

**Calculation of sectoral economic-tax impacts caused by tax changes:
computable general equilibrium model applied to the Brazilian economy**

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ABSTRACT

This work aims to simulate the main proposals for tax reforms currently under discussion in the country as well as other changes suggested, through CGE model adapted to Brazilian needs. The model used was *ORANI-G*, widely used for public policy analysis. The model was calibrated with data from the Brazilian economy for 2015. The changes in the model were aimed at providing it with greater tax breakdown, as well as allow simulating the implementation of a tax on value-added. The implemented simulations deal with the replacement of employers' social security contributions for a new contribution on gross or a contribution on the value-added revenue, besides the tax on replacement products or services by a VAT. It is concluded that the changes bring positive effects, both in relation to the main macroeconomic variables and in relation to the performance of the great majority of economic sectors.

Keywords: Tax reform. Computable general equilibrium models. *ORANI-G* Model. Value added tax.

JEL codes: C68, E62, H21.

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1 INTRODUCTION

The tax system plays a fundamental role in the economy of any country as it affects the decisions of economic agents and, consequently, has a direct influence on growth, competitiveness, and income distribution. One of the characteristics of a good tax system is that it causes the least possible disturbance in the economy. In the Brazilian case, there seems to be a consensus that our tax system is inefficient and one of the most complex in the world, as will be seen in a little more depth in the next chapter.

Thus, it can be said that since the promulgation of the Federal Constitution in 1988, which established the foundations of the national tax system, there has been talk of reform of the system, to adapt it to a structure more consistent with the needs imposed by the Constitution, along with economic growth and development. However, until now, all attempts at reform have failed, generally due to the huge federative and distributive conflicts involved in the tax issue.

As well highlighted by Mirlees et al. (2011), the more complex and inconsistent a tax system is, the greater the incentive to tax evasion and the more legislation will be needed, so more efforts are made to increase tax revenues, rather than following a coherent reform strategy, to make the tax system more in line with economic growth. This seems to apply perfectly to the Brazilian case.

The reform of the national tax system is currently under discussion in the National Congress, considered as one of the main reforms necessary to stimulate sustainable economic growth in the country, as well as addressing the serious fiscal problem that the different entities of the federation are experiencing. Among the proposals under discussion, Constitutional Amendment Proposal N° 45 (PEC 45), by Deputy Baleia Rossi (MDB/SP), stands out. According to the Chamber of Deputies (2019, p. 22), this proposal, which has as a reference the tax reform proposal developed by the Centro de Cidadania Fiscal (CCiF)¹, aims to:

[...] propose a broad reform of the Brazilian model of taxation of goods and services, by replacing five current taxes with a single tax on goods and services (IBS). The taxes that will be replaced by the IBS are: (i) tax on industrialized products (IPI); (ii) tax on transactions related to the circulation of goods and on the provision of interstate and intercity transportation and communication services (ICMS); (iii) tax on services of any nature (ISS); (iv) contribution to the financing of social security (Cofins); and (v) contribution to the Social Integration Program (PIS). The IBS will have the

¹ The Centro de Cidadania Fiscal (CCiF) is an independent think tank that aims to contribute to the simplification of the Brazilian tax system and to the improvement of the country's fiscal management model. Information available at: <http://ccif.com.br/>.

characteristics of a good value added tax (VAT), a model adopted by most countries for taxing the consumption of goods and services.

Additionally, there is a great debate in the country about the volume of social security taxes levied on companies' payroll in conjunction with their economic impacts, and about the increase in informality and “pejotização”² in the labor market. In 2019, the then Secretary of Federal Revenue, Marcos Cintra, even proposed replacing the companies' social security contribution (CPFP) by a tax on financial transactions, or the inclusion of additional rate at the Single Tax³, earmarked for the financing of social security system⁴.

In an article available on the CCiF website, Appy (2016) presents the main distortions of the Brazilian tax system as well as suggests some reform alternatives, among which the incidence of taxes on the payroll is discussed. One of the proposals presented to reduce this taxation is the elimination of the levy on the payroll not linked to benefits (Sistema S, Salário Educação etc.). According to Appy (2016, p. 9):

The actions today financed by these contributions should have other sources of funds, preferably taxes. In the case of Sistema S expenses, in particular, these should be part of the budget and compete for resources with other public administration priorities, as it does not make sense for private entities to be financed by linked taxes.

Another important debate today deals with taxation on corporate profits, considered by some to be excessive. In that same interview with *Estadão* newspaper, quoted above, the then Secretary Marcos Cintra considered the extinction of Contribuição Social sobre o Lucro Líquido, and its inclusion in the Single Tax to be created. Still according to him, the idea is to reduce the tax rate on corporate profits from the current 34% to a level between 15% to 20%.

As it turns out, there are many proposals under discussion, however, what is perceived is the scarcity of quantitative data that show the macroeconomic and, mainly, sectoral impacts of such changes in the national tax system. In this respect, quantitative analysis becomes essential to support these proposals.

² “Pejotização” is a neologism created to define the employer's practice of hiring an employee as a legal entity (PJ) or dismissing an employee with a formal record and rehiring him in the form of a legal entity, with the objective of reducing payroll tax.

³ Version of the Value Added Tax, to be created for federal taxes (includes only the Tax on Industrialized Products - IPI, the Contribution to the Social Integration Program - PIS and Contribution to the Financing of Social Security - Cofins).

⁴ “Governo vai propor fusão de impostos e menos encargos” – *Estadão* – Available at: <https://economia.estadao.com.br/noticias/geral,governo-vai-propor-fusao-de-impostos-e-menos-encargos,70002787103>. Accessed on: 13 abr. 2019.

Therefore, the main objective of this work is to simulate the main proposals of tax reforms currently under discussion in the country through a computable general equilibrium model, adapted to Brazilian needs to allow such simulations.

Secondary objectives are the construction of the data matrix of the model to be used, with a higher level of detail than other works, especially regarding to the breakdown of taxes, together with the adaptation of the aforementioned model to allow such simulations, or others that might be suggested.

It is important to highlight that, in the present work, regarding the analysis of tax reform proposals, it is not intended to evaluate, from a theoretical point of view, whether the institution of a value added tax, or the exemption from charges on the payroll, are the best proposals for the Brazilian tax system, but only to calculate the impacts of the referred proposals on the economy as well as on the economic sectors, in order to provide subsidies for a more objective and transparent discussion of the theme.

It should be noted that there are other studies that use the same base model as the one used in this work, including for assessing tax reforms, such as the objective proposed here. However, the difference of this study lies in the fact that in addition to simulating the tax reform proposal currently under discussion in the country, which, in itself is already an innovation, presents a greater tax breakdown, allowing for other simulations.

To achieve the proposed objectives, this work will have seven chapters, including this introduction and the final considerations. The second chapter will review the theoretical and empirical literature on the themes developed in the work. The third chapter presents the methodology describing the general equilibrium model used. The fourth chapter details the construction of the database used, whilst the fifth chapter discusses the main adjustments made in the original model, in order to enable the planned simulations. The sixth chapter presents the simulations, which describes the shocks performed, their implementation and the discussion of results. In addition, different simulations and sensitivity analyzes of the model to the parameters used are carried out. Finally, the final considerations described the main achievements at work.

2 LITERATURE REVIEW

This chapter deals with relevant aspects of taxation on goods and services, on the payroll and on corporate income, which are related to the issues addressed in this work, in addition to, at the end, it discusses the models of computable general equilibrium and its applications in the analysis of fiscal policy impacts on the Brazilian economy.

2.1 Taxes on goods and services

Appy (2017) considers that the Brazilian tax structure causes great allocative distortions, with negative impacts on economic efficiency. As a consequence, the amount of production is less than what could be produced using the same number of primary factors (maintaining the same level of income) if the economy were to organize itself more efficiently. Also, according to the author, the biggest allocative distortions come from the taxation of goods and services. However, the distortions caused by the taxation of capital income and the payroll cannot be overlooked.

The author cites three negative consequences of cumulative taxes on goods and services. The first is the increase in the cost of investments and exports. The second is the loss of transparency about the amount of taxes charged in the production and commercialization chain of a good or service, which depends on how this chain is structured. The third is the cumulativeness, by inducing production verticalization in order to reduce taxes, that affects the way production is organized, at the expense of productivity. In other words, in the absence of cumulative impacts, it would be possible to organize production more efficiently, with more specialization and gains in scale.

The article also points out two characteristics of the Brazilian model of taxation, namely the high level of litigation on tax matters, not only due to the complexity of the legislation, but also of inadequate design of the tax administrative process, with a strong impact on the cost of companies and the increase in legal uncertainty, along with the high cost of tax compliance in the country, which represents an unproductive allocation of labor and capital. Finally, Appy (2017, p. 28) points out that “A good agenda for changes in the Brazilian taxation model is perhaps the item on the agenda of microeconomic reforms with the greatest potential for impacting the country's productivity in a horizon of ten or fifteen years”.

According to Lukic (2018), the system of taxation of goods and services in Brazil is one of the most complex in the world, presenting segmentation of the bases of incidence and different taxes on the same basis, which causes several problems and obstacles to the Brazilian system, among others, the inefficient organization of business activities, with an impact on national productivity, the high cost of compliance, the increase in legal uncertainty and administrative and judicial litigation.

The author points out that the main problems with the taxation of goods and services in Brazil can be summarized as follows:

- In the case of ICMS and PIS / Cofins, the system used to guarantee non-cumulativity is limited based on the physical credit system, in which only inputs and intermediate products that are physically incorporated into the final product enable the right to credit, unlike the model adopted in VAT which uses the financial credit system, in which everything that the company purchases can be used as credit. For ICMS the exemption from capital goods, provided for in the Kandir Law, as well as the immediate crediting of goods for use and consumption has been systematically rendered unfeasible by several subsequent rules that limit this right, by cause of the loss of revenue resulting from these measures. The same occurs with PIS / Cofins, in which several normative acts limit the right to credit. As a consequence, there is a significant increase in legal uncertainty and administrative and judicial litigation.
- The tax calculation mechanism uses the “calculation from the inside” system, in which the tax itself, or other taxes, make up the calculation basis, meaning that the actual tax rate does not correspond to the nominal rate, making it difficult to perception of tax incidence, which makes the system less transparent. It is important to note that this practice is not used in more than 150 countries that adopt taxation of consumption on value added.
- Another important issue concerns the accumulation of credits generated, in the case of ICMS, by differences in interstate rates, mainly as a result of the absence of clear and effective reimbursement mechanisms. The same phenomenon occurs in relation to exporting companies since there are no taxes on exports.
- In the case of the ICMS, taxation at source and the intensification of the fiscal war are among the main problems. The increase in the fiscal war stems from the unique characteristic of Brazilian taxation, in which the consumption tax is in the autonomous management of subnational entities. Furthermore, in the medium and long term, it leads to positive results for the victorious states. A striking feature of the fiscal war is that, once started, all other entities are forced to participate under pain of losing production, intensifying the federative conflict. As everyone performs this practice, its effectiveness decreases leading to mutually damaging reductions in tax revenues, due to the phenomenon known as “race to the bottom”, with losses for all participants. The modification of the ICMS collection regime, with the adoption of the “destination principle”, meaning that the collection is made in the state of consumption, would improve the revenue of the less

developed states, in addition to greatly mitigating the problem of the fiscal war. The adoption of the destination principle eliminates the possibility of a state granting an incentive whose cost in terms of lost revenue falls on another (VARSANO, 2014). It is important to note that charging at source is equivalent to taxing production, while taxing at destination (model adopted in VAT) is equivalent to taxing consumption (APPY, 2016).

- Indiscriminate use of the ICMS calculation system for tax substitution, in which the payment of the tax is imputed to a third party who did not practice the taxable event to facilitate the collection and inspection of the tax authorities. In the most used case, forward replacement, taxation is based on a presumed value, which in most cases does not correspond to the effective value of the operation, contrary to the logic underlying a market economy. This calculation technique is justified only in operations involving products whose marketing was dispersed, with a high concentration of manufacturers or distributors, which are difficult to control by state inspections, or highly relevant to tax collection. According to Appy (2017), the tax substitution model negatively affects productivity, by distorting relative prices, as more efficient trading systems are more taxed than in the VAT model.

- With regard to PIS / Cofins, there is a coexistence of different regimes (cumulative and non-cumulative), with negative effects on the organization of the production chain, generating economic inefficiency. As in the ICMS tax substitution, there is a single-phase regime over a series of products, in which the collection is concentrated in the producer or importer. In the case of agricultural products, there was a need to create presumed credit, given that many rural producers are not constituted as legal entities and therefore do not generate credit for the buyers of the goods. In addition, the tax calculation system using the model known as "base against base", generates undue credit when acquiring company inputs from the presumed profit, with distorting effects on the organization of the economy. All of this makes the legislation of these taxes extremely complex, with negative results for taxpayers, for inspection, as well as for society in general, as it generates large allocative distortions, harming the productivity of the Brazilian economy.

Orair and Gobetti (2018) add, to the problems mentioned above, the excessive amount of rates exemptions and non-incidences, which hinder tax coordination and make tax

administration more expensive, along with the extreme complexity and unjustifiable arbitrary treatments, which are responsible for substantial litigation and compliance costs.

Still according to Varsano (2014), four taxation principles are generally used to assess the quality of a tax:

- Neutrality - taxes must have the least possible effect on the behavior of economic agents;
- Equity - taxes must be fair, in the sense that they must be levied in accordance with the principle of benefit or, alternatively, levied in accordance with the principle of ability to pay. As for this, taxpayers under similar conditions must be equally taxed (horizontal equity) and taxpayers with greater contributory capacity must pay more than those with lesser capacity (vertical equity)
- Simplicity - taxes must be simple, with application rules that are easy to understand, and their administration and tax compliance costs must be low;
- Productivity - the tax must be able to generate the revenue that you want to obtain from it, which implies a preference for taxes that are broad based, increasing over time and immovable, and that are difficult to evade.

The author points out that a VAT based on best tax practices has, among others, the characteristics listed below:

- It is a broad-based tax (consumption) and, therefore, of high productivity if evasion is properly controlled;
- Although collected by the companies, the intention is that it is transferred to consumers, who are the agents that effectively support their burden, thus not affecting production decisions. If applied with a single rate to all goods and services consumed in the country it does not change the relative prices of the goods;
- It does not burden savings and investment, thus not harming economic growth;
- It is neutral in relation to foreign trade, that is, it does not encourage imports and exports in relation to domestic sales (pro-trade bias) or the opposite (anti-trade bias);
- It satisfies the principle of horizontal equity as long as it is a general tax, since individuals with similar consumption expenses are equally taxed, regardless of the composition of the baskets of goods and services they consume;
- It may not be satisfactory in relation to vertical equity if the contributory capacity is measured by family income and, as is usually the case, consumption is a greater proportion

of the income of poor families than of income of high-income families. If these two conditions occur, a general consumption tax, VAT or whatever, is regressive. It will be even more regressive if services, whose consumption is concentrated in the highest income families, are not taxed with the same intensity as goods.

According to Varsano (2014, p. 18):

“It can be said that VAT, to be a good tax, must be used with a single objective: to collect. It is not a good tool to correct externalities, to improve income distribution or to carry out trade policy. Other instruments more appropriate for these purposes exist. Selective taxes handle externalities well. Income and property taxes and, above all, the use of income to carry out programs and projects whose benefits are appropriated in whole or in the main by the poorest, are good instruments for dealing with poverty and inequality. The import duty is the appropriate tax instrument for carrying out trade policy.”

According to Varsano (2014), VAT is adopted in more than 150 countries, the United States being the only country of great economic importance that does not adopt it.

Mendes (2008) adds to the qualities of a good tax system: the ability to generate revenue; efficiency, in the sense of producing the least negative impact on the incentives to invest, save, work and export; effectiveness, expressed in the managerial and administrative capacity of the tax administration; harmony with international taxation standards; and, finally, the ability to maintain the balance of fiscal federalism. The author, based on recommendations from the IMF, stresses that the basic structure of a good quality system, in addition to a value added tax, must provide for specific (selective) taxes on luxury products that cause negative socio-environmental impacts, such as, beverages, tobacco and oil commodities, together with an income tax on legal entities with rates aligned with those of individuals, minimizing the use of tax incentives to specific sectors or activities.

With regard to selective tax, Appy et al. (2019) propose the incidence on goods and services that cause negative externalities, such as tobacco and alcoholic beverages. The tax would have a single phase impact being due only in the production stages and in imports. Thus, it does not generate credit for the acquirer in the subsequent stages of sale and is therefore considered a cost. It emphasizes that it has an extra-fiscal purpose, that is, a regulatory one whose consumption of the good or service is to be discouraged, unlike VAT which has a collection purpose.

2.2 Payroll taxes

According to Appy (2017), the payroll taxation model in Brazil affects productivity mainly considering the disincentive to formal employment. For a typical company, contributions on the payroll, for FGTS, and the employee's social security contribution vary from 42.3% to 50.8% of the reference salary. This high cost creates a strong disincentive to formalize work, with negative effects on productivity due to the lower efficiency of informal work compared to formal work.

As stated by Appy (2016), in addition to the high incidence of taxes on the payroll, another important deficiency of the model adopted refers to the lack of a clear relationship between the value of social security contributions levied on the payroll and the benefits perceived by the employees, partly by cause of the fact that several of the contributions levied on the payroll (Sistema S, Salário Educação etc.) have no relation to social security.

But the main reason for the gap between contributions and benefits, especially in the case of low-income workers, is because the floor of social security benefits (a minimum wage) is the same value as non-contributory welfare benefits. Thus, the incentive for the worker to contribute to social security is weak, since the benefit he will receive when he becomes elderly will be the same, regardless of whether or not he contributed. In the case of workers with higher incomes, the gap between the contributions levied on the payroll and the perceived benefits stems from the fact that the employer's contribution affects the entire salary and not just the contribution salary ceiling.

This absence of a link between contributions and benefits causes contributions, both by companies and employees, to be perceived as yet another tax intended to finance general government expenditures, discouraging the formalization of work and pressure to concession of favored treatments, since the taxation on the payroll is seen as a cost.

Finally, Appy (2016) suggests the elimination of the incidence on the payroll of contributions not linked to benefits, such as the Sistema S and Salário Educação, as well as that the contributions on the payroll focus only on the wage share that exceeds the value of the assistance benefit, observing the contribution salary ceiling.

Bird and Smart (2012) analyze the change in the financing of social security in developing countries, with a large participation of the informal sector in the economy, from a contribution on the payroll to a taxation on added value. According to the authors, even countries that have well-established payroll taxation have considered this change as a good

alternative due to unemployment concerns, as well as for macroeconomic reasons. They consider in the article that, regardless of whether the payroll tax is levied on the employee or the employer, the macroeconomic effects are similar.

The developed model considers a small open economy with formal and informal sectors, in which potential entrepreneurs choose whether they want to enter the market or not, and if they do, they will operate in the formal or informal sector. From there, comparisons are made between the two tax systems: taxation on the payroll or on the added value. In principle, the change in payroll taxation to VAT will move production to the informal sector, as a result of the additional tax on profitable companies in the formal sector. The authors show that there is a neutral reform in terms of revenue from payroll taxation that increases national production and well-being. Since the majority of corporate profits are inframarginal, the adoption of a VAT allows the collection of a lower legal rate than that of the payroll, so that the incentives for informality can be controlled and higher tax revenues are less costly. Therefore, a neutral shift in terms of revenue from payroll taxation to VAT generates less informality, higher wages and an improvement in the trade balance.

