Redistributive effects of consumption and income from subsidies to passenger transportation in the Brazilian economy

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Abstract

Brazilian households already spend practically the same amount on transportation and food. Despite the importance of public transport, it has become increasingly expensive for users, with increases in fares and reduced quality. Thus, it is necessary to discuss the role of subsidies to public transport, as well as the evaluation of the impact of the subsidy policy on the redistribution of household income, taking into account the peculiarities of different groups by income level. These effects can be captured by a national Dynamic Computable General Equilibrium (CGE) model, with a Social Accounting Matrix (SAM) as a data structure, detailing the generation and appropriation of income by different sources and expenditure structures, as well as the breakdown of 5 representative households and 4 passenger transport services. To evaluate the potential of the built model, this research performs the application involved with the redistributive and economic effects of subsidies in selected activities of urban public transport of passengers in the Brazilian economy. The conclusive results indicate that policies related to subsidies contribute positively to the economy, in addition to generating positive effects for the internal market of the Brazilian economy by favoring typical households in the middle and lower positions of the composition of income and consumption. Regarding sectoral results, the increase in household income contributes to an increase in the production of those sectors that are more related to household consumption, mainly due to the consumption profile of households in lower income strata, contributing to the increase in production and investment sector. The reduction of the impact of transport on the income of individuals and households contributes to the redistribution of income in the consumption of other goods, mainly those related to food and services.

Keywords: Passengers transportation; subsidies; SAM; Dynamic CGE model; household income distribution.

JEL Classification: C68; E16; H71; R4.

1 Introduction

Urban mobility is understood as the ease of movement of goods and people in urban agglomerations and is fundamental for the development of social and economic activities. In this context, Urban Public Transport (UPT) system is essential to ensure access to opportunities, especially for the middle and low-income population. In Brazil, transport is included as a social right among other rights (e.g., education, health, food, job, housing, leisure) only in 2015 with the Proposed Constitutional Amendment nº 74,

emphasizing the service as a vector of development related to productivity and to the quality of life of individuals (Erundina, 2013; Senado, 2015).

The cost of the UPT that reaches the consumer through the tariff price is often high and the quality of the transport service is low, contributing to a reduction in consumption by the population of public transport and its intermodal replacement for private transport. This contributes to the fact that, with the reduction in demand, the cost of tickets rises and the quality drops, culminating in a vicious cycle towards the unsustainability of the UPT service (Carvalho and Pereira, 2012; Oliveira Filho, 2018). An increase in urban fares for passenger transport directly affects household incomes, and may also affect the cost structure and competitiveness of passenger transport industries. The high cost of transport would end up affecting the poorest households more intensely, a situation that worsens in periods of decline in the real income of households. Between 1995 and 2003, for example, there was a drop in the volume of paying passengers, users of public transport, due to the loss of purchasing power of the minimum wage in the Brazilian economy (Carvalho and Pereira, 2012).

In recent years, a rising trajectory has been observed in final fuel prices in the Brazilian economy, raising the cost of living for society as a whole and contributing to the downturn in economic activity. In the UPT the impact of an increase in diesel oil, the sector's basic input responsible for, on average, 23% of companies' operating costs, has an effect on transport tariffs, pushing them upwards. In this activity, the recurring price adjustments for this fuel, in 2021, further aggravated the existing crisis in the sector, which accumulated 11.75 BRL billion in losses in the period from March 2020 to February 2021, in the Covid-19 pandemic, with a drop in passenger demand and a reduction in revenues (NTU, 2021; NTUrbano, 2021). According to Pozzobon et al. (2017), changes in fuel prices generate changes in expenditures with the transport sector, influencing, in turn, the choice of consumers in the demand for travel.

Fuel taxes, in turn, make these prices (urban transport fares) even higher. An increase in urban bus fares, for example, tends to increase inequality, especially in urban areas due to household budget constraints. Among the elements that make up the final price of gasoline, diesel oil and ethanol are federal and state taxes. It appears that 40.6% of the price of gasoline and 21.4% of diesel, both sold to consumers, is due to the tax burden incurred in the operation (Petrobras, 2021). Such taxes are used by governments with the aim of restricting consumption or increasing revenues for the budget, being common in several countries. In addition, attempts are also made by governments with the purpose of containing the inflationary pressures of successive increases in fuel prices, whose oscillation has generated problems for various sectors such as road transport, food, energy and urban transport tariffs. This is what is currently happening in Brazil, especially with the policy adopted by Petrobras of changing prices according to the price of the international barrel of oil. Since 2016, Petrobras has adopted the Import Parity Pricing (IPP)

on the grounds of generating return for the company's shareholders and avoiding distortions in the Brazilian market when dealing with a commodity (NTUrbano, 2021). A correction of these tax distortions or an exemption of these fuel taxes could affect the economy through multiple channels, including positive impacts on the job offer, utility, production and the household welfare.

