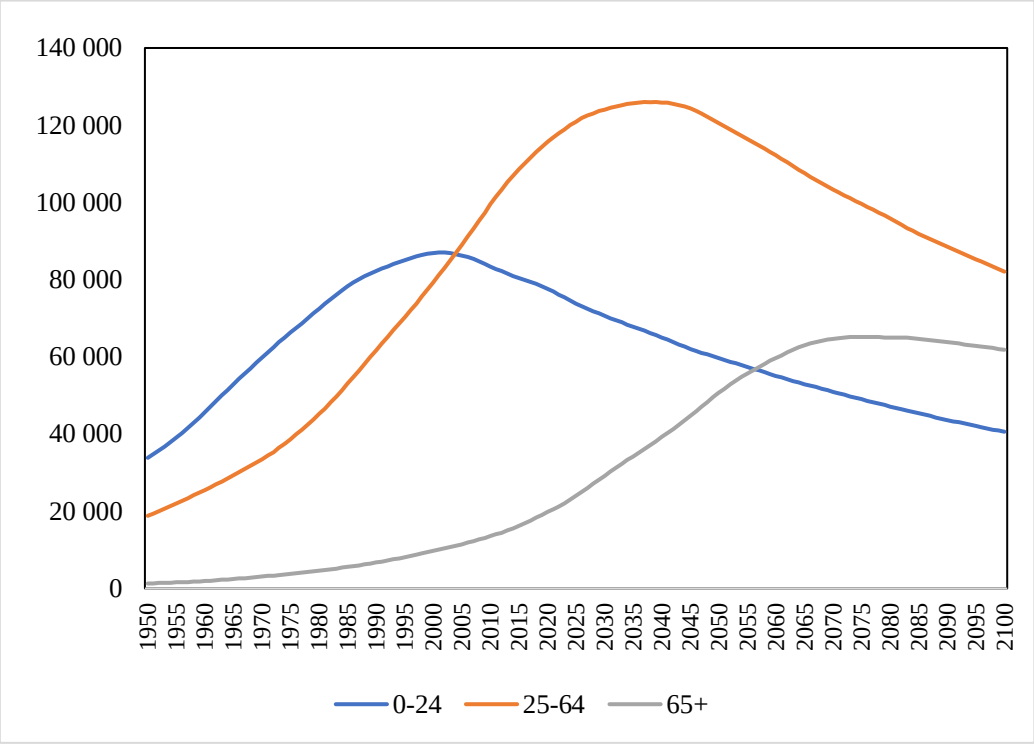


Source: Lee and Mason (2011).

The System of National Accounts (SNA) was developed during the “in-between wars” period for the systematic measurement of employment and the need for accurate measures of aggregate economic activity (Kuznets, 1937) and, despite concerns about its adequacy to modern times (Sen, Fitoussi and Stiglitz, 2010), it has been a tool for economics evaluation for multiple sources, e.g., macroeconomic policymakers, public and private managers, analysts, researchers, the media, and the general public, ever since then. The problem showed in Figure 1.1 also happens within the traditional statistics of the SNA, that do not clearly highlight generational and demographic aspects intrinsic to aggregate accounts.

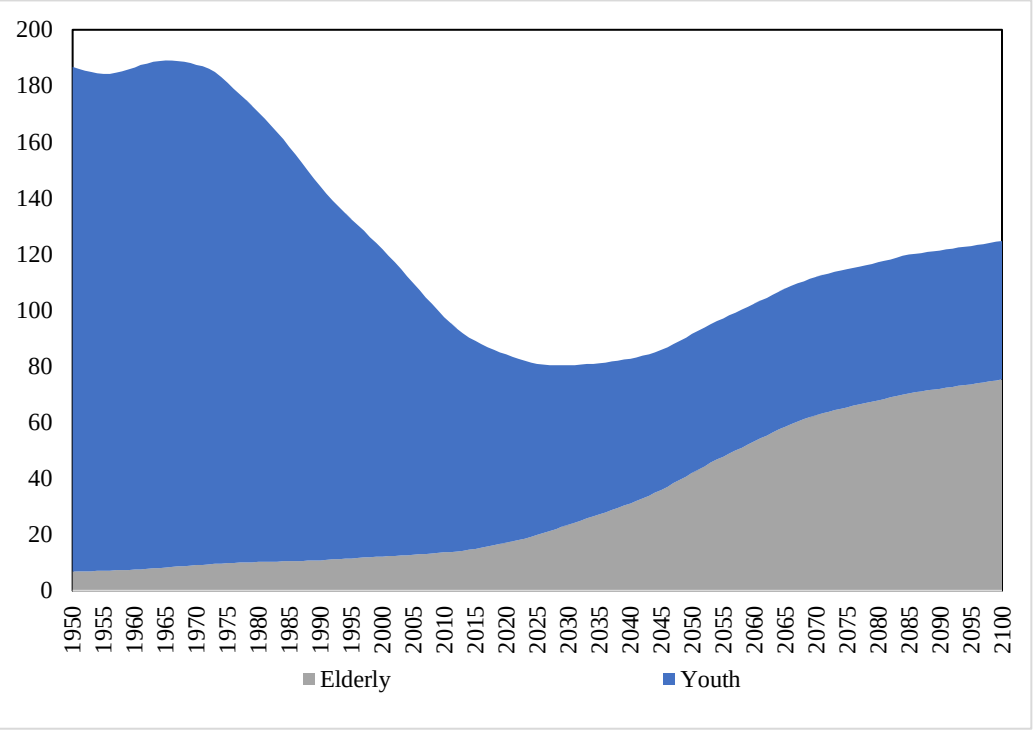
The influence of population trends on the Brazilian economy has occurred more visibly since the Demographic Transition, triggering a process of increasing life expectancy and relative aging of the population (Carvalho and Wong, 1995), shifting the country from the Indian aggregate picture towards the German’s, as a matter of comparison to the bottom of Figure 1.1 – for the individual patterns at the top of the figure be rather similar amongst the countries. Brazilian fertility rate started to fall in the late 1960s and the consequent change in the age structure of the population has manifested in an unique momentum of demographic bonus for the economy (Alves, 2020; Mason, 2005; Turra and Queiroz, 2005). Graph 1.1 shows Brazilian total population by age group, historic and projection; and Graph 1.2 shows the dependency ratios for child/youth and elderly groups to the 25–64-year-old group. The demographic bonus starts in the moment when the youngest group hits its maximum size relatively to the rest (late 1960s – perceivable in both graphs), and the dividend, when it is no longer the larger group (early 2000s – clearly perceivable in Graph 1.1; in Graph 1.2, when the ratio is less than 100).

Graph 1.1 – Total Population by age group, Brazil (1950-2100) (thousands)



Source: Own elaboration. Data from UN - Revision 2022 (Medium fertility variant for 2022 onwards).

Graph 1.2 – Dependency ratios for child/youth and elderly to 25–64-year-old groups, total population, Brazil (1950-2100)

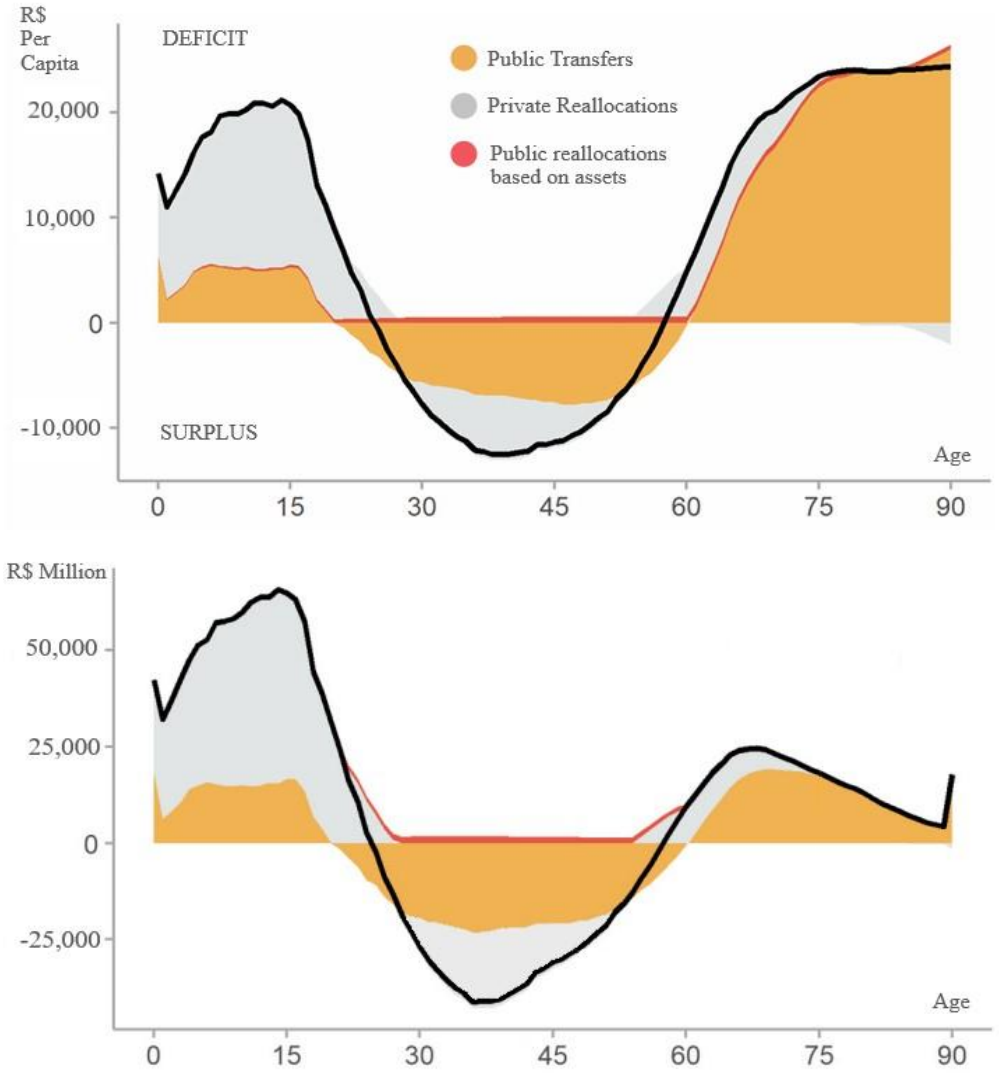


Source: Own elaboration. Data from UN - Revision 2022 (Medium fertility variant for 2022 onwards). One person per one hundred 25–64-year-old people.

The United Nations Population Division recognized the importance of dealing with economy and population trends together and supported the development of the 2013 National Transfer Accounts Handbook. The manual was based primarily on a network of academic research on the topic, including from Brazil (NTA, 2022; Mason *et al*., 2009; Correa, 2023). The National Transfer Accounts correspond to a coherent, comprehensive, and systematic method for the age disaggregation of the main components of the National Accounts (UN, 2013; Correa, 2023). It is based on the economic life-cycle of Modigliani (1966) on the consumption and income patterns of individuals throughout their lives.

For the crucial matter of this Thesis, Correa (2023) brings a remarkable contribution by adapting the NTA methodology to the Brazilian reality and by identifying and discussing the financing of the life-cycle deficit of consumption in Brazil. Figure 1.2 shows the life-cycle of income and consumption in both individual and aggregate perspectives, addressing the origins of the resources by age in the life-cycle. In both, the black curve shows the frontier of income deficit and surplus along the three main stages of life: childhood/youth; working-age and elderly. As the working-age phase is the only one that accumulates surplus, it is clear the relevance of the private role in financing the consumption of the youth and the public sector in financing the elderly. In the public sector, the reallocation of resources between ages through public transfers is also noteworthy. In the aggregate economy, public transfers to the elderly are closer to public transfers to the youth because of the much higher proportion of this age group, but, because of the demographic transition, that is about to change.

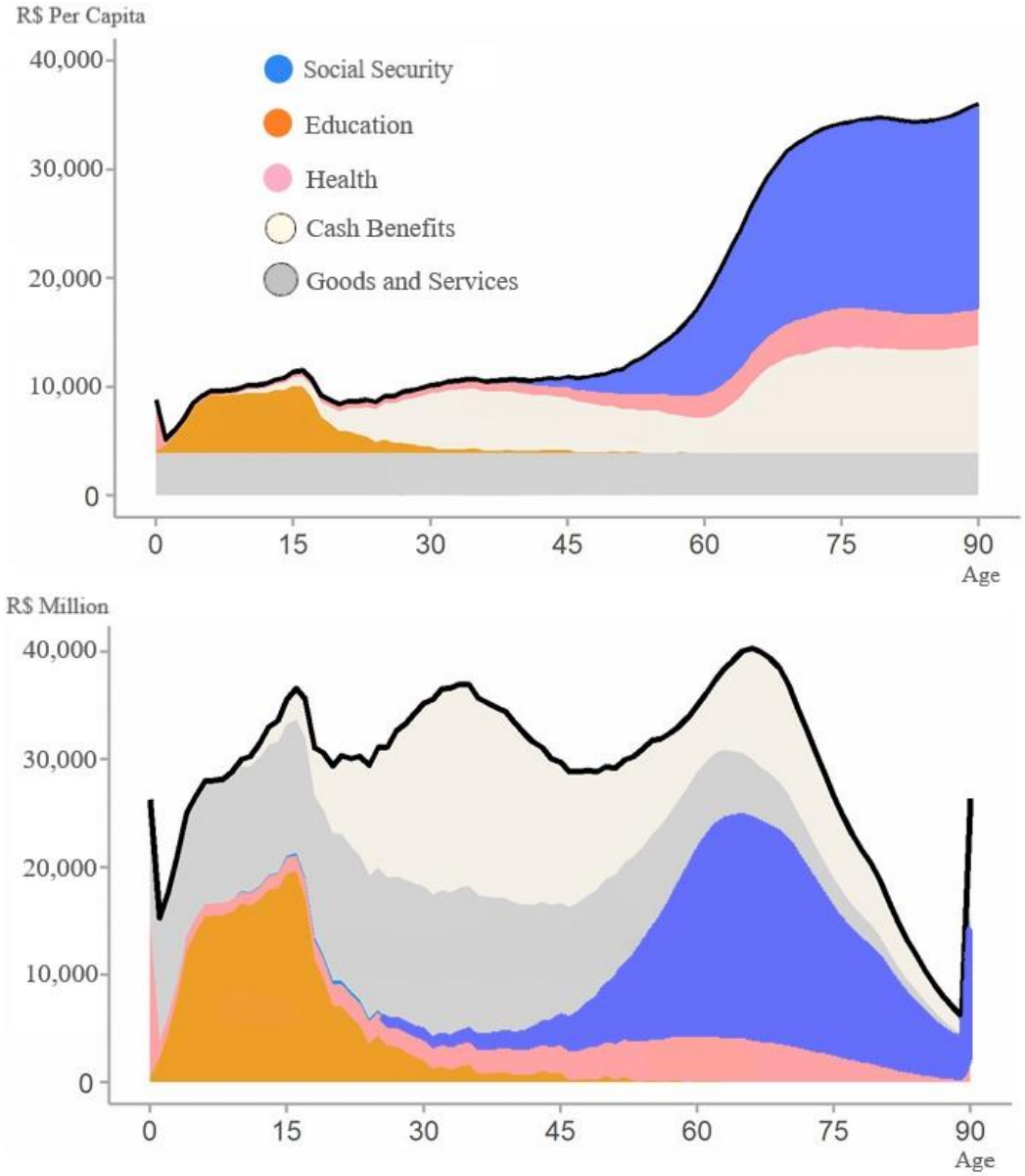
Figure 1.2 –Individual and Aggregate life-cycle deficit, by simple age, Brazil, 2018



Source: Correa (2023) (adapted).

Figure 1.3 shows the public transfers flows to households in both individual and aggregate perspective, disaggregated by use. In the individual perspective, it shows an important share of public education and services (constant along the life-cycle) in the younger ages; in the working-age, cash benefits are the top transfer and health starts to grow; in the last third of the cycle, at last, social security and cash benefits grows abruptly. The movement from individual to the aggregated form reproduces the same pattern depictured in Figure 2. It highlights the Brazilian characteristic of "elderly-biased public transfers" (Turra *et al.*, 2011).

Figure 1.3 – Individual Aggregate public transfers, by age and use, Brazil, 2018



Source: Correa (2023) (adapted).

With the end of the demographic bonus, there is a clear scenario of acute economic challenges ahead. The findings of Correa (2023) emphasize the fiscal pressure that an aging society with the Brazilian characteristics (whose life cycle deficit among the elderly is mainly financed by the public sector and whose labor force shows a downward trend – which tends to imply lower tax revenues) may have in the future.

Modigliani's model contributed to a reasonable understanding of the economic life-cycle decisions, both under individual and aggregate perspectives. It has a close relation with the foundation of the "micro aspects of the economic demography" (see

Becker, 1979; 1993) as well as the starting point for the “macro aspects”, considering the valuable NTA presented in this chapter. In this way, Abio *et al.* (2014) and Sánchez-Romero (2013) bring experiments of the NTA through Overlapping Generations General Equilibrium (OLG-CGE) models.

Brazilian NTA reveals essential information about the country’s symbiosis of economy and demography. The work of Correa (2023) shows that, because of the country’s main model of social security – historically cover up on the country’s demographic bonus, the PAYG style – there is an age-biased public expenditure towards the elderly population. Allied with an impending ageing trend, there is a fiscal pressure for the future, forcing pension parameters changes as well as to the financing sources of the dissaving phase of the life-cycle (e.g. the fully and “partially”-funded schemes of pension).

This Chapter presented the Thesis’ ground by showing its theoretical foundations. Different literature review shall appear along the next chapters, especially in the experimental ones. Chapter 2 presents the BRIGHT model, showing the Brazilian National Accounts and describing the modelling of the social security accounts and other flows within the Computable General Equilibrium methodology.

Chapter 2 – Methodology and Database

Computable General Equilibrium (CGE) is part of the deterministic class of models in which variables with known fixed values are connected by a known set of equations – making it a perfectly predictable system. Actuarial models, on the other hand, are normally probabilistic, where the risk (or hazard) such as property damage, death, natural misfortune, etc., is a crucial – but unpredictable – event[2].

When the subject is pension and the social security, actuarial and demographic models normally rely on *life tables* – see Lee and Miller (2001) and Queiroz and Ferreira (2021) –, in which fertility and mortality are important keys to estimate outputs such as the total and the working age population. Those, in turn, are useful inputs for models in which the economic mechanism is more sophisticated, as CGE models are.

There is an extensive amount of works that use CGE models to evaluate the economic impacts of pension reforms. The well-known contribution of Auerbach e Kotlikoff (1985) is considered the cornerstone of the line of those models. Sánchez-Romero *et al.* (2013) investigates the role of recent pension reforms for the development of the social security system and economic growth in Austria through a CGE model with overlapping generations. For a survey of the use of this type of methodology applied to pensions and social security, see Fehr (2016). The work of Mai *et al*. (2013), Zuo *et al.* (2020), and Nassios *et al*. (2019) are examples of applications of CGE models to pension policies. They all come from the Centre of Policy Studies (the Australian School of CGE – Dixon and Rimmer (2016)), place from where the model developed in this Thesis is enrooted through Cedeplar-NEMEA research laboratory[3].

This Chapter presents the structure of BRIGHT (Brazilian Social Accounting – General Equilibrium Model for Income Generation, Households and Transfers) developed by Freire Cardoso (2020) based on PHILGEM (Corong and Horridge, 2012). Since then, it has been explored, updated, and innovated to access new possibilities of experiments involving income transfers in the Brazilian economy. Apart from this brief introduction, the next section delivers a glimpse of what is new in the BRIGHT model

[2] According to Kirchsteiger (1999), though, both approaches to risk analysis can provide adequate results if applied in a correct and non-biased way. See Hertel et al. (2007) for a CGE validation discussion.
[3] https://pesquisas.face.ufmg.br/nemea/.

from its original form, section 2 explores the model's Pension Module, followed by its Fiscal Module in section 3. Section 4 shows its households' income distributional quality, followed by the additional aspects section.

2.1 BRIGHT: What is new?

The base for this Thesis methodological framework is BRIGHT (Brazilian Social Accounting – General Equilibrium Model for Income Generation, Households and Transfers), a CGE model of national aggregation with elements of recursive dynamics that incorporates the income circular flow through a Social Accounting Matrix (SAM). In its original version, developed by Freire Cardoso (2020)[4], there were 55 productive sectors, 110 commodities and 13 institutional sectors: 10 representative households (defined by 10 different income classes), Enterprises, Government[5] and Rest of the World. There were 3 primary factors (land, labor, and capital), 2 margin sectors (Transport and Retail), imports by commodity for each of the 55 sectors and final demand components, indirect taxes over production and direct taxes over households' income. Its main database was the 2008's SAM, developed by Burkowski *et al.* (2016), in which desegregations through the Consumer Expenditure Survey (POF[6]) 2008-2009 (IBGE, 2014) were done accordingly. GEMPACK[7] (Horridge *et al*., 2019) is the software where BRIGHT is run.

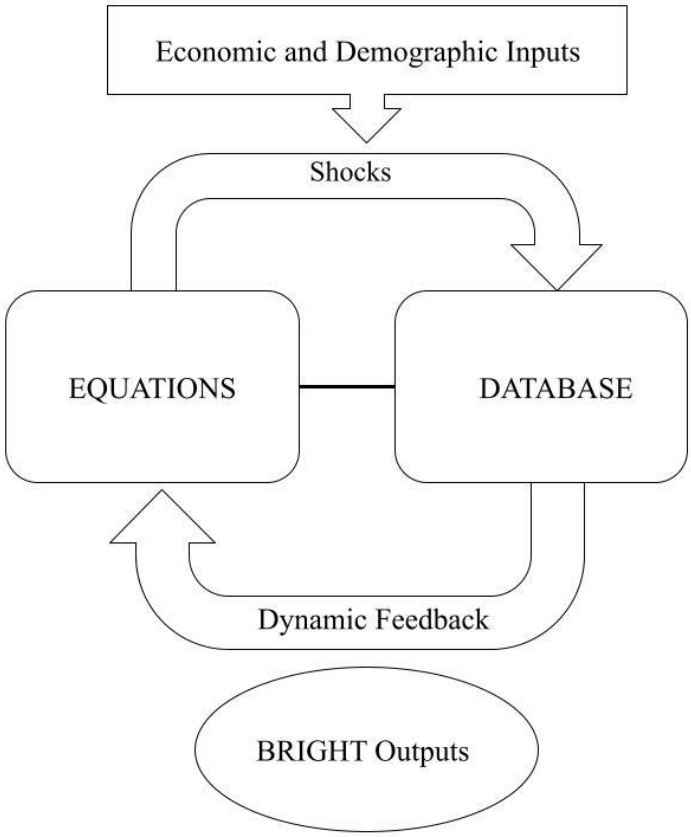
BRIGHT has been applied on several policy studies for the Brazilian economy. To evaluate the multi-dimensional impacts of the income transfers of the Bolsa Família Program (PBF), the income transfers flow from Government to Households was disaggregated between "PBF" and "Others" through POF 2008-2009 (IBGE, 2014), for the 10 representative households. Freire Cardoso (2020) also verifies the impacts of changes in taxation, also explored by Libânio (2021). In the context of fiscal austerity adopted by Brazilian Federal Government through the Constitutional Amendment 95/2016 (the "Expenditure Ceiling"), Cardoso (2019) verifies the effects of a government expenditure stagnation in the economy over a 20-year projection. Freire Cardoso *et al.*

[4] A meticulous exploration of the model can be found in Freire Cardoso (2020) original structure and Corong and Horridge (2012), for this Thesis is focused on the innovations and the fiscal perspectives of the model.
[5] General Government: according to the OECD definition, it consists of central, state, and local governments and the social security funds controlled by these units.
[6] Pesquisa de Orçamentos Familiares.
[7] https://www.copsmodels.com/gempack.htm

(2024) evaluate the impact of unidirectional cuts in pension and assistance benefits on the Brazilian economy.

Figure 2.1 illustrates the diagram of the model: built over the classical economic theory[8], its database and equations are connected in a way that shocks (inputs) shape the database dynamically over the extension of the simulations, providing multiple format outputs[9](period-by-period and cumulative percentage deviations, updated values from the database, etc.), according to the model's features.

Figure 2.1 – Stylized Diagram of BRIGHT



Source: Own elaboration.

The first step of the methodological work of this Thesis was to update BRIGHT's database with the Brazilian 2015's SAM (Burkowski et al. 2016), in which 11 household income classes were disaggregated according to the POF 2017-2018 (IBGE, 2019) data, incusing its class dimension in every income transfer from and towards households[10]. It

[8] See the Tablo files of Corong and Horridge (2012), available at the "TPEC0138" archive, at https://www.copsmodels.com/archivep.htm.
[9] See GEMPACK manual, available at https://www.copsmodels.com/gpmanual.htm, for detailed explanations.
[10] Annex 1 shows the list of POF 2017-2018 variables used as proxy for BRIGHT flows disaggregation.

also brings 65 industries and 130 commodities in its structure. This version of the model has already been applied to investigate the impacts of the social aid (Auxílio Emergencial Program – PAE) transfers during and after the Covid-19 crisis (Freire Cardoso *et al.*, 2021); the essay of a tax reform (Freire Cardoso *et al.,* 2022); and the PBF expansion policy (Domingues *et al.*, 2023).

According to IBGE's definition, "the Consumer Expenditure Survey - POF assesses the structures of consumption, expenditures, income, and part of the asset variation of the households, providing a profile of the life conditions of the population based on the analysis of the household budgets. In addition to the information directly associated with the budget structure, several characteristics of the housing units and households are also investigated, including the subjective self-assessment of life quality." Table 2.1 shows the households characteristics according to BRIGHT's standard disaggregation by POF 2017-2018 (IBGE, 2019). One can have a glimpse of the economic aspects of Brazilian society, especially regarding its income distribution, as shall be further detailed in this Chapter.

Table 2.1 - BRIGHT Households main characteristics

Household Income Classes	Minimum wage brackets	Households (million)	%	Population (million)	%	Per capita Monetary Income (R$)	Total Income (R$ million)[1]	%
HOU1	0 –| 1	4	5.8	11.4	5.5	182	22,523	0.4
HOU2	1 –| 2	12.7	18.4	34.1	16.5	439	160,501	2.8
HOU3	2 –| 3	13.1	19	37	17.9	704	307,740	5.3
HOU4	3 –| 5	16.2	23.5	50.7	24.5	1,012	794,551	13.8
HOU5	5 –| 6	4.9	7.1	16.1	7.8	1,348	400,490	7.0
HOU6	6 –| 8	6.2	8.9	20.4	9.8	1,702	659,518	11.4
HOU7	8 –| 10	3.3	4.8	10.7	5.2	2,274	470,651	8.2
HOU8	10 –| 15	4.3	6.2	13.4	6.5	3,120	838,478	14.6
HOU9	15 –| 20	1.8	2.6	5.5	2.6	4,514	476,983	8.3
HOU10	20 –| 30	1.4	2	4.3	2.1	6,703	562,347	9.8
HOU11	> 30	1.2	1.7	3.5	1.7	13,506	1,066,721	18.5
Total		69	100	207.1	100	3,228	5,760,503	100

Source: Own elaboration according to POF 2017-2018 (IBGE, 2019).
[1]From BRIGHT's SAM database.

Table 2.2 shows BRIGHT Aggregate Social Accounting Matrix 2015 database, the “macro-SAM”. It is a square matrix made from 16 accounts with entries along the rows representing receipts while column entries track expenditures, summarizing the most important information about the model’s database. To help to understand it, the accounts are divided by dotted lines in “Firms and Commodities” group; the “Value Added” group; the single “Direct Taxes”[11], the institutional sectors’ Households, Enterprises and Government current demand; and at last, the Private and Public Investment, along with Stocks and the Rest of the World (ROW).

One must read the numbers in the matrix understanding that the inputs are flows from the agent in the columns appropriated by the agent in the rows. In this way, for example, Government revenues are given by the sum of the entries in its respective row, while expenditures are the entries in the column. Thus, according to the matrix, Government have spent R$1.181 trillion on direct consumption of domestic goods and services. It is worth remembering that, according to the System of National Accounts, public services such as administration, health and education are accounted as Government consumption and not of households. The first entry in the Government row in the matrix, the Gross Operating Surplus (GOS), is precisely the sum of this factor earned by public sectors (R$ 87.589 billion). The rest of the Value-Added section made from indirect taxes (ProdTax; ComTax and Tariff) is Government's main source of income and sums to R$898.750 billion. It also receives transfers from Households, Enterprises, and itself and, finally, from the ROW. One may notice the balance R$ -361.917 billion in Government’s column intersection with Private Investment row: that is for Government savings, given from the difference between its revenue and expenditure, that the SAM accounts as part of Private Investment (also detailed in the Fiscal Module). GDP could be then read according to its income side: the sum of the entries formed by the intersections of the institutional sectors in the rows with the Value-Added columns (approximately R$5.995 trillion).

[11] Drained out of household’s income, after the value-added consolidation thus.

Table 2.2 - BRIGHT Aggregate Social Accounting Matrix (SAM) Database (in millions of Reais (BRL) – R$ 1,000,000) – 2015.

SAM	1 Firms	2 DomCom	3 ImpCom	4 Labor	5 Capital	6 ProdTax	7 ComTax	8 Tariff	9 DirTax	10 Households	11 Enterprises	12 GovCurrent	13 GovInvest	14 PrvInvest	15 Stocks	16 ROW	Total
1 Firms	0	10226869	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10226869
2 DomCom	4092532	0	0	0	0	0	0	0	0	3272953	0	1181381	23067	911090	-21186	767032	10226869
3 ImpCom	636966	0	0	0	0	0	0	0	0	150360	0	2615	2209	87245	2090	0	881484
4 Labor	2952907	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1450	2954357
5 Capital	2143943	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2143943
6 ProdTax	58751	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	58751
7 ComTax	341770	0	0	0	0	0	0	0	0	411689	0	1883	1131	44656	0	0	801129
8 Tariff	0	0	38870	0	0	0	0	0	0	0	0	0	0	0	0	0	38870
9 DirTax	0	0	0	0	0	0	0	0	0	195923	273770	0	0	0	0	0	469693
10 Households	0	0	0	2952907	676649	0	0	0	0	98358	909267	1108318	0	0	0	15003	5760503
11 Enterprises	0	0	0	0	1379704	0	0	0	0	413007	1389183	410739	0	0	0	-11526	3581107
12 GovCurrent	0	0	0	0	87589	58751	801129	38870	469693	711302	210677	553345	0	0	0	8859	2940215
13 GovInvest	0	0	0	0	0	0	0	0	0	0	0	26406	0	0	0	0	26406
14 PrvInvest	0	0	0	0	0	0	0	0	0	304572	708867	-361917	0	3380495	0	545944	4577962
15 Stocks	0	0	0	0	0	0	0	0	0	0	0	0	0	-19096	0	0	-19096
16 ROW	0	0	842614	1450	0	0	0	0	0	202339	89343	17444	0	173572	0	0	1326762
Total	10226869	10226869	881484	2954357	2143942	58751	801129	38870	469693	5760503	3581107	2940215	26406	4577962	-19096	1326762	45995823

Source: Own elaboration according to BRIGHT database.

2.2 Pension Module

The Pension Module described in this section is the biggest contribution of this Thesis to BRIGHT model development. Although inspired in similar CGE proposals, our approach brings distinctive characteristics of the Brazilian social security structure and its connections to the rest of the economy.

Usual to this CGE approach, this section is divided into two main parts about pensions, the accounts – or database –, showing the aggregate numbers of Brazilian Social Security as part of the country's national accounts (from the macro-SAM's perspective); and the equations, showing how they interact with the other variables of the model.

2.2.1 Pension Accounts

It took some effort to disaggregate BRIGHT's Social Accounting Matrix structure database according to the Brazilian public pension accounts. The aggregated values from the social security yearbooks and reports were identified in the SAM respective flows and then the household class disaggregation followed the usual routine according to the POF 2017-2018 data. That was the step number one in the ambition of modelling a robust system of pensions in a CGE structure. BRIGHT is now able to access multi-aspects experiments on both the National Pension Scheme (RGPS) and the Civil Service Pension Plan (RPPS), as well as the Military, and the Continuous Cash Benefit (BPC), a non-contributory assistance benefit aimed at poor elderly and disabled people.

Under control of the National Institute for Social Security (INSS), the National Scheme aggregated data is marked by a transparent multi open-source of regular publicity. To introduce pension information to BRIGHT's database, the Statistical Yearbook of Social Security[12] - AEPS (BRASIL, 2015) and the AEPS Infologo platform (DATAPREV) data were contrasted with the SAM aggregated flows. BPC data come from the MDS[13], available through the Federal Government open-source platform. Usual to BRIGHT's multiple household disaggregation routine, transfers were then split according to the POF 2017-2018 information.

[12] Anuário Estatístico da Previdência Social (AEPS).
[13] Ministry of Development and Social Assistance, Family and Fight Against Hunger.

Differently from the National Scheme, the Civil Service Pension Plan ("Own" Scheme – or schemes) are not centralized in a single jurisdiction such as the INSS. They are established by the Union, States, the Federal District and Municipalities separately to support its public workers that hold permanent positions. As the National Scheme, the more than 2000 own schemes are equally guided, supervised, inspected, and monitored by the Ministry of Social Security. Another significant difference is that the public sector is made from two very distinct categories: civil and military; in which pension and social security rules apply significantly differently over each of them. The main source for data disaggregation is the Summary Report on Budget Implementation from the Federal Government and Other Demonstratives[14] (National Treasury, 2015). Appendix A brings details about it as well as some discussion on the characteristics of the Public Sector's "Own" Schemes of Social Security.

i. Contributions

BRIGHT's macro-SAM database, depictured in Table 2.2, shows that the total flow Labor gets from Firms (4-1) is 2,952,907 (R$ 2.953 trillion). According to the Brazilian System of National Accounts (IBGE, 2016), however, this total equals the sum of Wages (R$ 2.410 trillion) and Social Contributions (R$ 542 billion), compulsorily taken from both private and public sector formal workers to subsidize Brazilian social security and other programs[15]. That total is exactly what Households earn from Labor (10-4), although social contributions are not part of their disposable income (IBGE, 2015).

Table 2.3 shows that part of the flow from Households to Government (12-10) can be split into the two main schemes of public pensions, the National Scheme (mainly made by private sector workers) and the public sector's "Own Schemes". Contributions[16] to the National Scheme accounts R$300 billion. Contribution from public civil workers to the RPPS sum R$ 71.2 billion while military contributions, R$ 6.45 billion.[17] The rest of the

[14] Relatório Resumido da Execução Orçamentária do Governo Federal e Outros Demonstrativos (RREO).
[15] Salary bonus, the Severance Fund Contribution (FGTS), and others aimed at funding programs such as the unemployment compensation, the job search assistance and training and the microenterprise support schemes (Amaedo *et al.*, 2000).
[16] It is divided between compulsory contributions, from the hired employee, and individual contributions, as detailed in Chapters 5.
[17] Appendix A shows how the values were calculated (see Table A1).

flow (12-10), mainly made from real state and motor vehicle taxation and fines revenue[18], is R$ 333.4 billion, totaling R$ 711.3 billion.

Table 2.3 – Contributions to Pension Schemes as part of Households transfers to Government (R$ million). Brazil, 2015.

	RGPS	RPPS		-
Households	Total Contributions	Civil	Military	Rest
H1	1,478	29	0	3,859
H2	12,201	690	11	10,171
H3	23,886	1,831	15	17,485
H4	62,370	5,284	220	44,875
H5	27,141	3,211	192	24,071
H6	41,607	6,345	1,078	37,934
H7	27,625	6,562	857	31,591
H8	42,661	12,632	2,228	54,254
H9	19,128	7,420	665	29,158
H10	21,328	11,395	813	33,623
H11	20,656	15,821	460	46,441
Total	300,081	71,220	6,540	333,461

Source: BRIGHT database.
RGPS – National Pension Scheme.
RPPS – Public Sector's "Own" Schemes of Social Security.

Government also contributes to the National Scheme (as well as to the RPPS), mostly by transfers from the National Treasury to the INSS. The Intra-Government flow (12-12) from the macro-SAM is then divided into National Scheme, R$ 87.5 billion, RPPS (Civil), R$ 49.2 billion, RPPS (Military), R$ 3.86 billion and Rest, R$ 412.7 billion, totalizing R$553.345 billion.

ii. Benefits

As Table 2.2 shows, the total amount that Households get from Government (10-12) is 1,108,319 (R$ 1.1 trillion). One could split that flow into National Scheme benefits (R$ 467.5 billion), RPPS benefits (R$ 198.9 billion, for civil workers; R$ 62.7 billion for militaries), BPC (R$39.6 billion), and Rest (R$ 339.5 billion).

There are two major kinds of benefits common to all schemes, however: retirement pensions benefits (by age and length of contribution) – hereafter *pensions* – and other kinds of benefits – hereafter *other benefits* – not related to one's work life-cycle contributions, such as accident leave, retirement by disability, pension inherited by death,

[18] See Item 11 of Annex 1.

sustenance benefits for elderly and disabled, etc.[19]. As Table 2.4 shows, the sum of both benefits from the National Scheme are almost the same, the distributions vary for the fact that poorer households (H1 to H5) get a higher share of the other kinds of benefits compared to retirement benefits. Militaries and public civil workers' retirement pension and other benefits, historically more generous than the National Scheme, are more concentrated amongst richer households, while BPC transfers are tinier and concentrated amongst poor households. The Rest of Government's transfers astonishes by its size and distributional aspects. They are made from restitutions, obligations, and other assistances. Combined, they represent approximately 30% of the transfers from Government to Households and show a completely different distribution: the richest class (H11) takes the biggest share of it, summing up to 8% of the whole (10-12) flow.

[19] Synonyms are: non-retired pensioner or only pensioner.

Table 2.4 – Pension benefits as part of Households income from Government. Brazil, 2015

	RGPS		RPPS Civil		RPPS Military		BPC		
Households	Pensions	Others	Pensions	Others	Pensions	Others	Pensions	Others	Rest
H1	1,084	1,110	234	234	60	119	190	229	963
H2	20,370	21,225	1,169	742	300	379	5,054	6,099	6,389
H3	40,273	43,318	2,708	2,243	695	1,146	5,119	6,178	14,146
H4	54,013	62,138	9,050	5,840	2,322	2,985	5,033	6,073	45,329
H5	17,250	21,959	5,082	1,913	1,304	978	1,054	1,272	20,487
H6	28,000	27,710	12,220	3,649	3,136	1,865	719	868	45,564
H7	18,451	15,780	11,509	4,000	2,953	2,044	430	519	26,027
H8	25,454	19,280	29,004	7,607	7,443	3,888	166	201	41,371
H9	12,815	7,725	23,975	8,664	6,152	4,428	114	138	17,057
H10	8,772	5,767	21,597	4,271	5,542	2,183	60	72	31,850
H11	10,952	4,053	36,506	6,672	9,368	3,410	26	31	90,398
Total	237,434	230,066	153,056	45,835	39,276	23,427	17,966	21,680	339,579

Source: BRIGHT model's database. Own calculations based on the average monthly number of individual beneficiaries. Basis of Social Security historical data — Aeps Infologo.
RGPS – National Pension Scheme.
RPPS Civil – Civil Service Pension Plan.
RPPS Military – Military "Own" Scheme of Social Security.
BPC – Continuous Cash Benefit.

2.2.2 Pension Equations

Frame 2.1 shows the equations that identify contributions as part of the BRIGHT's SAM flows. As previously explained, those transfers are made by both households and Government, and are addressed according to each pension scheme, accounted as Government income. As part of GEMPACK syntax, equations show the upper-case aggregates variables weighted by each associated nominal percentage growth rate lower-case variable[20].