2.3 Taxes on corporate income

As reported by Orair and Gobetti (2018), the tax rates on corporate profits are very high and, although several special regimes and tax benefits greatly reduce the effective rates, they also generate arbitrariness in the tax treatment between economic sectors and between taxpayers. Furthermore, the model presents asymmetries in the tax treatment between the various sources of capital income, with an unfavorable bias to productive assets. The rates on the company's profit (up to 34%) are generally higher than those on capital gains (15%) and financial investments (usually 15 to 22.5%, in addition to numerous exemptions).

If, on one hand, corporate taxation seems to be high, especially when compared to OECD countries, on the other in Brazil dividends distributed to individuals are not taxed, which is also an anomaly of our tax system. According to the authors, the ideal is that there is a greater integration of taxation on the income of individuals and legal entities in order to prevail a more balanced taxation between corporate profits and distributed dividends. The introduction of dividend taxation would make it possible to reduce taxation on corporate profits.

As stated in Johansson et al. (2008), in a ranking of taxes and economic growth, considering long term reduction in GDP per capita, the least distorting tax is the tax on real

estate, followed by the tax on goods and services, the income tax on individuals and, finally, the corporate income tax. Furthermore, considering only income taxes, shifting corporate taxation to individuals can increase efficiency.

The article highlights that the reduction of taxation on corporate income, together with the removal of tax incentives can increase investment in several ways. First, if the main objective is to reduce distortions that delay the level of domestic investment and to attract foreign direct investment, the reduction of the corporate tax rate may be preferable to the reduction of the personal income tax on dividends and capital gains. Second, reducing the corporate tax rate and removing differentiated tax treatment can also improve the quality of investment, reducing possible tax-induced distortions in the choice of assets. Finally, providing greater certainty and predictability in the application of corporate income tax can lead to greater investments, which, in turn, can improve the performance of economic growth.

As the article points out, one of the ways to improve productivity through tax policy is to reform corporate taxes, as they influence productivity in several ways. Evidence suggests that reducing corporate taxes can lead to particularly large productivity gains in dynamic and profitable companies, that is, those that can make the greatest contribution to GDP growth. It also appears that corporate taxes negatively influence productivity in all firms, except for young and small firms as these firms are generally not very profitable. One possible implication is that tax exemptions or reduced corporate tax rates for small businesses may be much less effective in increasing productivity than a general reduction in the overall corporate tax rate. This reduction could be financed by reducing exemptions granted for the size of the company, as they only waste resources without substantial positive effects on growth.

Also, in consonance with Johansson et al. (2008), one cannot ignore the role of globalization as a factor of increasing influence in the tax system, especially the corporate income tax, when choosing the location of the factories and offices of large companies. In this respect, corporate income tax is the most affected by the effect of globalization since multinational companies find it increasingly easy to change the location of their businesses. Thus, countries that ignore this effect may experience slower growth.

Therefore, as stated in the document, there are several channels through which the corporate income tax can affect the total factor productivity (PTF). They can distort the relative price of factors of production, resulting in reallocation of resources towards less productive sectors. Furthermore, complex corporate income taxation systems impose a high cost of

compliance for firms and a high administrative cost for the government, absorbing resources that could be used in productive activities. High taxation also decreases the incentive to invest in innovative activities by reducing the return on investment after paying the tax. Finally, as they reduce foreign direct investment and the presence of multinationals in the country, they become obstacles to the transfer of technology and knowledge to national companies.

Finally, Johansson et al. (2008) points out that a country's attractiveness as a place for foreign direct investment (FDI) depends, among other things, on how its tax system compares with the possible destinations of competitors. The FDI can be more sensitive to taxes on small countries (or countries with a small market) or in countries facing comparative disadvantages related to distance or transaction costs. The continued integration of world capital markets and increased capital mobility have affected capital sensitivity to tax changes. This can further stimulate fiscal competition and have important implications for the design and effect of fiscal policies.

Orair and Gobetti (2018) highlight, as international trends in the field of taxation underway in this century, the adoption of VAT, with increasingly broad bases, not restricted to goods and services, with the inclusion of digital and intangible services, reduced number of rates, full credit exempt from investments and exports, with few tax benefits. In addition, there is an exhaustion of models based on payroll taxation, in view of the negative effects on national competitiveness, inclusive of considering new forms of labor relations. Finally, they highlight the erosion of the tax base on corporate profits, coupled with pressure to lower rates, due to the increasing mobility of capital.

Also, according to the authors, after the 2008 financial crisis, several cyclical tax reforms were necessary to promote fiscal consolidations in several countries. However, as of 2015, tax policies were reoriented in order to prioritize economic growth. Thus, in the OECD countries, several trends were observed, among which, by cause of the aspects treated in this work, the predominance of measures to reduce taxes on labor income and on corporate profits are worth mentioning, the latter offset by expansion of the tax base, in order to protect the domestic bases of evasion and tax avoidance practices by multinationals, along with increases in taxation on capital income at the shareholder level, especially through the elimination of tax benefits on dividends. In addition, the aforementioned reductions were also offset by increases in consumption taxes.

2.4 Computable general equilibrium models and their applications in impact analysis of fiscal policies in Brazil

The use of computable general equilibrium models has become increasingly frequent in the calculation of policy impacts adopted by several countries, especially in the last two decades, largely by virtue of the intense technological advancement, which allows even models with thousands of equations can be solved in a few minutes using a personal computer.

Fochezatto (2005) presents a detailed review of the literature with the characteristics foundations and applications of these models, with emphasis on the analysis of tax policies insofar as they capture the main interactions between the agents and markets of the economic system, in addition to identifying the winners and losers of the analyzed policies.

As for the applications of these models to the Brazilian economy, Siqueira et al. (2001) analyzes the effects of input taxation on the final incidence of indirect taxes in Brazil, based on data from the 1995 input-output matrix (MIP). The authors conclude that the effective incidence of taxes on goods and services is quite different from that which emerges from nominal tax rates and therefore quite different from those recommended by policy makers or desired by society. The export sector is an example of an activity that, although it is exempted in the text of the law, suffers the effects of the taxation of inputs on the production chain. It was also observed a great dispersion in the calculated effective rates, which is considered undesirable from the point of view of economic efficiency, although the authors understand that the optimal taxation structure is not necessarily uniform.

Silva, Tourinho and Alves (2004) evaluate the long-term economic impacts on the Brazilian economy of three measures that are part of the reform of the tax system: the partial transformation of the Contribution to the Financing of Social Security (Cofins) into a contribution on added value, the adoption of PIS / Pasep and Cofins on imports and the partial replacement of the social security contribution with a contribution on added value. The instrument used was a static model of general equilibrium of the Brazilian economy (CGE-IPEA), whose fiscal block was adapted to allow a detailed analysis of those measures.

The model used allowed analyzing the effects of the measures, generating results both at the macroeconomic and sectoral levels. At the macro level, they concern the fiscal impact of the proposed measures, in conjunction with the impact on the balance of payments the exchange rate and real wages. At a disaggregated level, there are different effects on the various sectors, by cause of the differences in rates and the specific variation in costs and prices, all of which

interact through the sectoral interdependence represented by the input-output matrix. In addition, there is the impact of imports and exports on the balance between supply and demand for the various goods.

With respect to the third measure mentioned above, which is of most interest in this study for comparative purposes, the substitution of 50% of the employer's social security contribution (CPP) for a non-cumulative contribution on the value added was simulated, keeping the collection unchanged. However, this change was only implemented in sectors that started to contribute to Cofins based on the value added (first measure), which, according to the authors, corresponds to only 36.6% of GDP. The resulting rate was 6.9%.

Lledo (2005) uses a dynamic computable general equilibrium model, calibrated for the average of the Brazilian economy in the 1995/2002 period, based on the approach of the overlapping generations model of Auerback and Kotlikoff (1987), to calculate the macroeconomic and distributional impacts of replacement of PIS, Cofins, CPMF and IOF by VAT, under the restriction of fiscal adjustment, that is, keeping the public debt unchanged. The author concludes that the expected long term positive effects of switching to a consumption-based tax system, commonly reported in the literature, also apply to the Brazilian economy. In the long run, the change may lead to an increase of 9% in GDP, 8% in capital stock, 2% in consumption and 7% in real wages. The simulated reform does not compromise the country's growth trajectory as it does not cause any substantial decrease in income labor supply or capital stock. In addition, there is no increase in interest rates or a decrease in wages, with welfare gains for 70% of individuals. Thus, the need for fiscal adjustment cannot be considered an obstacle to the implementation of a more efficient tax system.

Pereira and Ferreira (2010) assess the impact on the Brazilian economy of a tax reform that contemplates three aspects, namely, payroll tax exemption, with a reduction in the employer's social security contribution, from 20% to 14%, together with the extinction of the contribution for Salário Educação, which would be offset by the creation of a federal VAT; reduction of cumulative tax structure with the creation of a Federal VAT to replace PIS / Cofins; and the exemption of investments. A standard dynamic recursive model calibrated for the Brazilian economy based on 2002 was used.

The long-term results, considering the more conservative simulation implemented by the authors, point to a 14% growth in GDP, 11% in consumption (despite a 3% drop in the first year after the reform), 29% in private investment (as a percentage of GDP), 35% in the private

capital stock. In the first eight years after the reform, the average annual increase in the product growth rate would be 1.2% above the GDP growth that would be observed without the reform. In terms of a measure of well-being, the gains reach 3.6%, meaning that the benefits promoted by the reform would be equivalent to a permanent increase of 3.6% in the levels of pre-reform consumption.

Godoy (2013) investigates the impacts of policies to stimulate Brazilian industry through a computable general equilibrium model (*GTAPinGAMS*) calibrated for the 2009 year. The work analyzes the impact of some incentive measures to the industrial sector, among which there is the exemption from payroll and a tax reform with the replacement of intermediate taxes by a value added tax, the latter under the hypothesis of fiscal neutrality. For both simulations, two different scenarios were considered. In the case of exemption from payroll, the first scenario sought to reflect the measures adopted by the federal government, with the replacement of the employer's contribution on the payroll by a contribution on gross revenue, with rates of 1% and 2% depending the exempt sector. The second scenario, alternative, proposes that the exemption applies to all sectors of the manufacturing industry, with a rate of 1%. Regarding tax reform, in the case of the alternative scenario, the exemption from investment and export taxes is added to the basic scenario of substituting intermediate taxes for value added tax, in this case, relaxing the hypothesis of fiscal neutrality adopted in the main scenario.

As for the sectoral results compared, the measures proportionally more affect the sectors with the highest technological intensity, which promote a greater link “forward” and “backward” in the economy. They also increased the export of goods of greater technological intensity, as well as a drop in the export of commodities. It concludes that tax reform, which is neutral from a fiscal point of view, is capable of raising GDP and well-being, in addition to improving the sectoral composition of production and exports, without the government's activity being negatively affected. Regarding the payroll exemption, along with tax reform with reduction of tax revenue, the results are good, but they are not sustained in the long term if there is no change in the efficiency of public spending, since the measures generate a decrease in activity from the government.

Beppler (2019) uses the same basic model used in the present work, for the 2015 year to evaluate the effect of fiscal policy spending and taxes, expansionary and contractionary, on the Brazilian economy. One of the simulations involves the adoption of an expansionary fiscal policy, implemented by reducing, at fixed intervals in the range of 0.2% to 1.4%, in the rate of

production taxes. When considering the biggest shock, equivalent to a 1.4% reduction in taxation, it generated significant positive results, with considerable growth in employment (reaching almost 6% in the short term), real wages (4% in the long term), the return on capital (reaching almost 4% in the short term) and real GDP (reaching almost 2% in the long term).

It concludes that fiscal policies based on government spending have a limited economic effect, while the reduction in taxation has caused considerable growth in the observed macroeconomic and microeconomic variables, reflecting scenarios of recovery in Brazilian economic growth. However, the author emphasizes that the use of 2015 may have greatly influenced the results, since it is a period in which the Brazilian economy was starting to recess, with pressures on economic growth, public finances, exchange rates and general framework of the industrial sectors.

Souza, Cardoso and Domingues (2016) assess the economic impacts of payroll tax relief as instituted by the Federal Government, using a computable general equilibrium model whose basis is the same model used in this work. In addition to the simulation of the policy effectively implemented by the government, the authors also carry out an alternative simulation, considering the objectives of a policy to strengthen the industrial sector, in which all industrial, agricultural, and related services sectors are exempted (sectors of services provided to families and the public sectors were not included), with the purpose of verifying which policy design would have the greatest benefits for the Brazilian economy. In this alternative simulation, the payroll tax is replaced by a tax with a rate of 1% on the gross value of the sector's production and imports.

The model covers 60 sectors and 116 commodities and was calibrated based on the 2005 year. The simulations carried out promote the replacement of the employer's social security contribution with a social security contribution on gross revenue with rates of 1% and 2%, depending on the benefited sector. In addition, an increase with these same rates on Cofins' gross revenue on imports is necessary, in order to reduce the asymmetries in taxation between domestic and imported commodities.

The long-term results for the first simulation (policy adopted by the government) point to positive effects on GDP, employment and household consumption, which have increased by 0.10%, 0.27% and 0.25%, respectively, in addition to incentives to the capital goods sector. However, the authors make some reservations: (i) the increase in taxes on imports encourages sectors chosen by the policy, which reduce the share of imports, however, leads to negative

impacts on the Brazilian economy, as it burdens the import of inputs productive; (ii) sectors not elected by the policy lose competitive advantage, since the policy, at the same time that it exempts production, presses prices as a result of the increase in domestic demand for consumption and labor; and (iii) for some sectors the result on the economy as a whole is negative, although the sector itself benefits, making the choice of sectors a crucial point for the effectiveness of the policy.

The alternative simulation, in which only the sectors that would have a positive impact on the economy are considered, would have the potential to generate 2.13% growth in GDP, 2.27% in employment and 2.46% in investments. When considering all sectors, that is, also considering the sectors with negative impacts, the total impact on GDP would be 0.76%.

However, this selection of sectors is controversial, insofar as it opposes vertical and horizontal industrial incentive policies. Thus, the systemic effects of a policy that chooses sectors (vertical) can lead to indirect impacts that oppose the initial objective, as occurred with the disincentive to some exporting sectors and incentives to imports from sectors not elected by the policy. However, the option for a more transversal policy, may lead to the risk of perpetuating the industrial structure exactly as it is, in the Brazilian case, a diversified structure specialized in the export of commodities with low technological content.

Regarding the calculation of the impacts resulting from tax changes, according to Domingues and Haddad (2003), in most cases, the impacts calculated on the tax revenue refer only to the first order term, that is, the variation of the rate is applied on a fixed tax base. Whether *BAS*, the tax base, *TAX*, indirect tax revenue and *t*, the tax rate. So, if:

$$TAX = BAS * t, \text{ So: } \Delta TAX = BAS * \Delta t + \Delta BAS * t$$

Neglecting the second-order term in this equation ($\Delta BAS * t$), implies considering that the new tax rate does not cause changes in the various economic variables, such as relative prices, quantities produced and consumed, income, corporate income, labor market, investment etc., which can cause significant errors in the calculation of the impacts of the tax change. Therefore, the advantage of using a general equilibrium model is clear when it is intended to calculate sectoral and economic impacts in a broad way.

3 METHODOLOGICAL PROCEDURES

This work uses the computable general equilibrium approach to calculate the economic-tax impacts caused by tax changes, in which the analysis of the impacts is carried out at the level of the economic sectors, together with the other economic agents present in the matrix

data of the model. Economic-tax impacts involves variations in several variables, such as: tax collection, production, GDP, consumption, investment, level of employment and income, exports, imports, prices etc.

The CGE model used is the *ORANI*, developed in the 1970s and widely used for the analysis of public policies by academics, the private sector and the government of Australia. More specifically, the model used here is *ORANI-G*, which is similar to *ORANI*, and served as a basis for models from different countries. To solve the model equations, the GEMPACK program is used⁵. The *ORANI-G* model has typical theoretical framework of static CGE models, consisting of equations that describe for a period of time: the demand of firms for inputs and primary factors; the supply of goods by firms; the demand for inputs for capital formation; the household demand; the export demand; the government demand; the relationship of basic values to production costs and sales prices; the equilibrium conditions for goods and primary factors; and multiple macroeconomic variables and price indices.

The supply and demand equations are obtained by solving optimization problems (minimizing costs, maximizing utility etc.), which are the basis of the behavior of economic agents in the neoclassical approach, that is, agents are considered price takers, with producers operating in competitive markets. The model solutions are presented in the form of percentage variation of the variables. The *ORANI-G* model allows comparative static simulations to be made, meaning that the model itself is atemporal, which tells us nothing about the adjustment process but only about the final result. The detailed structure of the *ORANI-G* model, inclusive of its equations, can be found in Horridge (2006).

The first two simulations of tax changes made in this paper deal with replacing the payroll tax (social security contributions on the payroll - CPF and on gross revenues - CPRB), by a new contribution on gross revenue (NCPRB) or by a value added contribution (CVA), in the same way as VAT.

Next, the third simulation involves the extinction of the following taxes: Contribution to the Social Integration Program (PIS), Contribution to the Financing of Social Security (Cofins), Tax on Industrialized Products (IPI), Tax on the Circulation of Goods and services

⁵ *GEMPACK* (General Equilibrium Modeling PACKage) is a set of economical modeling software. It is especially suitable for computable general equilibrium models but can handle a wide range of economic behavior. Detailed program information can be found at: <http://www.copsmodels.com/gempack.htm>.

(ICMS) and tax on services (ISS), in addition to the creation of an Value Added Tax (IVA) levied on the value added at each stage of the production process, and an excise tax (ISSP) levied on the value of production and import of specific products, in the case hereof, just about the beverage and tobacco commodities ("Bebidas" and "Fumo"), along the lines of what is adopted in most developed economies. This is essentially the main tax reform proposal that is being discussed in the national congress.

Finally, a joint simulation was carried out dealing with the replacement of the payroll tax by a value added contribution (CVA), along with the institution of IVA / ISSP in substitution of commodities taxes mentioned above. Thus, one can verify the isolated impact of each change, as well as, at the end, the joint impact of the changes. In addition, joint simulations were carried out along these same lines, but with changes in the standard closures of the model, along with the elimination of CSLL (Contribuição Social sobre o Lucro Líquido) and contributions to Salário Educação and Sistema S, as detailed in section 6.4.

Horridge (2006, p. 9) presents the initial structure of the *ORANI-G* model, represented by the absorption matrix⁶. For the present work, this structure had to be altered in order to simulate the aforementioned tax proposals. The main changes, both in the database and in the model structure, are explained in more detail in the next two subsections.

Also Considering that one of the objectives of the work is the development of methodologies that allow simulating other tax changes, different from the main proposals under discussion, the construction of the absorption matrix has a very detailed level of tax breakdown, especially for the main federal taxes.