In addition, in the last two decades, with regard to passenger transport policies, Brazil has prioritized transport by cars and motorcycles (private transport), particularly due to the strong policy of attracting investments from the automobile industry that began in the mid-1990s. Policies were created to stimulate private transport, such as the reduction of the tax on industrialized products, the low price of licensing and taxes on motor vehicle ownership, credit expansion for households, in addition to subsidies such as free parking on public roads. In this way, public transport subsidies are an important option for reducing ticket prices and improving the quality of the service provided. For the specific case of public transport, the government concession aims to maintain fares at prices that are affordable by the population (Carvalho and Pereira, 2012).

Transport has become a typical consumption item in the Brazilian household budget, reaching a higher share than that spent on food. The most recent household budget surveys for 2017-2018 by the Brazilian Institute of Geography and Statistics show evidence that Brazilian households commit 17.5% to food expenses, while transportation expenses occupied 18.1% (IBGE, 2018). Despite the data, the burden of transport is higher for high-income households. According to the survey, while the poorest (the first three income strata) committed 9.58% of their expenses with transport, this percentage was much higher (23.09%) in the budget of households with higher income (10° more rich) (IBGE, 2018). However, low-income Brazilian households are the greatest demanders of public transport and the ones who waste more time commuting home-to-work-to-home, as they live on the outskirts of urban areas, far from their workplaces. In 2013, for example, travels by the poorest took 20% longer than those of the richest (Pero and Mihessen, 2013).

Since households have spending and income links from different sources with other economic institutions (government, firms, rest of the world), the economic consequences of policies in passenger transport services are also transmitted directly and indirectly in the production system from the country. Thus, the present paper aims to analyze and project the economic effects of subsidies granted to passenger transport activities on the Brazilian economy, as well as the redistributive effects on consumption and income of typical households. Recent studies have applied computable general equilibrium modeling (CGE) to address tax policy issues and policy implications. Most studies focus on the increase or decrease in world fuel prices and oil subsidies (see, for example, O´Ryan et al., 2005; Arndt et al., 2008; Yusuf and Resosudarmo, 2008; Henseler and Maisonnave, 2018; Dartanto, 2013; Alshehabi, 2012; Rahiminia and Moghadam, 2015). However, there is a lack of empirical studies for the Brazilian economy that carry out

analyzes related to passenger transport subsidies using CGE models and, therefore, this research in particular directs attention to these pertinent policy issues. The subsidy policy for the provision of passenger transport services can lead to a substitution between public and private transport, affecting the Brazilian productive system. With the aim of reconciling applied economic theory and relevant empirical studies for policy makers, we use the CGE models as a methodology for the analysis. In addition to this introduction, this paper consists of six other sections. The second section briefly reviews subsidies for public passenger transport. The third section presents some applied studies with CGE models for transport. The fourth section describes the database and the fifth the dynamic CGE model. The sixth section presents the results and the last one the final considerations and policy implications for the Brazilian economy.

2 Subsidies for public passenger transport

Passenger transport can be understood as a term designated for the activity of moving people. When this movement of people occurs in the inner environment of cities, we have urban transport. Public transport services in turn can be provided by both private companies and the government. In this way, the Urban Public Transport (UPT) system directly influences exchanges within urban agglomerations and, therefore, is as important for cities as basic sanitation and electricity, and are vital for the quality of life of the population. Among the various categories of urban public transport, we can mention the metro-railway, which has greater capacity, speed, high levels of safety and high cost of implementation, and the road, which in Brazil is still the most used mainly for the transport of loads. Of these, bus transport is considered democratic for passengers, as it is cheap and safe, and can also contribute to ensuring more sustainable urban mobility. Public transport by bus gains in the cost-benefit ratio between the use of fuel and the space occupied by the optimized transported passenger (Oliveira Filho, 2018).

With regard to payment for the service provided in public transport, this is called a tariff. The cost of the ticket follows tariff models declared by the local authorities and considers the definition of expenses, revenues and appropriations by the providing companies. Regarding the value of fares charged in Brazil, it is important to first understand the main costs incurred by public transport. The biggest source of costs is personnel, labor, and taxes, in that order. The biggest source of costs is personnel, labor and charges, in that order. In second place, there is fuel, which is the disbursement for the acquisition of lubricants and diesel oil. Thirdly, there are expenses with tires, parts and accessories and, finally, expenses with remuneration, administrative expenses and depreciation (Oliveira Filho, 2018).