Frame 2.1 – BRIGHT Main Equations – Contributions to Pension Schemes

From Households Income

$$VDISPINC_h * wdispinc_h = VINCHOU_h * winchou_h - VTAXHOU_h * wtaxhou_h - VGOVHOU_h * wgovhou_h - VCONTRIB_{hs} * wcontrib_{hs} \quad (1)$$

In which:

$VDISPINC_h$: Households disposable income

$VINCHOU_h$: Pre-tax Households' income

$VTAXHOU_h$: Households income tax to Government

$VGOVHOU_h$: Households transfers to Government

$VCONTRIB_{hs}$: Contributions by households to the pension schemes

From Households Savings perspective

$$VSAVHOU_h = VINCHOU_h * winchou_h - V3TOT_h * w3tot_h - VGFTHOU_h * wgfthou_h - VENTHOU_h * wenthou_h - VGOVHOU_h * * wgovhou_h - VCONTRIB_{hs} * wcontrib_{hs} - VTAXHOU_h * wtaxhou_h - VROWHOU_h * wrowhou_h \quad (2)$$

In which:

$VSAVHOU_h$: Households savings

$V3TOT_h$: Total purchases by households

$VGFTHOU_h$: Inter-household transfers gift pool

$VENTHOU_h$: Enterprises receipts from Households

$VROWHOU_h$: Households transfers to the Rest of the World

[20] If not, it is considered a formula, in which variables are modelled separately (as in Households savings).

From Inter-Government transfers

$$VGOVGOV = VGOVCON_s + Rest \quad (3)$$

In which:

$VGOVGOV$: Inter-Government transfers

$VGOVCON_s$: Government contributions to the pension schemes

Rest: Rest of the Inter-Government transfers

To Government Income

$$VINCGOV * wincgov = V0TAX\_CSI * w0tax\_csi + VGOVGOS * wgovgos + VGOVENT * wgovent + VTAXENT * wtaxent + VGOVROW * wgovrow + VGOVHOU_h * wgovhou_h + VTAXHOU_h * wtaxhou_h + VCONTRIB_{hs} * wcontrib_{hs} + VGOVGOV * wgovgov \quad (4)$$

In which:

$VINCGOV$: Government income

$V0TAX\_CSI$: Total indirect tax revenue

$VGOVGOS$: Government receipts/income from GOS

$VGOVENT$: Transfers from Enterprises to Government

$VTAXENT$: Enterprise direct income tax payments

$VGOVROW$: Transfers from the Rest of the World to Government

Note 1: Upper-case variables represent the aggregates values; they are weighted by each associated nominal growth rate lower-case variable.

Note 2: Subscript *h* stands for households and it means that the flow is disaggregated by the household dimension (11 household income classes). The subscript *s* stands for pension scheme (RGPS, RPPS – Civil and Military, and the BPC).

Source: Own elaboration according to BRIGHT equations.

Frame 2.2 shows the pension schemes' benefit flows from Government to Households. For all the schemes, they are divided in two main flows: retirement pensions (VBENAPOS) and other pensions (VBENREST).

Frame 2.2 - BRIGHT Main Equations – Pension Benefits

From Government Current Expenditure

$$VCURGOV * wcurgov = V5TOT * w5tot + VGOSGOV * wgosgov + VROWGOV * wrowgov + VHOUGOV_h * whougov\_h + VBENAPOS_{hs} * wbenapos_{hs} + VBENREST_{hs} * wbenrest_{hs} + VENTGOV * wentgov + VGOVGOV * wgovgov \quad (5)$$

In which:

$VCURGOV$: Current Government Expenditure

$V5TOT$: Total value of government demands

$VGOSGOV$: Government Gross Operational Surplus payments

$VROWGOV$: Government transfers to the Rest of the World

$VHOUGOV_h$: Government transfers to Households

$VBENAPOS_{hs}$: Benefits from the pension schemes to retired people

$VBENREST_{hs}$: Other benefits from the pension schemes to households

$VENTGOV$: Interest on public debt/Transfers from Government

$VGOVGOV$: Transfers from Government to Government

To Households Income

$$VINCHOU_h * winchou_h = VHOUGOS_h * whougos_h + VHOUENT_h * whouent_h + V1LABINC\_IO_h\ w1labinc\_io_h + VHOUGOV_h * whougov_h + VBENAPOS_{hs} * wbenapos_{hs} + VBENREST_{hs} * wbenrest_{hs} + VHOUGFT_h * whougft_h + VHOUROW_h * whourow_h \quad (6)$$

In which:

$VINCHOU_h$: Pre-tax Household income

$VHOUGOS_h$: Households receipts/income from GOS

$VHOUENT_h$: Households receipts from enterprises

$V1LABINC\_IO_h$: Aggregated Households Labor Income

$VHOUGOV_h$: Households receipts from the Government

$VBENAPOS_{hs}$: Households income from retirement benefits

$VBENREST_{hs}$: Households income from others benefits

$VHOUGFT_{h}$: Inter-household transfers gift pool

$VHOUROW_{h}$: Households receipts from Rest of the World

Note 1: Upper-case variables represent the aggregates values; they are weighted by each associated nominal growth rate lower-case variable.

Note 2: Subscript *h* stands for households and it means that the flow is disaggregated by the household dimension (11 household income classes). The subscript *s* stands for pension scheme (RGPS, RPPS – Civil and Military, and the BPC).

Source: Own elaboration according to BRIGHT equations.

Frame 2.3 and 2.4 show how pension contributions and benefits are really modelled in the BRIGHT structure. The lower-case linear variables are modelled as change or percentage change.

Following Peng (2019) and Zuo *et al.* (2020), contributions from households are function of the aggregate employment and the derived wage bill matrix (Labor income)[21]. Additional shifters are often used as scalars but they can also serve as slack variables for making contributions exogenous. Government contributions follow households' contributions.

[21] That seems to be a reasonable idea, although problems regarding the labor market and the pension scheme enrollment might occur, as it shall be better explored in Chapter 5.

Frame 2.3 - BRIGHT Main Equations – Modelling the Contributions to Pension Schemes (percentage change variables)

From Households

$$wcontrib_{h,s} = \boldsymbol{employ\_i} + w1labinc\_io_{h} + fcontrib_{h,s} + fcontrib\_h_{s} \quad (7)$$

In which:

$wcontrib_{h,s}$: Households' contributions to each pension scheme

$\boldsymbol{employ\_i}$: Aggregate employment

$w1labinc\_io_{h}$: Total Labor income

$fcontrib_{h,s}$: Pension contribution rate shifter (by household and scheme)

$fcontrib\_h_{s}$: Pension contribution rate shifter (by scheme)

From Government

$$wgovcon_{s} = wcontrib\_h_{s} \quad (8)$$

In which:

$wgovcon_{s}$: Government's contributions to each pension scheme

$wcontrib\_h_{s}$: Households' contributions to each pension scheme

Note 1: In GEMPACK syntax, when a letter follows an underscore, like the letter *i* in employ_i (*i* stands for the *industry* dimension), it means that the flow is in the aggregated form. Letter *o* stands for occupation (only one general type in BRIGHT – *workers* – however).

Note 2: Variables in **bold** come from demographic projections, presented in Chapter 4.

Source: Own elaboration according to BRIGHT equations.

Frame 2.4 shows the linearized equations that postulate pension benefits to retired households (wbenapos) and the one that models the other pension benefits growth rates (wbenrest). One important difference is that, while the former follows the senior population growth rate (eligible pensioners), the latter follows the entire population growth rate. They both consider, in addition, a price component effect measured by the average nominal wage – that hypothesis follows the fact that the minimum wage is an important price index in the Brazilian economy, especially for determine the basic salaries

and the public transfers, as well as influence negotiations on salary floors for professional categories.

Frame 2.4 – BRIGHT Main Equations – Modelling the Benefits of the National Scheme (percentage change variables)

Retirement Pension Benefits

$$wbenapos_{hs} = \boldsymbol{numpens} + p1lab\_io + fbenapos_{hs} + fbenapos\_h_s \quad (9)$$

In which:

$wbenapos_{hs}$: Households income from retirement pension benefits

$\boldsymbol{numpens}$: Population eligible for retirement benefits

$p1lab\_io$: Average nominal wage

$fbenapos_{hs}$: Pension benefit shifter by household and scheme

$fbenapos\_h_s$: Households' pension benefit shifter by scheme

Other Pension Benefits

$$wbenrest_{hs} = \boldsymbol{q_h} + p1lab\_io + fbenrest_{hs} + fbenrest\_h_s \quad (10)$$

In which:

$wbenrest_{hs}$: Households income from other Pension Benefits

q_h : Number of households (total population)

$p1lab\_io$: Average nominal wage

$fbenrest_{hs}$: Other pension benefits' shifter, by household and scheme

$fbenrest\_h_s$: Households other pension benefits' shifter, by scheme

Note 1: Every household has the same growth rate in q_h.
Note 2: Variables in **bold** come from demographic projections, presented in Chapter 4.

Source: Own elaboration according to BRIGHT equations.

Frame 2.5 shows the other two BRIGHT equations where population growth rate appears. Essentially, they are: the subsistence consumption equation (the counterpart of the luxury demand for composite commodities, see section 3.5.4) and the total labor income equation.

Frame 2.5 – BRIGHT Main Equations – Other Populational Aspects

Subsistence demand for composite commodities

$$x3sub_{ch} = DUMMYLUX_{ch} * [\boldsymbol{q_h} + a3sub_{ch}] \quad (11)$$

In which:

$x3sub_{ch}$: Subsistence consumption, by commodity and household class

$DUMMYLUX_{ch}$: Dummy variable for lux commodity consumption (by commodity and household class)

q_h : Number of households (total population)

$a3sub_{ch}$ = Taste change (by commodity and household class)

Labor Income

$$w1labinc_{ioh} = p1lab_{io} + x1lab_{io} + \boldsymbol{q_h} + labslack_{io} \quad (12)$$

In which:

$w1labinc_{ioh}$: Total labor income, by industry, occupation, and household class

$p1lab_{io}$ = Wages by industry and occupation

$x1lab_{io}$ = Employment by industry and occupation

$labslack_{io}$ = Employment rate by industry and occupation (slack variable).

Note 1: Variables in **bold** come from demographic projections, presented in Chapter 4

Source: Own elaboration according to BRIGHT equations.

It became quite clear how pension schemes are modelled in the CGE perspective. More specifically, how contributions and benefits are driven in BRIGHT model, especially considering the role of the population, the senior population, the workforce, and employment. It answers the initial development of this chapter by showing how actuarial and demographic projections can feed the model, and how the economic effects might spread over the rest of the economic chain, aspects that may become clearer as the experiments of this Thesis come. The next section continues this approach by detailing the functioning of BRIGHT Fiscal Module.

2.3 Fiscal Module

It takes well-structured aspects to build a robust fiscal module in a CGE framework such as BRIGHT's. As in the Pension Module, there is also a database, with detailed Government income sources and expenditure allocations and, naturally, several equations to model each of them accordingly. This section unfolds BRIGHT's Fiscal Module, showing how important Brazilian pension schemes flows are from Government's perspective, how it deals with Government savings and taxation, and the best strategy to work them interactively within a policy evaluation experiment.

2.3.1 Government Savings

To start this subsection, it is worth it to spend some lines of explanation on the matter of *ordinary change* variables, since they shall appear more frequently from this point on in this Chapter.

According to the GEMPACK manual (Horridge *et al.*, 2019), many level variables (for example, prices, quantities, monetary values) are always positive and so it is natural for the associated linear variable to be a percentage change. However, when the relevant levels variable can be positive or zero or negative (apart from Government Savings, examples are the Balance of Trade and an ad valorem tax rate), it is wiser to specify that the associated linear variable is an ordinary change. This is because, in such a case, if the levels value happens to be zero at the start of any step of a multi-step simulation, the associated percentage change could not be calculated (since it would require division by zero). Also, there are often numerical problems (which slow or hinder convergence of the solutions) when a percentage-change variable changes sign in the levels; these problems may be overcome if an ordinary change variable is used because then GEMPACK works with a slightly different linearization of the equations involving this variable.

Government savings, an ordinary change variable, is given by the difference between Government income and expenditure, as Equation 13 postulates. Again, each variable is accompanied by its respective growth rate percentage form (lower-case variable).

$$100 * delSAVGOV = VINCGOV * wincgov - VEXPGOV * wexpgov \qquad (13)$$

i. Government Income

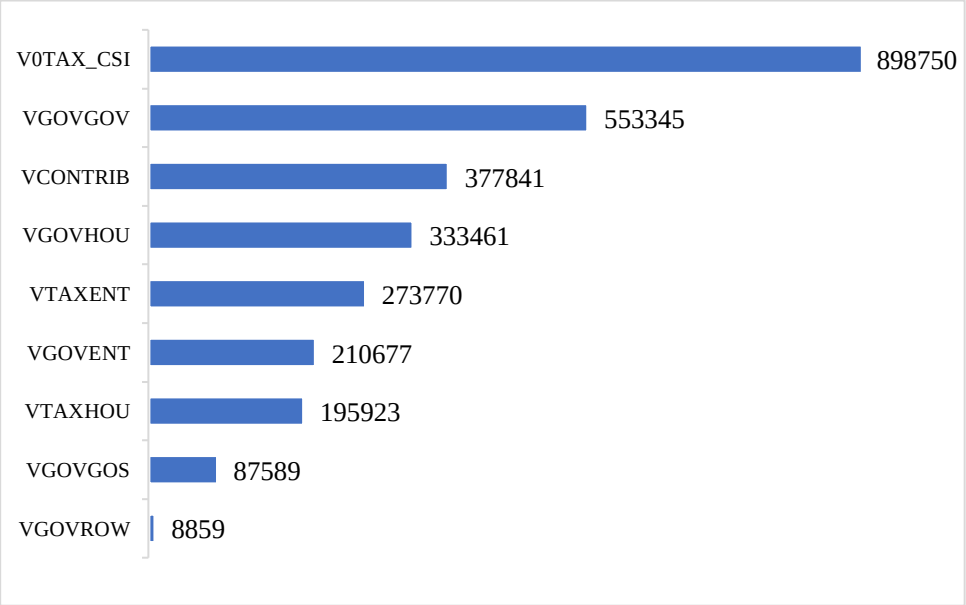
There is a plenty of sources that aggregates Government Income, as Equation 14 shows.

$$\begin{aligned} VINCGOV * wincgov \\ = V0TAX\_CSI * w0tax\_csi + VGOVGOS * wgovgos \\ + VTAXENT * wtaxent + VGOVENT * wgovent \\ + VGOVHOU_h * wgovhou_h + VCONTRIB_{hs} * wcontrib_{hs} \\ + VTAXHOU_h * wtaxhou_h + \text{VGOVROW} * \text{wgovrow} \\ + \text{VGOVGOV} * \text{wgovgov} \end{aligned} \quad (14)$$

Followed by the associated percentage growth rate variables, $V0TAX\_CSI$ is the Total indirect tax revenue; $VGOVGOS$ is the receipts/income from GOS; $VTAXENT$ is the Enterprise direct income tax payments; $VGOVENT$ is the transfers from enterprises; $VGOVHOU_h$ is the transfers from Households, by household income class; $VCONTRIB_{hs}$ is the Households contributions to the pension schemes, by household income class and pension scheme; $VTAXHOU_h$ is the Household income tax payment, by household income class; VGOVROW is the Transfers from the rest of the world; and VGOVGOV are the inter-government transfers.

Table 2.2 has shown that Government Income is 2,940,215 million in 2015. Graph 2.1 shows all the components of Government Income in BRIGHT's database.

Graph 2.1– Government Income Sources (R$ million). Brazil, 2015



Source: BRIGHT database. $V0TAX\_CSI$ – Total indirect tax revenue; VGOVGOV – Inter-government transfers; $VCONTRIB$ – Households contributions to the Pension Schemes; $VGOVHOU$ – transfers from Households; $VGOVGOS$ –Receipts/income from GOS; $VTAXENT$ – Enterprise direct income tax payments; $VGOVENT$ – transfers from enterprises; $VTAXHOU$ – Household income tax payment; VGOVROW – Transfers from the rest of the world.

One can observe that indirect taxes revenue (V0TAX_CSI) represent the biggest share of it (almost R$900 billion), followed by inter-government transfers, such as those between federative levels (VGOVGOV, R$553 billion). Contributions to pension schemes are the third most significant rubric (VCONTRIB, R$377 billion).

ii. Government Expenditure

In BRIGHT model, Government expenditure is a mix of Current and Capital rubrics, as postulates Equation 15.

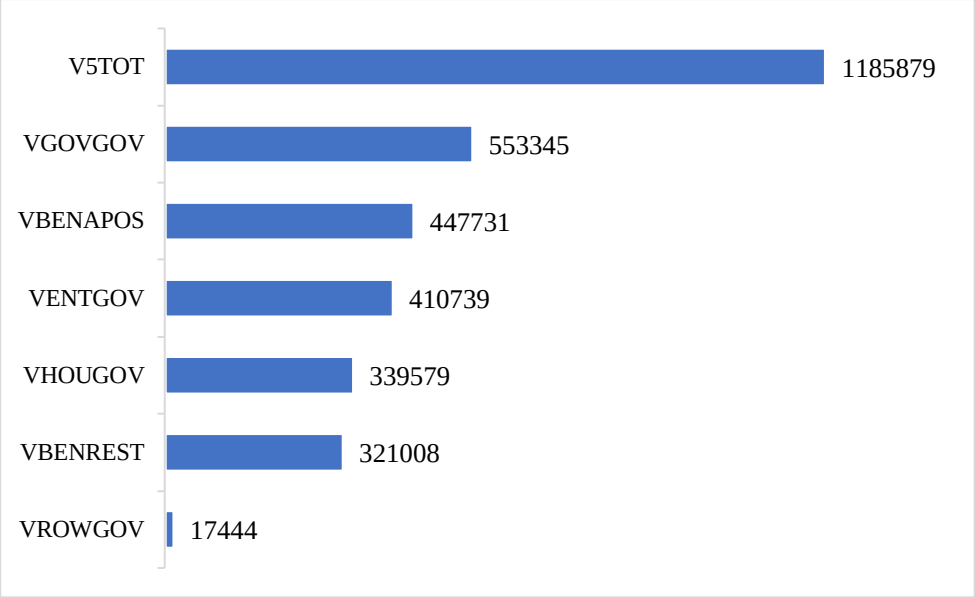
$$VEXPGOV * wexpgov = VCURGOV * wcurgov + VCAPGOV * wcapgov \quad (15)$$

Government current expenditure is then given by Equation 16. The aggregates are also weighted by each associated growth rate lower-case variable.

$$\begin{aligned} VCURGOV = {} & V5TOT * w5tot + VGOSGOV * wgosgov + VROWGOV \\ & * wrowgov + VHOUGOV_h * whougov\_h + VBENAPOS_{hs} \\ & * wbenapos_{hs} + VBENREST_{hs} * wbenrest_{hs} + VENTGOV \\ & * wentgov + VGOVGOV * wgovgov \end{aligned} \quad (16)$$

Followed by the associated percentage growth rate variables, $V5TOT$ is the Total value of Government demands; $VGOSGOV$ is made out of GOS payments from Government; $VROWGOV$ are Transfers to ROW; $VHOUGOV_h$ are transfers to households, by household income class; $VBENAPOS_{hs}$ are Pension Benefits to retired senior households while $VBENREST_{hs}$ are the other benefits from the schemes, both disaggregated by household income class and pension scheme; $VENTGOV$ is made out of Interest on public debt/Transfers from Government to Enterprises and $VGOVGOV$ are inter-Government transfers. Government current expenditure sums R$ 3,275,726 million in BRIGHT's 2015 database. Again, all aggregates shares are depictured in Graph 2.2.

Graph 2.2 – Government Expenditure Components (R$ million). Brazil, 2015



Source: BRIGHT database. $V5TOT$ – Total value of Government demands; $VGOSGOV$ – GOS payments from Government; $VROWGOV$ – Transfers to ROW; $VHOUGOV$ – transfers to households; $VBENAPOS$ – Pension Benefits to retired senior households; $VBENREST$ – other benefits from the schemes; $VENTGOV$ –Interest on public debt/Transfers from Government to Enterprises and $VGOVGOV$ – inter-Government transfers.

Equation 17 describes the Government capital expenditure.

$$VCAPGOV * wcapgov = GOVSHRINV_i * V2TOT_i * [s2gov_i + p2tot_i + x2tot_i] \quad (17)$$

Followed by the associated percentage growth rate variables, $GOVSHRINV$ and $V2TOT$ are respectively the Government share of investment and the total investment, both by industry; and $s2gov$, $p2tot$ and $x2tot$ are respectively the growth rates of the government share of investment, the cost of unit of capital and investment, by industry. BRIGHT's database show a Government Capital Expenditure of R$ 26,406 million.

Capital plays a minor role amongst Government expenditure rubrics. Government demands (consumption) is R$1.1 trillion, followed by Government inter-transfers (it balances the revenue) and, again, in the third position, is the retirement benefits payments (VBENAPOS, R$ 447 billion) – bigger than the Interest on public debt/Transfers from Government to Enterprises (VENTGOV, R$ 410 billion). Government total expenditure sums R$ 3.3 trillion in BRIGHT's database.

There is then a R$ 361.917 billion deficits on Government Savings, as initially verified in Table 2.2. This is an important information when it comes to analyze the fiscal results of the further simulations.

2.3.2 Taxation

To model a taxation system requires a clear identification of the economic agents involved and their respective behavior on transactions and decisions. As one can observe, BRIGHT taxation structure is complete: all production (intermediate), investment, households, exports[22], Government, corporations, and other tickets[23] are subject to taxation at some extent. The general tax shifter for direct and indirect taxes (*ftaxgen*) variable plays an important role, it is a "free" – exogenous variable that relates to the entire tax system of the model, and that is why it is crucial to assess the fiscal dynamics of an experiment.

Equation 18 describes the ordinary change in production tax revenue $delV1PTX_i$, by industry *i*.

$$delV1PTX_i = PTXRATE_i * delV1CST_i + V1CST_i * delPTXRATE_i + 0.01 * V1TOT_i * ftaxgen \quad (18)$$

As previously shown, that is an important source of Government income. In Equation 18, $PTXRATE_i$, $delV1CST_i$ *and* $V1CST_i$ are respectively the Rate of production tax, the Change in ex-tax cost of production, and Total cost of industry, by industry dimension. $delPTXRATE_i$ is the Change in rate of production, $V1TOT_i$ is the Total industry cost plus tax, weighted by the general tax shifter $ftaxgen$.

i. The Power of the Tax

Take an ad valorem tax rate V (specified as a fraction, say 0.2 for a 20 per cent tax or -0.1 for a 10 per cent subsidy); it can be related to an equivalent power of tax T by the simple relationship: T = 1 + V. Because T is always positive (we can exclude the

[22] Imports are subject to *tariffs*, a strictly different concept.
[23] Other cost tickets are miscellaneous production costs, the cost of holding liquidity, and the cost of holding inventory (Dixon et al., 1982).

possibility of a -100 per cent ad valorem tax rate), it can appear in the model as a percentage change variable.

Frame 2.6 shows the tax rate equations of the model, bringing in the concept of an alternative way of describing tax rates: the power of the tax. Apart from *ftaxgen* (the general direct and indirect tax shifter), it is notable the important role of the General sales tax shifter – another example of indirect tax.

Frame 2.6 – BRIGHT Tax Rate Equations: The Power of Taxes

Power of tax on sales to intermediate (t1)

$$t1_{csit} = f0tax\_s_c + f1tax\_csi + f0tax\_cs + ftaxgen \quad (19)$$

In which:

$f0tax\_s_c$: General sales tax shifter, by commodity

$f1tax\_csi_h$: Uniform % change in powers of taxes on intermediate usage

$f0tax\_cs$: General sales tax shifter

$ftaxgen$: General tax shifter for direct and indirect taxes

Power of tax on sales to Investment (t2)

$$t2_{csit} = f0tax\_s_c + f2tax\_csi + f2taxt_{st} + f0tax\_cs + ftaxgen \quad (20)$$

In which:

$f2tax\_csi$: Uniform % change in powers of taxes on investment

$f2taxt_{st}$: Uniform % change in powers of taxes on investment by tax

Power of tax on sales to Households (t3)

$$t3_{csth} = f0tax\_s_c + f3tax\_csh + f0tax\_cs + ftaxgen \quad (21)$$

In which:

$f3tax\_csh$: Uniform % change in powers of taxes on household usage

Power of tax on sales to individual exports (t4a)

$$t4a_{ct} = f0tax\_s_c + f4tax\_trad + f0tax\_cs + ftaxgen \quad (22)$$

In which:

$f4tax\_trad$: Uniform % change in powers of taxes on tradable exports

Power of tax on sales to collective exports (t4b)

$$t4b_{ct} = f0tax\_s_c + f4tax\_ntrad + f0tax\_cs + ftaxgen \quad (23)$$

In which:

$f4tax\_ntrad$: Uniform % change in powers of taxes on non-tradable exports

Power of tax on sales to Government (t5)

$$t5_{cst} = f0tax\_s_c + f5tax\_cs + f0tax\_cs + ftaxgen \quad (24)$$

In which:

$f5tax\_cs$: Uniform % change in powers of taxes on Government usage

Note: as usual, the subscript *c* stands for commodity; *s* is for source (domestic and imported origins); *I* is for industry and *h* is for household income class. Additionally, *t* stands for taxes, in case one is interested in disaggregate it into several different types.

Source: Own elaboration according to BRIGHT model.

Those power of tax ***t*** will then be added over producers, capital creators, households, etc., basic flows to make, respectively, producers, capital creators, households, etc., purchases values. The variable *ftaxgen* can be applied over both ordinary change and power of tax equations – the only difference between the ordinary change Equation 18 and the power of tax equations, previously shown in Frame 5, is the fact that, in equation 18, *ftaxgen*, a percentage change variable, weights the Total industry cost plus tax $V1TOT_i$, making it suitable for the equation's purpose.

Additionally, equations 25, 26 and 27 show that *ftaxgen*, for its direct taxation role, respectively interacts with the indexing of prices of "other cost" tickets ($p1oct_{(i)}$), where $p3tot$ is the Consumer price index and $f1oct_{(i)}$ is the Shift in price of "other cost" tickets; the Corporation taxation ($wtaxent$), where $ftaxent$ is the Ad valorem rate of corporation tax and $went$ is the Total income of enterprises; and the Household's income tax ($wtaxhou_{(h)}$), where $winchou_{(h)}$ is Households Pre-tax income, $f\_inctaxrate_{(h)}$ is the income tax shifter, by household income class, and $f\_inctaxrate\_h$ is the Overall income tax shifter.

$$p1oct_i = p3tot + f1oct_i + ftaxgen \tag{25}$$

$$wtaxent = ftaxent + went + ftaxgen \tag{26}$$

$$wtaxhou_h = winchou_h + f\_inctaxrate_h + f\_inctaxrate\_h + ftaxgen \tag{27}$$

2.3.3 The Role of the Closure

In most economic models, the number of variables exceeds the number of equations. To solve the equations, some of the variables must be predetermined — the exogenous variables — by giving them actual values. This is done by specifying the shocks. Then the equations of the model can be solved to determine the remaining endogenous variables.

The closure of the model is the partition (split) of the set of variables into exogenous and endogenous. For the closure to be valid, the number of endogenous variables must be equal to the number of equations.

Experiments with the BRIGHT model normally stablish a set of exogenous variables that, because of the nature of the evaluated public policy, can be shocked according to external forecasts or ad hoc decisions – e.g., productivity, population, and labor force growth rates, as Frame 2.7 shows.

Frame 2.7 – BRIGHT Regular Closure (Exogenous variables)

Exogenous

a0com ; Commodity CET technology shifter (negative=good)
a1cap ; Capital-augmenting technical change, by industry
a1com ; Intermediate basic tech. change, by industry, source and commodity
a1lab_o ; Labor-augmenting technical change, by industry
a1lnd ; Land-augmenting technical change, by industry
a1tot ; All input augmenting technical change, by industry
a2tot ; Neutral technical change–- investment, by industry
a3_s ; Taste change, hhold imp/dom composite, by source
aprimtot ; General factor augmenting technical change
btslack ; make endogenous to exogenize balance of trade
delPTXRATE ; Change in rate of production tax, by industry
emptrend ; Trend employment
f0tax_cs ; General sales tax shifter
f1lab_io ; Overall wage shifter
f1oct ; IND Shift in price of“"other cos”" tickets, by industry
*f_tax_csi**; Uniform % change in all powers of taxes (as seen in Frame 5)
f3tot_h ; Over-all shifter for consumption
f4p ; COM Price (upward) shift in export demand schedule
f4p_ntrad ; Uniform upward (price) demand shift for collective exports
f4q_ntrad ; Uniform right (quantity) demand shift for collective exports
f5 ; COM*SRC Government demand shift
f5tot2 ; Ratio between f5tot and x3tot
*fben**; All pension benefits shifter by household class and scheme)
*fcontrib** ; All pension contributions shifter by household class and scheme)
ftaxent ; Ad valorem rate of corporation tax
ftaxgen ; General tax shifter for direct and indirect taxes
fx6 ; Shifter on rule for stocks, by commodity and source
f_inctaxrate ; Income tax shifter: by household
f_inctaxrate_h ; Income tax shifter: overall
gtrend ; Trend investment/capital ratio, by industry
invslack ; Investment slack variable for exogenizing aggregate investment
numpens ; number of eligible pensioners, by scheme
pf0cif ; COM C.I.F. foreign currency import prices
phi ; Exchange rate, local currency/$world
q ; Number of households
rnorm ; Normal gross rate of return, by industry
s2gov ; Gov share of investment by industry
t0imp ; Power of tariff, by commodity
x1cap ; Current capital stock, by industry
x1lnd ; Use of land, by industry
x2tot ; Investment by using industry, by industry

Optional swaps:

Old Exogenous = New Exogenous

ftaxgen = *delgovsavrat*; adjust all taxes to hold constant gov. savings/GDP ratio
w3lux = *f3toth*; Household consumption follows Disposable Income
btslack = *del*b; Balance of trade / GDP ratio exogenous
x2tot = *finv4*; Shifter to toggle long run investment rule
x1cap = *faccum*; Shifter to switch on accumulation equation
f1lab_io = *employ_i*; Long run employment growth rate exogenous
f5tot2 = *f5tot3*; Aggregate real government demands follow GDP as in: *x5tot = x0gdpexp + f5tot3 + btslack*

Source: Own elaboration according to BRIGHT model.

When evaluating a policy related to the fiscal side of the economy, for example, it is reasonable to assure Government fiscal balance through a swap between an adjustment variable, i.e., taxes[24], in order to hold constant the ratio of government savings to GDP, as follows the equations 28 and 29.

$$ftaxgen_{(old\ exog.)} = delsavgovrat_{(new\ exog.)} \tag{28}$$

$$\frac{GOVSAV_t}{GDP_t} = \frac{GOVSAV_{t+1}}{GDP_{t+1}} = \cdots = \frac{GOVSAV_{t+n}}{GDP_{t+n}} \tag{29}$$

Note that, because of its wide interaction, the general tax shifter for direct and indirect taxes *ftaxgen* is the most suitable variable for it. Also, *delsavgovrat,* directly derived from Government Savings, is usually endogenous. When the swap of Equation 28 is activated, *ftaxgen* floats endogenously to adjust taxation and hold constant the ratio of Government Savings over GPD as Equation 29 show – that is the fiscal adjustment condition.

However, because GPD and GOVSAV often show different growth patterns (sometimes even opposite directions), that would not be reasonable to use in a baseline forecast: the results might be way contractionary. Because the increase of Government savings is achieved by raising all taxes, in an unrealistic scenario where GDP grows (following the increase of factors productivity or any variable) but taxes grow even more, it is expected then an inadequate Investment and a negative chain effect in the dynamics of the economy because:

a. It raises the effective price of primary factors in a way that discourages capital formation; and
b. Prices, wages, thus transfers from Government shrink in an unrealistic way for a long-run projection.

Fiscal or any similar type of adjustment may still be useful to the CGE modelling style where cumulative deviation results are available[25]. In this example, the deviation of

[24] Question: would it be reasonable to use the pension balance instead? Without surplus, that is no longer possible.
[25] For more information, see GEMPACK Manual, chapter 41 (Horridge *et al.,* 2019).

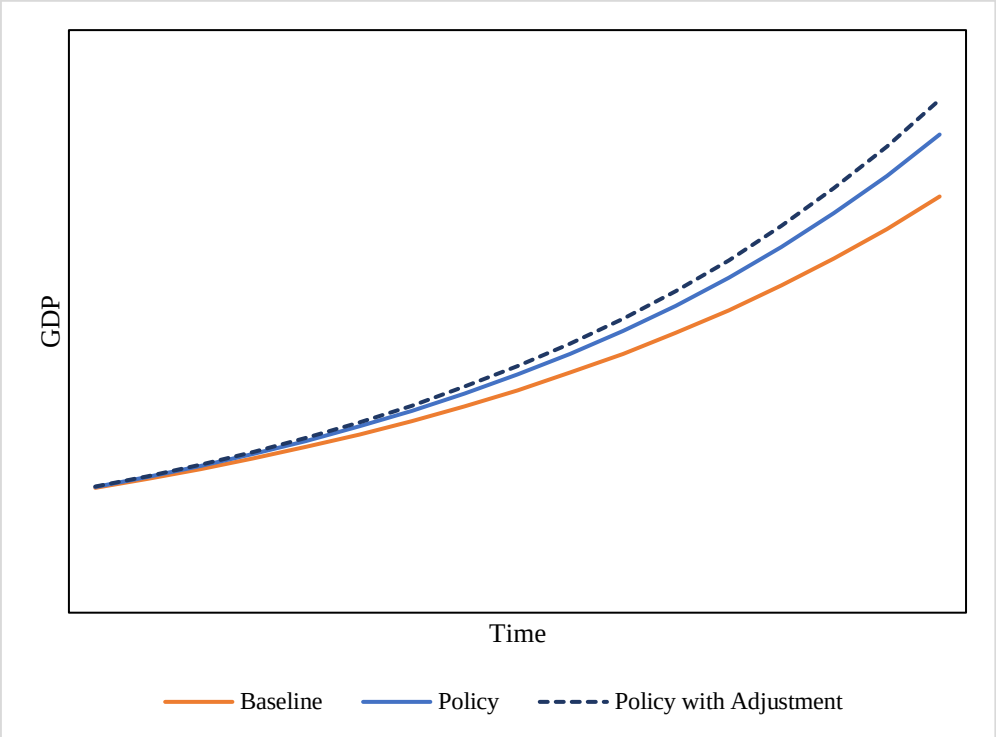
delsavgovrat, an ordinary change variable, is given by the difference to the end of each year *t* caused by the policy shock. Because of the swap, however, the cumulative deviation between policy and baseline scenarios is zero, according to Equation 30, held by the floating *ftaxgen* percentage change variable, calculated each year *t* according to Equation 31. In other words, the swap between *ftaxgen* and *delgovsavrat* enforces changes in Government savings to be compensated by identical changes in general direct and indirect taxation.

$$\sum_{t=1}^{n}\left[\frac{GOVSAV_{t+1}^{pol}}{GDP_{t+1}^{pol}}-\frac{GOVSAV_{t+1}^{base}}{GDP_{t+1}^{base}}\right]-\left[\frac{GOVSAV_{t}^{pol}}{GDP_{t}^{pol}}-\frac{GOVSAV_{t}^{base}}{GDP_{t}^{base}}\right]=0 \tag{30}$$

$$\frac{GOVSAV_{t}^{pol}}{GDP_{t}^{pol}}-\frac{GOVSAV_{t}^{base}}{GDP_{t}^{base}}=100\left[\frac{(1+\frac{ftaxgen_{t}^{pol}-ftaxgen_{t}^{base}}{100})}{(1+\frac{ftaxgen_{t}^{base}}{100})}\right] \tag{31}$$

In this type of modelling, in which policy experiment shocks are added *over* a baseline projection, it is then not only possible to evaluate the direct gain/loss of a policy relatively to a neutral baseline forecast – the deviation –, but the general equilibrium boost/hinder provoked by the adjustment set by that closure in face of a particular policy. Graph 2.3 shows a schematic resolution where a policy impacts endogenous variables – such as GDP – over time, deviating the economy's path from the baseline scenario. Dotted is the line that represents the adjustment's additional effect over the policy. That condition is an alternative for allowing the mechanisms behind the expansionary adjustment hypothesis – see Cardoso (2019) – and brings to the policymakers an allocative perspective derived from the policy. On the other hand, if the idea is to use the occasional surplus to relief Government's budget and reduce its deficit, one should keep $ftaxgen$ exogenous and see $delgovsavrate$ floating accordingly.

Graph 2.3 – Policy Cumulative Deviation to the Baseline (schematic): the Role of the Adjustment Condition



Source: Own elaboration.

2.4 Income Distribution

BRIGHT applications have been well known for its distributional aspect. In fact, that is one of the main advantages of using the model, especially knowing that different sources of income (a BRIGHT's specialty) have different distributions amid households (another specialty). This is true from its very first application, in which Freire Cardoso (2020) concerns about the effects of the *Programa Bolsa Família* (PBF) over the economy through the raise of poorer households' income. Pension contributions and benefits do also show very different distributional patterns amid households, bringing the distributional aspect to the center of the discussion of any reform plan. Summing up:

a. The share of income sources varies considerably between households.

b. Every policy might potentially affect a source of income.

c. Households behave differently.

This last aspect has an important impact: although the consumption/saving pattern is constant in BRIGHT, since the consumption ratio over total expenditure is fixed for all household classes, each household show a different consumption composite of domestic and imported goods and services. It is also worth remembering that, as it is an endogenous account, the level of consumption also varies for each household. Also, according to Freire Cardoso (2020), income elasticities vary between all households according to Hoffman (2010) estimations.

Table 2.5 show, in three parts, the total decomposition of households' income database (from households' total income – the result of a sum of multiple sources of income –, to households' disposable income, after tax deduction and other duties) considering the distributional aspect of each source of income. The blue bars are the result of the conditional formatting over all flows, highlighting that some sources are way more bounteous than others. The reported Gini indexes turn out to be efficient compasses when evaluating the distributional result of an experiment. It is worth highlighting that the Gini indexes might be underestimated, since they do not consider the individual ("intra-class") inequality but only 11 income classes.

Table 2.5 – Income decomposition with the distributional aspect. BRIGHT model database, 2015

Household Classes	VLABINC	VHOUGOS	VHOUENT	RGPS (Retiree)	RPPS (Retiree)	Military (Retiree)	BPC (Age)
HOU 1	36,447	4,847	1,312	1,084	234	60	190
HOU 2	174,484	20,395	10,145	20,370	1,169	300	5,054
HOU 3	287,729	22,903	25,165	40,273	2,708	695	5,119
HOU 4	568,740	52,838	76,517	54,013	9,050	2,322	5,033
HOU 5	229,869	15,040	32,133	17,250	5,082	1,304	1,054
HOU 6	344,597	49,983	73,185	28,000	12,220	3,136	719
HOU 7	240,857	30,404	50,683	18,451	11,509	2,953	430
HOU 8	386,103	45,105	100,179	25,454	29,004	7,443	166
HOU 9	191,336	35,142	68,827	12,815	23,975	6,152	114
HOU 10	251,198	70,705	108,641	8,772	21,597	5,542	60
HOU 11	241,546	329,287	362,480	10,952	36,506	9,368	26
Total	2,952,907	676,649	909,267	237,434	153,056	39,276	17,966
Gini Index	0.4147	0.7295	0.7518	0.4652	0.7678	0.7678	-0.1907

Source: Own elaboration according to BRIGHT database.
VLABINC – Household Labor Income; VHOUGOS – Household receipts/income from Gross Operational Surplus; VHOUENT – Household receipts from Enterprises; RGPS (Retiree) – Retirement Pension Benefits from RGPS; RPPS (Retiree) – Retirement Pension Benefits from RPPS (Civil); Military (Retiree) – Retirement Pension Benefits from RPPS (Military); BPC (Age) – Pension Benefit from Continuous Cash Program (to elderly).

Table 2.5 – Income decomposition with the distributional aspect. BRIGHT model database, 2015 (continued)

Household Classes	RGPS (Other)	RPPS (Other)	Military (Other)	BPC (Disabled)	VHOUGOV	VHOUROW	VHOUGFT	VINCHOU
HOU 1	1,110	234	119	229	963	2	920	47,753
HOU 2	21,225	742	379	6,099	6,389	5	2,818	269,573
HOU 3	43,318	2,243	1,146	6,178	14,146	21	3,260	454,905
HOU 4	62,138	5,840	2,985	6,073	45,329	259	5,652	896,788
HOU 5	21,959	1,913	978	1,272	20,487	256	2,021	350,619
HOU 6	27,710	3,649	1,865	868	45,564	761	5,294	597,552
HOU 7	15,780	4,000	2,044	519	26,027	898	4,303	408,859
HOU 8	19,280	7,607	3,888	201	41,371	2,417	9,325	677,544
HOU 9	7,725	8,664	4,428	138	17,057	2,011	3,436	381,823
HOU 10	5,767	4,271	2,183	72	31,850	2,985	5,184	518,825
HOU 11	4,053	6,672	3,410	31	90,398	5,388	56,145	1,156,263
Total	230,066	45,835	23,427	21,680	339,579	15,003	98,358	5,760,503
Gini Index	0.1906	0.6401	0.6401	-0.1907	0.6326	0.8715	0.7552	0.5201

Source: Own elaboration according to BRIGHT database.