The model was calibrated with data from the Brazilian economy for the year 2015, according to the MIP 2015 published by IBGE (IBGE 2018). 67 sectors and 127 commodities are considered, 2 margins, trade and transport, and 2 sources, domestic and imported⁷.

Short and long-term closures are used in the simulations. According to Domingues and Haddad (2003) the basic distinction between them is related to the treatment used in the standard microeconomic approach of adjusting the capital stock to economic policies. In the short-term environment capital stocks are kept fixed, while in the long-term policy changes can affect capital stocks. It is important to highlight that when choosing a specific closure for the

⁶ The absorption matrix is the *ORANI-G* database.

⁷ Absorption matrix dimensions: *COM* (products); *IND* (sectors); *DOM* (domestic source); *IMP* (imported source); *Comerc* (trade margin) and *Transp* (transport margin).

model the macroeconomic environment of the economy is imposed. The Figures 1 and 2 (Appendix II) show, respectively, the short and long terms schematic pattern of macroeconomic environments used in this study. It should be noted that, in the simulations, government consumption is endogenous and is limited by the public spending ceiling established by Constitutional Amendment nº 95, of 2016. The Figure 3 (Appendix II) presents alternative closure long term, used in the last two simulations, whereupon the real household consumption follows the real income of factors with endogenous trade balance⁸.

The Table 1 below shows the exogenous variables that differentiate the long and short term in the standard simulations. According to Horridge (2006), the main differences between long-term and short-term closure are:

- the capital stock (*x1cap*) is free to adjust in such a way that fixed rates of return (*gret*) are maintained. An open capital market is implicitly assumed, since there is no link between capital formation and domestic saving;
- aggregate employment is fixed (*employ_i*) and the real wage adjusts (*realwage*). This would be consistent with the idea that both the workforce and the unemployment rate are, in the long run, determined by mechanisms outside of the model;
- household and government spending move to accommodate the constraint in which the trade balance as a fraction of GDP (*delB*) is fixed, expressing the idea that, in the long run, the rest of the world might be reluctant to finance an increased trade deficit. The aggregate investment follows the aggregate capital stock.

Table 1 - Specific exogenous variables of short and long term - Standard simulations

Term	Variable	N. Var.	Dimension	Name
Short	<i>realwage</i>	1	1	Realwage
	<i>x1cap</i>	2	IND	Aggregate capital stock, rental weights
	<i>f3tot</i>	3	1	Ratio, factor income/ consumption
	<i>finv1</i>	4	ENDOGINV	Shifter to enforce DPSV investment rule
Long	<i>employ_i</i>	1	1	Aggregate employment: wage bill weights
	<i>gret</i>	2	IND	Gross rate of return = Rental/[Price of new capital]
	<i>delB</i>	3	1	(Nominal balance of trade)/{nominal GDP}
	<i>finv3</i>	4	ENDOGINV	Shifter for longrun investment rule

Source: Author's elaboration

Note: The variables are exchanged between short and long term, observing the corresponding number of the variable (N. Var.)

⁸ This point will be detailed in Section 6.4.

4 DATABASE CONSTRUCTION

As highlighted in the previous chapter, the database is based on the 2015 MIP, with 127 commodities and 67 sectors. It should be noted that, at MIP, both the commodity and the sector, referring to wholesale and retail trade, encompass, in addition to general trade, the trade in motor vehicles, which is why these commodities and sectors are grouped, whilst in the National Accounts System⁹ (SCN) these are different commodities and sectors, thus the SCN has a size of 128 x 68.

It should be noted that in MIP there is an amount of R\$ 6,337 million related to the export of the imported commodity “Aircraft, vessels and other transport equipment” (Table 04 - MIP 2015¹⁰). As in *ORANI-G* there is no “*IMP*” dimension for export, this value was reallocated to the “*IMP*” dimension of the stock variation (*V6BAS*).

Considering that there is only one transportation margin commodity in *ORANI-G*, the transportation margin for the commodity “Waterway transportation” was redistributed to the transportation margin for the commodity “Inland cargo transportation”.

In MIP spreadsheets the investment is part of the final demand, therefore, it is a vector with a “*COM*” dimension. Considering that in *ORANI-G* this component has a “*COM x IND*” dimension, investment should be distributed across sectors. Generally, the way most widely used to make the distribution is by multiplying the share of gross operating surplus (EOB) of each sector in total EOB, according to the resources and uses tables¹¹ (TRU) “*VA*” spreadsheet.

However, in the present work it was decided to make this distribution respecting the investment value of the institutional sectors¹² (SI) according to the Integrated Economic Accounts (CEI). Thus, the investment share of each institutional sector in the total investment was calculated and was applied to the investment value by commodity of each MIP table (Tables 03 to 10). Afterwards, an adjustment was made with the redistribution of investment in

⁹ National Accounts System - Brazil - Reference 2010 - IBGE (2016).

¹⁰ MIP 2015 tables are available at: <https://www.ibge.gov.br/estatisticas/economicas/contas-nacionais/9085-matriz-de-insumo-produto.html?=&t=downloads>.

¹¹ TRU 2015 is available at: <https://www.ibge.gov.br/estatisticas/economicas/contas-nacionais/9052-sistema-de-contas-nacionais-brasil.html?edicao=17895&t=resultados>.

¹² IBGE defines the following institutional sectors: Non-financial companies (ENF), Financial companies (EF), General government (GOV), Non-profit institutions serving families and Families (FAM).

commodities in theory not consumed by families¹³, for other commodities consumed by households in proportion to the consumption of the commodity in the total household consumption. In order to maintain consistency between the lines (commodities) and columns (institutional sectors), the value added in a given commodity was subtracted from the other institutional sectors, proportionally to the share of the respective investment in the total of these sectors (ENF, EF and GOV). This entire procedure culminated in the generation of a “*COM x SP*” dimension matrix.

Finally, the institutional sectors ENF and FAM are added and distributed among the sectors of the MIP by the application of EOB share only from these sectors. The same procedure was done for the institutional sectors GOV and EF, with the application of the EOB share of the respective sectors of the MIP. As a result, the *V2BAS*, *V2MAR* (trade and transport) and *V2TAX* (domestic and imported) components of the database were generated, all with *COM x IND* dimensions.

The parameters used in the model, namely elasticity of substitution among workers (*SIGMA1LAB*), elasticity of substitution between primary factors (*SIGMA1PRIM*), elasticity of transformation (*SIGMA1OUT*), with *IND* dimension; Armington elasticities for intermediate consumption, investments and household consumption (*SIGMA1*, *SIGMA2*, *SIGMA3*, respectively), individual or collective exports indicator (*IsIndivExp*), export demands elasticities (*EXP_ELAST*), household expenditure elasticities (*EPS*) , with *COM* dimension; Frisch parameter (FRISCH), collective exports elasticities (*EXP_ELAST_N*), with unitary dimension; were obtained from the Center for Regional and Urban Economics at USP (NEREUS) , which has extensive experience in the use of general equilibrium models applied to the Brazilian economy .

¹³ Products considered not consumed by household investment, according to item 2.1.4 of Methodological Note nº 13 - IBGE (2015): 06801-Oil, natural gas and support services; 16001-Wood products, excluding furniture; 24912-Semi-finished, flat, long rolled and steel tubes; 25001-Metal products, excluding machinery and equipment; 26002-Office machines and computer equipment; 26003-Electronic material and communications equipment; 26004-Measurement, test and control, optical and electromedical equipment; 27001-Electric machines, apparatus and materials; 27002-Household appliances; 30001-Aircraft, vessels and other transport equipment; 31801-Furniture; 31802-Products of various industries; 33001-Maintenance, repair and installation of machinery and equipment; 62801-Development of systems and other information services; 71801-Research and development; 71802-Architectural and engineering services.

In addition to the sets already existing in *ORANI-G* database (Basedata.HAR¹⁴), the sets listed in Table 2 were created, below:

- **ISSP** - Products subject to excise tax - in the present work, only “Beverage” and Tobacco”. The others, as they are also not subject to IVA, are part of the set, but have a zero rate.
- **NONIVA** - Sectors not subject to IVA - to be used in case a sectoral IVA is instituted, in which this tax is treated based on the primary factors of the sectors, not used in the present work, but maintained for eventual need.
- **NCVAP** - Products not subject to CVA - commodities in which it does not make sense to establish a CVA (public, domestic and imputed rent sectors).
- **NONCPP** - Sectors not subject to CVA - to be used in case of establishing a sectoral CVA, in which this tax is treated based on sectors, not used in the present work, but maintained for possible needs.
- **TAXS** - indirect taxes / contributions - the item ISSP stands out, which includes both ISSP and IVA, since they are exclusive.
- **DTAX** - taxes levied on production - items “Other taxes on production” and “Other subsidies on production”, originating from the TRU’s “VA” spreadsheet. Contributions to the Sistema S (*SistS*) and Salário Educação (*SalEduc*), whose bases are equal to the wages, come from the sectoral data of the consolidated federal collection of the RFB. The other taxes (*OutDtax*) were obtained on a residual basis in relation to the total of the item.

Table 2 - New Basedata sets (*ORANI-G*)

<i>Set Name</i>	<i>ISSP</i>	<i>NONIVA</i>	<i>NCVAP</i>	<i>TAXS</i>	<i>NONCPP</i>	<i>DTAX</i>
Description	Products subject to ISSP	Sectors not subject to IVA	Products not subject to CVA	Indirect tax / contributions	Sectors not subject to CVA	Production tax
Dimension	9	7	6	5	4	3
1	<i>Bebidas</i>	<i>Bebidas</i>	<i>AlugImp</i>	<i>IPI</i>	<i>AdmPublica</i>	<i>SalEduc</i>
2	<i>Fumo</i>	<i>ProdFumo</i>	<i>SerAdmPub</i>	<i>ICMS</i>	<i>EducPublica</i>	<i>SistS</i>
3	<i>AlugImp</i>	<i>AdmPublica</i>	<i>ServPrevid</i>	<i>OutTaxSubs</i>	<i>SauPublica</i>	<i>OutDtax</i>
4	<i>SerAdmPub</i>	<i>EducPublica</i>	<i>EducPubl</i>	<i>ISSP</i>	<i>ServDomes</i>	
5	<i>ServPrevid</i>	<i>SauPublica</i>	<i>SaudPublica</i>	<i>CVA</i>		
6	<i>EducPubl</i>	<i>OrganAssos</i>	<i>ServDom</i>			
7	<i>SaudPublica</i>	<i>ServDomes</i>				
8	<i>OrgPatrSind</i>					
9	<i>ServDom</i>					

Source: Author’s elaboration

¹⁴ Database file used in the *ORANI-G* model.

Considering the objective of simulating changes in social security contributions of companies, especially the payroll tax, TRU's "VA" spreadsheet, heading "Previdência Oficial / FGTS" was spun off in the following lines, all with dimensions *IND* or *IND x OCC*¹⁵:

- *VIFGTS* (contribution to FGTS), available on the Caixa Econômica Federal (CEF) website under "Economy Sections" - CEF (2018). Correspondence was established between the sections of the economy (CEF) and the sectors of national accounts (SCN). In case the national accounts sector is more disaggregated, the FGTS of the corresponding sector in CEF was distributed proportionally to the salary of the national accounts sectors.
- *VICFPF* (social security contribution on wages) *VICPRB* (social security contribution on gross revenue) *VIRAT* (contribution work accident risks) *VICPSS* (employer's social security contribution of public server) *VIPASEP* (contribution to Pasep), *VICPSN* (Social Security Contribution of Simples Nacional), come from the sectoral data of the consolidated federal collection of the RFB, and *VICPOT* (social security contribution - others) obtained in a residual way in relation to the total of the item "Previdência Oficial / FGTS".

Thus, the *VILAB* field started to refer only to wages. The item *VINCPRB* (new social security contribution on gross revenue) was also created in order to cover the values of the new contribution on gross revenue, with uniform rate, as a result of a simulation in which both currently contributions levied on companies are replaced (*VICFPF* and *VICPRB*).

VIPPR (private pension plans) and *VICSI* (imputed social contribution) were also created with amounts taken directly from TRU's "VA" spreadsheet, whose bases are also salaries.

The base of the *VIFGTS*, *VICFPF*, *VIRAT*, *VICPSS*, *VIPPR*, and *VICSI* taxes is the salary (*VILAB*), while the base of *VICPRB*, *VIPASEP*, *VICPSN*, *VICPOT*, and *VINCPRB* is the total production value (*VITOT*).

In relation to capital, in order to simulate changes in the profit taxes, especially in the social contribution on net profit (CSLL), the item "Gross Operating Surplus - EOB" in the TRU's "VA" spreadsheet, is considered "proxy" of profit¹⁶, therefore, the basis of IRPJ

¹⁵ As there is only one occupation (*OCC* = 1), it makes no difference in the model.

¹⁶ The EOB refers to the return on capital, therefore, directly related to the profit of the companies, starting point of the real profit, base of the referred taxes.

(Corporate Income Tax) and CSLL, based on real profit, was broken down into the following items, all with *IND* dimension:

- *VIIRPJ_LR* (Corporate Income Tax - Real Profit¹⁷) and *VICSLL_LR* (Social Contribution on Net Profit - Real Profit), derived from sectoral data from the consolidated federal collection of RFB, whose bases considered are the EOB.
- *VIIRPJ_LP* (Corporate Income Tax - Presumed Profit) and *VICSLL_LP* (Social Contribution on Net Profit - Presumed Profit), *VIIRPJ_DR* (Corporate Income Tax - Other Income¹⁸) and *VICSLL_DR* (Social Contribution on Net Profit - Other Revenues), derived from sectoral data of the consolidated federal collection of RFB, whose bases considered are the total value of production (*VITOT*).

The item *VIRMB* (Mixed Gross Income) was created with amounts taken directly from the TRU's "VA" spreadsheet.

Finally, *VIIVA* and *VICVA* were created to be used in the case of establishing a sectoral IVA and / or CVA, not used in the present work¹⁹.

With regard to indirect taxes, MIP 2015 considers them in tables 05 (national) and 06 (imported), on a consolidated basis. In SCN 2015 (Resources and Uses Tables - TRU), Table 1, "oferta" spreadsheet, the "IPI", "ICMS" and "Other taxes less subsidies" (OISP) taxes, broken down by commodity, are available. Considering that in *ORANI-G* the indirect taxes are the same as those of the SCN, these taxes should be distributed in the economic sectors and components of the final demand, maintaining the equivalence with tables 05 and 06 of the MIP²⁰.

For this purpose, the proportion of domestic and imported shares was calculated (without considering II, which in *ORANI-G* is incorporated into the base value of imported commodities) per commodity, which was multiplied by the respective tax, thus generating a coefficient per source (*DOM/IMP*), tax, and commodity. This coefficient, which is the same for

¹⁷ The following are classified as revenue from taxable income (Real Profit): quarterly balance sheet, monthly estimate and adjustment statement.

¹⁸ The other revenue from IRPJ and CSLL refer to all collection from these taxes except real and presumed profits.

¹⁹ The value added tax treated in this work is treated based on the products.

²⁰ It should be noted that Table 06 of the MIP includes the Import Tax (II), which, in the *ORANI-G*, is incorporated in the base value of imported goods (*V1BAS* to *V5BAS* imported).

all sectors and components of final demand, is applied on tables 05 and 06. Thus, the taxes are distributed while maintaining the required equivalence mentioned above. The equations are:

$$TAX_{DOM\ c,i_df} = \frac{TAX_c}{T05_c + T06_c - II_c} * T05_{c,i_df},$$

$$TAX_{IMP\ c,i_df} = \frac{TAX_c}{T05_c + T06_c - II_c} * T06_{c,i_df} * \left(1 - \frac{II_c}{T06_c}\right),$$

$$II_{c,i_df} = \frac{II_c}{T06_c} * T06_{c,i_df},$$

Where, $TAX \in (IPI, ICMS, OutTaxSubs)$; $c \in COM$; $i \in IND$; df are the components of final demand; T05 and T06 are MIP's table and II import tax tables.

The OISP item includes several taxes and it is necessary to explain its components for calculating the shock to be applied in the simulations, which are restricted to the elimination of PIS, Cofins, and ISS only. Therefore, the following methodology was used: the collections of the various components of the OISP item derived from the sectoral data of the consolidated federal collection of the RFB, with the exception of ISS and ITBI, were distributed by commodity according to the coefficients of the *MAKE* matrix²¹, calculated over each sector (coefficients per commodity add up to one for each sector), generating a matrix ($COM \times IND$). The total value by commodity of this matrix is then distributed between national and imported according to the proportion of the commodity produced nationally and imported, obtained from Table 01 (MIP 2015). Subsequently, the distribution is made between the SCN sectors and components of the final demand according to the proportion of the tables “Table 03 - Supply and demand of national production at basic price - 2015”²², for the national production portion, and “Table 04 - Supply and demand for imported commodities at basic price - 2015”, for the import portion (MIP 2015).

Naturally, there is a difference between the total of the OISP item, as calculated according to the methodology described, and the total of the item under the MIP 2015. This difference is distributed among the taxes, commodities, sectors, components of the final demand, and destination proportionally to the participation of each tax in the composition of

²¹ *ORANI-G* production matrix.

²² This table is adjusted for margin products, excluding total margins. Furthermore, for government taxes (*V5TAX*) to be closer to the values of the original database (MIP), considering that the government produces public products and consumes all of these products, the coefficients in table 03, referring to the demand final component “Government consumption”, unitary in the case, were reallocated to the respective government sectors of intermediate consumption.

the respective OISP item (commodities, sectors, final demand and destination). In this way, consistency with the total of the item is maintained, as stated in the model database.

This item comprises the following taxes:

- Contribution to Social Security Financing - COFINS.
- Contribution to the Social Integration Program - PIS.
- Services Tax - ISS, of municipal competence, whose collection, obtained in RFB (2016), was allocated only to the predominant sectors in services.
- Tax on Financial Operations - IOF.
- Property Transfer Tax - ITBI, of municipal competence, whose collection, obtained in RFB (2016), was entirely allocated to the commodity “Buildings” in the component “Gross fixed capital formation” of the final demand, according to IBGE (2014).
- Contribution of Intervention in the Economic Domain - Fuels - CIDE-C, allocated only to the commodities " Gasoálcool " and "Diesel - Biodiesel"²³.
- Contribution of Intervention in the Economic Domain - Remittances Abroad - CIDE-R.
- Additional Freight for Renewal of the Merchant Navy - AFRMM, fully allocated to the commodity “Waterway transportation”.
- Contribution on Revenue from Predictive Competitions - CRCP, fully allocated to domestic sources.
- Contribution on Telecommunications Companies Revenue - CRET, allocated entirely to the commodity “Telecommunications, Pay TV and other related services”.
- Contribution on Revenue from Electric Energy Companies - CREEE, allocated entirely to the commodity "Electricity, gas and other utilities".

The simulated tax reform proposals provide for the maintenance of the current differentiated taxation model for micro and small businesses (Simples Nacional - SN), that is, companies opting for SN would have the option, if IVA is implemented, of remaining in the current regime based on gross revenue taxation. Therefore, there is a need to calculate the installments of the IPI, ICMS, ISS, PIS and Cofins taxes referring to the SN, which would be

²³ The other products susceptible to the incidence of CIDE-C, namely "Aviation fuels", "Naphtha for petrochemicals", "Fuel oil", "Other petroleum refining products" and "Ethanol and other biofuels", had zero rate in 2015.

maintained after the implementation of the IVA. The other taxes above that would not be involved in the tax reform proposal would also be maintained.