In turn, the Brazilian economy is heavily taxed on consumption, in addition to having a high tax burden compared to other developing countries, especially on fuels. The price of fuel sold at Brazilian refineries follows the current policy practiced by Petrobras of Import Parity Pricing (IPP), which monitors the value of a barrel of oil in international markets plus the exchange rate variation and also logistical

costs. Thus, variations in the dollar, the main currency of the world economy, and/or fluctuations in the price of a barrel of oil tend to have an impact on the final consumer price. Taxes make these prices even higher, affecting the budget of households, especially the poorest who indirectly demand, for example, diesel oil, a product that undergoes these changes and is demanded in various economic activities (e.g., freight and passenger transport, agriculture). That is, higher prices are passed on to households, having effects on the entire productive chain of the economy, generating distortions, a downturn in economic activity and putting pressure on inflation.

On the other hand, there is a discussion that in Brazil the costs of public transport by bus are covered exclusively by fare collection, including in this context transport vouchers. Subsidies for this mode of transport in Brazil are inexpressive, when they exist. In systems without subsidies, there is the so-called "breakeven tariff", in which the amount collected by paying users is equal to the total cost of the system in a given period. In this way, both the increase in the cost of any transport production component and any drop in paying demand contribute to a financial imbalance that will only be recovered with the tariff increase (Carvalho and Pereira, 2012).

The increase in public transport costs may compromise not only the quality of services provided by firms, but also the accessibility of the population to these services, especially the low-income population. This situation is aggravated when there are periods of decline in household income (Carvalho and Pereira, 2012). Regarding public passenger transport, particularly urban buses, in June 2013, the readjustment of BRL 0.20 in fares in São Paulo, as well as in other cities, was the cause of a series of popular demonstrations, which took place by the Brazilian cities, which gained visibility in the international media. The Free Pass Movement, which started on social networks, gained popular acceptance and brought to the agenda the need to discuss new sources of financing for public transport services. The search for a fair fare was the motto of the demonstrations, bearing in mind that an ever-increasing portion of income spent on transport services, whose fares are readjusted above inflation, penalizes households with lower purchasing power. The current financing and cost structuring model, in which the sector adopts tariff regulation based on the cost of the service and with few pre-established rules, public leaders had difficulties in meeting the demands. In addition, dissatisfaction with the amount charged for fares brought to the debate the question of the current financing of the operation of public transport by bus, which falls on the direct users of the services (Carvalho, 2016; Silveira and Cocco, 2013; Couto, 2011; Ipea, 2016; Carvalho et al., 2013).

Therefore, the quality of the UPT has a direct impact on the number of users who use this mode of transport. This lack of quality contributes to users resorting to private transport as the main mode of transportation. In this sense, the subsidy can be basically understood as a financial concession, made by governments to a certain activity with the objective of keeping the prices of the products accessible or

also to stimulate the country's exports. For the specific case of public transport, the government concession aims to maintain fares at prices that are affordable by the population (Carvalho and Pereira, 2012). The demand for public transport is sensitive to tariff changes, since the tariff reduction policy (subsidies) can encourage the use of public transport in order to reduce the appropriation of private cars (Bresson et al., 2003).

For Delgado and Bezerra (2018), the subsidy can be evaluated from the perspective of the Urban Mobility Law as the difference between the tariff charged from the user and the remuneration tariff for the concession service in full. The subsidy is a key factor in improving urban mobility, providing quality public transport services and implementing environmental sustainability policies. This is what justifies the fact that a project that is profitable from a socioeconomic point of view, but with a low rate of internal return due to lack of sufficient commercial revenues, can receive public funding. Furthermore, the benefits of any public transport system go beyond productivity measurements. Additional dimensions would include impacts on health, accidents, mobility, income and household budgets (Brinco, 2017; Haddad et al., 2015). In Brazil, law nº 12,578/2012 of the Federal Government, which instituted the guidelines of the National Policy on Urban Mobility, explained the legal possibility of adopting subsidies for public transport, which allows for legal support for the implementation of subsidy rates for the UPT (Oliveira Filho, 2018). Also, for Delgado and Bezerra (2018), in Brazil there is a lack of a specific public transport financing law, unlike what happens in countries like France, Holland, Italy and Germany. However, there is a recent project that institutes the National Assistance Program for the Mobility of the Elderly in Urban Areas. The purpose of this project is to subsidize the right to free urban public transport for those over 65 years of age and, at the same time, guarantee a low fare for other users (Senado, 2022). It is worth mentioning that the growth in discounts and exemptions (gratuities) also contributes to the increase in the final price of transport fares, especially exemptions for the elderly. The fare benefit has an average impact of 20.9% on the price of bus fares (NTU, 2018).