RGPS (Other) – Other Benefits from RGPS; RPPS (Other) – Other Benefits from RPPS (Civil); Military (Other) – Other Benefits from RPPS (Military); BPC (Disabled) – Benefit from Continuous Cash Program (to disabled people). VHOUGOV – Other transfers from Government to Households; VHOUROW – Households receipts from the Rest of the World; VHOUGFT - – Inter-households transfers; VINCHOU - Households Total Income.

Table 5 – Income decomposition with the distributional aspect. BRIGHT model database, 2015 (continued)

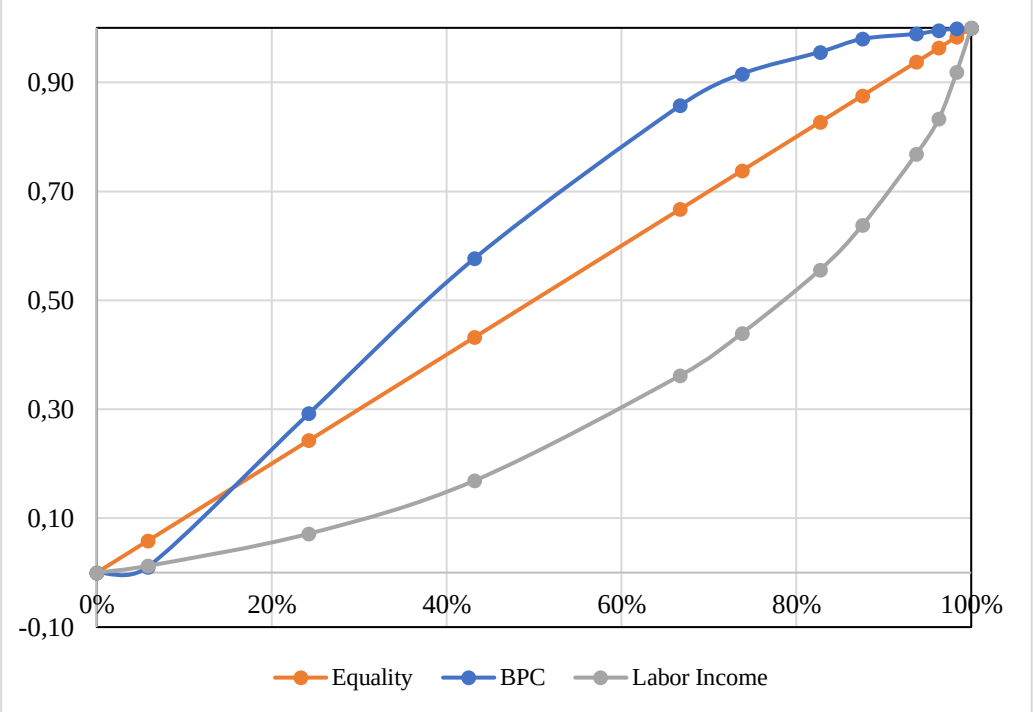
Household Classes	VTAXHOU	RGPS (Contrib.)	RPPS (Contrib.)	Military (Contrib.)	BPC	VGOVHOU	DISPINC
HOU 1	22	1,478	29	0	0	3,859	42,365
HOU 2	68	12,201	690	11	0	10,171	246,432
HOU 3	277	23,886	1,831	15	0	17,485	411,411
HOU 4	3,384	62,370	5,284	220	0	44,875	780,655
HOU 5	3,342	27,141	3,211	192	0	24,071	292,662
HOU 6	9,932	41,607	6,345	1,078	0	37,934	500,656
HOU 7	11,726	27,625	6,562	857	0	31,591	330,497
HOU 8	31,566	42,661	12,632	2,228	0	54,254	534,204
HOU 9	26,258	19,128	7,420	665	0	29,158	299,194
HOU 10	38,981	21,328	11,395	813	0	33,623	412,685
HOU 11	70,367	20,656	15,821	460	0	46,441	1,002,518
Total	195,923	300,081	71,220	6,540	0	333,461	4,853,278
Gini Index	0.8715	0.5078	0.7329	0.7537	-	0.5674	0.5036

Source: Own elaboration according to BRIGHT database.

VTAXHOU – Direct taxes from Households; RGPS (Contrib.) – Households contributions to RGPS; RPPS (Contrib.) – Households contributions to RPPS (Civil); Military (Contrib.) – Households contributions to RPPS (Military); BPC – Households Contributions to BPC; VGOVHOU – rest of the Households transfers to Government; DISPINC – Households Disposable Income.

Table 2.5 shows a bunch of information. It is sensible to start by comparing the difference between household's total income (VINCHOU) – the sum of the several different sources of income – and household's disposable income, concluding that income duties have a slightly progressive role in the Brazilian economy. Then one can notice that the three biggest sources of household's income, labor, capital, and transfers from enterprises, show very different distributional patterns. Then, when analyzing pension flows, one can notice that the RGPS (National Scheme's) benefits are more well-distributed than the RPPS (civil) and the militaries', though the richer contribute relatively more under those schemes[26]. The other type of pension benefits is more equally distributed for all schemes, especially in the National Scheme, although those of the RPPS and the military are still very concentrated on the top. At last, the most curious result is the negative index for BPC disabled and age distributional aspects[27]: a result of the mathematical notion that that income is more representative amongst the poorer than the population itself, so that the curve is above the "perfect equality line" [28], as the Lonrez Curve depictured in Graph 2.4 shows.

Graph 2.4 –Lorenz Curve (selected variables)



Source: Own elaboration according to BRIGHT database.

[26] See Appendix A for more information about the Public Sector social security.
[27] It was not possible to distinguish them with POF information.
[28] The 45º line represents the total number of households (as Table 1 shows), where each knot represents one household class. If an income has the exactly distribution of the population in analysis, the lines are overlapped and the Gini Index (given by the area of the two lines difference) is zero.

2.5 Additional Aspects

As the full explanation of BRIGHT structure can be found in Freire Cardoso (2020) and Corong and Horridge (2012), this methodological chapter finishes with some additional aspects of the model that, although no significant change has taken from its original structure, are still crucially important to comprehend the model's dynamic, especially considering the experiments performed in this Thesis.

2.5.1 Labor Market

Usual to this class of CGE models, the first step of the firm's production structure assumes labor as a homogeneous factor, combined with capital, to be demanded in the first decision stage through a Constant Elasticity of Substitution (CES) technology.

The nesting structure then combines the optimal composition of the labor factor with capital in each sector. At the same time, the demands for intermediate inputs to produce each sector are determined based on an Armington-CES function (Armington, 1969), which specifies the presence of imperfect substitution between domestic and imported commodities. The product materializes in the next stage, through a Leontief aggregation of compounds of primary factors, intermediate inputs, and other costs, such as trade and transport margins.

Each firm supply decision is based on a two-stage profit-maximization process. In Stage 3, firms decide the optimal mix of products to be produced based on a CET (constant elasticity of transformation) function. Then, in the last stage (4), another CET is used to divide the supply of goods between the domestic and foreign markets.

Summing up, the multistage structure results from each firm's optimization decisions. The demand side assumes cost minimization, while the supply side assumes profit maximization. Therefore, their associated first-order conditions generate, respectively, (i) the input of domestic and imported factors and intermediate products; and (ii) production for national and international supply. Although sectors share a common production structure, their behavioral elasticities and input ratios may vary.

Real wage is then given by the ratio between the actual price of labor and economy's general price level. Changes in real wages are given by the dynamic element of the gap between labor supply and demand, the so-called *real wage adjustment*

mechanism. In a long run evaluation, however, Labor demand tends to follow Labor supply – wages are then uniform, flexible and market-clearing.

i. Labor and Capital Income

In BRIGHT structure, labor is a homogeneous production factor. The models presented in Corong and Horridge (2012) and Roos (2014), however, based on a similar structure, add to the production structure and, consequently, to the demand and supply for labor elements that distinguish labor in categories of occupation, age, and gender.

According to the Brazilian System of National Accounts, along with the regular labor income[29] and the gross operating surplus (GOS), the remuneration of the capital factor of the production units legally constituted, there is also the *gross mixed income*, that corresponds to the income obtained by employers and self-employed (autonomous) workers. The mixed income is treated separately by the SNA because it is not clearly to identify whether a self-employed income comes from capital or labor. However, with no impediment to keep labor factor as a single category, i.e., to disaggregate labor according to all those types, the gross mixed income was then split between labor and capital income according to the actual shares of both factors in the Brazilian official input-output table, by industry, differently from BRIGHT's original version, where mixed income was treated as GOS.

2.5.2 Capital Accumulation

The model is solved on a year-to-year basis (that is, recursively) starting from the database year[30]. For each subsequent year-window, the starting data is the updated data produced by the previous simulation (Horridge *et al.,* 2019). Investment and capital stock follow intersectoral displacement and accumulation mechanisms based on pre-established rules, associated with expected rates of return and depreciation of capital stock. Following Dixon and Rimmer (2003), in each simulation year-window, it is assumed that the rates of capital growth are determined by the willingness of investors to invest resources in a sector based on the expected rate of return. Basically, if the rate of return expected by

[29] The wage bill earned by several types of workers: apart from the formal worker under the Consolidation of Labor Laws (the "hired employee"), also the public workers (civil and military), entrepreneurs, outsourced, temporary and part-time workers, and housekeepers.
[30] In experiments of this thesis, on a 5-year-to-5-year basis from 2015 to 2100.

investors is higher than the pre-established normal rate of return, the capital accumulation will be above the normal rate (Dixon and Rimmer, 2003).

There are two main alternatives of investment equations, the short-run rule or DPSV, taken from the Dixon *et al.* (1982) – Equation 32; and the long-run rule, represented in Equation 33. They are both explored in the experiments of Chapter 4.

The value 0.33 and 2.0 correspond to the DPSV ratios I, the ratio of gross investment in industry j to its future capital stock, and Q_i, the ratio of the gross rate of return in industry *i* to the net rate of return, typical values of this ratio.

$$\left(\frac{I}{K}\right)_i = 0.33 \times 2 \times \left(\frac{Rental}{Price\ of\ new\ capital}\right)_i \tag{32}$$

Equation 33 stablishes the planned investment/capital ratio, g, as the difference between investment y and current stock of capital *k* for every industry *i*.

$$g = y - k \text{ - } or\ G = \frac{Y}{K} \tag{33}$$

2.5.3 Balance of Trade

The general SNA postulates a few equations regarding GDP, Income, Investment, Savings and the Rest of the World.

Equation 34 describes the GDP in its expenditure $[C + I + G + (X - M)]$ and income $[WL + RK]$ sides, where WL represents the labor income (total wage bill times total labor factor) and RK, the capital income (total capital return times total capital stock).

$$GDP = C + I + G + (X - M) = WL + RK \tag{34}$$

Equation 35 implicitly shows that investment plus balance of trade [I + (X – M)] equals domestic savings (Sd) if the net transfers flow from the rest of the world (NT) is

zero. If that is the case, GDP=GNP. From this statement, one could tell that a country is being "funded" by the rest of the world if GNP<GDP because [I+(X-M)]>Sd or NT>0.

$$GNP = C + G + Sd = WL + RK + NT = GDP + NT \quad (35)$$

Equation 36 rearranges Equation 1 and Equation 2.

$$C + I + G + (X - M) + NT = C + G + Sd \quad (36)$$

Equation 37 and 38 show that the gap between domestic savings and investment is the current account of the balance of trade. Notice that even with the absence of net transfers flow from the rest of the world, a negative trade balance could fund a country's investment.

$$I + (X - M) + NT = Sd \quad (37)$$

$$Sd - I = (X - M) + NT \quad (38)$$

Investment is then funded by domestic and foreign savings (39), which can be read as the negative current account balance (and vice versa – equation 40).

$$Sd + Sf = I \quad (39)$$

$$Sd - I = -Sf \quad (40)$$

In BRIGHT, a closure could set balance of trade exogenous (nominal balance of trade over nominal GDP ratio, *delB*) by endogenizing a slack variable *btslack* as equation 41 shows. The variable *btslack* is normally exogenous in the Household and Government consumption and Investment standard equations.

$$btslack_{\ old\ exog.} = delB_{new\ exog.} \quad (41)$$

$$Investment_i = capitalstock_i + btslack \quad (42)$$

$$HouCons_h = f3tot\_h + f3tot_h + disposableincome_h + btslack \quad (43)$$

$$GovCons = f5tot + gdp + btslack \quad (44)$$

In which $f3tot\_h$, $f3tot_h$ and $f5tot$ are shifters.

The basis for this assumption is that investment must be financed solely from domestic saving and thus capital is not mobile across regions. The rationale for fixing the trade balance exogenous is firstly, because of the empirical tendency for domestic saving to finance domestic investment; and secondly, by removing all capital flows there are no changes in the foreign ownership of capital and hence results can be interpreted as changes in welfare (Dixon *et al.*, 1982).

2.5.4 Households Demand

CGE models require external parameters for proper estimations such as the linear expenditure substitution (LES) demand elasticities and the Frisch parameters, that measure the sensitivity of the marginal utility of income to total expenditures and establishes a relationship between income and own-price elasticities (Jussila *et al.*, 2012). In the case of BRIGHT, it is the ratio of the value of total household consumption to luxury consumption (Corong and Horridge, 2012; Freire Cardoso, 2020).

As previously shown, Equation 11 determines subsistence consumption, $x3sub_{ch}$, as a function of household size, q_h, and a subsistence taste change parameter, $a3sub_{ch}$. Equation 35specifies each household's luxury or supernumerary demands, $x3lux_{ch}$, based on marginal budget shares, $a3lux_{ch}$.

$$x3lux_{ch} = a3lux_{ch} \quad (35)$$

By default, BRIGHT uses FRISCH=-2.48, by household class. A higher (lower) FRISCH value indicates higher (lower) proportion of consumption devoted to subsistence.

Chapter 3 – Modelling the Economic Impacts of the Minimal Age Introduction of the Brazilian Pension Reform of 2019

3.1 Introduction

Brazilian population is ageing fast due to the lower fertility rate and higher life expectancy. According to the Brazilian Institute for Geography and Statistics (IBGE), in 2022, the number of people with 65 years old or more (22,169,101) represented 10.9% of total population, 57.4% higher than 2010, when the contingent was 14,081,477, or 7.4% of total population (IBGE, 2023). That number tend to increase to more than 42.62% in 2060 (IBGE, 2018) – and that is because the Institute's last projection, in 2018, before the Census 2022 release, predicted a median age in 2022 of 32 years old, when it turned out to be 35, according to the Census 2022 (that was 29 in 2010); showing that population ageing trend is happening faster than expected.

The demographic transition that happens because of the population ageing has deep and lasting impacts in a country's economic growth. It implies stagnancy or even shrinkage of the working age population, increasing labor scarcity and costs as well as the risk of pension schemes unsustainability. According to the Modigliani (1966) life-cycle of consumption theory, population ageing also implies a lower saving and investment rate in the economy. The process of aging is often accompanied with a country's changing competitiveness in the international markets, hence leading to the re-adjustment of the economy's structure (Zuo *et al.*, 2020). Those facts corroborate Wagner's Law, or the "Law of the Increasing Extension of State Activity" (Wagner and Weber, 1977), that dissertates about the growing trend of the share of the public expenditure over GDP, especially in the health sector, as an intrinsic phenomenal of modern societies (Lamartina e Zaghini, 2010; Reis *et al.,* 2016).

Along with this demographic scenario, Brazil has faced a long period of economic stagnation, marked by turbulent experiences on both political and social scenarios. Influenced by the New Institutionalists – those oriented to the economy' liberalization (Coase, 1998) – the Brazilian economic policies have been guided by fiscal austerity[31]

[31] The Constitutional Amendment 95/2016, also known as the "expenditure ceiling", stablished zero real growth for the Federal primary expenditure in a 20-year horizon from 2017.

and the constant need for reforms – changes in labor laws, taxation, and social security's as well as privatization attempts.

The empirical literature shows that this set of reforms has been evaluated in terms of its ability to act positively alongside fiscal consolidation measures, as currently seen in Brazil. According to the favorable positions, the transmission effects happen through the productivity growth, which might mitigate the contractionary impacts of fiscal consolidation. For OECD countries, Anderson et al. (2014) argues in favor of reforms marked by the liberalization of the labor and product markets. In the same way, Bouis (2012) finds that reforms based on the flexibility of labor legislation reduce restrictions on hiring and firing employees and that increase labor productivity. Thats result, however, is contested in Rubery and Piasna (2016) and Shin (2012), who highlight the fact that these measures reduce worker's bargaining power and often increase labor precariousness.

That kind of duality is also true for pension reforms, where most of the empirical work focus on developed countries. According to estimates of Bassanini and Duval (2006), reforms that promote an extension of the retirement age and actuarial neutrality[32] can raise labor force participation rate to a new equilibrium in 10 years. However, these measures are also likely to have adverse effects on the worker's well-being (Boeri et al., 2002; Kodar, 2004).

Since the 1990s, in Brazil, all governments tried to make a pension reform, with a varying degree of success. The main reasons are the high expenditure with benefits, the growing deficit, and the inequalities between the schemes of the private and public (civil servants and military) workers. As previously stated, this scenario tends to worsen due to the country's demographic trends (Turra, 2018). In line with this diagnosis, the Government of the former president Jair Bolsonaro presented, through the Ministry of Economy, Paulo Guedes, at the very beginning of the term of office, the Proposed Amendment to the Constitution nº 6/2019. Processed by the Congress all over 2019, the

[32] A pension design in which one is indifferent between the situation in which people tend to claim benefits before or after the full retirement age, because, on average, the increase that people receive for claiming later is approximately offset since they receive fewer payments until the end of their lives.

reform was approved in December of that year with substantial changes, officially made through the Constitutional Amendment nº 103/2019.

The reform implied on two main changes to the National Pension Scheme (RGPS): it stablished a retirement age of 65 years for men and 62 years for women and changed the benefit formula for both. The aim of this Chapter is to analyze the impacts the minimal age introduction by the pension reform on the Brazilian economy, and especially on the RGPS and the Government saving deficits, throughout the remainder of the 21st century. To this goal, we use a methodology of Computable General Equilibrium (CGE) in which is possible to access the dynamic effects on consumption, production, well-being, and inequality that social security benefits and contributions have on the economy. The methodological strategy consists on estimating the effects of different demographic projections of population and labor force pre- and post-reform, considering contributions and benefits flows of the RGPS.

We have updated and adapted BRIGHT model (Brazilian Social Accounting – General Equilibrium Model for Income Generation, Households and Transfers), developed by Freire Cardoso (2020), to the Brazilian pension structure. It is now especially capable of evaluating issues related to pension schemes transfers, as it was already to taxation, generation, appropriation, and distribution of income in the Brazilian economy.

3.2 The Brazilian National Pension Scheme

The Brazilian National Pension Scheme (RGPS), from this point onwards, the National Pension Scheme, is Brazil's main pension scheme. Following sequent attempts of broadening the country's social security[33], it has been under control of the National Institute for Social Security, a federal autarchy[34] connected to the Ministry of Social Security, since 1990.

Designed in the PAYG style[35], the National Pension Scheme is currently made from mandatory contributions of hired workers from the private sector and the non-statutory[36] workers from the public sector; individual contributions of unregistered workers from both private and public sector; as well as optional contributions of unemployed and out of the labor force people such as students and volunteers. Entrepreneurs and employers also fit in the National Pension Scheme. Defined benefits are roughly split into retirement pension benefits and other pension benefits, not necessarily related to one's working life cycle. Retirement pension benefits are granted according to an official retirement age, size related to contributions.

According to Holzmann (2013), international trends in pension reforms successfully supported the key objectives of pension schemes – poverty alleviation and consumption smoothing over the life-cycle – but failed in achieving better *performance goals* such as coverage, adequacy, affordability, sustainability, and robustness (Barr and Diamond, 2006; World Bank, 1994). It is worth it to summarize each of these concepts, for they can be rather similar at first sight:

i. *Coverage*: Labor force enrollment (Barrientos, 1998);

ii. *Adequacy*: the ability to prevent and mitigate the risk of poverty in old age and to replace income earned before retirement, considering the equitable

[33] Social Security in Brazil has its origins in the Constitution of 1824, more specifically in the so-called "public aid". More of its history can be found in Malloy (1977) and Malloy (1979).
[34] In Brazil, the term is to refer to a public law entity, with economic, technical, and administrative autonomy, although supervised and often subsidized by the State, and constitutes an auxiliary body for its services.
[35] See the classical work of Samuelson (1958) and the revival theories of Westerhout *et al.* (2022).
[36] Hired as public servant without a public tender.

cost distribution between different groups and generations of society (European Commission, 2021);

iii. *Affordability*: Encouraging contributors' saving, with lower additional subsides (Blake, 2000; Seekings, 2017);

iv. *Sustainability*: Fiscal capacity of keeping itself running, actuarially speaking (Ramaswamy, 2012);

v. *Robustness*: whether the system implies an incentive structure supporting its underlying objectives; whether the system is financially viable and resilient to changes, i.e., longevity or financial markets (financial crisis or a low interest rate scenario) (Anderssen, 2015).

As the Chapter 2 of this Thesis showed, the National Pension Scheme has a relatively equal distribution among households, as Brazilian elderly population benefits the most from public transfers, compared to other generational groups (Turra *et al.,* 2011). Although poverty alleviation transferences such as the BPC is, accordingly to the robustness concept, out of pension schemes' underlying objective – the National Pension Scheme retirement pension plays an important role on poverty reduction amongst the elderly, as well as the other pensions of the scheme aid sick and injured workers as well as worker's destitute families.

Roughly speaking, policymakers of pension schemes, especially of those under the PAYG style, should be concerned about macroeconomic and demographic trends to avoid inadequate benefit provision in the payout phase (which affects a scheme's sustainability), despite the open dilemma whether higher contributions and later retirement should be mandated by Government or should be left to individuals to decide (Holzman, 2013). That is exactly the main cause of the Brazilian National Pension Scheme last reforms – the country it is not alone though.

According to the OECD (2015), in the period 2009-2015 all the 34 countries in the organization have made changes in their pension schemes system, mainly trigged by demographic changes (Carone et al., 2016). A considerable part of the literature is focused on the multiple impacts of pension system reforms. These reforms can be considered parametric, restricted to modifying a set of rules for taxpayers and beneficiaries; or

structural, which, according to the definition of Mesa-Lago (2002), are more radical as they aim to replace or complement public systems with private alternatives.

An unprecedented act in any modern economy was the complete privatization of the Chilean social security system in 1981, where the country transformed its public PAYG system in a fully-funded scheme of individual accounts controlled by private management companies. Holzmann (2013) reviews the trends in pension reforms that have marked global economies since Chilean scheme's privatization while Mesa-Lago (2002) writes the "12 myths of pension reforms" covering the experience of eight Latin American countries.

Storto and Afonso (2018), Afonso and Carvalho (2022) and Silva (2018) cover the fiscal and economic impacts of the last attempts of reforms of the Brazilian National Pension Scheme. Poverty and distributional aspects of the scheme are found in Souza *et al*. (2021), Silveira *et al.* (2020) and Freire Cardoso *et al*. (2024). Other countries' experiences on the same subjects are found in Barrientos (2005), Dethier *et al.* (2011), Sánchez-Romero *et al.* (2013), Cammeraat (2020), Wang *et al.* (2017) and Zuo *et al*. (2020).

This literature review also remarks the researches that address the economic impacts of reforms as a whole – especially regarding their expansionist potentials (Alesina *et al*., 2019; Bouis *et al.*, 2012). Following the theory of expansionary austerity, through expectations that less expenditure leads to less taxation and lower interests, an institutional reform that alleviates Government's budget could boost the economy (Carvalho, 2018). Particularly connected to this experiment, Cardoso (2019) provides a full review on the subject.

3.2.1 The 2019 Reform

The Brazilian National Pension Scheme used to work solely through the *length of contribution* system, in which, to retire, a man/woman would need 35/30 years of contribution (regardless of their age). So, a man/woman that uninterruptedly contributed since their 18 would be able to retire at 53/48 years old (or even younger, depending on their occupation) and get the full benefit, according to their contribution history. It did not take long for the problem of early retirement appear in the 2000s, affecting the scheme's performance.

It was then adopted the *system of points* of retiree, in 2015, an example of a length of contribution with the age aspect. Under this system, to get the full defined benefit a man should achieve 95 points (age + years of contribution) to retire and a woman, 85. In the previous example, the man with 35 years of contribution and 53 years old would only sum 88 points and the woman with 30 years of contribution and 48 years old, 78 points. So, if they still wanted to retire, their benefit would have been reduced by the *pension coefficient* – p – another feature introduced to avoid early retirements. Its formula considers the contribution length, the age and life expectancy of the contributor. It reduces the benefit by multiplying the average of someone's 80% highest base wages of contribution. E.g., a man with 53 in 2019 that had contributed since his 18 years old (therefore 35 years of contribution) had a pension coefficient of only 0,63 (age too low, life expectancy too high).

$$p = \frac{CL \times r}{LE}\left[1 + \frac{(A + CL \times r)}{100}\right] \quad (1)$$

In which:

CL: Contribution Length
r: Contribution rate
LE: Life expectancy
A: Age

The reform approved at the end of 2019 simplified the benefit rules of the National Pension Scheme as well as updated the age and length of contribution boundaries. It postulates that women must be at least 62 years old with 15 years of contribution and men at least 65 years old with 20 years of contribution. The minimum length of contribution remained 15 years for men who were affiliated to the National Pension Scheme before the start of the new rules established by the Constitutional Amendment. Summing up, after the transition phase for those on the edge of the working-life cycle, the two main types of retiring (by age and by length of contribution) will no longer exist – in fact, they will turn into a single new group stablished by the reform.

To avoid abrupt changes over the expectancy of the right to retire, several transition rules were set by the policymakers, as Frame 3.1 shows.

Frame 3.1 – Transition Rules of the Brazilian National Pension Scheme 2019 Reform

Transition 1: System of points

The length of contribution would remain 35 years/30 years for men and women, respectively. But, instead of 85 points for women and 95 for men, the rule has increased one point each year, reaching 100 for women and 105 for men, starting in 2019. So, in 2028, men will have ceased the transaction period while women will cease it in 2033 (achieving 105/100 is to convert into the new general retirement rule of 65/60 + 40 years of contribution).

Transition 2: Contribution length + minimum age

Minimum age starts at 56 for women and 61 for men. Each year, the age increases by 6 months until reaching 62 years (women) and 65 years (men). The transition ends at 12 years for women and 8 years for men. The minimum contribution period is 30 years for women and 35 years for men.

Transition 3: 50% toll for those who are close to retiring (for INSS)

The toll applies to those who were just about to retire (2 years or less of contributions) with a minimum contribution period of 30 years for women and 35 years for men. Anyone who was one year away from retirement would work for 6 more months, totaling a year and a half. The *pension coefficient* would still be in effect.

Transition 4: by age

Starting in January 2020, there would be an increase of 6 months in the minimum retirement age for women. That is, the initial rule of 60 years of age and 15 years of contribution will reach 62 years in 2023.

Transition 5: 100% toll

Valid to both private and public sector, in which a minimum age of 57 years (women) and 60 years (men), and 30 years of contribution (women) or 35 (men), in addition to a toll of 100% of the remaining length to achieve the new minimum length of contribution after the reform. Example: a woman of 57 years old and 28 years of contribution, would have to contribute for more four years to achieve the 30 years of contribution.

Source: Own elaboration according to BRASIL (2019).

For a simulation purpose, detailed in the next section, there is a stylized general transition that sets a minimum age of retirement soothly over every new year of a certain length of time, like the Transition 4 described in Frame 3.1. Table 3.1 shows the eligible

ages of retirement for men and women in each year of the pre-reform, transition phase, and post-reform periods. Table 3.2 shows the total population of men and women in each age, from 2015 to 2100. In red are those that represent the boundaries of the minimum age retirement (the average between two age group populations in every two years represents the “half-ages”). The National Pension Scheme would be fully running under the new rule after 12 years from its approval (men’s transition will be completed after 8 years).

Table 3.1 – Stages of the reform and Eligible age for retirement, by sex

	Year	Men	Women
Pre-reform	**2015-2019**	60	55
Transition phase	**2020**	60,5	55,5
	2021	61	56
	2022	61,5	56,5
	2023	62	57
	2024	62,5	57,5
	2025	63	58
	2026	63,5	58,5
	2027	64	59
	2028	64,5	59,5
	2029	65	60
	2030	65	60,5
	2031	65	61
	2032	65	61,5
New system	**2033-2100**	65	62

Source: Own elaboration. Projections from United Nations (2022).

Table 3.2 – Elderly population 2015-2100 (in million)

	Men						Women							
	60+	61+	62+	63+	64+	65+	55+	56+	57+	58+	59+	60+	61+	62+
2020	13,0	12,0	11,0	10,2	9,3	8,5	22,6	21,3	20,1	18,8	17,6	16,5	15,4	14,3
2021	13,4	12,4	11,4	10,5	9,6	8,8	23,3	22,0	20,7	19,5	18,3	17,1	15,9	14,8
2022	13,9	12,8	11,8	10,9	10,0	9,1	23,9	22,6	21,4	20,1	18,9	17,6	16,5	15,3
2023	14,4	13,3	12,3	11,3	10,3	9,5	24,6	23,3	22,0	20,8	19,5	18,3	17,1	15,9
2024	14,9	13,8	12,8	11,7	10,8	9,9	25,3	24,0	22,7	21,5	20,2	19,0	17,7	16,5
2025	15,4	14,3	13,3	12,2	11,2	10,3	26,1	24,8	23,5	22,2	20,9	19,6	18,4	17,2
2026	16,0	14,9	13,8	12,7	11,7	10,7	26,8	25,5	24,2	22,9	21,6	20,3	19,1	17,8
2027	16,5	15,4	14,3	13,2	12,2	11,1	27,6	26,2	24,9	23,6	22,3	21,0	19,7	18,5
2028	17,0	15,9	14,8	13,7	12,6	11,6	28,3	26,9	25,6	24,2	22,9	21,7	20,4	19,1
2029	17,5	16,4	15,3	14,2	13,1	12,1	29,1	27,7	26,3	24,9	23,6	22,3	21,0	19,8
2030	18,0	16,9	15,7	14,6	13,6	12,5	29,9	28,4	27,0	25,6	24,3	23,0	21,7	20,4
2031	18,6	17,4	16,2	15,1	14,0	13,0	30,7	29,2	27,8	26,3	25,0	23,6	22,3	21,0
2032	19,1	17,9	16,7	15,6	14,5	13,4	31,5	30,0	28,5	27,1	25,7	24,3	22,9	21,6
2033	19,6	18,4	17,2	16,0	14,9	13,8	32,3	30,7	29,2	27,8	26,3	24,9	23,6	22,2
			...							...				
2100	34,7	33,6	32,4	31,3	30,1	29,0	44,1	43,0	41,9	40,8	39,7	38,6	37,5	36,3

Source: Own elaboration. Projections from United Nations (2022).

The benefit formula has also changed: as the pension coefficient is no longer required, it now defines it as 60% of the average of all the base wages of contribution[37], plus an accrual rate of 2 percentage points per year additionally to the 20 years of contribution for men and women. In other words, the eligibility for the full benefit requires 40 years of contribution for men and 35 for women: 60% + (extra years of contribution x 2 p.p.). The average benefit is expected to be lower after the reform, for now the formula considers the average of all the base wages of contribution during the entire working life-cycle, and not only the 80% highest, as it used to be. That is not directly captured in this experiment, though.

[37] The base wage of contribution is the value of the remuneration up to the National Pension Scheme ceiling (R$ 7,507.49 in 2023) on which it applies the rate of contribution.

3.3 Simulation Strategy

The effect of the reform was to raise the retirement age in Brazil by introducing a new minimum age of eligibility. Considering that a pension benefit is proportional to lifetime wage earnings and it its indexed to minimum wage, the strategy to model a minimum age shift reform in the National Pension Scheme (RGPS) relies on the following assumptions[38],[39]:

i) Contributions growth rate follows aggregate employment and total labor income growth rates (Equation 3.1);
ii) Retirement benefits growth rate follows the eligible population (seniors) growth rate, according to projections, also weighted by the labor nominal price component (average nominal wage) growth rate (Equation 3.2); and
iii) Other benefits growth rate follows total population growth rate, also weighted by the average nominal wage growth rate (Equation 3.3).

$$Contributions_{ht} = Employment_t + Labour\ Income_{ht} \tag{3.1}$$

$$RetirmentBenefits_{ht} = SeniorPop_t + Nominal\ Wage_t^{ave} \tag{3.2}$$

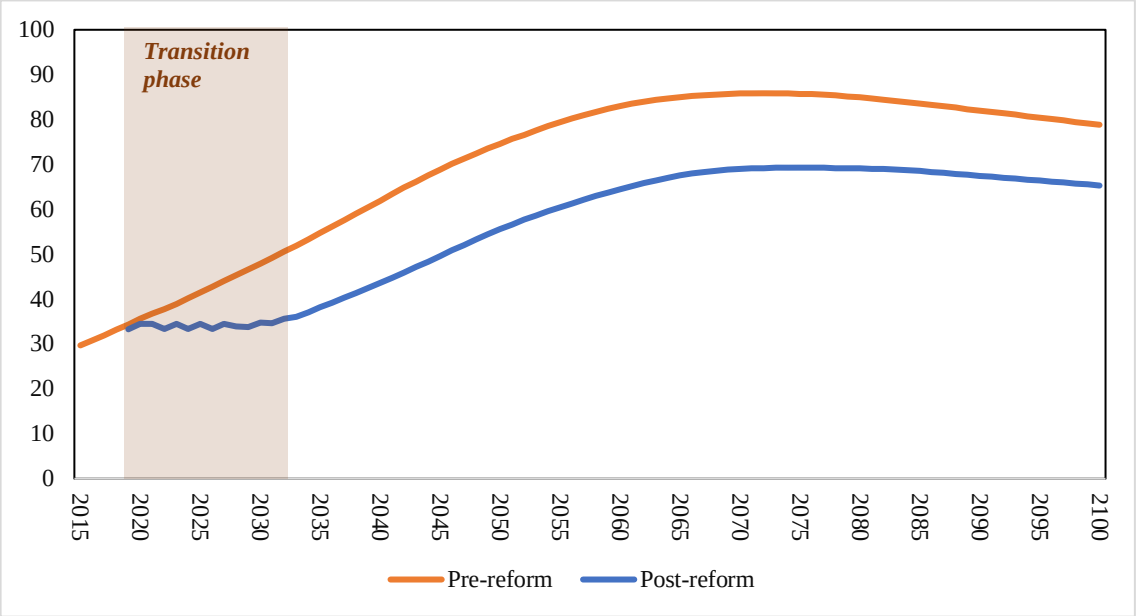
$$OtherPensBenefits_{ht} = TotalPop_t + Nominal\ Wage_t^{ave} \tag{3.3}$$

Where the subscript *h* stands for household income class and *t* is for time.

Because a person can retire at the start of their eligibility, Graph 3.1 shows the number of eligible pensioners according to the minimum age of retirement on both pre and post reform – they are a proxy of the expenditure bill on pension benefits. One can observe that the baseline proxy for benefits growth path follows the pre-reform senior population growth path (men with 60 years old or more, women with 55 years old or more), as for the policy scenario, it follows the new minimum age for men and women as the transition phase of the reform goes by.

[38] Thoroughly evaluated in the Appendix B, where potential problems such as underestimation of pension's contributions and benefits flows are also foreseen. Considering the benefits grant, for example, it is true that – due actuarial aspects or not - some occupations are eligible to retire early than the average.
[39] No shock was given on any of the other schemes' flows (RPPS, Military and BPC). They keep floating endogenously according to the labor income level and the average nominal wage, as equations 3.1, 3.2 and 3.3 postulate, though.

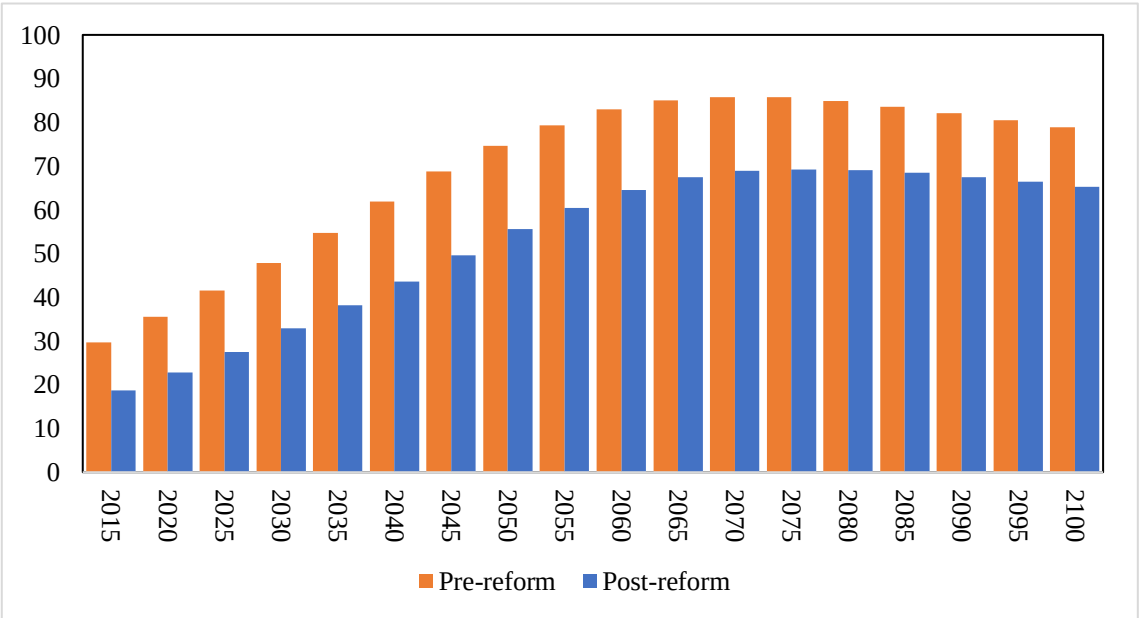
Graph 3.1 – Population Eligible for Retirement Pension Benefits of the National Pension Scheme – in million (2015-2100)



Source: Own elaboration. Projections from United Nations (2022).

Graph 3.1 shows a delay in the slope of the blue curve (post-reform) in the years associated with the transition phase (from 2019 until 2032). Graph 3.2 aggregates the number of the eligible pensioners in quinquennials. It shows a slight shift of the peak towards the future: the number of eligible pensioners post reform will reach its maximum level in 2075 (69.2 million) while the number of the pre-reform eligible pensioners does it in 2070 (85.7 million).

