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FRANCISCO GERMANO CARVALHO LUCIO

ESSAYS ON PUBLIC SECTOR EFFICIENCY

FORTALEZA
2021

FRANCISCO GERMANO CARVALHO LUCIO

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Tese apresentada ao Programa de Pós-Graduação em Economia da Universidade Federal do Ceará, como requisito parcial à obtenção do título de doutor em Economia. Área de concentração: Economia.

Orientador: Prof. Dr. Ricardo A. de Castro Pereira.

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A Deus.

Aos meus pais, José Lucio e Sulineide.

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“There's huge opportunities to continue to improve efficiency in the way the government operates and improve the way government provides services to its citizens.”

Steve Daines

RESUMO

Embora questões acerca da eficiência no setor público sejam amplamente estudadas pela academia, ainda há lacunas na literatura sobre tópicos específicos relacionados a esse tema. Assim, esta tese é composta por quatro ensaios abordando questões referentes a eficiência no setor público. O primeiro ensaio foca na eficiência geral do setor público nos governos estaduais do Brasil. Aplica-se um procedimento de duas etapas. Especificamente, a primeira etapa usa um método de estimativa não-paramétrica de eficiência para as despesas e a tributação. Além disso, propõe um índice para expressar a eficiência geral do setor público combinando as eficiências estimadas. A segunda etapa aplica dados em painel utilizando as eficiências estimadas como variável dependente. Verifica-se que a maioria dos estados melhorou a eficiência na tributação entre 2011 e 2013. Porém, tais ganhos não foram suficientes para compensar as perdas de eficiência nas despesas. Os resultados adicionais mostram efeitos negativos para desemprego e informalidade do trabalho e positivos para densidade populacional. O segundo ensaio analisa a eficiência da arrecadação de impostos como alternativa para superar os problemas fiscais gerados pela pandemia da Covid-19 no estado do Ceará. Primeiramente, estima-se a eficiência na arrecadação do ICMS e da receita total dos estados brasileiros. Em seguida, adapta-se um modelo CGE regional dinâmico para considerar essas eficiências e para representar a economia do estado do Ceará. Com base na eficiência estimada, são realizados exercícios simulando melhorias nos níveis de eficiência em duas vertentes, uma aumentando a eficiência na arrecadação do ICMS e outra combinando esse aumento de eficiência com a redução da alíquota do ICMS. Os resultados mostram que dentre os estados brasileiros o estado do Ceará apresenta um dos maiores índices de eficiência na tributação. Além disso, uma melhoria na eficiência da arrecadação de impostos aumentaria a receita tributária. A abordagem do terceiro ensaio assemelha-se à utilizada no ensaio anterior. Aplica um modelo CGE dinâmico para avaliar possíveis ganhos com melhorias de eficiência na arrecadação de impostos. Porém, neste caso, o modelo é calibrado para representar a economia brasileira. Da mesma forma, políticas alternativas de redução de alíquotas de impostos são simuladas. Todas as políticas simuladas gerariam ganhos positivos no PIB, no bem-estar figurando-se, portanto, como formas sustentáveis de aumentar a receita tributária. Por fim, o quarto ensaio considera a corrupção como um tipo específico de eficiência e investiga os efeitos da corrupção na renda dos estados brasileiros. Dadas as dificuldades de variáveis para corrupção para unidades subnacionais, cria-se *proxies* objetivas com dados do órgão de fiscalização e controle de corrupção. Visando obter maior precisão nas análises, considera-se correlação espacial. Embora a corrupção tenha apresentado um efeito negativo e significativo nos modelos padrão (não espaciais), esta apresentou-se não significante ao considerar a dependência espacial. Portanto, é possível que a corrupção no nível estadual de governos no Brasil não tenha impacto sobre o PIB *per capita* dos estados brasileiros. Com base nos resultados de todos os ensaios, espera-se que esta tese contribua para a discussão a respeito da eficiência no setor público, bem como com algumas implicações de política como alternativas factíveis que podem ser utilizadas para superar ou pelo menos mitigar os problemas discutidos como por exemplo o das finanças públicas, tanto no nível estadual quanto federal de governo.

Palavras-chave: Eficiência. Corrupção. Setor Público. Pandemia da COVID-19.

ABSTRACT

Although efficiency issues in the public sector are widely reported in academia, there is still undeveloped literature concerning specific topics of this theme. Based on that, this thesis is composed of four essays covering these topics. The first essay focuses on the overall efficiency of the public sector in the state-level governments in Brazil. It applies a robust two-step procedure. Specifically, the first step uses a robust nonparametric efficiency estimation method for both expenditures and taxation. Besides, it proposes an index to express the public sector's general efficiency by combining the efficiency on both expenditure and taxation. The second step applies standard panel data. It finds that most of the states improved efficiency in tax collection from 2011 to 2013. However, considering a dynamic analysis, it was not enough to compensate for the expenditure efficiency losses. The second step results show positive effects for unemployment and labor informality and negative for population density. The second essay analyzes the efficiency in tax collection as an alternative to overcome fiscal problems left by the Covid-19 pandemic, focusing on the Ceará state. A double analysis is performed. Firstly, it estimates the efficiency in the collection of both ICMS, which is the most important tax the state governments control, and total revenue for the Brazilian states. Then, it adapts a regional dynamic CGE model to consider these efficiencies, which is also calibrated to represent the economy of the Ceará state. Based on the efficiency estimated, exercises are performed simulating improvements of efficiency in two strands, one increasing the efficiency in ICMS collection and the other combining it with a reduction in ICMS tax rate. Results show that the Ceará state presents one of the highest levels of efficiency in tax collection for both measures. Additionally, an improvement in tax collection efficiency would increase tax revenue. The approach of the third essay is similar to the previous one. It also applies a dynamic CGE model to evaluate possible gains with efficiency improvements in tax collection. However, in this case, it is calibrated to represent the Brazilian economy as a whole. Similarly, alternative policies of tax rate reductions are simulated, controlling for the total tax revenue to keep at least the same level in the short run. All of the simulated policies would yield positive gains on GDP and well-being, figuring as a sustainable way to increase tax revenue. Finally, the fourth essay takes corruption as a specific type of efficiency and investigates the effects of corruption on income *per capita* over the Brazilian states. Given the difficulties of proxies for corruption in subnational units, it creates objective proxies for that. To achieve more accuracy on analyses, it controls for spatial correlation. Although corruption had presented a negative and significant effect in a-spatial models, it is indeed nonsignificant as long as it controls for spatial dependence. Hence, it seems corruption on the state tier of government has no impact on GDP *per capita* in Brazilian states. Based on the results from all essays, this thesis contributes to the public debate and provides some policy implications as feasible alternatives that can be applied to overcome or at least mitigate the problems discussed at both tiers of government, state and country.

Keywords: Efficiency. Corruption. Public sector. COVID-19 Pandemic.

LIST OF FIGURES

LIST OF TABLES

CONTENTS

1 INTRODUCTION

It is widely accepted in the literature that the public sector is an important agent in the economy, firstly due to its ability to impact the behavior of the other agents, basically, households and firms, changing their incentives by its direct, such as public expenditures, and indirect actions, such as tax rates. Nevertheless, there is no consensus in the literature concerning how important is the public sector, hence the impacts of its actions and interventions depend on factors such as the development level of the studied unit, the share of the government in the economy, and the efficiency level that the public sector performs its duties.

The share of the government in the economy is closely related to the tax burden it applies. However, high taxes influence negatively the global tax competitiveness. In 2020, the Brazilian tax burden was around 31.64%[1]. Additionally, according to Chen and Mintz (2015), Brazil presents a 31.7% of the marginal effective tax rate[2] on capital investment, which makes it occupies the 10th highest tax rate of a set composed by 90 countries in the year 2014. As a tax rate, it is considered that the higher the worse. Among 10 emerging countries within the economic group so-called G-20, the average of this tax rate is 23.5% and in OECD countries is 19.4%. The best-positioned country in Latin America is Chile with an 8.1% tax rate. This scenario in terms of high tax rates brings forth the need to discuss tax reductions and take their benefits. Notwithstanding, it would come along with an enhancement in the efficiency of taxation.

Based on the awareness that efficiency is one important factor to explore in the public sector, this thesis presents four essays regarding this topic. However, each one of these essays examines different research questions by using different approaches and methods, namely that, efficiency estimation, application of dynamic CGE models both regional and national, and corruption, which is a specific way that the public sector manifests inefficiency.

The first essay studies the efficiency of the public sector in the state-level governments in Brazil. More specifically, it firstly estimates the efficiency levels of the public sector in expenditures and tax collection. Then, it compiles them into an index that expresses the general efficiency level of the state governments. Secondly, as an attempt to improve

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[1] Available at: https://www.tesourotransparente.gov.br/publicacoes/carga-tributaria-do-governo-geral/2020/114?ano_selecionado=2020

[2] "The Marginal Effective Tx Rate – METR - is the portion of capital-related taxes paid as a share of the pre-tax rate of return on capital for marginal investments (on the assumption that businesses invest in the capital until the after-tax return on capital is equal to the cost of financing capital)" (CHEN and MINTZ, 2015).

analytic accuracy, it analyzes exogenous factors that potentially affect the efficiency levels in this specific case.

Based on the existing or oncoming fiscal problems at the state level of governments either caused or worsened by the Covid-19 pandemic and the restrictive measures implemented, the second essay proposes a potential alternative to solve or at least mitigate them. This alternative is increasing the efficiency in collecting taxes. Firstly, it estimates the efficiency in tax collection for the Brazilian states, focusing on the Ceará state. Secondly, it adjusts a regional and dynamic CGE model to incorporate parameters of these sorts of efficiencies. Moreover, it simulates policies of increasing efficiency in tax collection in the economy of Ceará. Additionally, it also simulates a compensation between an increase in efficiency and a reduction in tax rates. To perform this last part an axiom was created by adapting the double dividend hypothesis.

The approach of the third chapter is similar to the previous one. It also applies a dynamic CGE model to evaluate possible gains with efficiency improvements in tax collection. However, in this case, the model is calibrated to represent the Brazilian economy as a whole. Similarly, alternative policies of tax rate reductions are simulated, controlling for the total tax revenue keep at least the same level as observed before the implementation of the policy. It is emphasized that the simulated economic environment takes into account Constitutional Amendment No. 95/2016.

Berg *et al.* (2015) claim that corruption is one specific way the public sector might manifest inefficiency. Furthermore, corruption is another problem involving the Brazilian public sector, which has been increasingly seen in the public debate countrywide, mostly during the past few years. Although this debate is more active concerning the central government, the state-level governments face similar problems. Therefore, given the importance of this specific topic of inefficiency in the current scenario, this thesis includes an essay for this specific approach.

Based on that, the last essay explores the effects of corruption on income issues at the state level in Brazil. One of its main contributions is to create objective proxies for corruption and apply them in these types of analyses. Furthermore, to achieve more accuracy in the connection among the Brazilian states, it also performs a spatial approach of the intended analysis.

These topics concerning both taxation and corruption go beyond their own issues, combined they also influence the Global Competitiveness Index[3]. In 2014 Brazil was the 80th position in a list of 137 countries. Tax rates are at the top of the list of the most problematic factors for doing business in Brazil. Specifically, among the countries analyzed, the effect of taxation on incentives to work puts Brazil in the last position and the effect of taxation on incentives to invest makes it the second worse case. Notwithstanding, corruption is the third of those most problematic factors above-mentioned. One associated cause is that Brazil figures in the last position on public trust in politicians. These facts contribute to justify the development of this thesis and the proposal of public policies to improve this scenario.

These four essays share the common topic of public sector efficiency. Moreover, the order they are placed is arranged to express a consistent line of development. Roughly speaking, the main point of the first essay is to estimate efficiency, the second and third incorporate efficiency in CGE models, and the last one goes deeper from the general efficiency to a specific form it can be manifested, which is corruption.

It is expected that this thesis or any of its four essays not only further our understanding but also contribute to the current public debate with important issues and findings concerning public sector efficiency in both general and specific ways. Moreover, it might assist policymakers to design and/or evaluate appropriate public policies.

Beyond this general introduction, this thesis dedicates one chapter to each essay briefly introduced along this section. Although the essays are linked and might present some textual references of the others, it is mostly related to the third and fourth chapters, which apply different approaches of CGE, it emphasizes that the essays can be read as independent works regardless of the order. Besides, a final chapter addresses general concluding remarks, which contemplates policy implications based on the findings achieved associates with references in literature.

[3] Source: International Monetary Fund. Available at: http://www3.weforum.org/docs/GCR2017-2018/03CountryProfiles/Standalone2-pagerprofiles/WEF_GCI_2017_2018_Profile_Brazil.pdf

2 PUBLIC SECTOR EFFICIENCY: A STATE-LEVEL ANALYSIS IN BRAZIL

2.1 Introduction

This chapter focuses on the efficiency of the public sector in the state-level governments in Brazil. Specifically, it firstly estimates the public sector's efficiency levels on both expenditures and tax revenue. Then it compiles them into an index that expresses the general efficiency level of the state governments. Secondly, it brings forward exogenous factors that potentially affect the efficiency levels in this specific case to improve analytic accuracy.

In terms of taxation, the Brazilian tax burden was around 33.17% and 31.64% in 2019 and 2020[4], respectively. This amount is similar to the average of the OECD members. Despite the high tax burden, Brazil has not been performing satisfactorily in providing its duties. For instance, Brazil presented a homicide rate[5] of 30.5 in 2017, one of the highest in the world. Furthermore, the OECD's Programme for International Student Assessment – PISA 2015 report[6] showed that Brazil had achieved results below the average in all assessed fields: science, reading, and Mathematics.

The combination of collecting as a developed country and delivering poor outcomes can be explained by low expenditure efficiency. Additionally, Brazil has presented fiscal deficits since 2014, contributing to an enlargement of the public debt. One could say that paying interest rates is an inefficient way to spend public resources, plus it likely shortens transfers for the state governments. Romer and Romer (2010) point out, among other categories, that inherited budget deficit motivates tax changes. However, their main results show that tax increases are highly contractionary. It could make the fiscal deficit situation even worse. Conversely, increasing tax collection efficiency might increase the amount collected without the distortion created by the tax rate increments or their side effects.

Most public services are provided by the state-level governments that manage a considerable part of the budget. However, local governments have a clear dependence on central government resources distributed at the national level. More importantly in terms of education, health, and security. It might interfere with state-level governments' budget and, thus, on the provision of public services or the quality of those. Once part of their budget comes from their

[4] Available at: https://www.tesourotransparente.gov.br/publicacoes/carga-tributaria-do-governo-geral/2020/114?ano_selecionado=2020
[5] The total of deaths caused by violent acts divided by 100.000 inhabitants.
[6] OECD (2018). Available at http://www.oecd.org/pisa/.

tax collection, improve the efficiency of performing this task figures as an alternative to provide more resources. Cevik *et al.* (2019) shows that the efficiency in collecting the value-added tax may change over the years, depending on the structural transformation.

According to Pritchett (2000), it is not correct to believe that the government will convert each monetary unit spent into the same amount of public capital. Assuming it might work regarding the provision of the public sector, it is reasonable to consider inefficiency as an eligible explanatory factor for the Brazilian scenario previously described, including the state-level governments, once they perform most of their activities. However, as roughly shown in the previous paragraphs, efficiency issues are spread over the public sector activities, namely that, spending resources and collecting taxes. Thus, once these two duties are linked, studying their efficiency levels separately might not lead to a complete understanding of the public sector's efficiency.

The literature regarding the approaches used to measure efficiency is divided into two major methods, namely that, parametric and nonparametric. Besides, there is a semiparametric model recently developed by Ferrara and Vidoli (2017). The most known parametric method is the stochastic frontier analysis, independently and simultaneously developed by Aigner, Lovell, and Schmidt (1977) and Meeusen and van den Broeck (1977). Regarding the nonparametric approach, despite seminal contributions such as those in Farrell (1957) and Farrell and Fieldhouse (1962), the two most applied methods to measure efficiency concerns to Data Envelopment Analysis (DEA), introduced by Charnes, Cooper, and Rhodes (1978)[7], and the Free Disposal Hull (FDH), by Deprins, Simar, and Tulkens (1984).

The applications mainly assess the efficiency and productivity of both public and private sector activities. The nonparametric methods are used the most, and the DEA is the most commonly applied among them. Cooper, Seiford, and Tone (2007) explore a discussion by comparing both nonparametric DEA and FDH. Focusing on criteria such as growth statistics on publications and the commonly used academic journals, Emrouznejad and Yang (2018) compiled information regarding DEA-related papers from 1978 to 2016. Similarly, but focusing on recent years, Liu, Lu, and Lu (2016) list research fronts in DEA.

Cazals, Florens, and Simar (2002) proposed a new approach by defining a partial production frontier's statistical concept in the relatively recent literature. This chapter follows the *Order-m* efficiency estimation, which is more robust to outliers and/or extreme values, which are the main points under criticism against the envelopment estimators. It has been

[7] Banker, Charnes, and Cooper (1984) provide an alternative approach on DEA method.

increasingly applied for real-data since then (Pilyavsky and Staat (2008); Cunha Marques and De Witte (2011); Tauchmann, 2012; Felder and Tauchmann (2013)).

The remainder of this chapter unfolds as follows. The next section discusses the methodology and data. It also introduces the efficiency measure created in this chapter. In section three, the results are presented based on the two-stage method applied. Section four brings a discussion and some policy implications. Moreover, to conclude, the main topics and the most interesting results are highlighted as final remarks.

2.2 Methodology, Efficiency Measure, and Data

The method applied in this essay follows a two-step approach, as in Simar and Wilson (2007). However, in the first stage, instead of using a Data Envelopment Analysis – DEA, it applies the *Order-m* efficiency estimation from Cazals, Florens, and Simar (2002). Although this efficiency estimation method is related to the usual nonparametric estimators such as DEA and FDH, it is more robust to extreme values and outliers. Based on this approach, it estimates the state-level government's efficiency scores in terms of expenditure and taxation and creates an index that compiles them in a general efficiency measure.

Then, in the second stage, a panel data analysis evaluates the variation in efficiency scores obtained in the previous stage controlling for a set of non-discretionary inputs. It performs the regressions by considering both the index and its components as dependent variables, which might provide more accuracy to the analysis. Besides, with the two-step approach, it takes advantage of the panel set to control for time-invariant unobservable characteristics that can affect efficiency at the local level.

This approach comes at the cost of relying on the separability assumption, which states that the environmental factors affect the relative efficiency but not the production frontier's shape (Bădin, Daraio, and Simar, 2014). However, it is assumed it is not too restrictive because the technology of the provision of goods and services is expected to be defined at the national level and not at the local level. Recent applications can be found in Agasisti and Zoido (2019), Ayala-García and Dall’erba (2020), and Gu and Ayala-García (2020).

2.2.1 Efficiency Estimation

In terms of estimation of the efficiency levels, there are different estimations based on the main idea of estimate a general level of efficiency of the public sector. Starting with the simplest one, the tax revenue efficiency is a single input and single output procedure. On the expenditure side, on the other hand, the efficiency levels are estimated in two ways: first by sector individually and then by combining them into only one measure, the total efficiency in expenditures. A single input to the expenditure is created by applying a simple sum in the sectors' inputs.

The compiled efficiency requires a weighted average. It weights the expenditure sector efficiency with their respective shares of the total input, following the price independent method proposed by Färe and Zelenyuk (2003). The assumption behind this is that the shares represent the concerns the governments assign to each sector. Once the efficiencies are estimated for both taxation and expenditure, they are combined into a single efficiency measurement to create every state's general efficiency score. The procedure to obtain this measure and the possible outcomes, as well as their interpretations, are expressed in the following section.

2.2.2 Public Sector General Efficiency

Once this chapter aims to create an index to represent a general efficiency level in the public sector. It compiles expenditure and tax collection efficiency into a unified index. The most intuitive way to perform this is by taking a simple average of them in each cohort. Since it is made year by year, the Public Sector General Efficiency Index, henceforth PSGEI, is given as:

$$PSGEI_t = 0.5 * (\epsilon_{col,t} + \epsilon_{exp,t}) \quad (2.1)$$

where at time t, $\epsilon_{col,t}$ and $\epsilon_{exp,t}$ are the efficiency levels in tax collection and expenditure, respectively.

Beyond the analyses of estimated levels of efficiency both separately and compiled into the PSGEI, given there is a set of years range, it can also analyze how they behave over the years. However, since it combines two types of efficiency, which can be either positive or negative, both the index and its variations can mislead the analysis. Understanding how every component of the index changes over the years could be as interesting as the full index. Therefore, this analysis covers the evolution over the years for the index and its components.

As long as the outcomes of each term of the PSGEI can assume either positive or negative values, the index by itself can also assume either positive or negative values. Another possibility, although it is highly unlikely to occur, is to be zero. The main reason for the low probabilities is that the variations need to present the same magnitude and opposite directions.

Regarding those feasible combinations, there are different cases. It mostly depends on the directions of both types, whether positive or negative. In cases that the variations present the same direction, the efficiency gains or losses are boosted. Conversely, a combination of opposite directions results in different outcomes, depending on their magnitudes. A positive effect can overcome a negative one making it ends up as an efficiency gain. Additionally, it might be not enough to do so but enough to mitigate it resulting in a loss of efficiency.

Based on this brief overview, all the possible outcomes may be classified. The classification makes the status of efficiency variation well defined, formal, and easily understandable. Therefore, consider the following axiom.

Axiom: The Public Sector General Efficiency Index Status.

Let the change in the government efficiencies in both expenditure and taxation in a certain range of time, from $t - i$ to t, where $i = \{1, \dots, T\}$ is within the studied range, be expressed respectively by $\Delta\epsilon_{exp} \gtreqless 0$ and $\Delta\epsilon_{col} \gtreqless 0$. The Public Sector General Efficiency Index yields one of the following five mutually exclusive status.

i) Global Efficiency Improvement.

It occurs when $\Delta\epsilon_{col} > 0$ and $\Delta\epsilon_{exp} > 0$.

The final result is $PSGEI > 0$.

ii) Partial Efficiency Improvement.

It occurs when either $\Delta\epsilon_{col} \geq 0$, and $\Delta\epsilon_{exp} \leq 0$, and $|\Delta\epsilon_{col}| > |\Delta\epsilon_{exp}|$, or $\Delta\epsilon_{col} \leq 0$, and $\Delta\epsilon_{exp} \geq 0$, and $|\Delta\epsilon_{col}| < |\Delta\epsilon_{exp}|$.