For the calculation of the SN portion referred to above, the following procedures were adopted:

- IPI_SN: RFB (2016) has the consolidated value of the total IPI (Table “T03”) and the IPI except SN (Table “INC03”), the difference of which results in the value of the IPI_SN. It was considered that the proportion of *DOM* and *IMP* of SN is the same as the total of the respective tax and respective destination (*VITAX*, *V2TAX* etc). Thus, the total SN tax is divided between destinations based on the *DOM / IMP* and *VKTAX* ratios (*K* from 1 to 5).
- ICMS_SN: Total collection of ICMS_SN available on the Simples Nacional website²⁴. The same procedure as above is adopted.
- ISS_SN: Total collection of ISS_SN available on the Simples Nacional website. This amount is distributed across sectors using the same proportion as the total ISS, that is, ISS_i / ISS_TOTAL , ($i = IND$).
- PIS_SN, Cofins_SN: Total collection of SN from sectoral data from the consolidated federal collection of RFB. The proportion between the total SN value by sector and the total SN value (VT_SN_i / VT_SN) is calculated. RFB (2016) has the consolidated value of the total PIS / Cofins (Table “T03”) and PIS / Cofins except SN (Table “INC03”), whose difference results in the value of PIS_SN and Cofins_SN. The calculated proportion is applied to these values. Thus, the sectoral proportions of PIS_SN, Cofins_SN and VT_SN are equivalent.

Based on the sectoral distribution above, the distribution by commodity, activities and components of final demand is made in the same way as described for the OISP item.

5 CHANGES IN THE ORANI-G CODE

This work uses the *ORANI-G* base EGC model, with the adaptations introduced by the technical team of the Foundation Institute for Economic Research - FIPE, made available by

²⁴ Available at <https://www8.receita.fazenda.gov.br/SimplesNacional/Arrecadacao/EstatisticasArrecadacao.aspx>.

the Center for Regional and Urban Economics at USP - NEREUS²⁵. This chapter contains the main changes in the *ORANI-G*'s TABLO file²⁶, resulting from the changes in BASEDATA, in order to allow the implementation of the proposed simulations. The rest of the program's excerpts have not undergone any notable changes and can be consulted in Horridge (2006).

Excerpt 5 - Coefficients of labor and capital

The labor coefficient, *VILABTOT*, comprises the salary (*VILAB*) and the taxes levied on the salary, while the capital coefficient, *VICAPTOT*, is composed of the mixed gross income, gross operating surplus and the taxes on real profit.

Excerpt 7 - Demand for work - Variables for calculating the portion related to the variation in the tax rates on wages and capital

The equations that calculate the change in total wages and capital prices include the portion due to the change in the rates of taxes levied on these bases. Differentiating these portions becomes important insofar as, for example, if there is a decrease in taxes on wages, companies have a decrease in the cost of the payroll (wages plus taxes), while families suffer the effect of only the portion of the wages received. The equation that calculates the real change in labor (by sector and occupation) is based on the change in total labor price.

Excerpt 8 - Primary factors

The main change in this excerpt is found in the equation for calculating the total variation in the cost of primary factors, with the inclusion of the portion referring to the variation in the rates of taxes levied on wages and capital. The equations for calculating changes in the real quantities of labor and capital takes into account the changes in total prices.

Excerpt 11 - Cost of production - Equations of tax variations on labor and capital

The total value of production now includes the portions of taxes on wages and capital that were included in the items of the TRU's "VA" spreadsheet, but were broken down, as they

²⁵ The main changes made by the Nereus team were: exclusion of the regional extension of the model; addition of dimension t (*TAXS*) in the set of indirect taxes (IPI, ICMS, Other Taxes on Products); addition of two more dimensions in the item "Taxes on production" (which in this work were used for contributions to Sistema S and Salário Educação).

²⁶ TABLO is the module of the GEMPACK program that translates the algebraic specification of an economic model into a form suitable for performing simulations with the model. The code referring to the changes made was not included in this work, therefore, for a better understanding, it is recommended to read this chapter with the support of Horridge (2006).

have a basis equal to the total value of production. The new social security contribution on gross revenue (*VINCPRB*) is also based on the total value of production.

The equations for the tax variations of the various taxes follow the pattern of the *ORANI-G* model, that is, the rate multiplied by the change in the base, added to the base multiplied by the change in the rate.

Excerpt 18 - Government demands and stocks - Government closures

In the original *ORANI-G*, there are two closures to the government. The level of government consumption is determined exogenously, or takes into account Constitutional Amendment Nº 95, which limited the variation of the government spending ceiling each year, to the value of inflation (IPCA - IBGE²⁷). Therefore, the variation in nominal government consumption, defined as the sum of real and price variations, must be equal to the IPCA. Consequently, the variation in real government consumption is limited to the difference between the IPCA and the government spending price index.

Excerpt 22 - Purchase prices - Inclusion of IVA / CVA

The imposition of a value added tax at each stage of production is equivalent to a tax on the final consumption of goods and services. Therefore, the components of final demand can be considered as IVA base. However, the export sector should be exempted from the tax, as a way to encourage exports. Furthermore, it would make no sense to tax government consumption, as this would mean that the government pays tribute to itself. Thus, it remains to use household consumption as the basis for IVA / CVA, which must be added to the margins, since they make up the final price of the commodity.

The purchase price equations for intermediate consumption and components of final demand, except household consumption, differ from that contained in Horridge (2006) only by the fact that the variable t (power of tax) has one more dimension (dimension *TAXS*), which requires adjustments in equations (furthermore, IVA and CVA are not levied on these bases). In the equations, as the term “ $V_kBAS * p0$ ” ($k = 1,2,4,5$, refers to intermediate consumption, investment, export and government consumption) it is repeated five times (once for each

²⁷ Broad National Consumer Price Index.

TAXS), the term “4 * $VkBAS$ ” appears with a negative value, to suit the right side of the equation. The following components are arrived at in these equations²⁸:

$$\begin{aligned}
 & [VkBAS + VkTAX_{IPI}] * [p0 + tk_{IPI}] + [VkBAS + VkTAX_{IPI}] * [p0 + tk_{IPI}] + \\
 & [VkBAS + VkTAX_{ICMS}] * [p0 + tk_{ICMS}] + [VkBAS + VkTAX_{ICMS}] * [p0 + tk_{ICMS}] + \\
 & [VkBAS + VkTAX_{OutTaxSubs}] * [p0 + tk_{OutTaxSubs}] + [VkBAS + VkTAX_{CVA}] * [p0 + tk_{CVA}] + \\
 & [VkBAS + VkTAX_{IVA}] * [p0 + tk_{IVA}] - 4 * VkBAS * p0 + VkMAR * (p0dom + akmar)
 \end{aligned}$$

In the case of household consumption, the purchase’s price equation is subdivided into three sub-equations: in the first, the same treatment applies, since it refers to commodities that do not incur CVA (imputed rent, public products and domestic services), nor IVA; the second, applies to commodities in which CVA is levied, but IVA is not levied (tobacco, beverages and employers' organizations, unions and other associative services); while the third equation applies to the other commodities (commodities that affect both CVA and IVA).

For the last two sub-equations, considering that the CVA / IVA base includes the margin, we have, for TAXS equal to CVA, the following terms:

$$\begin{aligned}
 V3TAX_{CVA} &= (V3BAS + V3MAR) * (T3_{CVA} - 1) \\
 delV3TAX_{CVA} &= V3BAS * T3_{CVA} * (x3 + p0 + t3_{CVA}) + V3MAR * T3_{CVA} * (x3mar + p0dom + t3_{CVA}) \\
 &- V3BAS * (x3 + p0) - V3MAR * (x3mar + p0dom)
 \end{aligned}$$

As $x3mar = x3 + a3mar$, $x3$ cancels with the left side of the equation²⁹. See that a negative term equal to “ $V3MAR * p0dom$ ” is generated, which is canceled with the positive term generated for TAXS equal to IPI, ICMS and OutTaxSubs. As $T3_{CVA} = (1 + aliquota_CVA)$, the following term is reached in the second equation ($TAXS = CVA$)³⁰:

$$[1 + aliquota_CVA] * [V3BAS * (p0 + t3_{CVA}) + V3MAR * (p0dom + t3_{CVA})].$$

For TAXS equal to IVA, the result is the same, however, two negative terms “ $V3MAR * p0dom$ ” (CVA and IVA) are generated, which results in the following terms in the third equation ($TAXS = IVA$ and CVA)³¹:

$$\begin{aligned}
 & [1 + aliquota_IVA] * [V3BAS * (p0 + t3_{CVA}) + V3MAR * (p0dom + t3_{CVA})] + \\
 & [1 + aliquota_CVA] * [V3BAS * (p0 + t3_{CVA}) + V3MAR * (p0dom + t3_{CVA})] - \\
 & V3MAR * (p0dom + a3mar).
 \end{aligned}$$

Excerpt 23 - Equations for tax variations - Dismemberment of the power of tax by impost

²⁸ Here, only the part referring to taxes is considered. For the purpose of deducting the formula, the remaining matrix dimensions involved (c, s) are ignored.

²⁹ As demonstrated in Horridge (2006), p. 36.

³⁰ The other terms ($TAXS = IPI, ICMS, OutTaxSubs, IVA$) do not change.

³¹ The other terms ($TAXS = IPI, ICMS, OutTaxSubs$) do not change.

For the IPI, ICMS, and OutTaxSubs tributes, the equations that represent the power of tax were broken down by impost.

Excerpt 24 - Update on commodity taxes

For the IPI, ICMS and OutTaxSubs tributes, the equations that represent the variations of the taxes were broken down by impost.

Excerpt 26.1 - Calculation of IVA / ISSP and CVA

The Selective Tax on Products is levied on the total value of production, therefore, its base, per commodity, corresponds to the sum of the base values of intermediate consumption and components of final demand. In this case, there are no exemptions for exports. Equations are also included for calculating the power of tax, as well as for changes in ISSP, IVA and CVA. These equations follow the pattern adopted in the *ORANI-G* model.

Excerpt 27 - GDP and factor income - Inclusion of the variation of rates in the calculation of the total variation of labor and capital / Calculation of the components of the total tax variation

In calculating the tax coefficients, the CVA, as it has a social security destination, is removed from the calculation of indirect taxes, which, in turn, includes taxes on profit, since they are part of the government's freely available revenues. The social security taxes, with specific destination, are consolidated in their own coefficient. Finally, a coefficient for the total of taxes is created, which includes, in addition to indirect and social security taxes, taxes on production, V1PASEP, V1FGTS, V1RAT, and V1CPSS, all with different specific destination and, therefore, not falling under the previous categories.

The necessary adjustments were made in the calculation of the GDP coefficient from the income side, to reflect the above changes, and the portion referring to the variation in the tax rates levied on these bases was included in the calculation of the total primary factors variations.

Finally, tax variations were broken down into the real and price components. The real part is an average of the real variations in the tax bases, weighted by the share of the respective taxes in the total of taxes. The price portion comes out by difference in relation to the total value of the variation. It is also calculated the fraction of the tax variation related to the variation in the tax rates levied on labor and capital, which were considered part of the total real component.

Excerpt 28 - Aggregates of GDP - Spending - Calculation of the variation in the public sector borrowing requirement

The public sector borrowing requirement (NFSP) can be obtained from the following formula³²:

$$NFSP = DCF(P.3) + FBCF(P.51) - ISPLIQ(D.2 - D.3) - VAB(B.1) + RE(D.1) - RPLIQ(D.4) - IRPLIQ(D.5) - CS(D.61) - OTC_{LIQ}(D.7) + BS(D.62) + AFFP(D.8) - TC_{LIQ}(D.9) + AFNP(NP),$$

Wherein:

DCF = Government final consumption expenditure;

FBCF = Investment;

ISPLIQ = Taxes, net of subsidies, on production and imports - net (everything the government receives from these taxes minus what it pays);

VAB = Gross government added value, corresponding to production minus intermediate consumption;

RE = Wages;

RPLIQ = Property income - net;

IRPLIQ = Current taxes on income, equity, etc. - net;

CS = Social contributions;

OTC_{LIQ} = Other current transfers - net;

BS = Social benefits, except social transfers in kind;

AFFP = Adjustment for changes in the net share of households in pension funds;

TC_{LIQ} = Capital transfers - net;

AFNP = Acquisitions less disposals of non-produced non-financial assets.

As it turns out, the first three terms of the equation above are available in the database and correspond to the difference between government consumption and investment expenditures, and indirect tax revenues. The other items have a balance of R\$ 41,818 million and correspond to only 9% of the NFSP of that year. We adopted the hypothesis that other items above vary according to GDP, so that it was possible, even in an approximate way, calculate the variation of NSFP in percentage of GDP along the same lines as the calculation of the variation in the trade nominal balance in relation to GDP, in excerpt 29.

Excerpt 30 - Aggregated primary factors

In the equations for calculating labor and capital prices (macro variables), one should consider, on the right side, the price with the inclusion of the variation in the tax rates on labor and capital. However, in the equation that deals with real wages, the value of the variation in

³² See "Sistema de Contas Nacionais – SCN – Tabelas / Contas econômicas, a preços correntes, segundo as contas, transações e saldos - Governo geral - 2000-2015", available at <https://www.ibge.gov.br/estatisticas/economicas/servicos/9052-sistema-de-contas-nacionais-brasil.html?edicao=17895&t=resultados>.

the tax rates on labor must be deducted from the variation in the total labor price, since, in Excerpt 32, in the equation for the labor price (here with dimension $IND \times OCC$), the value on the left side does not have the rates variation mentioned above.

Thus, in the case of standard closure, in which wages follow the consumer price index, the wages in question are those paid to families. The impact on the cost of companies is different, with the presence of variations in the rates mentioned above.

Finally, the portions referring to the variations in the rates are calculated.

Excerpt 31 - Investment equations

The equation for calculating the gross rate of return on capital includes the effect of changes in tax rates on capital, as this portion interferes with the return on capital.

Excerpt 33 - Miscellaneous equations (families closures)

In the simulations carried out, there is the option of linking the real consumption of families to the real income from the production factors. In this case, f_{3tot} is exogenous.

Excerpt 36 - Decomposition of GDP

The changes in excerpt 36 aim to adapt the calculation of the variation in real GDP from the income perspective.

6 SIMULATIONS AND ANALYSIS OF RESULTS

The standard simulations seek to implement changes, a priori, the revenue collection neutral point of view. However, as a result of changes in prices and quantities, the real collection changes. Thus, alternative simulations were also implemented, maintaining the real collection level.

The summary of the simulations is presented below:

Macro Simulation³³ 1.1: Full replacement of social security contribution on payroll and the social security contribution on gross revenue with new social security contribution on gross revenue (NCPRB), with single sectoral rate, endogenous.

³³ So called the sets of two simulations, one short-term and one long-term (except for Macro Simulation 4.2 where they are all long-term), as shown in Table 3.

Macro Simulation 1.2: Full replacement of the social security contribution on the payroll and social security contribution on gross revenue with value added contribution (CVA), with single sectoral rate, endogenous.

Macro Simulation 2.1: Replacement of IPI, PIS, Cofins, ICMS and ISS, except for a portion corresponding to Simples Nacional, for a value added tax (IVA), with a single sectoral rate, endogenous - in the case of “Beverages” and “Tobacco” is substituted by a selective commodity tax (ISSP), with an endogenous rate sufficient to generate the same level of collection in the respective sectors.

Macro Simulation 3.2: Joint simulation of Macro Simulations 1.2 and 2.1.

Macro Simulation 4.2: Joint simulation of Macro Simulations 1.2 and 2.1 (long term only). For the third simulation, was include the withdrawal of CSLL, along with contributions to Salário Educação and the Sistema S.

As for shocks, the values of the replaced taxes are as follows:

- CPF and CPRB: R\$ 166,770 million;
- IPI / PIS / Cofins / ICMS / ISS, except for the portion of Simples Nacional: R\$ 698,780 million;
- IPI / PIS / Cofins / ICMS / ISS, except for the portion of Simples Nacional - commodity "Beverages": R\$ 16,118 million; commodity “Tobacco”: R\$ 10,092 million.

The Figure 4 (Appendix II) shows the causal relationship underlying the proposed simulations. There are two channels of transmission of shocks, the first via the cost of companies, and the other one via demand from families. In the case of the replacement of CPF and CPRB by NCPRB, in place of the second transmission channel, there is a second cost channel for companies, that is, in the first there is a decrease in costs over the primary factors, but in the second there is an increase in the costs of indirect taxes on production.

It should also be considered that there is sectoral tax reallocation due to the IVA / CVA rates, or the NCPRB, being unique for all sectors. As it turns out, there are opposite effects on prices in each channel of transmission of shocks, a fact that justifies the relevance of using the CGE model to calculate economic-tax impacts, especially at the sectoral level.

The Table 3, below, shows the closures for the government and for families with the coded identification of performed simulations³⁴, referring to each Macro Simulation.

³⁴ As they are identified in the result tables.

Table 3 - Simulations performed

Closure	SR/LR	Government (*1)	Families (*2)	Macro Simulations (*3)				
				1.1	1.2	2.1	3.2	4.2
1	SR	EC nº 95/2016 [p3tot-p5tot]	Renda fatores real	020	220	420	820	
2	LR	EC nº 95/2016 [p3tot-p5tot]	-	105	305	505	905	915
3	LR	EC nº 95/2016 [p3tot-p5tot]	Renda fatores real					975
4	LR	EC nº 95/2016 [p3tot-p5tot]	Renda fatores real					985

Source: Author's elaboration

(*1) - Real government consumption follows the public spending ceiling (EC nº 95/2016).

(*2) - Real household consumption follows the real factor income. In the long run, household consumption is endogenous. The restriction is imposed on the trade balance, except for simulations 975 and 985, in which the real consumption of households goes back to accompanying the real income of the factors.

(*3) - Shocks: standard simulations: nominal CVA / VAT collections equal to the collection of substituted taxes.

sim915: real social security / tax collection <-> nominal collections CVA / IVA.

sim975: real social security collection <-> nominal collection CVA |

NFSP variation <-> nominal IVA collection.

sim985: the same as sim975 + elimination of CSLL, SE and SS.

6.1 Macro Simulations 1.1 and 1.2 - Full replacement of employer's social security contributions³⁵

In the first two Macro Simulations the aim is to assess the impact of replacing employer's social security contributions, represented by CFPF and CPRB, by a new social security contribution on gross revenue, or by a value added contribution (such as IVA), both with uniform rate for all the economic sectors. According to Table 3 two closures are proposed for each Macro Simulation.

For the first closure of Macro Simulation 1.1 (sim020 - short term) there is a decrease in the average nominal wage (labor cost) paid by companies³⁶ of 9.31%, which, together with the significant drop of 5.52 % in the return on capital, impacts the price of the primary factor by -7,49%. The decrease in labor cost is by cause of the fact that this variable is made up of two installments: the first linked to the consumer price index, which decreases 3,52% and the

³⁵ In the analyzes that follow, considering space limitations, only the main results are presented, referring to all simulations, which are found in tables 5 to 8 (Appendix I), especially in Table 7, which presents the main macro variables. Tables 4 and 9, also in Appendix I, are restricted to certain simulations.