UPT subsidies are well below what is needed in most cities in Brazil. This problem, added to the increase in the price of inputs and the low efficiency of service providers, reduces the quality of the transport service. In this sense, as the service is financed exclusively by users, it becomes expensive, reduces the demand for services and their exchange for private transport modes, impacting the level of service, decreasing the quality of transport and increasing the tariff even more. This situation culminates in a vicious cycle towards the unsustainability of the UPT service (Carvalho and Pereira, 2012; Oliveira Filho, 2018). Despite being an exception to the existing financing model in the country, subsidies in the case of São Paulo, for example, are well below average European grant levels, as in Prague (74.4%), Warsaw (59.5%), Budapest (58.5%), Madrid (56%), Barcelona (54.8%) and Berlin (51.1%). In 2012, the operating costs of public transport in European metropolitan areas were covered by 48.2% by fare

revenues and 45.6% by subsidies. Paris has the minimum coverage through public subsidies (20.2%), but has a 40.4% coverage of operating costs that comes from other revenues (e.g., Versement transport tax) (EMTA, 2012). Given this discussion, it becomes relevant to evaluate subsidy policy in a dynamic CGE model to project year-to-year economic effects.

3 CGE approaches to passenger transport and issues related to the environment and fuel policy

A number of recent studies have applied various approaches to discussing fuel taxation and passenger transport subsidies, and other related issues, and formulating economic policy implications, including near-term developments. Of these approaches, a computable general equilibrium (CGE) model provides a consistent and complete framework for examining the role of public transport subsidies. Depending on the analysis, the CGE models include a Social Accounting Matrix (SAM) in their database structure, capable of detailing the generation and appropriation of income by different sources and the structure of expenses, such as this research. An extensive empirical review can be found at Proque et al. (2022). The research by Proque et al. (2022) explores the links between consumption, income and transport of the redistributive and economic effects of Cide-fuels (specific tax on gasoline and diesel oil in Brazil) through a dynamic CGE model. The results showed positive effects on aggregated variables, such as GDP, positively affected by the internal market and the reduction of income inequality. Typical low- and middle-income households would benefit from the simulated fuel policies, regardless of whether they are close to a general cut by Cide-fuels or a cross-subsidy policy (taxes gasoline and uses the resource to finance the urban bus fare).

EGC modeling has been a popular tool to investigate the impacts of a fuel tax, production subsidies and also carbon taxes within the climate policy framework. Cao (2008) simulated the effect of a fuel tax and a product tax using a dynamic CGE model calibrated with a SAM for the Chinese economy. The author found that taxes contribute to discouraging the flow of migrants from the interior to the cities and that, therefore, the policy would have implications for the Chinese labor market. In a more recent study, Kim and Samudro (2019) analyzed government policies to transfer fuel subsidies to investments in transport infrastructure. Using a multi-sectoral CGE model with a financial SAM, the authors found that GDP would increase by 0.0157% and the transport sector would produce the largest increase in value added due to direct gains from the benefit of the additional road stock.

In addition, other research also used CGE models and the same SAM framework to analyze the 100% increase in fuel taxes in Chile (O´Ryan et al., 2005), increase in world fuel and food prices for Mozambique (Arndt et al., 2008), fuel price reform in Indonesia (Yusuf and Resosudarmo, 2008), reduction of oil prices, reduction of fuel subsidies and reallocation to the transport sector in the economy of South Africa (Henseler and Maisonnave, 2018), elimination of fuel subsidies in Indonesia (Dartanto,

2013), elimination of oil and fuel subsidies in Iran (Alshehabi, 2012), fuel subsidy targets on micro and macroeconomic variables in Iran (Rahiminia and Moghadam, 2015), taxation policies and biofuel subsidies in Thailand (Chanthawong et al., 2018). In common, these studies show how fossil fuel subsidies and taxation can affect the economy, employment and household income.

Other modelers have developed special attention to climate policies and the production of alternative fuels such as biofuels, as such policies have effects on economic growth. With the recent increase in the number of vehicles in cities, particularly private transport, the transport sector has contributed to rising energy consumption and emissions. In an application to the Chinese economy, Guo et al. (2014) investigated the impacts of a tax on carbon and emissions. For the authors, a moderate carbon tax would significantly reduce carbon emissions and energy consumption from fossil fuels. Doumax et al. (2014) evaluated an increase in oil prices and fiscal policies on fossil fuels, while Ge and Lei (2017) used a CGE model for the Chinese economy with policies of production subsidies and consumption tax on the use of gasoline in order to promote the development of bioethanol. Already Li et al. (2017) developed a CGE model with disaggregation of households by income level to study the ramifications of removing energy subsidies in Malaysia. The oil and gas subsidy removal policy improves economic efficiency and would encourage economic activity.