The final result is $PSGEI > 0$.

iii) Partial Efficiency Loss.

It occurs when either $\Delta\epsilon_{col} \geq 0$, and $\Delta\epsilon_{exp} \leq 0$, and $|\Delta\epsilon_{col}| < |\Delta\epsilon_{exp}|$, or $\Delta\epsilon_{col} \leq 0$, and $\Delta\epsilon_{exp} \geq 0$, and $|\Delta\epsilon_{col}| > |\Delta\epsilon_{exp}|$.

The result is $PSGEI < 0$.

iv) Global Efficiency Loss.

It occurs when both $\Delta\epsilon_{col} < 0$ and $\Delta\epsilon_{exp} < 0$.

The result is $PSGEI < 0$.

v) Neutral

It occurs when either $\Delta\epsilon_{col} \geq 0$, and $\Delta\epsilon_{exp} \leq 0$, and $|\Delta\epsilon_{col}| = |\Delta\epsilon_{exp}|$, or $\Delta\epsilon_{col} \leq 0$, and $\Delta\epsilon_{exp} \geq 0$, and $|\Delta\epsilon_{col}| = |\Delta\epsilon_{exp}|$.

The result is $PSGEI = 0$.

The formula to perform that uses the general term i to specify the lag component within the range. In this chapter, it will be calculated by setting $i = 1$, which means the lag between the target year and its prior.

2.2.3 Regressions

This section describes the second step of the applied method. After measuring the efficiency on both sides and compile them, creating the PSGEI index, one can go beyond that by investigating exogenous factors related to the efficiency scores. It might provide more accuracy to the analysis. Thus, a standard panel data model is performed, which allows evaluating the variation in efficiency level among the Brazilian states controlling for a set of observable and unobservable characteristics. It performs the regressions by considering both the index and its components as the dependent variables. The econometric approach is the following proposed model:

$$Y_{its} = \alpha_s + X_{it}\beta_s + c_{is} + c_{ts} + e_{its} \quad (2.2)$$

where Y_{its} is the efficiency level of the state i in time t for the score s, which works for the efficiency scores individually as well as the PSGEI index, X_{it} represents the set of exogenous variables, c_{is} and c_{ts} are the fixed effects for space and time, respectively, and, finally, e_{its} is the error term. The set of variables for both steps are described in the following section.

2.2.4 Data

2.2.4.1 First Stage: Efficiency Estimations

Due to this Chapter's main intention to express a global level of efficiency of the public sector, the approach applied considers the expenditures and tax collection, which are the local government's two core duties. Besides, the purpose of performing a dynamic analysis requires a certain range of all data. However, given the limited availability of data, the cross-sections are taken every two years, making it a three-year sample, which is 2009, 2011, and 2013.

For the expenditure side, this essay considers three government sectors: education, healthcare and sanitation, and security. These sectors are chosen because they represent around 70% of the total expenditures of the state-level governments. It is considered one input by sector, which is the average expenditure on that specific sector, in *per capita* terms. Regarding the outputs, on the other hand, the multiple outputs approach is used.

The public expenditures used as inputs are usually spent in two different ways, salaries of the public sector workers, classified as a flow component, and investment and maintenance, which can increase the stock of public capital. Thus, the outputs in one specific year are undoubtedly affected by the previous years' expenditure. Therefore, this is the main reason behind using an average instead of the spendings in a specific year.

For the security sector, the outputs used are homicide rate[8], Narcotics traffic, and Rape rate. For the health and sanitation sector, the outputs cover both health and sanitation. The health-related outputs[9] are the Child Mortality rate, the number of hospital beds, and the number of ambulatories[10]. Regarding sanitation, the outputs are the coverage of sewer and the coverage of drinking water. For education, different outputs consider both quantity and quality. In terms of quality of education, it uses the Basic Education Development Index – IDEB, while for the quantity it uses the attendance rate and the age-grade distortion. Because the state-level governments mostly fund the high school level, both quantitative and qualitative regard to this school level. Table 2.1 summarizes all the components of the expenditure side analysis.

Table 2.1 - Summarized description of Inputs and Outputs

Sector	Input	Output
Education	Average expenditure in Education (*per capita*).	IDEB; Attendance Rate; Age-grade distortion.
Health and Sanitation	Average expenditure in Healthcare and Sanitation (*per capita*).	Child Mortality rate; Number of Hospital beds; Coverage of sewer; Coverage of drinking water.
Security	Average expenditure in Security (*per capita*).	Homicide Rate; Narcotics traffic; Rape rate

Source: Author’s elaboration.

We apply the single input-output approach for taxation, where the input is the GDP, and the output is the tax revenue. This amount includes all the taxes the state-level government is responsible for collecting. Although the variables are all transformed to *per capita* terms,

[8] Collected in the official government database named IPEADATA. Available in http://www.ipeadata.gov.br/Default.aspx

[9] These inputs use data collected from the official site of the Central Government’s Ministry of Health in its official database called DATASUS. Available in http://www2.datasus.gov.br/DATASUS/

[10] Both numbers, hospital beds and ambulatories, were population-normalized.

and the inputs have the same metric, the outputs present different scales, making them not compatible. The Min-Max Scaling method is applied to overcome this issue.

2.2.4.2 Second Stage: Regressions

The explanatory variables used are related to the units' structural characteristics such as the informal sector's size, the unemployment rate, the population size, and the population density. Table 2.2 summarizes the variables used as well as a short description of them.

Table 2.2 - Summarized description explanatory variables for the regressions.

Variable	**Description**
Population	The logarithm of the resident population.
GDP	The logarithm of the Gross Domestic Output - GDP
Unemployment	Share of people who did look for a job but did not find it.
Informality	Share of employees with no formal work or labor contracts.
Demographic Density	Total of Population divided by the total area (Km2)

Source: Author’s elaboration.

2.3 Results

Given the composition of this chapter, specifically regarding the two-step method, which regards both the estimation of the efficiency scores for the Brazilian states and the regressions for exogenous drivers of efficiency, the results are divided into two sections. As long as it brings light to the importance of the understanding of the scores of efficiency and the dynamics associated with them, this first part shows the results for the efficiency scores and their variation. Worthy to emphasize that these efficiency scores are relative measures. Therefore, each year estimated is a comparison considering all the Brazilian states.

2.3.1 Results for the Estimations of Efficiency and Efficiency Measurement

To assure this analysis, it provides the states' status in terms of the Public Sector General Efficiency Index, from the axiom abovementioned. This one-period dynamic analysis, 2011 - 2013, allows us to look at the states' directions concerning improvements or losses in the efficiency levels. Table 2.3 shows the efficiency scores and the status of the PSGEI from the first period (2009) to the last (2013) by setting the states by region.

Table 2.3 - Expenditure efficiency in the Brazilian States, 2009-2013

States / Region	PSGEI 2009	PSGEI 2013	Change in Exp. Eff.	Change in Tax Eff.	Change in Total Eff.	Status PSGEI
Northeast						
AL	.31	.31	.00	-.01	-.00	Partial Loss
BA	.60	.59	-.03	.01	-.02	Partial Loss
CE	.71	.68	-.04	.01	-.03	Partial Loss
MA	.69	.63	-.04	-.01	-.06	Global Loss
PB	.57	.59	.02	.01	.02	Global Improve
PE	.58	.49	-.01	-.08	-.09	Global Loss
PI	.69	.66	-.03	.00	-.03	Partial Loss
RN	.36	.27	-.09	-.01	-.09	Global Loss
SE	.31	.29	-.01	.00	-.01	Partial Loss
North						
AC	.28	.23	-.05	.00	-.05	Partial Loss
AM	.32	.31	-.02	.00	-.01	Partial Loss
AP	.24	.25	.01	.00	.01	Global Improve
PA	.55	.61	.04	.03	.07	Global Improve
RO	.38	.35	-.01	-.01	-.03	Global Loss
RR	.38	.29	-.09	.00	-.09	Partial Loss
TO	.34	.33	-.01	.00	-.01	Partial Loss
Midwest						
DF	.44	.42	-.02	.00	-.01	Partial Loss
GO	.50	.47	-.05	.02	-.03	Partial Loss
MS	.38	.37	-.01	.00	-.01	Partial Loss
MT	.40	.41	-.01	.02	.01	Partial Improve
Southeast						
ES	.44	.41	-.01	-.01	-.03	Global Loss
MG	.85	.87	.00	.02	.01	Global Improve
RJ	.65	.66	-.01	.02	.01	Partial Improve
SP	.92	.91	-.01	.00	-.01	Partial Loss
South						
PR	.59	.61	.00	.02	.02	Global Improve
RS	.62	.63	.00	.01	.01	Global Improve
SC	.56	.54	-.02	.00	-.02	Partial Loss

Source: Author’s elaboration from the research results.

At a glance, it is easy to notice that there exist more statuses related to losses than to improvements. The general efficiency captured by the PSGEI decreased in 19 out of the 27 states. This result is driven mainly by the decrease in expenditure efficiency (20 out of 27). In contrast, most states improved efficiency in taxation, in which only six states performed reductions on it. By taking into account the construction of the PSGEI, it implies that the increases in the taxation were not enough to compensate the reductions on the expenditure efficiencies for those units that presented the specific status of a Partial Loss, which are present in 14 states.

Since this specific status of partial loss means the government is catching more resources in form of taxes and the expenditure side is getting worse spending them, one would assume this type of partial change is worse than it is when the improvement comes from the expenditure. It is reasonable to think of it due to the amount of resources is being wasted.

It also stands out that the Northeast region presents the lowest portion of improvements, only the Paraiba state (PB) shows a Global Improvement status in this region. Besides, among the other eight states, three of them presented a Global Loss status, namely that, Maranhão (MA), Pernambuco (PE), and the Rio Grande do Norte (RN), which are by the way among the highest losses considering the whole sample. It makes the situation of this region even worse in this sort of analysis. On the other hand, the South region presents the biggest share of improvements, two out of its three components. Also, it is emphasized that the states of Rio Grande do Sul (RS) and Paraná (PR) presented Global Improvements, which is the best scenario of improvements according to the axiom previously shown.

Based on the axiom of the Public Sector General Efficiency Index status, a Brazilian state that partially improves its efficiency might still be wasting more resources than before, although this wasting is relativelly lower than in cases of partial loss discussed before. It happens when the improvements in taxation are higher than the efficiency reductions in expenditures, as observed in the cases of Mato Grosso (MT) and Rio de Janeiro (RJ).

This discussion suggests that positive changes in tax collection require efficiency improvements on the expenditure side to compensate for the increasing amount of resources and avoid wasting more available resources.

2.3.2 Results for the Regressions

Regarding the regressions performed for the second step, it considers the full sample, which is composed of the years of 2009, 2011, and 2013, and considers the expenditure and revenue efficiency scores as dependent variables, as well as the aggregated PSGEI. It also takes into account the different expenditure sectors: Education, healthcare, and security. Once the public sector has no control over some factors likely related to the efficiency levels, they are exogenous drivers. As previously described, it applies fixed effects regressions with robust standard errors, as suggested in Hoechle (2007) and Wooldridge (2010). Table 2.4 shows these results.

The results show the expected signs for most of the coefficients, although they are not always statistically significant. The population's size negatively affects the efficiency of the public sector expenditures as a whole and the Education sector specifically. Thus, more populated states tend to have reduced efficiency in expenditures. It makes the efficient provision of public goods harder, once controlling for GDP and population density. Conversely, the population size is correlated to increases in tax collection efficiency.

Table 2.4 - Second stage: effects of non-discretionary variables on efficiency scores and PSGEI.

Independent variables	PSGEI	Expend. efficiency	Education efficiency	Health care effic.	Security effic.	Tax Collect.
Log(Pop.)	-.011	-.470**	-.876**	-.032	-.270	.448**
	(.135)	(.208)	(.384)	(.396)	(.653)	(.214)
Log(GDP)	.188**	.423**	.714**	.393**	.067	-.048
	(.090)	(.172)	(.260)	(.178)	(.347)	(.125)
Unemployment	-.003	-.012*	-.008	-.001	-.033**	.006
	(.003)	(.006)	(.014)	(.007)	(.013)	(.004)
Informality	-.004	-.007	-.008	.003	-.018**	-.002
	(.003)	(.004)	(.009)	(.005)	(.008)	(.002)
Pop. Density	1.052***	1.772**	1.807*	-.149	5.294**	.332
	(.377)	(.843)	(.995)	(.643)	(2.336)	(.418)
Constant	-3.647*	-2.056	-2.868	-8.651*	4.147	-5.239*
	(1.964)	(4.036)	(5.605)	(4.878)	(9.388)	(2.679)
Observations	100	100	100	100	100	100
R-squared	.516	.457	.410	.116	.274	.375

Source: Research results. *, **, and *** represent the significance respectively at 10%, 5%, and 1%. Standard deviations in parentheses.

Regarding the population density, on the other hand, the coefficients are positive. It might be related to a sort of gains of scale. It is reasonable to think that distance to public facilities such as hospitals and schools is important. Therefore, one facility placed in a more geographically dense area tends to serve more people as long as there are no serious difficulties to head to the facility comparing to more spread areas.

Concerning the effects of the GDP, the coefficients for the efficiency in expenditure show that the richer a state is, the higher its expenditure efficiency, except for the security sector. However, although not significant, this positive effect is not observed on the taxation side. There is no doubt that with more resources, it is possible to hire more qualified people and companies to improve efficiency, reduce costs, assess the resources spent on projects and programs, etc. Besides, it might result from possible spillovers coming from the higher education level associated with richer states.

Unemployment and Informality present negative and significant impacts on the security sector. It suggests a correlation between social problems related to the job market and the local government's ability to provide safety to their residents. Based on this result one would say that places with higher labor informality and unemployment may require more public resources to fight against crime and illegal activities.

In fact, according to a study performed by a commerce-related agency in Brazil[11], high rates of theft of cargo and commercial establishments are related to informality in the labor market. The goods and products resulting from thefts tend to be resold irregularly in the informal market, generating losses for the economy and society, especially in the period close to important commercial dates such as Christmas and Easter.

2.4 Discussion and Policy Implications

The Brazilian central government's budget is facing deficits, and so are the state tiers of governments. This situation becomes more relevant considering the economic impacts coming from the Covid-19 pandemic already reported in the literature (McKibbin and Fernando (2020); Fernandes (2020); Zhang, Hu, and Ji (2020); Sumner, Hoy, and Ortiz-Juarez (2020)). Also, some studies have already found negative consequences of the Covid-19 pandemic for the Brazilian economy (Domingues, Cardoso, and Magalhães, 2020; Domingues *et al.*,2020). Besides, both the central and the state-level governments will deal with a reduction in the tax revenue given its dependence on the GDP, which is affected by the economic activity decline and unemployment increase.

Since Brazil's tax burden is already high, an increase in tax rates is a short-term solution highly unlikely to be approved by politicians. Thus, increasing tax revenue efficiency might be a better way to mitigate the highly likely negative impacts left by the pandemic after the economy starts to recover. In other words, the amount collected may increase by improving efficiency in tax collection. This policy helps both the central government and the state tiers to overcome the problems of both provision and budget, which are closely related.

On the other hand, improving efficiency in expenditures allows the governments to provide more in terms of quantity and quality of public services, spending the same amount of resources or even less. Besides, considering the harmful effects of these pandemic times, working on efficiency improvements might help the states soften the impacts for the citizens. Indeed, these government actions present higher potential benefits for the people, mainly in the

[11] Pirataria do Brasil: Radiografia do Consumo. Available at: https://www.igac.gov.pt/documents/20178/557437/Pirataria+no+Brasil.pdf/60bedb42-fbb1-4cfa-9b4d-8857cdc95f47

poorest states since their dependence on public goods and services is higher than those with a higher income *per capita*.

According to Berg *et al.* (2015), a government might increase its efficiency in different ways. They indicate some examples of efficiency drivers such as misallocation of resources and wasting from failure in planning and execution of public projects or programs. The efficiency scores estimated in this Chapter provide a diagnosis for policymakers. The results from the regressions, on the other hand, provides an understanding out of the public sector controls but that it can interfere with public policies.

In a nutshell, as an important stakeholder in the economy, the government must find ways to assist the agents, namely that, households and firms, mostly the poorest ones. This assistance is not necessarily related to providing more public services. States can provide better incentives to the productive sector targeting economic growth. It must boost the recovery of the economy, not only for these pandemic-related situations but also for any other that involves a reduction in economic activity.

Finally, although it takes many administrative and institutional efforts, one of the most important takeaways is a supposably costless policy. It means that the workers and the physical structure required for increasing efficiency are already available. Perhaps, it is only missing a plan, a direction, or even the willingness to perform the necessary steps.

2.5 Final Remarks

This chapter brings light to a general understanding of efficiency. Firstly, it goes beyond estimating the efficiency levels in the public sector expenditures and taxation by combining them to create an index to express the general level of the efficiency of the Brazilian states, which is called the Public Sector General Efficiency Index - PSGEI. Besides, the axiom of the status of the PSGEI shows how these efficiency levels behave over a certain period.

The findings firstly highlight the low level of efficiency for most of the Brazilian states. Splitting the states by region provides a way to compare. The differences between the poor and the rich states stand out. For instance, São Paulo state (SP), which has the highest income among them, presents the higher efficiency levels in both years displayed. Conversely, the state of Acre (AC) presents the lowest level of the PSGEI. These results are confirmed for the second step, which presents a significant and positive correlation between the efficiency scores and GDP.

Another noteworthy result regards the dynamic analysis. It is found that most of the states presented some sort of loss in the efficiency levels. Even though there is a gap of a few years between the results and the current situation, it is reasonable to think that there are still different levels of efficiency among the states, given that public policies for improving efficiency can be hard to implement.

Regarding taxation, a low-efficiency level makes the government apply a higher tax rate than it could do by achieving higher efficiency. It distorts the economy and works as negative incentives for the economic agents composing the private sector that maintain the public sector by paying taxes. As an important stakeholder in the economy, the government should find better economic arrangements by increasing its efficiency levels.

This chapter provides an alternative and budgetary costless way to mitigate problems with the governments' resources and the expected negative economic and social effects of the Covid-19 pandemic. Therefore, it contributes to the literature and provides some insights for the policymakers concerning this topic and its potential that remains unexplored so far, especially in terms of public policies.

3 EFFICIENCY IN TAX COLLECTION: OVERCOMING THE EFFECTS OF THE COVID-19 PANDEMIC ON PUBLIC FINANCES OF THE CEARÁ STATE

3.1 Introduction

This chapter proposes a potential alternative to solve or at least mitigate an upcoming problem on the finances of state-level units in Brazil led by the Covid-19 pandemic and the measures applied by the governments. This alternative is increasing the efficiency of tax collection. Therefore, it proposes to estimate the efficiency in tax collection for the Brazilian states, focusing on the Ceará state, and apply it in a regional and dynamic CGE model to simulate these sorts of policies in the economy of Ceará. Additionally, it also simulates a compensation between an increase in efficiency and a reduction in tax rates.

The Covid-19 pandemic that has plagued worldwide since the beginning of the year 2020 has led several governments, both national and local, to declare an emergency, consequently adopting measures to promote social distancing. Therefore, for a few months beginning in March, the main measures imposed restrictions on economic activities, given the fact that not only the workplaces but also the common daily activities usually gather people.

Given the fact that this health crisis has shown impacts in the whole world, a considerable amount of studies has been developed and published so far covering several different fields. Specifically for economics, for instance, there are works for the economic effects from it (McKibbin and Fernando (2020), Fernandes (2020), and Atkeson (2020)) for financial markets (Zhang, Hu, and Ji (2020) and Ashraf (2020)), for poverty (Sumner, Hoy, and Ortiz-Juarez (2020), Buheji *et al*. (2020), and Martin *et al*. (2020)). Specifically for the Brazilian case, these impacts are reported for instance by Domingues *et al*. (2020).

Regarding the economic effects in the Ceará state specifically, IPECE (2020a), using an indicator for the trend of the performance in the short-term, namely that, the Quarterly GDP, shows that the GDP of the Ceará state in the second quarter of 2020, the period with more severe measures to reduce the speed the virus spreads out, has decreased 14.55% comparing to the same period of 2019. Meanwhile, Brazil presented an 11.4% decrease. Considering the cumulative first semester, this decrease for Ceará represented 7.58%, while Brazil presented 5.9%. However, considering the cumulative from the last four quarters, the decrease is around 2.72% and 2.2% for Ceará and Brazil, respectively. So far the forecast for the economic growth of Ceará's economy for the year 2020 is -4.5%. It is better than the expectation for the Brazilian economy as a whole. According to IFI (2020), the government itself maintained its projection of a 4.7% decline and the International Monetary Fund (IMF) updated its projection to a retraction by 5.8%. This value is also close to the market expectations estimated by the Central Bank, which is a 5% drop. Finally, the IFI's fiscal scenarios consider a 6.5% decline.

Specifically in terms of the job market, based on the data published by PNAD COVID from IBGE for the period from May to August, IPECE (2020c) shows the estimated level of occupation in Ceará, which is the share of the population aged 14 over the number of people who worked even in some informal occupation, fell from 41.6% in May to 39.9% in August. The estimated participation rate, which is the percentage of people in the workforce in the reference week relatively to people of working age, went from 45.6% in May to 46.0% in August. The unemployment rate, which is the percentage of unemployed people in the reference week relative to people in the workforce that week, increased from 8.6% in August to 13.1%.

Revenues fall due to the retraction of economic activity and tax exemptions and deferrals. At the same time, expenditures are rising rapidly to mitigate the effects on the income of the most vulnerable part of the population and the financial situation of smaller companies, besides the increase in spends directly on the health system (IFI, 2020). According to official data from IPECE (2020b), in April 2020 it was observed a significant reduction in the collection of ICMS (Tax on the Circulation of Goods and Services), which is the main source of revenue for the Ceará state government and accounts for approximately half of the current tax collection. It shows it was 36.7% lower than in the same month of the previous year. The biggest drop was in May 2020, with a reduction of 39.4%. Subsequently, in June and July there was still a decrease in revenue, but with a lower intensity than in previous months. Considering the four months, which is the period that lasts the policy of social distancing and that it starts to be relaxed, the reduction in the collection of ICMS was approximately 22.7%.