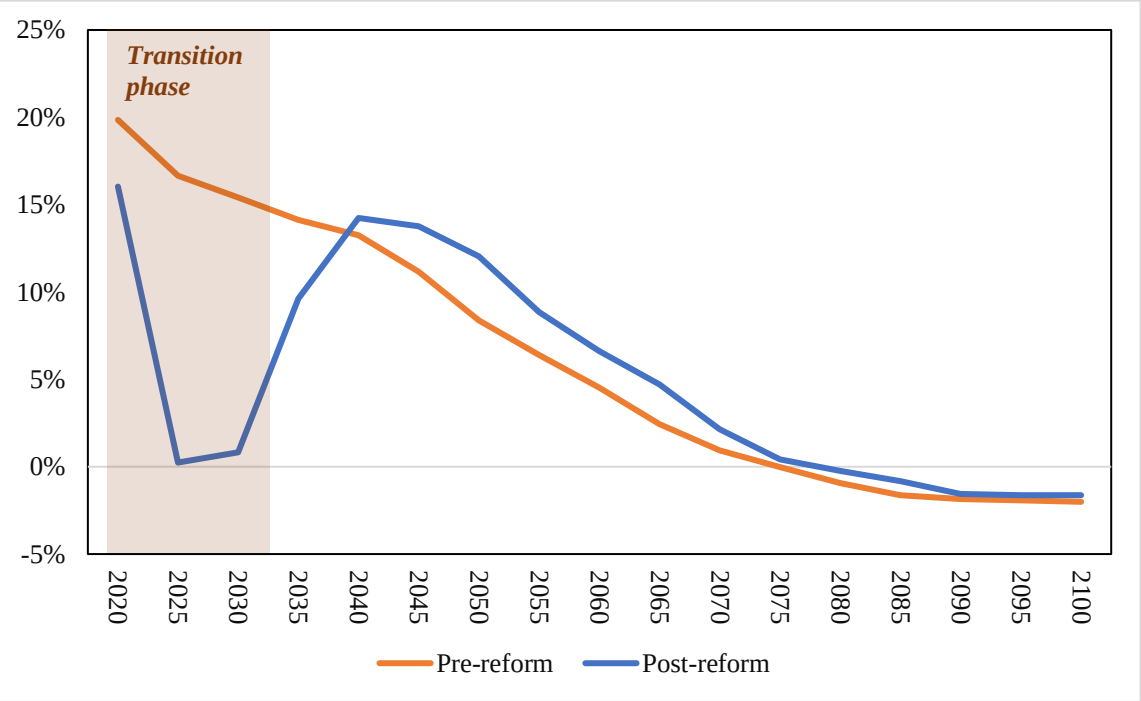
Graph 3.2 – Elderly population: Proxy to the Eligible Pensioners according to the National Pension Scheme's rule of minimum age (in million)



Source: Own elaboration. Projections from United Nations (2022).

Graph 3.3 compares the growth rates of the derived benefits granted to men and women under both rules (pre- and post-reform), that grow according to each eligible age of retirement. It is quite clear that the reform slows the new retiree growth rate in the transition phase, for it allows only a new "half of an age" cohort each year. After that, it grows even higher the baseline rate. That is particularly important: it means that the lower fertility rate persists, also affecting the seniors' entrance in the future, for the post-reform group (65+/62+, men and women) grow more than the pre-reform (60+/55+, men and women) group.

Graph 3.3 – Retiree Growth Rates (Quinquennial)

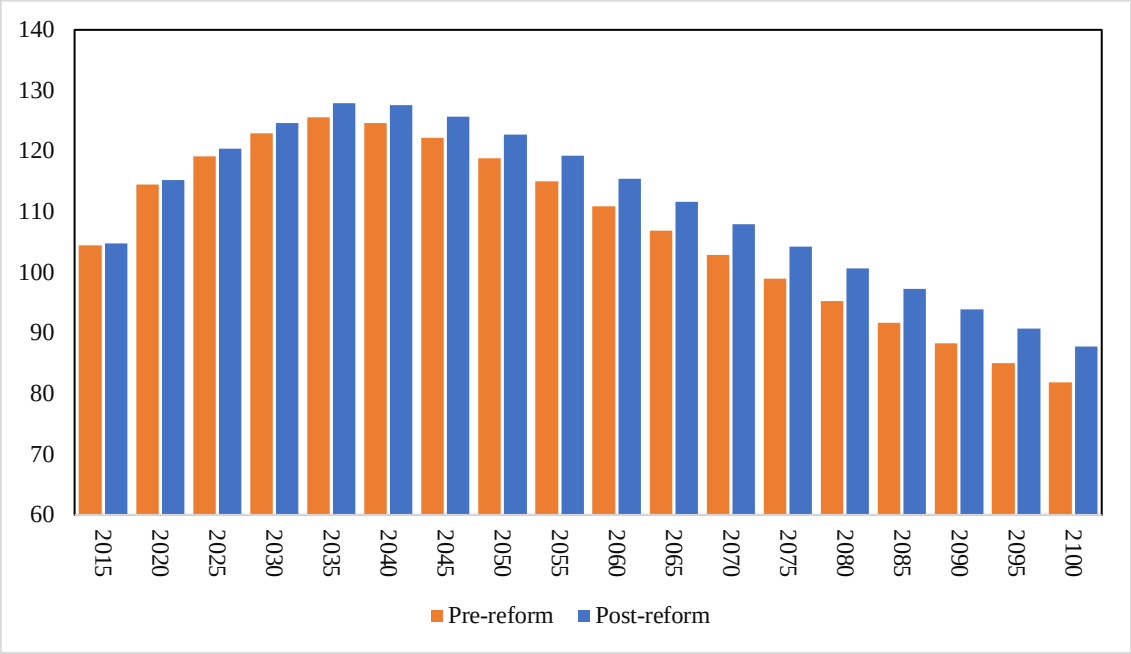


Source: Own elaboration. Projections from United Nations (2022).

Labor force scenarios come from Queiroz and Ferreira (2021) and Fernandes and Queiroz (2024), depictured in Graph 3.4. The first uses demographic projections that captures recent trends of participation rates, the second does a counterfactual analysis of the effect of structural changes on Brazilian labor supply. That projection assumes that the participation rate of the elderly in the labor force in the future will be the participation rate of the most educated group today: that is the "most optimistic" amongst several projections. It also considers the new minimum age of retirement after the reform. Both

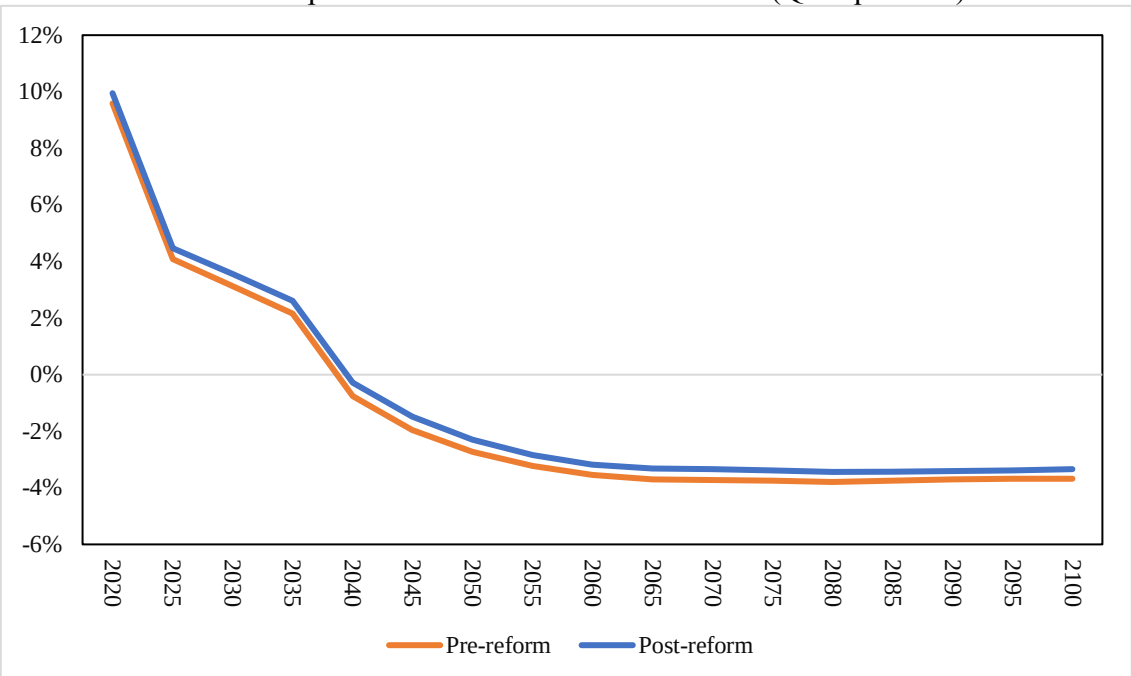
projections rely on UN data depictured in Graph 3.1[40]. Contributions grow according to the labor force growth rates in each scenario, as Graph 3.5 shows.

Graph 3.4 – Labor Force projection (in million)



Source: Own elaboration. Projections from Queiroz and Ferreira (2021) and Fernandes and Queiroz (2024).

Graph 3.5 – Labor Force Growth Rates (Quinquennial)



Source: Own elaboration. Projections from Queiroz and Ferreira (2021) and Fernandes and Queiroz (2024).

[40] It is important to emphasize that Brazilian most accurate statistics of age and gender comes from the Census of 2022, information that has only been released in 2023 by IBGE.

3.3.1 The Baseline Scenario

To develop the baseline scenario, we have first updated the model's database up to 2020 using actual data from IBGE Statistical Yearbooks, as well as the National Pension Scheme data from the Statistical Yearbook of Social Security (AEPS Infologo) (BRASIL, 2023) and the Census 2022 (IBGE, 2023) as Table 3.3 shows.

Table 3.3 – Growth Rates – Historical Baseline Forecast (2016-2020)

Variable	Average Yearly Growth Rate (%)	Cumulative Growth Rate (%)
Household Consumption	-0.8	-0.27
Investment	-1.5	-7.61
Government Consumption	-1.4	-4.8
Exports	1.4	5.57
GDP	-1.2	-2.96
Actual Employment	-1.4	-6.0
Total Population	1.3	3.9
RGPS Benefits	2.0	36
RGPS Contributions	-1.3	-3.9

Source: Own elaboration. IBGE (2023) and BRASIL (2023).

Then, for the forecast period from the 2021-2025 quinquennium to 2096-2100's, we have assumed that the growth pattern of the Brazilian economy will be driven by an increase of factors productivity of 10 percent in every quinquennium. Labor force and population growth follow the rates previously shown in the Simulation Strategy section. This is the assumption that GDP is a linearly homogeneous function of labor and capital (under a CES input substitution function). The macroeconomic results of this set of shocks are depictured in Graph 3.6. The average growth rate of the GDP components floats around the productivity shock, as Table 3.4 shows.

Graph 3.7 shows the total factor input evolution in the economy, in nominal values. In a long-run projection closure, actual employment grows according to the labor force projection and only the real wage is endogenous. Investment makes a planned ratio to capital, by industry, in a way that they are both endogenous. Because population and hence labor supply shrink in the Brazilian long-run scenario, and capital and labor are not

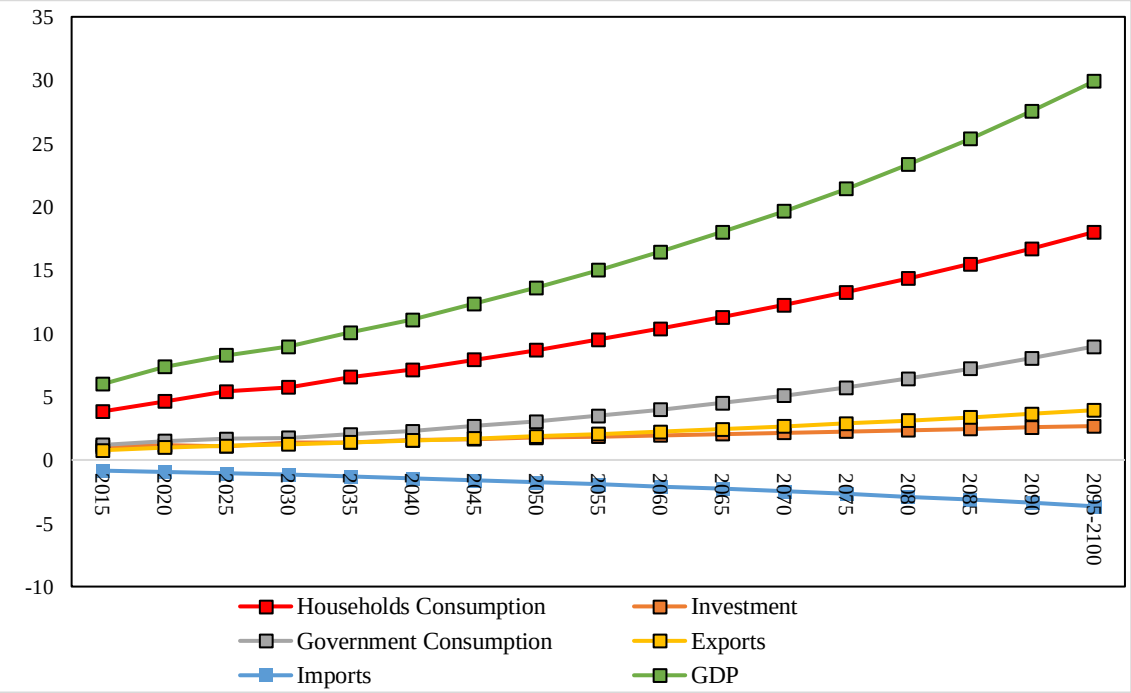
perfect substitutes, assuming fixed rates of return in the long run, capital grows constrained to labor while labor price (wages) grows abruptly, as Graph 3.8 and Table 3.5 shows. That impacts considerably the dynamics of the General Pension scheme, as the modelling methodology showed. Government consumption follows GDP and the Balance of Trade is exogenous (constant ratio over GDP).

Table 3.4 – Average Growth Rate of the GDP Variables of the Expenditure Side by Quinquennium – Baseline Forecast

Variable	Average Growth Rate (%)
Household Consumption	11.9
Investment	7.2
Government Consumption	10.4
Exports	11.8
Imports	9.7
GDP	10.6

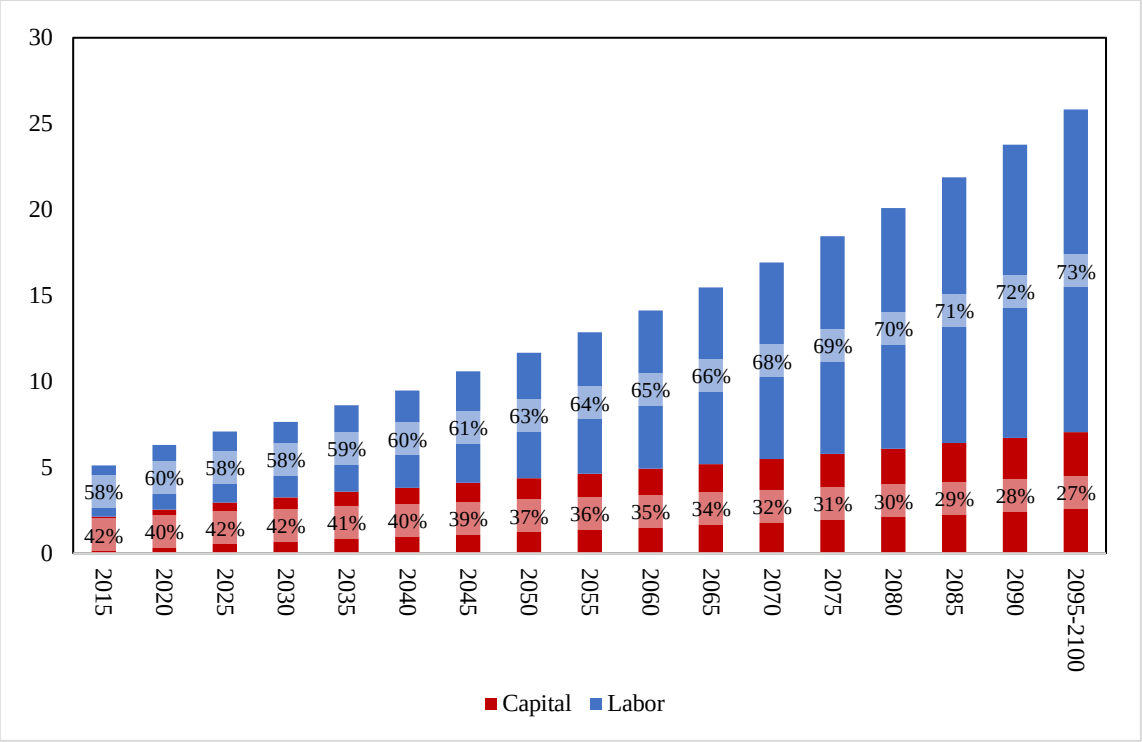
Source: Own elaboration. Results of BRIGHT model.

Graph 3.6 – GDP Variables of the Expenditure Side (R$ Trillion) – Baseline Forecast



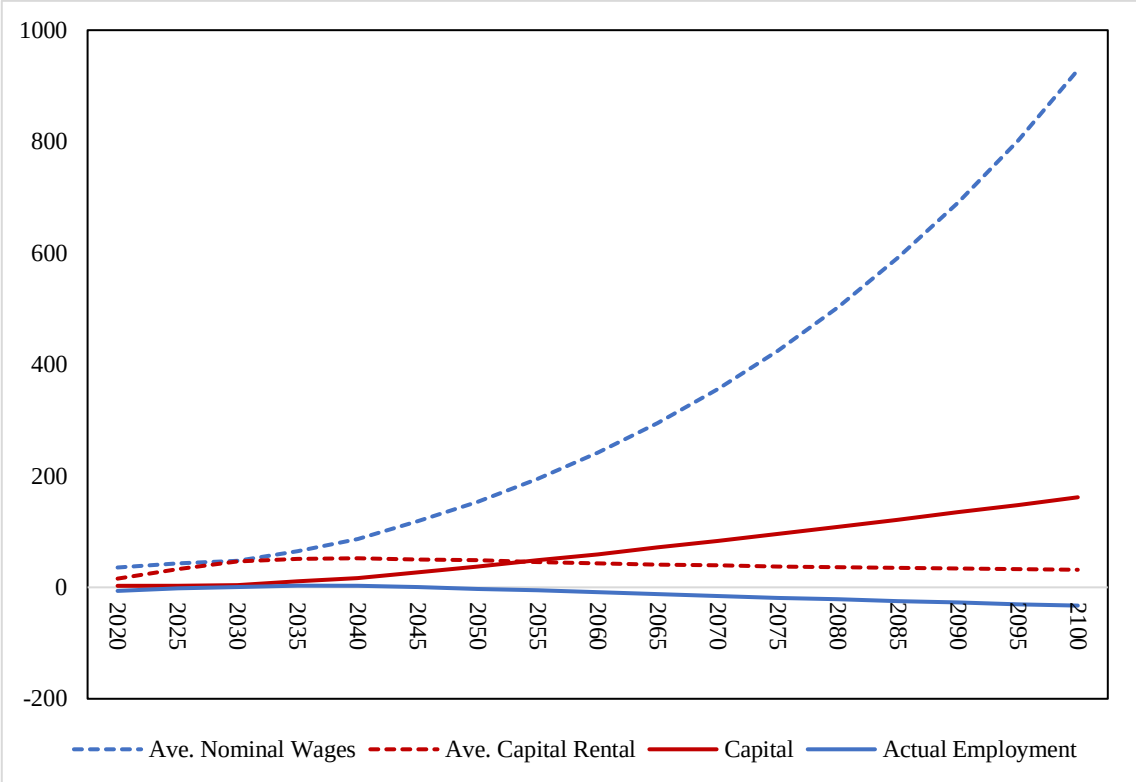
Source: Own elaboration. Results of BRIGHT model.

Graph 3.7 – Capital and Labor Income Shares – Baseline Forecast



Source: Own elaboration. Results of BRIGHT model.

Graph 3.8 – Factors and Prices Cumulative Growth Rates – Baseline Forecast



Source: Own elaboration. Results of BRIGHT model.

Table 3.5 - Average Growth Rate of the Factors and Prices by Quinquennium – Baseline Forecast

Variable	Average Growth Rate (%)
Employment	2.3
Wages	14.8
Capital	6.8
Rent	-2.4

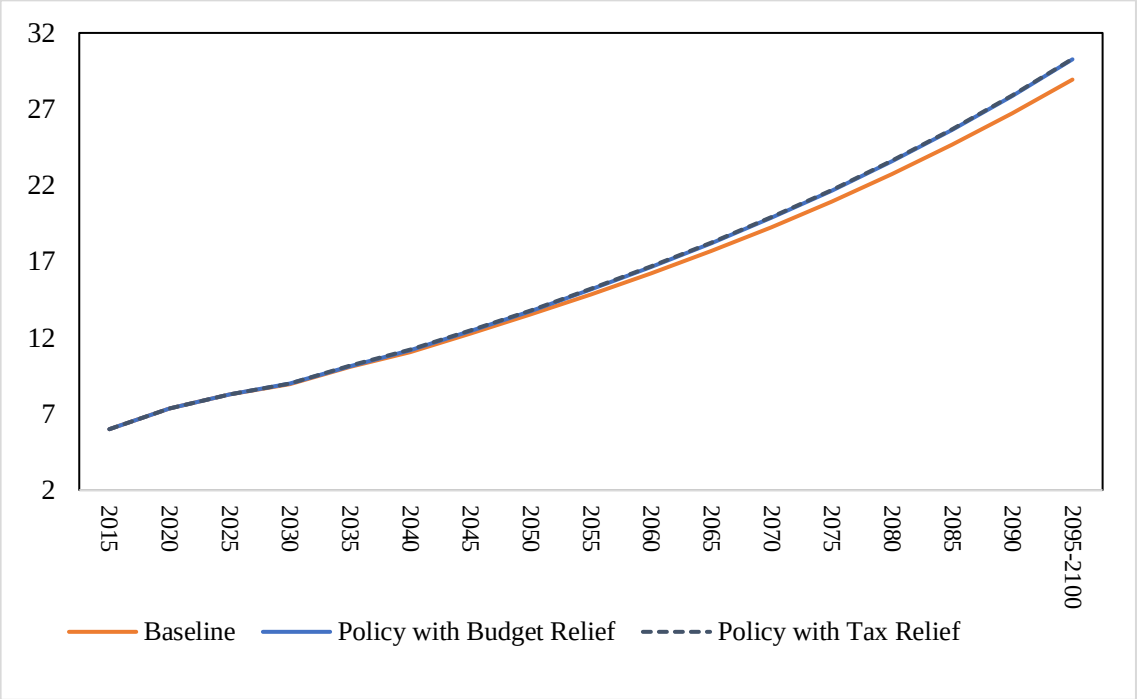
Source: Own elaboration. Results of BRIGHT model.

3.4 Results

Initially, it is important to recapture the discussion of the Fiscal Module section of Chapter 2 of this thesis about the fiscal adjustment condition. According to the explanation in "The Role of the Closure" subsection, because of the mechanisms of taxation over the economy, the adjustment setting in a policy forecast might deliver different results from the one with no adjustment. The results of the experiment are then evaluated under both closures, they are the "Policy with Tax Relief", where the fiscal adjustment condition is activated; and the "Policy with Budget Relief", operated under the model's "default"– i.e. no fiscal adjustment condition. In the case of the tax relief response at the Brazilian National Pension scheme reform, GDP differences is positive but barely noticeable, as Graph 3.9 shows.

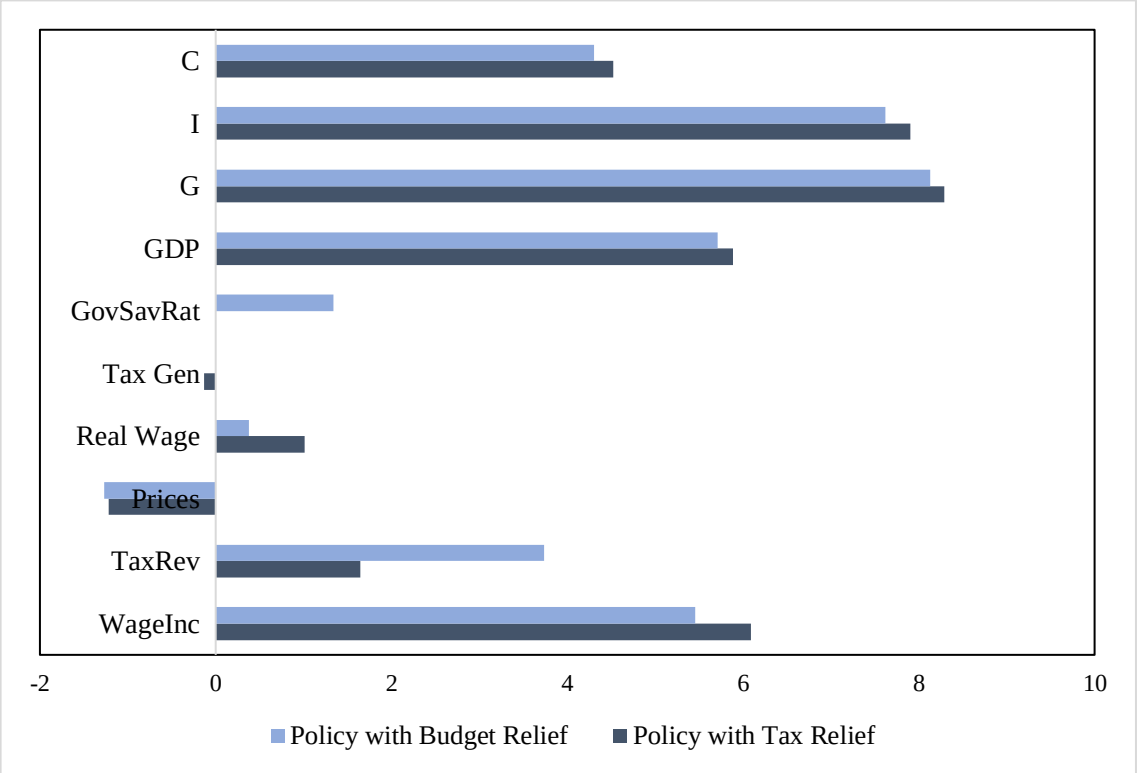
Graph 3.10 shows the differences of the cumulative deviations to the baseline of a set of variables under both policy scenarios in 2100. One can notice that the swap of the adjustment condition makes GovSavRat (growth of the Government Savings ratio to GDP) zero in the Policy with Tax Relief, while TaxGen (growth of the General tax shifter for direct and indirect taxes) is zero under the Policy with Budget Relief simulation. It is possible to see that the general tax relief boosts the economy, relatively to the baseline, more than the budgetary relief condition does. Intuitively, tax revenues and Government savings ratio to GDP are bigger under the budget relief scenario.

Graph 3.9 – Brazilian GDP under three scenarios (R$ Trillion)



Source: Own elaboration. Results of BRIGHT model.

Graph 3.10 – Selected Variables from Both Policy Scenarios in 2100 (% Cumulative deviation to Baseline)



Source: Own elaboration. Results of BRIGHT model.
Set of variables: Real Household Consumption; Real Aggregate Investment; Real Government Consumption; Real GDP, Government Savings Ratio to GDP; General Direct and Indirect Tax Shifter; Real Wage; Consumer Price Index; Income and commodity tax nominal total revenue; Aggregate payments to labor (nominal), respectively.

For a matter of abstractness, the following subsections compares the results of the Policy with Tax Relief cumulative deviations growth rates to the Baseline. That is enough to understand the main mechanisms of the policy through the economy, however with the fiscal adjustment condition closure. In the fiscal subsection (3.4.4), the results of both policy scenarios will be recaptured.

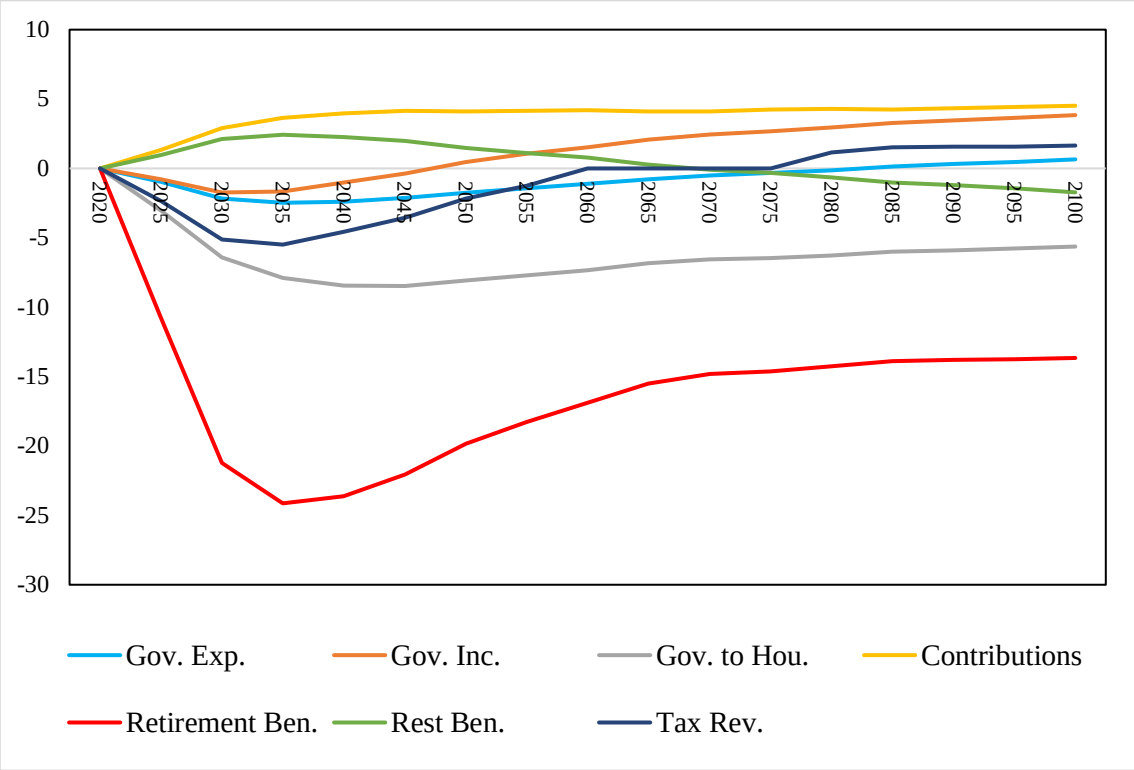
3.4.1 "First-Round" Effects

Graph 3.11 shows the "first-round" impacts of the reform – i.e., the movement of the National Pension Scheme flows, that directly impact Government expenditure and its sources of revenue[41]. As one can see, there is a considerable decrease of retirement benefits growth rate. Because it follows the number of eligible pensioners, it falls abruptly during the transition phase of the reform (retirement age raise) and recovers gradually as it finishes, but remaining quite lower compared to the baseline growth rate at the end of the projection. The rest of the benefits' growth path follows the total population growth.

Contributions follow the nominal wage bill growth path, that mainly responds to the extended labor force deviation. One thing to notice is that, although tax adjustment condition has lowered taxation, Graph 3.11 shows that the total "Income and Commodity tax revenue – *Tax Rev*" responded positively to the policy because of the final effect on the activity level, as shall be detailed along this section. Because of the total reduction of Government transfers to Households, the difference between Government's income and expenditure (Government nominal savings growth rate) is positive, indirectly suggesting a growth of GDP, for its ratio to that variable is set to grow zero under the fiscal adjustment condition.

[41] Except for the dynamics of capital, that works lagged, is true that CGE results do not follow an exact order, for everything is connected. The concept of "first-round" effects is helpful in analyzing a policy, though.

Graph 3.11 – First-Round Effects of the Policy with Tax Relief (% Growth Rate, Cumulative deviation to Baseline)



Source: Own elaboration. Results of BRIGHT model.
Set of variables: Government Expenditure; Government Income; Government Transfers to Households; Contributions to the RGPS; Retirement Benefits of the RGPS; Other Benefits from the RGPS; Income and Commodity tax revenue, respectively.

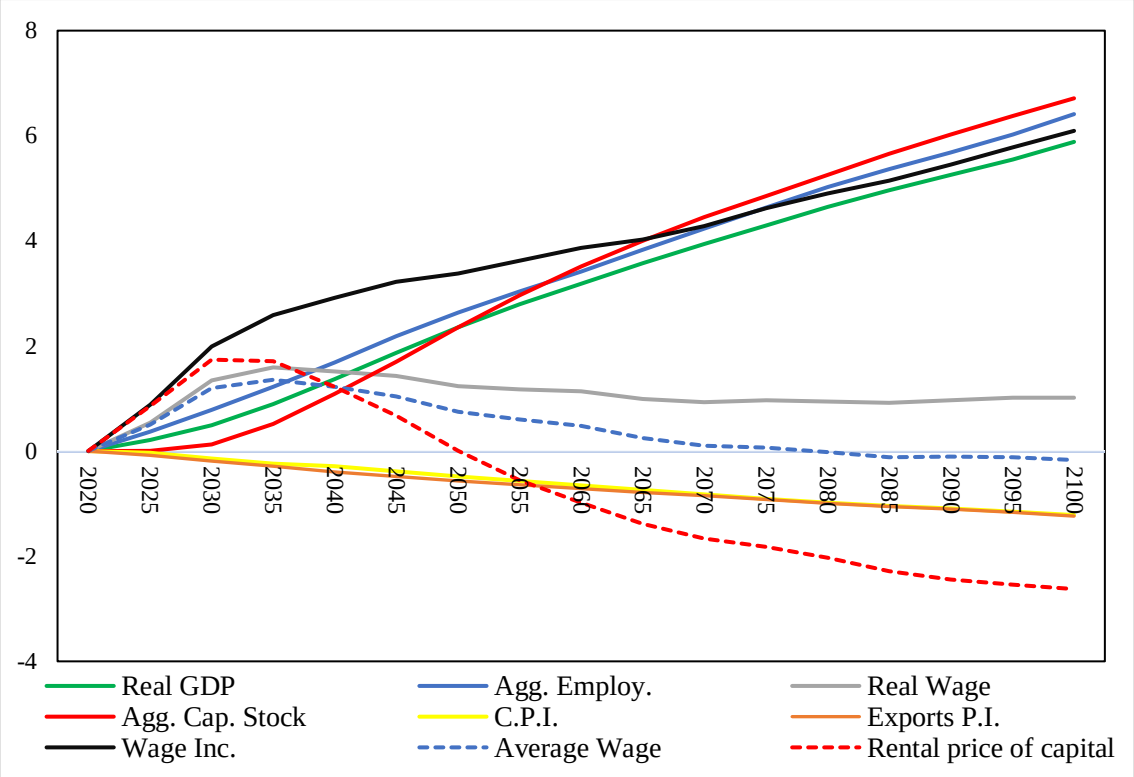
3.4.2 Macroeconomic variables and Industrial Output

The pension reform delivers a positive effect over Brazilian economy. The raise of the minimum age of retirement extends working age population and reduces Government total expenditure relatively to its income, bending taxation downwards. Apart from the increase of the aggregate employment, capital stock also plays an important role on the real GDP 5.9% growth in the Policy with Tax Relief scenario compared to the baseline, as Graph 3.12 shows.

As previously explained, in a classical long-run structure, labor supply equals labor demand through the real wage adjustment mechanism, and capital tend to follow labor force as a correlation of primary factors composite requirement. Graph 3.12 essentially shows that, by the income side, GDP is a function of the primary factors labor and capital, in a way that a positive deviation of labor increases GDP. The reason why capital growth is slightly higher than the aggregate employment cumulative growth in

2100 (and why it only overcomes around 2055) has to do with the wage and the capital accumulation adjustment mechanisms: one can notice that, after 2035, wages' deviations start to fall due to the chain effect caused by the labor extension (abundant factor, cheaper factor), that affects prices. Because real wage is positively weighted by the decreasing CPI and labor bill by the growing employment, they do not shrink as much as the average nominal wage. Because investment follows a planned ratio to capital and the average rental price of capital falls (following wages in the primary composite function), the rate of return expected by investors overcomes the pre-established normal rate of return (trend), allowing higher capital accumulation.

Graph 3.12 – Macroeconomic Result of the Policy with Tax Relief (% Cumulative deviation to Baseline)

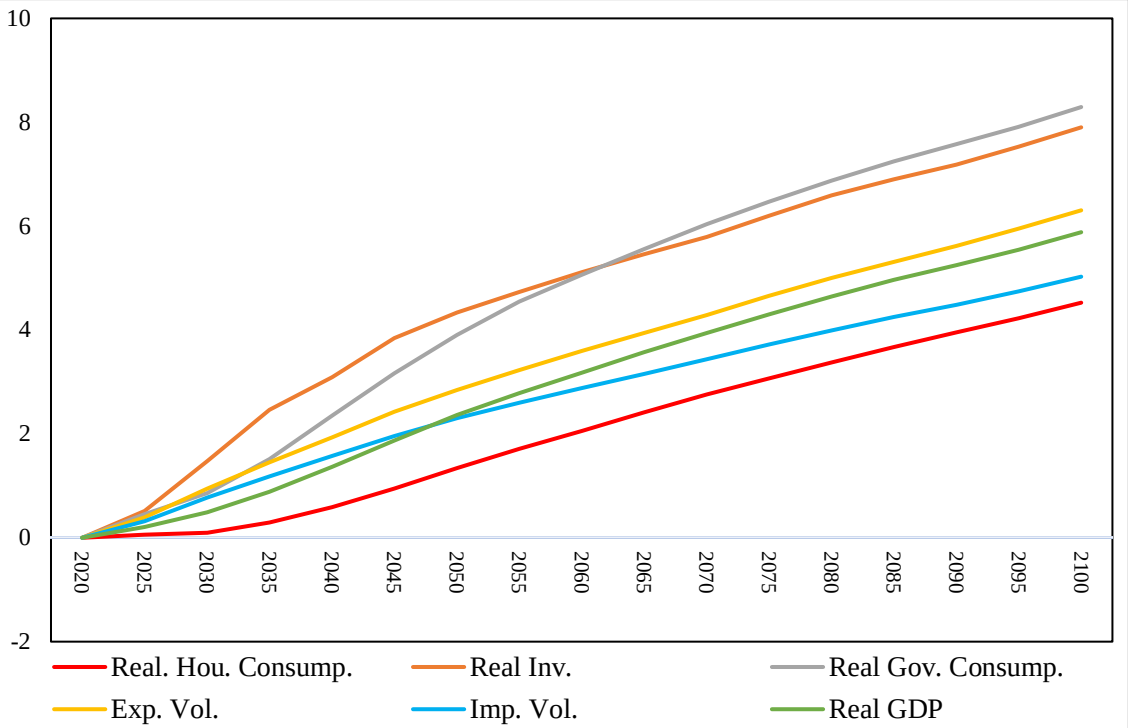


Source: Own elaboration. Results of BRIGHT model.
Set of variables: Real GDP; Aggregate employment; Real Wage; Aggregate Capital Stock; Consumer Price Index; Exports Price Index; Aggregate payments to labor (labor bill), Average Nominal Wage; Average nominal rental price of capital, respectively.

The results depictured in Graph 3.13 summarizes the growth path of the components of the expenditure side of GDP. The decrease of Government transfers to Households improved its budget and so its demands. But Government consumption is set to follow GDP growth path anyhow. Nonetheless, the reason why it overcomes GDP's growth path is because of another adjustment, the Balance of Trade's. As explained in the

respective section in Chapter 2, the *btslack* adjustment variable positively responds to keep balance of trade ratio to GDP constant and make the welfare gain domestically guided. The long-run investment rule assures a balanced Investment/Capital ratio all over the projection, also weighted by *btslack*. Although compensated by the total wage income increase and the balance of trade adjustment, households' lower income from Government transfers limits their consumption relatively to Government's. A certain degree of inequality is then expected, as the next subsection shows.