However, not all studies develop a SAM with disaggregation for households. The study by Wianwiwat and Asafu-Adjaye (2013) examines the Thai government's renewable energy development plan, in particular biofuels. In Brazil, Porsse (2008) evaluated the effects of the shock of the increase in the rates of the Tax on the Circulation of Goods and Services on the economy of Rio Grande do Sul. The results pointed to a reduction in GDP and employment in Rio Grande do Sul. Bistafa et al. (2016) investigated the long-term economic effects of pre-salt exploration, with attention to the ethanol sector. In the same perspective, Magalhães and Domingues (2012) and Moraes (2013) also used CGE models to study the impacts of pre-salt exploration on the Brazilian economy. The various quantitative studies discussed above focus on fuel-related policies, most of which are disaggregated by households' groups, which makes it possible to compare different impacts of policies on different income groups and also the economic viability of the policy for those less favored groups. Or rather, the poorest households. Tscharaktschiew and Hirte (2012) used a calibrated CGE model for the German economy to examine the efficiency, environmental (CO_2 emissions) and spatial effects of increasing subsidies on passenger transport, discriminating between types of residences. Verikios and Zhang (2015) calibrate a multi-regional EGC model to assess the effects of structural changes on household income groups from substantial reforms during the 1990s of the Australian urban transport industries. For a more complete review see Proque et al. (2019). CGE model in this study provides a consistent framework for analyzing

the role of passenger transport subsidies in the Brazilian economy. The model is solved using Gempack's RunDynam (Harrison and Pearson, 2002).

4 Data base

The present paper uses the Annual Survey of Services (Pesquisa Annual de Serviços - PAS) and the Tables of Resources and Uses (Tabelas de Recursos e Usos - TRU) of the Brazilian Institute of Geography and Statistics (Instituto Brasileiro de Geografia e Estatística - IBGE) as its database source. In this paper, information regarding subsidies for land transport in Brazil will be used, both for passengers and for cargo. The collected data refer to the 2010-2018 time series. PAS analyzes information about the structural characteristics of the business segment of providing non-financial services in the country, having formally constituted companies as the unit of investigation, that is, those that present the National Register of Legal Entities (Cadastro Nacional da Pessoa Jurídica - CNPJ). As mentioned, the research aims to portray the economic reality of the non-financial services sectors in the country and their transformations over the years. The investigation objective of the research is the companies that operate in the sectors formed from the grouping of the National Classification of Economic Activities (CNAE 2.0), namely: services provided to families, information and communication services, professional, administrative and complementary services, transport, auxiliary transport and postal services, real estate activities, maintenance and repair sectors, and other service activities. In the research, information was used regarding subsidies for the land transport sector - passengers and cargo, for companies with twenty or more employed persons.

The TRU elucidate the production effort and income generated in the economy from the perspective of the sectors of productive activity, contain results at current and constant prices, present the flows of supply and demand for goods and services, and the generation of income and employment in each economic activity. They are part of the country's System of National Accounts (SNA) and are linked to the CEI (Integrated Economic Accounts) through the results of supply and demand, and income aggregated by sectors of activity. The TRU are divided into tables of resources of goods and services, table of uses of goods and services, and components of value added by sector of activity. In the present paper, information on the value added referring to the operation “Other subsidies to production” for the sector “Land transport” was used.

From the PAS, land transport activities were selected - rail, metro, road freight and road passengers. With the set of selected activities in hand, a few steps were followed. First, the subsidy amounts for the selected activities were broken down. Then, the percentage participation of each variable was performed in relation to the total subsidies for each year. Finally, production subsidies for TRU land transport were disaggregated based on the percentage share held in the previous stage. It was observed that the TRU and SBP disaggregation values were very similar. Thus, the PAS was chosen for the database for technical

reasons related to the ease of disaggregation of information for the selected years. It should be noted that the subsidy values found in the TRU refer to the Value Added (VA) referring to the net subsidy value, composed of the value of production and product. Of the transport activities previously selected, only four that suffered the shock in the model were selected. The selected variables were: metro-railway passenger transport, road passenger transport in the city and in the metropolitan region (urban bus), school transport, taxi and chartered passenger road transport and intercity, interstate and intercity passenger road transport. For these variables, the net operating revenue for the period 2010-2018 was evaluated. Finally, the relationship between subsidies and net operating revenue in the period 2010-2018 was evaluated. The values contribute to compose the policy shock in the selected transport activities, as will be seen in the following sections.