Based on that, the Emergency Aid, implemented by the Complementary Law 173/2020[12] and provided by the Central Government, as well as extraordinary credits for the Ministry of Health, are very close to supplement this reduction in tax collection. Indeed, according to IPECE (2020d), the amounts transferred in order to mitigate the effects of Covid-19 outweigh the observed drop in the collection of ICMS. However, it should be noted that the second main source of state revenue, the State Participation Fund (FPE), consists of revenues from the Income Tax and taxes on industrialized products collected by the Federal government

[12] It defines the Federative Program for Confronting the Coronavirus SARS-CoV-2 (Covid-19), which basically suspends the payments of contracted debts between the central government and subnational units, transfers from National funds as financial assistance to the States, the Federal District, and the Municipalities, in the year 2020, to apply in actions to confront the SARS- Coronavirus CoV-2 (Covid-19).

and transferred to the subnational units, and that are sensitive to the economic cycle. It is emphasized that the transfers carried out were lower than the revenue losses for this period in 163 million. In terms of net impacts, it can be concluded that the policies taken by the federal branches, Executive and Legislative, during the health crisis contributed significantly to mitigate their negative fiscal effects.

Even though the compensation from the Central Government has been enough for a while, one must remember there was still a reduction in the GDP for the year 2020. Hence, there is a reduction in tax collection. Moreover, it should be noted that there is a possibility that the tax collection will not recover quickly after the end of the pandemic period as well as the Central Government might not keep its policies to aid the state-level governments. It means that in the coming months the tax collection at all, not only the ICMS collection, will be at levels lower compared to the previous year.

The very first way that comes up in one's mind to surpass this upcoming and delicate fiscal situation is increasing tax rates. However, in terms of the tax burden, Brazil presents a tax burden/GDP ratio similar to the average of OECD's members. Official data shows it was around 33.17% in 2019 and 31.64% in 2020[13], considered one of the highest tax burdens in the world. However, this amount collected has been not enough to afford public spends and it is facing successive fiscal deficits since 2014, contributing to a continuous enlargement of the public debt. Besides, according to Romer and Romer (2010), tax increases are highly contractionary. Therefore, it is highly likely that increasing tax rates would worsen the current economic situation, hence it is unlikely to be approved in congress.

Based on Brazilian federalism, which is the way the central government collects and distributes the revenues to the subnational units, this scenario combined with the remaining effects of the Covid-19 pandemic might bring future fiscal problems for the public finances of state-level governments as well. Therefore, an increase in efficiency in tax collection might provide a feasible alternative to mitigate the remaining effects of the Covid-19 pandemic in public finances.

The literature of efficiency performance in tax collection issues has not been properly explored, although very recent literature has analyzed the efficiency on taxation, especially looking for explanatory factors (Morrissey *et al*. (2016), Aizenman and Jinjarak (2018), Cevik *et al*. (2019)). However, there is a gap in the literature combining efficiency on tax collection and dynamic CGE models, which allow the analysis to cover the whole economy.

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[13] Available at: https://www.tesourotransparente.gov.br/publicacoes/carga-tributaria-do-governo-geral/2020/114?ano_selecionado=2020

Therefore, combining it with the described scenario, the approach of this chapter is justified, namely that, it analyzes the efficiency in tax collection for the Brazilian states, focusing on the Ceará state, and incorporates it in a regional and dynamic CGE model to simulate policies of both increases in efficiency and compensations with a reduction in tax rates.

Concerning the national literature about regional CGE, there are several references. Based on ORANI type models (Dixon, Parmenter, and Sutton (1978) and Dixon *et al*. (1982)), Guilhoto (1995) developed a model for Planning and Analysis for Agricultural Policies, which works for the State of São Paulo as well as for Brazil as a whole. Yet, based on Dixon e Parmenter (1996), Haddad (1999) created the first inter-regional CGE model totally operational for Brazil, called B-MARIA (Brazilian Multisectorial And Regional/Inter-Regional Analysis). From it, several other models have been developed such as the B-MARIA-SP (Domingues and Haddad (2002)), the B-MARIA-27 (Haddad (2004)), the B-MARIA-27-IT (Haddad and Perobelli (2005)) and the B-MARIA-RS (Porsse (2005)).

Domingues e Haddad (2002) and Domingues e Lemos (2004) splits Brazil into two regions, namely that, the state of São Paulo and the rest of Brazil. This is way easier than models based on the TERM (The Enormous Regional Model), from Horridge, Madden, and Wittwer. (2003), which disaggregates for more regions. Aiming to evaluate the long-term effects of the installation of petroleum refineries in the Northeast region, Ribeiro (2017) creates a dynamic model called the Brazilian Northeast Inter-regional Model - B-NORIM. Fochezatto (2002) and, more recently, Braatz *et al*. (2015) for the Rio Grande do Sul state, which is both dynamics.

It is emphasized that none of the models presented in these references considers efficiency in the public sector. Only Lucio *et al*. (2020) includes efficiency in a CGE model. However, it refers to efficiency in the provision of public goods and it uses a static model. Therefore, this chapter aims to contribute to the literature by filling this gap by creating a dynamic and regional CGE model that considers the efficiency in terms of tax collection. Additionally, once the governments influence the other economic agents by incentives, one way the government might take action is by increasing its efficiency level performing tax collection, which emphasizes the convenience of this approach.

Five more sections compose this chapter, beyond this introduction. The following two sections present, respectively, the dynamic CGE model for the Ceará state and the calibration of it. In section four, the efficiency scores are estimated and minor analyses are performed as partial results. In section five, some simulations of changes in efficiency in tax collection are performed and discussed. Finally, the most relevant results are highlighted as well as some policy implications are provided.

3.2 The Iterative, Recursive-Dynamic, and Ceará's Economy Model of Analysis – IRACEMA.

The model developed in this chapter is based on a recursive dynamic CGE model, from Hosoe, Gasawa, and Hashimoto (2016). The Iterative, Recursive-dynamic, and Ceará's Economy Model of Analysis – IRACEMA[14] brings forth two major changes compared to its reference model. Firstly, once it was developed for state-level analysis, the foreign sector is divided into two regions, namely that, the rest of Brazil and the rest of the world, as in a static version presented in Paiva *et al*. (2019) and Lucio *et al*. (2020), which in turn is based on Hosoe, Gasawa, and Hashimoto (2010). Secondly, for covering the main point of the chapter, efficiency parameters are included in the taxation duties of the government.

Although the feature of the division of the foreign sector seems unnecessary for the intended approach, it yields a more realistic model for the type of region that is being considered. Besides, this model can be used as a reference model that considers differences in foreign trade, in which one region is subject to the exchange rate but the other is within a common area of trade, which in turn can be either a state-level approach or a region using a similar currency such as the European Union. The improvement proposed stands as a contribution not only to the national literature but also to the CGE literature as a whole. The IRACEMA Model is presented in detail in the following sections.

3.2.1 Productive Sectors

As long as the Iracema Model is dynamics, this feature must be emphasized in this beginning. Thus, the factor endowments, labor, and capital evolve over the periods. The labor endowments (FF_{LAB}) grow at the same rate as the population growth (pop), then it is driven by this equation:

$$FF_{LAB,t+1} = (1 + pop) * FF_{LAB,t} \tag{3.1}$$

Once installed the capital is assumed immobile among the sectors. Let the parameter dep represent the depreciation of capital, the capital stock in sector j in the following period is determined by the combination of the current capital stock combined with new capital, converted from investment ($II_{j,t}$). It can be represented as.

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[14] Iracema is a very famous native/indigenous fictional character related to the Ceará's lands, which also names the novel written by José de Alencar, nationwide known novelist. The model name was chosen to be this way associated with the Ceará State.

$$KK_{j,t+1} = (1 - dep) * KK_{j,t} + II_{j,t} \tag{3.2}$$

where $II_{j,t}$ is produced from various investment goods $I_{j,t}$ using a Cobb-Douglas type of function $\sum_j II_{j,t} = \iota \prod_i I_{j,t}^{\lambda_i}$, with ι representing the scale parameter in composite investment and λ_i representing the investment demand share.

As a basic and common assumption in CGE models, each sector is a profit-maximizing firm. Therefore, in every period it employs optimal levels of intermediate inputs $(X_{j,i,t})$ and the productive factors $(F_{h,t})$, which are combined into a composite factor $(Y_{j,t})$. Although the production process occurs in one shot, in order to achieve a satisfactory understanding, this conception requires the production to be divided into two stages:

First stage:

$$\max_{F_{h,j,t}} \pi_{j,t}^{y} = p_{j,t}^{y} Y_{j,t} - \sum_{h} p_{h,t}^{f} F_{h,j,t} \quad \text{s.t.} \quad Y_{j,t} = b_{j,t} \prod_{h} F_{h,j,t}^{\beta_{h,j}} \tag{3.3}$$

Second stage:

$$\max_{Y_{j,t}, X_{j,i,t}} \pi_{j,t}^{z} = p_{j,t}^{z} Z_{j,t}^{S} - \left(p_{j,t}^{y} Y_{j,t} + \sum_{j} p_{j,t}^{qF} X_{j,i,t} \right) \tag{3.4}$$

$$\text{s.t. } Z_{j,t}^{S} = \min\left(\frac{X_{j,i,t}}{ax_{j,i,t}}, \frac{Y_{j,t}}{ay_{j,t}} \right)$$

To make the description easier to understand the index t is omitted. The parameter b_j is a scaling coefficient, $\beta_{h,j}$ is a share coefficient of the productive factors, the parameters $ax_{j,i}$ and ay_j are input-requirements coefficients to produce one unit of output (Z_j^S). Finally, the prices of domestic goods, composite factor, and composite good, are respectively represented by p_j^z, p_j^y, and p_j^{qF}.

3.2.2 Foreign Trade: the rest of Brazil and the rest of the world.

As already known, the Iracema Model represents the Ceará's economy, thus the trade must be computed as at least two different flows, which are to the rest of Brazil and the rest of the world. Given that the economy of the Ceará state only represents around 2% of the Brazilian economy (IPECE, 2016), it is considered a small region. Combining these characteristics, namely that, an open and small economy, suggests that the Ceará state plays no significant economic impact on its trade partners. Therefore, both prices, export, and import are considered exogenous. The prices are all converted to the national currency by using a marketability margin, which in the case of foreign trade also takes into account the exchange rate.

Armington's assumption, from Armington (1969), takes place at this part of modeling, according to which all the final demanders, namely that, consumers, productive sectors, government, and investment goods, acquire not goods directly from the productive sector but rather the Armington's composite good (Q_i^F). It is actually a good composed of imports, coming from the rest of Brazil (M_i^C) as well as from the rest of the world (M_i^W), and local sectorial goods (Q_i^S). This combination is performed in a virtual sector for each one of the i-th Armington's composite good. The optimization problem is represented as:

$$\begin{aligned} &\max_{M_i^C, M_i^W, Q_i^S} \pi_{i,t}^{qF} = p_{i,t}^{qF} Q_{i,t}^F - \left[p_{i,t}^{qS} Q_{i,t}^S + p_{i,t}^{mC} M_{i,t}^C + (1+\tau^m) p_{i,t}^{mW} M_{i,t}^W \right] \\ &s.t. \quad Q_{i,t}^F = \gamma_i \left(\delta q_i^S \left(Q_{i,t}^S\right)^{\eta_i} + \delta m_i^C \left(M_{i,t}^C\right)^{\eta_i} + \delta m_i^W \left(M_{i,t}^W\right)^{\eta_i} \right)^{\frac{1}{\eta_i}} \end{aligned} \tag{3.5}$$

Again, the time index is omitted. Thus, the p_i^{qS}, p_i^{mC}, and p_i^{mW} are respectively the prices of the goods locally offered, imports from the rest of Brazil and the rest of the world. The following parameters are considered constant, so τ^m is an import tariff, γ_i is a scaling coefficient, and η_i is based on the elasticity of substitution. Finally, δq_i^S, δm_i^C, and δm_i^W are input share coefficients for the quantities abovementioned.

Similarly, it is necessary to analyze the decisions considering the supply side. In each period t, These decisions regarding what is offered to the intern market $(Q_{i,t}^S)$ and what is exported to the rest of Brazil $(X_{i,t}^C)$ as well as to the rest of the world $(X_{i,t}^W)$. It is assumed that the sectors divide the domestic output by using a CET function in which every sector adjusts its output for both consumptions, domestic and foreign.

$$\begin{aligned} &\max_{Z_i^S, X_i^C, X_i^W, Q_i^S} \pi_{i,t}^{zS} = \left(p_{i,t}^{qS} Q_{i,t}^S + p_{i,t}^{xC} X_{i,t}^C + p_{i,t}^{xW} X_{i,t}^W \right) - (1+\tau_i) p_{i,t}^z Z_{i,t}^S \\ &s.t. \quad Z_{i,t}^S = \theta_i \left(\xi q_i^s \left(Q_{i,t}^S\right)^{\phi_i} + \xi x_i^c \left(X_{i,t}^C\right)^{\phi_i} + \xi x_i^w \left(X_{i,t}^W\right)^{\phi_i} \right)^{\frac{1}{\phi_i}} \end{aligned} \tag{3.6}$$

where p_i^{xC} and p_i^{xW} represent the export prices respectively for the rest of Brazil and the rest of the world. τ_i is a joint tax composed of two taxes, namely that, the τ_i^{ICMS} for the ICMS tax and the τ_i^{OT} for all of the other taxes, including the Federal ones. It is applied to locally produced goods. Additionally, the parameter θ_i is a scaling coefficient, and $\phi_i$is defined by the elasticity of transformation. Similarly displayed in the previous maximization problem, ξq_i^s, ξx_i^C, and ξx_i^W are share coefficients.

3.2.3 Government

As commonly assumed in CGE models, the government is a tax collector and its consumption is set exogenous but growing at a constant rate. The government collects a direct tax from the household's income (T_H^D), which is imposed in a lump-sum style so that the fiscal balance is achieved. Additionally, it also collects from production, based on the ICMS tax (T_i^{ICMS}) and other taxes combined (T_i^{OT}) and from the imports (T_i^M). The tax rates are constant over time and expressed respectively as τ_H^D, τ_i^{ICMS}, τ_i^{Ot}, and τ_i^m.

In order to cover the efficiency in the public sector, one of the main changes in the original model is the inclusion of parameters of efficiency in every channel of tax collection. Thus, the efficiency parameters associated with the tax rates are $\epsilon_{col,d}$, $\epsilon_{col,icms}$, $\epsilon_{col,ot}$, and $\epsilon_{col,m}$, respectively. Equation 3.11 shows the total revenue collected in a specific period t. This number already carries within it the efficiency levels coming from all of the sources of collecting.

The government spends its tax revenues in consumption of every sector (G_j^F), which is consumed in a constant ratio (μ_j), and savings (S^G). The key equations for the government are expressed by equations from (3.7) to (3.12).

$$T_{H,t}^D = \epsilon_{col,d}\, \tau_H^D \sum_h p_{h,t}^f FF_{h,t} \;\; \forall\, h,t \tag{3.7}$$

$$T_{j,t}^M = \epsilon_{col,m}\, \tau_j^m p_{j,t}^{mW} M_{j,t}^W \quad \forall\; j,t \tag{3.8}$$

$$T_{j,t}^{ICMS} = \epsilon_{col,icms}\, \tau_{j,t}^{ICMS} p_{j,t}^z Z_{j,t}^S \quad \forall\; j,t \tag{3.9}$$

$$T_{j,t}^{OT} = \epsilon_{col,ot}\, \tau_{j,t}^{Ot} p_{j,t}^z Z_{j,t}^S \quad \forall\; j,t \tag{3.10}$$

$$T_{Total,t} = T_{H,t}^D + \sum_j (T_{j,t}^M + T_{j,t}^{ICMS} + T_{j,t}^{OT}) \;\; \forall\, t \tag{3.11}$$

$$G_{j,t}^F \le \frac{\mu_j}{p_{j,t}^{qF}} \left(T_{H,t}^D + \sum_j \left(T_{j,t}^M + T_{j,t}^{ICMS} + T_{j,t}^{OT}\right) - S_t^G \right) \forall\, j,t \tag{3.12}$$

3.2.4 Savings and Investment

The recursive dynamics are savings-driven so that the allocation of investments among the productive sectors depends on that. The private savings in a period t (S_t^P), coming from the households, follows a propensity to save (ss^P), assumed to be constant, as indicated in the following equation:

$$S_t^P = ss^P\left(\sum_{h,j} p_{h,j,t}^f F_{h,j,t} - T_t^d\right) \tag{3.13}$$

The total savings is composed of the private savings (S_t^P) plus the government savings (S_t^G), plus the foreign savings, which in this work is a combination of savings from the rest of Brazil (S_t^c) and the rest of the world (S_t^f). These foreign savings are calculated taking the diffeence between trade flows with these two regions. This amount of resources is spent on investment goods in each sector ($II_{j,t}$) to accumulate capital stock. The allocation of the investment goods follows the sectoral share of operation surplus:

$$p_t^k II_{j,t} = \frac{(p_{CAP,j,t}^f)^\zeta F_{CAP,j,t}}{\sum_i (p_{CAP,i,t}^f)^\zeta F_{CAP,i,t}}\left(S_t^P + S_t^G + S_t^c + \varepsilon_t S_t^f\right) \tag{3.14}$$

where the parameter ζ represents the sensitivity of investment goods allocation to the capital service price ($p_{CAP,j,t}^f$), it means it is a weight parameter. ε_t represents the Exchange rate.

3.2.5 Households

The households' aggregate consumption function is a Cobb-Douglas type and the constraint of available income composes the optimization process, specified below:

$$CC_t = a\prod_i C_{i,t}^{p\ \alpha_i}\ s.t.\ \sum_i p_{i,t}^{qF} C_{i,t}^p \le \sum_h p_{h,t}^f FF_{h,t} - S_t^p - T_{H,t}^D \tag{3.15}$$

where C_i^p is the private consumption of the sector i, p_h^f and p_i^{qF} are the prices of factors and sectorial goods respectively, FF_h is the endowment of factors. Similar to the description of the sectors, the parameter a is a scaling coefficient and α_i is a share coefficient. Based on the solution coming from this problem and letting ror represents a basic interest rate, the fictitious objective function, or in other words, the Utility function is given as:

$$UU = \sum_t \frac{CC_t}{(1+ror)^{t-1}} \tag{3.16}$$

3.2.6 Market Clearing Conditions

A CGE model describes the behavior of all the economic agents. To reach the general equilibrium, some assumptions are usually set. Firstly, there is no waste in this economy so that market conditions are imposed to achieve equality between supply and demand in every market. It not only means the market of goods produced by every sector, but it also includes the labor market so that the labor employed in all of the sectors must be equal to the labor endowment, which grows at a constant rate of the population growth. Given the dynamic characteristic of the Iracema Model, the composite investment goods must be completely set in the sectors as well. Finally, Walras' Law allows us to choose a *numeraire*, one price in which all of the other prices are comparable.

3.3 Calibration

This section also follows close to Hosoe, Gasawa, and Hashimoto (2016). The parameters and exogenous variables required to run a CGE model are calibrated directly from a Social Accounting Matrix – SAM, which in turn is derived from an Input-Output table. This work uses a SAM that disaggregates Ceará's economy into six productive sectors for the base year of 2013. This SAM[15] has been applied in the literature as in Paiva et al. (2019) and Lucio et al. (2020). A Technical Staff Report (IPECE, 2021) describes the elaboration of the SAM.

The SAM includes accounts corresponding to the components of the model, roughly speaking, a representative household, government, investment/savings account, rest of the country and the rest of the world, two factors of production, capital and labor, and four different types of taxes, which are ICMS, Other taxes, Import tax, and income tax.

It is worth mentioning that there is no single way to disaggregate and organize data in a SAM, Andrade and Najberg (1997) claims that the disaggregation level depends on the target analysis, which in this case is not compromised by a low level of disaggregation. The sectors considered are shown in the following table.

Table 3.1 - Codes for short denomination of the sectors.

Code	Sectors
S1	Agriculture, including support for agriculture and post-harvest.
S2	Extractive industry.
S3	Transformation Industry, Building, Power Electricity, Water and Sewage, and Others.
S4	Trade and repair of motor vehicles and motorcycles, transportation, storage and mail, accommodation and food.
S5	Private Services.
S6	Management, security, public education and health, and social security.

Source: Author's elaboration.

[15] Available at: https://www.ipece.ce.gov.br/modelo-de-equilibrio-geral-computavel-para-economia-cearense/

The parameters are calibrated from the SAM based on the solution of the key equations. Considering the initial values[16], these equations can be rearranged to isolate the parameters, as following described. The fiscal parameters representing the tax rates are given as $\tau_i^{ICMS} = T_i^{ICMS}/Z_i^S$, $\tau_i^{OT} = T_i^{OT}/Z_i^S$, and $\tau_i^M = T_i^M/M_i^W$. The propensity to save is given by $ss^p = S^p/\sum_h FF_h - T_H^D = 0.220$. Additionally, the scaling coefficients in the composite investment production function and composite consumption function are represented, respectively, by $\iota = \text{II}/\prod_i I_{j,t}^{\lambda_i} = 1.953$ and $a = CC_t/\prod_i C_{i,t}^{p\ \alpha_i} = 3.369$.

