Fuel tax, Cross Subsidy and Transport: Assessing the Effects on Income and Consumption Distribution in Brazil

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Abstract: Passenger transport has become a typical item in the household budget in Brazil, and structural changes in this type of service affect households differently. Our paper explores the links between consumption, income and transport in assessing the redistributive and economic effects of the fuel tax in the Brazilian economy, called contribution of intervention in the economic domain (CIDE). To accomplish this task, we developed a dynamic computable general equilibrium model that recognizes a Social Accounting Matrix (SAM). Two scenarios are evaluated: (1) an overall cut of CIDE-fuels to assess its role in economy; (2) the burden of the gasoline tax and reduction of the diesel tax to subsidize public transport services. The main findings indicate a deviation from real GDP above the baseline forecast path, positively affected by internal market and the reduction in income inequality. Typical households in the middle- and lower-income bracket would benefit most from these policy instruments.

Keywords: Fuel tax; cross subsidy; dynamic CGE model; household income distribution; economic growth.

JEL Classification: C68; E16; H71; R4.
Área de Submissão: 7 – Infra-estrutura, transporte, energia, mobilidade e comunicação

1. Introduction

Most of the transport sectors in the Brazilian economy have undergone reforms since the 1990s, leading to structural changes at the regulation, operation and competition form. Tariff and cost structures have changed with the promotion of some microeconomic policies, expanding the demand for some transport modes and the possibilities of intermodal competition over the past 20 years, such as between subway and city bus services, as well as public and private transport. The recurring subsidy policy for subway services has been causing distortions in prices for urban bus services, which induces substitution between these modes by households. Nevertheless, the per capita income growth, credit policies and cost measures for the purchase and use of private vehicles also have contributed to a shift in modal distribution across the country, increasing the household preferences from all income strata for private transport over public passenger services[1]. Among the measures to stimulate the acquisition and use of private vehicles, we can highlight the reduction to zero of automobile production tax (known as IPI zero), the low price of licensing and property taxes on motor vehicles (IPVA), the direct subsidies such as free parking on public roads and the decrease of the Economic Intervention Contribution (CIDE) tax on fuel – CIDE-fuels (Carvalho and Pereira, 2012; Castro, 2003; Cibulska et al., 2012; Farranha and Frezza, 2014; Rolim and Brasileiro, 2009).

As a result of these policy measures, transport has become a typical consumption item in the Brazilian family budget, reaching a close share of the main expenditure item, that is, foods. According to the Consumer Expenditure Survey (POF), 2008 and 2009, elaborated by the Brazilian Institute of Geography and Statistics (IBGE), the average monthly expenses with the transport service reached 419 BRL, a portion very close to food (421BRL), equivalent to 16.1% of total household expenses. Of a total

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[1] From 2008 to 2014, there was an increase in average household per capita income of 41% in Brazil, while the national vehicle fleet grew by 59% and the resident population by 6%. In the same period, specifically, the car fleet grew by 50% and the bus fleet by 43% (Brasil, 2019; IBGE, 2015).

of 58 million Brazilian families, 76.5% of them spend their expenses on urban transport, being 25.1% on public services and 29.8% on private transport. About 46.1% of total spending on ground passenger services is concentrated in families with up to 2075 BRL *per capita* income, the equivalent of five minimum wages. In general, poorer families are the biggest demanders of public transport, while higher-income families demand more private transport (IBGE, 2010b).

Notably, the Brazilian experience has prioritized private transport and changed household spending patterns regarding the use of private vehicles. However, the political measures also have generated redistributive effects of income and consumption on the economy, which are hardly considered in their analysis or applied studies for Brazil. Especially the CIDE-fuels[2] represent a national diesel and gasoline tax that since 2001 has gone into a trust fund that finances the nation's interstate highway system and other roads, as well as environmental projects related to the oil and gas industry, and subsidizes the transport of ethanol fuel, natural gas, oil and derivatives. Even with all these financing links, the tax revenues collected are not used for these purposes and does not fulfill its social function (Lacerda, 2005; Morais and Costa, 2010; Vinha, 2006). Consequently, without this compensation, and by raising costs of public bus transport and the private transport differently, this fuels tax can promote intermodal substitution and significant redistributive effects between poorer and richer households, even widening income inequality and the use of private vehicles in the country. This concern has been recurrent in the debate about the CIDE-fuels and Carvalho (2016) and a Proposed Constitutional Amendment (PEC)[3] of 2007 suggested that part of the tax collection from gasoline subsidizes the provision of public transport services. With this policy instrument, it would be possible to cross-subsidize between private and public transport, as well as cheap bus fare and the competitiveness of public services against private transport (Carvalho, 2016).

Nevertheless, the redistributive effects of both the cross-subsidy proposal and CIDE-fuels depend on the relative position of a typical household in the distribution of income and expenditure by a transport type. For example, raising diesel taxes should make public transport more expensive and cause a shift in the budget constraint of poorer households by the income and substitution effect – reduction of other consumption items (Gomide, 2005). This direct change in the consumption pattern has impacts on the production and the relative price structure, and the remuneration of primary factors, whose income and price changes indirectly, may further restrict the budget of certain household groups and even widen income inequality. Moreover, the tax policy directly impacts production costs of more road-intensive sectors or diesel input in an economy, making the change in household income and consumption distribution more intense. Thus, this type of impact analysis on the overall economy is a complex task, since it includes direct and indirect channels, requires great attention to the relative position of the household groups and involves a theoretical framework that presents expenditure and income links between different economic institutions: households, productive sectors and public administration. These characteristics and relationships have been little explored in economic models for transport policy analysis (Steininger et al., 2007), and no applied research stresses the long-run economic repercussions of the CIDE-fuels and cross-subsidy proposal in Brazil.

Our paper contributes to filling this gap and analyzes the economic deviations and redistributive effects on household groups of both policy instruments from the Brazilian baseline forecast path up to 2030. The research simulates a withdrawal of the CIDE-fuels in scenarios with and without cross subsidy between 2011 and 2017, which gives us the role of these policy instruments. To do so, we propose the development of a dynamic computable general equilibrium (CGE) model that incorporates flows of the Brazilian Social Accounting Matrix (SAM) in its theoretical and data structure, recognizing in detail the passenger land markets. Besides this introduction, this paper is comprised of four other sections. The second section briefly reviews previous CIDE-fuels. The third section presents some applied studies with CGE models for transport. The fourth section describes the dynamic CGE model, namely, the BIG-TP

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[2] Similarly, the United States has had a national gasoline tax since 1956 into a Highway Trust Fund to finance Interstate Highway and other roads. The European Union, for example, seeks to ensure that all users pay at least their short-run marginal costs allocated to the track provision and that full long-run cost is recovered (Button, 2010; Creightney, 1993).

[3] PEC, Proposed Constitutional Amendment (Proposta de Emenda Constitucional), nº 179/2007.

(Brazilian Income Generation and Transport of Passengers). The fifth section presents the conclusions and remarks of the research.

2. The CIDE-fuel policy in Brazil

The Brazilian CIDE-fuels policy was established in 2001 and represents a tax on demand for domestic and imported petroleum products, such as gasoline, diesel, kerosene, fuel oils and liquefied petroleum gas, including gas derivatives. This fuel tax is based on the idea of the benefits principle of a tax system, which finances the maintenance and expansion of highways or other transport infrastructure, as well as environmental and social projects to reduce and offset the negative externalities from multiple uses of roads and production at oil refineries[4]. The gasoline tax was aimed at reducing the consumption of automotive fuels and use of private transport, as long as transport infrastructure financing was intended to improve urban transport routes, expanding public transport demand and passenger welfare. The policy was intended to encourage the substitution between private and public transport, promoting a redistributive effect of income among Brazilian families (Lacerda, 2005; Morais and Costa, 2010; Vinha, 2006).

This CIDE-fuels policy has been constantly changing since 2001 with the constitutional decrees, which especially reduced gasoline and diesel taxes. These ad valorem rates are fixed per cubic meter of each fuel. Figure 1 reports rate changes under Brazilian law between 2001 and 2018. Under specific conditions in the global or domestic economic environment, the Brazilian government may change the CIDE-fuels tax rate to reduce fuel cost pressure. According to history of CIDE-fuels, we can observe that tariffs showed a downward and continuous trajectory between 2004 and 2011. Only in 2011 did the diesel tariff increase. As of 2012 (decree nº 7,764), the public administration zeroed the CIDE-fuels rates on domestic market operations and on the import of petroleum-derived fuels and their substitutes in order to avoid inflationary pressure arising from the increase of 7.8% in gasoline and of 3.9% in diesel (Leroy et al., 2017). The measure was aimed at neutralizing the possible perverse effects of fuel readjustments on the Brazilian economy and, on the other hand, supported the use of fossil fuels to the detriment of renewable fuels, such as ethanol. By relieving its taxation and focusing on fossil products, such as gasoline, the government ends up encouraging the auto industry and the consumer with the tax incentives given. More than half of Brazilian households (53%) have a car or motorcycle for daily trips, which leads to an increase in vehicle ownership by Brazilian families, especially those with lower incomes (Carvalho, 2011). This ease of purchasing automobiles has an impact on public passenger transport, since less users mean fare rise.