5 The CGE Model

Despite the emergence of several CGE models and works in the literature, it is observed that passenger transport is little studied in relation to the economic and distributive effects within the present methodology and also for the Brazilian economy. The model used in this study is the BIG-TP (Brazilian Income Generation and Transport of Passengers), a single country recursive dynamic CGE model, calibrated from the 2010 input-output matrix (IBGE, 2010a), capable of analyzing passenger transport policies and their relationship to income structure, consumption composition and production system. For more details see Proque et al. (2022). Therefore, the model includes a Social Accounting Matrix (SAM) for the Brazilian economy and the mechanisms of recursive dynamics, whose specification is based on the modeling of intertemporal behavior and on results from previous periods (Dixon and Rimmer, 2002), in conformity with the model of the Australian tradition PHILGEM (Corong and Horridge, 2012; Corong, 2014), which extends the ORANI model (Dixon et al., 1982; Horridge, 2006) with the mechanisms of recursive dynamics.

The BIG-TP includes a Social Accounting Matrix (SAM), calibrated in the year 2010, detailing the generation and appropriation of income by different sources and the structure of expenses, as well as the preferences of 5 representative households for 4 transport services passengers. More than the distribution of income, the aforementioned model recognizes the transmission channels of income and expenditure between economic institutions (i.e., households, firms and government). In the theoretical structure of the CGE model, typical families determine an optimal composition of their consumption baskets based on a Linear Expenditure System (LES), subject to a budget constraint. The LES derives from the property that expenditure on each good is a linear function of prices and expenses, in which a portion of expenditure is allocated to household subsistence and another portion to “luxury spending” (Klein and Rubin, 1947). There are two intermodal substitution modules for passenger transport services in the theoretical

specification of households (public and private transport; urban bus and train/metro services) in order to deal with variations in relative prices for the substitution process between markets transport (Proque et al., 2022).

The closing scenario, called the reference scenario (baseline), consists of the real variations of the main components of final demand, divided between those observed until 2020 and forecast until 2040, according to Table 1. The variations observed between 2011 and 2020 comprise the IBGE statistics (2021, 2019). On the other hand, the forecasts until 2040 of the macroeconomic scenarios are available in the forecast of the federal development strategy for Brazil (Brasil, 2020b). As the reference scenario represents the expected changes in the Brazilian economy over the period, it therefore reproduces the trajectory of the economy without the policy instrument. That is, it is the scenario without any recent policy of subsidies for passenger transport.

Table 1 – Real variations (%) of the macroeconomic scenario for closing the model

Indicators	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Forecast (a.a.)*	
											2021-2027	2028-2040
GDP	3.97	1.92	3.00	0.50	-3.55	-3.28	1.32	1.32	1.14	-4.06	2.2	2.2
Household consumption	4.82	3.50	3.47	2.25	-3.22	-3.84	1.98	2.05	1.84	-5.45	-	-
Government spending	2.20	2.28	1.51	0.81	-1.44	0.21	-0.67	0.36	-0.44	-4.68	0.0	2.2
Exports	4.81	0.71	1.83	-1.57	6.82	0.86	4.91	4.00	-2.54	-1.76	-	-
Investments	6.98	0.78	5.86	-4.02	-14.35	-12.42	-2.56	3.91	-0.44	-0.78	-	-
Current job	1.47	1.41	1.56	2.86	-3.34	-1.56	1.25	1.20	1.20	-7.94	-	-
Trend employment	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.0	2.0
Population	0.88	0.87	0.85	0.86	0.87	0.83	0.80	0.85	0.85	1.00	1.0	1.0

Source: IBGE (2019, 2021) and Brasil (2020b).

Note: * Hidden values ("-") denote that the variables are endogenous in the period.

Macroeconomic observations show that in the period from 2011 to 2020 there was a slowdown in the Brazilian economy, with a drop in exports and investments, less dynamic domestic demand and sluggish domestic consumption. In 2020, for example, GDP, household and government consumption showed the lowest growth rates in the entire period considered due to Covid-19. The world we knew changed after the World Health Organization (WHO) declared that Covid-19, the disease caused by the new coronavirus, was a global pandemic. The outbreak that began in the Chinese city of Wuhan in the Hubei province quickly turned into an emerging public health crisis. In 2020, more than 7 million cases were confirmed with more than 190,000 deaths in Brazil (Brasil, 2020a). The main measure adopted in Brazil to curb the spread of the disease was the partial shutdown of some non-essential economic activities. Some preventive or emergency social distancing measures, such as closing schools, bars, restaurants and shops, and banning public events, were enacted by different spheres of government, having a direct effect on the economy (CNT, 2021). As a result, Brazil's GDP declined by 4.06% in 2020, compared to the positive

GDP growth rate of 1.14% in 2019 (see Table 2). Negative growth is also observed in 2020 in all GDP aggregates, highlighting household consumption (-5.45%) and government spending (-4.68%).