The following block of equations shows the calibration of the parameters that need a value for every sector. They are the share parameters in composite consumption function (α) and in the production function (β), the scale parameter in production function (b), input requirement coefficient (αy_j), and the investment share (λ_i). Additionally, there are the scaling coefficients in Armington function (γ_i) and in Transformation function (θ_i) as well as the input share coefficients in Armington function (δq_i^S, δm_i^C, and δm_i^W) and in Transformation function (ξq_i^s, ξx_i^C, and ξx_i^W). The values of the parameters are displayed in Table 3.2.

$$\alpha_j = C_j^P \Big/ \sum_i C_i^P \tag{3.17}$$

$$\alpha y_j = Y_j / Z_i^S \tag{3.18}$$

$$\beta_{h,i} = F_{h,i} \Big/ \sum_h F_{h,i} \tag{3.19}$$

$$b_i = Y_j \Big/ \prod_h F_{h,i}^{\beta_{h,i}} \tag{3.20}$$

$$\lambda_i = I_i \Big/ \sum_j I_j \tag{3.21}$$

$$\delta q_i^S = p_i^{qS}\left(Q_i^S\right)^{1-\eta_i} / p_i^{qS}\left(Q_i^S\right)^{1-\eta_i} + p_i^{mC}\left(M_i^C\right)^{1-\eta_i} + (1+\tau^m)p_i^{mW}\left(M_i^W\right)^{1-\eta_i} \tag{3.22}$$

$$\delta m_i^C = p_i^{mC}\left(M_i^C\right)^{1-\eta_i} / p_i^{qS}\left(Q_i^S\right)^{1-\eta_i} + p_i^{mC}\left(M_i^C\right)^{1-\eta_i} + (1+\tau^m)p_i^{mW}\left(M_i^W\right)^{1-\eta_i} \tag{3.23}$$

$$\delta m_i^W = (1+\tau^m)p_i^{mW}\left(M_i^W\right)^{1-\eta_i} / p_i^{qS}\left(Q_i^S\right)^{1-\eta_i} + p_i^{mC}\left(M_i^C\right)^{1-\eta_i} + (1+\tau^m)p_i^{mW}\left(M_i^W\right)^{1-\eta_i} \tag{3.24}$$

$$\gamma_i = Q_i^F / \left(\delta q_i^S \left(Q_i^S\right)^{\eta_i} + \delta m_i^C \left(M_i^C\right)^{\eta_i} + \delta m_i^W \left(M_i^W\right)^{\eta_i}\right)^{\frac{1}{\eta_i}} \tag{3.25}$$

$$\xi q_i^S = p_i^{qS}\left(Q_i^S\right)^{1-\phi_i} / p_i^{xW}\left(X_i^W\right)^{1-\phi_i} + p_i^{xC}\left(X_i^C\right)^{1-\phi_i} + p_i^{qS}\left(Q_i^S\right)^{1-\phi_i} \tag{3.26}$$

$$\xi x_i^C = p_i^{xC}\left(X_i^C\right)^{1-\phi_i} / p_i^{xW}\left(X_i^W\right)^{1-\phi_i} + p_i^{xC}\left(X_i^C\right)^{1-\phi_i} + p_i^{qS}\left(Q_i^S\right)^{1-\phi_i} \tag{3.27}$$

$$\xi x_i^W = p_i^{xW}\left(X_i^W\right)^{1-\phi_i} / p_i^{xW}\left(X_i^W\right)^{1-\phi_i} + p_i^{xC}\left(X_i^C\right)^{1-\phi_i} + p_i^{qS}\left(Q_i^S\right)^{1-\phi_i} \tag{3.28}$$

$$\theta_i = Z_i^S / \left(\xi q_i^s \left(Q_i^S\right)^{\phi_i} + \xi x_i^C \left(X_i^C\right)^{\phi_i} + \xi x_i^w \left(X_i^W\right)^{\phi_i}\right)^{\frac{1}{\phi_i}} \tag{3.29}$$

[16] The time indexes are omitted to avoid equations too much loaded of indexes.

Table 3.2 – Calibrated values for the parameters.

Parameters	Sector 1	Sector 2	Sector 3	Sector 4	Sector 5	Sector 6
δm_i^W	.204	.524	.156	.038	.006	.008
δm_i^C	.277	.179	.427	.102	.222	.017
δq_i^S	.519	.297	.417	.860	.772	.974
γ_i	2.585	2.534	2.648	1.330	1.550	1.053
ξx_i^W	.553	.647	.638	.679	.904	.710
ξx_i^C	.328	.164	.215	.233	.090	.286
ξq_i^S	.119	.189	.147	.088	.006	.004
θ_i	4.172	3.850	3.500	5.138	29.191	41.169
τ_i^{ICMS}	.014	.039	.049	.013	.040	.002
τ_i^{OT}	.034	.020	.131	.019	.011	8.13E-5
τ_i^M	.025	7.08E-5	.131	.131	.103	.069
α_j	.050	6.81E-6	.431	.196	.320	.003
β_{CAP}	.839	.690	.463	.589	.566	.094
β_{LAB}	.161	.310	.537	.411	.434	.906
b_i	1.554	1.857	1.995	1.969	1.983	1.366
αy_j	.735	.573	.337	.632	.703	.760
λ_i	.034	.002	.826	.064	.071	.004

Source: Author's elaboration.

For reasons of identification in systems of equations, some parameters are taken from the literature. Following Hosoe, Gasawa, and Hashimoto (2016), from which the model was derived, as a simplification, the elasticity of substitution and elasticity of transformation are assumed equal $\sigma_i = \psi_i = 2$. As a result, the elasticity parameters of substitution and transformation are given, respectively as $\eta_i = \frac{\sigma_i - 1}{\sigma_i} = 0.5$ and $\phi_i = \frac{\psi_i + 1}{\psi_i} = 1.5$.

The calibration process in this dynamic model additionally requires information about the capital stocks employed for each sector. Once the SAM provides data for the capital services, the sectoral capital stocks are estimated by $F_{CAP,j,t} = ror * KK_{j,t}$. Combining it with the sectoral investment data, also available in the SAM, the growth rate can be observed. The deal is that the calibrated growth rate is likely to differ from the stylized fact of a growth rate generally assumed in this sort of CGE modeling known as the Business-as-Usual - BAU path, a set of assumptions that yields a steady BAU growth path at the rate of the population growth.

An adjustment in the investment registered into the SAM, given by the sum of the investments in all the sectors and formalized as $I^{SAM} = \sum_i SAM_{i,INV}$, is required to overcome the difference mentioned in the previous paragraph. The assumed investment to achieve the desired growth rate is given as $I^{Assumed} = \frac{pop + dep}{ror} * FF_{cap}^{00}$, where the parameters pop, dep, and ror are respectively the population growth rate, the depreciation rate, and the rate of returns. The FF_{cap}^{00} is the capital service input observed in the base year. Then, the ratio $adj = I^{Assumed}/I^{SAM}$ adjusts the investment good demand. It, in turn, readjust all the SAM making it compatible with a steady base equilibrium.

Once the average annual growth rate of the population in Ceará was around 1.53% in the period from 1987 to 2015[17], this work considers this parameter as pop=0.015. For the parameters of depreciation and interest rate it follows Hosoe, Gasawa, and Hashimoto (2016), then they are assumed as dep=0.04 and $ror = 0.05$, respectively.

3.4 Tax Collection Efficiency in Ceará State.

This Chapter, similarly to the previous one, follows Cazals, Florens, and Simar (2002) and applies a nonparametric estimator known as Order-m efficiency estimation, also well explored in Tauchmann (2012), to calculate the efficiency in tax collection of both ICMS tax and the total tax collection of the Brazilian states. Although part of the analysis regards all states, the focus is the Ceará state, especially because it also applies a CGE analysis. Thus, it uses the level of efficiency performed by the Ceará state as the efficiency parameter. Even though this method is closely related to the widely known nonparametric envelopment estimators, the Data Envelopment Analysis – DEA, it is more robust in terms of extreme values and outliers.

A single input-single output approach is applied for each one of the estimations, namely that, ICMS and Total tax collection, by taking the GDP *per capita* as the input for both of them and the tax revenue in ICMS and the total tax revenue, which includes all the taxes the state-level government is responsible for collecting, as the outputs. It emphasizes that this estimation procedure and the applied approach allow us to perform a specific analysis of efficiency besides using the estimated value as the efficiency parameter in the IRACEMA model. Once the biggest share of the required parameters comes from the SAM, which uses the 2013 base year, it uses the same year for the efficiency parameter to make the calibration compatible. However, this analysis covers the period from 2012 to 2016.

As an overview of the estimations, Fgures 3.1 and 3.2 show the efficiency average scores in five ranges, from 2012 to 2016, for all of the Brazilian states.

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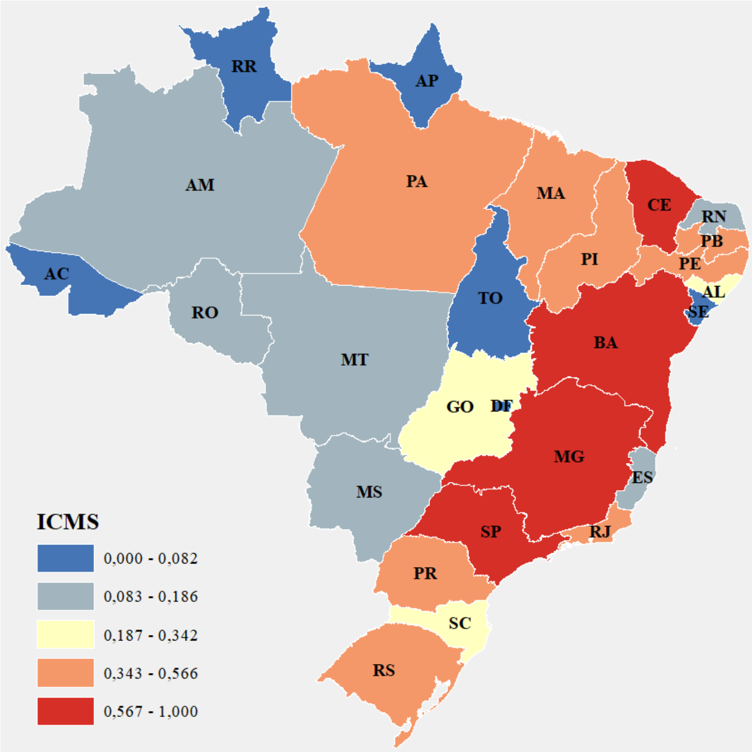
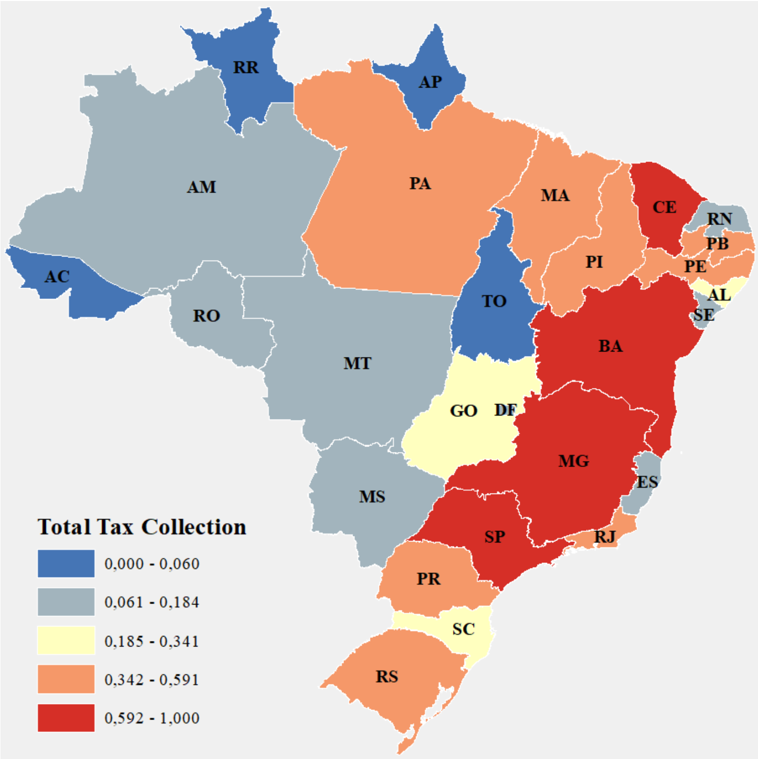
[17] Ceará 2050: Juntos Pensando o Futuro. Diagnóstico Qualitativo.
Available at: https://www.seplag.ce.gov.br/wp-content/uploads/sites/14/2020/07/1.5-Diagnostico-Qualitativo_TomoIV_Ceara2050.pdf

Figure 3.1 - Efficiency Average (2012-2016) in ICMS tax collection of the Brazilian States.



Source: Author's elaboration from the research results.

Figure3.2 - Efficiency Average (2012-2016) in Total Tax Collection of the Brazilian States.

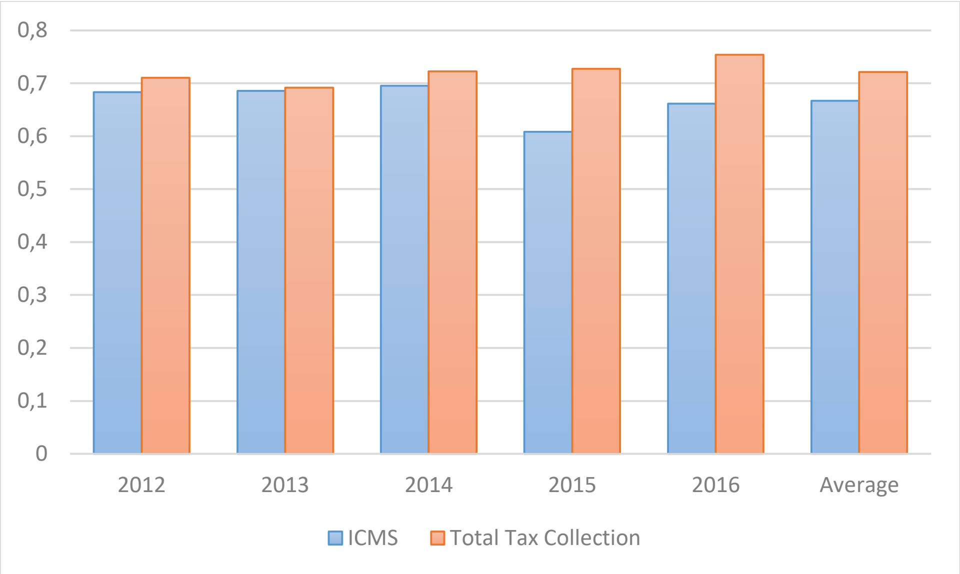


Source: Author's elaboration from the research results.

Even though this chapter focuses on the Ceará state, these Figures are important since they provide a quick and visual comparison among the Brazilian states. Worthy to mention that although only two states show differences on the maps, improving from the lower level to the lower-intermediate level in terms of total tax collection *vis-a-vis* ICMS, namely that, the Federal District and Sergipe, they fit in a range and the real scores are actually different. The Ceará state reaches the highest range of efficiency on both measures considered, as so the states of Bahia, São Paulo, and Minas Gerais. On the other hand, the states with the poorest efficiency in tax collection are Acre, Amapá, Roraima, and Tocantins.

Now, to be more specific about the state of Ceará, Figure 3.3 shows the efficiency scores, year by year as well as the average, for estimations of both ICMS and Total Tax Collection. Based on that, we see it keeps constant its efficiency levels of tax collection, except for a reduction in efficiency collecting ICMS in the year 2015, although it keeps slightly above 0.60, which still fits the highest level above-mentioned. Meanwhile, the efficiency of total tax collection presents a light trend of increasing.

Figure 3.3 - Efficiency Level in Collection of ICMS and Total Taxes for the Ceará state.



Source: Author's elaboration from the research results.

3.5 Simulation Exercises and Results

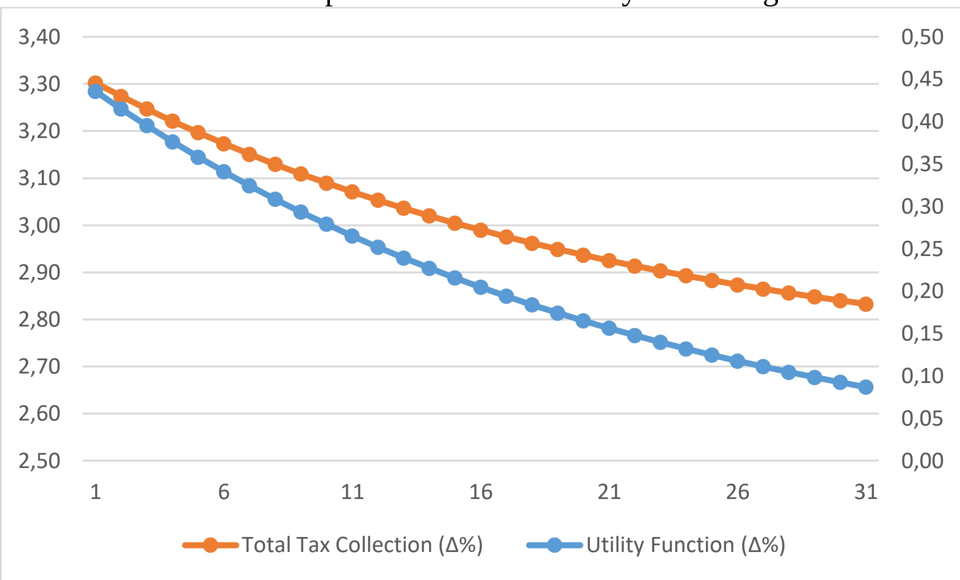
This chapter concerns public sector efficiency issues in tax collection. Therefore, it performs simulation exercises by changing the efficiency levels on taxation for the Ceará state. The assumption behind it is that the government enhances its efficiency by collecting taxes.

Although efficiency parameters are included in all the sources of tax collection and also that the analysis in the previous section contemplates efficiencies on both ICMS and Total tax collection, aiming to achieve more accurate outputs, the exercises are more specific and simulate changes in efficiency only in ICMS tax. An additional reason for this specific approach is the importance of this tax for the Brazilian states and the control they exert over it. Once the Calibration process is based on data for the year 2013, the efficiency level considered refers to the same year, which is 0.685.

3.5.1 Improving Efficiency in Tax Collection of ICMS.

Firstly, the simulation in this section consists of a positive variation of 10% over the efficiency level of the ICMS collection, which is changing from the base year value of 0.685 to 0.753. It is worth mentioning that, for simplicity, it is assumed that the efficiency improvements reach all the sectors equally. This change is moderate and feasible. The concerns on the tax revenue of the Ceará state already expressed in the introduction section require that the total tax collection changes are contemplated in the first analysis. Besides, considering the common measure usually delivered as a summary of the results in a CGE model, the percentage variation of the utility function, based on consumption, represents the variations in wellbeing. Thus, Figure 3.4 shows the evolution of these two measures over the 30 periods simulated.

Figure 3.4 - Percentage Change of the Total Tax Collection and Utility Function from a 10% Improvement of Efficiency Collecting ICMS tax.



Source: Research results.

On the left axis, there is the total tax collection variation, which represents a 3.3% variation in the first period and a 2.83% in the last. Given it regards the total tax revenue of the Ceará state, these values can represent a significant volume of resources, especially considering that the efficiency shocks are performed in only one sort of tax rate. On the other side, the right axis shows the percentage change in utility. It starts achieving a 0.44% change and finishes with a tiny change of 0.09%, but still positive. The decreasing trend over the years regards the way the variables evolve, considering the population growth rate

The model applied has a plethora of variables, hence the analysis picks just some of them. Table 3.3 below contemplates eight variables, which are the Tax Collection of ICMS (T^{ICMS}), the total tax collection of the sector j (T_j), the private consumption (C^p), the GDP (Z), the exports for the rest of the world (Xw) and the rest of Brazil (Xc), and the imports for the rest of the world (Mw) and the rest of Brazil (Mc).

Table 3.3 - Percentage Change of Selected Variables from a 10% Increase in Efficiency Tax Collection of ICMS.

Sector/Period*	ΔT^{ICMS}	ΔT_j	ΔC^p	ΔZ	ΔXw	ΔMw	ΔXc	ΔMc
$S1P1$	9.91	2.64	.470	-.053	-.196	.128	-.150	.082
$S1P5$	9.78	2.53	.367	-.206	-.437	.091	-.381	.035
$S1P10$	9.66	2.42	.260	-.366	-.689	.055	-.624	-.011
$S1P20$	9.47	2.26	.103	-.603	-1.066	.006	-.990	-.071
$S2P1$	9.73	6.35	.535	-.145	-.149	-.254	-.103	-.300
$S2P5$	9.53	6.16	.462	-.339	-.373	-.360	-.317	-.416
$S2P10$	9.31	5.95	.386	-.557	-.626	-.464	-.561	-.529
$S2P20$	8.94	5.59	.270	-.920	-1.055	-.604	-.978	-.681
$S3P1$	9.68	2.26	.502	-.221	-.285	-.132	-.239	-.178
$S3P5$	9.56	2.16	.423	-.341	-.439	-.193	-.383	-.249
$S3P10$	9.44	2.05	.342	-.464	-.595	-.257	-.530	-.323
$S3P20$	9.27	1.90	.226	-.638	-.814	-.351	-.737	-.428
$S4P1$	10.07	4.21	.357	.014	-.294	.409	-.248	.363
$S4P5$	9.99	4.13	.281	-.070	-.396	.347	-.340	.291
$S4P10$	9.90	4.05	.204	-.155	-.498	.283	-.433	.217
$S4P20$	9.78	3.93	.094	-.275	-.639	.186	-.563	.108
$S5P1$	10.22	8.01	.324	.086	-.355	.532	-.309	.486
$S5P5$	10.15	7.93	.262	.023	-.409	.460	-.353	.403
$S5P10$	10.07	7.86	.198	-.041	-.463	.385	-.398	.319
$S5P20$	9.95	7.75	.107	-.134	-.539	.276	-.462	.198
$S6P1$	10.00	9.52	.424	-.002	-.216	.211	-.170	.165
$S6P5$	9.95	9.47	.399	-.004	-.137	.129	-.081	.073
$S6P10$	9.90	9.42	.373	-.006	-.054	.043	.012	-.023
$S6P20$	9.83	9.35	.338	-.008	.071	-.087	.149	-.164

Source: Research results. Note: All of the variations represented in the table are percentage variations (%).
*S represents the Sectors and P represents the period after the implementation of the policy.

As expected, the results show increases in tax collection in ICMS and in the total collected from each sector j at a lower level since ICMS is just a share of it. Additionally, the decreasing trend, already mentioned, is a pattern observed for all variables, given that the population growth is being computed over the years.

The response to the shock is different for each sector. Sectors 4 and 5, for instance, start the implementation period with an ICMS collection higher than 10%, which represents the shock. Also, the total collected from a sector depends on the share the ICMS represents on it. For instance, sectors 3 and 1 present the lowest impacts on this variable, with changes respectively of 2.26% and 2.64%. Conversely, sectors 6 and 5 present the highest impacts on the total collected, with a 9.5% and an 8% increase, respectively. The results for the consumption, although seem no significant, are responsible for the changes in well-being previously mentioned.

3.5.2 Adapting the Double Dividend Hypothesis: Efficiency and Tax Rates.

As already mentioned in the introduction, the tax burden concerning both the central and the state-level governments in Brazil is high. Although this chapter has already discussed that both of them are facing an upcoming period of short and limited resources due to the current scenario, there still might be some margin to apply tax reductions, probably not in a pure way but by applying some sort of compensation.