In 2015, the Brazilian government announced the resumption of the CIDE incidence, directly affecting the country's transport companies by decree nº 8,395. CIDE has been charged since May 2015, with rates of 0.10 BRL per liter for gasoline and 0.05 BRL per liter for diesel. As a direct consequence, there was an increase in operating costs in transport companies, considering that diesel oil represents between 22 to 30% (Carvalho and Pereira, 2012) of the total costs of passenger transport companies. In view of this, the increase in the cost of this main input restricted the sector's own service provision. The activity is also hampered by the unfavorable conditions of the infrastructure, which, in addition to raising operating costs, negatively affects productivity and competitiveness in companies in this sector (CNT, 2015).

In 2018, the government decided to zero the CIDE-diesel rate (Decree no. 9,391). This reduction occurred due to the agreement made after the truckers' strike across Brazil, motivated by the constant increases in fuel prices, because of Petrobras' new pricing policy. In October 2016, Petrobras changed its fuel pricing policy and established monthly reviews of gasoline and diesel prices based on parity with the international market plus a margin practiced to compensate for risks inherent to production, such as volatility in production exchange rate. In the following year, the company announced the change to daily

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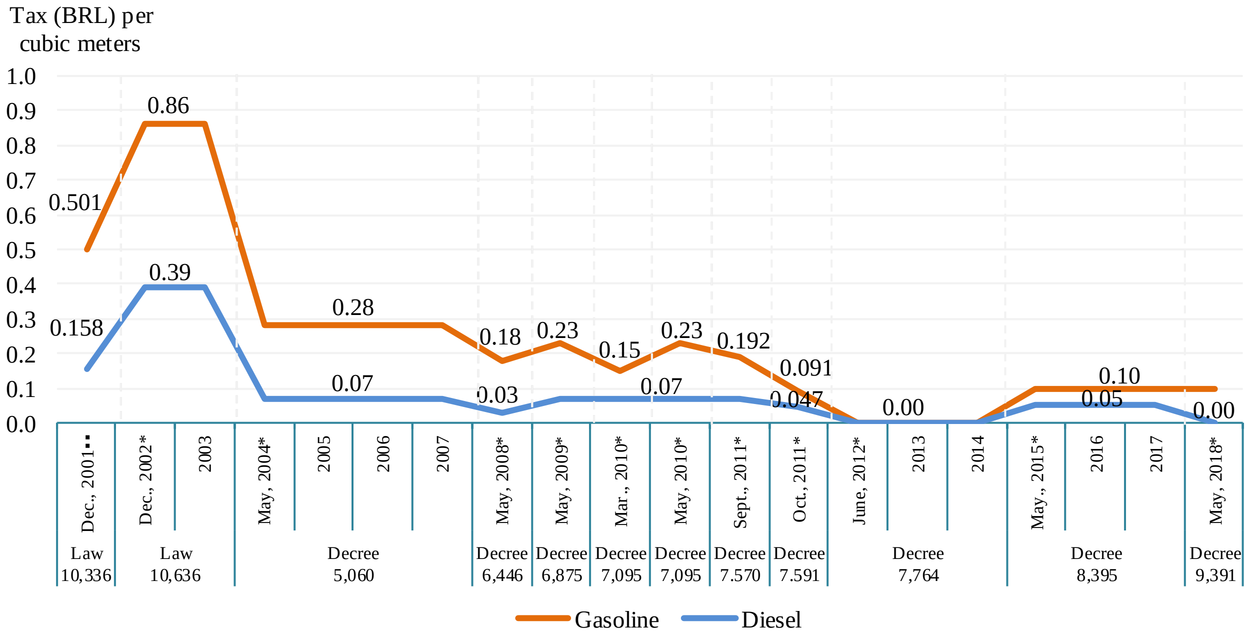
[4] The amount raised for social purposes involves social security, health care and education. Financing of environmental projects is intended for the recovery of natural resources sometimes affected by the oil industries (e.g., control and supervision of polluting activities, actions in areas of environmental impact, protection of coastal, marine and inland water conservation units, promotion of projects aimed at preservation and projects aimed at the biofuel production.

fuel price reviews (BCB, 2017; Petrobras, 2016). Thus, if the value of a barrel of oil increases abroad, this affects the price of fuels in Brazil and the profitability of the exploration and production sector. These subsequent readjustments led to an increase in the price of diesel oil and to the movement triggered by the truckers' strike of 2018. The loss of revenue from CIDE had payroll re-taxation on several productive sectors (excluding the road freight transport sector). The amount allocated to the economic subsidy program for the commercialization of diesel oil, planned in the Executive's budget in 2018, was BRL 9.5 billion (Brasil, 2018), but the disbursement was lower at the end of the payments (BRL 4,8 billion) due to the reduction in oil prices in the international market throughout the year (CNT, 2019).

Figure 1 – Trajectory of the Cide-fuel rate (2001-2018)



Source: Adapted from CNT (2015), according to Brazilian Constitution.

Note: •• Law no. 10,336/2001 and * its amendments.

Since 2002, CIDE-fuels have been seen as an alternative for the resumption of passenger transport, amid the increase in private transport in the country. The recovery of roads would generate a 30% reduction in operating costs, such as maintenance, diesel and tires, and would lead to improvements to the end user of the transport service with reduced travel time, greater safety and comfort (Cerqueira, 2007). The collection of CIDE-fuels would initially complement the resources available for investments in infrastructure in the transport sector (CNT, 2015). However, the amount collected from CIDE-fuels is not necessarily invested in highways, or in the urban transport infrastructure. There is no guideline capable of controlling the allocation of CIDE-fuels collected in the transport infrastructure (Nobrega, 2010). In the period from 2001 to 2009, of the almost BRL 43 billion spent on CIDE resources, BRL 29 billion were spent on transportation and general mobility, which amounts to around 68%. However, of this amount, only 7% (BRL 2 billion) went to urban transport (Morais and Costa, 2010). Between 2002 and 2012, of the BRL 75.8 billion of CIDE revenues, BRL 37.6 billion were invested in transportation infrastructure (CNT, 2015), that is, of the total amount, approximately 50% was destined for this purpose. Of the total collection of around BRL 22.3 billion, between 2002 and 2004, only BRL 3.1 billion (14% of the collection) was invested in highways by the Ministry of Transport.

The tax revenues collected from CIDE have been used for other purposes, such as to pay off debts, employees and public administration, but has not been used to invest in the transport sector. Even some of these purposes should be covered by other taxes. In the same period, for example, BRL 5.3 billion in CIDE-fuels resources were used with personnel and public administration expenses. Of the BRL 30 billion raised with CIDE between 2002 and 2005, BRL 15 million went to miscellaneous expenses, and the remainder went to public coffers, most of which was used to form the primary surplus, which confirms in practice the use of resources to increase government savings and help it, therefore, to meet the sector's primary surplus target (CNT, 2017; Lacerda, 2005; Lima, 2010; Morais and Costa, 2010; Vasconcellos et al., 2011).

In general, due to CIDE extra-fiscality, changes in rates provide control and stability in fuel prices. CIDE neutralizes the increases or decreases determined by refineries in fuel prices (Leroy et al., 2017). However, the increase in CIDE has positive impacts on unit costs of production in the economic system, negatively affects the households demand for gasoline and diesel, which may promote an imperfect substitution effect for the ethanol demand, and changes the composition by using public and private transport in economy. The rise in the diesel tax and the lack of funding for urban transport routes and the diesel tax make public transport services more expensive, affecting relatively poorer households (Morais and Costa, 2010).

Increase the rate or use tax revenue of the CIDE-gas rate to subsidize public transport service would be a way to mitigate the negative effects on poorest household and enhancement of public transport with the current CIDE tax system. This microeconomic proposal also has the character of income transfer, since users of private transport, generally of higher income class, would start to finance public transport for passengers from the poorest households. The proposed Constitutional Amendment (PEC) no. 159/2007, no. 179/2007, no. 200/2007 and no. 307/2013 of the Brazilian government indicate that 10% of CIDE-gasoline is used in the form of cross-subsidy to urban public transport. This proposal would generate loss of tax revenue to the public budget but could increase the welfare of users of public transport with the reduction of the service price (Carvalho, 2016). The practice of subsidies is legally supported by law no. 12,587/2012, which incorporates the statute of economic subsidy to finance public transport (Farias, 2009).

Therefore, the debate about CIDE-fuels in Brazil has gained momentum in the last 10 years in the Brazilian economy, especially due to the attention turned to the demand for public transport and the negative effects on the budget of poor families in the country. The expectation of the proposed cross-subsidy (PEC) is that it can mitigate the distortions generated by CIDE-fuels, in which the resources collected by this type of tax do not return properly in the form of investments in transport infrastructure. Nevertheless, the concern of this proposal lies in the balance of the public budget. In this variant, this paper contributes to that debate by quantitatively assessing the benefits and costs of the CIDE in conjunction with the PEC.