Graph 3.13 – GDP (Expenditure Side Variables) of the Policy with Tax Relief (% Cumulative deviation to Baseline)

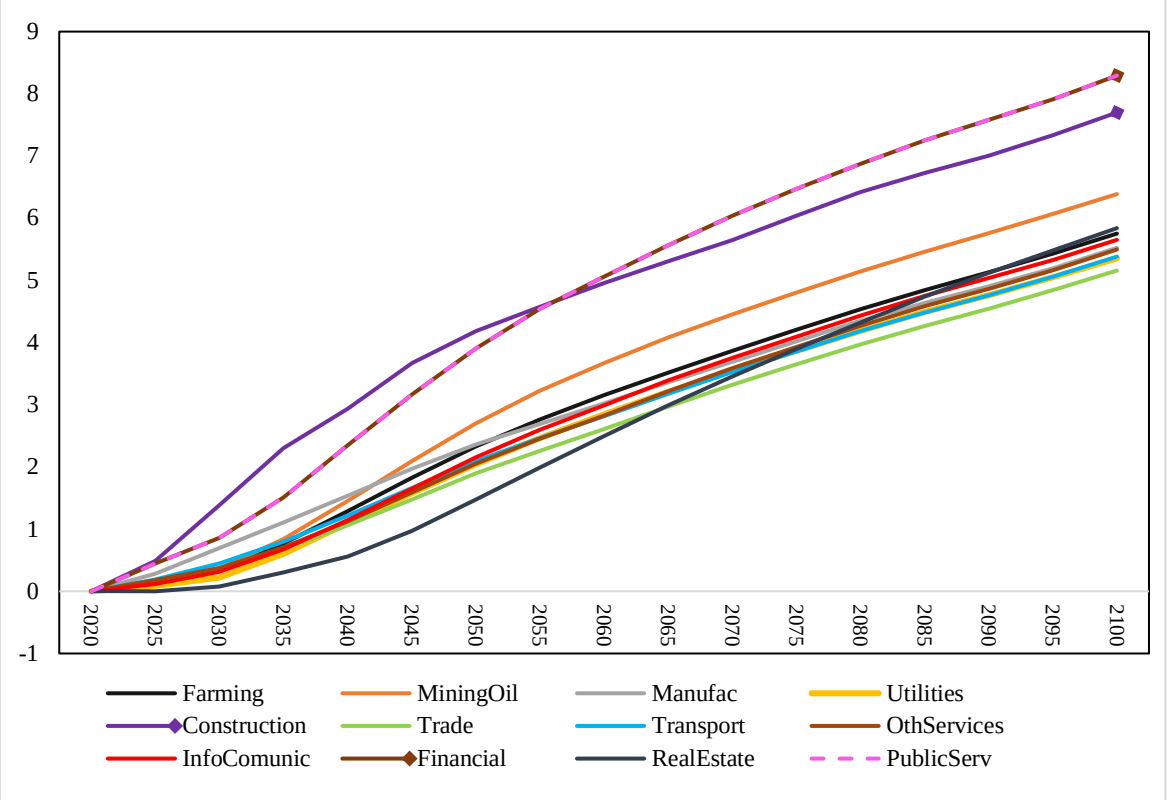


Source: Own elaboration. Results of BRIGHT model.

Considering the aggregate sectors output growth rates[42], Graph 3.14 shows that, because of a similar demand for capital and labor composite, financial sector cumulative growth is equal to the public sector's. Construction sector also performs well, following Investment growth, and Mining/Oil industry because of its capital intensity and trade exposition (recall that export prices shrinks less than domestic prices – C.P.I.). The condition of fixed balance of trade over GDP also prevents exports-oriented sectors to grow abruptly.

[42] BRIGHT has 65 sectors in its database (Annex 1 shows the mapping to the 12 sectors presented).

Graph 3.14 – Industrial Result of the Policy with Tax Relief (% Cumulative deviation to Baseline)



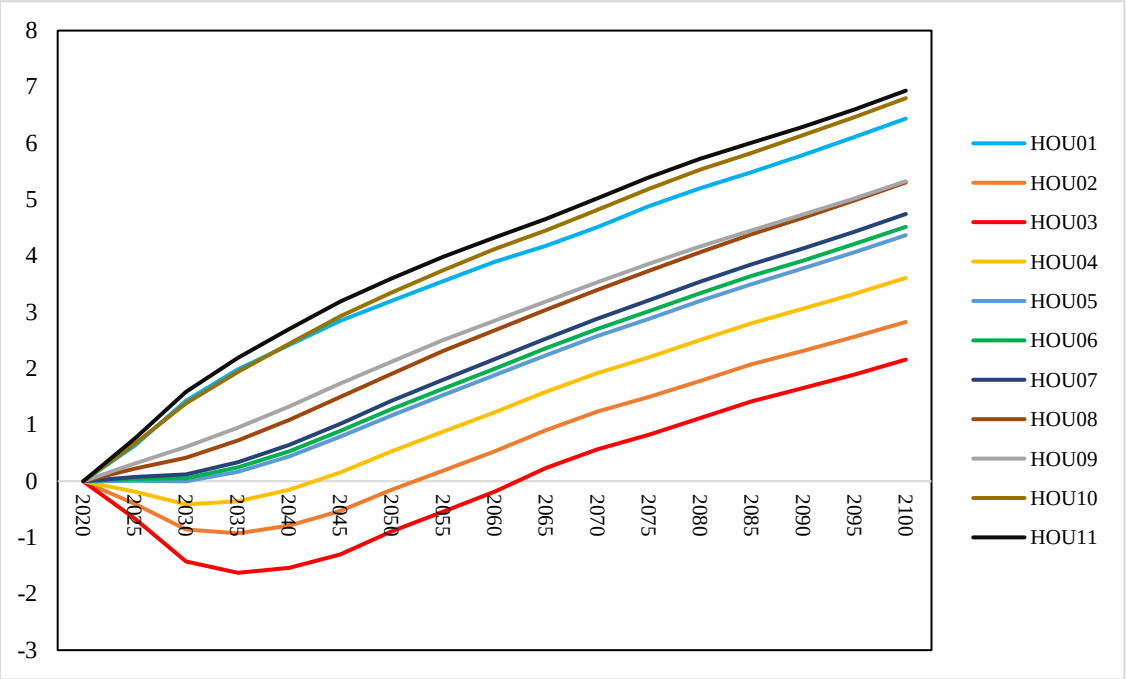
Source: Own elaboration. Results of BRIGHT model.

3.4.3 Households

As previously observed in the macroeconomic results, in a length of 80 years, real Households consumption grows 4.5% more under the Policy with Tax Adjustment scenario compared to the baseline. Graph 3.15 shows however that it has a heterogeneous pattern amongst household's income classes.

While the richest households HOU11 and HOU10 increase their consumption by 6.9 and 6.8, respectively, the poor and lower middle-income classes HOU2, HOU3 and HOU4 increase only by 2.8, 2.3 and 3.6, respectively. The poorest household HOU1 consumption shows a particular dynamic, as Chapter 2 showed: its income is less represented by labor or pensions, but by GOS and the rest of the transfers from Government, just as the richest classes. HOU9 and HOU8 income is also particularly affected by similar reasons.

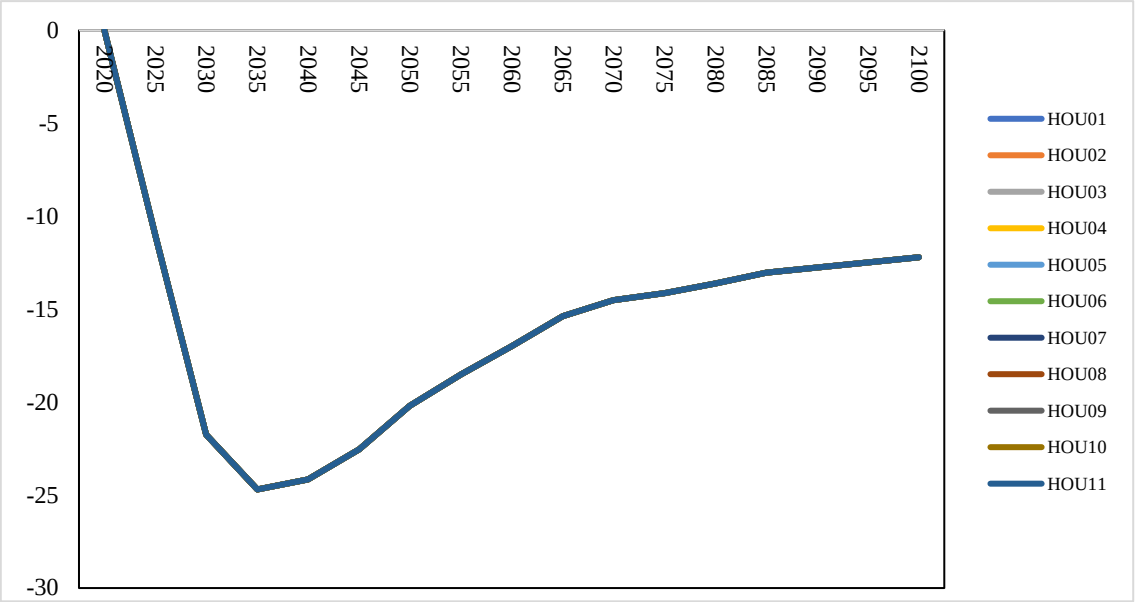
Graph 3.15 - Household Consumption Result of the Policy with Tax Relief (% Cumulative deviation to Baseline)



Source: Own elaboration. Results of BRIGHT model.

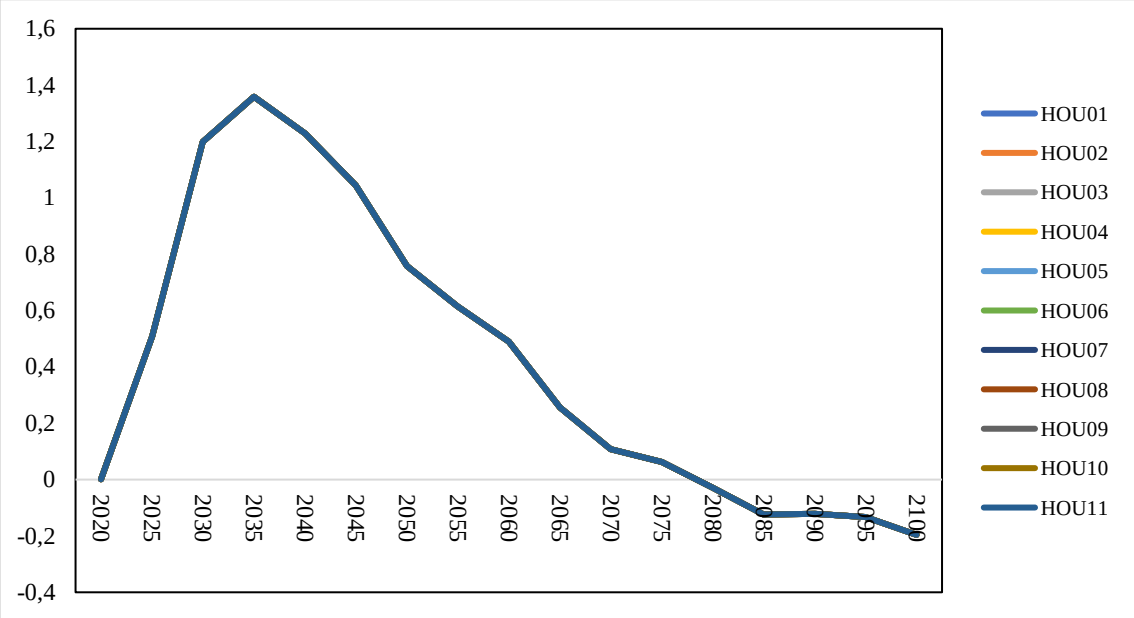
In BRIGHT model, the raise of the working age population (or lower-edge of eligible pensioners) is given equally amongst households, in a way that benefits changes do not vary between them (Graphs 3.16 and 3.17). Poorer households, however, are the ones with the biggest share of pension benefits in their income – harming their consumption initial path more than the richer households (initially benefited from the tax relief). That overcomes the effects of a relatively higher growth of labor income compared to capital income, that should benefit the poorer the most.

Graph 3.16 – RGPS Pension Benefits to Retired Households Result of the Policy with Tax Relief (% Cumulative deviation to Baseline)



Source: Own elaboration. Results of BRIGHT model. Lines overlapped.

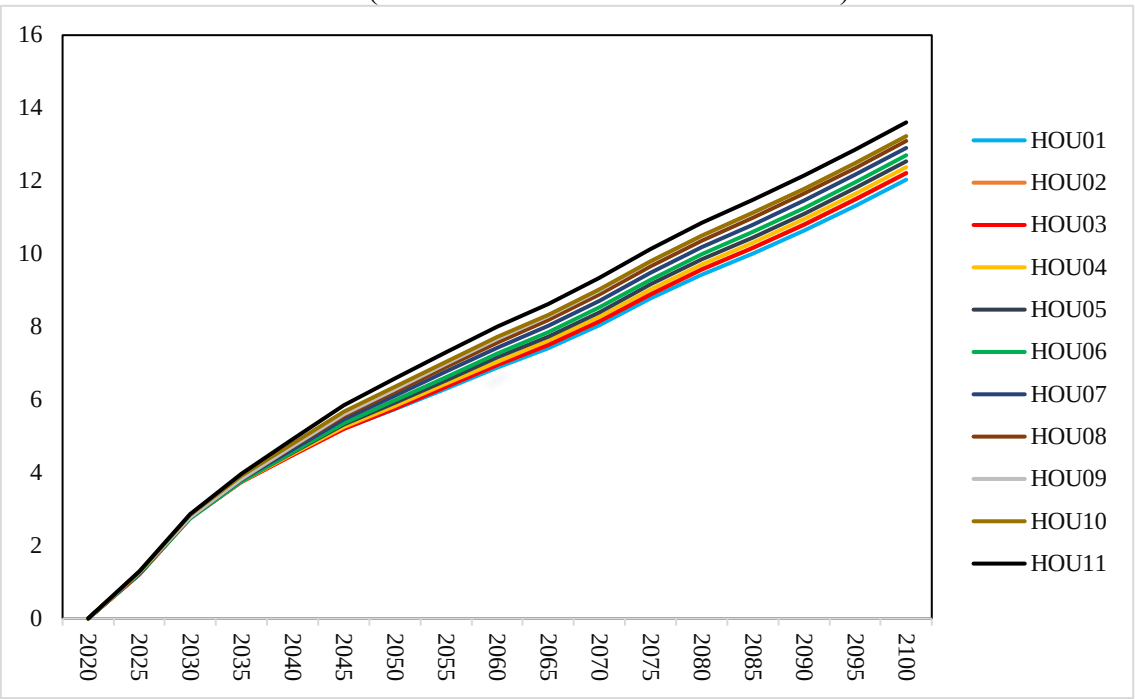
Graph 3.17 – Other RGPS Pension Benefits to Households Result of the Policy with Tax Relief (% Cumulative deviation to Baseline)



Source: Own elaboration. Results of BRIGHT model. Lines overlapped.

Graphs 3.16 and 3.17 show that households' benefits from the RGPS grow the same rate for all income classes (overlapping lines), differently from the contributions to the scheme, depictured in Graph 18, where it is related to labor income. Richer households labor income had grown relatively more because of the industrial outcome (public and financial sectors pay relatively more, therefore employ workers from the top income classes).

Graph 3.18 – Households Contributions to RGPS Result of the Policy with Tax Relief (% Cumulative deviation to Baseline)



Source: Own elaboration. Results of BRIGHT model.

The result leads to a gentle increase of inter-households' income inequality in 2100, measured by the inter-class Gini index (Table 3.6).

Table 3.6 – Inter-household Disposable Income Gini Index

Baseline	Gini Index	Policy w/ Tax Relief	Gini Index	Difference
2025	0.4929	2025	0.4929	0.0022%
2040	0.4922	2040	0.4922	0.0002%
2100	0.4530	2100	0.4595	1.45%

Source: Own calculation according to BRIGHT model results.

The results are explained by the distributional aspects of households' income. Figure 3.1 shows the differences between Policy with Tax Relief and Baseline in each income source (pre-tax income) and duty (post-tax income). The 2015 Gini Index for each income source/duty helps to associate each change to the Gini indexes shown in Table 3.6. The 1.45% difference observed between the Policy and the Baseline in 2100 (a distributional worsening) has to do with the sources and duties affected by the policy.

In Figure 3.1, it is possible to see that the balance between income sources and duties benefited, notwithstanding very little, those with the higher concentration, that is, with a higher 2015 Gini Index. In 2100, income sources such as labor income – the most representative and rather well-distributed source of households' income – is higher; but capital and transfers from Enterprises, rather "exclusive" sources of income (see that the 2015 Gini are 0.7295 and 0.7518, respectively), have too a higher share in the pre-tax income. Additionally, RGPS pensions, another well-distributed source of income, have a -2.38% lower share in 2100's policy scenario compared to the 2100's baseline. On the duties side, income tax is lower and contributions are higher. These two aspects combined contribute to a worse disposable income distribution.

Figure 3.1 – Income Sources and Duties Shares: Results from the Policy with Tax Relief (Comparative deviation to Baseline)

Income Source	Gini 2015	Deviation 2100
Labour	0.4147	2.09
GOS	0.7295	0.14
Enterprises	0.7518	0.19
RGPS Pension	0.4652	-2.38
RPPS Pension	0.7678	-0.06
Military Pension	0.7678	-0.02
BPC Pension	-0.1907	-0.01
RGPS Others	0.1906	-0.08
RPPS Others	0.6401	-0.02
Military Others	0.6401	-0.01
BPC Others	-0.1907	-0.01
Gov. Others	0.6326	0.14
ROW	0.8715	0.01
Gift	0.7552	0.01

Income Duty	Gini 2015	Deviation 2100
Income Tax	0.8715	-0.61
RGPS Contrib.	0.5078	1.64
RPPS Contrib.	0.7329	0.45
Military Contib.	0.7537	0.04
Gov. Others	0.5674	-1.52

Source: Own calculation according to BRIGHT model results.
Note: deviations sum zero inside sources and duties.

3.4.4 Fiscal

As introduced in this section, it is suitable to recapture the role of the closure's fiscal adjustment condition from this point ahead. "The Role of the Closure" subsection of Chapter 2 described that, if the modeler wants to test the hypothesis of using the occasional surplus from a policy to relief Government's budget and reduce its deficit, they should keep $ftaxgen$ exogenous and see $delgovsavrate$ floating accordingly. That is what happens in the "Policy with Budget Relief" scenario, as Graph 3.9 and 3.10 showed. It was also possible to compare some results of that scenario with the ones of the Tax Relief adjustment. That led to slightly better results the in terms of activity level but slightly worse results when it comes to tax revenues, naturally. Table 3.7 shows a tiny fiscal improvement when Government keeps the reform's surplus to its budget instead. As depictured in Graph 3.10, that is due to prices contraction and, naturally, general tax collection.

Prices contract under the Budget Relief scenario for the same reason that they do under the Tax Relief scenario (due to labor extension), but with the additional component of the lower activity level. For that reason, total wage bill is lower under that scenario and so the pension benefits aggregate flow – for the wage level is its price indexer. That affects RGPS balance nominally. Government Saving deficit, on the other hand, improves due to prices and more taxation, compared to the Policy with Tax Relief Scenario. Because of the reform, nevertheless, both Policy scenarios bring better fiscal results compared to the baseline. Finally, one can also observe that, although the RGPS scheme is modelled as part of Government budget, the generated surplus (R$ 944 billion in the Policy with Budget Relief) is not entirely transmitted to Government Saving surplus (R$ 562 billion in the Policy with Budget Relief), because the other Government's expenditure accounts are bigger in the policy (see that GDP is R$ 1,330 billion higher in the Policy with Budget Relief compared to the baseline's).

Table 3.7 – Summarizing Fiscal Results, 2100 (R$ Billion - cumulative)

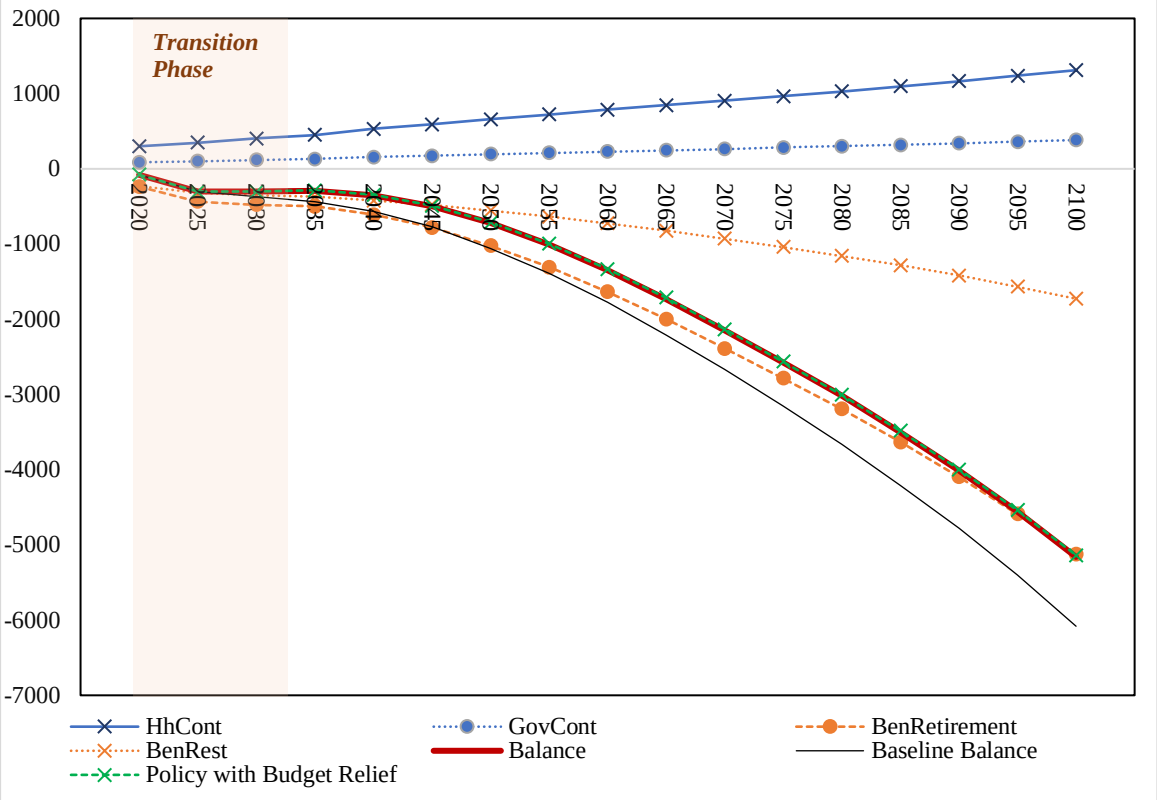
Variable	Baseline	Policy with Budget Relief	Policy with Tax Relief
GDP	28,937.12	30,267.22	30,299.85
Gov. Saving	-9,473.38	-8,911.29	-8,998.86
RGPS Balance	-6,081.54	-5,137.24	-5,160.01
Gov. Saving deficit ratio to GDP	32.73%	29.44%	29.70%
RGPS deficit ratio to GDP	21.01%	16.97%	17.03%

Source: Own elaboration. Results of BRIGHT model.

This fiscal subsection shows important nominal values and ratios that measure Government budgetary impacts of the reform introduced by the policy scenario. The effort to update the model's database have contributed to reproduce compatible numbers to those officially stated on the National Pension Scheme statistical yearbooks.

Graph 3.19 shows the paths of the aggregate flows of the RGPS from the Policy with Tax Relief scenario. The Policy with Budget Relief scenario balance and the baseline balance paths are also available for comparison matters. The historical shock for the window 2016-2020 brought the RGPS total balance in the 2021-2025 window close to the actual deficit shown in the last BEPS edition (-R$304 billion). After that, the reform can control it until the end of the effects of the transition phase, in the 2040-2045 window. By 2045 onwards, it grows exponentially up to -R$5.1 trillion in 2100 – a relief of approximately R$ 921 billion in 2100's prices level, however, compared to the baseline balance, as Table 3.7 shows. The Policy with Budget Relief balance path is barely distinguishable to the Policy with Tax Relief. As Table 3.7 showed, it delivers approximately R$ 23 billion saving to the scheme in 2100, comparatively. One interesting thing is that, because there is no reform in the baseline – hence no transition phase – that Baseline balance visually branches from the Policies' paths in the 2020-2025 window – starting a premature downhill.

Graph 3.19 – The Result of the RGPS: Contributions and Benefits Flows – Policy with Tax Relief Scenario Nominal Values (R$ Billion – cumulative)



Source: Own elaboration. Results of BRIGHT model.
Variables: HhCont – Households Contributions to the RGPS; GovGont – Government Contribution to the RGPS; BenRetirement – Retirement Benefits from the RGPS; BenRest – Other benefits from the RGPS.

Table 3.8 shows the Intra-household balance and Government contribution to the National Pension Scheme measured in nominal values. When it comes from households, negative values mean benefits inflows (pensions and other benefits) bigger than contributions outflows. It is noticeable the usual inflow for the lower-middle income households and an outflow of the richest up to the year of 2040. In other words, although poorer households are worse-off regarding contributions and benefits growth flows (not to say consumption growth path), they still contribute less than they get from benefits of the National Pension Scheme[43]. This result persists in the long run, an tend to spread amid all household classes. Government contributions follows Households contributions growth rate. The totals are the same depictured in the policy's balance results of Graph 3.19.

[43] Irrelevant information for a PAYG scheme overall structure, but relevant for its distributive aspects.

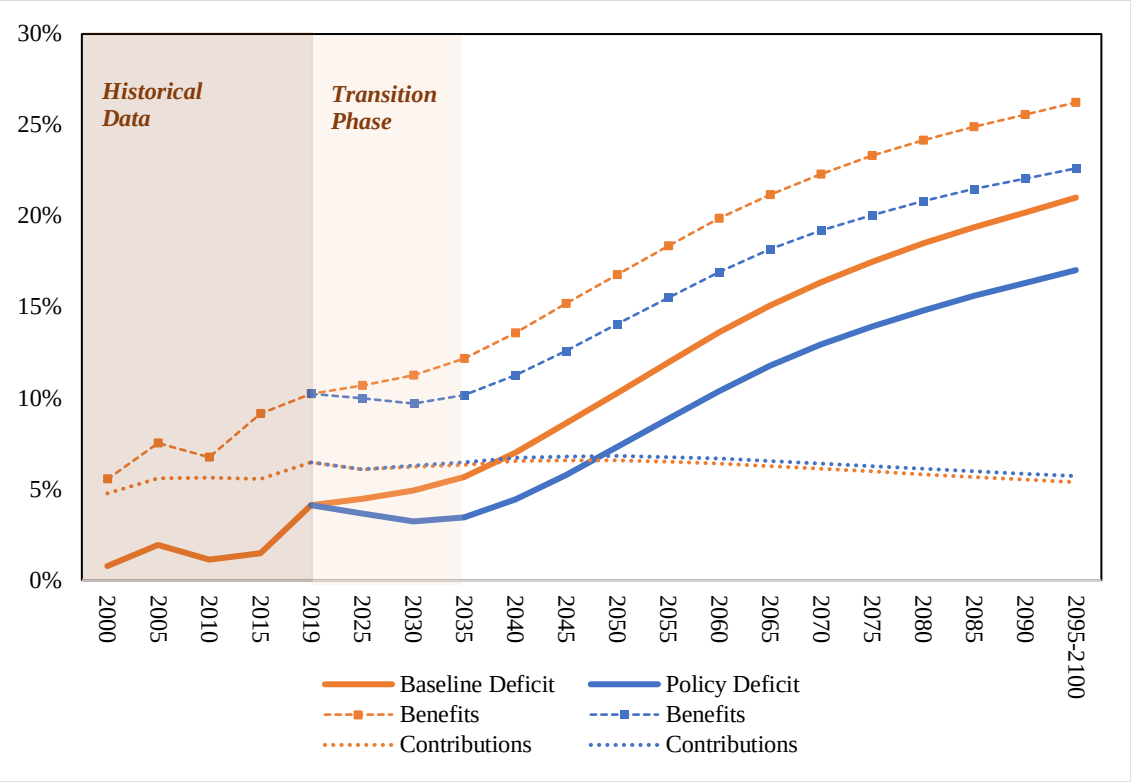
Table 3.8 – Households and Government Contribution to the National Pension Scheme – Policy with Tax Relief Scenario (R$ Million – cumulative)

HOU / Gov	2020	2040	2100
HOU1	-1.820	-3.063	-25.914
HOU2	-52.628	-87.716	-549.468
HOU3	-106.188	-176.353	-1.095.944
HOU4	-112.972	-185.718	-1.372.204
HOU5	-30.604	-49.454	-421.875
HOU6	-41.432	-67.863	-631.085
HOU7	-23.654	-39.033	-394.377
HOU8	-23.789	-39.270	-501.254
HOU9	-11.951	-20.086	-246.150
HOU10	713	1.718	-133.737
HOU11	-1.587	-2.955	-170.487
Gov. Contrib.	101.417	172.131	382.488
Total	-304.495	-497.662	-5.160.007

Source: Own elaboration. Results of BRIGHT model.

Graph 3.20 shows the ratios of RGPS flows over GDP in the Baseline and in the Policy with Tax Relief scenarios along the simulation length. Historical data guides the simulation accordingly, where both baseline and policy forecasts start from. One can notice from the policy curves that the reform sooths the scheme's deficit growth path, bringing its ratio to GDP down in 3 percentage points compared to the Baseline in 2040. After that, the deficit goes up again**.** In 2100, the National Pension Scheme deficit to GDP is 17% (21% is the ratio without the reform). Lower retirement pension benefits play the major role, since contributions ratios remain barely the same (there is less than 0.4 p.p. total increase due to the labor force extension of the reform).

Graph 3.20 – National Pension Scheme Flows ratio to GDP (%) – Policy with Tax Relief Scenario



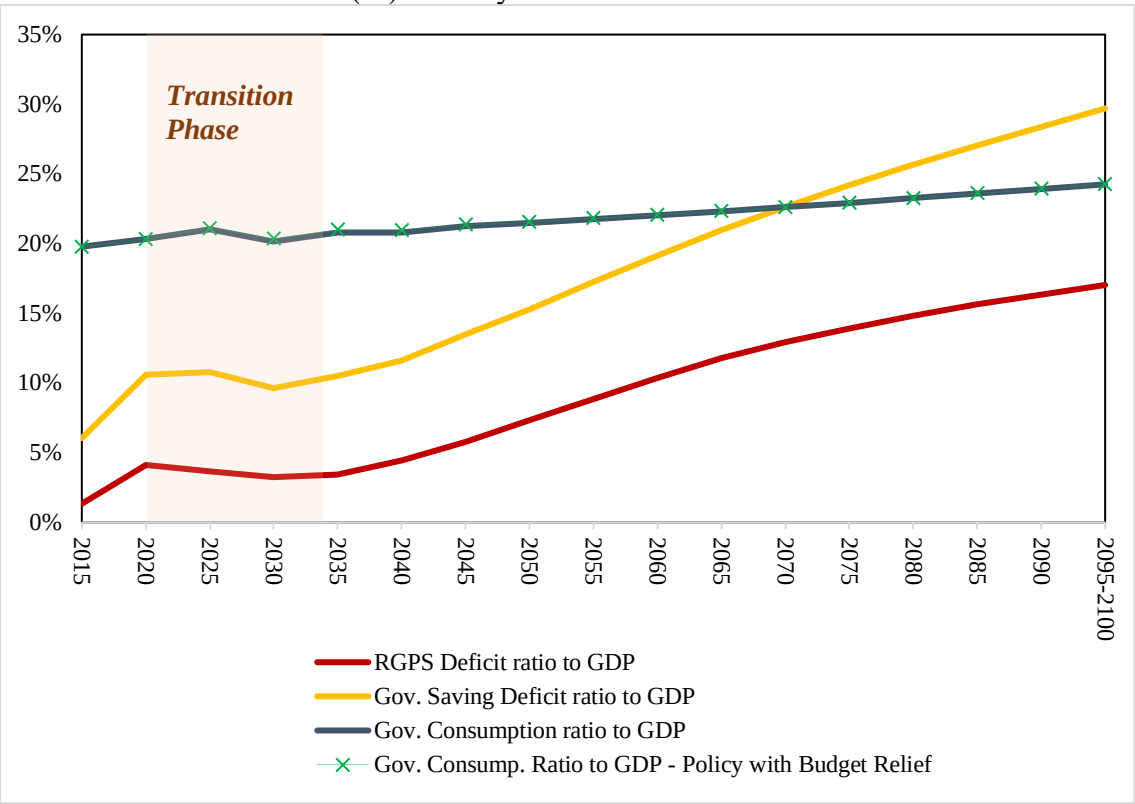
Source: Own elaboration. Results of BRIGHT model. Historical data from BEPS.

At last, Graph 3.21 compares the National Pension Scheme deficit ratio to GDP, the Government Saving deficit ratio to GDP and the Government Consumption ratio to GDP throughout the policy scenario. The abrupt unbalanced growth of the RGPS after the transition phase contributes to increase Government savings deficit, for Government demands path grows stable. For comparisons matters, it also shows the Government Consumption ratio to GDP path of the Policy with Budget Relief scenario – which is, again, closely identical to the one of the Policy with Tax Relief scenario. The results from both policy scenarios shows an increase of Government Consumption ratio to GDP because of the balance of trade adjustment variable, as explained in subsection 3.4.2.

As one can notice, the Policy with Tax Relief scenario shows that Government demands ratio to GDP starts from 20% (R$ 1,497 billion) in 2020, reaches 21% in 2040 (R$ 2,332 billion), and, finally, 24% (R$ 7,348 billion) in 2100, a total nominal growth of 391% in 80 years. On the other hand, the RGPS Deficit ratio to GDP starts from 4.1% in 2020 (-R$ 304 billion), reaches 4.4% in 2040 (-R$ 349 billion) and, finally, 17% in 2100 (-R$ 5,674 billion), a total nominal growth of 1,595% in 80 years. Government Savings deficit, in turn, starts from 11% of the GDP in 2020 (-R$ 781 billion), reaches

12% in 2040 (-R$ 1,302 billion) and, finally, 30% in 2100 (-R$ 8,998 billion), a total growth of 1,052% in 80 years.

Graph 3.21 – RGPS Benefits, Government Consumption and Saving ratios to GDP (%) – Policy with Tax Relief Scenario



Source: Own elaboration. Results of BRIGHT model.

3.5 Final Remarks

Population ageing implies a lot of changes to any society. Government normally faces a suppressing budget while labor force shrinks and becomes more expensive to firms. Households normally save less and investment might become scarcer. In response of such a scenario, public policies of the institutional reforms type are designed to alleviate the problems, often revealing unpredicted ones.

Models suggest that Brazilian labor force will start to shrink around 2035-40 while seniors will be the majority in the population. That will pressure its main scheme of pension, the National Pension Scheme, that also plays an important role on social security and income distribution. Therefore, we adapted a dynamic computable general equilibrium (CGE) model of the Brazilian economy to analyze the long-run impacts of a pension reform, with a suitable fiscal and pension module.

It was possible to see that the minimal age introduced by the pension reform in 2019 postpone the abruptic increase of the pension's deficit by keeping its balance path stable until 2040. This moment coincides with the end of the transition phase of the reform, where the growth rate of eligible pensioners catches up its "natural" path (the new senior population growth path). Summing up, the reform reduces the flow of benefits of the scheme by raising the target of eligible pensioners (shifts the lower-edge of eligibility upwards) and increases contributions by keeping workers longer in the labor force (a labor extension shock).

These effects lead to a positive macroeconomic result. Under a full employment capacity (labor trend equals actual employment), an increase in the labor force supply enhances capital stock and the total wage income. That contributes to a higher activity level and labor-intensive industries stand out under a tax and balance of trade adjustment conditions. As previously explained, the tax adjustment mechanism plays a particular allocative role under the reform's experiment, although the results of the policy without it do not change much.

In 2100, GDP is 5.88% higher under the policy with tax relief scenario and 5.71% under the policy with budget relief. The results of the policy with tax relief shows a 7.9% and an 8.3% increase of Investment and Government consumption, respectively, compared to the baseline. There is also a 4.53% increase of households' consumption but

with an unequal distribution amongst household classes. It was showed that benefits, contributions, and taxation, play important roles when it comes to households' inequality.

The fiscal results show that, although under deficit, the reform keeps National Pension Scheme result stable until 2040, in a ratio of 4% of the GDP. Deficit starts to go downhill from that moment on. By the year of 2100, it is expected to be about 17% of GDP, contrasted to the 21% result of the scenario with no reform. Summing up, the reform might contribute to reduce National Pension Schemes' deficit in approximately R$1 trillion. That does not mean a Government Savings' relief, however. The scheme's deficit pressures Government's primary deficit (dissaving) ratio to GDP almost fully even in under a budget relief condition policy, for Government consumption ratio to GDP path is pretty much stable.

This experiment lacks important actuarial features of a probabilistic model that might contribute to some limitations of accuracy on the pension flows forecast. Nonetheless, we have managed to incorporate the main demographic changes of ageing and pension's reform through shocks and a quite well specified equations system that transmit them to the rest of the CGE structure in a dynamic way. In a future agenda, it would be suitable to test simulations with updated population and labor projections, for Brazilian Demographic census has just been released, as well as to incorporate estimations of the reduced average benefit, also affected by the reform.

Population ageing matters to a pension scheme's sustainability, in a way that, through robustness and adequacy guarantee, it should respond to society's maturing working-life cycle. In this paper, it was also possible explore the equity aspects of the National Pension Scheme's flows. The next experiment deals with its affordability and coverage.

Annex 1

Table A3.1 – Mapping from 65 sectors of BRIGHT to 12 sectors

From	**To**	**From**	**To**
1 Agricultura	Farming	36 MRepMaqEq	Industry
2 Pecuaria	Farming	37 EnerEleGasN	Utilities
3 PrFloPesSil	Farming	38 AguaEsgResid	Utilities
4 ExtCarMi	MiningOil	39 Construcao	Construction
5 ExtPetrGas	MiningOil	40 ComOut	Trade
6 ExtMinFerro	MiningOil	41 TranspTerr	Transport
7 ExtMMetNF	MiningOil	42 TransAqua	Transport
8 AbateCarne	Industry	43 TranspAere	Transport
9 FabRefAcu	Industry	44 AAuxTransp	Transport
10 OutAliment	Industry	45 Alojamento	OthServices
11 Bebidas	Industry	46 Alimentacao	OthServices
12 ProdFumo	Industry	47 EdIntImpres	InfoComunic
13 Texteis	Industry	48 AtiTVRadio	InfoComunic
14 Vestuario	Industry	49 Telecomun	InfoComunic
15 FabCCalcado	Industry	50 DesenSisInf	InfoComunic
16 FabProdMad	Industry	51 IntFinSegPr	Financial
17 FabCelPapel	Industry	52 AtivImobili	RealEstate
18 ImpRGrava	Industry	53 AtiConCons	OthServices
19 RefPetCoq	Industry	54 SerArqEng	OthServices
20 FabBiocom	Industry	55 OutProfCien	OthServices
21 FabQuiOrIno	Industry	56 Alugueis	RealEstate
22 FabDDesinf	Industry	57 OutAtivAdm	OthServices
23 FabProdLim	Industry	58 AtiVigSegInv	OthServices
24 FabFarmoFar	Industry	59 AdmPublica	PublicServ
25 FabBorPlast	Industry	60 EducPublica	PublicServ
26 FabMinNMet	Industry	61 EducPrivada	OthServices
27 ProFerrFde	Industry	62 SauPublica	PublicServ
28 Metalurgia	Industry	63 SauPrivada	OthServices
29 FabProdMet	Industry	64 AtivArtCria	OthServices
30 FabEqInform	Industry	65 ServPesDom	OthServices
31 FabMaqEqEle	Industry		
32 FabMaqEqMec	Industry		
33 FabAutoCam	Industry		
34 FabPecAcVei	Industry		
35 FabMovOutr	Industry		

Source: Own elaboration.

Chapter 4 – Understanding Brazilian Workforce

Prospects about Productivity and the Social Security Enrollment

4.1 Introduction

The 2010s were bitter for Brazilian economy. In response of a multiple-source crisis that accelerated deindustrialization and rose the unemployment rate, a liberal agenda reappeared strongly towards labor market flexibilization, contributing to a significant change on the characteristics of the workforce.

There is an expressive share of workers in the Brazilian economy that do not contribute to any pension scheme. Indeed, "labor taxes" are high in Brazil – and social contributions to official pension schemes represent the biggest part of them. According to the System of National Accounts (IBGE, 2016), however, they are accounted as labor income – a labor right of social security shared with the employer. As informality is a persistent phenomenon in developing economies, the new forms of labor characterized by precarization and self-employment keep Brazilian labor force away from the desirable level of enrollment on the consequent unfunded and unbalanced pension system.

Through labor market and the public expenditure, the economic activity plays along with the demographic aspects of ageing in jeopardizing a scheme's performance. Therefore, discussions on the National Pension Scheme affordability have always been an issue. Nonetheless, the efforts to solve those problems also goes through its coverage expansion: constantly challenged by unemployment, informality and the precarization phenomenon in the labor market.

This experiment assumes that the pension reform of 2019, analyzed in the previous Chapter, has an intimate relation with the labor reform of 2017 and its consequences. For instance, they both tend to discourage pension enrollment by two aspects, respectively: the labor reform, by allowing a strong flexibilization in the labor market, where workers lose labor rights and keep themselves apart from a desirable level of formality; the pension reform, by changing the benefit formula and extending the working-life cycle, which might contribute to a shift from the National Pension Scheme

(RGPS) enrollment to the expectance of a social security rescue through the Continuous Cash Benefit (BPC), for example.