This compensation could be generated by adapting the double dividend hypothesis and using the recycling revenue issues. The double-dividend hypothesis, from Fullerton and Metcalf (1997), states that create or raise taxes on polluting activities might be able to provide two types of benefits. The first regards an improvement in the environment itself by reducing pollution and the second concerns an improvement in the efficiency of the economy by using the tax revenues collected by the new or higher taxes to reduce other taxes, which is also known as recycling revenues. However, it emphasizes that the validity of this hypothesis must not be taken as applicable in a general matter. Following this specific issue, after performing simulations, Freire-Gonzalez (2018), claims that even though the environmental benefits are almost always achieved due to the fact the changes in taxes also changes the behavior of the economic agents, there is no consensus in the literature, suggesting that it still needs further research.

In this literature, both Goulder and Hafstead (2013) and Beck *et al*. (2015) apply general equilibrium models, the former for the United States and the latter for Canada. Goulder and Hafstead (2013) evaluate what alternative tax reductions could be financed by the revenues from an environmental tax. They found that this tax promotes a substantial net revenue and also that the impacts on GDP and wellbeing strongly depend on how this revenue is recycled to benefit the productive sectors.

Roughly speaking, assuming that creating or increasing some tax generates higher tax collection allowing to reduce some other, this process can be seen as a composition of revenues. Therefore, it might be possible to compensate the components of the tax collection taking into account the efficiency by collecting. The following axiom formalizes this idea.

Axiom: Compensation of the Tax Revenue Components.

Let the equation for the Tax Collection be $T_{j,t}^{i} = \epsilon_{col,t}^{i}\tau_{j,t}^{i}Z_{j,t}^{i}$. From an i type of tax, a sector j, and at time t, the components, namely that, $\epsilon_{col,t}^{i}$, $\tau_{j,t}^{i}$, and $Z_{j,t}^{i}$, representing respectively the efficiency level on tax collection, the tax rate, and the incidence base of them, are the drivers of the tax collection $T_{j,t}^{i}$. For a given level of efficiency, higher than the current value, there is at least one value for the tax rate, lower than the current value, able to yield either the same level or a higher level of the Tax Collection, *ceteris paribus*.

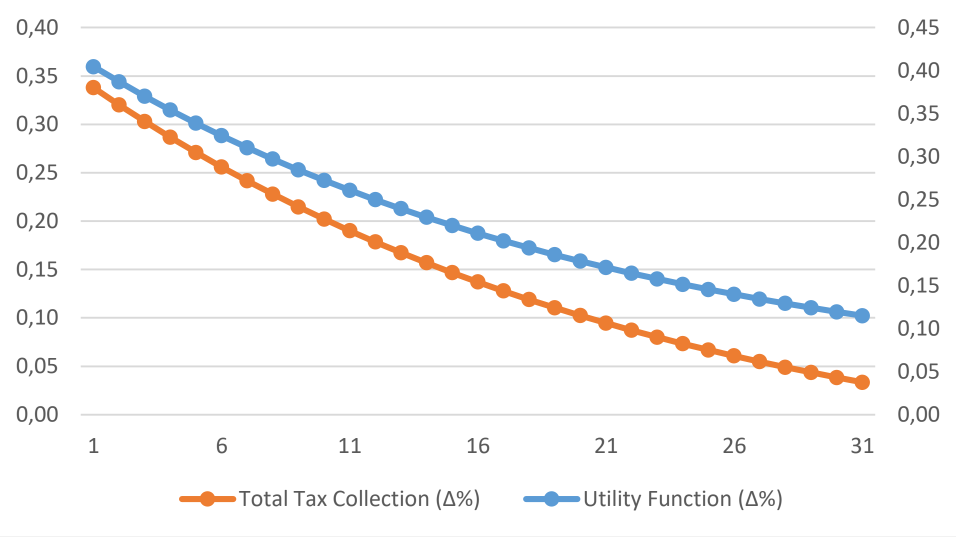
The axiom is generally set. Therefore, once included in a CGE model, it is supposed to be able to produce similar conclusions in other variables such as the total tax collection of a government and the wellbeing. Using the IRACEMA model proposed in this chapter, the following simulation exercise works as an empirical demonstration of it.

Keeping the modest change in the efficiency level of 10% in ICMS tax as performed in the previous section and applying the axiom of the compensation of the tax revenue components to keep the total tax revenues unchanged but still positive over the 30 periods considered, the findings show that it would require an 8.75% reduction on tax rates. It might be related to the boost effects this sort of incentive brings to the productive sectors.

Due to the population growth considered on the variation, there is a trend of diminishing effects over the years. So, the combination is chosen in a way there are no negative effects over all the years. This is the reason there are still some positive effects in the beginning. Worthy to mention that the changes in Total collection and Well-being are both lower than 0.4% in the first period after the implementation, as observed in figure 3.5. Based on that one can assume the percentages chosen fits the axiom.

Similar to the previous analysis, the percentage variation of total tax collection is placed in the left axis and it is around 0.34% in the first period and 0.03% in the last. On the right axis, there is a percentage change in utility starting at 0.4% and finishing at 0.12%.

Figure 3.5: Percentage Change of the Total Tax Collection and Utility Function from a Combination of a 10% Improvement of Efficiency Collecting ICMS tax and an 8.75% reduction in ICMS tax rate.



Source: Research results.

Table 3.4 - Percentage Change of Selected Variables from a Combination of a 10% Improvement of Efficiency Collecting ICMS tax and an 8.75% reduction in ICMS tax rate.

Sector/Period	ΔT_{icms}	ΔTs	ΔC^p	ΔZ	ΔXw	ΔMw	ΔXc	ΔMc
$S1P1$	.325	.101	.436	-.077	-.361	.316	-.382	.337
$S1P5$	.204	-.011	.313	-.277	-.727	.342	-.838	.370
$S1P10$	.058	-.146	.167	-.517	-1.162	.371	-1.199	.409
$S1P20$	-.110	-.301	-.005	-.796	-1.665	.402	-1.712	.450
$S2P1$	.356	.248	.540	-.127	-.165	.074	-.185	.095
$S2P5$	.177	.069	.475	-.364	-.390	.034	-.419	.062
$S2P10$	-.060	-.168	.395	-.575	-.695	-.015	-.732	.022
$S2P20$	-.385	-.492	.296	-.932	-1.123	-.068	-1.171	-.020
$S3P1$	.542	.274	.590	.084	.183	-.100	.162	-.080
$S3P5$	.476	.194	.527	.024	.128	-.162	.099	-.133
$S3P10$	.396	.128	.475	-.051	.056	-.235	.019	-.198
$S3P20$	.300	.034	.398	-.143	-.034	-.321	-.082	-.274
$S4P1$	.460	.275	.195	-.106	-.725	.722	-.746	.743
$S4P5$	.392	.192	.075	-.208	-.902	.722	-.930	.751
$S4P10$	.311	.127	-.015	-.324	-1.095	.713	-1.132	.750
$S4P20$	.219	.035	-.135	-.450	-1.291	.684	-1.338	.732
$S5P1$	.816	.745	.282	.049	-.532	.638	-.552	.659
$S5P5$	.755	.684	.214	-.010	-.593	.583	-.622	.611
$S5P10$	.682	.611	.160	-.079	-.664	.515	-.701	.552
$S5P20$	.599	.528	.083	-.158	-.740	.432	-.787	.480
$S6P1$	.730	.716	-.029	-.009	-1.162	1.158	-1.183	1.179
$S6P5$	.691	.677	-.051	-.011	-1.099	1.090	-1.127	1.119
$S6P10$	.645	.631	-.075	-.012	-1.020	1.006	-1.057	1.044
$S6P20$	.590	.576	-.103	-.014	-.920	.901	-.968	.949

Source: Research results. Note: All of the variations represented in the table are percentage variations (%).
*S represents the Sectors and P represents the period after the implementation of the policy.

It needs to be emphasized that the negative variations on the product for most of the sectors except for sectors 4 and 5, which are basically related to services, are small, lower than 1% in all cases. Also, there are positive variations in sectors 4 and 5, which might be resulting from a recomposition of resources from the other sectors and also compensating the negative ones. Some of these compensations follow the market clearing requirements.

Reducing the ICMS tax rate, which is the main tax for state tiers of governments, unlike the previous analysis this exercise might perturb the economy since there are channels to spread the impacts of this shock making them reverberate both directly and indirectly on the economy. Although in some periods there is a negative change in consumption, the aggregated net effect is positive, as seen in Figure 3.5. Remembering the focus here is to guarantee that the Total tax collection seems unchanged, but in a way that it is still marginally positive over 30 periods. This type of compensation can surely be applied by controlling for any other variable present in the model such as the consumption and/or the tax collected from each sector.

The simulation presented, in which the compensation reaches a minimum positive gain, is some sort of an extreme case. Remembering that the axiom also fits for different levels of compensation that could increase the tax collection. As already shown along the results presented so far, the efficiency gains themselves increase the collection, ceteris paribus. Then, reducing taxes but lower than the level required to exhaust the gains coming from the efficiency changes, there will still gather a higher amount of revenues. Besides, this process works as a booster effect for the productive sectors, which is related to lower tax rates. These types of outcomes support the original proposition of Laffer's curve according to which after a certain level tax rates might be reduced to increase the tax collection efficiency (CEVIK *et al*., 2019).

3.6 Final Remarks and Policy Implications

The general contribution of this chapter is to analyze the efficiency in tax collection as an alternative to overcome or mitigate residual problems on balance the budget in Ceará state left by the Covid-19 pandemic. It required a double analysis, firstly estimating the efficiency in tax collection and secondly adapting a CGE model to consider these issues. Finally, applying the estimated values into the model, exercises were performed simulating improvements in efficiency levels and also combining it with tax rate reductions.

The current fiscal situation of the Brazilian central government, which was already facing problems to balance its budget even before the Covid-19 pandemic starts and then with all resources it has transferred, plus the damage it has caused in the economic activities, constitutes a strong unfeasibility for raise taxes in the current economic and political scenario. Once tax changes require higher levels of political capital, one would say that it is not a feasible solution to recover public finances.

Conversely, it is worth mentioning that nowadays the alternative proposed in this chapter, improve tax collection efficiency, is feasible. It can be performed, for instance, by improving the collecting system technologically such as using electronic invoices. Additionally, according to the Subnational Entities Finance Bulletin, STN (2020), there are possibilities to review significant reducers of collection, namely that, tax waiver and tax expense, which are indirect government expenditures made through the tax system reducing potential revenue. Therefore, there is the possibility to perform continuous reassessments of them and convert them into higher tax collection.

Moreover, as long as these measures can potentially reverse the effects of the Covid-19 pandemic on the public finances or at least mitigate them, in normal economic scenarios they can also be applied to improve the business environment and boost the economy as development-oriented policies. It is emphasized the replicability of the propositions as an important feature of this work. Therefore, the results shown for the Ceará state might be observed in other subnational units or even in terms of the central government, considering that it is responsible for collecting a significant part of tax revenues.

Given that this sort of policy simulated along this chapter has the potential to enrich the tax collection and that the effects reverberate for some periods, once the negative effects from the Coivd-19 pandemic have been surpassed, depending on the values, there will still be some positive effects. It might a llow other uses for the extra resources such as implement a reduction in the public debt or even increase public investments, which might work as extra positive incentives for the productive sectors, similar to lowering tax rates.

The exercises performed in this chapter as well as the results presented might assist the policymakers to enrich their understandings helping them to find out other alternatives in which they can base new public policies. It emphasizes that the specificities of a unit and the current economic environment must be taken into account. The most important takeaways are the feasibility and the replicability of these improving efficiency policies.

4 EFFICIENCY IN TAX COLLECTION: AN AGGREGATE APPROACH FOR BRAZIL.

4.1 Introduction

Similar to the previous essay, this chapter focuses on efficiency in tax collection, using a dynamic computable general equilibrium model. However, it takes Brazil as a whole as opposed to the Ceará state. Specifically, it aims to propose an alternative approach to relieve the effects of the reduction on tax revenue caused by the restrictions on economic activities as some of the sanitary measures adopted to prevent the spreading of the Covid-19 pandemic. This alternative lies in improving efficiency in tax collection in a country level.

The Brazilian macroeconomic scenario has been characterized in recent years by an intense debate regarding the evolution of the public debt trajectory and, therefore, the management of public spending. The explosive path of the public debt has required solutions to contain the fiscal deficits, which started in 2014 after a period of distancing from the so-called tripod of macroeconomic policy, which adopts the primary surplus targets as one of its main pillars.

To contain the accelerated growth in government spending and moderate the evolution of the debt/GDP ratio and reduce the instability generated in the Brazilian economy, the Constitutional Amendment (EC) No. 95/2016 was approved instituting the New Tax Regime imposing individualized limits on the primary expenses, valid for up to twenty financial years, although it can be revised in 10 years, that is, in 2026.

This debate has been intensified with the effects of the new coronavirus pandemic. According to a report from The Independent Fiscal Institute (IFI, 2020), the increase in economic activity in the third quarter of 2020 was not enough to bring GDP back to the pre-pandemic level. Additionally, the collection in October was driven by the payment of deferred taxes, a fact that should be considered in the analysis as it is not related to the improvement in economic activity. Indeed, the tax collection as a share of the GDP decreased from 33.17% in 2019 to 31.64% in 2020[18], which represents a reduction of 0.87 percentage points (p.p.) of GDP. Despite it, the General Government's Gross Debt registered an increase of 15 p.p. of GDP in the accumulated 2020.

For 2021, there is a moderate risk of breaking the new fiscal regime established by

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[18] Available at: https://www.tesourotransparente.gov.br/publicacoes/carga-tributaria-do-governo-geral/2020/114?ano_selecionado=2020

the Constitutional Amendment No. 95/2016. Despite the risk, it is expected to be accomplished as well as the primary deficit target of R$ 247.1 billion. Add to that the primary deficit of R$ 681.0 billion between January and October 2020, the gross debt is expected to reach 92.7% of GDP in 2021. Nevertheless, it is estimated the continuous growth of the debt/GDP ratio up to 103.4% in 2030 (IFI, 2021).

It is emphasized that the measures applied so far has their potential suppressed due to the rigidity in the structure of Brazilian public spending established by the Federal Constitution of 1988. As highlighted by Santana, Cavalcanti, and Paes (2012), the Brazilian central government has obligations, guaranteed by the Constitution, that cannot be changed or reduced. Data from the National Treasury show that in 2016 these mandatory expenditures made up about 90% of the central government's primary expenditure, where the largest part relates to salaries. It creates the need to propose alternative policies other than reducing public spending. One alternative is to work on the public sector efficiency.

There are a plethora of empirical studies estimating tax compliance rates at the country level. A part of this literature considers a Value-Added tax - VAT compliance rate and/or VAT gaps. According to Sokolovska and Sokolovskyi (2015), one of the most important characteristics of this rate, hence the tax efficiency, is the estimation of the tax gap due to the tax non-compliance. Some of them apply it in OECD countries (Agha and Houghton (1996); OECD (2012)), other in terms of European Union countries (Nam, Barbara, and Rudiger (2001); Christie and Holzner (2006); Barbone et al. (2013)) and also concerning countries worldwide (Keen (2013)).

There is no doubt that the ability to collect taxes is necessary to a country’s capacity to finance its duties such as health and education, infrastructure, and other public goods and services. Additionally, issues concerning taxation and state-building have recently received attention in the literature. Braütigam, Fjeldstad, and Moore (2008) and Everest-Phillips (2009) emphasize the importance of political engagement and transparency as well as simple tax systems. According to Akitoby (2018), many countries might incur a sizable loss of revenue through ill-designed tax exemptions. However, regardless of the constraints countries can present, they can strengthen their potential to collect tax revenues by applying reforms, specifically in the tax systems.

Additionally, after reviewing the literature on the potential impact of public investment inefficiencies on productivity and outcome, Kangur and Papageorgiou (2017) emphasize that despite recent progress in assessing and incorporating inefficiencies in economic analysis, the composition of public capital and its linkages with other factors of production and with structural economic conditions remain as important research issues. Therefore, this approach is also advisable to be considered in the current scenario in Brazil.

Considering the basic needs a country is likely to present, Akitoby (2018) claims that the low level of tax collection might difficult economic development. Hence, it can also make the recovery of difficult times such as this Covid-19 pandemic more difficult. Moreover, results from Afonso, Schuknecht, and Tanzi (2005), including three indicators to reflect the standard tasks of the government, which are allocation, distribution, and stabilization, suggest that there is a large potential for expenditure savings in many countries, in other words, gains of efficiency. Therefore, it is feasible to improve the public sector efficiency levels.

Additionally, assuming that the public consumption and public investment are associated with the provision of public goods and services for the households and public capital for the firms, Chatterjee and Ghosh (2011) claim that tax reforms performed by the government and imposing limits over the public spends might affect the level of wellbeing and efficiency of the economy. Therefore, simulating tax reductions could be appropriate in this approach.

The topics presented so far justify this essay. It applies a dynamic CGE model to simulate policies of improvements in efficiency in tax collection. Additionally, extra simulation exercises are performed to propose a sustainable alternative to reduce tax rates, which is compensating the gains in revenue obtained with the efficiency improvements. It is emphasized that the simulated economic environment takes into account Constitutional Amendment No. 95/2016.

Beyond this introduction, this chapter contains four more sections. The following section describes the model and its components as well as specifies the variables and parameters. The third section describes the calibration process while specifies the data used for it. Simulation exercises are performed in the fourth section as well as reporting the results. Finally, general comments and policy implications are drawn as a conclusion.

4.2 Dynamic Computable General Equilibrium Model

This section describes the dynamic computable general equilibrium model based on a combination of models from Barro (1990) and Turnovsky (1996), as in Gomes *et al.* (2020), from which this chapter also uses a similar notion for the variables and parameters. It regards a Neoclassic economic growth model featured by a closed economy. Based on Holland (2019), who states that the Brazilian case of the opening economy has not presented relevant changes over time, emphasizes that this characteristic brings no limitation to this analysis.

The contribution of this essay regarding the model for the aggregate economy is the insertion of efficiency parameters (ef_{tc}) in the tax collection equations. The main assumption behind it is that the government presents some level of inefficiency while performing tax collection activities.

4.2.1 Households

There are two types of households that use the services provided by the government not only through the availability of public infrastructure such as roads, airports, power, communications but also of public services such as public education and health as well as entertainment like parks and museums. The specification of the congestion in the public services is similar to the one found in Eicher and Turnovsky (2000) and Pintea and Turnovsky (2006). The main difference is that only one type is able to save and has access to the capital market. This type is named the r households. The other is named the p households.

It is emphasized that the services provided by the government directly increase the households' utility. However, some services are rivals and exclusive, then the congestion in consumption of public services is incorporated in this model similarly to Turnovsky (1996), for both types of households.

$$cg_{p,t}^{S} = \frac{C_{g,t}}{N} \tag{4.1}$$

$$cg_{r,t}^{S} = \frac{C_{g,t}}{N} \tag{4.2}$$

$$N = N_p + N_r \tag{4.3}$$

where N representes the whole population, N_p is the number of households of the type p, and N_r is the number of the type r.

4.2.1.1 $\boldsymbol{p}$ Households

The group of households not able to save and/or to invest is called p households. It allocates its time in work $(h_{p,t})$ and leisure $(1 - h_{p,t})$, with $h_{p,t} \in [0,1]$. It consumes from the private sector ($c_{p,t}$) and from the public sector ($cg_{p,t}^{S}$), where part of the public services is subject to congestion in its use. Therefore, given an intertemporal discount factor, $\beta \in (0,1)$, the households have preferences about the flows of private consumption and leisure as the utility function specifies below.

$$U_p(c_{p,t}, h_{p,t}, cg_{p,t}^S) = \sum_{t=0}^{\infty} \beta^t (1+n)^t \{\ln(c_{p,t} + \mu\, cg_{p,t}^S) + \psi_p \ln(1 - h_{p,t})\}, \mu \geq 0 \quad (4.4)$$

where μ represents how much this type of individual values public services compared to private consumption, n is the population growth rate, ψ_p shows how they value leisure, and $h_{p,t}$ represents the average hours they work. It is supposed that consumption and labor are taxed based on the respective rates $\tau_{c,p}$ and $\tau_{h,p}$. Therefore, the budget constraint of the p households is given by:

$$(1 + \tau_{c,p})c_{p,t} = (1 - \tau_{h,p})\xi_p w_t h_{p,t} + tr_{p,t} \quad (4.5)$$

where ξ_p is the labor productivity, w_t is the average gross salary, it means, before the taxes, and $tr_{p,t}$ represents the transfers from the government to this type of households.

4.2.1.2 r Households

The rest of the households in this economy are compiled into another group, called r households, which are able to save and invest. Like the previous group, they allocate their time to work and leisure and also consume goods and services from both the private and the public sectors. The r households' utility is, therefore, given as follows.

$$U_r(c_{r,t}, h_{r,t}, cg_{r,t}^S) = \sum_{t=0}^{\infty} \beta^t (1+n)^t \{\ln(c_{r,t} + \mu\, cg_{r,t}^S) + \psi_r \ln(1 - h_{r,t})\}, \mu \geq 0 \quad (4.6)$$

Here, the characteristics of the preferences about the leisure and the average hours worked, the productivity, and the transfers from the government are specific and represented respectively as ψ_r, $h_{r,t}$, ξ_r, and $tr_{r,t}$. Besides, differently from the p households, they are endowed with a stock of capital (k_t) and government bonds (b_t), which give them the returns of $r_t k_t$ and $\rho_t b_t$. It is supposed that all of the sources of income, as well as the consumption, are taxed based on the taxes $\tau_{c,r}$, $\tau_{h,r}$, τ_k, and τ_b.

This representative r household starts with a stock of capital, k_0, and decides how much to increase it through investments. Every period of time, this capital depreciates at a constant rate of δ, with $0 < \delta < 1$. Once there are n households of this type, the composition of their investments makes the capital grows at a rate of $(1 + n)$. Therefore, the law of movement of physical capital is:

$$(1 + n)k_{t+1} = (1 - \delta)k_t + i_t \quad (4.7)$$

The budget constraint is applied every period limiting the spends in consumption ($c_{r,t}$), investment (i_t), and accumulation of government bonds ($b_{t+1} - b_t$), as described below:

$$\left(1+\tau_{c,r}\right)c_{r,t}+i_t+\left((1+n)b_{t+1}-b_t\right) \\ =\left(1-\tau_{h,r}\right)\xi_r w_t h_{r,t}+(1-\tau_k)r_t k_t+(1-\tau_b)\rho_t b_t+tr_{r,t} \tag{4.8}$$

Finally, since the households are supposed to maximize their utility every period of time, satisfying their respective budget constraints. Thus, the problem of the p households is maximized (4.4) subject to (4.5) while the r households maximize (4.6) subject to (4.8). Both types must take into account the congestions present in equations (4.1) and (4.2).