3. CGE approaches to passenger transport

CGE models have been widely used in the economic analysis of many types of public policies that can influence the transport, the shape and mobility of individuals' intra-urban commuting (see, for example, Robson et al., 2018; Shahrokhi Shahraki and Bachmann, 2018). The CGE modeling contains a link between the microeconomic structure and the macroeconomic environment, which can assess the direct and indirect effects of policy changes on any economic variable, such as product, prices, income and welfare. Depending on the scale, the consideration of the temporal effect and the type of analysis, CGE models can be classified into six types, as shown in Table 1: a static national model, a dynamic national model, a static multiregional model, a dynamic multiregional model, a static spatial model and a dynamic financial model. The first two types are applied for impact assessment at the national level as is the case with our model. CGE models based on a social accounting matrix (SAM) are detailed in terms of the different flows (transactions and transfers) between productive activities, production factors and economic agents (Henseler and Maisonnave, 2018). Similarly, some models explore these relationships with the effects between consumption, income and transport according to a SAM structure.

In the empirical studies, O´Ryan et al. (2005) apply the dynamic CGE model to simulate the impact of a 100% increase in fuel taxes in Chile. For this, they created a SAM as a database. The results showed negative effects on aggregate variables, such as consumption, production, trade and GDP. Households were also negatively affected by the policy, partly by an increase in domestic prices and partly by a reduction in income. Other researches use the same SAM structure to show that declining oil prices, reducing fuel subsidies and reallocating these subsidies to support the transportation sector can help the poorest households. Oil price subsidies are an inefficient political instrument because they mainly benefit high-income households that can afford a car (Henseler and Maisonnave, 2018). The complexity and political relevance of the problem create an ideal scenario for applying a dynamic CGE modeling approach. For example, AlShehabi (2012) considers analyzing together issues related to energy and unemployment policies with a SAM structure that includes data on several types of labor and fuel commodities. The main purpose was to investigate the political implications of distributing extra revenue from eliminating consumer subsidies such as tax rebates, as well as the possibility of directing revenues to increase investment. The dynamic approach to biofuel policy analysis has not been widely applied. Chanthawong et al. (2018) present a dynamic CGE model for Thailand which focused on the energy sector to facilitate the analysis of biofuel taxation and subsidy policies. The model uses econometric results for coefficients of demand and supply of biofuels for investigation in the SAM database.

Table 1 – Summary of transport sector policy assessment using the CGE analysis

Category	Region	SAM	No. Of Households	Objective	Reference
Static National Model	South Africa	yes	5	Reduction in fuel subsidies and reallocation to support the transport	Henseler and Maisonnave (2018)
	Chile	yes	5	Increased fuel taxes and a tariff reduction	O´Ryan et al. (2005)
	Belgium	no	1	Study the marginal efficiency effects of the revenue-neutral introduction of transport	Mayeres (2000)
	Belgium	no	5	Assess the marginal welfare and equity impacts of transport	Mayeres (2001)
	Denmark	yes	2	Study the introduction of road pricing	Munk (2006)
	Belgium	no	-	Transport tax reform	Van Dender (2003)
	Austria	yes	4	Analyze the impacts of car road pricing	Steininger et al. (2007)
	Sweden	no	9	Improve the modelling of household demand for transport services	Berg (2007)
	Germany and Austria	yes	4	Assess the impact of road charging	Kalinowska and Steininger (2009)
	Indonesia	yes	10	Analyze the poverty impact of phasing out fuel subsidies	Dartanto (2013)
Dynamic National Model	Iran	yes	2	Analyze the effects of eliminating crude oil and fuel subsidies on the labour market	AlShehabi (2012)
	Thailand	yes	1	Analyze the impacts of biofuel policies	Chanthawong et al. (2018)
Static Multiregion Model	Australia	no	10	Analyze structural change in ports and rail freight industries	Verikios and Zhang (2015a)
	Australia	no	10	Analyze structural change in urban transport	Verikios and Zhang (2015b)
Dynamic Multiregion Model	Australia	no	1	Households´demands for residential land, urban mobility and transport	Lennox and Adams (2016)
Static SCGE	Kampala	no	2	Analyze the impacts of urban transport improvement	Bernard et al. (2016)
	Germany	no	3	Examine effects of increasing different kinds of passenger transport subsidies	Tscharaktschiew and Hirte (2012)
	Beijing	no	1	Examine the economic effects of public transport subsidy policies	Xu et al. (2018)
	Brazil	no	1	Assess the economic impacts of the existing underground metro infrastructure	Haddad et al. (2015)
Dynamic Financial CGE	Indonesia	yes	4	Simulate the fiscal policies regarding reduction in the fuel subsidy	Kim and Samudro (2019)

Source: Authors' own table.

Some other modelers have also developed special attention to policies for the demand for certain transport services (i.e. Mayeres, 2000, 2001; Munk, 2006; Van Dender, 2003); however, not all research develops SAM. As shown in Table 1, several CGE models were developed and applied to evaluate transport policies with households differentiated by income group. For example, in Steininger et al. (2007), households were divided by per capita income class to differentiate household spending between income groups in terms of public transport and use of private cars. For the authors, the distributive effects related to urban passenger transport are hardly considered in economic models of transport policy. Berg (2007) extended a CGE model to Sweden with a consumer demand module to describe the behavior of each agent in relation to energy use. The model was extended to nine heterogeneous household groups with income and spatial dimensions. To analyze the effects of microeconomic reforms on the urban transport industries in Australia, Verikios and Zhang (2015b) used a multiregional CGE model that includes ten household income groups. Kalinowska and Steininger (2009) analyzed the repercussions of a household income tax collection of four households using a CGE model for Austria and Germany. The authors introduced the pricing policy measure in the private motorized transport mode and applied it to the global road network.

In addition, CGE models were adopted to analyze the impacts of improvements in urban transport (Bernard et al., 2016), passenger transport subsidies (Tscharaktschiew and Hirte, 2012), public transport subsidies (Xu et al., 2018), elimination of fuel subsidies (Dartanto, 2013), reallocation of fuel subsidies to infrastructure investments (Kim and Samudro, 2019), structural changes in Australian ports and rail freight services (Verikios and Zhang, 2015a), the relationship between household demands for residential land and urban mobility in the context of various modes of transport (i.e. automobiles, buses, trains) (Lennox and Adams, 2016). For Brazil, Haddad et al. (2015) studied mobility, accessibility and work productivity. This study followed an integrated spatial CGE model to assess the economic impacts of the existing subway infrastructure in São Paulo.

Our model is a dynamic recursive version (Horridge, 2012) and implements two intermodal substitution modules for passenger transport services (public and private transport, and urban bus services and train/subway, considering the difference between short- and long-term impacts), in addition to incorporating a fiscal balance module and with transfer payments in the economy according to a SAM as a database (Corong and Horridge, 2012; Corong, 2014). Literature deals with price competition between certain transport services because different travel expenses imply different increases in costs and in families' budget constraints. The relative importance of urban transport costs differs significantly by mode, with buses generally having high fare prices and being slower, and cars with cheaper and faster costs. The way individuals move and the restructuring of the sector can affect the economy through multiple channels, including investment in infrastructure, purchase and manufacture of new technology vehicles, production of alternative fuels, such as biofuels and electricity. For example, with the recent increase in the number of cars on the streets, the transport sector contributes to increased energy consumption and carbon dioxide emissions. Therefore, the implicit costs of passenger transport are of importance for the impact on GDP and household budgets. Our model deals with this type of substitution between transport services for the Brazilian economy.

To improve the applicability of the CGE model in assessing the distributional effects of political intervention in the passenger transport sector, the model distinguishes among 10 different classes of household income similarly to other studies cited. This analysis would be incomplete if we disregard the distinction by groups, because, according to Bröcker (2002), CGE models have become popular in estimating the welfare effects of transport projects, when differentiation by social group is necessary. This income level classification contributes to identify which types of households are mostly affected by government policies including subsidies to urban bus fares. Although some studies highlight the importance of the channels between income distribution, the productive system and passenger transport policies, there is a lack of measure of these distributive and economic effects for the Brazilian economy. Our approach allows for the implementation of detailed model structures suitable for applied analysis. Our model has an explicit link between research topics such as inequality and income distribution and public passenger transport policies in Brazil.

4. The CGE Model

4.1 Model Description and Social Accounting Matrix (SAM)

The model developed for this study is a recursive dynamic single country CGE model capable of analyzing passenger transport policies and their relationship with the income structure, consumption composition and the production system. According to Dixon and Rimmer (2002), our model covers (1) a dynamic accumulation between investment and the capital stock, (2) a positive relation between investment and expected rate of return, as well as (3) relation between the real wage rate change and employment. Our model, like Johansen’s (1960) type, simulates a Walrasian economic balance, matching demand and supply in the commodity markets, obtaining balanced prices and quantities. In addition, the model also has a detailed consideration of the transportation activities of passengers, which may contribute to the debate on the reform of Brazilian fiscal policy by bringing a relevant approach, which is the redistributive impact of fuel taxation policies.