³⁶ As seen in Sections 5.2 and 5.12, there is a difference between the cost of the labor factor paid to families and the total cost of this factor borne by the companies. In the second case, they include employer's social security contributions and other taxes on wages.

second, related to the variation in the tax rates levied on the payroll³⁷, also negative, due to the elimination of CPF.

Thus, the real wage paid by companies suffers drop in average of 6%, which, in principle, should stimulate hiring relatively more in labor-intensive sectors, since it has greater impact on wage fall. However, this did not occur in the simulation 020 as shown in Table 4, which presents the correlation index³⁸ between some variables. It appears that the correlation between the participation of work in the use of primary factors and the level of employment was weak and negative, in the order of 0,36 ($p < 0.01$). Furthermore, there is no correlation between labor participation in the use of primary factors and the value of production.

Considering that the wages paid by companies experience a greater fall the greater the labor charges on the payroll³⁹ supported by the sector, it is expected higher increase in employment in the sectors most benefited by the exemption, however, the correlation, although positive, between labor costs and the level of employment in the sector was negligible and not significant for the short-term simulation.

Making a little digression, in agreement with Salanié (2011), in the analysis of tax incidence in the framework of general equilibrium there are two categories of effects in the imposition of primary factors taxes. The first one is the volume effect, which acts through the relative demand for goods across sectors and that depends on the demand elasticities. The second one is the substitution effect, which acts through the relative factor demands and which depends on the substitution elasticities between factors.

So, in case of reduction of taxes on labor the substitution effect occurs with the decrease in the use of capital factor, for a given level of production, which will be so much more intensive the much higher the relative labor intensity⁴⁰. But there is also a change in the relative prices of

³⁷ This portion (*rt1lab*) is the same for all simulations that involve the elimination of the CPF, as it only depends on the starting salary and the variation of the CPF rate, which is the same, sectorally, independent of the simulation (in the simulations involving the CPF). The average value of *rt1lab* is -6%, which means that the average real wage paid by companies falls by 6%, while the real wage received by families does not change. It should be noted that the real wage, whenever mentioned in this way in the text, refers to the real wage received by families.

³⁸ The correlation indices were classified as follows: [0 to 0.2 [- negligible; [0.2 to 0.4 [- weak; [0.4 to 0.7 [- moderate; [0.7 to 0.9 [- strong; [0.9 - 1 [- very strong.

³⁹ Defined as $V1CPF(i) / V1LAB(i)$. The charge referring only to the CPF is used, which was the tax excluded.

⁴⁰ Defined in Salanié (2011) as the ratio between the amount of labor in the sector and the amount of total labor, so that the sum of all relative labor intensities is equal to one. The same goes for the relative capital intensity.

sectors that depends on the relative labor intensity in all sectors, which, in turn, affects the demand for goods (volume effect) and thus the factor demands again.

Thus, when taxes on labor are reduced different effects occur depending on the relative factor intensities. In labor-intensive sectors, relative labor income always increases, as the substitution and volume effects act in the same direction. The decrease in the relative prices of the labor-intensive sectors causes an increase in demand in these sectors (volume effect), which, in turn, contributes to the increase in demand due to the factor in which the sector is more intensive, in this case, labor (substitution effect).

In capital-intensive sectors the result depends on the intensity of the substitution and volume effects, which in turn depend on the demand and substitution elasticities between factors. If the volume effect, which acts by decreasing the demand for goods in the sector, exceeds the substitution effect, there will be a decrease in labor demand and, hence, in the relative labor income, and vice versa.

It is important to highlight that this theoretical analysis applies to the effects of the imposition of taxes on a specific sector, which can be labor or capital intensive. It happens that, in the real case treated here, the tax change occurs in all sectors. Consider also that the CPF rates, which are based on effective collection data and, in theory, should be approximately equal, are very different across sectors⁴¹, in addition, there is no correlation between this variable and labor participation in the use of primary factors⁴².

Therefore, this characteristic of the data, associated with the fact that the volume and substitution effects, described above, can act in any direction, makes it difficult to establish correlations between variables. Hence, the advantage of using a computable general equilibrium model.

Returning to the analysis of the results, although the total investment, in the short term is fixed, can vary by sector in the companies where it is endogenously treated. Considering that the sectoral capital stock is fixed in the short term the gross growth rate of capital accompanies the sectoral investment. The gross growth rate of capital, in turn, is proportional to the difference between the gross rate of return on capital and the basic rate of return of the economy. Since the gross rate of return on capital is equivalent to the difference between the return on

⁴¹ The CPF base rate is 20% levied on companies' payroll.

⁴² Not even with the variable relative labor intensity (see Note 40).

capital⁴³ and the price of a new capital unit, the lower the return on capital, the lower the investment.

It should be added that, with the fixed capital stock by sector, the demand for labor is directly proportional to the difference between the cost of capital and the cost of labor. As this has a significant drop caused by the exemption from payroll, there is an incentive to use labor, that is, capital becomes more costly than labor resulting in a lower investment value. The correlation coefficients between employment levels and the difference between the cost of capital and labor costs, as well as between the share of labor in the use of primary factors or labor charges, and the investment, shown in Table 4, corroborate this analysis.

The Table 4 shows also the negative correlation, moderate and statistically significant ($-0.61, p < 0.01$), between the labor participation in the primary factors use and the total taxes supported by producers and investors. In this respect, as expected, the sectors with the greatest tax reduction were the most labor intensive.

Real GDP has growth of 1,18%, despite the decline in nominal GDP of 3,09%, due to the further decline of 4,21% in the GDP price index. The level of employment increases by 2,32%. Real government consumption increases 0.42%, a consequence of the positive difference between the consumer price index and the government price index, which allows the government to consume more without disrespecting the public spending ceiling. The NCPRB rate, which is neutral from a nominal point of view, is 1.91%, levied on the total turnover of companies. From the fiscal point of view the public sector borrowing requirement falls 0,31 percentage point of GDP.

From the perspective of expenditure, a real currency devaluation of 4.40% occurs, stimulating exports, which grow 1.68% in volume, while imports decrease 0.78%. In spite of this, the trade balance shows a slight deterioration, equivalent to 0.04 percentage point of GDP, considering that the price effect, which was negative, outweighed the quantity effect, positive. The real consumption of families, which in the short-term closure accompanies the real income of the factors, grows 1,19%, reflecting the increase in the use of primary factors. Tables 5 and 6 present the contributions to the GDP considering the expenditure and income, respectively. Household consumption accounts for the most significant share in the composition of GDP.

⁴³ The return on capital must be at least equal to the cost of capital, in order to create value for the company. Cost of capital can be defined as the minimum return on a certain capital raised so that the value of the shares (or market value of equity) remains the same.

In the second closure of Macro Simulation 1.1 (sim105 - long term), with fixed employment, there is a fall in real GDP of 0,32%, nominal GDP growth of 6.93%, while real wages increase 4.26%⁴⁴, with an impact on the nominal wage paid by companies, which rises 4.03%. Real household consumption increased by 1.69% with emphasis on the nominal consumption of luxury goods by households, which increased significantly by 10.64%, well above the consumer price index, which was 6.16%. Investment and capital stock fell by 1.00%, while the cost of capital increased by 5.13%.

The expected positive correlation between the labor costs and the level of sector employment, which was negligible and not significant in the short term, now appears in the long-term simulation indicating a weak correlation (0.36), however, with a significance level of 1%, as shown in Table 4.

In the long run, the gross rate of return on capital is exogenous and equal to zero, which makes the return on capital equal to the price of a new unit of capital. With the rate of return of the economy also exogenous, and a variation equal to zero, for companies in which investment is treated endogenously the gross growth rate of capital also does not change. Thus, investment and capital stock are equal, that is, the investment follows the capital stock⁴⁵, which, in turn, is proportional to the actual use of primary factors, as well as the difference between the price of primary factors and the price of capital. Therefore, also in the long run, the greater the participation of labor in the use of primary factors, the lower (or greater the drop in) the price of primary factors and, consequently, the lower the investment in the sector (see Table 4⁴⁶).

The increase in real wages due to the level of employment being fixed in the long run, associated with the maintenance of the cost of the employer's social security contribution⁴⁷, leads to an increase in total costs for companies and, consequently, a general increase in prices. The real government consumption drops 2.18%, as the situation is reversed with respect to the short term, and the government's price index becomes higher than the consumer price index,

⁴⁴ In order to obtain the real wage paid by the firms, one must add the portion referring to the variation of the CPFP rates (which is negative and equal, on average to 6%, although different between sectors, for all simulations involving relief companies' payroll). Thus, in the case in question, the real wages paid by firms, on average, fell by 0.55%.

⁴⁵ Capital adjusts to keep the gross rate of return on capital fixed.

⁴⁶ The correlation between *Sht* and *x2tot* was weak, but significant at 1%.

⁴⁷ There is only a shift from a cost associated with the use of the labor factor (CPFP), to a cost on gross revenue (NCPRB). The maintenance of this cost does not occur in the same intensity in each sector, since, because the NCPRB has a single rate, reallocations between sectors occur.

which imposes restrictions on government spending. The impact of real wages on the cost of public sectors, as they are labor intensive, and are not influenced by the payroll tax exemption, causes an increase in the government price index in an amount higher than the consumer price index.

Considering that the shock applied in the NCPRB was the equivalent to maintain the level of nominal collection of the CPFPP plus CPRB (R\$ 166,770 million), coupled with the aforementioned price increase, it appears that the real social security revenue fell by 5,08%, with the NCPRB rate standing at 1.76% (a decrease of approximately 8% compared to the short-term simulation).

The real exchange rate appreciates by 6.78%, due to the significant increase in the GDP price index (7.27%), which is decisive for the 3.08% drop in real exports and the increase in real imports at 2.91%. Despite this, the change in the trade balance as a percentage of GDP remains unchanged, as a result of the significant increase in nominal GDP (6.93%). The public sector borrowing requirement declines by 0.08 percentage points, dropping to 7.67% of GDP.

When analyzing Macro Simulation 1.2, in the short term it appears that the price variables, in conjunction with the nominal variables, present absolute values lower than those of Macro Simulation 1.1. This is because, in the short term, when a tax on the payroll or on the companies' gross revenue is replaced by another on the value added, supported solely by household consumption, the consumer price index tends to increase since the tax incidence on families increases. As, in the adopted model, the wage paid by companies depends on the consumer price index and the portion related to the variation of the CPFPP rate, the wage paid by companies is higher (or does not fall so much) than that paid in Macro Simulation 1.1. As a result, the cost of companies is higher reflecting in the other price indices in the economy.

In the long run, with the possibility of wages adjusting, the decrease in the cost of companies, as a result of the removal of payroll taxes, causes a drop in product prices, reflecting in the consumer price index, which remains lower than in Macro Simulation 1.1, as well as in other economy price indices.

Regarding the main correlations of Macro Simulation 1.2 (Table 4) the same interpretations of Macro Simulation 1.1 are valid, with the reservation that the negative correlation between the labor participation in the primary factors uses and the price of primary factors disappears in the long run, as well as with investment. However, the negative correlation

between labor charges and investment, also in the long run, becomes moderate and significant at 1%.

In this Macro Simulation the positive correlation between labor charges and the sector's employment level is more evident. For the short term the intensity of the correlation is weak, but significant at 5%. However, in the long run, the intensity is strong also with a significance level of 5%. This is probably by cause of the fact that here there was really a reduction in labor charges for companies, whereas in Macro Simulation 1.1 what happens is a shift in cost associated with the use of primary factors for a cost over the total value of production with different effects on each sector, depending on the reallocation of the employer's social security contribution.

For the first close (sim220 – short-term) real household consumption grew by 1.34% a figure very close to that found in the corresponding previous simulation. The consumer price index increases by 2.44%. The highlight is the increase of 1.45% in real government consumption, which leads to an increase in real GDP and employment of 1.35% and 2.63%, respectively. The CVA rate is 5.70% levied on the value added. Tables 5 and 6 show the contributions to GDP from the perspective of expenditure and income, respectively.

The highlight of the second closure of Macro Simulation 1.2 (sim305 – long-term) goes to real GDP, which, although it presents a decrease in relation to short term simulations, increases by 0.38%, compared to a decrease of 0.32% in the equivalent Macro Simulation 1.1. However, with regard to household consumption, still in comparison with the previous Macro Simulation, what is noticeable is that there is a significant drop. Thus, there is a sharp decrease in the share of household consumption in the composition of the GDP⁴⁸ attenuated by the slight increase in investment and the not too high fall in the components of the external sector, which contributes to keeping the real GDP positive.

Unlike what happened in the long-term simulation of Macro Simulation 1.1, here, the increase in real wages, of 4.32%, did not cause a generalized increase in prices but only in some prices, even so, in values lower than that simulation. As a consequence, it turns out that the real social security revenue fell by 1.55%, compared to a fall of 5.08% in that simulation with the CVA rate equal to 5.71%.

⁴⁸ It is important to point out that, in the long run, with government consumption and the trade balance fixed, and investment moving together with the capital stock, household consumption is determined on a residual basis in the composition of GDP.

The real exchange rate appreciates by 2.08%, a rate much lower than that observed in the previous simulation. As a result, real exports, although decreasing in relation to the short term still maintain an increase of 1.01%, while imports fall by 0.39% keeping the trade deficit constant. The public sector borrowing requirement increases by 0.47 percentage point, rising to 8.22% of GDP. The capital stock and investment, which go together, increased by 0.80% and 0.85%, respectively.

Real government consumption drops 1.03%. Thus, the government contributes negatively to the composition of GDP (-0.21%), positively offset by the participation of the external sector, with exports increasing 1.01% and imports decreasing 0.39% as shown in Table 5.

Table 8 presents the results of the main variables, for long-term simulations⁴⁹, grouped by macro economic sector⁵⁰. In the simulation involving the adoption of the NCPRB the value of production falls in all sectors except for the tertiary sector. The capital stock also decreases with the exception of the government. Costs, labor, and production are rising. The primary and government sectors experience more pronounced job losses, reallocated, mainly to the tertiary sector. Note that the tertiary sector is the least affected by the change.

It appears that the results are better for the simulation that involves CVA's implementation. With the exception of the government the cost of production decrease, the capital stock and production increases. As for the level of employment, the primary sector and the government have losses, with the reallocation of labor to the tertiary and, mainly, secondary sectors.

Regarding taxes, two variables were created to measure the tax variation. The first one, *vstaxtot*, considers indirect taxes borne by producers and investors, along with other taxes and sectoral contributions including income and social contribution taxes. The second one, *v0taxtot*, covers all taxes on the economy including PPR and CSI. In this case, the taxes on families, government, and exporters, as they have a "commodity" dimension, were consolidated by sector through the aggregation matrix⁵¹. In this way, one can compare the direct effect on the

⁴⁹ It was decided to show only long-term results, as these are the definitive results after the tax change.

⁵⁰ Primary, Secondary, Tertiary and Government sectors.

⁵¹ The aggregation matrix for the domestic source was prepared based on the *MAKE* matrix. It is a matrix of coefficients, the sum of which, for each commodity (across sectors) is equal to one. In the case of the imported source, a matrix was created with the same characteristics, but

sector (first case), with the total effect (second case), when the impact of tax changes on family and government consumption, as well as on exporters, is incorporated.

Table 8 shows that, for the NCPRB simulation, there is an increase in taxes for all sectors in both measures especially for the primary sector. The tertiary sector has the smallest increase. As for the CVA there are intense direct sectoral falls, with the exception of the government, which does not suffer tax relief, as it does not contribute to the CPFP and CPRB. When considering the total tax values there is a more pronounced increase in the primary sector. The tertiary sector remains the most benefited.

The negative results presented by the long-term simulation involving NCPRB, especially regarding GDP, investment, and exports, are in line with the general understanding that taxes on gross revenues have a distorting effect on the economy.

6.2 Macro Simulation 2.1 - Value added tax

In this block of simulations the main tax reform proposal currently under discussion in the National Congress is evaluated, which deals with the replacement of the PIS, Cofins, IPI, ICMS and ISS taxes by an added value tax. The imposition of a tax on companies' value added, pure, is equivalent to the imposition of a tax on the components of final demand. Considering that investors and exporters should be exempted from these taxes with a view to economic development, and that it does not make sense to institute a government consumption tax, the tax base of such a tax falls only on household final consumption. It is worth noting that, for the commodities "Beverages" and "Tobacco", the ISSP was instituted, with no IVA incidence, maintaining the nominal collection of the substituted taxes.

In the short term (sim420) the transfer of indirect taxes currently supported by intermediate consumption to household consumption leads to an increase in the consumer price index of 12.89%. As the real wage is fixed this price increase is passed on to wages increasing the cost of companies' primary factors, however, even so, there is a slight increase in the real use of these factors and, consequently, in the real consumption of families (0,11%), since these are variables with joint movement depending on the option of simulation closure. The government's real consumption grows 3.07% being decisive for the performance of real GDP, which rises 0.21%, the same increase in the level of employment.

based on the import of the products. For both matrices, post simulation values were used in the construction.

The withdrawal of taxes on goods and services, especially in the case of producers, leads to a decrease in the commodities prices reflecting on the intermediate consumption production cost, which is reduced. However, as seen, the cost of primary factors increases, and the influence on production's cost for each sector is variable and can be positive or negative.

However, in the long run (sim505), with the removal of taxes on intermediate consumption and on the components of final demand (except households), basic product prices fall much more sharply. In the case of households, as they fully support IVA, the consumer price index (-5.12%) falls below the nominal wage paid by companies⁵² (-7.54%) reflecting a fall in real wages of 2.55%.

Therefore, with the prices associated with production falling significantly, the same occurs with the investment price and, consequently, with the capital price, since they are linked, leading to an increase in investment and capital stock, which, together with the increases in real government consumption and exports lead to an increase in real GDP, which grows 1.75%. Furthermore, as the fall in the price of capital is greater than the fall in the price of primary factors, the increase in the stock of capital and investment is greater than that observed for primary factors use. However, considering the restriction on the trade balance the only component of GDP that needs to adjust is household consumption⁵³, which falls 4.34%.

The IVA rate necessary to maintain the same level of collection of taxes on eliminated goods and services is 31.42%. As a result of the sharp drop in prices real tax revenue grew 14.86% contributing to the 0.53 percentage point drop in the public sector borrowing requirement. Regarding selective taxes, the rates, levied on the value of production, necessary to maintain the nominal collection of the beverage and tobacco sectors, are 20.91% and 59.74%, respectively.

Table 5 shows, in the long-term simulation, the important participation of the external sector in the composition of GDP reflecting the strong devaluation of the currency (12.12%) together with government consumption. Household consumption contributes strongly and negatively to the composition of GDP. The drop in household consumption is also reflected in the drop in the share of indirect taxes in the composition of GDP from the income perspective.

⁵² Remember that in this Macro Simulation there is no component of variation of payroll tax rates.

⁵³ Obtained residually in the long run.

As shown in Table 8, in simulation 505, the increase in government spending makes the difference causing the sector to present numbers of production, employment, and capital stock well above the others.