4.2.2 Firms

The representative firm yields a final good through a Cobb-Douglas function based on Eicher and Turnovsky (2000). So, to produce Y_t, it uses private capital (K_t), labor (H_t), and stock of public capital $(K_{g,t}^S)$. Similar to Uzawa (1961), it is assumed that the production function shows a productivity grow allowing the economy to growth in *per capita* terms in the long term. The technological progress (A_t) increases the labor and grows at a rate $(1+g)$. Thus, the production function is:

$$Y_t=AK_t^{\sigma_K}(A_tH_t)^{1-\sigma_K}\left(K_{g,t}^S\right)^{\gamma} \tag{4.9}$$

where $K_{g,t}^S=\frac{K_{g,t}}{K_t}$.

It is assumed that the firm maximizes profit (Π_t) in a way that on the equilibrium the gross return of capital is equal to r_t, and the wages before the taxes are w_t. Therefore, for each time t, the firm's problem of maximizing is:

$$\max_{K_t,H_t}\Pi_t=\left\{AK_t^{\sigma_K}(A_tH_t)^{1-\sigma_K}\left(K_{g,t}^S\right)^{\gamma}-w_tH_t-r_tK_t\right\} \tag{4.10}$$

4.2.3 Government

The tax revenue (T_t) is basically composed by the taxes over the consumption $\tau_{c,p}C_{p,t}$ and $\tau_{c,r}C_{r,t}$, the income from labor, $\tau_{h,p}w_{p,t}H_{p,t}$ and $\tau_{h,r}w_{r,t}H_{r,t}$, the return from the capital, which evolves both direct and indirect taxes, $\tau_k r_t K_t$, and the return of the public bonds, $\tau_b\rho_t B_t$. Besides, the government can also raise funds by issuing new government bonds. Into this process, there are efficiency parameters (ef_{tc}) associated with all the tax bases, except for the one that is levied on the returns of government bonds. It is due to the fact the government exerts direct control over it. Thus, the government's budget constraint, as well as the equation that determines tax collection, are represented by the following equations.

$$T_t + B_{t+1} - B_t = C_{g,t} + I_{g,t} + TR_{p,t} + TR_{r,t} + \rho_t B_t \quad (4.11)$$

$$T_t = \tau_{c,p}\, ef_{tc}\, C_{p,t} + \tau_{c,r}\, ef_{tc}\, C_{r,t} + \tau_{h,p}\, ef_{tc}\, \xi_p w_{p,t} H_{p,t} + \tau_{h,r}\, ef_{tc}\, \xi_q w_{r,t} H_{r,t} + \tau_k\, ef_{tc}\, r_t K_t + \tau_b \rho_t B_t \quad (4.12)$$

where $B_t = N_{r,t} b_t$ is the stock of aggregate public bonds.

Additionally, the law of movement of public capital is represented below. Where δ_g represents the depreciation rate of public capital and I_g is the public investments.

$$K_{g,t+1} = \left(1 - \delta_g\right) K_{g,t} + I_{g,t} \quad (4.13)$$

Every time t, the government allocates a share of the GDP to finance public services, public investment, and transfers to the households. Thus, the fiscal policies are specified as $C_{g,t} = \alpha_g Y_t$, $I_{g,t} = \alpha_I Y_t$, $TR_{p,t} = \alpha_p Y_t$ e $TR_{r,t} = \alpha_r Y_t$, where the $\alpha_g, \alpha_I, \alpha_p$, and α_r are the policy parameters.

4.2.4 Equilibrium in the aggregate economy

Given sequences of fiscal policies $\{\tau_{c,p};\ \tau_{c,r};\ \tau_{h,p};\ \tau_{h,r};\ \tau_k; \tau_b;\ \alpha_g;\ \alpha_I;\ \alpha_p\}_{t=0}^{\infty}$ and efficiency levels $\{ef_{tc}\}_{t=0}^{\infty}$, the equilibrium is set by a sequence of households' decisions, $\{c_{p,t}; c_{r,t};\ i_t; h_{p,t}; h_{r,t}; b_{t+1}\}_{t=0}^{\infty}$, by an optimal sequence of stocks of private and public capital $\{K_t; K_{g,t}\}_{t=0}^{\infty}$, by a sequence of prices of factors $\{w_{p,t}; w_{r,t}; r_t\}_{t=0}^{\infty}$, and the interest rate of the public debt, $\{\rho_t\}_{t=0}^{\infty}$. It is compatible with the optimization problems of both types of households and the firm, the conditions for aggregating individual decisions, which are represented as ($C_{p,t} = N_p c_{p,t}$; $C_{r,t} = N_r c_{r,t}$; $C_t = C_{p,t} + C_{r,t}$; $K_t = N_r k_t$; $TR_{p,t} = N_p tr_{p,t}$; $TR_{r,t} = N_r tr_{r,t}$; $I_t = N_r i_t$; $B_t = N_r b_t$; $H_{p,t} = N_p h_{p,t}$; $H_{r,t} = N_r h_{r,t}$), the government budget constraint, and finally, the constraint of the total resources in the economy: $C_t + C_{g,t} + I_t + I_{g,t} = A K_t^{\sigma_K} (A_t H_t)^{1-\sigma_K} \left(K_{g,t}^S\right)^{\gamma}$.

4.2.5 Wellbeing analysis

Given the basic fiscal policies in steady-state as show in the previous section, to calculate the variation of the wellbeing of the households from a change in the fiscal policy is uses a traditional method widely applied in the literature such as Chari, Christiano, and Kehoe (1994, 1995), Pereira and Ferreira (2008, 2011), Bezerra *et al*. (2014), Gomes, Pereira, and Bezerra (2019), and Gomes *et al*. (2020).

The measurement of wellbeing corresponds to the percentage change in consumption, x, related to the steady-state, keeping constant the hours worked and the consumption of public services in the levels also observed in the steady-state, required to equalize the level of utility to the one observed if the policy is in fact applied. Thus, it must satisfy the following equation.

$$\sum_{t=0}^{\infty} \beta^t (1+n)^t \{\ln(c_{i,t}^{BP}(1+x) + \mu_i\,(cg_{i,t}^{S})^{BP}) + \psi_i \ln(1-h_{i,t}^{BP})\} = \sum_{t=0}^{\infty} \beta^t (1+n)^t \{\ln(c_{i,t}^{AP} + \mu_i\,(cg_{i,t}^{S})^{AP}) + \psi_i \ln(1-h_{i,t}^{AP})\} \quad (4.14)$$

where $i = p, r$, BP means before the policy, and AP means after the policy.

4.3 Calibration

The calibration of the parameters uses information from official data provided mostly by government agencies and departments, namely that, Brazilian Institute of Geography and Statistics (IBGE), National Household Sampling Survey (PNAD 2014), Federal Government Transparency Portal, and Management Reports from the Federal Revenue Service (SRF). It follows closely Gomes, Pereira, and Bezerra (2019) and Gomes *et al*. (2020).

Assuming that the Brazilian economy was on a stationary path in 2014, the calibration process is carried out so that there is a correspondence between the stationary solution of the model and the observed data of the Brazilian economy in this particular year. Thus, for organization purposes in this process, since efficiency is the main topic, the efficiency parameters are specified at first in this section. Then, the division of the households are specified and the model parameters are divided and presented in i) technology parameters $(\sigma_K, \delta, \delta_g, \gamma, A, n, g, \xi_p, \xi_r)$; ii) fiscal parameters $(\tau_{c,p}, \tau_{c,r}, \tau_{h,p}, \tau_{h,r}, \tau_k, \tau_b, \alpha_g, \alpha_I, \alpha_p, \alpha_b)$; and iii) preference parameters $(\beta, \mu, \psi_p, \psi_r)$.

Firstly, concerning the efficiency parameters, which are associated with collecting taxes, for simplicity, it is assumed that the efficiency of collecting taxes is equal for all the tax bases (ef_{tc}). This essay uses the estimation for the Brazilian case in the year 2012 from Sokolovska and Sokolovskyi (2015), which is 75%. Therefore, $ef_{tc} = 0.75$. The VAT efficiency ratio estimation follows the equation:

$$Ef_{vat} = \frac{REV_{VAT\_act}}{REV_{VAT\_est}} * \frac{Base_{VAT}}{Cons} \quad (4.15)$$

where REV_{VAT_act} and REV_{VAT_est} are respectivey the actual and estimated VAT revenue, $Cons$

represents the final consumption of the households as a share of the GDP, and $Base_{VAT}$ represents the VAT tax base. Sokolovska and Sokolovskyi (2015) emphasize that this equation already takes into consideration the presence of factors that affect negatively the VAT efficiency such as tax evasions and underpayment of taxes.

4.3.1 Households' classification

The classification of households considers both household income *per capita* and the access, or not, to financial assets, such as savings, interest, dividends, and rents, as well as the possession of movable and/or immovable properties. Firstly, it uses the criterion of a quarter (1/4) of a minimum wage, below ore qual this value it belongs to the p households, and above it is qualified to be into the r group of households. Although controversial, poverty thresholds measures based on a salary share are widely applied into the literature and so are used by the governments to determine social assistance programs, as indicated in Loureiro, Suliano, and Oliveira (2010).

The division is based on Gomes *et al*. (2020), which identifies households with interest and dividend income. It uses microdata available on the Transparency Portal on payments made to households during 2014 related to social security programs as well as assistance programs to reduce the identification bias.

Based on the classification and in the number of households in Brazil, which in 2014 was about 67.2 million, it is identified that 16.73% belongs to the p households, which gives N_p= 11,236,463. On the other hand, 83.27% belongs to r households, which gives N_r = 55,937,699. Therefore, $L_p = 0.1673$ and $L_r = 0.8327$.

Once the classification of the households was done, it was identified that it was found that the average monthly income *per capita* of all the p households is approximately R$ 552.78, whereas for the r Family was around R$ 1,156.71. Regarding the income of all sources, the households of the types p and r get, respectively, R$ 852.37 and R$ 2,064.22.

It considers the average annual total hours worked per Brazilian worker obtained from the Penn World Table (PWT), referring to the period from 2006 to 2014. Therefore, $H = 0.2930$. Data from PNAD (2014) indicates that the total amount of worked hours on average the households p and r spend working are 22.24 and 24.69, respectively. Assuming that the relationship between the weekly working hours of types p and r follows the relationship between the hours of PNAD, then, given L_p, L_r, H and the relationship between the average wages of each type in PNAD, is determined as $h_p = 0.338$ and $h_q = 0.321$. It is similar to the value estimated for Cooley and Prescott (1995) for the American economy, which shows that American workers spend about one-third of the daily hours working.

4.3.2 *Technology parameters*

The depreciation rate of public and private capital comes from their laws of movement in steady-state. Therefore, solving $(1+n)(1+g)K_{t+1} = (1-\ \delta)K_t + I_t$ for the depreciation rate, it generates $\delta = I_t/K_t - g - n - g*n$. Similarly, solving $(1+n)(1+g)K_{g,t+1} = \left(1-\delta_g\right)K_{g,t} + I_{g,t}$, it generates $\delta_g = I_g/K_g - g - n - g*n$. The calibration of these parameters uses the average of data from 1998 to 2008. The average ratios of $(I_{g,t}\ /K_{g,t})$ and (I_t/K_t) are, 0.0509 and 0.0786, respectively. The population growth rate for this period, in turn, is about 1.97%, which makes $n = 0.0147$. Finally, for the growth rate of the labor productivity, it uses the average rate of the ratio of real GDP over the economically active population (PEA), which gives $g = 0.0055$. Thus, the calibration returns $\delta_g = 0.0305$ and $\delta = 0.0581$.

It is emphasized that the values for g and n showed in the previous paragraph are calibrated especifically for the depreciation parameters, it means the calibration itself takes into account other values for these parameters. Therefore, taking the same formula but the period from 1993 to 2013, which is larger than the previous one, so it is considerate more accurate for the calibratin as a whole. Thus, $g = 0.0111$. The population growth rate, in 2014, was in turn around 0.86%, hence $n = 0.0086$. The total productivity of the factors (A), in turn, was calibrated so that the stationary product in efficiency units is equal to the unity. Therefore, $A = 1.5044$.

The parameter γ expresses the value of the public capital of infrastructure on the economy's outcome. It comes from Ferreira (1993) and Ferreira e Nascimento (2006), which estimated the value of $\gamma = 0.09$. This value has been widely applied in the literature in Brazil (Bezerra *et al*. (2014), Gomes, Pereira, and Bezerra (2019), and Gomes *et al*. (2020)).

The returns of capital as a share of the GDP is measured as the sum of gross operating surplus with one-third of gross mixed-income as a share of GDP at cost of factors, which is obtained by subtracting taxes and subsidies on production and imports from GDP. From official data, the value of $\sigma_K = 0.4221$ is calibrated. As a result, the share of the returns of the labor must be the complementary part of it $(1-\sigma_K) = 0.5779$. Indeed, this values are close to those found in the literature such as Pereira and Ferreira (2010), Santana, Cavalcanti, and Paes (2012), Bezerra *et al*. (2014), and Campos and Pereira (2016). Table 4.1 summarizes the values of these parameters.

Considering that both types of households have the same preferences over the leisure time and that the r household is the most similar to represent the average individual in the economy, $\xi_r = 1$, plus the average worked hours from PNAD, it implies that the preferences of leisure are compatible to the value of $\psi_p = \psi_r = 1.2848$. Based on that, the productivity of the p household is $\xi_p = 0.4540$.

Table 4.1 - Technology parameters.

σ_K	n	g	δ_g	δ	γ	A	ξ_p	ξ_r
.4221	.0086	.0111	.0305	.0581	.09	1.5044	.4540	1

Source: Author's elaboration.

4.3.3 *Fiscal Parameters*

The tax rate over the consumption is calculated from a share of the tax revenue over the final consumption. In 2014, the tax revenue over the consumption was 9.13% of the GDP and the final consumption was 62.95% of the GDP, implying in $\tau_c = 0.1451$. Considering the tax revenue over the labor, which was 8.98% of the GDP, and income of the labor as a share of the GDP, as in $w_t H_t / Y_t = (1 - \sigma_K) = 0.5779$, there is $\tau_h = 0.1555$. Therefore, assuming that the p households pay only the minimum tax rate of the social security system (INSS), which is equivalent to 8% ($\tau_{h,p} = 0.08$) and that the total revenue from labor as a GDP share is expressed as $\tau_{h,p}\xi_p w h_p L_p + \tau_{h,r}\xi_r w h_r L_r = (Tax\ Rev.Labor/Y_t)$, it yields the value of $\tau_{h,r} = 0.1628$.

Based on reports of the public debts, from the National Treasury Secretariat (STN) and Law number 11.033 (Dec. 21, 2004), the average of tax rates over the public bonds returns weighted by different shares of maturity is about 16.97%. Then, it determines $\tau_b = 0.1697$.

The tax revenue over the returns of capital and bonds as a share of the GDP is about 13.78% and it can be represented as $(\tau_k r_t K_t + \tau_b \rho_t B_t)/Y_t$. It firstly requires the stock of public debt (B) and its real interest rate (ρ_t). Data from the Central bank shows that in December of 2014, the net public net was around 32.58% of the GDP, which is represented as $\alpha_b = 0.3258$. The series of the real interest rate of the public debt is defined from the expression

$\rho_t = (\rho_t^n - \pi_t)/(1 + \pi_t)$, where ρ_t^n is the nominal interest rate and π_t inflation rate set by the Wide consumer price index (IPCA). The average real interest rate on public debt between January 2008 and December 2011 is $\rho = 7.57\%$. Finally, using the elasticity of the outcome related to the capital (σ_k) already calibrated before, the calibration of this parameter is obtained as $\tau_k = 31.65\%$.

The shares of the government's consumption and investment are represented, respectively, for α_g and α_I. Based on the sum of the macroeconomic aggregate collected in the National account system, the final consumption of the public administration was 19.15% of the GDP and the gross fixed capital formation of the government, which is a widely accepted proxy for the government investment, was of 2.96% of the GDP. Then, it generates, respectively, $\alpha_g = 0.1915$ and $\alpha_I = 0.0296$.

Finally, the average transfers from the government to the households represent the ratio of $tr_{p,t}/tr_{r,t} = 0.0869$. Once the total amount transferred is composed by the sum of the individual transfers, including it into the government budget constraint plus being aware that in steady-state the outcome of this economy is calibrated to the unity, the transfers to the p households as a share of the GDP is set as $\alpha_p = 0.0061$.

Table 4.2 - Fiscal parameters.

τ_c	$\tau_{h,p}$	$\tau_{h,r}$	τ_b	τ_k	α_g	α_I	α_b	α_p
.1451	.08	.1628	.1697	.3165	.1915	.0296	.3258	.0061

Source: Author's elaboration.

4.3.4 *Preference parameters*

For the parameter μ, it is considered the value of 0.5, which is a widely used value in the literature (Ferreira and Nascimento (2006); Santana, Cavalcanti, and Paes (2012); Bezerra *et al*. (2014); Gomes, Pereira, and Bezerra (2019); Gomes *et al*. (2020)). Most of these authors are based on Bailey (1971) and Barro (1981), which in turn state that individuals interpret public spending as a substitute for private consumption.

The intertemporal discount factor (β) is calibrated from the household's first order condition in steady-state. As it is a behavioral parameter, it considers the parameters already calibrated above. Thus, it takes into account the formula $\beta = \frac{1+g}{1+\rho(1-\tau_b)}$ and the values of $g = 0.0111$, $\rho = 0.0757$, and $\tau_b = 0.1697$, that generates $\beta = 0.9513$.

The preferences for leisure were already introduced combined with the paramters of productivity in the section of the tecnology parameters. They are compatible to the value of $\psi_p = \psi_r = 1.2848$.

Table 4.3 - Preference parameters.

μ	β	ψ_p	ψ_r
.5	.9513	1.2848	1.2848

Source: Author's elaboration.

4.4 Simulation Exercises and Results

Aiming to provide a clear explanation of the results, this section is divided into two parts. Following the previous essay, it firstly analyzes a policy of a 10% improvement in tax collection efficiency. Then, it simulates different policies of tax reductions on the country level combined with this 10% improvement in tax collection efficiency.

4.4.1 Increasing efficiency in tax collection in Brazil

According to Arbel, Fialkoff, and Kerner (2019), statistical test outcomes support Laffer's controversial claim that for the few upper-brackets taxpayers, an efficient collection is associated with tax reduction rather than tax increase. Similarly, Romer and Romer (2010) show that tax increases are highly contractionary. Therefore, even though increase tax rates seems to be the easiest way to improve tax revenues, which are so required due to the current both situations fiscal and sanitary, it would likely yield opposite outcomes, making the fiscal deficit currently observed even worse. Thus, this essay proposes increase efficiency as an alternative to increase tax revenues.

Based on the main topic developed in this essay and given the similarity to the previous one, it simulates a policy of an increase in efficiency in tax collection. The magnitude of the change is arbitrary and also follows the previous essay. Thus, the policy consists of an increase of 10% in the efficiency in tax collection, which goes from the assumed inital value 0.75 to 0.825. For simplicity, this improvement is assumed to be similar in all sources of tax collection. Increases in efficiency like this could be obtained by performing improvements in technology system and changes in specific laws making the process easier.

The improvement in efficiency in tax collection would return an increase in tax revenue. Since the shock is implemented once for all, this increase in tax revenue is around 9.85% immediately in the first period after the implementation. It is a little shorter than the 10% shock due to the incidence of efficiency, which excludes the income coming from the public debt as assumed in the model description.

Therefore, given the current scenario described regarding the public finances, these possible extra revenues might be used firstly to mitigate the pandemic effects on public finances and then for other purposes such as reducing the public debt. This first simulation is used in the following section as the start point to base compensations of tax rate reductions, borrowing the axiom of the compensation of the tax revenue components from the previous essay.

4.4.2 The axiom of the compensation of the tax revenue components: a broader approach

Once this essay develops an approach similar to the previous one, it simulates the same sort of policies of compensation. However, in this case, the focus of the compensations is the tax revenue. It is due to the current scenario of the public finances in Brazil that combines consecutive fiscal deficits with the effects of the Covid-19 pandemic, which requires an increase in spendings in health and transfers to subnational units, as well as cash transfers to aid poor households at the same time the economic activity restrictions reduces tax revenue. Therefore, it is highly unlikely that congress approves some tax policy that reduces the tax revenue in the short run. Thus, the axiom is adapted to find compositions that yield at least the same amount of revenues collected before the implementation. This reconfiguration is described below.

Let the equation for Tax Collection be represented by the equation 4.12. Rewriting it: $T_t = ef_{tc} * (\tau_{c,p}C_{p,t} + \tau_{c,r}C_{r,t} + \tau_{h,p}\xi_p w_{p,t}H_{p,t} + \tau_{h,r}\xi_q w_{r,t}H_{r,t} + \tau_k r_t K_t) + \tau_b \rho_t B_t$. At time t, the efficiency covers the incidence bases of consumption, work, and capital, with the respective tax rates $\tau_{c,p}$, $\tau_{c,r}$, $\tau_{h,p}$, $\tau_{h,r}$, and τ_k. Thus, the efficiency, the tax rates, and the incidence bases are the components of the tax revenue. For a given level of efficiency, higher than the current value, there is at least one value for each tax rate, individualy or not, lower than the current value, able to yield either the same level or a higher level of Taxation, *ceteris paribus*.

Keeping the modest change in the efficiency level of 10% as performed above and applying the axiom of the compensation of the tax revenue components to keep the total tax revenues unchanged at least on the oncoming years, which are more difficult to adapt the budget given the problems discussed, this essay simulates policies consisting in reductions of the tax rates components both individually and combined. In order to facilitate the prior understanding of the proposed policies, they are shortly described in the following table.

Table 4.4 - Description of the policy simulations applying the axiom for a generalized 10% increase in efficiencyin tax collection.