Our CGE model[5] is based on the Social Accounting Matrix (SAM) that we developed for the Brazilian economy for the year 2010. The SAM serves as the benchmark data for a CGE calibration and represents a snapshot of the economy in terms of the different flows (transactions and transfers) among productive activities, factors of production and economic agents. The SAM recognizes 129 commodities and 71 economic sectors. There are two production factors: capital (K) and labor (L). There are four different types of institutions: firms (F), households (H), government (G) and the rest of the world (ROW). Households are divided into 10 groups according to family income following Ferreira Filho and Horridge (2006). Incorporating multiple households can enhance the capability of CGE models to analyze income distribution effects and tax-transfer policies (Zhang, 2015). The micro data from the Consumer Expenditure Survey (POF, 2008-2009) was used as a source of information on household income and expenditure structures. Of the total of 58 million Brazilian households, the average family income of the first group is BRL 548, while the richest family provides an average income 37.5 times higher (BRL 20,520). However, only 2.7% of households are concentrated in this upper stratum of the income level (IBGE, 2010b).

For the purpose of this study, the passenger transport sector was further disaggregated according to information from the Brazilian Institute of Geography and Statistics (IBGE) in (i) the subway (S); (ii) in the municipal passenger road and in the metropolitan region (UB); (iii) school, taxi and chartered passenger transport (STC), and (iv) intercity, interstate and international passenger transport (III). From the SAM and ANTP (2016), we find that public transport represents 28% of trips in the country, 86% by bus and 14% by subway. In this study, we will focus on municipal and metropolitan transport (urban shuttle), as it is the main transport that poor households demand. Along with the SAM, some additional data is needed. We adopted the Central Bank of Brazil household savings (S) concept, referring to non-compulsory savings (not considering contributions to pension funds) to balance the matrix (BCB, 2013). Table 2 presents the basic structure of the SAM for the Brazilian economy.

Table 2 – 2010 Brazilian SAM

			Production	Factor input	Institution	Capital account	ROW
Production	Passenger transport	S UB STC III	Intermediate input		Final consumption	FBCF	Exports
	Non-transport goods	Other					
Factor input		K L	Value-added paid by the productive sectors		Value-added paid by the institutions	Value-added to investments	Income received from the ROW
Institution		F H G		Value-added received by institutions	Property income and current transfers		Current transfers received from ROW
Capital account		S			Savings	Capital transfers	Capital transfers received from ROW
ROW			Imports	Income sent to the ROW	Current transfers sent	Capital transfers sent to the ROW	

Source: Authors' own table.

4.2 Theoretical Framework

In the model, the production and final consumption of the different sectors are modeled using nested Constant Elasticity of Substitution (CES) functions. Firms in all productive sectors make use of

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[5] The model is solved using RunDynam of Gempack (Harrison and Pearson, 2002), a program interface for specific use of dynamic-recursive CGE models developed by a software team at the University of Victoria.

intermediate inputs, labor, capital and other costs (taxes and subsidies) to produce a composite output that can be sold in both domestic and international markets, according to the Armington (1969) assumption. The CES function can be expressed as follows (Bor et al., 2010):

$$Y = A\left[\sum_{i=1}^{n} \delta_i X_i^{-\rho}\right]^{1/\rho} \tag{1}$$

where Y is the output of production; $X_1, X_2, ..., X_n$ are inputs; and A, δ, and ρ are parameters that satisfy $\sum_{i=1}^{n} \delta_i = 1$. At the upper level of the production structure, the hypothesis of combination in fixed proportions in the use of intermediate inputs, primary factors (added value) and other cost is adopted. The Leontief production function is used to aggregate these inputs to obtain the final production volume for the sector in question, being expressed as follows:

$$\bar{Y} = Cx\left[B_1, B_2, ..., B_n\right] \tag{2}$$

in which $\bar{Y}$ is the output of inputs; $B_1, B_2, ..., B_n$ represents the aggregates of inputs; and C is a parameter value. At the last level, two constant elasticity of transformation (CET) aggregate the optimal mix of commodities and can also divide the supply of goods between the domestic and foreign markets. Mathematically, this CET function is expressed as:

$$Q = B\left[\sum_{i=1}^{g} \gamma_i Y_i^{-\rho}\right]^{1/\rho} \tag{3}$$

where Q represents the supply-side output; $Y_1, Y_2, ..., Y_g$ are defined as output levels of various products; and B, γ, and ρ are parameters that satisfy $\sum_{i=1}^{g} \gamma_i = 1$. The BIG-TP model allows for multi-production. Similar to what happens to the production structure, investors combine intermediate-input composites by a Leontief function at the first level. Specific capital inputs are determined by the substitution between domestic and imported capital goods; therefore, there are no substitution effects between inputs.

In turn, household demand has a nested structure similar to that of investment demand, but with commodity compounds aggregated by a Klein-Rubin function, as depicted in Figure 2 (also known as the Stone-Geary or Linear Expenditure System), which has the features of non-homotheticity, allowing for budget shares to vary in response to changes in relative prices and income. The total household demand (U) consists of a combination of subsistence goods (or minimum) and a luxury goods (or supernumerary), so that variations in income lead to different changes in the consumption of products. Mathematically, this Klein and Rubin (1947) function is expressed as:

$$U(Z_1, ..., Z_c) = \sum_{i=1}^{c} S_i^{Lux} \ln(Z_i - Z_i^{Sub}) \tag{4}$$

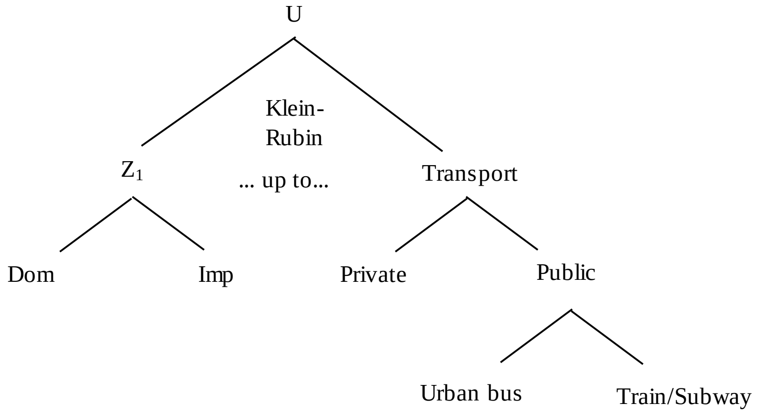
in which Z_i represents the total demand for good i; Z_i^{Sub} denotes the demand of households that consider the good i as a subsistence good; $Z_i - Z_i^{Sub}$ is the demand of households who consider the product i to be a luxury, which varies with their incomes; and finally S_i^{Lux} represents the share of the demand for luxury good i as the percentage of the total demand for luxury goods.

The consumption of transport services is allocated to private and public transport services according to CES function, whereas a CES also allocates the expenditure devoted to public transport services between 1) urban bus and 2) train/subway. Domestic transport consumption can be written as:

$$Z_T^h = \left(\delta_T^h Z_p^{h(\sigma_T^h - 1)/\sigma_T^h} + (1 - \delta_T^h) + Z_u^{h(\sigma_T^h - 1)/\sigma_T^h} \right)^{\sigma_T^h/(\sigma_T^h - 1)} \tag{5}$$

where Z_T^h represents the household consumption of transport; δ_T^h denotes the CES-distribution parameter in transport consumption for household h; Z_p^h is the private transport; Z_u^h is the public passenger transport; σ_T^h is elasticity of substitution between private and public transport demand for household h. Appendix A reports the model data structure and calibration.

Figure 2 – Structure of household final demand



Source: Authors' own table.

The substitution via relative prices between passenger services as depicted in Figure 2 (private and public transport) in the theoretical framework of our model follows Alfsen et al. (1996), Bruvoll and Larsen (2004), Steininger et al. (2007), Kalinowska and Steininger (2009), Kalinowska (2010), Lennox and Adams (2016). Private transport at BIG-TP was modeled by a compound created with costs related to fuel consumption and expenses related to vehicles (such as insurance). These elements form private transport compound and follow Schäfer and Jacoby (2005), Abrell (2010) and Shakya (2014). A given level of private transport services requires elements of fixed and variable costs [(i) gasoalcohol; (ii) diesel - biodiesel; (iii) other oil refining products; (iv) ethanol and other biofuels; (v) automobiles, vans and utilities; (vi) aircraft, vessels and other transportation equipment; (vii) storage and auxiliary transport services; (viii) financial intermediation, insurance and private pension] in the vector of household consumption. Berg (2007), for example, models the substitution between business trips among bus, train and car modes, the latter consisting of the use of gasoline and the cost of operating the vehicle. Expenditures devoted to public transport services are allocated between urban bus and train/subway, following Lennox and Adams (2016), based on the approach of Bruvoll and Larsen (2004).