With regard to taxes, there is a big sectoral drop, slowed down when considering the totality of taxes. The most benefited sector is the secondary, while the primary and tertiary sectors are the least benefited, but, while the first presents a small nominal decrease in taxes, the second reaches a small increase in total taxes⁵⁴.

6.3 Macro Simulation 3.2 - Value added tax associated with value added contribution

This section evaluates the implementation of the value added tax associated with the value added contribution. It was decided to carry out this joint simulation of IVA only with the CVA, because, when comparing this contribution with the NCPRB (Section 6.1) the CVA obtained better economic results in isolation.

The results are approximately equal to the percentage aggregation of Macro Simulations 1.2 and 2.1 except for the variables of tax revenues. The long-term IVA rate (sim905) is set at 31.65%, and the CVA rate at 7.14%, the latter significantly higher than that of the corresponding simulation in Macro Simulation 1.2⁵⁵, since here, the basis of CVA falls. Therefore, the total IVA rate added to that of the CVA would be 38.79%. The increase in real tax collection, of 15.82%, contributes to the approximately stable public sector borrowing requirement. Real GDP is up 2.05% with real government spending increasing by 6.32%. The ISSP rates for the beverage and tobacco commodities are 21.18% and 60.26%, respectively.

According to Tables 5 and 6, which show the contributions to GDP from the perspective of expenditure and income, in comparison with Macro Simulation 2.1, household consumption, investment, and exports, present superior performances, which contributes to the better performance of GDP.

With respect to Table 8, the analyzes are similar to those of Macro Simulation 2.1. As for the increase in the capital stock, in addition to the primary and secondary sectors, the government also stands out. With regard to taxes, there is a big sectoral drop slowed down when

⁵⁴ It should be noted that in all tables of this type, it should be considered that the variations in taxes are nominal and, therefore, one cannot compare the results, with regard to tax variations, with those of other Macro Simulations. The aim here is to compare the sectorial results of the same simulation.

⁵⁵ Simulation 305 - CVA rate equal to 5.71%.

considering the totality of taxes. The most benefited sector is the secondary sector, while the tertiary and primary sectors increased by 2.26% and 8.32%, respectively.

6.4 Macro Simulation 4.2 - Value added tax associated with value added contribution - Alternative closures and elimination of other taxes

This section evaluates, in the first three simulations, alternative long-term closures to those used in the previous section, together with, in the last simulation, also long-term, the elimination of the CSLL and the contributions from Salário Educação and Sistema S.

As can be seen in Macro Simulation 3.2, in the long-term simulation there is a large positive variation in real tax revenue both social security and non-social security by cause of the high price drop that occurred. This is due to the shock implemented in the IVA and CVA values to maintain the nominal collection of the eliminated taxes. In that situation, IVA and CVA rates were high, compared to world standards⁵⁶.

Therefore, as alternative closures, only in the long run, simulations were carried out keeping the real collection, instead of the nominal, considering the total values of IVA and CVA as endogenous variables.

Thus, for simulation 915, the rates required to maintain the real, tax and social security collection, was 25.81% for IVA and 6.30% for CVA. The ISSP for the beverage commodity is 22.14%, and 63.43% for the tobacco commodity. As seen in Table 5, in simulation 915, the contribution of government consumption remains positive despite the drop in tax collection, but it decreases considerably, with a 0.56 percentage point drop in the share of GDP. Thus, real GDP continues to show a positive variation of 1.75%, but in a lower value than that presented in the corresponding simulation of Macro Simulation 3.2.

With the decrease in IVA / CVA, still in comparison with the previous Macro Simulation, the consumer price index declines more intensely, reflecting on the real wage, which increases 3.49%. The negative point occurs with the public sector borrowing requirement, which increases 1.76 percentage points of GDP.

As previously mentioned, household consumption decreases as a result of the long-term closure of the model, in which the trade balance as a fraction of GDP remains fixed. According to Horridge (2006), the idea is that, in the long run, the rest of the world may be reluctant to finance a growing trade deficit.

⁵⁶ See for example Orair and Gobetti (2019).

However, the idea that household consumption follows the real factor income is also valid for the long term⁵⁷. Thus, in the second long-term closure of this section it was decided to relax the restriction on the trade balance keeping household consumption tied to the real income of primary factors. Additionally, considering the pressing issue of fiscal adjustment faced by the country, instead of restricting the increase in real tax revenue, it was decided to fix the public sector borrowing requirement as a fraction of GDP. Although this does not guarantee the sustainability of the public debt the idea here is that it does not occur the same as in simulation 915 in which there was an increase in this variable.

Furthermore, 2015 can be considered an atypical year. It was a recessionary year, with real GDP falling 3.5% the biggest drop in the last twenty years. The need for public sector financing, although it decreased in relation to 2014, still represented an expressive value in relation to GDP. Currently, its value is already at a level equivalent to approximately half of that presented that year. The real social security revenue was kept fixed, as a way to maintain the financial balance of the social security system.

In this simulation (sim975) there is a real increase in tax revenue of 11.93%, with the IVA rate being set at 26.39%, and the CVA rate at 5.89%, totaling 32.28%. The ISSP stands at 17.73% and 49.95% for the beverage and tobacco commodities, respectively. To respect the limit established by EC n° 95/2016, the government must decrease real consumption by 0.61%. The real wage increases 10.78% the consumer price index 6.59% with an impact on the use of primary factors. However, due to the drop in the cost of intermediate consumption, the total cost of companies remains practically unchanged. The capital stock and investment increased significantly by 12.97% and 13.65%, respectively. Real household consumption increases by 5.94% almost the same rate of increase in real GDP, which was 6.01%. As expected, the deficit in the trade balance increases by 0.84 percentage point of GDP, which raises the deficit to 2.10% of GDP.

It should be noted that the concept of trade balance in *ORANI-G* refers to the trade balance and non-factor services. It is known that Brazil has a recurring negative balance in the factor services' balance⁵⁸, which would further contribute to increase the above deficit.

⁵⁷ See, for example, Gomes (2004), whose results suggest that the consumption time series in Brazil is best explained when considering an agent who follows the pocket rule of consuming his current income, possibly by cause of the lack of access to credit.

⁵⁸ In 2015 the deficit in this item was 1.96% of GDP.

However, according to Nonnenberg and Mendonça (2005), who analyzed a sample of 38 developing countries, for the period 1975 to 2000, to estimate the determinants of foreign direct investments, it was evident that both the size of the economy, measured by GDP, and the average growth rate of previous years, positively affect the inflow of FDI and are strongly significant.

Furthermore, Ribeiro (2016, p. 31) analyzes the external vulnerability of the Brazilian economy in this century, and concludes that:

[...] the country is today in a reasonably comfortable situation with regard to external vulnerability, especially due to the accumulation of a large volume of international reserves and a more favorable profile of external financing, which occurred mainly in the form of foreign direct investments.

Therefore, it is reasonable to assume that the deficit in the trade balance can be offset by the entry of FDI, in an environment of strong GDP growth, as observed in simulation 975. In addition, one must consider the good condition of the Brazilian economy regarding external vulnerability.

Simulation 985 follows the same characteristics as simulation 975 it only adds the elimination of CSLL and contributions from Salário Educação and Sistema S. The results of the main macroeconomic variables improve even more compared to simulation 975. However, government consumption falls 1.10%, just as the trade balance has slightly worsened, compared to the previous simulation, with a fall of 0.93 percentage point of GDP, which raises the deficit to 2.19% of GDP.

According to Tables 5 and 6 it can be seen for simulations 975 and 985 that household consumption becomes the preponderant factor in the composition of GDP followed by investment, which presents a significant increase. The external sector loses participation in the composition of the GDP. By virtue of the increase in internal absorption, exports fall, and imports increase. Indirect taxes, in the last two simulations, have an important share in GDP from the income perspective reflecting the increase in household consumption.

In Table 8, for simulation 915, the increase in government spending improves the performance of this sector with the tertiary sector becoming the only one to present job loss in addition to a lower level of production, although it remains positive. In simulations 975 and 985 the increase in household consumption contributes significantly to the increase in production in the secondary and tertiary sectors, while the government, due to having to reduce spending, has a decrease in production. As for employment, there is a fall in the primary, tertiary, and

government sectors, reallocated to the secondary sector. There is a significant increase in capital in all sectors.

Regarding taxes, for simulation 915 there is a big sectoral drop slowed down when considering the totality of taxes. The most benefited sector is the secondary sector, while the least benefited is the primary sector. As for simulations 975 and 985 the only sector that does not show an increase in total taxes is the secondary sector. In the primary and tertiary sectors there are more significant increases.

6.5 Comparative analysis of Macro Simulations

Table 7 shows the comparison of the main macro variables for the simulations performed. For the standard simulations, in the short term, it is observed that the replacement of CPF and CPRB by NCPRB (sim020) produces positive results, and similar to the substitution by CVA (sim220), with emphasis on the increase in GDP and the level of employment. The replacement by NCPRB brings a greater gain in terms of social security revenue. The adoption of IVA (sim420) also brings gains in the selected variables, although at a much lower intensity, however, exports are affected. In the joint simulation (sim820) the gains are added, but the social security revenue suffers a significant drop.

When analyzing the long term, in comparing the simulations of substituting employers' social security contributions (sim105 and sim305), there is an advantage for adopting the CVA. GDP, capital, investment, and exports started to show positive variation compared to negative variation with the NCPRB. Household consumption, although decreasing, is still positive. Social security revenues are down, but at a much lower level.

The work of Silva, Tourinho and Alves (2004), when simulating the alteration of the Employer's Social Security Contribution by a CVA, calculated a rate of 6.9% for the CVA. However, the change of only 50% of the CPP was simulated, as well as, only on the sectors that collect non-cumulative PIS / Cofins (36.6% of GDP according to the authors). Therefore, it is difficult to compare with the results presented here. However, just to have an idea of order of magnitude, considering these two aspects of that simulation, the result of 5.71% for the CVA rate found here, applied over 50% of CPP and 36.6% of GDP, would be equivalent at a rate of 7.8% slightly higher than the value of 6.9% calculated by those authors.

The adoption of IVA (sim505) has positive results for the economy. However, household consumption has dropped significantly by cause of the closure's condition of the

model in the long run. As a restriction on the trade balance is imposed, as well as the investment accompanies the capital stock, household consumption is determined on a residual basis. Exports increase a lot and imports decrease due to the strong devaluation of the currency. Considering the intense drop in prices caused by the removal of taxes on intermediate consumption there is a large increase in real tax revenue. However, the IVA's rate, necessary to keep the nominal collection constant, is established at a high level of 31.42%.

The joint simulation (sim905) shows slightly better results than the simulation of IVA alone by virtue of the inclusion of positive CVA results. The real wage becomes positive, however, household consumption continues to show a sharp drop. The highlight goes to social security revenue which has a strong real increase. The joint IVA / CVA rate is 38.79%.

For alternative simulations, in the first simulation (sim915), in which real tax and social security revenues become exogenous the positive effects remain with the IVA's rate significantly lower, equal to 25.81%. Exports rise even more. The CVA's rate also declines, to 6.30%. Thus, the joint rate is 32.11%. However, household consumption is still falling sharply.

In the second alternative simulation (sim975), in which household consumption follows the real income of the factors, the main macroeconomic variables have increased sharply, household consumption rises 5.94% with the IVA's rate remaining practically unchanged, as well as, the social security rate has a slight decrease, which results in a total rate of 32.28%. Capital and investment show significant increases. Exports decreased significantly in relation to the previous simulation by virtue of the increase in internal absorption, but even so, they showed a significant increase. The currency appreciates increasing imports. Thus, the trade balance deficit increases, which could be offset by the entry of foreign direct investment in an environment of strong GDP growth.

Finally, in the last alternative simulation (sim985), similar to the previous one, but with the elimination of contributions to Sistema S, Salário Educação, and CSLL, the positive effects are even better with the joint rate being set at 34.00%. The real tax revenue shows a strong increase necessary to keep the public sector borrowing requirement fixed, however, in values lower than those observed in simulation 905.

In sectoral terms⁵⁹ the variable “Value of production” is the one that best summarizes the effects of tax changes in the various sectors. In short-term simulations the adoption of NCPRB (sim020) or CVA (sim220) has positive effects on the production of all sectors, with emphasis on transport, water and air, accommodation, textiles, engineering, and manufacturing services of plastics and rubbers. The worst results, yet positive, go to agriculture, forestry production, sugar manufacturing and refining, construction, and real estate activities.

The implementation of IVA (sim420) has positive effects for the air transport, tobacco products⁶⁰, biofuel manufacturing, cleaning and perfumery products, and public health sectors. The sectors negatively affected are water transport, education and private health, publishing, and accommodation.

In the joint simulation (sim820) the positive effects, in addition to the sectors already mentioned in the case of IVA, extend to the oil refining and coking plants sector, while, forest production, sugar manufacturing and refining, and food, along with education and private health, have the worst performances. It appears that in the joint simulation the production values are positive for practically all sectors. The only exceptions are those mentioned above. In the case of simulation of IVA alone the opposite occurs with the majority of sectors showing negative variation in production. Therefore, the joint implementation of reforms would help to convince those sectors most reluctant to adopt IVA.

In the long run, the performance achieved by adopting the CVA (sim305) is far superior to that of the NCPRB (sim105) with most sectors experiencing positive variation in the value of production. For the NCPRB the sectors, which in the short term showed the most positive changes, now show negative changes. In total 48 sectors showed this behavior of inversion in the value of production. The possibility of adjusting real wages and capital stock has a more adverse effect on the NCPRB alternative, which is in line with the general understanding that taxes on revenues have a distorting effect on the economy.

The implementation of IVA (sim505), in the long run, has, in general, a very good effect on the primary and secondary sectors. The tertiary sector shows the worst performance, but still shows growth in production in many sectors, such as transport, accommodation, engineering

⁵⁹ It was decided to cite only the sectorial results, and not to present the tables with the values, as they would be very extensive.

⁶⁰ Remember that this sector, as well as that of beverages, is not subject to IVA, but to ISSP.

services, and rentals. However, sectors that are important for household consumption, such as education and private health show significant drops in the value of production.

In the joint simulation (sim905) the production values tend to show superior performance since the positive effects of adopting the CVA are incorporated. Therefore, also in the long run, albeit on a smaller scale than in the short run, the joint adoption of measures would help in the approval of reforms.

The first alternative simulation (sim915) shows a slight improvement in terms of production value. However, in the last two simulations of this group (sim975 and sim985), with the real consumption of families following the real income of the factors, there is a significant improvement in practically all sectors, especially in the tertiary sector. The negative impacts of the education and private health sectors are greatly mitigated.

Therefore, it can be concluded that the adoption of a value added tax, replacing taxes on existing commodities, has positive effects, both in relation to the main macroeconomic variables and in relation to the performance of the great majority of economic sectors. The same can be said about the implementation of a contribution on value added, replacing the current employers' social security contributions. In addition, the joint adoption of these measures may facilitate the processing of proposals in parliament since they mitigate the adverse effects, in a few sectors, of the implementation of IVA alone.

Finally, we highlight the difficulty of comparing the results of this study with the various works cited in the bibliographic review, considering the diversity of models involved, especially regarding the closures, shocks and sectoral aggregations used. However, what is found, in general, in common between the studies cited and the one undertaken here, are the beneficial effects of tax changes, as shown in the table below.

Table 1 - Main macroeconomic results, different models

Work	Model	Reform	Results (%)
Silva, Tourinho e Alves (2004)	CGE IPEA - static 39 sectors	50% CPP -> CVA	GDP = +0,01
Lledo (2005)	CGE - dynamic A-K Model	PIS/Cofins/CPMF/IOF -> IVA	GDP = +9 Capital = +8 Consumption = +2
Pereira e Ferreira (2010)	Dynamic recursive	. 30% reduction CPP + SE elimination . PIS/Cofins -> IVA . Investments exemption	GDP = +14 Private Capital = +35 Publica Capital = -18 Consumption = +11
Godoy (2013)	CGE - <i>GTAPinGAMS</i>	1. CPP -> CPRB – Rate = 1% on transformation industry 2. Intermediate tax -> IVA	1. GDP = +0,30 2. GDP = +0,47

Beppler (2019)	CGE - <i>ORANI-G</i> 67 sectors x 127 commodities	Tax reduction on production by 1.4%	GDP = +1,65
Souza, Cardoso e Domingues (2016)	CGE - <i>ORANI-G</i> 60 sectors x 116 commodities	CPP -> CPRB - Rate = 1%	GDP = +0,76% GDP = +2,13% if only sectors with positive impacts are considered

6.6 Parameter sensitivity analysis

One of the main criticisms of the computable general equilibrium models concerns the question of the use of parameters, generally elasticities, based on scarce and inconclusive empirical studies regarding their values. Thus, key parameters of the model could greatly influence the results found. Therefore, according to Domingues et al. (2008), considering that there is considerable uncertainty about the value of these parameters, as well as that they are important parameters in determining the results of the model, it is necessary to implement a procedure for assessing the sensitivity of the parameters used.

The *RunGEM* module⁶¹ has specific functionality to perform systematic parameter sensitivity analysis (SSA). The implemented procedures are based on Stroud or Liu's Gaussian squares⁶², which are particular order 3 Gaussian squares. A summary of the systematic sensitivity analysis and Gaussian squares can be found in Domingues et al. (2008). Arndt (1996) presents an introduction on the topic.

To identify which parameters most affects the model's results, first, SSA was applied considering the joint variation of the components of the parameters. In this case, generally used when one is satisfied with the relative values presented by the components of the parameter under analysis, but its magnitude is not known for certain, the averages are approximately equal to those of the test considering independent variation between the components of the parameter, but the standard deviations tend to be larger.

⁶¹ *RunGEM* is a Windows interface that provides an environment specially adapted for simulations with a model. It consists of one of the *GEMPACK* modules, used in the present work to run the simulations.

⁶² A Gaussian square for a continuous distribution for several variables is a discrete distribution whose first moments are identical to those of the continuous distribution. If the first d moments agree, the square is said to be of order d . As, in this case, these have an order of three, the first three moments are the same as the continuous distribution. When a Gaussian square is used to generate the points at which the model is solved, to perform the sensitivity analysis calculations of the parameters, experience indicates that the estimates of the means and standard deviations produced are generally quite accurate, even for non-linear models.

Thus, the SSA was applied, considering the joint variation of the components of the parameter, with a symmetrical triangular distribution, with a scale factor equal to four, that is, the selected parameter varies from a quarter to four times its original value, individually, to the following parameters: *EXP_ELAST*⁶³ (demand elasticity for exported products), *EXP_ELAST_NT*⁶⁴ (demand elasticity for collective exported products), *SIGMA1*, *SIGMA2* and *SIGMA3* (Armington elasticity for intermediate consumption, investment, and household consumption, respectively), *SIGMAIOUT* (elasticity of transformation - CET) and *SIGMAIPRIM* (elasticity of substitution between primary factors - CES). The test result showed that *EXP_ELAST* is the parameter that most affects the result, followed by *SIGMA1*, but this on a much smaller scale. The others practically do not alter the result.