After a detailed literature review on Brazilian economy, focused on labor market and regulation policies, and a labor stratification of Brazilian workforce, it was possible to imagine two different scenarios and, consequently, formulate two additional experiments with BRIGHT model. One considers the optimistic possibility of the recovery of contributors in the National Pension Scheme and the other, a pessimist prospect of precarization in the labor market. General and fiscal results show the importance of maintaining labor productivity growing, shedding light on the role of enrollment and contributions to the social security system.

4.2 Literature Review

Brazilian labor market is marked by significant and persistent inequalities, strongly related to the phenomena of social exclusion that originate and reproduce poverty. This exclusion is enrooted in the slavery system that, linked to an extensive agricultural model, coined the economic formation of Brazil (Furtado; 1977; de Paula, 2002). The modernization of the Brazilian economy came through the abolishment of the old traditional system, in the end of the 19th century, followed by the industrialization at the first half of the 20th century, which absorbed that great supply of labor and lead the country's institutional development (Dedecca, 2005; Cano 1977). The economic opening of the 1980s and 1990s has changed the path of the country's labor market up to this date, that still suffers from the main symptoms of the early deindustrialization. (Cano, 2012; Torres e Cavalieri, 2015; Cruz e Santos, 2011; Morceiro e Guilhoto, 2023; Magalhães *et al.*, 2023).

Concentrated in the Southeast region, Brazil's industrialization succeeded through the transition of rural work to the urban centers (with a considerable inter-regional migration), in addition to immigration flows (Mello and Castro, 1984; Holloway, 1984). If at the end of the 19th century the Brazilian population was scattered over the territory, from 1920 onwards, the Southeast region's population (specially the state of São Paulo) grew and contrasted to the rest. That contributed to the persistent level of regional and urban inequality, reinforced by the economy's inability to adequately assist the growing labor supply (Ferreira and Diniz, 1995; Singer, 1977; Deddeca, 2005).

Between 1940 and 1942, the State stablished a broad regulation in the labor market – e.g., the minimum wage and the Consolidation of Labor Laws (CLT) for the non-agricultural workers. Despite that, public regulation failed in enforcing rights for that growing industrial workforce in a way that the industrialization process occurred with a low effectiveness of social protection. At the end of the long period of industrialization (1930-1980), approximately half of the employed population did not have access to the social protection system established in the early 1940s. The low degree of social protection reproduced a poorly institutionalized labor market – i.e., mainly informal and, therefore, unequal (Deddeca, 2005; Ulyssea, 2006).

The international oil crisis of the 1970s interrupted the foreign capital flow to the country, that also demanded a high trade surplus to meet the foreign debt burden, and led to an austere agenda in the early 1980s – that was the lasting "lost decade" (Grinberg, 2008). The 1994 Real Plan (Franco, 1996) managed to control the chronic inflation at the expense of a large flow of external resources through privatizations, which, consequently, established a productive dependence on imported inputs and goods of consumption – because of the liberalization policies of the International Monetary Fund (IMF) guidelines. The Brazilian labor market started to show an increase in the degree of informality. There was a structural component, the expansion of a sector characterized by a relatively higher degree of informality (the services sector) and the retraction of a sector more intensive in formal jobs (the manufacturing industry), and, on the other hand, a component within the manufacturing industry itself, marked by an increasing informality and lower degree of education among formal and informal workers. (Deddeca, 2005; Ulyssea, 2006; Krein *et al.*, 2012).

The hypothesis of the need for flexibility in the Brazilian labor market lacks strong popularity: Galvão (2007), Krein (2007), and Santos (2006), despite focusing on different aspects, argue that flexibilization – i.e., the strengthening of market's self-regulation in face of a public regulation regarding labor issues – caused precariousness and insecurity in the labor market. In their opinion, Brazilian labor market was not rigid and that the so criticized labor taxes were, in fact, labor rights. The increase of unemployment and the disorganization of the labor market was then linked to a bad macroeconomic dynamic of the 1990s (lower demand, restructuring companies, macro adjustments).

This last hypothesis gained additional support during the 2000s. Krein (2012) shows that under Lula's government, marked by high economic growth (driven mainly by the significant increase in international demand for commodities and, secondarily, by a devalued exchange rate and significant idle capacity in several sectors) contributed to a better market and labor relations (through the improvement of tax collection, job creation, economic-financial situation of companies and then collective bargaining conditions for workers).

Between 2004 and 2010, Lula pursued a policy of valuing the minimum wage, deepened the Bolsa Família program, and started a set of policies to promote development of infrastructure, industry, and regional development with the Growth Acceleration Program (PAC). As a result, even with the international economic crisis, the number of formal employees grew by 24.3% (much more than the Active Labor Force, 11.5%) and the total number of "precarious" occupations, those without registration, domestic workers, self-employed and unpaid workers, fell by -1.1%. The process of flexibilization was maintained for specific categories, such as legal enterprises, micro and small companies, and young people (Galvão, 2010).

Under the effects of globalization and the economic crisis at the turn of the 2010s, the international literature has baptized a new class of workers, the *precariat*: those with distinctive relations of production such as flexible labor contracts; temporary jobs; labor as casuals, part-timers, or intermittently for labor brokers or employment agencies (Standing, 2011). In Thornley *et al.* (2010), *casualization* is given in a sense of any opposition to the full-time standard. *Precarization*, on the other hand, is a broader term, understood as the process and politics of producing precariousness relations of production and employment, i.e., low paid, highly contingent, non-union, and with relatively few social protections, often due to policies of flexibilization in the labor market.

The global economic crisis has reactivated deindustrialization in Brazil, boosted by another oil price collapse in 2014-2016 (Stocker *et al.*, 2018), and changed its class structure, lowering the share of industrial capitalists, skilled and non-skilled workers, and managers (Magalhães *et al.*, 2023). In response to the turbulent years of the decade, a liberal agenda reappeared strongly towards labor market's flexibilization (CNI, 1998; 2010 and 2012). Changes in the CLT, the expansion of the part-time employment contracts, outsourcing of all company activities and the prevalence of the negotiated over

the legislated, that is, the validation of agreements between employers and workers who disagree with the labor law, were largely considered in Brazilian Labor Reform of 2017.

Krein *et al.* (2019) shows that the process of flexibilization and precariousness of the work relations has kept labor informal, in addition to more autonomous workers; under occupation, formal and informal temporary occupations; and workers with CNPJ – the National Registry of Legal Entities. Cardoso and Azïs (2019) observes a similar pattern through the Continuous National Household Sample Survey (PNADC): the increase in informality and the unemployment among the young people, as well as a lower chance of unemployed people in finding a job.

This section shed light on the labor market issue in Brazil and makes room for many lessons. The enrooted inequalities of Brazilian labor market mentioned here are in symbiosis with issues like gender bias, i.e., wage differentials (Yahmed, 2018), participation in the market and unpaid work (Passos and Guedes, 2018; Cardoso and Hermeto, 2021); race (Lovell, 2000; Firpo *et al.*, 2021); age – the participation, permanence and vulnerability of young people (Corseuil *et al.*, 2020; Cardoso and Hermeto, 2021) and elderly people (Camarano, 2001; Wajnman *et al.,* 2004; Paolini, 2016) – skills (Gonzaga et al., 2006); and other aspects (Engbom and Moser, 2022), which can greatly contribute to this Thesis main topics: labor and the social security. The next section is about to investigate the recent trend of the characteristics of Brazilian occupied workforce through a detailed stratification.

4.3 Stratification of the Brazilian Workforce

This section brings a longitudinal exploratory data analysis of the recent transformation of the Brazilian occupied workforce through the Continuous National Household Sample Survey (PNADC), starting from 2015 up to 2022. In this period, it is important to emphasize that at least three important facts have happened in the Brazilian economy:

1. the 2015-2016 recession, where Brazilian real GDP shrunk by 7%;
2. the 2017 Labor Reform;
3. the 2020-2021 COVID pandemic crisis.

In this way, the year-by-year information allow separate analysis over the period. Nonetheless, the total evolution might provide important insights for the labor market and therefore policy evaluation.

There are different approaches to class analysis, usually linked to the most suitable sociological perspective to each locality, e.g., the neo-marxist perspective of Wright (1997; 2005; 2009; 2015) and the Brazilian approach of Santos (2002; 2005) and Santos *et al.* (2024). Pompeu *et al.* (2023) brings a full guide on labor and class stratification for Brazilian society.

Usual to the Brazilians labor surveys, in this Chapter, the methodology follows the *categories of occupation* identification under five perspectives of socioeconomic stratification analysis that, together, can shed light to the problem of precarization of the Brazilian workforce. They are: education, working hours, working payment, hiring and pension enrollment.

Frame 4.1 summarizes the main characteristics of this category of occupation typification regarding hiring and pension enrollment eligibility. One modification in the original structure is in the public sector category, split according to the hiring type: the statutory worker, hired after an official public tender and then subject to the public sector *own* rules of labor and social security (more information in Appendix A); and the rest of them, subject to the general rules of the labor market in a certain extent.

Frame 4.1 – Characteristics of the Categories of Occupation

Category of Occupation	CLT	RGPS	RPPS
Housekeeper	X	X	
Military			X
Private Sector Employee	X	X	
Public Sector Employee (Statutory)			X
Public Sector Employee	X	X	
Employer		X	
Self-Employed		X	
Unpaid worker		X	

Source: Own authorship.
CLT – Consolidation of the Labor Laws.
RGPS – National Pension Scheme
RPPS – Public Sector's Schemes of Social Security.

Frame 4.2 summarizes the general rules of contributions to the RGPS. One can notice that the rules are many, for often more than one type of worker coexist in each category of occupation. Because of the employer's contribution (as part of the social contribution's burden), contributions of the workers under CLT tend to be higher than the average.

Frame 4.2 – Rules of Contribution to the RGPS

Category of Occupation	Worker under the CLT	Autonomous Worker	Individual Microenterpreneur	Employer	Informal[44]
Housekeeper	e				a
Private Sector Employee	b				a
Public Sector Employee	b				a
Employer				a	a
Self-Employed		a	d		c
Unpaid worker					c

a – 20% up to a maximum wage-base or 11% of the minimum wage
b – Progressively from 7.5% to 14% (up to a maximum wage-base) + 20% of Employer's contribution
c – 11% of the minimum wage
d – 5% or 12% of the minimum wage, depending on the activity
e – 8% of the wage

Table 4.1 shows the recent evolution of the Brazilian occupied workforce by category of occupation. As one can observe, the total number of workers shrunk in the beginning of the series due to the 2015-2016 recession and the recover was marked by the rise of the self-employed category and the non-statutory public sector employees. In absolute numbers, however, private sector had the highest growth of the series. The

[44] According to IBGE (2015), the *informals* are the employees out of CLT scope and the autonomous/self-employed and entrepreneurs without an official labor/business registration (often the CNPJ – the National Registry of Legal Entities). It is often possible to see workers out of the CLT scope and with no CNPJ working for registered enterprises (Santos *et al.*, 2024). Contributions of this type of worker are made voluntarily.

number of unpaid workers shrunk considerably, especially after COVID, just as the housekeepers after the same length of time.

Table 4.1 – Brazilian Total Occupied Workforce by Category of Occupation (2015-2022), Brazil

Category of Occupation	2015	2016	2017	2018	2019	2022
Housekeeper	6,001,056	6,025,802 (0.4%)	6,034,169 (0.6%)	6,058,729 (1.0%)	6,063,278 (1.0%)	5,932,187 (-1.1%)
Military	813,970	832,612 (2.3%)	834,160 (2.5%)	889,306 (9.1%)	858,428 (5.6%)	824,577 (1.7%)
Private Sector Employee	46,947,35	45,558,67 (-3.0%)	45,064,78 (-4.0%)	45,664,35 (-2.7%)	47,075,06 (0.4%)	49,744,50 (6.0%)
Public Sector Employee (Statutory)	6,724,643	6,675,888 (-0.7%)	6,055,188 (-10.0%)	6,796,823 (2.2%)	6,771,453 (1.9%)	7,056,848 (6.1%)
Public Sector Employee	3,593,322	3,364,157 (-6.4%)	4,146,879 (16.9%)	3,718,273 (6.6%)	3,740,718 (7.2%)	4,146,879 (18.0%)
Employer	3,965,123	4,164,074 (5.0%)	4,160,237 (4.9%)	4,416,833 (11.1%)	4,306,701 (8.6%)	4,370,314 (10.1%)
Self-Employed	21,879,27	21,987,30 (0.5%)	22,725,07 (3.8%)	23,133,15 (5.6%)	24,091,88 (9.8%)	25,809,99 (16.9%)
Unpaid worker	2,475,514	2,141,528 (-13.5%)	2,184,178 (-11.5%)	2,093,878 (-15.6%)	2,048,624 (-17.8%)	1,691,587 (-35.2%)
Total	92,400,258	90,750,040 (-1.8%)	91,204,674 (-1.3%)	92,771,358 (0.4%)	94,956,159 (2.8%)	99,576,891 (7.7%)

Source: Own authorship according to PNADC (IBGE, 2023) data. Cumulative growth in parenthesis.

Tables 4.2 and 4.3 show the evolution of the self-employed category and the rest, respectively, by degree of education. Table 4.2 shows that the self-employment rise is led by educated workers, for the cumulative growth rates increases according to the degree of education. That correlation is less evident in the trends in Table 4.3.

Table 4.2 – Brazilian Total Occupied Self-Employed Category by Degree of Education (2015-2022), Brazil

Degree of Education	2015	2016	2017	2018	2019	2022
None	1,250,024	1,174,605 (-6.0%)	1,016,276 (-19.5%)	894,722 (-31.5%)	885,459 (-32.5%)	946,582 (-25.6%)
≤ Primary	8,498,716	8,008,271 (-5.8%)	8,023,528 (-5.6%)	7,751,852 (-9.0%)	7,732,602 (-9.2%)	7,076,095 (-17.7%)
Priamary	2,548,363	2,364,662 (-7.2%)	2,318,000 (-9.2%)	2,254,802 (-11.9%)	2,388,885 (-6.0%)	2,250,818 (-11.7%)
≤ Secondary	1,305,695	1,338,537 (2.5%)	1,500,971 (14.7%)	1,501,535 (14.7%)	1,731,843 (30.0%)	1,876,139 (38.4%)
Secondary	5,530,252	6,015,071 (8.8%)	6,484,506 16.6%)	6,720,814 (20.2%)	7,160,590 (26.8%)	8,478,975 (45.2%)
≤ Tertiary	651,892	690,929 (6.0%)	763,655 (16.5%)	961,694 (42.4%)	1,051,137 (51.7%)	1,123,188 (58.6%)
Tertiary	2,094,335	2,395,229 (14.4%)	2,618,143 (23.7%)	3,047,737 (40.1%)	3,141,372 (43.2%)	4,058,201 (72.3%)
Total	21,879,277	21,987,303	22,725,078	23,133,157	24,091,888	25,809,999

Source: Own authorship according to PNADC (IBGE, 2023) data. Cumulative growth in parenthesis.

Table 4.3 – Brazilian Total Occupied Workforce (Rest) by Degree of Education (2015-2022), Brazil

Degree of Education	2015	2016	2017	2018	2019	2022
None	1,421,785	1,447,014 (1.8%)	1,246,771 (-12.1%)	1,104,741 (-23.5%)	1,067,557 (-26.8%)	1,331,435 (-2.1%)
≤ Primary	15,638,559	14,545,708 (-7.0%)	14,336,541 (-8.4%)	13,930,154 (-11.3%)	13,418,829 (-14.9%)	11,898,740 (-26.3%)
Priamary	7,036,635	6,099,743 (-13.3%)	5,760,335 (-18.9%)	5,608,059 (-21.5%)	5,424,289 (-24.8%)	5,040,698 (-31.9%)
≤ Secondary	4,821,839	4,529,235 (-6.1%)	4,824,716 (0.5%)	4,843,178 (0.8%)	4,810,827 (0.2%)	5,167,979 (7.6%)
Secondary	23,857,791	23,806,327 (-0.2%)	23,722,073 (-0.6%)	24,168,247 (1.3%)	25,160,961 (5.4%)	27,195,142 (13.5%)
≤ Higher	4,532,543	4,332,561 (-4.4%)	4,534,379 (0.2%)	4,778,916 (5.6%)	5,014,077 (10.6%)	4,914,118 (8.6%)
Higher	13,211,828	14,002,149 (6.0%)	14,054,781 (6.4%)	15,204,906 (14.5%)	15,967,731 (19.6%)	18,218,780 (33.7%)
Total	70,520,981	68,762,737	68,479,596	69,638,202	70,864,270	73,766,892

Source: Own authorship according to PNADC (IBGE, 2023) data. Cumulative growth in parenthesis.

Tables 4.4 and 4.5 handle with the working hour aspect in the labor market. If in Table 4.4 no significant difference could be noticed in the average weekly working hours by category of occupation, Table 4.5 show that the total number of workers with a reduced working shift have increased for some categories. Overall, this points to the casualization phenomena, understood as work insecurity due to the difficulty in accessing jobs with compatible working hours to a desired level of income (full-time jobs).

Table 4.4 – Average Weekly Working Hours by Category of Occupation (2015-2022), Brazil

Category of Occupation	2015	2016	2017	2018	2019	2022
Housekeeper	33.6	33.2	32.7	32.7	32.7	33.0
Military	42.8	42.6	42.9	42.4	43.2	42.9
Private Sector Employee	41.7	41.4	41.2	41.3	41.3	41.2
Public Sector Employee (Statutory)	36.5	37.0	36.8	37.0	37.0	37.6
Public Sector Employee	37.1	37.0	37.9	38.2	37.7	38.0
Employer	46.3	45.6	45.7	46.0	46.4	45.4
Self-Employed	37.8	37.6	37.3	37.2	37.4	37.9
Unpaid worker	29.5	30.1	28.9	29.1	29.0	29.6

Source: Own authorship according to PNADC (IBGE, 2023) data.

Instead of cumulative growth, the numbers in parenthesis in Table 4.5 show the ratio to the total number of workers of Table 4.1. One can notice that, while the self-employed, the housekeepers and the unpaid workers categories have the share increased in the period, both public sectors' have decreased. Military and Private sector employee shares remained constant. That indicates the proximity of the precarization and casualization processes verified in the period.

Table 4.5 – Brazilian Total Occupied Workforce (Less than 20 Hours of Work per Week) by Category of Occupation – Recent Evolution (2015-2022)

Category of Occupation	2015	2016	2017	2018	2019	2022
Housekeeper	1,426,378 (24%)	1,506,749 (25%) (5.6%)	1,637,503 (27%) (14.3%)	1,643,890 (27%) (14.7%)	1,641,289 (27%) (14.5%)	1,586,495 (27%) (11.2%)
Military	8,992 (1%)	4,714 (1%) (-47.6%)	8,144 (1%) 25.2%)	9,523 (1%) 42.1%)	4,375 (1%) (-11.9%)	10,727 (1%) (133.2%)
Private Sector Employee	2,284,305 (5%)	2,223,836 (5%) (-2.6%)	2,495,218 (6%) 9.6%)	2,669,558 (6%) 16.5%)	2,724,309 (6%) 18.6%)	2,704,413 (5%) 17.9%)
Public Sector Employee (Statutory)	638,857 (10%)	575,252 (9%) (-10.0%)	574,648 (9%) (-10.1%)	542,433 (8%) (-15.7%)	561,143 (8%) (-12.2%)	497,671 (7%) (-23.5%)
Public Sector Employee	147,856 (4%)	119,697 (4%) (-19.0%)	111,481 (3%) (-25.9%)	104,607 (3%) (-32.1%)	126,433 (3%) (-11.2%)	128,333 (3%) (-9.7%)
Employer	135,730 (3%)	183,265 (4%) (35.0%)	184,213 (4%) (35.5%)	190,346 (4%) (38.9%)	184,747 (4%) (35.9%)	186,289 (4%) (36.8%)
Self-Employed	3,791,234 (17%)	3,831,447 (17%) (1.1%)	4,324,324 (19%) (13.9%)	4,514,503 (20%) (18.3%)	4,744,332 (20%) (23.4%)	4,495,808 (17%) (18.2%)
Unpaid worker	951,393 (38%)	837,511 (39%)	919,138 (42%)	901,558 (43%)	891,578 (44%)	694,737 (41%)
Total	9,384,746	9,282,472	10,254,668	10,576,419	10,878,208	10,304,473

Source: Own authorship according to PNADC (IBGE, 2023) data. Share in parenthesis.

Table 4.6 shows the average monthly working payment of each category of occupation. One can observe that the emergent self-employed and non-statutory public sector employee have the highest growth rates, despite the lower average compared to their "peers" (the natural contrast of the self-employed category is the private sector employee while the non-statutory public sector employee should be the statutory public sector employee). That might be the result of the educational trend of those categories, as well as to the insufficient working schedule. Afterall, that is another sign of precariousness

Table 4.6 – Average Monthly Working Payment by Category of Occupation (2015-2022), Brazil (R$)

Category of Occupation	2015	2016	2017	2018	2019	2022
Housekeeper	742	813 (9.6%)	830 (11.7%)	874 (16.9%)	893 (19.2%)	1,071 (39.1%)
Military	3,665	4,005 (9.3%)	4,384 (18.7%)	4,777 (27.7%)	4,806 (28.3%)	5,655 (46.0%)
Private Sector Employee	1,625	1,784 (9.8%)	1,824 (12.0%)	1,882 (15.2%)	1,970 (19.9%)	2,403 (41.9%)
Public Sector Employee (Statutory)	3,262	3,552 (8.9%)	3,690 (12.8%)	3,959 (20.1%)	4,114 (24.0%)	4,660 (37.2%)
Public Sector Employee	2,454	2,806 (14.4%)	3,314 (32.5%)	3,455 (36.7%)	3,595 (40.8%)	4,134 (55.8%)
Employer	4,755	5,162 (8.6%)	5,163 (8.6%)	5,646 (17.9%)	6,044 (25.0%)	6,580 (33.9%)
Self-Employed	1,431	1,510 (5.5%)	1,559 (8.7%)	1,644 (14.2%)	1,662 (15.3%)	2,188 (46.9%)

Source: Own authorship according to PNADC (IBGE, 2023) data. 2022 Deflator. Cumulative growth in parenthesis.

The hourly working payment trend in Table 4.7 is a relevant metric for the evolution of income in different categories. The evolution of the hourly payment follows the average monthly working payment, for no significant changes have happened to the average weekly working hours, despite the increase of reduced-schedule workers.

Table 4.7– Average Hourly Working Payment by Category of Occupation — Recent Evolution (2015-2022), Brazil (R$)

Category of Occupation	2015	2016	2017	2018	2019	2022
Housekeeper	5.26	5.84	6.04	6.36	6.50	7.73
Military	20.39	22.36	24.36	26.81	26.50	31.39
Private Sector Employee	9.28	10.26	10.53	10.86	11.36	13.87
Public Sector Employee (Statutory)	21.29	22.88	23.85	25.46	26.48	29.53
Public Sector Employee	15.75	18.04	20.82	21.52	22.68	25.90
Employer	24.43	26.95	26.88	29.25	31.01	34.51
Self-Employed	9.01	9.57	9.96	10.53	10.59	13.74

Source: Own authorship according to PNADC (IBGE, 2023) data. 2022 Deflator.

Table 4.8 brings the information that might signify the most symbolic change of the Brazilian occupied workforce towards precariousness in the recent years: the fall of the CLT. It is important to emphasize that that happened in parallel to the rise of the self-employment, for that category is, by definition, not eligible to the CLT scope. Another thing to consider is that the content of the CLT was also subject of flexibilization in the 2017's labor reform. Nonetheless, private, and public sector employees out of CLT scope are therefore unprotected employees, often irregular to the nature of their job[45].

As the average in Table 4.8 shows, the total number of workers under CLT decreased from 70% to 65% of the occupied workforce in the length of seven years, led in absolute numbers by the private sector. Housekeepers is the category with the highest relative reduction, while in the public sector the number shrunk by 4 percentage points. Another aspect to consider has to do with the timing. The first significant break of registered employees was in 2017, due to the labor reform; in the public sector, however, the number had recovered in the following years before it breaks again after COVID, just as the share of registered housekeepers.

Table 4.8 – Percentage Share of the Brazilian Occupied Workforce Hired under CLT, by Category of Occupation — Recent Evolution (2015-2022)

Category of Occupation	2015	2016	2017	2018	2019	2022
Housekeeper	32%	32%	30%	28%	28%	25%
Private Sector Employee	78%	77%	75%	74%	74%	73%
Public Sector Employee	35%	35%	31%	34%	34%	31%
Average	70%	69%	67%	66%	66%	65%

Source: Own authorship according to PNADC (IBGE, 2023) data.

Table 4.9 shows the evolution of the average monthly working payment, distinguished according to hiring aspect. It is clear that the workers under CLT earn

[45] E.g., waiters, bar and restaurant's employees, that work under their Individual Micro-Entrepreneur (MEI) register (or cash in hand) are still employees – not self-employed – for their work activity is not compatible to the autonomous work IBGE (2015) definition. The same is for doctors hired by local Governments to work in public hospitals and health unities – they are not statutory employees, for they often did not face an official public tender, nor they are hired under the CLT, for they often use their Individual Micro-Entrepreneur register. Still, they are public sector employees, for they are not autonomous workers. Note that autonomous and self-employed workers are roughly synonyms. Despite the conflictual situation, all workers under MEI are considered legal – or formal.

considerably more than those under other type of contract; the gap is narrowing, especially after the labor reform of 2017, the wage differential is decreasing to all categories of occupation.

Table 4.9 – Average Monthly Working Payment, by Category of Occupation (Eligible to CLT) — Recent Evolution (2015-2022), Brazil (R$)

Category of Occupation	CLT	2015	2016	2017	2018	2019	2022
Housekeeper	Yes	992	1,121	1,165	1,234	1,263	1,505
	No	622	668	686	734	751	925
	Diff.	59%	68%	70%	68%	68%	63%
Private Sector Employee	Yes	1,774	1,968	2,028	2,087	2,168	2,622
	No	1,100	1,178	1,208	1,296	1,406	1,817
	Diff.	61%	67%	68%	61%	54%	44%
Public Sector Employee	Yes	2,575	2,771	3,381	3,633	3,671	4,070
	No	1,452	1,699	1,742	1,846	1,938	2,321
	Diff.	77%	63%	94%	97%	89%	75%

Source: Own authorship according to PNADC (IBGE, 2023) data.

The previous information of the CLT coverage is deeply related to the next one, about the RGPS enrollment. As Frame 4.1 summarized, while some categories are eligible to the RPPS (in fact, those are compulsorily enrolled); the eligibles to the RGPS are the employees (including housekeepers) in addition to the employers and the self-employed categories. Table 4.10 presents the share of workers enrolled in the RGPS. Because the CLT scope guarantees workers' compulsory enrollment in the RGPS, it does not consider the total number of registered workers hired under CLT, but only those that contribute individually or by other rule of contribution, such as those for workers under the Individual Micro-Entrepreneur register.

Table 4.10 – Percentage Share of the Brazilian Occupied Workforce Enrolled in the RGPS, by Category of Occupation — Recent Evolution (2015-2022)

Category of Occupation	2015	2016	2017	2018	2019	2022
Housekeeper	10%	11%	10%	11%	11%	11%
Private Sector Employee	3%	3%	4%	4%	4%	5%
Public Sector Employee	44%	44%	38%	45%	43%	45%
Employer	76%	76%	73%	70%	72%	71%
Self-Employed	29%	31%	30%	30%	30%	33%
Total Average*	64%	64%	62%	61%	61%	61%

Source: Own authorship according to PNADC (IBGE, 2023) data.
*Considering workers under CLT.

One can observe that the total average share of enrollment fell by 3 percentage points in the length of 7 years. Again, the most significant break happened in 2017, after the labor reform, and remained lower up to 2022 for all categories except for the self-employed. The self-employment higher share of enrollment suggests that this emergent category, with an increasing share of educated professionals, chase social security and the right for labor protection that it offers, despite the lower average income. The same is true for the rest of the employees out the CLT scope: the reduced worker protection might be somehow compensated by the social security enrollment increase. The employer's category has its coverage shrunk by 5 percentage points.

Summing up, this plain labor stratification analysis could show many sings of precariousness in the recent years. They are:

1. After the 2015-2016 recession, the recovery of the total occupied workforce was marked by the rise of the self-employed category and the non-statutory public sector employees.

2. Despite the overall growing labor income, self-employed and non-statutory public sector employee categories earn significantly less than their "pairs" employed in the private and public sector, indicating an aggregate productivity reduction.

3. The rise of the self-employment is considerably led by educated workers, differently from the trend of the rest of the categories.

4. Part-time or insufficient hour-shift jobs were mainly occupied by self-employed, housekeepers and unpaid workers categories.

5. Raise of general labor insecurity due to:

   i. lower pension enrollment, for the CLT coverage have shrunk by 5 p.p.; and

   ii. lower contributions, for the increasing share of enrolled self-employed and unprotected employees earn less than both public and private sector's under CLT.

For this last aspect, another thing to consider is that, according to the rules depictured in Frame 4.2, the contributions of those categories tend to be considerably lower than those of CLT workers.

4.4 The CGE Experiment

Running over BRIGHT Pension Module main equations, as Chapter 2 showed, one can roughly structure the two main pension equations as follow:

$$C_{ht}^{schm} = \alpha_{ht}^{schm} + e_{ht} + y_{ht} \tag{4.1}$$

$$B_{ht}^{schm} = \beta_{ht}^{schm} + POP_{ht}^{65+} + w_t^{ave} \tag{4.2}$$

In which:

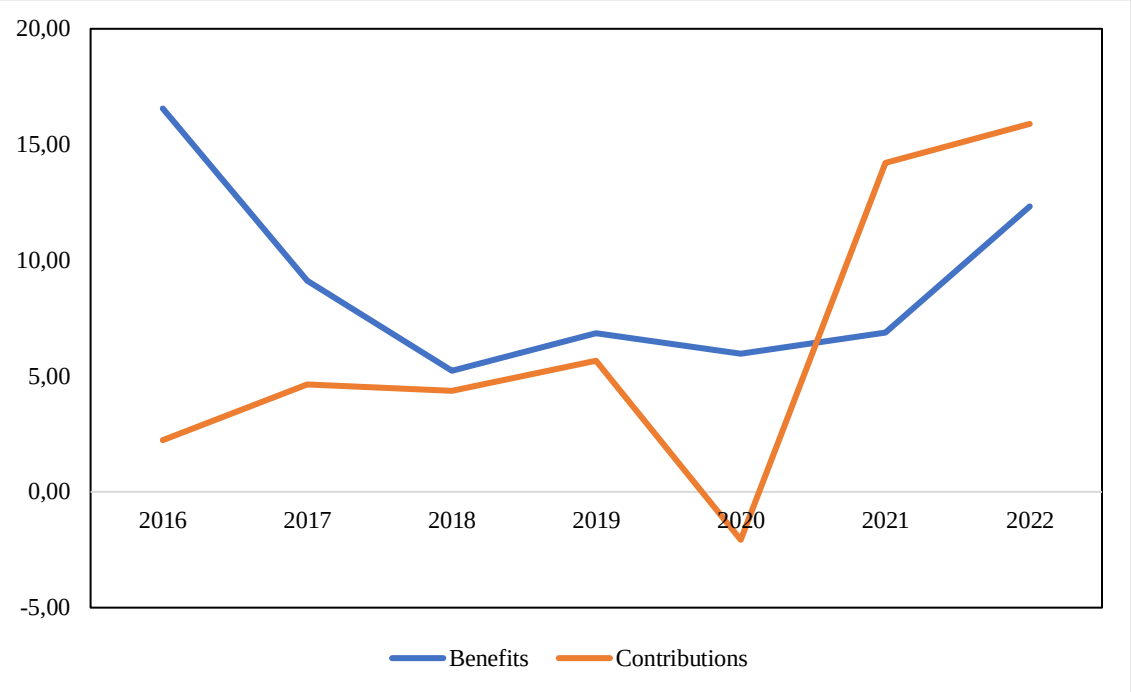
i) Contributions growth path C_{ht}^{schm} follows aggregate employment e_{ht} and total labor income y_{ht} growth paths, by scheme and household class in every year t, where α_{ht}^{schm} is a scalar (Equation 4.1);

ii) Retirement benefits growth path B_{ht}^{schm} follows the eligible population (seniors) growth rate POP_{ht}^{65+}, weighted by the labor nominal price component (average nominal wage) w_t^{ave}, by scheme and household class in every year t, where β_{ht}^{schm} is a scalar (Equation 4.2); and

Two relevant aspects should be noticed: usual to the CGE modelling syntax, the scalars act both as slack variables, to swap with endogenous variables, and shifters (the natural role of any scalar); in this case, it may be understood as a coverage parameter.

Despite the disenrollment, the Social Security Statistical Bulletins (BEPS) (BRASIL, 2023) of the 2015-2022 period show a modest increase of the total amount of contributions (except for the first year of Covid crisis) and benefits transfers, as Graph 4.1 shows. That is a sign that indeed contributions still follow employment and wage income.

Graph 4.1 – Total Contributions and Benefits (Nominal) – Annual Growth Rates



Source: Own elaboration according to the Social Security Statistical Bulletins (BEPS) data.

Inspired by the recent trend depictured in Graph 4.1, this experiment brings a policy strategy of raising the National Scheme's enrollment $\alpha^{RGPS}_{2023-2026}$, uniformly amongst households, in 1% a year in the short-run period of 2023 to 2026. Alternatively, in response to the 2015-2022 disenrollment showed in Table 4.10, no compensation is given in a way that it leads to a similar reduction of beneficiaries 40 years later, β^{RGPS}_{2060}, along with similar a raise of Government's assistance BPC holders, β^{BPC}_{2060}, however. That is for the unprotected workers might increase the demand for this type of aid, for no retirement pension should be applicable. Additionally, because they are also not eligible to any type of assistance during the working-age cycle, a -1.5% shock of productivity is

simultaneously given, following the ILO (ILOSTAT) estimates for Brazil in the 2016-2019 period.

Tables 4.11 and 4.12 shows the historical projections of each baseline scenario. In the short-run baseline, the shocks reproduce the observed growth rates, year by year, of the 2016-2022 period; in the long-run baseline, the observed and projected growth rates for the 2016-2020 and 2021-2025 quinquennium. Differently from the historical baseline projection of Chapter 3 experiment, the nominal form of variables such as GDP and the RGPS flows were prioritized to produce more accurate estimates. The long-run baseline scenario is not exactly the same to the one of the previous chapter.

Table 4.11 – Growth Rates – Historical Baseline Forecast (2016-2022)

Variable	Average Yearly Growth Rate (%)
Household Consumption	0.90
Investment	2.01
Government Consumption	0.16
Exports	2.00
Imports	1.6
GDP (Nominal)	0.81
Actual Employment	1.63
Total Population	0.69
RGPS Ret. Benefits (Nominal)	1.70
RGPS Oth. Benefits (Nominal)	1.70
RGPS Contributions (Nominal)	6.42

Source: IGBE and AEPS Infologo (BRASIL, 2023).

Table 4.12 – Growth Rates – Historical Baseline Forecast (2016-2025)

Variable	Average Yearly Growth Rate (%) 2016-2020	Cumulative Growth Rate (%) 2016-2020	Average Yearly Growth Rate (%) 2021-2025	Cumulative Growth Rate (%) 2021-2025
Household Consumption	-0.24	-1.18	2.99	14.99
Investment	-2.14	-10.68	6.46	32.28
Government Consumption	0.77	3.85	2.50	12.48
Exports	1	4.97	3.78	18.91
GDP (Nominal)	5.2	25.98	7.15	35.77
Total Population	0.78	3.90	0.53	2.63
Actual Employment	-1.20	0.80	2.12	8.60
RGPS Ret. Benefits (Nominal)	10.30	51.50	7.52	37.59
RGPS Oth. Benefits (Nominal)	10.30	51.50	7.52	37.59
RGPS Contributions (Nominal)	3.12	15.60	5.34	26.70

Source: IGBE and AEPS Infologo.
Note: It was considered a yearly 2.5% growth rate of all variables in the 2023-2025 period.

Frame 4.3 summarizes both policy scenarios. They are built over the new minimal age forecast scenario, introduced by the Pension Reform of 2019 – now the baseline – in which labor force and RGPS pension benefits and contributions growth rates follows the post-reform trends[46].

[46] See section 3 of Chapter 3. It was considered a yearly 2.5% growth rate of nominal GDP in the 2023-2026 period for baseline forecast of Policy 1, and a 10% productivity quinquennial gain in Policy 2.

Frame 4.3 – Simulation Strategy

	Policy 1	**Policy 2**
Description	Recovery	Precarization
Aspect	Cyclical (short-run)	Permanent (long-run)
Shocks	**2023-2026:** $\alpha_h^{RGPS} = 1\%$ (each year)	**2020:** $a1lab\_io *= 1.5\%$ **2060:** $\beta_{ht}^{RGPS} = -4\%$ $\beta_{ht}^{BPC} = 4\%$

Source: Own Elaboration. * Labor-augmenting technical change. A positive shock means that more labor factor is required to produce the same quantity of output, a *negative* productivity shock thus.

One thing to consider is that the labor market and investment short and long-run dynamics vary according to the closure's settings of the model, as Frame 4.4 summarizes.

Frame 4.4 – Main Closure Settings

	Policy 1	**Policy 2**
Aspect	Cyclical (2023-2026)	Permanent (2020-2100)
Labor Market	*Employment trend* grows according to the labor force projection; both *real wage* and *actual employment* endogenous	Actual employment grows according to the labor force projection (*employment trend*); only *real wage* endogenous
Capital/Investment	DPSV investment rule (Dixon *et al.*¸ 1982): *Gross growth rate of capital* follows *Gross rate of return* (rental price over cost of unit of capital), by industry	Planned investment/capital ratio: both *investment* and *capital accumulation*, by industry, endogenous (*Gross rate of return* not considered)

Source: Own Elaboration.

4.5 Results

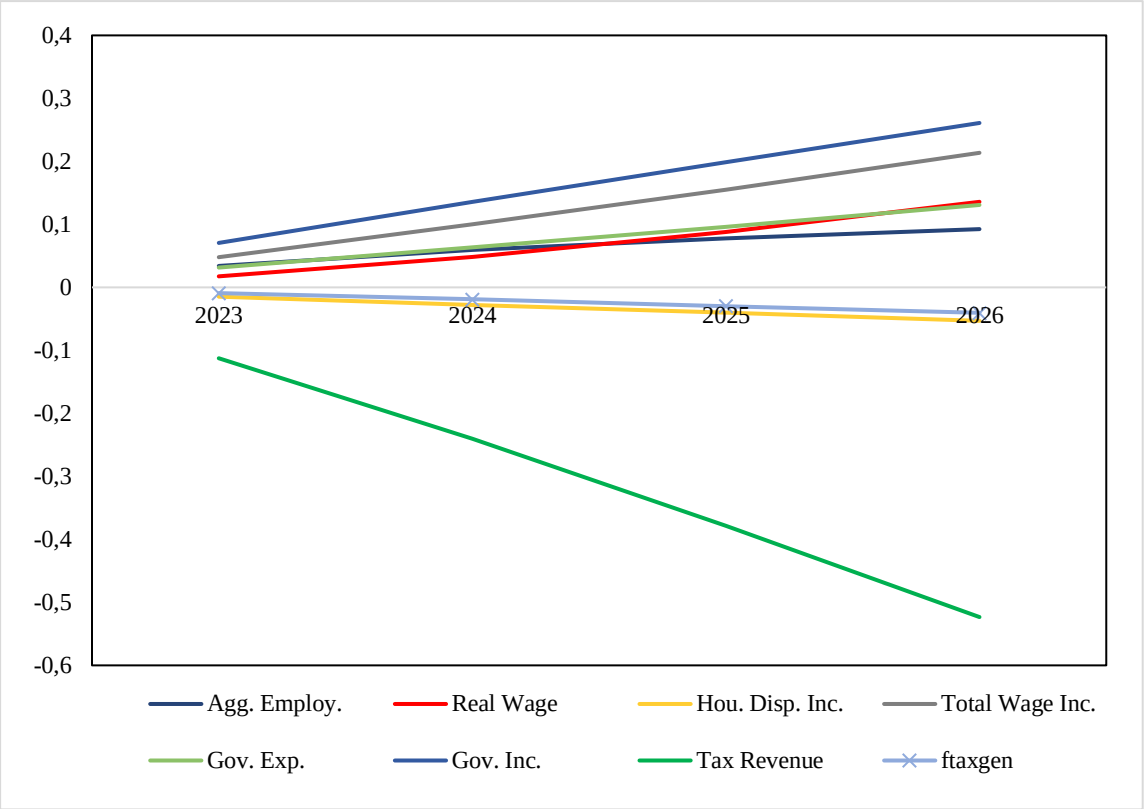
As the previous section presented, the results in this section are divided according to two different experiments divided in two respective subsections. Each of them shows the model's transmission mechanisms to the main results, focused on the macroeconomic and fiscal spheres, as well as on households[47]. They can shed light on the potentialities that labor aspects might deliver to the National Pension Scheme, as well as to the whole Government account.