5. Closures and Policy Analysis

In dynamic CGE models, we have a sequence of two solutions: one that shows the prospective projections for the future without policy analysis and the other that has a policy in place. The simulated policy scenario is compared with a baseline that represents a situation in which a macroeconomic scenario or more precisely, the real variations of the main components of the final demand are implemented without changes in the CIDE policy until 2030. In this scenario, we have historical (observed) and prospective projection simulations until 2030 (see Table 3). In this paper, this baseline scenario represents the expected changes in the Brazilian economy over time, reproducing the trajectory of the economy without the instrument of taxation policy and subsidy to the transport sector. In turn, the simulation of scenarios shows the deviations of trajectory measured to assess the effects of a policy shock in future periods. In policy simulations (our policy simulates a withdrawal of the CIDE-fuels in scenarios with and without cross subsidy between 2011 and 2017), it is allowed to analyze the consequences of a change in economic policy, which is a deviation from economic indicators in relation to the baseline scenario (Dixon and Rimmer, 2002).

The choice of closures reflects the availability of observed or independent prospective projections data over our simulation period. The macroeconomic scenario data were obtained from the statistical information of the System of National Accounts (SNA) of the Brazilian Institute of Geography and Statistics (IBGE) and the Foundation for Foreign Trade Studies Center (Funcex) for the years 2011 to 2015, while the prospective projections were obtained from the National Bank for Economic and Social Development (Tinoco and Giambiagi, 2018). Table 3 shows that, in the period observed, there was a slowdown in Brazilian economic activity, with declines in demand components, such as household consumption, investments and government spending. In the period of deceleration in the Brazilian economy (2011-2015), for example, in 2014, GDP, household and government consumption showed the lowest growth rates in the entire period considered. After 2018, there was a recovery period. In addition to the macroeconomic variables, we incorporated in the baseline the information on indirect taxes (i.e., IPI, ICMS and Other taxes less subsidies) made available by the IBGE's National Accounts and the direct taxes on the income of households (individual income tax) and companies (corporate income tax) of Brasil (2018) and IBGE's Integrated Economic Accounts, respectively.

Table 3 – Real variations (%) of baseline shocks

Indicators	Observed								Prospective projections
	2011	2012	2013	2014	2015	2016	2017	2018	2019-2030 (year-to-year)
GDP	3.97	1.92	3.00	0.50	-3.55	-3.46	1.00	1.70	2.00
Household consumption	4.82	3.50	3.47	2.25	-3.22	-4.30	-0.60	1.50	1.50
Government demands	2.20	2.28	1.51	0.81	-1.44	-0.06	-0.56	0.70	0.70
Exports	4.79	0.27	2.39	-1.13	6.82	1.92	5.18	4.60	4.60
Investment	6.83	0.78	5.83	-4.22	-13.95	-10.3	-3.70	1.70	1.70
Population	0.97	0.94	0.90	0.87	0.83	1.00	1.00	1.00	1.00
Employment	1.47	1.41	1.56	2.86	-3.34	-2.10	2.00	2.00	2.00
Imports price index, C. I. F.	14.28	0.95	-1.17	-1.97	-11.88	-8.94	4.06	3.00	3.00
Individual income tax	3.99	0.81	-0.97	1.63	3.52	2.28	-	-	-
Corporate income tax	0.99	-1.40	-6.47	-3.07	2.86	17.18	-	-	-

Source: IBGE; Funcex; BNDES (2018).

In the baseline and policy closure, we define two types of economic environment for the productive Brazilian system (Fig. 3): (1) budgetary compensation and (2) free government budget. In the policy simulation, budget compensation is applied exclusively to the simulation of CIDE tax cut between 2011 and 2017 and points out that the reduction in tax revenue is accompanied by a reduction in government spending to keep the budget balanced (scenario 1). Thus, one admits that, for the government to finance an eliminate the CIDE in the entire period, it would be necessary to reduce its consumption, since its original budget constraint did not foresee this drop in revenue. The second policy simulation (scenario 2) proceeds to assess the possibility of cross subsidies in the chain of derivatives, being a social and income transfer policy, as a CIDE taxation policy on gasoline penalizes private transport users and, on the other hand, it benefits users of public transport with the subsidy granted to this market. In this, it assumes that the decrease in nominal tax revenue is independent on public spending.

In this study, the concept of tariff power in CGE models can be used to apply shocks to cut fuel tax rates (diesel and gasoline), following mathematically:

$$\Delta ttax = \frac{(1+ttax_{t+1})-(1+ttax_{t})}{(1+ttax_{t})}*100 \tag{6}$$

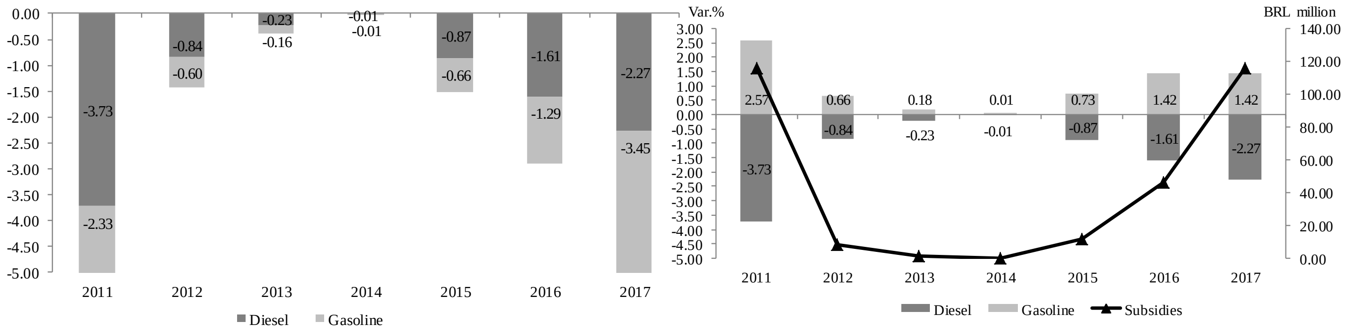
in which $ttax$ represents CIDE effective tariff in a certain period, computed by the ratio between the amount collected from CIDE and the total demand value at basic prices; and $1+ttax_t$ denotes the power of the tariff annually. The monetary data of the collection for the calculation of the effective tariff of CIDE were obtained from IBGE until the year 2016 and Federal Revenue for 2017, while the participation of gasoline and diesel was obtained from the National Agency of Petroleum, Natural Gas and Biofuels (ANP). Finally, Figure 4 shows the shock values for the two policy simulations. Scenario 1 covers a set of shocks of annual reductions in the product of gasoline and diesel oil for the CIDE cut-off policy (see panel “a” in Fig. 4).

Figure 3 – Hypotheses underlying the BIG-TP dynamic model

Type of scenario	Scenario objective	Baseline shock	Policy shock
Scenario 1: budgetary compensation (2011-2030)	An overall cut of CIDE-fuels to assess its role in Brazilian economy	a) Macroeconomic scenario: Shock in real GDP, investment, household consumption, government demands, imports price index, population and employment b) Indirect taxes: Shock in power tariff (IPI, ICMS, Other taxes less subsidies) c) Direct taxes: Shock in individual income tax and corporate income tax	a) Tariff power (2011-2017) Shock in diesel and gasoline (both cuts) Description: link beteween the variable nominal revenue and nominal government expenditure
Scenario 2: free government budget (2011-2030)	Burden the gasoline tax and reduce the diesel tax to subsidize public transport (cross subsidy) and influence an intermodal substitution of these transport services	a) Macroeconomic scenario: Shock in real GDP, investment, household consumption, government demands, imports price index, population and employment b) Indirect taxes: Shock in power tariff (IPI, ICMS, Other taxes less subsidies) c) Direct taxes: Shock in individual income tax and corporate income tax	a) Tariff power (2011-2017) Shock in diesel (cut) and gasoline (encumber 10%); and shock in production subsidy Description: transfer of CIDE-gasoline taxation to subsidize the production of urban buses

Source: Authors´own table.

Figure 4 – Policy shocks



Panel (a): Real variations (%) (scenario 1)

Panel (b): Real variations (%) and BRL million (scenario 2)

Source: Research results.

In general, changes in tariff power were low in 2013 (-0.23% for diesel and -0.16% for gasoline) and in 2014 (-0.01% for diesel and gasoline) due to decree nº 7,764, which resets CIDE rates in 2012. In those years, remaining funds were registered. It is worth mentioning that the period captures two historic milestones of the CIDE: 1) in 2012, the government zeroed the rates to neutralize the impact of the adjustments made at gas stations; and 2) in 2015, the CIDE on fuels resumed with the expectation of increasing tax collection and regaining the confidence of economic agents. As mentioned, scenario 2 simulates a policy of cross-subsidy via the burden of CIDE-gasoline together with a tax relief for that of CIDE-diesel. It is, therefore, a set of policies that would stimulate both the supply and the demand for the urban bus service. More precisely, in this scenario, the CIDE tax rate is 10% for gasoline, the collection of which is intended to subsidize the provision of urban public transport services.