Then, only for these two parameters, the SSA test was performed again, maintaining a symmetrical triangular distribution, however, with independent variation between the components of the analyzed parameter, a situation in which there is little confidence in the relative values of its components⁶⁵. Therefore, SSA was performed, simultaneously on the *EXP_ELAST* and *SIGMA1* parameters. As the parameters *SIGMA2* and *SIGMA3*, in this work, have the same values as *SIGMA1*, they also varied in the same proportion. The variation in *EXP_ELAST* was from one to four times its original value, while for *SIGMA1*, the variation was from a quarter to four times its original value. Finally, the same test was performed with both variables varying simultaneously, however, considering a joint variation between the components of the same parameter.

SSA was implemented for simulations 820 (short-term standard joint), 905 (long-term standard joint), and 975 (long-term alternative joint). The variables analyzed were the real variations in GDP, capital, primary factors, investment, household consumption, exports, imports, and wages, in addition to tax rates, all macro variables, as well as the value of production, which has a sectoral dimension.

⁶³ For this parameter, the variation was from one to four times its original value. It was considered that the original values of *EXP_ELAST* are already in low values in relation to those used in several other works, therefore the variation was only in the sense of increasing its value.

⁶⁴ For this parameter, the variation was from zero to four, since its original value is zero.

⁶⁵ This strategy was used, because when the variation is independent, the number of necessary simulations grows a lot, requiring high computational time. For any elasticity, for example, considering that there are 127 commodities, 254 simulations are required (if using the Stroud method). This number is multiplied by the number of parameters tested simultaneously.

Table 9 presents the result of the SSA test (independent variation) for the macro variables of the aforementioned simulations⁶⁶. In each table, the original value of the simulation, the mean and standard deviation of the SSA simulations, the lower and upper limits of the variable are presented, considering a 90% confidence interval, based on Chebychev inequality, the value absolute of the ratio between the mean and the standard deviation, the maximum probability that the variable will have a negative value, also based on Chebychev's inequality, and, finally, the percentage difference between the mean and the original value of the respective variable.

For the short-term standard simulation (sim820), from Macro Simulation 3.2, a small variation of the average is observed in relation to the original value of the simulation for the macro variables except for exports. As expected, considering that the changed parameters refer to the export demand elasticities and substitution between domestic and imported products, for the short term (in which the trade balance is endogenous), the greatest impacts occur in the export variables and import. As the currency's real devaluation index remains approximately constant the effect of the increased elasticity of demand for exported products (parameter effect) has a strong influence on the increase in the volume of exports.

The higher, in absolute value, the value of the export demand elasticity, in the event of a fall in the domestic prices of exported commodities, considering that the exchange rate is fixed, the greater the demand for the exported commodity. In addition, the higher the elasticity of substitution values the greater the substitution between domestic and imported sources with a positive impact on foreign trade and macroeconomic variables.

However, in the long run (sim905), when comparing the average - original value, by cause of the appreciation of the exchange rate real exports remain approximately constant, that is, the parameter effect (positive) is offset by the exchange effect (negative), while real imports are growing significantly⁶⁷.

⁶⁶ It was decided to present the results only for the independent SSA macro variables. The results for the joint SSA present practically the same average, but with a higher standard deviation. As for the sectoral variables, the results were commented, but the tables, being very extensive, were not presented.

⁶⁷ Remember that here the variation in the trade balance is exogenous and null.

In simulation 975 (long-term), in which there is no restriction imposed on the trade balance, both exports and imports increase in comparison. Currency appreciation also occurs here, but at a lesser intensity.

It is also noted that the probability that the variables in question have negative values is generally very low⁶⁸, which is a good indication that the tax changes analyzed will have a positive impact on the economy.

Another point to note is that the average values of the variables in the SSA simulations, with the exception of tax rates, are higher than those of the original simulations, that is, even for the simulation 905, in which it is found that the elasticities in question have a strong influence in the model result, this influence is positive for the main macro variables analyzed. Thus, it can be considered that the original simulations are conservative, in the sense that, if the elasticities present higher values than those used⁶⁹ the results will be better.

As for the IVA and CVA tax rates, for simulations 820 and 975, Table 9 shows that they are not very sensitive to the elasticities in question. As for simulation 905, they show a significant reduction. Therefore, also for these variables, the original results are conservative.

The same can be said in relation to the variable “Production value”, in which it is verified that there are few sectors in which the SSA averages are lower than the values obtained in the original simulations.

7 FINAL CONSIDERATIONS

This work aimed to simulate the main tax reform proposals currently under discussion in the country using a computable general equilibrium model adapted to Brazilian needs, in addition to providing the model with characteristics that allow simulating other tax changes. The model used was the *ORANI-G*, derived from the *ORANI* model, developed in the 1970s and widely used for analysis of public policies by academics, the private sector, inclusive of the Australian government. The model was calibrated with data from the Brazilian economy according to the 2015 MIP, as well as tax collection obtained from the RFB.

⁶⁸ Except for the Real devaluation index variable.

⁶⁹ This applies mainly to the export demand elasticity, which is the parameter that most influences the result, and for which the variation in SSA is always in the sense of increasing its value.

The main changes in the model were in the sense of endowing it with a greater tax breakdown, especially with regard to taxes on labor, capital, and production. In addition, the model was changed in order to simulate the implantation and / or alteration of the value added tax, selective product tax, taxes on gross revenue, and corporate income tax.

Four Macro Simulations were carried out, called standard simulations, with closures for the short and long term. For short-term closure the government's real consumption is limited by the public spending ceiling rule, as EC nº 95/2016. Real household consumption follows the real factor income. For the long term the government's closure remains, however, a restriction on the trade balance is imposed in order to maintain the ratio of its balance to GDP.

The first two tax changes simulations deal with the replacement of employers' social security contributions (CPF and CPRB), with a new contribution on gross revenue (NCPRB), or with a contribution on value added (CVA). The third simulation involves the extinction of the PIS, Cofins, IPI, ICMS and ISS taxes along with the creation of a Value Added Tax (IVA) levied on the value added at each stage of the production process, and a Selective Tax on Products (ISSP), levied on the value of the production and import of beverage and tobacco commodities. This is basically the main proposal for tax reform that is being discussed at the national congress.

Finally, a joint simulation was carried out dealing with the replacement of the Employer's Social Security Contribution by a contribution on value added (CVA) in conjunction with the institution of IVA / ISSP in substitution of taxes on products mentioned above. Thus, it was possible to verify the isolated impact of each change, as well as, in the end, the joint impact of the changes. All of these Macro Simulations mentioned above were based on neutrality in terms of nominal tax revenue.

In addition, as a variation of this fourth simulation, alternative joint simulations were carried out along these same lines, but with changes in the standard closures of the model, as well as with the elimination of CSLL and contributions to Salário Educação and Sistema S. long-term simulations were used, in which the real revenue was kept, instead of the nominal, or the restriction on the trade balance was removed, considering that the real consumption of the families follows the real income of the factors.

When analyzing the long term, the main conclusions about the various simulations carried out in this work can be summarized as follows:

- When analyzing alternatives to the current employer's social security contribution model the adoption of a contribution on value added outperforms the adoption of a social security contribution on gross revenue with most sectors obtaining positive variation in the value of production. The neutral CVA rate, in terms of nominal collection, would be approximately 6%.
- The adoption of a value added tax, replacing the current taxes on products (PIS, Cofins, IPI, ICMS, and ISS), has a positive result for the main macroeconomic variables. However, household consumption has dropped significantly, due in large part to the condition of the model closure in the long run. In addition, the IVA rate, necessary to keep the nominal collection constant, is approximately 31%, a high level when compared to other countries that use this tax. Considering the intense drop in prices, caused by the removal of taxes on intermediate consumption, there is a great increase in real tax revenue, which contributes to the relief of public accounts. In sectoral terms, the implementation of IVA has a great effect on practically all sectors. The tertiary sector shows the worst performance, but still shows growth in production. The export sector presents considerable gains, reflecting the intense real devaluation of the currency.
- Joint simulation, with the adoption of IVA and CVA, improves the result compared to the adoption of IVA only. The sectoral production values tend to show superior performance since the positive effects of adopting the CVA are incorporated. However, the total rate would be almost 39%. In addition, there is a strong increase in real revenue, both tax and social security, with the public sector borrowing requirement remaining stable. The export sector continues to show considerable gains.
- In the alternative simulation, in which real tax and social security revenues become exogenous the positive effects remain with the IVA rate significantly lower. The CVA rate also declines resulting in a total rate of approximately 32%. However, household consumption is still falling sharply. The value of sectoral production has little changed compared to the previous simulation. However, the public sector borrowing requirement increases 1.76 percentage points of GDP.
- In the alternative simulation, in which the real consumption of households accompanies the real income of the factors, the main macroeconomic variables are strongly increased. Real household consumption rises by almost 6% with the IVA rate remaining virtually

unchanged, as well as the social security rate falling slightly. The total rate would remain at 32%. However, the trade balance deficit increases, which could be offset by the entry of foreign direct investment in a scenario of strong economic growth. There is a significant improvement in the tertiary sector. Real tax revenue rises again to keep the public sector borrowing requirement unchanged.

- Finally, in the last simulation, similar to the previous one, but with the elimination of contributions to Sistema S, Salário Educação and CSLL, the positive effects are even better. However, the total rate would rise to approximately 34%.

Therefore, it can be concluded that both the implementation of a value added tax, replacing taxes on currently existing products, as well as the adoption of a value added contribution, replacing the current employer's social security contributions, has positive effects both in relation to the main macroeconomic variables and in relation to the performance of the great majority of economic sectors. In addition, the joint adoption of these measures may facilitate the processing of proposals in parliament since they mitigate the adverse effects, in a few sectors, of the implementation of IVA alone.

Lastly, a sensitivity analysis of the results was carried out regarding changes in the key parameters of the model, namely, export demand elasticity and Armington elasticities for intermediate consumption, investment and household consumption. As for the export demand elasticity the range of variation of the parameter was from one to four times its original value, while, for the Armington elasticities, from one quarter to four times its original value.

The results were shown to be sensitive, especially for the standard long-term joint simulation, and, mainly, in relation to the export demand elasticity, however, this influence is positive for the main macroeconomic variables analyzed. Thus, it can be considered that the original simulations are conservative, in the sense that, if the elasticities present higher values than those used, the results, both macroeconomic and sectoral, will be better. As for the IVA and CVA tax rates, they are not very sensitive to the elasticities in question, or vary downwards, which also shows that the original results are conservative.

It should be considered that the 2015 year, the data base period used in the present study, was an atypical year in economic terms with several macroeconomic indicators showing very poor performance. Ideally, the database used in general equilibrium models should, as far as possible, be free from extraordinary economic events, which was not the case in 2015.

According to the IBGE⁷⁰, real GDP fell by 3.5% in relation to 2014, the services sector, 2.7%, and industry, 5.8%. Only the agricultural sector showed an increase of 3.3%. Thus, GDP per capita fell by 4.3%. The investment rate decreased to 17.8%, a decrease of approximately 20% in relation to 2014, a reduction of 3.1 percentage points in relation to the peak of 20.9% (2013) of the historical series 2000-2015. Finally, household consumption, which accounts for 62.5% of GDP, fell 3.2%, the first drop since 2003 (-0.4%). The public sector borrowing requirement, although it decreased in relation to 2014, still represented an expressive value in relation to GDP. Therefore, it should be considered that the macroeconomic performance of 2015 may have affected some of the results obtained.

The tax changes made in this work simulated the implementation of tax alternatives with uniform tax rates, as recommended by the literature in the case of value added taxes⁷¹, so that distortions on the economic system are kept to a minimum. However, it is difficult to find in practice a IVA model with only one rate. Those sectors that are most affected will certainly endeavor to obtain differentiated treatment. Thus, for future development, it is suggested to change this characteristic of the model, to allow simulations with varying rates between sectors⁷², in order to obtain greater consensus on the reform to be implemented.

Another proposal for future development concerns the improvement of the public finance component in the model. In calculating the public sector borrowing requirement, several items that comprise it are not available in the database and, therefore, it was assumed that they vary in the same proportion as GDP. Therefore, this improvement would bring more certainty regarding this variable.

It is important to emphasize that, when using computable general equilibrium models, the choice of the closure to be adopted determines, in good measure, the results obtained. This was evident especially in the alternative simulations presented here. Therefore, in future work, these closures can be changed in order to include other policy options or economic environments.

As mentioned in the introduction, the main objective of the paper was to simulate the main tax reform proposals currently under discussion in the country, using a computable general

⁷⁰ IBGE News Agency. Available at: <https://agenciadenoticias.ibge.gov.br/agencia-sala-de-imprensa/2013-agencia-de-noticias/releases/17902-pib-cai-3-5-em-2015-e-registra-r-6-trilhoes>

⁷¹ This is also valid for taxes on gross revenue, as is the case with the NCPRB.

⁷² Even so, keeping a few rates, as an IVA should be.

equilibrium model, adapted to Brazilian needs, without entering into the merits of the proposals, but only calculating the impacts of such tax changes on the economy, as well as on the economic sectors, in order to provide subsidies for a more objective and transparent discussion of the topic. I think that goal was achieved with the results presented.

As a secondary objective, we tried to provide the model with attributes that would allow to carry out other simulations, different from the ones implemented here, as well as other works on the theme, as stated in chapter 2. This objective also seems to have been achieved to the extent that the tax breakdown contained in the model allows simulations in a considerable range of taxes, especially social security (CPF, CPRB, CPSN, CPOT, CPSS, RAT, PASEP, FGTS, PPR, CSI), on production (Salário Educação, Sistema S, Others), as well as on capital (IRPJ and CSLL, Real, Presumed Profits, and Other Income), in addition, of course, to commodity taxes (ICMS, IPI, PIS, Cofins and ISS). This characteristic of tax breakdown, associated with the fact that simulation of proposals for tax changes that are currently being discussed by society has been carried out, are the main innovations of the present work.

Furthermore, despite the difficulty of comparing the results obtained here with those of other works cited either considering the diversity of the models used, or to the different closures, shocks and sector breakdown employed, it can be said that the results achieved are in line with those of other studies insofar as they show positive macroeconomic effects on the economy arising from tax changes in the sense of implementing a IVA, or in the change in the form of financing of the social security system.

Therefore, one of the main objectives of the work, which was methodological and data organization, was achieved, by enabling the development of an important simulation tool that can be used for different designs of tax reform and macroeconomic closures, in a fast, precise manner, and comprehensive.

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APPENDIX I – TABLES

Table 4 - Correlation indices - Macro Simulations 1.1 and 1.2

Variable 1	Variable 2	Correlation Index (*1)			
		NCPRB (1.1)		CVA (1.2)	
		sim020	sim105	sim220	sim305
<i>SHt</i> (*2)	<i>x1lab_o</i>	(0,36)	(0,26) (**)	(0,42)	(0,13) (ns)
<i>ET</i> (*3)	<i>x1lab_o</i>	0,17 (ns)	0,36	0,29 (**)	0,74 (**)
<i>SHt</i>	<i>x1tot</i>	0,16 (ns)	0,00 (ns)	0,23 (**)	0,00
<i>x1lab_o</i>	<i>pt1cap-p1lab</i> (*4)	0,69	0,33	0,68	0,75
<i>SHt</i>	<i>p1prim</i> (*4)	(0,63)	(0,57)	(0,67)	(0,15) (ns)
<i>SHt</i>	<i>x2tot</i> (*4)	(0,53)	(0,33)	(0,58)	(0,19) (ns)
<i>ET</i>	<i>x2tot</i>	(0,58)	(0,27) (**)	(0,55)	(0,55)
<i>SHt</i>	<i>vstax_tot</i> (*5)	(0,61)	(0,63)	(0,61)	(0,65)

Source: Author's elaboration

(*1) - Excluding public administration and domestic services, which have their own dynamics.

Significance level:

(ns) - not significant.

(*) - significance level = 10%.

(**) - significance level = 5%.

others - significance level = 1%.

 (*2) - *SHt* is the labor participation in the use of primary factors - $[V1LABTOT(i) / V1PRIM(i)]$

 (*3) - *ET* is the labor charge (CPFP) on payroll borne by the sector - $[V1CPFP(i) / V1LAB(i)]$

(*4) - Calculated only for sectors where the investment is endogenous.

(excludes sectors of public administration, domestic services and membership organizations).

(*5) - It includes indirect taxes on producers and investors, in addition to other taxes and sectoral contributions, including income and social contribution taxes.

Table 5 - Contributions to GDP from the perspective of expenditure (%)

GDP [Expenditures]	NCPRB (1.1)		CVA (1.2)		IVA (2.1)		IVA / CVA (3.2)		IVA / CVA (4.2) (LR)		
	020	105	220	305	420	505	820	905	915	975	985
	Household consumption	0,76	1,08	0,87	0,25	0,07	-2,87	1,00	-2,60	-2,84	3,87
Investment	0,00	-0,18	0,00	0,15	0,00	0,90	0,00	1,04	0,93	2,29	2,58
Government consumption	0,08	-0,43	0,29	-0,21	0,60	1,44	0,86	1,26	0,70	-0,12	-0,22
Exports	0,22	-0,39	0,17	0,13	-0,10	1,43	0,09	1,51	1,87	0,65	0,75
Imports	0,11	-0,40	0,03	0,05	-0,36	0,85	-0,31	0,83	1,09	-0,67	-0,71
Total	1,18	-0,32	1,35	0,38	0,21	1,75	1,64	2,05	1,75	6,01	6,75

Source: GEMPACK - simulation results - Author's elaboration

Table 6 - Contributions to GDP from the perspective of income (%)

GDP [Income]	NCPRB (1.1)		CVA (1.2)		IVA (2.1)		IVA / CVA (3.2)		IVA / CVA (4.2) (LR)		
	020	105	220	305	420	505	820	905	915	975	985
	Labor	0,96	0,00	1,09	0,00	0,09	0,00	1,24	0,00	0,00	0,00
Capital	0,00	-0,39	0,00	0,31	0,00	2,00	0,00	2,30	2,02	4,82	5,45
Indirect tax	0,22	0,07	0,26	0,07	0,13	-0,24	0,39	-0,26	-0,27	1,19	1,31
Total	1,18	-0,32	1,35	0,38	0,21	1,75	1,64	2,05	1,75	6,01	6,75

Source: GEMPACK - simulation results - Author's elaboration

Table 7 - Comparison of simulations - selected variables - (%)