4.5.1 Policy 1 – Recovery

Policy 1 deals with the possibility of a short-run recover of contributors in the National Pension Scheme. Graph 4.2 shows the "first-round" effects of the policy. The raise of contributors increases contributions, which affects Government income (the highest cumulative growth) more than it does to Government expenditure. That leads to a lower need for taxation, according to the fiscal adjustment condition, slightly boosting private sector: aggregate employment goes up, along with total labor income and real wage. Total tax revenue goes down. The raise of contribution disbursement however makes those gains virtually zero from households' perspective, for general disposable income is slightly lower.

[47] They were both projected under the allocative "Tax Relief" condition. See Chapter 2, section 3.3.3.

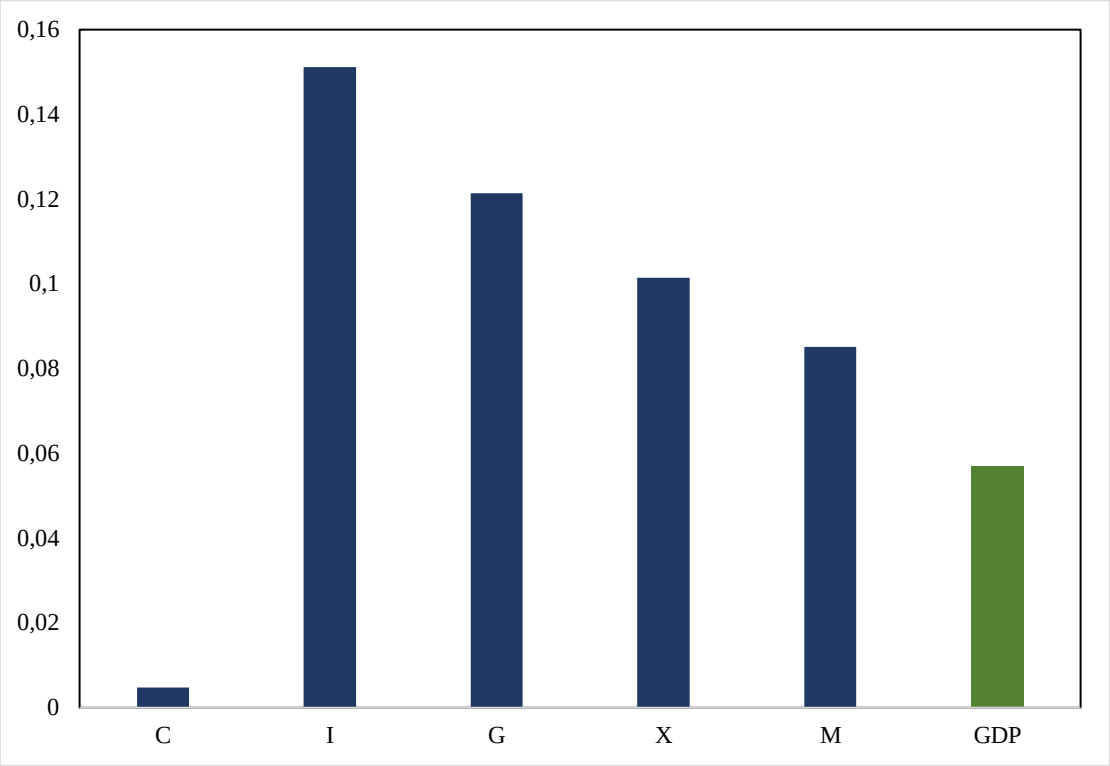
Graph 4.2 - Direct Effects of Policy 1 – (% Cumulative deviation to Baseline)



Source: Own elaboration. Results of BRIGHT model.

Graph 4.3 shows the cumulative growth of the aggregate components of the GDP by its expenditure side. The raise of contributions has the potential of gently raise the economy's output through Government's tax relief position. Although inexpressive, that mechanism affects investment the most (mainly through prices), followed by Government consumption and exports. Because of the direct effects previously explained – higher contributions and lower disposable income – Households consumption shows the lower cumulative growth, with an inequal behavior between classes, as Graph 4.4 shows.

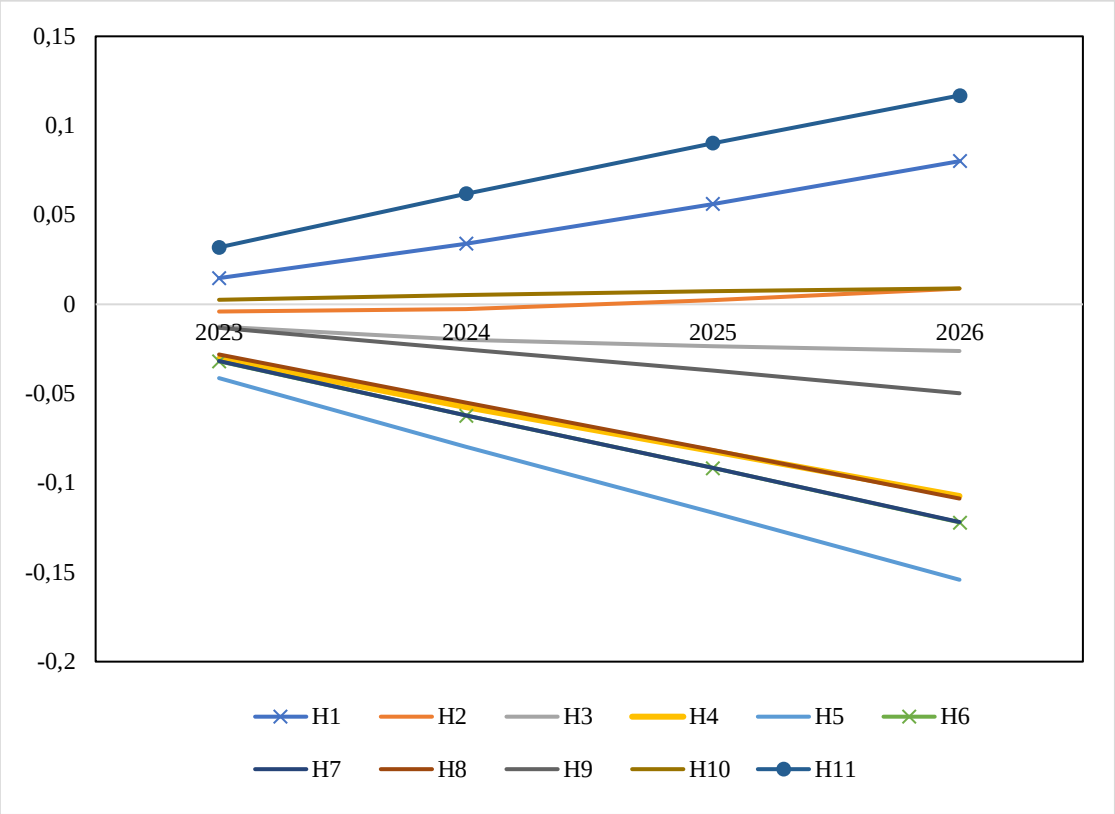
Graph 4.3 – Macroeconomic results of Policy 1 – (% Cumulative deviation to Baseline – 2026)



Source: Own elaboration. Results of BRIGHT model.

As one can observe, while the richest households HOU11 increase their consumption by 0.11%, the poor and middle-income classes present a negative growth. That is because contributions have a higher share in poorer households' income, as well as capital income (derived from Investment growth) is over represented in the richest class. The poorest household H1 income has a particular dynamic: differently from the lower middle classes, it benefits from the higher labor income but contributions disbursement is not a relevant duty in their budget.

Graph 4.4 – Households Disposable Income, by Household Class (% Cumulative deviation to Baseline)

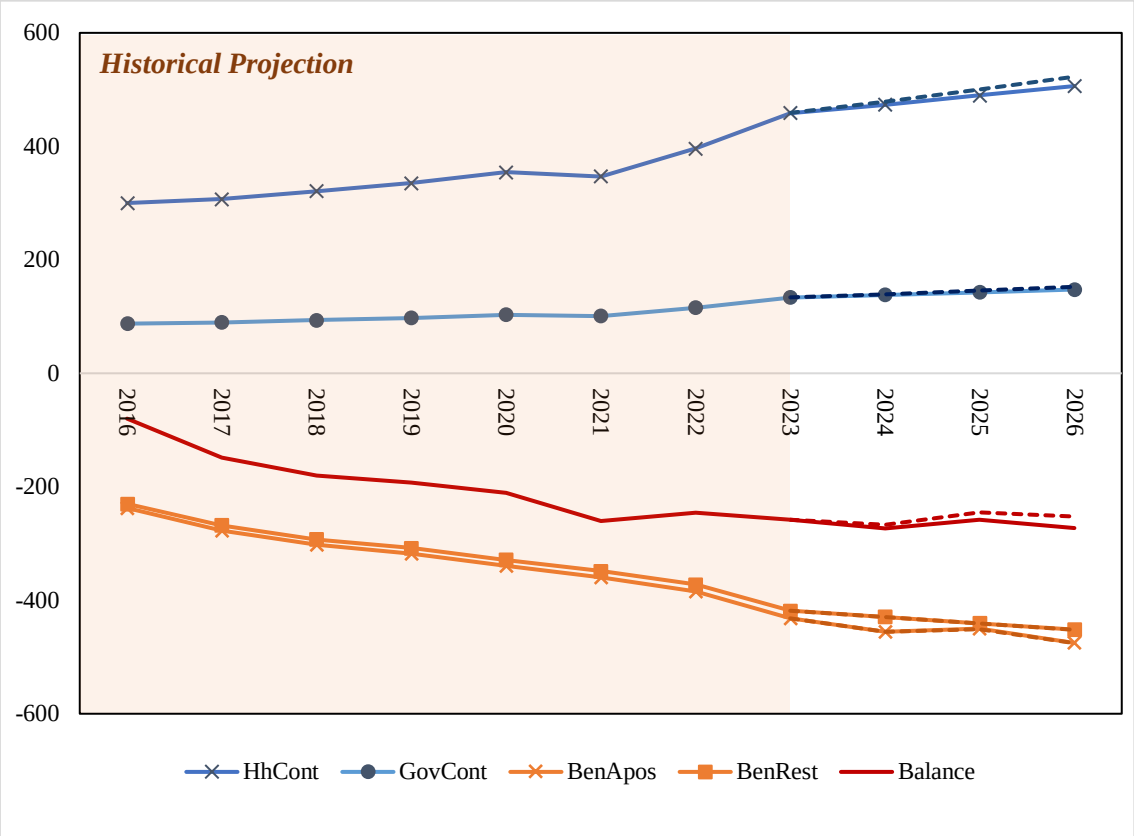


Source: Own elaboration. Results of BRIGHT model.

The fiscal results consist on nominal flows and ratios of the National Scheme. Similarly to the previous chapter, the effort to update the model's database have contributed to reproduce compatible numbers to those officially stated on the National Scheme's statistical yearbooks.

Graph 4.5 shows the evolution of the National Scheme's aggregate flows along the policy projection. From 2023 onwards, dotted lines branches from the Baseline flows: those are the policy deviations. The series show a higher deficit in 2020-2021 due to the covid crisis, that affected both employment and the contributions flows. The historical shock for 2016-2022 updated the total balance deficit to -R$245.5 billion, close to the actual deficit shown in 2022 BEPS edition. The baseline projection leads it to a value of -R$273 billion in 2026, while the raise of contributions simulated in Policy 1 makes it -R$252.5, a relief of more than R$20 billion in four years.

Graph 4.5 – Contributions and Benefits Flows of the National Pension Scheme (RGPS) – Policy 1 and Baseline (Nominal Values - R$ Billion)



Source: Own elaboration. Results of BRIGHT model.
Note: Dotted lines are the policy deviations.
Hhcont – Households contributions to the RGPS
GovCont – Government contributions to the RGPS
BenRetirement – Retirement Benefits of the RGPS
BenRest – Other Benefits of the RGPS

Table 4.13 shows the ratios of RGPS flows over GDP. One can notice that a higher coverage sooth the total deficit of the scheme, bringing its ratio to GDP down in 0.2 percentage points – from 2.5 to 2.3 – compared to the Baseline in 2026. Again, that is purely by raising contributions, for the benefit ratio path remains virtually unchanged.

Table 4.13 – National Pension Scheme Flows over GDP (%) – Policy 1 and Baseline

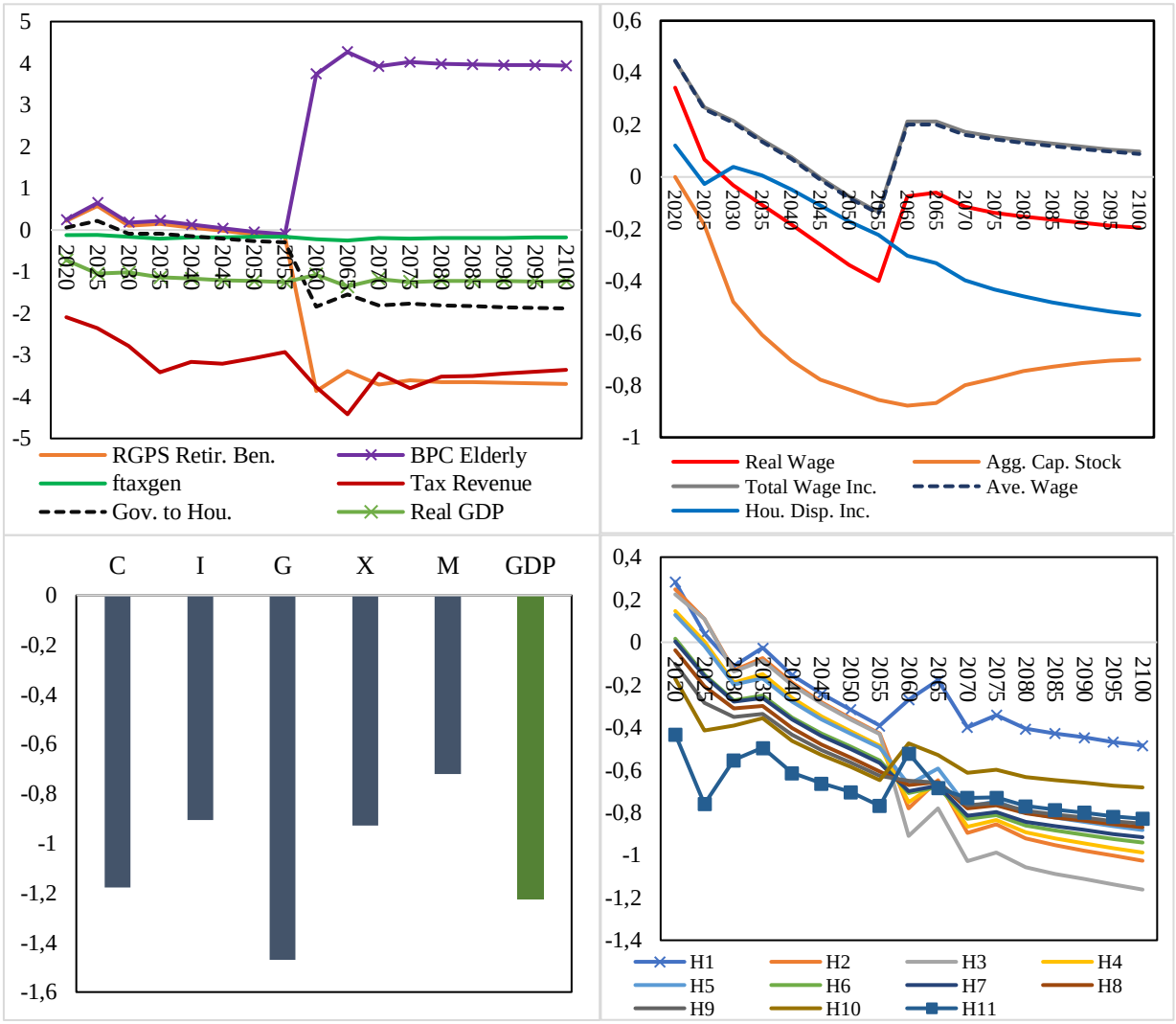
Baseline	2023	2024	2025	2026
Total Contributions	5.90	5.94	5.99	6.04
Total Benefits	8.46	8.59	8.44	8.56
Deficit	2.56	2.65	2.45	2.52
Policy	2023	2024	2025	2026
Total Contributions	5.90	6.00	6.12	6.23
Total Benefits	8.46	8.59	8.44	8.57
Deficit	2.56	2.59	2.32	2.33

Source: Own elaboration. Results of BRIGHT model.

4.5.2 Policy 2 – Towards Precarization

Policy 2 simulates a long-run scenario marked by workforce precarization. It negatively interprets the signs of the stratification reported in Section 3 of this Chapter, in a way that the pension disenrollment and the workforce liberalization towards self and unprotected employment contribute to a permanent reduction of labor productivity. It starts with a negative shock of -1.5% of labor productivity and, after 40 years, a negative shock of -4% of beneficiaries of the National Scheme and a positive shock of 4% of BPC beneficiaries. That is for the unprotected workers might increase the demand for this type of aid, for no retirement pension should be applicable. Figure 4.1 compiles the four main components of analysis of this experiment: quadrant 1 and 2 show the first-order effects of the policy, quadrant 3 shows the macroeconomic effects accumulated in 2100, and quadrant 4, the disparities of household's disposable income.

Figure 4.1 – General Effects of Policy 2 (% Cumulative deviation to Baseline)



Source: Own elaboration. Results of BRIGHT model.

The first quadrant of Figure 4.1 shows the direct effects of the policy. The negative productivity shock implies a lower industry demand for labor, which, under a "full-employment" setting (fixed employment, on a growing trend until 2040[48]), affects Capital stock negatively and labor price goes up simultaneously (the average wage follows total wage income), though on a downward trend due to the lower productivity.

The second quadrant shows a GDP decrease, due to the lower productivity, leading to a lower taxation, due to lower activity level. RGPS and the BPC benefit flows respond to the raise of the average wage and go up. In 2060, one can observe the positive shift of BPC transfers and the negative deviation of RGPS retirement benefits transfers; because the latter is considerably larger than the first, total transfers (Gov. to Hou.) deviation prevails negative. That alleviates taxation and incentive production – wages then adjust due to the fixed employment trend. Looking back to the first quadrant, one can notice a slight gain on real wage (similar movement of total wage income and the average wage) and on primary composite, but households' disposable income keeps its downhill track due to Government transfers reduction.

The third quadrant of Figure 4.1 shows the macroeconomic aggregates from the expenditure side accumulated deviation in 2100. Following the previous explanation, one can observe that a tiny decrease in all components. Because of the significant tax revenue decrease, Government consumption suffers the most. Households' consumption has the second higher decrease rate between GDP aggregate components because of the cut on Government transfers. There are differences between classes, however.

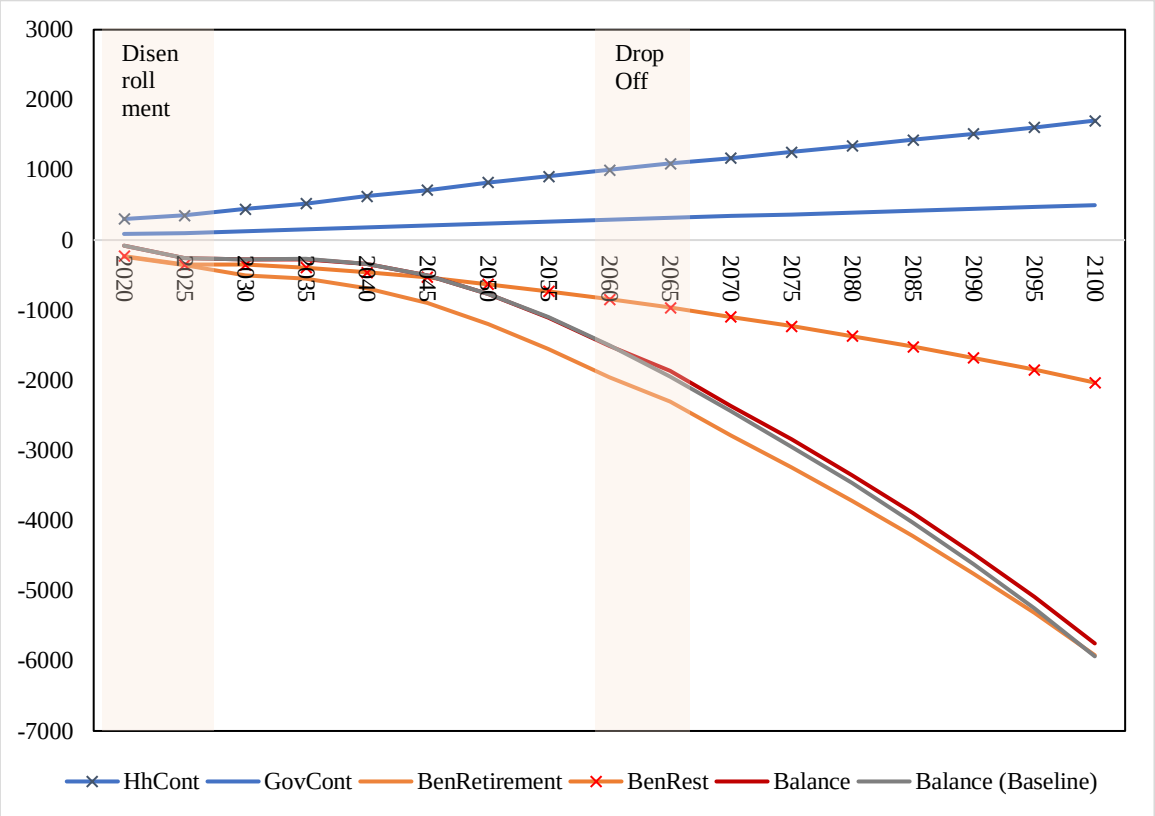
The fourth quadrant shows that, along the projection length, the combinations of shocks of Policy 2 harms poorer middle-income households the most but also the richest class H11 – that is justified by a) lower transfers from Government to households – an important source of income of the poorer) and b) the dynamics of the investment and capital accumulation – an important source of income of the richest class H11. As in the short-run simulation of Policy 1, the disposable income of the poorest household H1 shows the least bad evolution. After 2060, one can observe that H1 is better off, and lower income classes (H2, H3, H4) are worse off. That is due to the substitution of the RGPS

[48] See graphs 3.4 and 3.5 of Chapter 3.

retirement benefit to the BPC assistance benefit. In other words, it inflates the poorer household class.

Graph 4.6 shows the evolution of the National Scheme's aggregate flows along the policy projection. The baseline balance is also added for comparison matters. It is visually imperceptible the effect of the initial productivity shock over the policy balance deviation from baseline balance. That is because both RGPS benefits and contribution flows are not really affected by it, as one can infer from the movements depictured in quadrants 1 and 2 of Figure 4.1. From 2060 onwards, however, the benefit payments alleviation due to the initial disenrollment appears, as one can see through the balance path deviation from the baseline in the drop-off phase[49] – that leads to an approximate saving of R$184 billion to the scheme's balance compared to the baseline in 2100.

Graph 4.6 – Contributions and Benefits Flows of the General Pension Scheme – Policy 2 (Nominal Values - R$ Billion)



Source: Own elaboration. Results of BRIGHT model.
Hhcont – Households contributions to the RGPS
GovCont – Government contributions to the RGPS
BenRetirement – Retirement Benefits of the RGPS
BenRest – Other Benefits of the RGPS

[49] Here, drop-off is a consequence of the initial disenrollment.

Table 4.14 shows the ratios of RGPS and BPC flows over GDP in the Baseline and in the Policy scenarios in 2100. Because the productivity shock reduces GDP, the cumulative savings of the policy do not lead to a significant reduction of the scheme's balance ratio. It is true, however, that, due to its relative inexpressiveness, the raise of BPC deficit ratio is only very low.

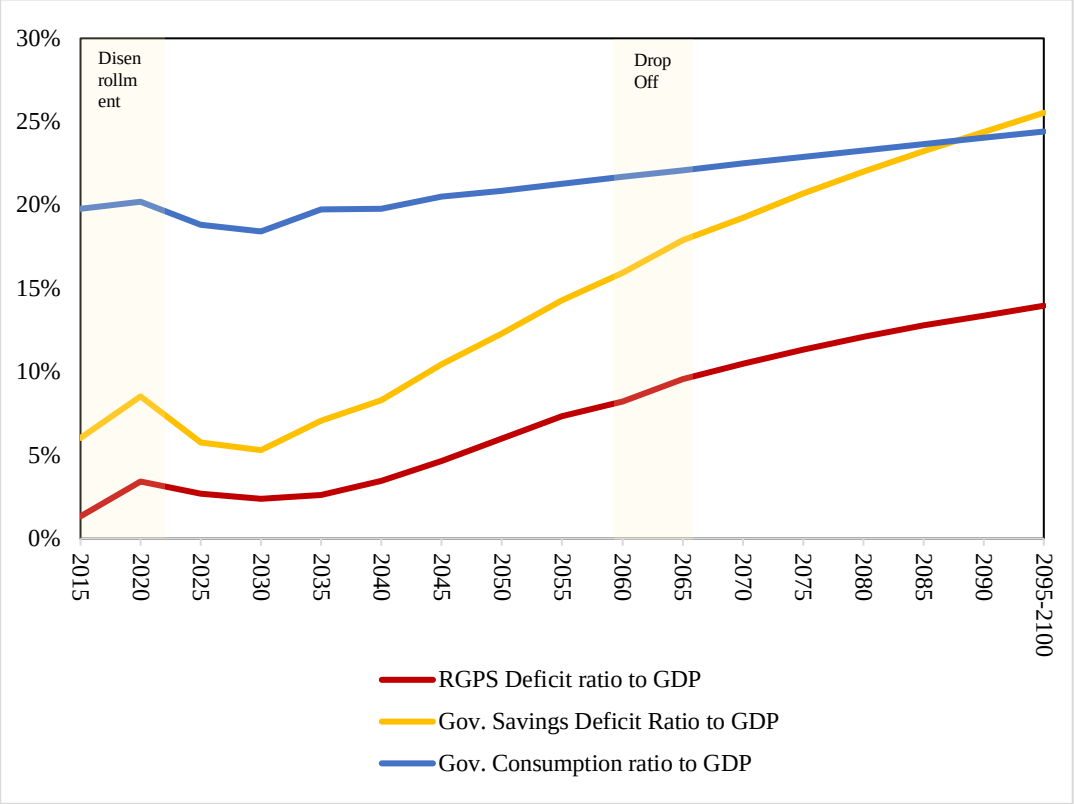
Table 4.14 – Pension Flows ratio to GDP (%) – Policy 2 (2100)

RGPS			
Scenario	Deficit	Contributions	Benefits
Policy	13.96	5.34	19.31
Baseline	14.38	5.29	19.67
BPC			
Scenario	Expenditure	Contributions	Benefits
Policy	0.61	-	0.61
Baseline	0.59	-	0.59

Source: Own elaboration. Results of BRIGHT model.

Finally, Graph 4.7 shows the evolution of the National Pension Scheme deficit ratio to GDP, the Government Saving deficit ratio to GDP and the Government Consumption ratio to GDP throughout policy scenario. One can still observe the effects of the 2019 reform over all ratios starting from 2020 up to 2035. As explained in that previous experiment, it lasts until the end of the transition phase of that reform. Regard the effects of Policy 2, on can barely notice the changes in the RGPS deficit ratio and, consequently, on the Government Savings to GDP ratio paths in 2060. Government consumption ratio over GDP remains pretty much stable, as it is set to be.

Graph 4.7 – RGPS Benefits, Government Consumption and Saving ratios to GDP (%) – Policy 2



Source: Own elaboration. Results of BRIGHT model.

4.6 Final Remarks

This Chapter has attempted to connect the current labor issue to the pension deficit problem. As the literature review showed, Brazilian labor market is marked by significant and persistent inequalities, strongly related to the phenomena of social exclusion and, more recently, the early deindustrialization. The labor stratification reported in section 3 showed a recent trend of precarization of Brazilian workforce, marked by pension disenrollment and liberalization towards self and unprotected employment.

The CGE experiment then prospected two alternatives from within the current scenario. Policy 1 projected a short-run recover of contributors in the National Pension Scheme. That movement impacted Government Savings positively, lowering taxation and raising – though very modestly – investment and output. It contributed to a R$20 billion saving in the National Scheme's balance. The scheme's deficit ratio to GDP is also relieved.

Policy 2 was designed to capture some movements of precarization in the labor market, intimately related to pension scheme's performance goals. They are:

a. Reduction of workers' productivity;

b. Reduction of workers' income when they retire; and

c. Exclusion of workers of social security protection during their working life-cycle.

It showed that a flexibilization towards self and unprotected employment might relief the scheme's deficit in the long-run but it is generally inefficient, for the negative impact on GDP potentially jeopardizes it. Its main negative effect is to discourage the demand for productive factors. Besides, it substitutes potential pensioners of the RGPS to those of the BPC, a lower benefit, contributing to a poverty increase. Fiscally, it is insufficient to hold constant the RGPS deficit to GDP and deliver optimistic prospects on Government's suppressing budget. It only reduces the ratio when potential pensioners are finally excluded, in 2060, due to the disenrollment of the 2015-2020 window.

Summing up, there are a few limitations in this study, which might contribute to enrich the agenda for future research. They are:

1. The exclusion of workers' dependents from social security protection and the consequent impacts on the other benefits of the RGPS was not considered, demanding further investigation about the implications and potential solutions associated with this;

2. An actual increase in the number of contributors might not be proportional to the increase in the sum of contributions. Variations in experience, wage levels, and vulnerability between new entrants and seniors may be considered, since new entrants may face challenges in terms of labor income, stability, and pension enrollment;

3. The introduction of the productivity shock in this study was implemented according to the ILO 2016-2019 GDP per worker trend, and not to the outcomes presented in the labor stratification analysis section, that showed signs of substitution from "protected" categories to "unprotected" ones, that

earn less and might be significantly worse-off in terms of productivity during their working life cycle. A more in-depth exploration on the transmission mechanisms of the precarization phenomena and the workers long run productivity may be crucial for similar researches;

4. The potential shift from the National Pension Scheme (RGPS) enrollment to the expectance of the social security rescue through the Continuous Cash Benefit (BPC) should also be more deeply investigated;

5. One might also be tempted to model Brazilian workforce distinguishing it by labor types, as the country's inequality in the labor market is significant and productivity may behave differently amongst them. Appendix C brings a glimpse of what it could be like.

That said, it is also important to consider that the workers' tendency to self-employed jobs may not be a problem from an individual economic life-cycle perspective. Those workers may be happy working without a "corporate standard" and with only the minimum of labor security, regardless of their income. At the social security level, this may or may not be a problem. If no one else contributes or enrolls to the scheme, the social security deficit is solved in the very long run: the PAYG scheme "expires" and new self-funded ways of financial protection must emerge. A certain degree of regulation is expected. Anyways, Government will have to finance the emptied RGPS solely until then. That is an issue for another experiment, though.

Conclusion

This Thesis aimed to model the Brazilian pension flows under a Computable General Equilibrium model framework. Therefore, it conciliated many different perspectives of the theme, from the theoretical referential trial up to the simulation strategies, through many databases and methodological approaches, to deliver robust results and methods useful to policymakers and the whole Brazilian society.

It started with the economic life-cycle decisions of saving and consumption presentation, the demand for wealth and the derived inequalities of the ageing societies and how the imminent demographic transition of Brazilian population shapes a scenario of acute economic challenges by pressuring the country's fiscal side (Modigliani, 1966; Piketty, 2014; Correa, 2023). Essentially, Chapter 1 showed that the Brazilian aggregate working-age population often struggles to accumulate the enough surplus to finance youth and, mainly, the elderly's consumption, for the aggregated form of the Brazilian National Transfers Accounts shows an "elderly-biased public transfers" characteristic of the country (Turra, 2011). That said, the role of the chapter was to shed light on the thesis upcoming path.

Chapter 2, Methodology and Database, presented the adaptations implemented on BRIGHT (Brazilian Social Accounting – General Equilibrium Model for Income Generation, Households and Transfers), developed by Freire Cardoso (2020) based on PHILGEM (Corong and Horridge, 2012), to achieve the Thesis' main objective. It details the model's Pension database and equations, presenting the Brazilian National Pension Scheme (RGPS) and the rest of the social security accounts from within the Brazilian System of National Accounts and households class structure, BRIGHT's main qualities; as well as its fiscal structure, showing the ways of setting it to best deal with budgetary and taxation issues. It also details the additional aspects, such the balance of trade's constraint condition – a useful setting for policy evaluation analysis. Those were essentially important for the experiments of this thesis.

"Modelling the Economic Impacts of the Minimal Age Introduction of the Brazilian Pension Reform of 2019" presents the very first experiment with the new modules of BRIGHT. The chapter contextualizes the recent history of the National Pension Scheme (RGPS) and presents the main aspects of the 2019 reform, the trigger for

this Thesis' development. The RGPS reform aimed at enhancing the PAYG scheme's sustainability by increasing the minimum age of retirement of its contributors and changing the benefit formula. After synthesizing the main aspects of reform, it finally presents the inputs for the simulations: the demographic projections of total and senior population and the workforce; that proved to be suitable proxies for such an experiment, as the methodological chapter introduced. That was the moment when one could catch a glimpse of the "shape of the reform" – i.e., its transition design, known as the *transition phase*. It happened to be crucial for the reform initial success, for it holds the new eligible pensioners growth rate as it reaches the new minimum age of retirement, simultaneously deviating the workforce of a premature shrinkage. That effect only lasts until 2040, though. After the end of the transition phase, RGPS and Government saving deficits go downhill.

As the "The Role of the Closure", in Chapter 2, explained, it is possible to interpret a policy such as the National Pension Scheme reform under two closure alternatives of fiscal condition, baptized in Chapter 3 experiment as the "Policy with Budget Relief" scenario, where the surplus of the reform increases Government's budgetary position, and the "Policy with Tax Relief" scenario, coined after the expansionary fiscal consolidation theory (Cardoso, 2019), where the surplus is compensated with a lower taxation, so that Government savings ratio to GDP remains constant. Intuitively, the Policy with Budget Relief delivers better fiscal results: R$ 562 billion savings to Government (R$87.5 billion more than the Tax Relief scenario), and R$ 944 billion savings in the RGPS pension scheme (R$ 23 billion more than the Tax Relief scenario), compared to the baseline (scenario with no pension reform) in 2100. On the other hand, the Policy with Tax Relief brings better economic outputs, in a way that both Government savings deficit and RGPS deficit ratios to GDP remains closely to the Budget Relief's in 2100 (17.03% compared to 16.97% and 29.7% compared to 29.4%, respectively), considerably detached from the ratios of the baseline though (21% and 32.7%, respectively). Modelling such a policy trough BRIGHT model also allowed us to see a distributional worsening of households' income, for the retirement benefits of scheme consist of an important source of income among the lower-income classes.

Chapter 4 prospected about labor productivity and the RGPS enrollment, after dissertating about Brazilian persistent structure of inequalities and social exclusion in the labor market. That normally has a minor floor when dealing with fiscal issues such as the

"Social Security deficit", but, as the labor stratification of the chapter showed, the number of workers unprotected by law and unenrolled in the social security has increased in the period of 2015-2022, when not only the pension but other labor reforms towards flexibilization were approved. That became known as the "precarization" of the labor force, also characterized by the increase of self-employed workers, often irregulars, due to the nature of their jobs. Modelling this scenario required two alternatives: to consider it as a transitory movement, forced by the turbulent years of the middle 2010s, so that a recovery could be done in the following years; or to interpret is as a permanent sign of precarization that reduces workers' labor productivity and goes toward a general flexibilization that undermines the National Pension Scheme's enrollment in the long-run.

The CGE recovery experiment of Chapter 4 showed that a 1% a year increase of the RGPS contributors might play favorably with the reform and reduce its deficit in R$ 20 billion in a four years length. On the other hand, a -1.5% shock of labor productivity in the 2015-2020 window, as the ILO statistics shows, along with a future drop-off of pensioners of the scheme, might reduce RGPS and Government saving deficit ratios to GDP, but also delivers lower economic activity, poverty, and inequality, for the increase of the BPC assistance should be necessary. The long-run experiment of Chapter 4 is just an initial step towards the investigation of the impacts of labor precarization in the Brazilian economy under a CGE framework. A more in-depth exploration of this phenomenon and its overall implications, especially on labor productivity, may be particularly useful for this kind of experiment.

The experiment of the reform, developed in Chapter 3, indicates that, as society gets older, it is possible to extend the minimum age of retirement to guarantee the schemes' sustainability by stablishing a new senior's edge. This setting should be constantly reviewed to maintain the performance goals of the scheme (Holzmann, 2013; Barr and Diamond, 2006; World Bank, 1994), for it is impossible, or at least too risky, to set a very long *transition phase* to a new overestimated age in a very long advance. In other words, the experiment shows that, as soon as the current transition phase gets to an end, in 2033, and the RGPS deficit starts to increase again in the following years, the "old-new" parameters might be out of date to society's future perspective, in a way that a new set of parameters might arise in the public debate. The experiments of Chapter 4, on the other hand, shows that coverage is an important foundation for a scheme's

performance, in a way that formality (as well as higher wage levels) should be pursued. It also shows that, by leading workers to informality and precarization, policymakers discourage enrollment and contribution, potentially undermining the scheme as whole.

That said, it is possible to identify at least three important agendas for future research. The first is to carry out more sophisticated labor market modelling for the Brazilian economy – Appendix C introduces a potential disaggregation of labor types, but still lacks essential parameters such as elasticities about their mobility, preferences, and other aspects to make it work. The age dimension might also be considered in the model, for labor income and wealth and particular age-related decisions, such as retirement and labor extension, play important roles on the economy. Appendix B gives a glimpse of the age aspect of Brazilian workforce. Finally, this Thesis presented an important step towards the public sector's pension scheme modelling by introducing civil and militaries pension accounts in the model's database, but no experiment has been fulfilled. As Appendix A shows, there have been significant changes in the public sectors' Civil Service Pension Plan (RPPS) while the military "scheme" remains generous. Although not as significant as the RGPS, the focus of this Thesis, in terms of its fiscal size, they are still relevant, as well as the public sector have always been for Brazilian economy.

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Appendix A – The Public Sector's "Own" Scheme of Social Security at a Glance

Out of the scope of policy evaluation experiments in this Thesis, this appendix section brings a brief discussion on the Civil Service Pension Plan (RPPS). Also known as the Public Sector's "Own Schemes"[50] of Social Security for civil public workers and militaries. It also shows the origins of the social security aggregated data for both categories, currently available in BRIGHT's database.

Although with a relatively higher deficit than the Brazilian National Pension Scheme (RGPS), mostly aimed at workers from the private sector, the Public Sector Scheme had a minor floor during the 2019 Pension Reform discussion, and the reasons are:

1) A few reforms were made along the last decades to move it from a bounteous scheme towards the National Scheme's standard – e.g., the Constitutional Amendment n. 41/2003;
2) It is made from several little *own schemes* from the various *federation entities* (i.e., federal, states and municipalities), and different rules may apply to different *own schemes*; and
3) The total values are not as significant as the National Scheme's.

Besides, it is made from two very different labor categories: the statutory public workers – civilians –, and the military; with totally different rules of operation. In fact, no financial or actuarial balance is required in the military scheme and the category's contributions are only to ensure relatives' pensions (non-retirement, other benefits) – the reason why it is not officially called a pension scheme.