6. Results

In the year of the policy simulation, the CIDE cut (scenario 1) causes a reduction in the purchase prices (paid) of gasoline and diesel oil, generating a direct drop in production and final consumption costs in the economy. The drop in costs due to the demand for these oil refining goods is transmitted by the production system, promoting a generalized reduction in sector costs and prices. In a cost-competitive approach, the CIDE cut policy makes domestic products more competitive (price-effect). The general fall in prices in the economy induces an increase in demand in the various markets, whether due to the expansion of the real income of households, sectorial activities and investors, or the increase in the level of competitiveness of the economy. The increase in the competitiveness of domestic products drives external demand. The domestic market expands, increasing production requirements and, therefore, pushing up prices in the markets for primary factors and intermediate inputs of the model. The increase in production, therefore, raises the remuneration of primary factors, expanding the income flow between the main economic institutions (activity-effect). Even though the policy may initially induce a drop in the prices of public and private transport, leading to a shift in demand in favor of one of these services, the activity-effect can alter and reverse the result of this structure of competition established in household consumption. Therefore, the intensity of the forces between the price-effect and the activity-effect defines the magnitude and direction of the effects of the simulated policy.

As for scenario 2, on the one hand, the encumbrance of the CIDE-gasoline rate produces an increase in the gasoline market price, restricting the production of the main activities that demand this product and oil refining, as well as negatively affecting the households that use the most private transport. The increase in private transport promotes a shift in the household consumption basket for public transport (substitution effect). With the decrease in production, capital and labor are less required, leading to lower prices for these primary factors. On the other hand, a CIDE tax exemption for diesel would have consequences for the economy and for the Brazilian transport sector as a whole (e.g., cargo and passenger transport services), since, by reducing the price of the main transport input, the public administration would increase the level of activity in the sector (CNT, 2015).

Figure 5 shows the macroeconomic effects of fuel policies. In both scenarios, it is clear that the impacts on economic activity are positive. In CGE models, when distortion is eliminated, there should be an increase in activity and gains in welfare. The reduction of taxes, especially on diesel, reduces the cost of living for society as a whole, contributing to the expansion of economic activity, reducing operating costs in the sectors of public transport by bus, cargo transportation, agriculture and livestock activities. The effect on GDP of budgetary compensation is greater than in a government free budget scenario. Thus, the effect on long-run GDP with budgetary compensation would be 0.84%. In general, CIDE cut (scenario 1) causes a reduction in the purchase prices (paid) of gasoline and diesel oil, generating a direct fall in the production and final consumption costs in the economy. The drop in costs due to the demand for these oil refining goods is transmitted by the production system, promoting a generalized reduction in costs and sectorial prices. This drop induces an increase in demand in different markets, due to the expansion of real household income, sectorial activities and investors or the increase in the level of competitiveness of the economy. The increase in the competitiveness of domestic products drives external demand, contributing marginally to the balance in the trade balance, with positive deviations of 0.66% in the long run. The domestic market expands, increasing production requirements and, therefore, pushing up prices in the markets for primary factors and intermediate inputs of the model. Given the possibility of substitution between domestic and imported goods, positive price deviations in the domestic market would stimulate imports until 2030 (0.67%) (see panel “a” in Fig. 5).

Therefore, the increase in production raises the remuneration of primary factors, expanding the income flow between the main economic institutions (activity-effect). In a balanced budget economy, the GDP deflator reaches an accumulated deviation of 0.13% above the baseline. This result, associated with a positive variation in the GDP growth rate, indicates that the CIDE fuels cut policy promotes an activity-effect higher than the price-effect. Similar results with increased economic activity and reduced product prices were found by Santos (2006), when analyzing the reduction in indirect taxes on goods and services in São Paulo.

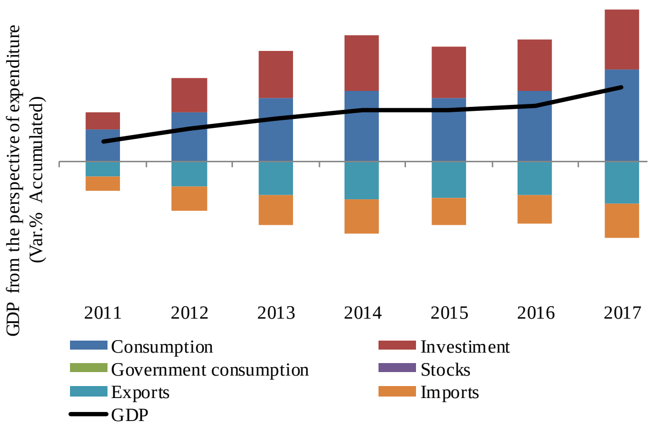
The activity-effect can also be seen in the job market. As the capital stock presents a one-year lag of current investments, the expansion of economic activity occurs mainly through the additional hiring of workers in the years of the policy shocks. Growth in employment in the short run by the activity-effect would influence real wages in the following period. In the real wage trajectories, expansions represent the increase in the cost of the labor factor per unit produced, discouraging the demand for labor in the economy in subsequent years. On the other hand, negative deviations from real wages would again stimulate employment significantly. There is, therefore, an explicit mechanism of lagged adjustment in the labor market, in which there is a negative relationship between employment and real wages, leading the convergence of current national employment to the trend. The real wage would increase by 1.50% in the CIDE fuel cut in long-run. Despite this, national employment would experience a positive impact in the long run in the Scenario 1 (0.06%) (see panel "a" in Fig.5).

Figure 5 – Macroeconomic impacts

Panel (a): Macroeconomic impacts (cumulative %)

Variables	Scenario 1		Scenario 2	
	Short-run	Long-run	Short-run	Long-run
GDP	0.39	0.84	0.35	0.46
Investiment	2.31	1.93	1.67	0.55
Household consumption	0.74	1.31	0.71	0.88
Government consumption	-1.48	-2.31	0.00	0.00
Exports	-0.14	1.33	-1.47	-0.22
Imports	0.99	0.67	1.35	0.57
Trade balance	-1.13	0.66	-2.82	-0.79
Trade terms	0.10	-1.34	1.42	0.15
Employment	0.14	0.06	0.19	-0.01
Real wage	0.40	1.50	0.72	1.40
Capital stock	0.44	1.56	0.39	0.88
Real tax revenue	-1.48	-2.31	-0.94	-1.49
GDP deflator	0.07	0.13	0.22	0.21
Factor cost index	0.75	0.88	0.60	0.59
Nominal tax revenue	-1.23	-1.32	-0.41	-0.57
Nominal gov. expenditure	-1.23	-1.32	0.52	0.92

Panel (b): Effects of scenario 2 on GDP aggregates



Source: Research results.

The expansion of economic activity, promoted by both scenarios, would generate pressure for capital demand. Due to the lagged movement of capital stock, capital-intensive activities exhibit greater difficulties in expanding production in the years of policy shocks. The increase in capital profitability would promote higher rates of return on investments in the economy. As a fuel cut presents a more direct transmission of the effects because of the elimination of distortions, the time trajectory of deviations in investment is greater (2.31%) than in a scenario that cuts tax only for diesel in the short run (1.67%). In the following years, investments would become operational and the capital stock would expand, which in turn would lead to a drop in its price, reducing the expected rate and, finally, investments in the following period. In the long run, this policy deviation above the baseline is positive for investment, with 1.93% in scenario 1 and 0.55% in scenario 2.

It is assumed that, for the government to finance a CIDE fuel cut (scenario 1) over the entire period, it would be necessary to reduce its consumption, since its original budget constraint did not foresee this revenue drop. A real fall in government spending of 2.31% in the long-run, that is, an average annual reduction of almost 0.12% over the entire period, would negatively affect the GDP growth rate of 0.28% in the long run, whose accumulated variation carries the induced effect on the tax collection of the expansion in economic activity by cutting CIDE in the country. The government's tax revenue is reduced, that is, the change in the CIDE rate (cut) affects the transfer of revenue collected by the government. Thus, the policy causes a drop in the nominal tax revenue by the government (-1.32% in the long run) and a real tax revenue negative variation (-2.31%).