The variables that received the shock in the historical simulation are GDP, real aggregate investment, displacement of household consumption, export volume index, real aggregate government demand and wage adjustment mechanism. All these variables have their endogenous counterpart. Also receiving the baseline shock is the variable devo1, which corresponds to the ratio of grants to net operating income for the selected transport activities in the period 2010-2018 and which will generate monetary values for the policy shock in the selected transport activities. The variable that receives the shock is delV1PTX – ordinary change in tax collection on production. To isolate this effect, a swap was performed between delV1PTX and delPTXRATE, with the objective of remaining endogenous to the ordinary change in the collection of taxes on the production of economic activity and, its counterpart, exogenous.

The subsidy policy in the passenger transport sectors can be carried out with an impact on the following SAM products: (1) Metro-railway passenger transport, (2) Municipal and in metropolitan region (urban bus) passenger road transport, (3) School transport, taxi and chartered passenger road transport and (4) Intercity, interstate and intercity road passenger transport. To calculate the value of the shock in the selected products, the baseline was first run. The variable devo1 generated a second variable called devo 2, in which monetary values were estimated for the four transport activities selected in the period 2021-2040. These values were used for the shock in the analyzed period. The cumulative shock values as well as the annual average in the selected activities are shown in Table 2. This methodology aims to evaluate the impact of the presence of subsidies consistent with what was applied in the sectors analyzed in the period 2010-2018.

Table 2 – Nominal amounts of subsidies for passenger activities (BRL $Million)

Sectors	2021-2025		2021-2040	
	Accumulated	Annual average	Accumulated	Annual average
Metrorailway	2,333.16	466.63	8,225.83	411.29
Municipal and in metropolitan region (urban bus)	430.64	86.13	1,507.37	75.37
School, taxi and chartered	5.40	1.08	19.55	0.98
Intercity, interstate and international	4.44	0.89	15.64	0.78

Source: Search results.

6 Results

Below are the macroeconomic results of the subsidy policy for public passenger transport. Thus, Table 3 provides the accumulated deviations on the growth rates of the selected macroeconomic variables, namely: GDP, imports, exports, household consumption, investments, capital stock, real wage, national

employment, nominal tax revenue, deflator and terms of trade. The analysis of the results of the subsidy policy on macroeconomic variables aims to assess the impact of the policy on the economy in general.

Table 3 – Macroeconomic effects of policies related to public transport subsidies (Var.%)

Variables	Short term	Medium term	Long term
	2021-2025	2021-2030	2021-2040
GDP	0.03	0.07	0.35
Import	0.26	0.61	1.07
Export	-0.29	-0.74	-1.10
Household consumption	0.18	0.39	0.90
Investments	0.24	0.86	1.24
Capital Stock	0.00	0.13	0.77
Actual Salary	0.17	0.47	1.32
National Employment	0.07	0.11	0.12
Nominal income from taxes	-0.40	-0.78	-1.40
Deflator	0.39	0.95	1.14
Terms of trade	0.28	0.71	1.04

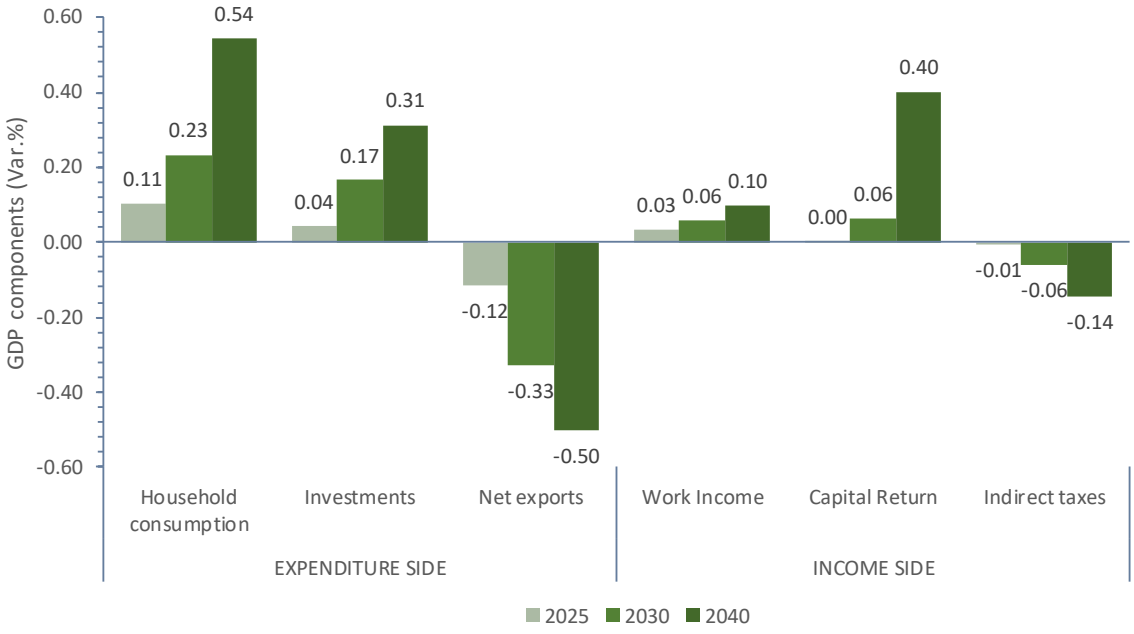
Source: Search results.