Policies	Description
Policy 1	Reduction of 40.3% on tax rates over consumption, $\tau_{c,p}$ and $\tau_{c,r}$.
Policy 2	Reduction of 41.3% on tax rates over work, $\tau_{h,p}$ and $\tau_{h,r}$.
Policy 3	Reduction of 23.9% on tax rates over capital, τ_k.
Policy 4	Reduction of 20.5% on tax rates over consumption and work, $\tau_{c,p}$,$\tau_{c,r}$,$\tau_{h,p}$, and $\tau_{h,r}$.
Policy 5	Reduction of 11.2% on tax rates over consumption, work, and capital, $\tau_{c,p}$, $\tau_{c,r}$, $\tau_{h,p}$, $\tau_{h,r}$, and τ_k.

Source: Author's elaboration.

Once the policies for simulation are properly presented above, henceforth they are called just by their codes. Remembering that all policies consider a 10% increase tax collection efficiency. The following table reports the steady-state results, in percentage variation, for some of the macroeconomic variables considered in the model and for all policies proposed. It should be emphasized that the variables as well as the wellbeing gains are determined by the *per capita* variables and take into account the increases in the population growth rate and productivity together, $(1 + n)(1 + g)$, being transformed therefore in efficiency units. Besides, it is worth mentioning that these same factors cause a drop in the variables in efficiency units.

Table 4.5 - Steady-state results for selected macroeconomic variables for all policies.

Variable	Policy 1	Policy 2	Policy 3	Policy 4	Policy 5
GDP (Y)	3.59	5.06	8.30	4.36	6.34
Consumption p HH* (Cp)	5.92	3.38	5.92	4.66	5.40
Consumption r HH (Cr)	3.40	5.20	4.65	4.33	4.65
Consumption of Gov.** (Cg)	3.59	5.06	8.30	4.36	6.34
Investment of Gov. (Ig)	3.59	5.06	8.30	4.36	6.34
Private Investment (I)	3.59	5.06	20.29	4.36	11.86
Transfers p HH (TRp)	3.59	5.06	8.30	4.36	6.34
Worked Hours p HH(hp)	.11	-.004	-.005	-.002	-.003
Worked Hours r HH (hr)	3.93	5.58	2.21	4.79	3.65
Wage (w)	.00	.00	6.22	0.00	2.95
Interest rate (r)	.00	.00	-.10	.00	-.05
Private Capital (K)	3.59	5.06	20.29	4.36	11.86
Capital of Government (Kg)	3.59	5.06	8.30	4.35	6.34
Tax Revenue (T)	1.15	1.85	5.87	1.48	3.52
Wellbeing (Δ%) p Household	6.29	4.44	6.32	5.38	5.97
Wellbeing (Δ %) r Household	.18	.56	.03	.38	.30

Source: Author's elaboration. Note: *HH = Households. **Gov.=Government.

Firstly, since the results are displayed in percentage variation, stands out the similarities among the results concerning GDP and some variables ran by the government such as the public consumption, transfers to the p households, and public investment, which also makes the public capital grows at the same rate. This sort f result is already expected since these variables are created as shares of the GDP.

Considering only the steady states, it means disregarding the transition from the initial period, in which the policies are implemented, to the new equilibrium the economy achieves after the policies, all of the policies returns positive changes for the main variables considered such as GDP, private consumption for both households, and tax revenue.

Policy 3, which reduces the tax rate over the capital, yields the highest effect on GDP as well as the wellbeing of the poor households. This effect on GDP follows the impact this policy plays over private investment. This kind of policy exerts good incentives to the productive sector. Therefore, it is an expected result. Besides, this impact on GDP also raises the tax revenue, resulting in the highest variation of the policies.

Policy 1 yields the second-highest wellbeing variation for p households. Although it presents the smallest impact on GDP of all simulations, a 3.59% increase in GDP is considered a good outcome, it represents a growth rate higher than the observed recently. This policy incentivizes consumption the most, and poor people tend to absorb promptly these incentives, assuming their basic needs are not being fully covered before the implementation.

The bolder policy, Policy 5, which applies reduction in all tax rates the government is supposed to exert some efficiency collecting, reaches the second highest result for GDP, about 6.34% increase in the long term. Similar to previously discussed regarding Policy 3, this policy incentivizes investments, which in turn enlarges the potential of the GDP. The results show that policies that reduce tax rates over the capital, either purely or combined, are those that boost the largest changes in GDP.

Although negative variations are observed in the worked hours of the poor households for all policies, except for Policy 1, it emphasizes that these variations are small. Nevertheless, if on one hand, these changes increase leisure time, which is a positive factor in the utility function, on the other hand, it might reduce the returns from work hence potentially reducing consumption, which another positive factor of the utility function. The matter of fact is that the net effect observed by the positive wellbeing variation is positive.

Regarding the steady-state analysis, it highlights only the outstanding results. From now on it develops an analysis based on the dynamics provided by the model. These analyses are deeper since it is possible to look at the movements of the variables right after the implementation of the policies and their behavior through the years. Table 4.6 compiles results for all policies, for selected variables over time.

Table 4.6 - Dynamic results (% changes) for selected macroeconomic variables of all policies.

Policy/Variables*	Time period after implementation (years)					
Policy 1	1	2	4	8	16	50
GDP	2.42	2.51	2.68	2.91	3.16	3.48
Tax Revenue	.00	.17	.32	.52	.75	1.04
Consumption *p* HH	4.01	4.20	4.51	4.95	5.38	5.80
Consumption *r* HH	1.13	1.37	1.76	2.29	2.82	3.27
Private Investment	6.01	5.65	5.06	4.31	3.68	3.52
Households' Wellbeing	*p* type		6.29	*r* type		.18
Policy 2	1	2	4	8	16	50
GDP	3.39	3.52	3.76	4.09	4.45	4.89
Tax Revenue	.00	.30	.54	.88	1.25	1.69
Consumption *p* HH	.77	1.03	1.46	2.05	2.64	3.20
Consumption *r* HH	1.99	2.32	2.87	3.62	4.37	5.01
Private Investment	8.42	7.92	7.11	6.05	5.17	4.95
Households' Wellbeing	*p* type		4.44	*r* type		.56
Policy 3	1	2	4	8	16	50
GDP	3.35	3.88	5.88	5.88	6.99	8.01
Tax Revenue	.00	1.08	3.26	3.26	4.50	5.57
Consumption *p* HH	-3.21	-2.15	1.87	1.87	4.05	5.60
Consumption *r* HH	-6.68	-5.35	-.25	-.25	2.49	4.33
Private Investment	36.29	34.18	25.98	25.98	21.76	20.09
Households' Wellbeing	*p* type		6.32	*r* type		.03
Policy 4	1	2	4	8	16	50
GDP	2.93	3.04	3.24	3.40	3.84	4.22
Tax Revenue	.00	.22	.41	.56	.98	1.34
Consumption *p* HH	2.37	2.60	2.97	3.26	4.01	4.51
Consumption *r* HH	1.58	1.86	2.34	2.70	3.62	4.18
Private Investment	7.27	6.84	6.13	5.61	4.46	4.27
Households' Wellbeing	*p* type		5.38	*r* type		.38
Policy 5	1	2	4	8	16	50
GDP	3.16	3.48	4.00	4.71	5.43	6.12
Tax Revenue	.00	.64	1.16	1.88	2.61	3.31
Consumption *p* HH	-.24	.39	1.43	2.82	4.15	5.16
Consumption *r* HH	-.023	-.015	.002	1.56	3.23	4.41
Private Investment	21.13	19.86	17.78	15.01	12.59	11.71
Households' Wellbeing	*p* type		5.97	*r* type		.30

Source: Author's elaboration. Note: *All results are displayed in percentage variations.

As long as consumption is a significant share of poor people, most of the time all of it is even enough for their basic needs, policy 1 reaches the highest impact on consumption of these households. It would increase their consumption by about 4% in the very first year after the implementation, reaching 4.5% within 4 years and reaching an almost 5% increase in 8 years. Besides, since consumption is a significant share of GDP, this policy would generate a 2.4% increase in GDP in the first year, achieving more than 3% after 16 years. A considerable positive result, although the lower of all policies.

This policy would be responsible for the second-highest wellbeing gains for poor households of all policies. Once the composition of the utility also considers the consumption of public goods, which grows accordingly to the growth rate of the GDP, it compensates the raising of private consumption into the composition of utility, softening it.

Policy 2, which focuses on the reduction of tax rates over the labor force, also reaches considerable positive effects in all the variables displayed on the table. The positive variation on GDP is the highest in the very first year after the implementation, slightly higher than it would be observed in policy 3, which by the way would proportionate the highest long-run variation on GDP. Although policies 3 and 5 overcome this variation over the years.

Policy 3 would proportionate the highest variation of investment, over 36% in the first period then decreasing ending up with a still high variation of 20%. Before questioning these magnitudes, one might firstly remember that this policy applies a 23.9% drop in tax rates over the capital. This policy has the best incentives for investments. The effect is positively reflected in both fiscal and macroeconomic aspects. In terms of the macroeconomic aspects, it helps to bypass the economy's bottlenecks, specifically in terms of the supply side. This booster effect, in turn, promotes an increased tax revenue hence facilitating balanced fiscal management and getting extra resources for reducing public debt.

Despite the positive effects on GDP, it stands out the negative impact on the private consumption over the firsts periods for both types of households. The p households achieve a positive variation in the fourth year after implementation. On the other hand, the r households last over 10 years to get a positive variation on it. In this case, since the r households are also investors, their incentives to allocate their incomes change when the tax rate drops, hence they might be reallocating their income taking from consumption to investments in the firsts periods. Regarding the p households, these rearrangements of investments are causing a reduction in worked hours by around 1.5% while the firsts years converging to the initial value in the long run. It would explain the decrease in consumption right after the implementation.

Once again, Policy 4 would result in positive effects for all variables discussed. As a combination of policies 1 and 2, it also compiles features from both of them such as a high incentive to consumption, which turns out to be the second-highest among the policies. In terms of tax revenue, it would bring an increase of over half percent in 8 years and around 1% in 16 years, which overcomes the level of variation performed by Policy 1.

Finally, Policy 5, which is the bolder policy simulated here because it applies reductions in all tax rates the government may express inefficiency over, would require a huge political effort to implement. However, it emphasizes it is still considered feasible and could be implemented by a reform in the tax system, which is already being discussed by congress. Once in evolves a variety of tax rates, the percentage of reduction is smaller than the those required for the other policies. It may be considered as an advantage to legitimate its feasibility in a possible reform.

Another noteworthy result is that policy 5 would achieve the highest increase of tax revenue variation among the policies simulated, which would be over 0.6% in the second year and almost 2% in 8 years. Remembering that this generalized effort requires a drop around 11.2%, which is considerably lower than other reduction that has been simulated so far concerning specific tax rates, namely that, policies 1, 2, and 3. This percentage of reduction combined with the gains reported also helps to justify some efforts to implement these sort of policies.

Given its generalized tax reduction, it compiles the incentives from the specific policies highlighting some features. This is the case of the negative variation of the consumption, similar to those observed in policy 3. However, in this case, it is lower due to the lower reduction of the tax rates. Besides, it turns to a positive variation faster for both types of households.

As shown, all of these simulated policies yield positive gains on GDP, well-being for both types of households as well as a sustainable way to increase tax revenue over the years providing an alternative to solve or at least mitigate the problems in public finances in Brazil. Therefore, the results described throughout this section demonstrate the need to consider public policies of efficiency improvements, as well as tax reductions.

4.5 Final Remarks and Policy Implications

Brazil has shown an expressive increase in the Gross Debt of the Central Government since 2001. As highlighted by Souza Junior and Santos (2017), one important factor that has contributed to this is the continuity of tax exemptions. Therefore, increase efficiency in tax collection also evolves a review of the tax exemptions policies aiming to evaluate the benefits, adjusting them most efficiently.

Although in the previous essay a structural reform on the tax system was not discussed due to the limits the state tiers of government have to change tax issues, in this country-level analysis, it is possible. Therefore, this is one topic in which the central government can work on as a tool to improve efficiency in tax collection. These efficiency improvements can be achieved by enhancing the structure of the tax system focusing on reducing the complexity of the tax system, changing tax rates, which in turn might change economic incentives, and reducing the distortions caused by tax exemptions.

There is a direct relationship between tax collection and the health of economic activity. It means that the higher the GDP, the higher the tax collection tends to be. The magnitude of the response of tax revenues to a GDP boost, however, depends on the composition of the economic expansion due to the structure of the tax system. Therefore, it is highly advisable policies of formalization on economic activities as a way to facilitate tax collection, hence improving it.

Afonso, Romero, and Monsalve (2013) suggest that the efficiency scores might be improved by more transparency and regulatory quality. It is highly emphasized that these sorts of policies are feasible. However, be feasible differs from being easy to implement. In this sense, Brinkerhoff and Brinkerhoff (2015) highlight the challenge of measuring results and the practical difficulties in achieving a contextual adjustment and accounting for the uncertainty inherently observed in reform processes. Notwithstanding, it is eventually expected that this work contributes to the current national debate regarding both economic and political issues guiding policymakers and lawgivers in terms of public policies based on this framework.

As assumed that the government performs some level of inefficiency in all of its activities, it is also true that state-owned companies are less efficient than private ones. Therefore, another way to improve public sector efficiency would be by privatizing. Indeed, a state-owned company loses attraction not only when it is not profitable but also when the profit is not as much as expected because it makes the investors and individual shareholders more uncertain and likely to run away. Even though some of the state-owned companies must be approved by congress to be privatized, most of them depend only on the arrangements of the president and the economic team. It was established in 1997 by Law 9491, which deals with the National Privatization Program.

Additionally, in this national aggregation approach, the revenues from the privatization process can be used to reduce the public debt as an attempt to maintain the debt level stable under the argument that pays interest for public debt is inefficient once these resources could be applied in public services such as education, health, and security. Besides, Pereira e Ferreira (2018) and Bezerra *et al*. (2018, 2019) show that privatization brings forth the possibility of welfare gains, which comes mostly from increases in output and consumption of public services. Therefore, privatization policies might work as a double force to increase efficiency in the public sector.

Finally, once Constitutional Amendment No. 95/2016 is already running and that there is a possibility of remodeling it planned for 2026, allowing to change the restrictions imposed in the currently running version, the results provided in this essay might also orientate changes to enhance its effects and results. Indeed, efficiency improvements in tax collection, which would likely increase tax revenue, might concern the areas and shares these extra resources are spent, whether to reduce the public debt or any other destination the government considers important or necessary.

5 GREASE OR SAND THE WHEELS? A STATE-LEVEL APPROACH ON CORRUPTION IN BRAZIL

5.1 Introduction

Given that corruption is a specific form of the inefficiency of the public sector, this essay is dedicated to this topic and analyses the effects of corruption on income issues in state-level at Brazil. One contribution is to create objective proxies for corruption and apply them in these types of analyses. Furthermore, to achieve more accuracy in the connection among the Brazilian states, it also performs a spatial approach in the above-mentioned analyses.

Corruption is a world phenomenon, a common problem the governments must face. Once corruption takes away part of the public resources available, the magnitude of the effects depends on, among other factors, the level of observed corruption. Additionally, it fosters an inefficient allocation of these resources yielding outputs lower than they could potentially be. Therefore, in small and poor economies in which resources are usually scarcer, each portion of wasted resources tends to be proportionally more costly.

Although the recent scandals of corruption in Brazil have been focused on the central government, they regard the state-level governments as well. As a result, it not only undermines the trust the individuals, voters and investors, lodge in government but also implies different fiscal problems. In other words, corruption may lead to political instability, which is an important channel through which corruption affects economic growth, as stated by Mo (2001) and Ghalwash (2014).

According to Solé-Ollé and Sorribas-Navarro (2018), after a scandal capital grants from higher tiers of government tend to fall. Conversely, taxes and deficit tend to increase. Besides, local governments do not adjust their spending as a response to the corruption effects. All these results have a potential negative influence on economic indicators. In fact, Campos and Pereira (2016) and Bezerra *et al.* (2019) analyze this topic for the Brazilian case using computable general equilibrium models. The former splits the corruption of the whole public sector inefficiency and shows that when corruption is eliminated, in general, private investment and output increase in the long run. The latter, on the other hand, combines it with privatization and shows gains in terms of private investment and welfare.

According to Schwab and Zahidi (2020), based on the well-known Corruption Perceptin Index, which is set from 0 to 100, where the higher the score the lower the corruption, Brazil presented a score of 35 in 2019. Among a set of 39 countries[19] used in this study, Brazil is better off only compared to Russia and Mexico. This study also show that only around 20% of the population trust in the politicians. In this case better only compared to Greece.

A sizeable body of literature on corruption and growth issues uses subjective indexes such as the Corruption Perception Index and the control of corruption indicator, which are available for country-level only. On the other hand, just a smaller share of this literature has applied objective proxies for corruption. Regarding analyses in the Brazilian territory, Ferraz and Finan (2011) created an objective measurement for corruption by using reports from an anti-corruption program in the Brazilian municipalities. Concerning a state-level corruption, in turn, Boll (2010) created the State-level Government Corruption Indicator. The latter, however, only performs analyses by ranking them in terms of their corruption levels.

Taking Brazil as the target region and also considering local governments as mentioned in the previous paragraph, the literature concerning corruption analyses mostly uses municipalities as the geographical divisions and takes into account different topics such as elections (Ferraz and Finan (2011) and Brollo *et al*. (2013)), corruption itself (Avis, Ferraz, and Finan (2018)), and economic outcomes (Bologna (2017)). It still lacks a work to investigate corruption and income outcomes by using an objective measurement of corruption at the state level in Brazil.

Besides, according to LeSage and Fischer (2008), income issues commonly present spatial dependence among the analyzed units. In the context of the Brazilian states, spatial correlation indicates that wealthier states tend to be geographically clustered as well as the poorest ones. There is no work into the literature taking the Brazilian states with a spatial approach and including corruption and income issues. Therefore, this chapter aims to fulfill the gap discussed in the two previous paragraphs.

Beyond this introduction, this chapter is organized into four more sections, as follows. The next section presents a literature review. In section three are specified the methodology and data. The fourth section displays the results split into different econometric approaches. Finally, the last one highlights the main conclusions.

[19] Data set includes: Greece, Chile, Spain, Brazil, Finland, Sloveni Mexico, United States, Australia, Belgium, Italy, South Africa, Denmark, France, Costa Rica, Luxembourg, Turkey, Sweden, United Kingdom, Estonia, Austria, Latvia, New Zealand, Canada, Netherlands, Russia, Republic of Korea, Hungary, Czech Republic, Portugal, Israel, Lithuania, Japan, Ireland, Iceland, Germany, Slovakia, Switzerland and Poland.

5.2 Literature Review

As an essential driver for economic growth, the investment can also be a transmission channel of the effects of corruption on growth as shown by Pellegrini and Gerlagh (2004). As long as corruption yields uncertainty over the economic environment and discourages investment activities, it presents negative effects on economic growth, as shown in Mauro (1995, 1997, 1998), Ahmad, Ullah, and Arfeen (2012), and Cieślik and Goczek (2018), among others. Hence, it has impacts on investments in open economies, which, in turn, can hamper economic growth. This negative relationship between corruption and economic growth has been increasingly presented in the literature since the work of Myrdal (1989).

As slightly shown in the previous paragraph, corruption might harm economic growth. This standpoint is compatible with the "sand the wheels" hypothesis. Indeed, the literature investigates corruption and poverty levels such as Easterly (2005), Dike (2005), and Alenoghena and Evans (2015). Dike (2005) claims that corruption works as a poverty enlarger and Alenoghena and Evans (2015) classifies the effects as perverse and dangerous. Also, Gyimah-Brempong (2002) combined corruption with economic growth and income inequality.

An alternative proxy to link the relationship between corruption and economic issues has been increasingly applied in the literature, the control of corruption indicator. In this case, the link is supposed to be positive assuming corruption is mostly considered as a negative factor. Indeed, works such as Hall and Levendis (2017), Cieślik and Goczek (2018), Sharma and Mitra (2019), and Leite, Lucio, and Ferreira (2019) found a positive relationship between control of corruption and economic growth, among other results specific from each work and considering different variables. It is noteworthy that Leite, Lucio, and Ferreira (2019) focused on the long-term effects of that relationship.

Despite the above-mentioned negative relationship between corruption and economic growth, works such as Bardhan (1997), Huntington and Fukuyama (2006), and Thach, Duong, and Oanh (2017), among others, conversely present a positive relationship for that. Similar results are found by Wang (2016) by using the Chinese Anti-corruption campaign as an alternative measurement. In this context, the "grease the wheels" hypothesis is an alternative to explain that corruption might reduce bureaucracy, hence it might positively affect economic activities in specific cases such as countries with higher regulation. Corruption activities may reduce barriers to investment yielding positive economic stimulus (MÉON AND WEILL, 2010) as well as it works specifically concerning foreign direct investment (EGGER AND WINNER, 2005).

The literature concerning corruption in the Brazilian subnational units presents reasons such as elections and also corruption itself (Ferraz and Finan (2011), Brollo *et al*. (2013), and Avis, Ferraz, and Finan (2018)). However, in terms of economic issues, Bologna (2016, 2017), using data from different samples of Brazilian municipalities, found that both higher levels of corruption and a huge informal sector are associated with lower economic outcomes. Nevertheless, only the informal sector presented a significant effect on it.

Studies applying spatial approaches to economic growth and income issues are relatively new. Rey and Montouri (1999) had first explored the regional income convergence process in the US by applying a spatial approach to it. Then, this approach has been spread around the world becoming popular throughout the years. As some examples, there are Magalhães, Hewings, and Azzoni (2005) in Brazil; Dall'erba and Le Gallo (2008) and in Europe; and Hou and Long (2019) in China. However, there is no previous work including corruption and economic issues controlling for spatial dependence focusing on the Brazilian states.

5.3 Estimation Method and Data

This section specifies the econometric methods applied as well as describe the data used. The methods are presented separately in a-spatial, and spatial approaches, respectively.

5.3.1 A-spatial Econometric Model

Since Brazil has only 27 states, therefore insufficient to reach reliable results by using a cross-section approach, a panel data approach is instead applied considering a time range from 2005 to 2013. The standard static panel data model, from Greene (2002), for units $i = 1, \ldots, 27$ and time $t = 1, \ldots, 9$ is shown as follows.

$$y_{i,t} = \boldsymbol{x'}_{i,t}\,\boldsymbol{\beta} + \boldsymbol{z'}_i\,\boldsymbol{\alpha} + \varepsilon_{i,t} \tag{4.1}$$

Where $\boldsymbol{x}_{i,t}$ is a vector of explanatory variables, $\boldsymbol{z'}_i$ represents the heterogeneity, in which $\boldsymbol{z}_i$ accommodate a constant term and a set of either observed or unobserved specific variables, and $\boldsymbol{\beta}$ the vector of the slopes, independent of i and t. Finally, the error term, $\varepsilon_{i,t}$, varies over units and time.