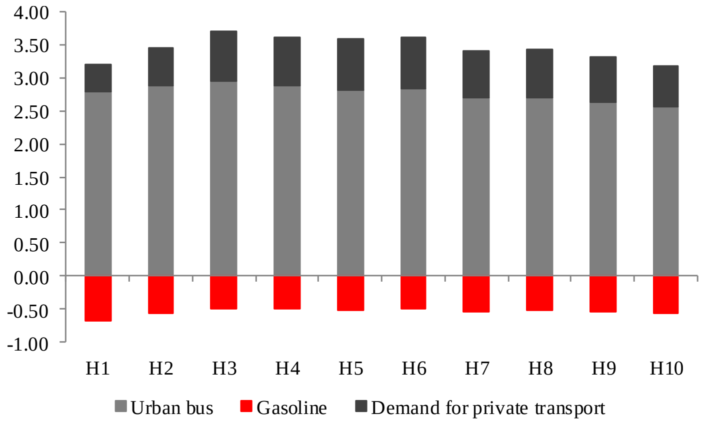
Alternatively, a cross-subsidy policy could be implemented in the Brazilian economy (scenario 2). Taxing gasoline with the allocation of resources to finance urban public transport would be a way to mitigate the existing externalities of transport services (i.e. congestion, accidents, pollution, hours lost in transit). Despite increasing the use of private transport for certain typical households, the positive deviation of this policy over GDP (0.46% in the long-run) would be influenced especially by the expansion of household consumption, which presents a deviation of 0.88% in the long run, that is, the improvement in household consumption due to the increase in real wages (0.72% in short run and 1.40% in long-run) and the reduction in the price of goods and services increase the purchasing power of households. The expansion of consumption of goods and services would, in turn, trigger a series of indirect effects on the households' own basket. Since the government's total real spending is kept fixed (0.00%), changes in GDP stem from increased household demand, investment and the deterioration of the trade balance (see panel "b" in Fig.5). In addition, the policy promotes an increase in the utility of households, and the result reflects the theoretical specification of the Linear System of Spending (LES) in the model in which the variation in utility is a function of the variation in real household consumption above the subsistence portion. Therefore, all households would obtain welfare gains in relation to the baseline (see panel "a" in Fig.6).

Figure 6 – Impacts on household welfare and consumption

Panel (a): Effects on household utility

Households	Scenario 1		Scenario 2	
	Short-run	Long-run	Short-run	Long-run
H_1	1.65	2.52	1.23	1.41
H_2	1.73	2.76	1.48	1.72
H_3	1.89	2.97	1.66	1.91
H_4	1.78	2.86	1.58	1.83
H_5	1.70	2.69	1.55	1.78
H_6	1.66	2.64	1.58	1.8
H_7	1.31	2.29	1.36	1.61
H_8	1.30	2.15	1.40	1.55
H_9	1.29	2.15	1.31	1.50
H_{10}	0.84	1.79	1.17	1.44

Panel (b): Effects on bus and gasoline consumption and demand for private transport (Scenario 2)



Source: Research results.

In addition, the cross-subsidy policy (scenario 2) promotes a reduction in public transport prices (increases service consumption), reducing the cost of living for the poorest households who benefit the most. This impact on the consumption of typical households would also be felt by other products, such as "school transport, taxi and chartered passenger transport (STC)", as part of it demands for diesel oil, in addition to "intercity, interstate and international passenger road (III)". Redistributing income in favor of the poorest households reduces income inequality to some extent and increases welfare. The poorest and median income households would experience the greatest gains (see panel "a" in Fig.6; for example, H_3 would have a utility gain of 1.91% in the long run). This effect is also found in Chanthawong et al (2018). For a policy that imposes a 10% tax on oil products, the authors found a welfare gain of 4.5% in the long run.

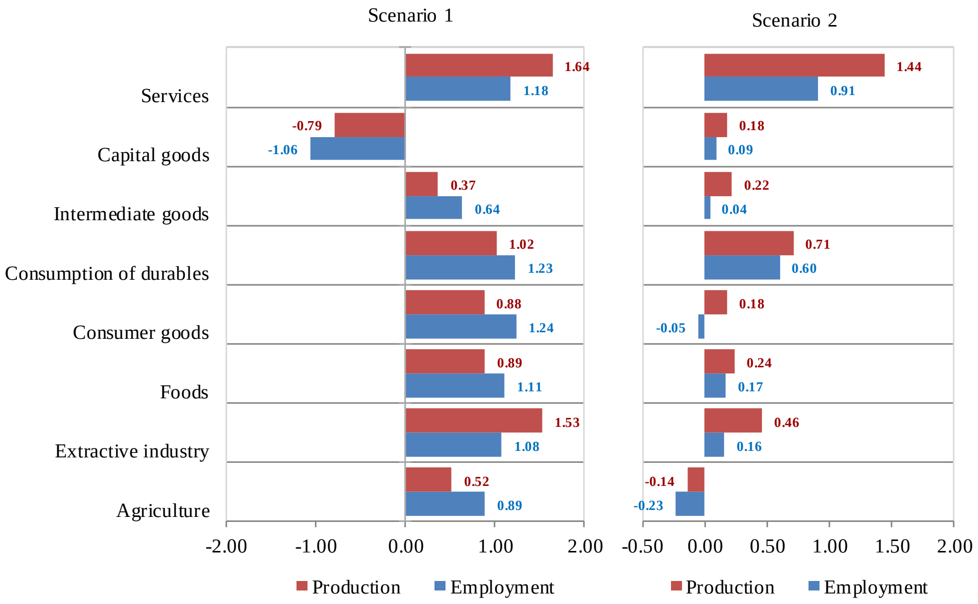
In distributive terms, wealthier households or self-employed workers, sometimes working in the informal market, would end up subsidizing the urban bus service as they are more dependent on gasoline-powered modes of transport. The price of private transport would result in a rise given the increase in the price of gasoline, restricting the production of certain activities that depend directly on road transport and oil input. By charging CIDE-gasoline, there is a reduction in demand for private transport or taxi services (e-hailing transport) in favor of the use of public passenger transport (see panel "b" in Fig.6). However, the demand for private transport is positive due to the activity effect. That is, the positive effects of the economic subsidy policy to produce urban buses are greater than the negative costs of CIDE-gasoline, so that the domestic and foreign markets expand with less demand for private transport.

All groups of households would experience nominal and real income gains in both periods because of both scenarios. Poorer households have higher percentage growth in income, as these classes demand public transport, and the cut of CIDE-diesel increases production and reduces the market price of public passenger transport activities. As household income expands, the consumption of "urban buses (UB)" decreases, whose ownership would be of an inferior good, as in the case of public transport. This characteristic would be associated with the non-homotheticity function in the theoretical specification of household consumption. The non-homotheticity function carries a little bit of a lower good characteristic for subsistence products (Burfisher, 2011; Button, 2010). In scenarios 1 and 2, the increase in income and real consumption indicate that the simulated policy options result in an increase in the welfare of households, as shown Fig. 6.

For the product "diesel oil", the price reduction with the elimination of CIDE would imply, for example, a reduction in the transportation costs of the machines, tractors and trucks used in the field. A rural producer could win by increasing revenue and reducing production costs. The demand for transportation services, in turn, could pass on the lower diesel costs, before the tax cut, to consumers, reducing the prices of products and food. Consumption would reflect more intensely on households in the lower stratum of distribution in the CIDE elimination policy. These results converge with the studies by Pera et al. (2018), in which reductions in diesel prices have impacts on the entire agribusiness chain, affecting rural producers, self-employed drivers, consumers, in addition to having effects on inflation.

Figure 7 shows the short-run effect of fuel policies on employment and production in aggregated sectors. Basically, the fuel policy benefits the economic sectors most related to the consumption profile of households, which would increase the use of production and employment. This result would be explained by the household consumption structure, especially by the profile of the poorest household, whose consumption of subsistence goods would be high. The positive short-run effect on production would fall on the sectors of food (0.89%), consumer goods (0.88%) and services (1.64%), which are demanded by all households, in cutting CIDE for budget compensation. For this same policy (scenario 1), the increase in employment would be 1.11% in food, 1.24% in consumer goods and 1.18% in services (see Fig.7).

Figure 7 – Main results of fuel policy simulations in aggregated sectors

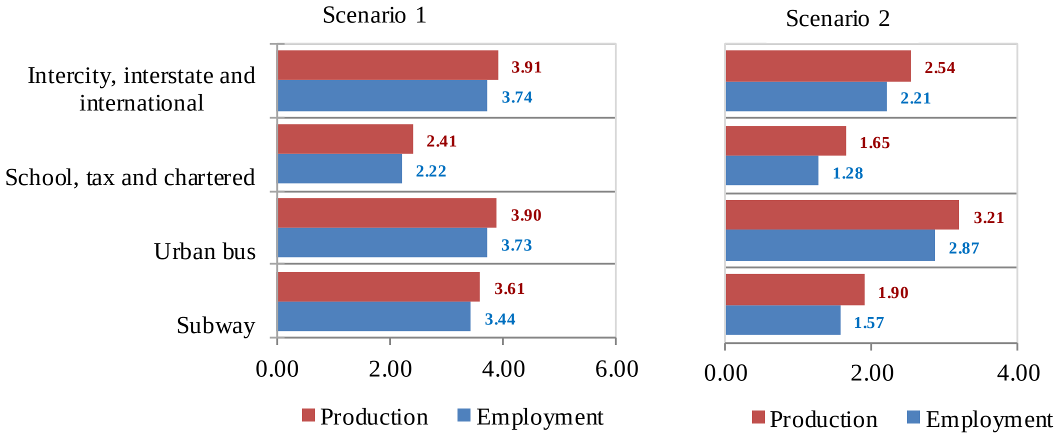


Source: Research results.
Note: % cumulative deviations from baseline.