Simulations / Variables (*)	NCPRB (1.1)		CVA (1.2)		IVA (2.1)		CVA / IVA (3.2)		CVA / IVA (4.2)		
	020	105	220	305	420	505	820	905	915	975	985
IVA Rate	-	-	-	-	24,07	31,42	24,49	31,65	25,81	26,39	28,09
NCPRB / CVA Rate	1,91	1,76	5,70	5,71	-	-	5,52	7,14	6,30	5,89	5,91
GDP - real	1,18	-0,32	1,35	0,38	0,21	1,75	1,64	2,05	1,75	6,01	6,75
Employ level - real	2,32	ve	2,63	ve	0,21	ve	2,97	ve	ve	ve	ve
Wage - real	ve	4,26	ve	4,32	ve	-2,55	ve	1,41	3,49	10,78	12,22
Capital - real	ve	-1,00	ve	0,80	ve	5,24	ve	6,19	4,98	12,97	14,71
Primary fac. - real	1,19	-0,49	1,34	0,38	0,11	2,45	1,52	2,87	2,34	5,94	6,69
Househ. cons. - real	1,19	1,69	1,34	0,39	0,11	-4,34	1,52	-3,92	-4,29	5,94	6,69
Gov. cons - real	0,42	-2,18	1,45	-1,03	3,07	7,29	4,38	6,32	3,48	-0,61	-1,10
Investment - real	ve	-1,00	ve	0,85	ve	5,23	ve	6,21	5,44	13,65	15,47
Exports - real	1,68	-3,08	1,33	1,01	-0,82	11,42	0,74	12,27	15,02	5,38	6,18
Import. CIF - real	-0,78	2,91	-0,19	-0,39	2,69	-5,68	2,35	-5,67	-7,21	4,82	5,13
Real devaluation	4,40	-6,78	-0,79	-2,08	-9,32	12,12	-9,46	8,42	21,67	-2,85	-2,52
GDP price index	-4,21	7,27	0,79	2,13	10,28	-10,81	10,45	-7,77	-14,36	2,93	2,58
Wage - nominal	-9,31	4,03	-3,69	0,88	12,89	-7,54	7,94	-5,78	-16,04	11,00	12,28
Capital rental	-5,52	5,13	0,61	-1,57	11,12	-18,25	11,36	-19,02	-24,16	-9,26	-10,18
Index of factor cost	-7,49	4,56	-1,63	-0,30	12,04	-12,78	9,58	-12,28	-20,01	0,91	1,05
Cons. price index	-3,52	6,16	2,44	2,88	12,89	-5,12	14,78	-1,24	-8,90	6,59	6,44
Gov. price index	-3,93	8,53	0,98	3,94	9,53	-11,57	9,96	-7,11	-16,11	7,25	7,63
Invest. price index	-4,95	5,13	-4,07	-1,57	-1,10	-18,24	-5,75	-19,01	-24,15	-9,24	-10,16
Exp. price index	-2,47	5,78	-1,97	-1,66	2,59	-15,03	0,18	-15,96	-21,31	-7,76	-8,87
GDP - nominal	-3,09	6,93	2,15	2,51	10,52	-9,25	12,26	-5,88	-16,49	9,12	9,51
Labor - nominal	-7,20	4,03	-1,16	0,88	13,12	-7,54	11,15	-5,78	-16,04	11,00	12,28
Capital - nominal	-5,52	4,08	0,61	-0,78	11,12	-13,96	11,36	-14,01	-20,38	2,51	3,04
Primary fac. - nom.	-6,39	4,05	-0,30	0,08	12,16	-10,64	11,25	-9,75	-18,14	6,90	7,82
Househ. cons. - nom.	-2,37	7,95	3,82	3,28	13,01	-9,24	16,53	-5,11	-15,62	12,92	13,57
H. cons. luxury - nom.	-0,68	10,64	5,86	3,93	13,19	-15,49	19,10	-11,01	-21,22	22,47	24,33
Gov. cons. - nom.	-3,52	6,16	2,44	2,88	12,89	-5,12	14,78	-1,24	-16,11	6,59	6,44
Invest. - nominal	-4,95	4,08	-4,07	-0,73	-1,10	-13,96	-5,75	-13,97	-20,11	3,14	3,74
Exp. - nominal	-0,84	2,52	-0,67	-0,67	1,75	-5,33	0,92	-5,65	-7,48	-2,80	-3,24
Tax revenue - real	0,96	0,44	1,18	0,40	-1,11	14,86	1,26	15,82	ve	11,93	11,92
Soc. sec. rev. - real	2,74	-5,08	0,81	-1,55	-0,08	0,43	-3,03	8,39	ve	ve	ve
Total tax rev. - real	1,52	-0,61	1,36	0,01	-0,71	9,75	0,75	11,76	0,06	7,80	5,05
Tax revenue - nom.	-2,55	5,56	-1,24	-1,10	2,78	-2,60	2,11	-2,75	-21,19	4,10	3,33
Soc. sec. rev. - nom.	-1,27	2,41	0,27	0,53	10,19	-9,87	3,54	-2,81	-18,04	3,46	3,27
Total tax rev. - nom.	-2,17	5,71	-0,07	0,42	5,63	-4,84	4,66	-2,57	-19,06	5,97	2,66
Var. PSBR - % GDP	-0,31	-0,08	0,37	0,47	1,31	-0,53	1,45	0,02	1,76	ve	ve
Var. BOT - % GDP	-0,04	ve	-0,03	ve	-0,02	ve	-0,05	ve	0,00	-0,84	-0,93

Source: GEMPACK - Simulation results - Author's elaboration

(*) Observations:

ve = exogenous variables with null variation.

Tax revenue - Includes indirect taxes and IRPJ / CSLL.

Social security revenue - Includes soc. sec. taxes for "Regime Geral de Previdência Social".

Total tax revenue - Includes, in addition to those already mentioned: FGTS, Pasesp, RAT, CPSS and Other Production tax.

Initial PSBR = 7,75 % GDP.

Initial BOT = -1,26 % GDP.

Table 8 - Result by macro economic sector - main variables (%) - LR simulations

Simulations	Sectors	Variable (%)						
		Prod.	Empl.	Capital	Nom. Wage	Prod. cost	vstaxtot (*1)	v0taxtot (*2)
sim105 [NCPRB]	Primary	-1,57	-1,28	-1,45	5,60	5,08	26,97	24,35
	Secondary	-0,69	0,53	-2,10	0,39	4,32	7,49	7,57
	Tertiary	0,18	1,47	-0,66	1,63	4,20	1,71	2,99
	Govern	-2,22	-2,52	0,37	10,60	8,55	6,47	6,43
	Average	-0,55	0,00	-1,00	4,07	4,81	5,26	5,88
sim305 [CVA]	Primary	0,64	-0,43	0,89	2,39	-1,10	-7,54	8,40
	Secondary	0,72	1,10	0,31	-2,65	-1,57	-15,29	2,75
	Tertiary	0,66	0,59	0,79	-1,45	-1,59	-17,55	-2,49
	Govern	-1,12	-1,61	3,14	7,25	3,96	3,52	4,04
	Average	0,47	0,00	0,80	0,92	-0,91	-12,74	0,74
sim505 [IVA]	Primary	4,93	-0,10	5,64	-7,54	-17,76	-59,94	-0,69
	Secondary	3,36	0,09	7,75	-7,54	-16,79	-45,46	-12,03
	Tertiary	0,63	-3,96	3,94	-7,54	-16,61	-33,98	2,69
	Govern	7,14	6,42	13,49	-7,54	-11,52	-11,84	-9,91
	Average	2,71	0,00	5,24	-7,54	-16,18	-34,51	-4,75
sim905 [IVA / CVA]	Primary	5,46	-0,73	6,50	-4,44	-18,14	-66,48	8,32
	Secondary	4,04	1,04	8,13	-9,15	-17,61	-58,98	-7,48
	Tertiary	1,30	-3,50	4,90	-8,03	-17,35	-48,95	2,26
	Govern	6,08	4,85	17,42	0,09	-7,04	-7,17	-4,72
	Average	3,16	0,00	6,19	-5,82	-16,33	-45,23	-2,22
sim915 [IVA / CVA]	Primary	6,67	1,36	7,33	-10,05	-20,98	-67,30	-8,44
	Secondary	4,34	1,91	7,25	-14,48	-20,49	-60,56	-21,63
	Tertiary	1,51	-2,34	3,94	-13,42	-20,81	-51,01	-11,43
	Govern	3,29	2,24	12,81	-5,78	-11,87	-14,54	-12,79
	Average	3,12	0,00	5,33	-11,34	-19,68	-48,04	-15,44
sim975 [IVA / CVA]	Primary	6,88	-1,07	8,86	12,66	-9,10	-62,10	14,28
	Secondary	9,02	4,28	15,81	7,11	-8,73	-51,64	-1,54
	Tertiary	6,84	-0,54	12,93	8,43	-6,34	-39,10	13,66
	Govern	-0,63	-2,02	12,68	18,01	7,89	1,76	3,83
	Average	6,76	0,00	12,97	11,04	-5,80	-36,51	6,52
sim985 [IVA / CVA]	Primary	7,75	-1,06	9,97	13,96	-9,81	-68,75	12,34
	Secondary	10,14	4,83	17,93	8,35	-9,32	-58,80	-2,64
	Tertiary	7,86	-0,41	14,74	9,69	-6,76	-50,18	7,78
	Govern	-1,12	-2,61	13,27	19,37	8,36	2,06	4,22
	Average	7,62	0,00	14,72	12,32	-6,20	-44,20	3,44

Source: GEMPACK - Simulation results - Author's elaboration

(*1) - It includes indirect taxes on producers and investors, in addition to other taxes and sectoral contributions, including income and social contribution taxes.

(*2) - It encompasses all taxes, including PPR and CSI.

Table 9 - Independent SSA - selected macro variables - simulations 820, 905 and 975 (IVA / CVA)

Variable / Simulation (*)		SIM	Mean	SD	LI	LS	t	P [<0]	DIF%
sim820 [SR]	Real GDP	1,64	1,72	0,04	1,58	1,85	40,36	0,03	4,97
	Primary factors - real	1,52	1,59	0,04	1,48	1,71	43,36	0,03	4,55
	Household cons. - real	1,52	1,59	0,04	1,48	1,71	43,36	0,03	4,55
	Exports - real	0,74	1,61	0,40	0,34	2,88	4,01	3,11	117,33
	Imports CIF - real	2,35	2,85	0,29	1,93	3,78	9,71	0,53	21,25
	Real devaluation	-9,46	-9,54	0,14	-9,97	-9,11	70,22	99,99	-0,78
	BOT Var. (% GDP)	-0,05	-0,01	0,04	-0,13	0,12	0,18	0,50	86,64
	IVA rate	24,49	24,45	0,05	24,29	24,60	491,90	0,00	-0,17
	CVA rate	5,52	5,51	0,01	5,48	5,55	488,02	0,00	-0,16
sim905 [LR]	Real GDP	2,05	5,59	0,23	4,85	6,32	24,00	0,09	172,76
	Real wage	1,41	10,56	0,63	8,56	12,56	16,68	0,18	649,55
	Capital - real	6,19	12,43	0,41	11,13	13,73	30,19	0,05	100,98
	Primary factors - real	2,87	5,70	0,18	5,12	6,28	31,02	0,05	98,29
	Investment - real	6,21	13,08	0,46	11,61	14,54	28,28	0,06	110,41
	Household cons. - real	-3,92	3,87	0,52	2,22	5,53	7,39	0,92	198,72
	Exports - real	12,27	12,63	0,51	11,01	14,26	24,55	0,08	2,98
	Imports CIF - real	-5,67	3,92	0,74	1,59	6,25	5,33	1,76	169,15
	Real devaluation	8,42	-1,63	0,69	-3,83	0,56	2,35	90,97	-119,42
	BOT Var. (% GDP)	-	-	-	-	-	-	-	-
	IVA rate	31,65	26,26	0,34	25,19	27,32	77,97	0,01	-17,04
CVA rate	7,14	5,92	0,08	5,69	6,16	78,36	0,01	-17,00	
sim975 [LR]	Real GDP	6,01	6,47	0,06	6,29	6,65	112,15	0,00	7,59
	Real wage	10,78	12,04	0,15	11,58	12,50	82,14	0,01	11,64
	Capital - real	12,97	13,94	0,12	13,57	14,32	118,29	0,00	7,50
	Primary factors - real	5,94	6,37	0,05	6,20	6,53	121,46	0,00	7,23
	Investment - real	13,65	14,71	0,14	14,26	15,16	104,04	0,00	7,75
	Household cons. - real	5,94	6,37	0,05	6,20	6,53	121,46	0,00	7,23
	Exports - real	5,38	8,79	0,48	7,26	10,33	18,14	0,15	63,59
	Imports CIF - real	4,82	6,66	0,36	5,52	7,80	18,45	0,15	38,14
	Real devaluation	-2,85	-5,02	0,26	-5,86	-4,19	19,04	99,86	-76,55
	BOT Var. (% GDP)	-0,84	-0,41	0,05	-0,57	-0,25	8,06	99,23	51,13
	IVA rate	26,39	26,11	0,03	26,01	26,21	805,91	0,00	-1,05
CVA rate	5,89	5,90	0,00	5,89	5,91	2034,48	0,00	0,15	

Source: GEMPACK - Simulation results - Author's elaboration

Observations:

SIM: result of the original simulation.

Mean: average of the variable obtained in the SSA routine.

SD: Standard deviation

LI / LS: lower and upper limit of the 90% confidence interval (based on Chebyshev's inequality).

|t|: absolute value of the Mean / SD ratio.

P [<0]: maximum probability that the variable is less than zero (based on Chebyshev inequality).

DIF%: percentage difference between the mean (SSA) and the value of the variable obtained in the original simulation.

APPENDIX II - FIGURES

Figure 1 – Standard short-term closure

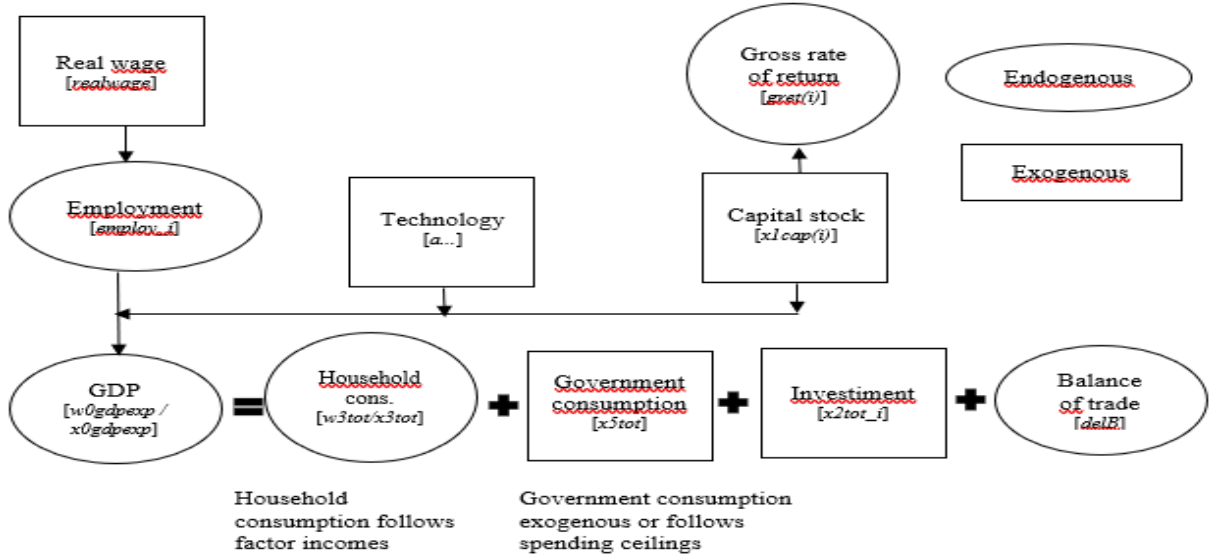


Figure 2 - Standard long-term closure

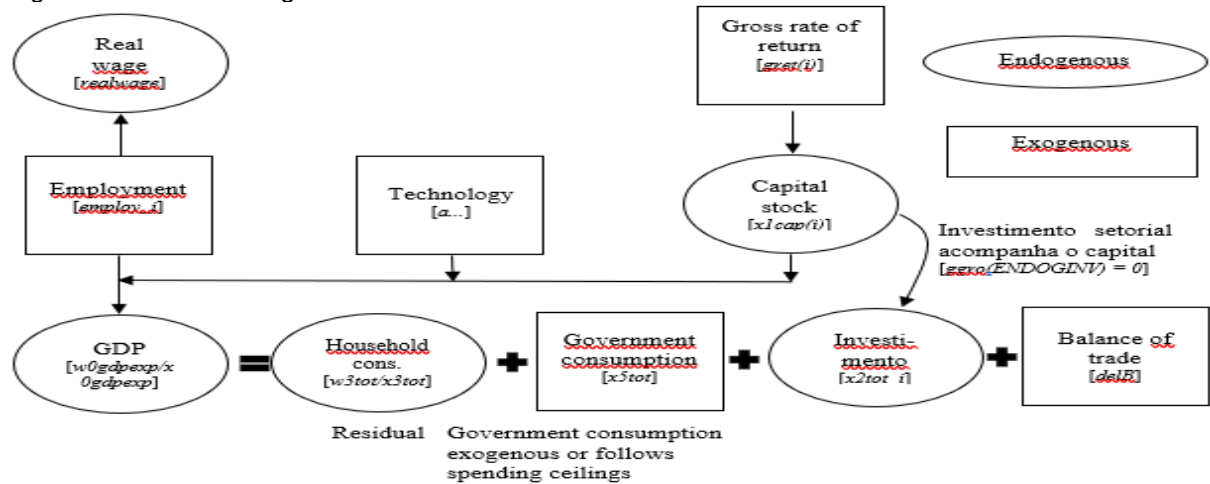


Figure 3 - Alternative long-term closure

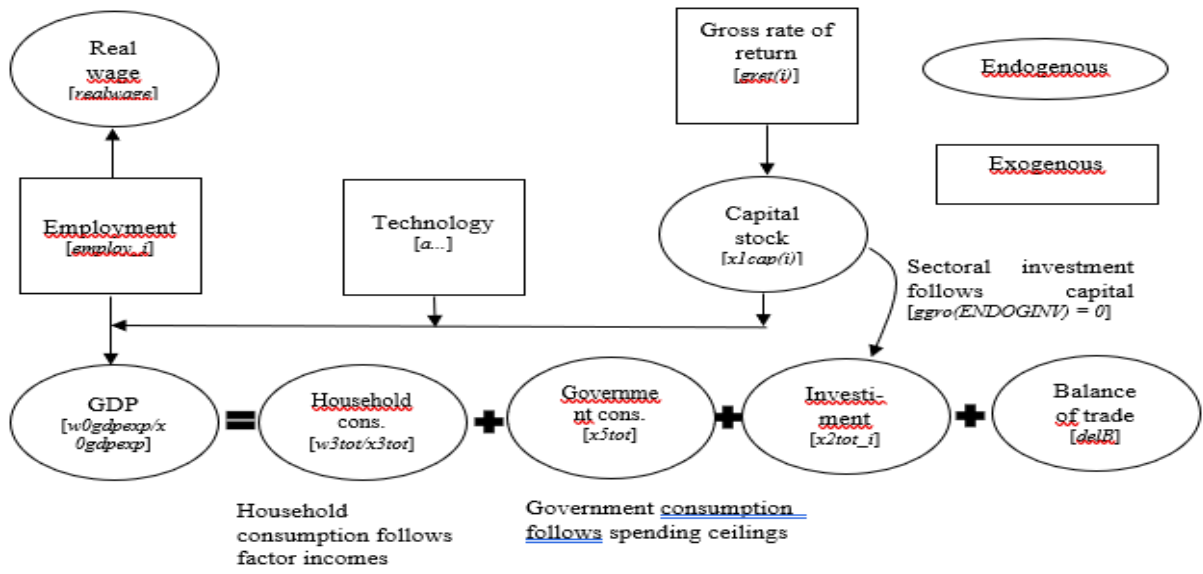


Figure 4 - Causal relationship of the main simulations