Once investigate the effects of corruption on income is the main goal in this study, proxies for corruption objectively measured are added. Besides, variables other than those presented in traditional models such as Mankiw, Romer, and Weil (1992) are included to avoid the problem of omitted variable bias. The variables used are the stock of physical capital, human capital, public investment, unemployment, and corruption. All of these variables and proxies are detailed in subsection 5.3.3.

5.3.2 Spatial Econometric Model

Spatial autocorrelation refers to the coincidence of attribute similarity and locational similarity (Anselin, 1988). In econometric modeling, spatial methods are required as long as data are correlated over space. It might either solve the problem or mitigate it. Although the literature in this field has been applied mostly in cross-sectional spatial dependence models, there is a relatively recent development in the class of spatial panel models. The estimations outperform those obtained from both the a-spatial and non-panel modeling as they are not biased and efficient (Elhorst, 2010).

LeGallo, Ertur, and Baumont (2003) applied the spatial lag model (SAR) and the spatial error model (SEM) on cross-sectional regional convergence. Conversely, Arbia, Basile, and Piras (2005) are considered the pioneers to include this type of spatial autocorrelation effects in a panel data framework. Following Elhorst (2003), they expanded the above-mentioned analysis from LeGallo, Ertur, and Baumont (2003) to a panel data approach.

Since there are only 27 states in Brazil, not enough to achieve reliable results in a cross-section approach, panel data is the best approach to this case. The time range used is from 2005 to 2013. Based on Millo and Piras (2012), the static SARAR panel data model is applied in this essay. This specification also allows for interaction effects involving the disturbances (LeSage, 2014), as following specified.

$$y = \lambda(I_T \otimes W_N)y + X\beta + u \tag{4.2}$$

$$\text{with } u = (\iota_T \otimes I_N)\mu + \varepsilon \text{ and } \varepsilon = \rho(I_T \otimes W_N)\varepsilon + v$$

$$v_{it} \sim N(0, \sigma_v^2)$$

where y is the vector of the dependent variable, X is the matrix of non-stochastic exogenous regressors, already mentioned in the previous section, I_T is an identity matrix of dimension T, ι_T is a vector of ones, and W_N is the spatial weight matrix and λ the spatial autoregressive coefficient. The idiosyncratic errors (ε) are spatially autocorrelated, in which ρ represents the spatial autoregressive parameter, μ is a not-spatially-autocorrelated individual effect. This structure comes from Baltagi, Song, and Koh (2003). Given there is no consensus in the literature for the notation of these parameters, this chapter applies the same as Millo and Piras

(2012). Although, they appear differently on other papers as briefly shown in Bivand and Piras (2015).

5.3.3 Data and Spatial Weight Matrix

The data used in this chapter were collected from different official sources from the government. Each component of the data is in a different time series length, hence the intersection of them was considered as a way to amplify the time component. Thus, a nine-year range was selected, from 2005 to 2013. The GDP *per capita* is used as the dependent variable to represent the income. This data was collected from the Applied Economics Research Institute – IPEA[20]. The values were deflated by the GDP implicit deflator, which is the most appropriate for this variable.

The proxy used for physical capital is the consumption of non-residential electric power. This is the best option available due to the fact it takes into account all of the economic sectors as opposed to another widely used proxy, electric power spent in the industry sector.

This chapter follows Mankiw, Romer, and Weil (1992) and it includes a human capital proxy. The literature concerning human capital has focused on considering the quality of education instead of only some type of quantity of it. In this regard, a proxy combining both quantity and quality of education was created by using Years of Schooling[21] as the quantity part and the High School level of the Basic Education Development Index - IDEB[22] as the quality part. Taking only the high school level for IDEB increases the accuracy since students finish high school with age legally able to work.

Additionally, to strengthen the model specification, extra variables other than corruption are added, namely that, public investment and the unemployment rate. Public investments are deflated by a proper index and represent the acquisition of facilities, equipment, and creation or increase in the stock of capital. The decision for unemployment specifically lies in a theoretical motivation provided by Bräuninger and Pannenberg (2002).

Using data from the Irregular Accounts Register of the Federal Court of Accounts as the main source Boll (2010) created a corruption index based on data from irregular reports concerning the state-level governments' spends. A governmental agency, the Federal Government Accounts Court, is responsible for either accepting or overruling the reports. The

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[20] Available at www.ipeadata.gov.br

[21] Years of schooling from the population legally able to work. Available at: https://www.ibge.gov.br/.

[22] Available at : http://ideb.inep.gov.br/resultado/resultado/resultado.seam?cid=1211699

assumption behind this measurement is to consider the overruled reports as a source of corruption. The composition of this index also includes GDP and Population as weights for the values from the above-mentioned irregular reports.

This chapter applies two proxies for corruption. The first one uses the same components present in the index created by Boll (2010). It is called the corruption index of Brazilian states 1, in short Corruption 1, and it is described in equation 4.3. The second one excludes the components weighted by population and GDP as an attempt to expurgate possible endogeneity problems. Therefore, it takes into account only two components, namely that, the value of the Irregular Accounts - VIA from the Federal Court of Accounts as a share of the Annual Budget Law – ABL and the annual number of irregular cases as a share of the total cases. It is, in turn, called the corruption index of Brazilian states 2, briefly Corruption 2, as described in equation 4.4, where i and t represent the states and the time respectively.

$$Corruption\ 1_{i,t} = 0.25\left(\frac{VIA_{i,t}}{Pop_{i,t}} + \frac{VIA_{i,t}}{GDP_{i,t}} + \frac{VIA_{i,t}}{ABL_{i,t}} + \frac{Cases_{i,t}}{Total_t}\right) \quad (4.3)$$

$$Corruption\ 2_{i,t} = 0.5\left(\frac{VIA_{i,t}}{ABL_{i,t}} + \frac{Cases_{i,t}}{Total_t}\right) \quad (4.4)$$

Finally, by performing the well-known Moran's I test, using a method presented by Gittleman and Kot (1990), a Queen type of weight matrix, which classifies the neighbors in contiguity, was chosen. As a robustness check, a Monte-Carlo simulation of Moran's I was performed as well. Anselin (2018) claims that using the queen criterion is recommended in practice to deal with potential inaccuracies in the polygon file such as rounding errors. It makes this type to be considered as the default for contiguity weights.

5.4 Results and Discussion

The results are divided into two parts based on the absence and presence of spatial dependence. Model specifications 1 and 2 are used to refer to the regressions using respectively the proxies for corruption 1 and 2. Henceforth, only the model designations are applied.

5.4.1 Results from the A-spatial Regressions

The tests required to guarantee reliable estimations are performed. Firstly, to verify individual effects, the F test detected significant interstate variation. It suggests that the fixed effect specification is more relevant than the pooled one for both models. Additionally, the Lagrange Multiplier Test for panel models, which tests of individual and/or time effects for panel models, are performed for both fixed and random effects. Using the Breusch-Pagan type, from Breusch and Pagan (1980), they confirm that both fixed and random models outperform the pooled model for both models. Then, the well-known Hausman specification test, from Hausman (1978), assessed that the fixed effect model fits better than the random effect model.

Studies such as Gupta, Davoodi, and Tiongson (2000) and Reinikka and Svensson (2005) have shown that corruption may reduce human capital levels. Based on that, from Fox and Monette (1992), the Variance Inflation Factors (VIF) test was performed and no multicollinearity was detected. Another test related to these issues, the Breusch-Pagan test, from Breusch and Pagan (1979), for heteroscedasticity is also required in panel data approaches. It reports the expected presence of that.

Additionally, two tests were performed to check for serial correlation, the Breusch-Godfrey test, from Breusch (1979) and Godfrey (1978), and The Wooldridge, from Wooldridge (2010). The first tests for serial correlation in the idiosyncratic component of the error terms and the second performs that specifically in fixed-effects panel models. The results of both tests confirm the presence of serial correlation.

Given the presence of heteroscedasticity as well as of serial correlation, the estimation must apply the widely recommended method of Arellano, from Arellano (1987), for fixed effects panel data models, which treats simultaneously for both heteroscedasticity and serial correlation yielding, as a result, heteroscedasticity consistent standard errors. The results are shown in Table 5.1.

Table 5.1 - Estimation of Fixed Effect (FE) Panel Data, 2005-2013.

Variables	**Model 1**	**Model 2**
Physical Capital	.4583*** (.000)	.4735*** (.000)
Human Capital	.4045*** (.000)	.3744*** (.000)
Unemployment	-.0766** (.037)	-.0790** (.028)
Public Investiment	.0464*** (.002)	.0476*** .000)
Corruption 1	-.0510 (.109)	
Corruption 2		-.0274* (.066)
R-Squared	.7896	.7927
Adj. R-Squared	.7587	.7622

Source: Research results. (i) All variables are log transformed. (ii) The symbols ***, **, and * denote the significances respectively at 1%, 5%, and 10%. (iii) The values in parentheses represent the p-values.

First of all, assuming that negative effects from corruption on economic activity are possible, all of the coefficients presented the expected signal for both models proposed. Specifically, physical capital, human capital, and public investments affect positively the level of income *per capita* in Brazilian states. Conversely, unemployment and corruption yield negative effects on that. Considering all of the performed tests and the treatment for the specific problems detected, roughly speaking, it seems that both models are well specified. In terms of significance, in turn, correcting by the Arellano consistent standard errors, only corruption is nonsignificant in Model 1. It marginally crosses the borderline of significance becoming nonsignificant. Nevertheless, all of the coefficients are significant in model 2.

Notwithstanding the above results and as previously mentioned in the introduction section, income issues commonly present spatial dependence among the analyzed units (LeSage and Fischer, 2008). Therefore, there exists a strong possibility that income *per capita* among the Brazilian states presents some sort of spatial dependence. If so, the results presented so far might change, mostly in terms of significance. To achieve more accuracy on this approach, this chapter also tests for spatial dependence. Once detected, these new estimators must outperform those estimated by the classical a-spatial model as long as they are unbiased and efficient (LESAGE AND PACE, 2009). The tests and regressions are exposed in the following section.

5.4.2 Results from the Spatial Regressions

Following the structure of the previous subsection, before the results are shown, tests are performed. Given the fact the a-spatial analysis have already detected the presence of heterogeneity in the units, pointing to the usage of fixed effects, there is no reason to perform the panel version of the locally robust Lagrange multiplier tests of Anselin *et al*. (1996), which is suitable for spatial error dependence based on a pooling assumption only. Instead, the Baltagi, Song, and Koh LM test, from Baltagi, Song, and Koh (2003) was performed, detecting spatial error correlation.

The tests of Breusch-Pagan and Pesaran, respectively from Breusch and Pagan (1980) and Pesaran (2004), were performed to check the correlation of the residuals across the states. Both tests indicate significant cross-sectional dependence. This dependence regards an unknown form, not necessarily related to geographical neighbors. However, using a Queen-type weight matrix, a significant presence of this type of spatial dependence was detected.

Many determinant factors might induce spatial dependence in regions. Some examples one may easily find in the literature are trade, mobility of the productive factors, and technology diffusion. A caution worth mentioning, however, is that spatial dependence might be related to omitted variables or other types of model misspecifications. Nevertheless, it must be discarded by the inclusion of extra variables others than those considered in the original model of Mankiw, Romer, and Weil (1992), combined with LeSage and Fischer (2008), who claim that income issues commonly present spatial dependence over the units.

To reinforce the use of fixed effects previously pointed out by the Hausman test, the Hausman specification test for the spatial approach of panel data models was performed, from Mutl and Pfaffermayr (2011). Therefore, combining the results of these tests to the fact that it is highly likely there exists spatial dependence for income issues, in this case in terms of GDP *per capita*, this chapter applies the SARAR panel data model with fixed effects. The following table shows the results.

Table 5.2 - Spatial Regressions of Fixed Effect SARAR Model, 2005-2013.

Variables	Model 1	Model 2
Physical Capital	.0433** (.011)	.0468*** (.009)
Human Capital	1.6036*** (.000)	1.5917*** (.000)
Unemployment	-.1203** (.027)	-.1153** (.036)
Public Investiment	.0265 (.336)	.0280 (.313)
Corruption 1	-.0381 (.531)	
Corruption 2		-.0154 (.499)
Rho	.6371*** (.000)	.1680*** (.000)
Lambda	.1697** (.012)	.1680** (.013)

Source: Research results. (i) All variables are log transformed. (ii) The symbols ***, **, and * denote the significances respectively at 1%, 5%, and 10%. (iii) The values in parentheses represent the *p*-values.

Firstly, measuring the strength of the spatial correlation, the spatial parameters are both significant in both models. In terms of the directions of the effects, again both models present the expected signals. Controlling for spatial dependence, however, only the traditional factors of this production function (physical capital and human capital) as well as unemployment are statistically significant.

In contrast to the a-spatial estimations, the magnitudes of the estimated coefficients changed as well. The human capital factor figures as the most important in this spatial approach, given that it represents the largest impact. Conversely, physical capital, which had presented the biggest effect before, now represents the smallest one. Besides, unemployment presents an impact even bigger than physical capital. One likely reason, which also would explain the size of the coefficient of human capital, is the mobility of labor as a productive factor.

On the other hand, in terms of the no significance for corruption, one would claim this is also a possible result as long as Bologna (2017) also found a nonsignificant effect regarding corruption and economic outcomes using, however, data of Brazilian municipalities.

There are two eligible reasons for the absence of significance on corruption related to the theoretically possible negative and positive results, which are linked to the "Sand the wheels" and "Grease the wheels" hypotheses, respectively. Firstly, once corruption on this approach level has been less noticed on the media, it might represent a small and insignificant interference on income drivers such as private investments, in contrast to when it regards the federal government actions. Secondly, since the corruption measurement applied only considers the misuse of public resources excluding, therefore, the treatment of the relationship between public and private sectors as a venue for corruption, there is no way to capture any possible positive effect. Both the no significance and the negative coefficient reassert that.

Finally, as extra information, Table 5.3 presents the spatial impacts split as direct and indirect effects as well as the total effects. The spatial impact of a variable is approximated by the indirect effect as a share of the total one. Golgher and Voss (2016) provide a detailed explanation of how to derive and interpret these spatial direct and indirect effects. It emphasizes that the results in terms of significance follow the results previously shown.

Table 5.3 - Estimated Direct, Indirect, and Total effects from Spatial Regressions.

	Model 1			Model 2		
Variables	Direct	Indirect	Total	Direct	Indirect	Total
Physical Capital	.04664*** (.008)	.0056** (.030)	.0522*** (.009)	.0503*** (.006)	.0060** (.043)	.0563*** (.007)
Human Capital	1.7239*** (.000)	.2076*** (.000)	1.9316*** (.000)	1.7087*** (.000)	.2046*** (.002)	1.913*** (.000)
Unemp.	-.1293** (.026)	-.0155* (.061)	-.1449** (.027)	-.1238** (.039)	-.0148* (.085)	-.1386** (.040)
Public Investiment	.0285 (.411)	.0034 (.431)	.0319 (.411)	.0300 (.291)	.0036 (.349)	.0337 (.295)
Corruption 1	-.0409 (.549)	-.0049 (.563)	-.0459 (.549)			
Corruption 2				-.0165 (.456)	-.0019 (.470)	-.0185 (.456)

Source: Research results. (i) The symbols ***, **, and * denote the significances respectively at 1%, 5%, and 10%. (iii) The values in parentheses represent the p-values.

5.5 Final Remarks

This chapter investigated the impacts of corruption on income *per capita* in Brazilian states. Given the absence of proxies at this subnational level, it created objective proxies to represent corruption. Although corruption has presented a negative and significant effect in the a-spatial models, it is actually nonsignificant when controlling for spatial dependence. Given that the spatial models are theoretically more accurate, it seems that for this specific approach of state-level in Brazil corruption presents no significant impact on GDP *per capita*. Hence, neither grease nor sand the wheels' hypothesis fits this relatioship in Brazilian states.

The nonsignificant results for corruption must not be seen as a green light to stop fighting against it. Even if it does not interfere significantly with GDP *per capita*, it still is directly related to the provision of public goods and services, reflecting directly in the well-being of individuals. Even though the previous chapter has been discussed analyses of well-being taking efficiency as a whole, it is not the focus of this one. This sort of result is mostly presented in the literature by those works applying general equilibrium, such as Zaki (2013).

As part of the public sector inefficiency, corruption encourages and promotes an inefficient allocation of government resources diverting them to vested interests in favor of a group rather than the population. It is widely accepted that poor people present more demands from the public sector relative to the rich people, hence corruption tends to affect this portion of the poor population more negatively. Additionally, considering the COVID-19 pandemic and the necessity of the most possible resources to the health sector, one would say that each currency unit embezzled by corruption can compromise the treatment and/or cure of people configuring, therefore, a clear case of harmful practice.

Finally, corruption might present distortive effects on economic drivers such as education and health as described respectively for Reinikka and Svensson (2005) and Gupta, Davoodi, and Tiongson (2000). Therefore, given the possibility of negative indirect effects on income as well as indirect effects on its drivers, governments must keep fighting against corruption.

6 CONCLUDING REMARKS

The essays discussed in this thesis have explored a current important issue not only in Brazil but also worldwide, which is the efficiency in the public sector. Broadly speaking, the essays aim to enhance the understanding concerning this topic as a whole and also specific issues treated individually, namely that, efficiency estimation and exogenous factors of efficiency levels in state-level governments, efficiency in tax collection and the possibility to recompose the tax revenue drivers, and corruption as a specific form that efficiency can manifest itself.

The first essay, which focuses on a general way to look at the public sector efficiency in state-level governments in Brazil, applies a two-step procedure. Specifically, the first step uses a robust nonparametric efficiency estimation method for both expenditures and taxation. Besides, it proposes an index to express the public sector's general efficiency by combining the efficiency on both expenditure and taxation. The second step applies standard panel data. It is found that most of the states improved efficiency in tax collection from 2009 to 2013. However, considering a dynamic analysis, it was not enough to compensate for the expenditure efficiency losses. The second step results show significant effects for unemployment, labor informality, and population density. These results are useful for a broader sort of public policy design considering factors others than those the governments can adjust by themselves.

The second and third essays are similar in terms of method and approach. However, while both of them apply dynamic CGE models considering efficiency in taxation, which is a core duty of the public sector, the second applies a regional CGE model for the Ceará state and the third an aggregate model for the Brazilian economy as a whole. Besides, given their similarities, both apply also similar policy exercises of combinations of increasing efficiency in tax collection and reducing tax rates, each one dedicated to its specific tax rates. The findings bring light to a feasible alternative to increase tax revenue without neither losing wellbeing nor distort the incentives of the productive sector.

Continuing on this topic but going inside the efficiency to study a specific form of it, the last essay explores the relationship between corruption and the economy’s outcomes at the state level in Brazil. Although in standard panel data model corruption presents a negative and significant effect, it is observed that these results are statistically nonsignificant when controlling for spatial dependence, since spatial correlation among the units was detected. It points that considering the Brazilian states, the time, and the set of variables used corruption in state tiers of governments presents no impact on the GDP per capita of the Brazilian states. One would say that would exist another measure more appropriate to capture the impacts of this level of corruption. However, it is emphasized that searching for this measure is not the scope of this essay.

Regarding plans for efficiency improvements, Curristine, Lonti, and Joumard (2005) claim that OECD countries have adopted different approaches to reforming key institutional arrangements such as changing budget practices, and introducing results-oriented approaches to both budgeting and management. This reference, combined with the results provided in this thesis, might guide the policymakers for upcoming necessary reforms or other changes in budgeting and management on the public sector in Brazil, such as the possibility of remodeling the Constitutional Amendment No. 95/2016, which is planned for 2026, allowing to change the restrictions imposed in the limits of public spendings.

Additionally, empirical evidence suggests that decentralization of political power, transferring the spending responsibility to subnational tiers of governments might enhance public sector performance. It indicates that more efficient outcomes can be achieved by reviewing and changing the rules of Brazilian fiscal federalism. Adam, Delis, and Kammas (2012), for instance, examine the relationship between fiscal decentralization and public sector efficiency in a country-level dataset for 21 OECD countries, identifying an inverted U-shaped relationship between government efficiency and fiscal decentralization, which means there is an optimum level for it. Besides, in some areas, increases in efficiency might be achieved by increasing the scale of operations. This sort of response is mostly observed in terms of the sectors of education and health.

Regarding option of solutions that cover both efficiency issues in general as well as corruption specifically, Akitoby (2018) states that technology might be used to improve efficiency and reduce opportunities for corruption, which figures as a specific form that inefficiency manifests itself, according to Berg *et al*. (2015). Accordingly, efficiency gains can be achieved by simplifying the tax system and curb exemptions as well as reforming indirect taxes on goods and services. Regarding the former, the Value-Added Tax (VAT) has also proved to be a potential and efficient revenue booster.

Additionally, since the Brazilian tax system itself, with its exceptions and differentiated regimes that amplify its complexity, is one source of inefficiency in taxation, the government could contribute to the improvement of efficiency by carrying out comprehensive tax reform, prioritizing the solution of the current bottlenecks and obstacles that the current system promotes. Another noteworthy point is the indirect effects of improving efficiency by reforming the tax system over the global competitiveness index, which is influenced by tax issues, and would possibly reach positive effects on the economy as a whole.

Moreover, as long as tax reductions work as good incentives for the economic agents, following the good practices the countries around the world have been implementing might help Brazil as a whole, which includes the states, to boost the economy, hence to recover from the side effects of the COVID-19 pandemic as well. Therefore, both Federal and state tiers of governments should focus on feasible tax policies, taking into account the structure of public finances and the low level of changes allowed for the current tax system. In this context, this thesis provides one option to set changes by improving efficiency on tax collection would allow for reducing tax rates.

The essays covered along this thesis represent a small share of the whole topic of public sector efficiency. Therefore, there still is a huge research agenda full of unsolved research questions. Nevertheless, it is expected that the findings provided so far might contribute to the current public debate regarding this topic in Brazil and hopefully guide policymakers through the policy implications discussed. Finally, although these policy implications might seem hard to implement, one of the main takeaways of this thesis is that they are feasible to accomplish.

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