Agriculture production (-0.14%) and employment (-0.23%) would be negatively affected in scenario 2 (see Fig.7). Considering that agriculture goods are representative in the composition of the Brazilian export basket, it can be concluded that the production of this economic activity would be relatively impaired due to the high internal costs and, consequently, the prices would make these products less attractive in the international market, reducing exports. The exception to this statement would occur in scenario 1, whose agriculture production would grow 0.52% and employment would increase 0.89% due to the growth in exports. This policy would promote a reduction in the production costs of final consumption and a drop in prices, which would imply a reduction in the prices of exportable goods, such as agriculture.

The passenger transport sectors would also benefit from fuel policies, as is the case with municipal transport and in the Metropolitan Region (urban bus) (see Fig. 8). This sector would benefit in the long run, with increases of 3.90% in production and 3.73% in employment in CIDE fuel cutting policy. As for other passenger transport activities (i.e., school, taxi and chartered passenger transport; intercity, interstate and international passenger road), the greatest impacts on production and employment would occur in the first policy, since these activities also demand diesel oil; thus, the tax cut would lead to a positive net effect for this type of service.

Figure 8 – Main results of fuel policy simulations in the transport sectors



Source: Research results.
Note: % cumulative deviations from baseline.

Although Fig. 7 and Fig. 8 do not show other sectors, it should be noted that there would be a positive effect in the long run of the CIDE elimination policy on the production of economic sectors that were not directly addressed by the exemption and are not intensive in the use of inputs (diesel and gasoline), with emphasis on "Air transport", "Printing and reproduction of recordings", "Development of systems and other information services", and "Television, radio, cinema and sound/image recording/editing activities".

7. Conclusion and Policy Implications

The estimated economic effects of the first policy are used to complement discussions in the second fuel policy. Given the possibility of substitution via price between public and private transport, the cut of CIDE fuels or the second policy that burdens CIDE-gasoline affect this relation of passenger transport activities. The cut-off of CIDE-diesel is a practical and recent policy of the Brazilian economy, considering that the price of diesel reduced with the strike of truck drivers that occurred in 2018. The benefits of this CIDE policy must be considered together with its costs in conjunction with the PEC. In practice, the price of diesel oil reduced, but did not allow the urban bus transport tariff to receive a certain tax exemption, making it cheaper and expanding the demand scale and discouraging the demand for private transport in Brazil. Thus, this study introduces a comprehensive modeling framework to assess the economic and redistributive impacts of fuel taxation policies in Brazil. By applying dynamic BIG-TP model, a detailed modeling procedure is developed for passenger transport activities to reflect both the short and long-run effect of our services on the debate on the reform of the Brazilian fiscal policy. Such a modeling procedure is expected to provide an important result in discussing the implications of CIDE policy and strategies in the country.

The results reveal that the fuel policy seems to benefit the Brazilian economy, regardless of how close it is to a fuel cut in general or a cross-subsidy policy. In both policies, in the short and long-run, the macroeconomic results pointed to an increase in the economic activity, accompanied by the other components of final demand, such as investment and household consumption. The positive economic benefits (increased real household income, employment and GDP) result from significant spillover effects between the transport sector and other sectors (e.g., foods, services). In the long run, the results on the marginal effects of the trade balance were positive for the first policy, boosting exports and the competitiveness of firms. For the second policy, the effects were negative, but with an increase in terms of trade. In terms of results on the groups of households, all income classes would obtain real gains in income and welfare with the simulated policies. The main conclusions indicate that the consumption of the poorest typical households is positively affected, since such policies would bring more benefit to these specific groups. Especially in developing countries, the two policy instruments work together in terms of economic efficiency and are aimed at providing access to mobility for the poorest people. A CGE-microsimulation could contribute to an analysis of the household poverty and inequality debate.

The public transport service has been showing a drop in passenger demand due to issues related to incompatibility between costs, gratuities, fares and revenues, as well as deficiencies in management and operation. The cross-subsidy policy could mitigate these problems in the sector. However, the concern with this type of public policy is in the public budget, since it would generate a loss of federal tax resources for the Union, but states and municipalities would gain in terms of reducing the price of the public transport fare. The problem with this proposal, despite the potential to reduce diesel prices, reduces the government's financial situation to balance its accounts. The waiver of the generated revenue may make the Brazilian government's fiscal adjustment plans unfeasible. On the other hand, in addition to reducing CIDE-diesel and thereby encouraging public transport tariffs, this policy would also encourage other activities that require diesel, such as agriculture, livestock and cargo transportation. The fall in fuel prices would reduce the cost of living for society. In other words, it would reduce the operating costs of these sectors, benefiting the entire production chain and the growth of economic activity without putting pressure on inflation.

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Appendix A – Data structure and calibration

The data structure of the BIG-TP model recognizes 129 commodities, 71 economic sectors and 13 institutional sectors: firms, government, 10 representative households and the rest of the world. In addition, 2 primary productive factors (labor and capital), 2 margin sectors (trade and transport), imports per product for each of the 71 sectors and components of final demand, indirect taxes (IPI, ICMS and Other taxes and subsidies), as well as direct taxes (taxes on income and wealth paid by households and firms). The core database is based on the 2010 Brazilian Input and Output Matrix (IBGE, 2010a).

Some behavioral parameters were calibrated according to the source of the CGE TERM-CEDEPLAR model (Domingues et al., 2007) and BIM-T (Betarelli Junior, 2013). Armington elasticities (substitution between domestic and imported origins) differentiated by product were calibrated based on Tourinho et al. (2007). The price elasticity of exports of traditional and non-traditional goods follows the one adopted in the SPARTA (Domingues, 2002), TERM-CEDEPLAR (Domingues et al., 2007) and BIM-T (Betarelli Junior, 2013). The elasticity of substitution between primary factors also follows the models of Domingues et al. (2007) and Betarelli Junior (2013).

To measure the sensitivity of the marginal utility of household spending, the model uses the Frisch parameter estimated with a negative value, the higher in module, the poorer the population under analysis. The BIG-TP uses the value of -1.94 for each household (i.e. invariant among representative household) according to Almeida (2011). Another parameter specified in household demand is the elasticity of expenditure obtained from estimates by Hoffmann (2010). The author calculated the income elasticities of various categories of expenditure (e.g. food, housing, clothing, transportation, recreation and culture, among others), using POF data from 2008-2009, divided into ten classes of household income per capita. From these estimates, the income elasticities were made compatible with the sectors of the BIG-TP model, thus obtaining a matrix of expenditure elasticity for 10 representative households, distributed by income ranges.

In turn, the substitution elasticities between public and private transport, as well as between urban bus and trains/subways, were calibrated based on Pozzobon et al. (2017), with the calibrated value being 0.4224 for the Brazilian economy. Such elasticities are similar to what is seen in Lennox and Adams (2016), who adopt the elasticities between public and private transport, such as between buses and trains, with a value of 1.2 for both substitutions in the Australian economy. The research of Steininger et al. (2007) attributed a value of 0.635 to the elasticity between public and private transport to Austria.

We also calibrate the elasticities of the recursive dynamic model. The ratio between the current and the trend level of employment was calibrated as 1.00 in the initial period. The wage-employment elasticity was calibrated with a value of 0.66 based on Gonzaga and Corseuil (2001). The research of Cardoso (2016) also attributed a value of 0.66 to the wage-employment elasticity. For the calibration of investment elasticity, the value of 4.80 was used for all sectors, as adopted by Haddad and Hewings (1997) and Perobelli (2004). For the calculation of the other parameters, the improvement for the investment simulation exercises was used, developed by the Investment Absorption Matrices (MAI) and estimated by Miguez (2016). The BIG-TP model was calibrated with a steady state of 2%, supported by a capital depreciation rate of 6%. Ferreira et al. (2000), for example, revealed that the choice of a depreciation rate between 3 to 12% is insignificant. Ferreira and Guillén (2004) and Clezar (2010) used a rate of 9%. In the CGE EFES model (Haddad and Domingues, 2001), the authors adopted an implicit rate of 3.7%. Betarelli Junior (2013) attributed a depreciation rate in the order of 5%. Thus, the endogenously calculated depreciation rate in the model is close to the national studies highlighted above.

Finally, a Social Accounting Matrix (SAM) was built for the year 2010. The SAM starts from 2010 Brazilian Input and Output Matrix (IBGE, 2010a), which corresponds to a system with 127 goods and services and 67 sectors of the National Accounts System (SCN), and the Integrated Economic Accounts (CEI). The incorporation of this database to the CGE model makes it possible to work more appropriately on the distribution of income generated in the Brazilian productive system and the transfer flows between economic agents (institutional sectors in SAM) over time. The micro data from the Consumer Expenditure Survey (POF), 2008 and 2009 (IBGE, 2010b) were chosen as a source of information on the income and expenditure structures of families. For each SAM source of income, as well as for the expenditure vector, one or more sources are identified in the POF that correspond to each resource and use of household income. In the disaggregation of the income vector, the strategy was to open the vector of remuneration for labor and capital, as well as inter-institutional relations (e.g. transfers received from companies, government, the rest of the world and inter-household transfers). Regarding the expenditure vector, the disaggregation occurs in the consumption vector, taxes, inter-institutional relations (e.g. transfers made to firms, government, the rest of the world and inter-households transfers), and finally, savings.