It is reasonable to assume that both categories started from similar pension schemes standards and as the public civil workers' scheme was gradually shaped into the National Schemes' standards (Souza, 2014; Gomes, 2016)[51], the Military "scheme" remained bounteous (Silva and Cambraia, 2019) – e.g., integral benefit at the moment of

[50] *Regime Próprio da Previdência Social*. Own is the translation of "*Próprio"* and, according to Campos (2011), it is so as opposed to *general*, having a universe of restricted personnel.
[51] Chapter 4 shows that there is an increasing share of non-statutory and even uncovered by Consolidation of the Labor Laws (CLT) public civil workers.

retirement – i.e., 100% of the last wage –, also valid to non-retirement pensions, and lower contribution). Frame A1 summarizes the current rules for both categories. One thing to notice is that workers keep their contribution to the scheme after they retire – this rule is also applied for holders of other benefit types (non-retired pensioners).

Frame A1 – Comparison of the general rules for the RPPS civil workers from the Federal Government and the military

	Requirements	Federal Government Civil Workers	Military
Costing	Contribution from active workers	If enrolled in the supplementary pension scheme, 14% up to the RGPS ceiling; if not, 14% of the total wage	10.5% of the full salary, just to cover the non-retirement pension
	Contribution from retirees and pensioners	If enrolled in the supplementary pension scheme, does not contribute; otherwise, 14% of the amount that exceeds the RGPS ceiling	10.5% of the full salary, just to cover the non-retirement pension
	Employer Contribution	22% of the wage	Absent
Retirement pension	Minimum age	Women: 62 years-old Men: 65 years-old	Absent
	Lenght of Contribution	Women: 30 years Men: 35 years	30 years
	Benefit value	Idem to RGPS: 60% of the average of all base-wage of contribution, corresponding to 100% of the entire contribution period + accrual rate of 2 p.p. per year after 20 years of contribution	Full pay according to the last wage level
	Adjustment rule	Consumer Price Index	Parity with active military personnel
Non-retirement pension	Benefit value	If not enrolled in the supplementary pension scheme: RGPS ceiling, plus 70% of the amount that exceeds the RGPS ceiling. If enrolled in the supplementary pension scheme, up to the RGPS ceiling	Full pay according to the last wage level
	Pension Lenght	Four months to twenty years, or lifetime, depending on the case.	Lifetime.

Source: Adapted from Silva and Cambraia (2019).

Figure A1 shows the number of official public workers in each category, thus enrolled in the RPPS, according to BRIGHT standard typification. One can observe that militaries represent less than 1% of Brazilian workers, while statutory public civil workers[52], less than 10%. Both categories are wealthier than the rest of the workers in Brazil.

Figure A1 – Number of Official Public Sector Workers, by Household Income Class. Brazil, 2015.

Household Income Class	Statutory Civil Worker	Military	Rest
HOU1	19,215	1,685	4,029,469
HOU2	319,751	11,107	12,689,515
HOU3	630,777	16,232	14,961,069
HOU4	1,523,979	86,238	23,661,200
HOU5	724,257	41,431	8,158,835
HOU6	1,147,057	156,621	10,394,534
HOU7	830,075	122,497	5,618,182
HOU8	1,333,980	233,986	6,832,706
HOU9	521,539	127,305	2,673,622
HOU10	582,974	50,102	2,112,007
HOU11	529,376	23,178	1,780,578
Total	8,162,980	870,382	92,911,717

Source: Own elaboration based on POF 2017-2018 (IBGE, 2019) and SNA-IBGE.

Table A1 summarizes the RPPS rubrics of the statutory public civil workers of the General Government (the sum of the three levels of the Federation: Union; States and Municipalities); while Table A2, the militaries. One thing to notice is that, although the latter category represents less than 10% of the former, the aggregate balance of both categories is almost the same. Also, the Intra-Budgetary revenue of the latter is less than 0,5% of the former, which means that:

a. Government contribution is expressive in the Civil Service Pension Plan; and

b. As reported in Frame A1, the employer's contribution (the Government) is also high in that scheme[53].

[52] Official public civil worker, hired after an official public tender.

[53] If active public civil workers' contribution is made out of 14% of their wages (Contributions from Active Insured Workers = R$ 27,696 million, from Table A1), and employers' contribution, treated as part of Government intra-budgetary expenses, is 22% (R$ 43,523 million, then), the total contribution of active public civil workers in 2015 is actually 27,696 + 43,523 = 71,219, as Table 2.3, in Chapter 2, shows. The

Table A1 – Summary: Civil Service Pension Plan (RPPS) – General Government – 2015 (R$ million)

RPPS Revenue - Civilians	Updated forecast
Total Revenue (Other than Intra-Budgetary)	59,579.40
Contributions	36,716.37
Contributions from Active Insured Workers	27,696.53
Contributions from Inactive Insured (retired)	5,730.72
Contributions of Pensioneers (non-retired)	3,289.12
Other Current and Capital Revenue	22,863.02
Intra-budgetary Revenue	92,760.82
Total Revenue	152,340.22
Benefits	198,891.35
Retirement pensions	153,056.32
Non-retirement pensions	45,835.03
Other Government Expenses	5,586.25
Total Expenses	204,477.60
Balance	**-52,137.38**

Source: Own elaboration based on "Siconfi RROE - Anexo 04 - Demonstrativo das Receitas e Despesas Previdenciárias do RPPS" and the "Demonstrativo das Receitas e Despesas Previdenciárias do Regime Próprio de Previdência dos Servidores - Anexo 4 RPPS do RELATÓRIO RESUMIDO DA EXECUÇÃO ORÇAMENTÁRIA DO GOVERNO FEDERAL E OUTROS DEMONSTRATIVOS".

Table A2 – Summary: Military Pension "Scheme" – General Government – 2015 (R$ million)

RPPS Recipes - Militaries	Updated forecast
Revenue	7,491.29
Military Personnel Contributions	6,539.85
Active	4,327.67
Inactive	1,345.21
Pensioneer	866.96
Other Current and Capital Revenue	951.44
Intra-Budgetary Revenue	3,860.23
Total Revenue	11,351.52
Benefits	62,702.57
Retired Military	39,275.66
Pensioneer	23,426.91
Other Government Expenses	1,698.90
Total Expenses	64,401.47
Balance	**-53,049.95**

Source: Own elaboration based on "Siconfi RROE - Anexo 04 - Demonstrativo das Receitas e Despesas Previdenciárias do RPPS" and the "Demonstrativo das Receitas e Despesas Previdenciárias do Regime

rest of the Intra-Budgetary revenues, i.e., Government contribution, is then 92,760 – 43,523 = 49,237. That does not apply to the Military "scheme" accounts.

Próprio de Previdência dos Servidores - Anexo 4 RPPS do RELATÓRIO RESUMIDO DA EXECUÇÃO ORÇAMENTÁRIA DO GOVERNO FEDERAL E OUTROS DEMONSTRATIVOS".

Summing up, although both categories are Government's employees, social contributions are quite higher amongst statutory civil workers, while none is applied to the militaries. If social contribution is taken from labor income, it seems that militaries have a much higher disposable income. Table A3 closes this appendix analysis with the average annual numbers of contribution and benefits of public civil workers and militaries.

Table A3 – Average Annual Contribution and Benefit of the Civil and Militaries Pension Schemes (in R$). Brazil, 2015

Average	Civil	Military
Contribution	7,423	4,004
Active	15,535	5,160
Retired	2,584	3,502
Pensioneer	4,149	3,351
Benefits	63,419	96,386
Retirement Benefit	69,014	102,232
Other Benefit	57,825	90,539

Source: Own elaboration based on POF (2017-2018) and the data from the Ministry of Social Security.

Due to the employer's contribution, a statutory civil worker contributes around three times more than an active military; retired military and military pensioners require almost two times more benefit resources than retired civil and RPPS pensioners. Due to the right to full benefit, retired military personnel contribute more than retired civil workers; the contribution charged on the average military non-retired pensioner, however, is lower than that charged on the statutory civil non-retired pensioner, on average.

The following tables show the original source of federal, state and local governments "own" schemes flows.

Table A4 – Civil Service Pension Plan (RPPS) – Federal Government - 2015 (R$ million)

Revenues	Updated Forecast
Social Security Revenue (Other than Intra-Budgetary)	12,130.44
Current Revenue (I)	12,130.44
Revenue from Contributions	12,128.90
Civilian Personnel	12,128.90
Active	8,991.56
Inactive	2,430.28
Pensioneer	707.06
Other Contribution Revenue (fines)	1.54
Tied Revenue	1.54
Untied of Union Revenues (DRU)	0.00
Social Security Revenue (Intra-Budgetary) (II)	18,358.05
Total Civil RPPS Social Security Revenue - (III) = (I + II)	30,488.49
Expenses	Updated Alloacation
Social Security Expense (Other than Intra-Budgetary)	69,676.62
Social Security Benefits (IV)	69,676.62
Civilian Personnel	65,757.67
Undefined	85.98
Retirement pensions	45,657.54
Non-retirement pensions	19,300.04
Other benefits	714.11
Other expenses	3,918.95
Social Security Expense (Intra-Budgetary) (V)	2.95
Total Civil RPPS Social Security Expense (VI) = (IV + V)	69,679.57
Civil RPPS Social Security Balance (VII) = (III – VI)	**-39,191.07**

Source: “Demonstrativo das Receitas e Despesas Previdenciárias do Regime Próprio de Previdência dos Servidores - Anexo 4 RPPS do RELATÓRIO RESUMIDO DA EXECUÇÃO ORÇAMENTÁRIA DO GOVERNO FEDERAL E OUTROS DEMONSTRATIVOS”.

Table A5 – Civil Service Pension Plan (RPPS) – States and the Federal District – 2015 (R$ million)

Revenue	Updated Forecast
Social Security Revenue (Other than Intra-Budgetary) (I) = (i)+(ii)	35,545.66
Current Revenue (i)	31,750.74
Revenue from Contributions	17,483.51
Civilian Personnel	17,092.12
Active	13,914.12
Retired	2,339.23
Pensioneer	838.77
Other Contribution Revenue	391.39
Equity Income	7,435.19
Real Estate Revenue	22.66
Securities Income	2,773.11
Other Equity Income	4,639.42
Service Revenue	72.85
Other Current Revenue	6,759.19
Social Security Compensations from RGPS to RPPS	890.94
Other Current Revenue	5,868.26
Capital Revenue (ii)	3,794.92
Disposal of Assets	2,985.68
Loan Repayment	144.51
Other Capital Income	664.72
Social Security Revenue (Intra-Budgetary) (II)	52,281.92
Total Civil RPPS Social Security Revenue - (III) = (I + II)	91,791.46
Expenses	**Updated Alloacation**
Social Security Expenses - RPPS (Other than Intra-Budgetary) (IV)	100,342.28
Administration	1,513.66
Current Expenses	1,423.99
Capital Expenses	89.68
Social Security	98,828.61
Civilian Personnel	97,524.17
Retirements	77,034.00
Pensions	20,098.20
Other Social Security Benefits	391.97
Other Social Security Expenses	1,304.44
Social Security Compensation from RPPS to RGPS	23.69
Other Social Security Expenses	1,280.75
Social Security Expenses - RPPS (Intra-Budgetary) (V)	1,427.58
Total Social Security Expenses - RPPS (VI) = (IV + V)	101,769.86
Civil RPPS Social Security Balance (VII) = (III – VI)	**-9,978.40**

Source: “Siconfi RROE - Anexo 04 - Demonstrativo das Receitas e Despesas Previdenciárias do RPPS”.

Table A6 – Civil Service Pension Plan (RPPS) – Municipalities – 2015 (R$ million)

Revenue	Updated Forecast
Social Security Revenue (Other than Intra-Budgetary) (I) = (i)+(ii)	17,217.06
Current Revenue (i)	16,649.65
Revenue from Contributions	10,146.94
Civilian Personnel	8,910.37
Active	8,308.04
Retired	523.98
Pensioneer	78.35
Other Contribution Revenue	1,236.57
Equity Income	5,263.53
Real Estate Revenue	181.58
Securities Income	4,891.36
Other Equity Income	190.60
Service Revenue	23.08
Other Current Revenue	1,216.10
Social Security Compensations from RGPS to RPPS	902.67
Other Current Revenue	312.02
Capital Revenue (ii)	567.41
Disposal of Assets	241.54
Loan Repayment	9.72
Other Capital Income	316.14
Social Security Revenue (Intra-Budgetary) (II)	17,654.88
Total Civil RPPS Social Security Revenue - (III) = (I + II)	34,871.94
Expenses	**Updated Alloacation**
Social Security Expenses - RPPS (Other than Intra-Budgetary) (IV)	34,270.17
Administration	3,884.05
Current Expenses	3,449.68
Capital Expenses	434.36
Social Security	30,386.12
Civilian Personnel	28,272.71
Retirements	23,079.15
Pensions	4,247.55
Other Social Security Benefits	946.01
Other Social Security Expenses	2,113.41
Social Security Compensation from RPPS to RGPS	77.98
Other Social Security Expenses	2,035.43
Social Security Expenses - RPPS (Intra-Budgetary) (V)	456.91
Total Social Security Expenses - RPPS (VI) = (IV + V)	34,727.08
Civil RPPS Social Security Balance (VII) = (III – VI)	**144.86**

Fonte: Siconfi RROE - Anexo 04 - Demonstrativo das Receitas e Despesas Previdenciárias do RPPS.

Table A7 – Civil Service Pension Plan (RPPS) – General Government – 2015 (R$ million)

Revenue (Other than Intra-Budgetary)	Updated Forecast
Current Revenue	60,530.84
Contributions Revenue	36,716.38
Civil Personnel	31,059.92
Active	23,429.65
Retired	4,847.86
Pensioneer	2,782.40
Other Contributions' Revenue	5,656.46
Other Current and Capital Revenue	23,814.46
Intra-Budgetary Revenue	96,621.05
Total Civil RPPS Social Security Revenue	157,151.89
Expenses	**Updated Alloacation**
Social Security Expenses (Other than Intra-Budgetary)	198,891.35
Social Security Benefits	198,891.35
Civilian Personnel	191,554.55
Retirement Pension	145,831.12
Non-retirement Pension	43,671.34
Other Social Security Benefits	2,052.09
Other Social Security Expenses	7,336.80
Administration	5,397.71
Current Expenses	4,873.67
Capital Expenses	524.04
Social Security Expenses - RPPS (Intra-Budgetary)	1,887.44
Total Social Security Expenses - RPPS	206,176.50
Civil RPPS Social Security Balance	**-49,024.61**

Source: Own elaboration based on the sum of Federal, State and Municipality values.

Table A8 –Military Pension "Scheme" – Federal Government – 2015 (R$ million)

Revenue	Updated forecast
Pension Revenue	2,527.76
Revenue from Contributions from Military Personnel	2,527.76
Tied Revenue	2,022.21
Untied Revenue (DRU)	505.55
Total Military RPPS Social Security Revenue (I)	2,527.76
Expenses	**Updated Allocation**
Military RPPS Social Security Expenses	35,158.71
Military Personnel	35,158.84
Retired Militar	18,562.86
Pensioneers	16,470.28
Other Social Security Benefits	125.44
Total Military RPPS Social Security Expenses (II)	35,158.84
Social Security Result - Military (III) = (I – II)	**-32,631.08**

Source: "Demonstrativo das Receitas e Despesas Previdenciárias do Regime Próprio de Previdência dos Servidores - Anexo 4 RPPS do RELATÓRIO RESUMIDO DA EXECUÇÃO ORÇAMENTÁRIA DO GOVERNO FEDERAL E OUTROS DEMONSTRATIVOS".

Table A9 – Military Pension "Scheme" –States and the Federal District – 2015 (R$ million)

Revenue	Updated Forecast
Active Military	2,965.01
Retired Military	803.23
Pensioneer	195.65
Total Military RPPS Social Security Revenue (I)	3,963.88
Expenses	Updated Alloacation
Military Personnel	27,525.85
Retired Military	20,599.88
Pensioneer	6,887.56
Other Social Security Benefits	38.42
Total Military RPPS Social Security Expenses (II)	27,525.85
Social Security Result - Military (III) = (I – II)	**-23,561.97**

Source: Siconfi RROE - Anexo 04 - Demonstrativo das Receitas e Despesas Previdenciárias do RPPS.

Table A10 – Military Pension "Scheme" – Municipalities – 2015 (R$ million)[54]

Revenue of Contributions	Updated Forecast
Active Military	35.59
Retired Military	2.56
Pensioneer	10.05
Total Military RPPS Social Security Revenue (I)	48.21
Expenses	Updated Alloacation
Retired Military	0.00
Pensioneer	1.72
Other Social Security Benefits	16.42
Total Military RPPS Social Security Expenses (II)	18.14
Social Security Result - Military (III) = (I – II)	**30.07**

Source: "Siconfi RROE - Anexo 04 - Demonstrativo das Receitas e Despesas Previdenciárias do RPPS.

[54] The military accounts did not show the Intra-Budgetary rubric. Therefore, the value of the Civil Workers' Intra-Budgetary rubric was weighted according to the share of each total revenue over both military and civil total revenue combined. That changes the totals reported in tables A1 and A2, comparing to those from tables A11 and A12.

Table A11 – Military Pension "Scheme"– General Government - 2015 (R$ million)

Revenue	Updated Forecast
Revenue of Contributions	
Active Military	4,327.67
Retired Military	1,345.21
Pensioneer	866.96
Total Military RPPS Social Security Revenue (I)	6,539.85
Expenses	Updated Allocation
Retired Military	39,162.74
Pensioneer	23,359.56
Other Social Security Benefits	180.28
Total Military RPPS Social Security Expenses (II)	62,702.57
Social Security Result - Military (III) = (I – II)	**-56,162.72**

Source: "Demonstrativo das Receitas e Despesas Previdenciárias do Regime Próprio de Previdência dos Servidores - Anexo 4 RPPS do RELATÓRIO RESUMIDO DA EXECUÇÃO ORÇAMENTÁRIA DO GOVERNO FEDERAL E OUTROS DEMONSTRATIVOS".

Appendix B – Validating Proxies

To validate the proxies presented at the Simulation Strategy of Chapter 3, the following tables compare the adherence of the senior population and the labor force totals and distributions to those of benefits and contributions, respectively, verified on Brazilian official pension historical data. One thing to consider is that, because the AEPS Infologo data are actual data (observed) and the labor force quantities are projections, some distortions are expected. Another thing is that, as previously explained, although the starting year is 2015, the policy simulation runs from 2021-2025 window onwards, avoiding occasional mismatches provoked by exogenous events verified in the 2016-2020 quinquennium (i.e., Brazilian economic crisis and COVID-19 pandemic). The total growth rates of contributors and beneficiaries from the RGPS shown in Figures B1 and B2 are used to calibrate the historical scenario from 2016-2020 in the baseline[55].

Figure B1 compares the recent evolution of the monthly average number of contributors (men and women) to the RGPS and total Labor Force, respectively, by age groups. In this case, labor force projection growth rate is the proxy for contributions growth rate[56]. As one can observe, the shape of both distributions matches in both years. The actual number of young contributors shrunk more than the number of young in the labor force, contributing to a lower total growth rate (-3.9% in face to 12%). This movement, however, is well adjusted to the expected path of labor and contributions in the Brazilian ageing society, where people, due to qualification and longer life expectancy, will start to work and retire later.

[55] 'Ignored' age group quantities of the AEPS database were weighted and distributed among the groups according to the shares of each age group over the totals.
[56] It is true that labor precarization might mislead this assumption, as the experiment of Chapter 4 develops.

Figure B1 – Recent evolution of the monthly average number of contributors to the RGPS and total labor force projection, respectively, men and women, by age group (in million)

Contributors

Age group	2015	2020	Diff.
Up to 19	1,647	0,921	-44%
20 to 24	6,134	5,031	-18%
25 to 29	7,815	6,759	-14%
30 to 34	8,309	7,391	-11%
35 to 39	7,448	7,599	2%
40 to 44	6,173	6,729	9%
45 to 49	5,444	5,502	1%
50 to 54	4,676	4,686	0%
55 to 59	3,332	3,714	11%
60 to 64	1,747	2,044	17%
65 to 69	0,595	0,758	27%
70 +	0,285	0,386	35%
Total	53,604	51,520	-3,9%

Labor Force

Age group	2015	2020	Diff.
Up to 19	7,415	6,350	-14%
20 to 24	12,719	13,297	5%
25 to 29	14,195	14,663	3%
30 to 34	14,505	15,285	5%
35 to 39	13,197	15,086	14%
40 to 44	11,500	13,429	17%
45 to 49	10,137	11,668	15%
50 to 54	8,697	9,866	13%
55 to 59	6,103	7,531	23%
60 to 64	3,466	4,271	23%
65 to 69	1,519	1,859	22%
70 +	1,233	2,617	112%
Total	104,686	115,921	10,7%

Source: AEPS Infologo (BRASIL, 2023) and Queiroz and Ferreira (2021), respectively.

Figure B2 compares the recent evolution of the active beneficiaries (urban, men and women) of the scheme, by group of age at the *initial date of the benefit* (DIB[57]), and the total population, respectively. In this case, the elderly population growth rate is the proxy for benefits' growth rate. As one can observe, the shapes of both distributions on age groups matches for both years, except to the fact that the elderly groups beneficiaries' growth rate shrunk earlier than the total elderly groups population. This is because the *initial date of the benefit* condition identifies the beginning of the pension, not the active number of retired people. The total growth of granted benefits is higher than the total 60+ population growth[58] (36% in face to 21%) in the observed period. Again, this movement is well adjusted to the expected growth path of seniors and benefit grants in the Brazilian ageing society, but such a difference might indicate potential underestimation of the later in our projections.

[57] Data de início do benefício.
[58] Men and women.

Figure B2 – Recent evolution of the active beneficiaries (urban), retired by minimal age, age the date of the beginning of the pension grant, and the total population, respectively, men and women (in million)

Active Beneficiaries

Age group	2015	2020	Diff.
60 to 64	2,063	2,784	35%
65 to 69	1,360	1,878	38%
70 to 74	0,094	0,116	23%
75 to 79	0,026	0,027	7%
80 to 84	0,007	0,007	-3%
85 to 89	0,001	0,001	-2%
90 +	0,00023	0,00022	-3%
Total	3,552	4,813	36%

Senior Population

Age group	2015	2020	Diff.
60 to 64	8,129	9,652	19%
65 to 69	6,035	7,515	25%
70 to 74	4,386	5,324	21%
75 to 79	3,084	3,589	16%
80 to 84	1,791	2,191	22%
85 to 89	0,732	0,922	26%
90 +	0,170	0,267	57%
Total	24,328	29,459	21%

Source: AEPS Infologo (BRASIL, 2023) and UN (2020), respectively.

I also point out the issue of modelling pension schemes reforms without considering the age dimension. This Thesis has covered the fact that total income (not to say wealth) is age-biased for several reasons. From the data of the Household Budget Survey (POF 2017/2018)[59] and the Brazilian SNA it is possible to see that labor income is also age biased in Brazil. Naturally, labor income is expectedly sectoral-biased, and might show curious information when crossed with the variable age.

Figure B3 shows labor income distribution by age, considering BRIGHT's households income classes distribution. It is possible to see that, because of experience and all sorts of vested rights, people with 60 years old or more share of labor income increases as household income class gets richer. In other words, seniors earn more and therefore tend to sustain richer households. Seniors' labor income is only 2.4% in the poorest household HOU1, but 22.8% in the richest class HOU11. More than 10 percent of the total labor income is made from seniors' wages. That plays a substantial role when considering a reform that shifts upwards the lower edge (i.e., the minimal age) of retirement. The extended working age population is then consisted of reminiscent seniors in the labor force and if they earn more, they contribute more than a young new entrant.

[59] Although provided with the suitable variables such as industry and worker age, because of its household income and consumption aim, it might not be the best survey for this kind of investigation (e.g., sample expansion might not be so accurate).

Figure B3 – Labor Income share by Household Income Class and Age (60 to 79 years old)

Age	HOU1	HOU2	HOU3	HOU4	HOU5	HOU6	HOU7	HOU8	HOU9	HOU10	HOU11	Total
60	0.2	1.0	0.8	1.3	1.0	0.9	0.9	1.6	1.8	1.7	2.3	1.5
61	0.3	0.7	0.6	0.7	1.0	0.4	0.7	0.8	0.2	0.6	0.5	0.6
62	0.7	0.4	0.4	0.6	0.6	0.6	1.2	1.8	1.0	0.9	7.2	2.1
63	0.5	0.6	0.4	0.8	0.4	0.4	1.0	1.0	1.5	0.8	3.1	1.2
64	0.2	0.3	1.4	0.4	0.4	0.2	0.3	0.5	1.6	0.3	3.6	1.1
65	0.2	0.3	0.2	0.8	0.2	0.3	0.3	0.9	5.8	0.5	0.2	0.9
66	0.0	0.2	0.4	0.2	0.3	0.5	1.0	0.9	0.4	0.2	2.6	0.9
67	0.1	0.2	0.4	0.1	0.1	0.1	0.4	0.6	0.7	0.5	0.1	0.3
68	0.1	0.1	0.2	0.1	0.1	0.3	0.2	0.2	1.4	0.1	0.2	0.3
69	0.0	0.1	0.1	0.2	0.1	0.3	0.3	0.1	0.1	0.7	0.4	0.3
70	0.0	0.1	0.2	0.1	0.1	0.2	0.1	0.3	0.0	0.3	0.8	0.3
71	0.0	0.1	0.2	0.1	0.1	0.1	0.0	0.1	0.2	0.9	0.7	0.3
72	0.0	0.1	0.3	0.1	0.0	0.1	0.0	0.0	0.1	0.0	0.5	0.2
73	0.0	0.1	0.1	0.0	0.8	0.1	0.0	0.1	0.0	0.2	0.1	0.1
74	0.0	0.0	0.1	0.1	0.0	0.2	0.0	0.0	0.2	0.5	0.0	0.1
75	0.0	0.1	0.1	0.0	0.0	0.2	0.0	0.1	0.7	0.1	0.0	0.1
76	0.0	0.0	0.0	0.1	0.0	0.1	0.1	0.0	0.4	0.0	0.0	0.1
77	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
78	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.1
79	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0
Total	2.4	4.4	6.0	5.9	5.4	4.9	6.5	9.1	16.1	8.3	22.8	10.5

Source: POF 2017/2018 and BRIGHT's database.

After verifying the labor income age structure by sector, it is possible to see that some industries – for some reason or not – are still dependent on senior's labor force. Figure B4 shows a peculiar sample of BRIGHT's database in which each of the distributions might have a coherent explanation.

While Forestry and Fish industry is capital intensive and Biofuel is labor intensive, they both, however, have the poor manual labor condition in common, in which, although experienced, workers cannot handle the job as the years pass by. That is not true in the Public Administration and Footwear sectors in which experience may be of good value. Besides, jobs in the Public Administration sector (at least the well-paid ones) are normally offered on public tenders, in a way that they are filled by qualified educated (and not so young) new entrants. This is also the kind of job that accumulates a lot of vested rights and automatic promotions, contributing to a higher remuneration in the end of a worker's career. Footwear industry has the most curious possible explanation: that is one of the few old Brazilian manufactory industries that could only survive due to the historical protection after the country's gradual opening since the 1980's. Therefore, not much investment in skilled labor formation has been taken since then and seniors might still be of good value.

Figure B4 – Labor Income share by Industry (sample) and Age (60 to 79 years old)

Age	Forestry and Fish	Footwear	Biofuel	Public Admin.
60	0.3	0.0	0.0	1.6
61	0.3	3.2	0.0	1.0
62	0.0	11.0	0.1	9.4
63	0.0	0.3	0.1	4.1
64	0.0	0.0	0.6	1.8
65	0.0	0.1	0.0	0.3
66	0.2	0.8	0.0	1.2
67	0.0	0.0	0.0	0.5
68	0.0	0.1	0.2	0.0
69	0.0	0.0	0.0	0.7
70	0.0	3.5	0.0	0.5
71	0.0	3.8	0.0	0.1
72	0.6	0.0	0.0	0.1
73	0.0	6.9	0.0	0.0
74	0.0	0.0	0.0	0.0
75	0.0	0.0	0.0	0.1
76	0.0	0.0	0.0	0.1
77	0.0	0.0	0.0	0.0
78	0.0	7.8	0.0	0.0
79	0.0	0.0	0.0	0.1
Total	1.4	37.5	0.9	21.5

Source: POF 2017/2018 and BRIGHT's database.

Appendix C – Labor stratification through POF 2017-18 and the Brazilian SNA

This Appendix shows a labor stratification through POF 2017-18 and the Brazilian SNA. It is a work in progress for further developments on this type of methodology towards labor and contributor type disaggregation by household class and industry of work.

Table C1 shows that the self-employed category of occupation represents more than ¼ of the total Brazilian workforce according to POF. One thing to consider is to divide the public sector workforce according to the type of employee: the statutory type is the official public civil worker, hired after an official public tender. As one can observe, that category represents approximately 70% of the total civil workers of the public sector. This is an important typification, for the statutory type is compulsory enrolled in the RPPS scheme, while the non-statutory public sector employee may be eligible to the National Scheme, depending on its type of contract, as Table C2 shows.

Table C1 – Brazilian Active Workforce by Category of Occupation

Category of Occupation	Total
Housekeeper	7,525,501
Military	838,621
Private Sector Employee	46,335,095
Public Sector Employee (Statutory)	7,754,117
Public Sector Employee	3,429,846
Employer	3,494,263
Self-Employed	26,867,003
Unpaid worker	2,314,229
Total	98,558,673

Source: POF 2017-2018.

In Table C2, it is possible to see that approximately two thirds of the workers of the private sector are under the CLT. On the other hand, less than ¼ of the housekeepers are. As a tautology, employers, self-employed and unpaid workers are ineligible categories, for the CLT is for employees subject to a work contract. Statutory civil worker and the militaries are out of the scope too. Less than 40% of the non-statutory public sector workers are under CLT – a sign of flexibility even in the public sector.

Table C2 – Brazilian Occupied Workforce by Category of Occupation and Contract Type

Category of Occupation	Hired (CLT)	Other Type
Housekeeper	1,703,048	5,822,452
Military	-	838,620
Private Sector Employee	32,734,994	13,600,100
Public Sector Employee (Statutory)	-	7,754,117
Public Sector Employee	1,319,269	2,110,576
Employer	0	3,494,262
Self-Employed	0	26,867,002
Unpaid worker	0	2,314,228
Total	35,757,312	62,801,360

Source: POF 2017-2018. V5304: "In this work, did ____ have a signed work permit (CLT)?".

Table C3 shows the number of workers that do contribute to any type of social security scheme. As one can see, the contributor worker type is bigger than the hired under the CLT type. It means that POF question does not only captures the compulsory contribution of hired employees, but also individual voluntary contributions. Even without the CLT registration, non-statutory public employees may have some type of security, including a contract with the employer (Government), 13th salary, proportional vacations and, naturally, contributions to the RGPS. These are requirements that are not necessarily true to informal workers in the private sector, although it might also happen to temporary or intermittent workers. The share of the non-statutory public employees out of the CLT scope that contribute to a scheme (65%) is much higher than those of the private sector out of the CLT scope (8%). The information of Table C3 might give one the clue of informality[60] in Brazil.

[60] According to IBGE, the *informals* are the workers out of CLT scope (obviously not included militaries and the statutory civil workers) and those entrepreneurs without CNPJ – the National Registry of Legal Entities. It is quite difficult to estimate through the standard surveys like POF (the ECINF database was an attempt). They are all sorts of salers (entrepreneurs and assistants) like *camelôs* (small shops selling clothes, imitation jewelry, and cheap manufactory); and autonomous services (from Uber drivers and delivery guys to downtown city center pavements' occupations) without an official labor/business registration. However, it is not impossible to see workers out of the CLT scope and with no CNPJ, working for registered enterprises (Santos *et al.*, 2024).

Table C3 – Brazilian Active Workforce by Category of Occupation and Contributor Type

	Contributor	Non-Contributor
Housekeeper	2,320,474	5,205,027
Military	838,620	-
Private Sector Employee	33,882,211	12,452,883
Public Sector Employee (Statutory)	7,754,117	-
Public Sector Employee	2,686,200	743,645
Employer	2,138,760	1,355,502
Self-Employed	5,321,128	21,545,874
Unpaid worker	0	2,314,229
Total	54,941,513	43,617,159

Source: POF 2017-2018. V5305: "In this work, was ____ a contributor to a social security institute?".

The following Figures show the 2015 SNA data according to the previous POF information shares, turning a compatible disaggregation of BRIGHT database.

Figure C1 – Brazilian Active Workforce by Contributor Type and Industry

Industry	Contributor	Non-Contributor	Statutory Civil	Military	Total
Farming	4,242,979	8,891,975	2,573	0	13,137,526
MiningOil	223,927	44,455	19,174	0	287,556
Industry	7,709,433	3,493,777	10,305	0	11,213,515
Utilities	473,369	89,690	114,362	0	677,421
Construction	2,767,755	5,855,481	16,648	0	8,639,884
Trade	9,671,421	9,196,231	5,721	0	18,873,373
Transport	2,615,289	1,994,257	101,554	0	4,711,100
OthServices	16,301,690	13,421,456	218,646	0	29,941,792
InfoComunic	1,029,669	311,208	8,880	0	1,349,757
Financial	976,349	164,121	59,395	0	1,199,865
RealEstate	492,609	253,147	0	0	745,756
PublicServ	2,322,220	369,208	7,605,723	870,380	11,167,531
Total	48,826,710	44,085,007	8,162,980	870,380	101,945,076

Source: Brazilian 2015 Input-Output Matrix (IBGE, 2019) (POF 2017-2018 shares).

Figure C2 – Brazilian Mixed Income[61] by Contributor Type and Industry (R$ Million)

Industry	Contributor	Non-Contributor	Statutory Civil	Military	Total
Farming	53,539	72,857	-	-	126,396
MiningOil	0	394	-	-	394
Industry	6,346	17,140	-	-	23,486
Utilities	984	771	-	-	1,755
Construction	44,448	34,802	-	-	79,250
Trade	22,203	54,897	-	-	77,100
Transport	6,408	15,661	-	-	22,069
OthServices	66,016	86,763	-	-	152,779
InfoComunic	4,360	4,443	-	-	8,803
Financial	745	1,415	-	-	2,160
RealEstate	2,734	2,483	-	-	5,217
PublicServ	0	0	-	-	0
Total	207,784	291,625	-	-	499,409

Source: Brazilian 2015 Input-Output Matrix (IBGE, 2019) (POF 2017-2018 shares).

Figure C3 – Brazilian Labor Income by Contributor Type and Industry (R$ Million)

Industry	Contributor	Non-Contributor	Statutory Civil	Military	Total
Farming	43,627	43,905	74	0	87,606
MiningOil	19,230	1,090	11,442	0	31,762
Industry	382,326	45,842	1,404	0	429,572
Utilities	25,721	1,762	7,602	0	35,084
Construction	113,384	65,249	1,071	0	179,704
Trade	187,453	189,609	95	0	377,157
Transport	105,957	24,101	6,722	0	136,780
OthServices	455,907	200,419	12,621	0	668,948
InfoComunic	189,479	33,270	4,164	0	226,913
Financial	6,865	803	387	0	8,056
RealEstate	23,519	5,547	0	0	29,066
PublicServ	97,962	10,846	549,134	84,319	742,261
Total	1,651,430	622,444	594,715	84,319	2,952,907

Source: Brazilian 2015 Input-Output Matrix (IBGE, 2019) (POF 2017-2018 shares).

[61] The income of the self-employed (IBGE, 2015).

Figure C4 – Brazilian GOS Income by Contributor Type and Industry (R$ Million)

Industry	Contributor	Non-Contributor	Statutory Civil	Military	Total
Farming	37,367	47,778	0	0	85,145
MiningOil	6,035	207	0	0	6,242
Industry	88,118	4,711	0	0	92,829
Utilities	3,389	411	364	0	4,165
Construction	19,956	14,821	0	0	34,777
Trade	90,374	29,967	0	0	120,342
Transport	20,362	5,880	4	0	26,246
OthServices	97,853	31,079	1,557	0	130,489
InfoComunic	13,023	2,985	0	0	16,008
Financial	83,063	860	1,279	0	85,201
RealEstate	70,101	2,351	0	0	72,452
PublicServ	2,585	0	168	0.0028	2,753
Total	532,226	141,052	3,372	0.0028	676,649

Source: Brazilian 2015 Input-Output Matrix (IBGE, 2019) (POF 2017-2018 shares).

Figure C5 – Brazilian Active Workforce by Contributor Type and Household Class

Household Income Class	Contributor	Non-Contributor	Statutory Civil	Military	Total
HOU01	536,915	3,492,555	19,215	1,685	4,050,370
HOU02	3,768,469	8,921,046	319,751	11,107	13,020,373
HOU03	6,487,631	8,473,437	630,777	16,232	15,608,077
HOU04	13,193,411	10,467,788	1,523,979	86,238	25,271,415
HOU05	5,146,854	3,011,981	724,257	41,431	8,924,523
HOU06	6,917,542	3,476,992	1,147,057	156,621	11,698,213
HOU07	3,699,731	1,918,451	830,075	122,497	6,570,754
HOU08	4,607,785	2,224,921	1,333,980	233,986	8,400,672
HOU09	1,775,891	897,729	521,539	127,305	3,322,465
HOU10	1,485,103	626,905	582,974	50,102	2,745,084
HOU11	1,207,377	573,201	529,376	23,178	2,333,131
Total	48,826,710	44,085,007	8,162,980	870,380	101,945,076

Source: Brazilian 2015 Input-Output Matrix (IBGE, 2019) (POF 2017-2018 shares).

Figure C6 – Brazilian Mixed Income by Contributor Type and Household Class

Household Income Class	Contributor	Non-Contributor	Statutory Civil	Military	Total
HOU01	1,197	8,082	0	0	9,279
HOU02	4,995	36,665	0	0	41,660
HOU03	11,016	37,352	0	0	48,368
HOU04	21,918	79,631	0	0	101,549
HOU05	9,135	16,970	0	0	26,105
HOU06	64,509	24,003	0	0	88,512
HOU07	24,595	13,002	0	0	37,598
HOU08	25,822	31,764	0	0	57,586
HOU09	13,354	12,326	0	0	25,680
HOU10	13,636	14,678	0	0	28,314
HOU11	17,607	17,151	0	0	34,758
Total	207,784	291,625	0	0	499,409

Source: Brazilian 2015 Input-Output Matrix (IBGE, 2019) (POF 2017-2018 shares).

Figure C7 – Brazilian Labor Income by Contributor Type and Household Class

Household Income Class	Contributor	Non-Contributor	Statutory Civil	Military	Total
HOU01	12,943	23,084	420	0	36,447
HOU02	82,209	81,744	10,196	335	174,484
HOU03	173,113	90,661	23,585	371	287,729
HOU04	358,746	142,413	63,141	4,441	568,740
HOU05	151,163	37,110	38,508	3,088	229,869
HOU06	227,854	51,809	54,142	10,792	344,597
HOU07	145,813	35,057	49,202	10,785	240,857
HOU08	217,868	51,639	96,308	20,287	386,103
HOU09	92,994	29,824	50,898	17,621	191,336
HOU10	125,602	66,975	53,742	4,879	251,198
HOU11	106,810	38,449	92,746	3,541	241,546
Total	1,695,113	648,766	532,888	76,141	2,952,907

Source: Brazilian 2015 Input-Output Matrix (IBGE, 2019) (POF 2017-2018 shares).

Figure C8 – Brazilian GOS Income by Contributor Type and Household Class

Household Income Class	Contributor	Non-Contributor	Statutory Civil	Military	Total
HOU01	592	4,255	0	0	4,847
HOU02	2,778	17,617	0	0	20,395
HOU03	5,977	16,926	0	0	22,903
HOU04	17,736	34,949	153	0	52,838
HOU05	7,191	7,849	0	0	15,040
HOU06	37,854	11,784	344	0	49,983
HOU07	24,692	5,593	119	0	30,404
HOU08	30,150	14,132	823	0	45,105
HOU09	27,380	6,136	1,626	0	35,142
HOU10	60,057	10,541	107	0.0028	70,705
HOU11	317,821	11,266	200	0	329,287
Total	532,229	141,049	3,372	0.0028	676,649

Source: Brazilian 2015 Input-Output Matrix (IBGE, 2019) (POF 2017-2018 shares).