According to Table 3, an increase in the GDP growth rate of 0.03% in the short term, 0.07% in the medium term and 0.35% in the long term can be observed. The observed changes in GDP can be explained by an increase in household consumption, investment and a reduction in the trade balance. With regard to household consumption, it can be seen that this grew by 0.18% in the short term, 0.39% in the medium term and 0.90% in the long term. This result contributes positively to the value of GDP, since this component is a demand absorption factor in the economy's total expenditure and a result of the domestic market via an increase in real household consumption.

The term of trade variable represents the relationship between the price of exports and the price of imports of a country, and aims to evaluate the performance of a country vis-à-vis abroad in terms of trade relations. Higher terms of trade values mean that the price of exports is valued in relation to imports from a country. It is observed that there is an increase in the variable in the long term, going from 0.28% in 2025 to 1.04% in 2040.

To assess the expansion of economic activity, Graph 1 shows the breakdown of GDP components from the perspective of expenditure and income. It can thus be seen that, on the expenditure side, the positive impact on GDP is mainly due to gains in investment and household consumption, which offset the negative effects on the trade balance – exports minus imports. The government spending component is exogenous and therefore does not change over the period. On the income side, GDP growth is related to remuneration for work and capital, as well as indirect taxes.

Graph 1 – Effects of public transport subsidies on GDP aggregates



Source: Search results

In this scenario, the subsidy policy for public passenger transport contributes to stimulating the country's economic activity, as it favors the reduction of costs passed on to the final consumer in the form of fares, encouraging greater consumption by individuals and households of transport, which leads to greater consumption of inputs throughout the public transport production chain. In addition, the reduction of the impact of transport on the income of individuals and households contributes to the redistribution of income in the consumption of other goods, mainly those related to food and services.

The GDP deflator that measures the average change in prices in the period compared to the previous period in an economy shows a variation of 0.39% in the short term, 0.95% in the medium term and 1.14% in the long term (see Table 3). This result is consistent with expectations, since with the policy, it would cause an increase in the market for goods and services, increasing the demand for primary factors and consequently generating a rise in product prices.

With the subsidy policy for public passenger transport, there is a reduction in prices and a consequent increase in demand for transport services. This impacts the demand for primary factors present in the production chain. Demand pressure raises capital income, which contributes to an increase in the percentage change in the prevailing rate of return. Consequently, investments increase. In the following period, when investments become operational, there is an expansion of the capital stock. Thus, there is an increase in the capital stock, especially in 2040, when it reaches 0.77% (see Table 3).

In the labor market, subsidy policy contributes to national employment growth that affects real wages. However, there are no constraints on the model for the labor market, since the demand for labor is elastic. It is noted that with the policy, there is an increase in real wages, from 0.17% in 2025, to 0.47% in 2030,

followed by 1.32% in 2040. National employment, on the other hand, shows a growth of 0 .07%, 0.11% and 0.12% in the same periods. Regarding the nominal tax revenue, it is observed that this is negative, going from -0.40% in 2025 to -1.40% in 2040 (see Table 3). The nominal tax revenue is negative since the policy was not enough to offset values.

To assess the distributive effects of subsidies on passenger transport in the Brazilian economy on households, the heterogeneity of five representative families presents in the BIG TP model, differentiated by income strata, was used. In this case, there was a disaggregation of households by monetary income in number of minimum wages (IBGE, 2010), where H_1 represents households that have up to three minimum wages of monthly income, H_2 represents those that have between four and six, H_3 refers to those that have between seven and ten, H_4 are households with incomes between eleven and twenty and, finally, H_5 represents households that have more than twenty minimum wages as monthly income. For the analysis of the impact of the policy on households, real disposable income and utility were evaluated in the period 2021-2025 as short term, 2021-2030 as medium term and 2021-2040 as long term. Table 4 presents the results of the impacts of subsidies on real income by groups of households.

With regard to the impact of subsidies on households, increases in real disposable income are observed for all income strata. This result is consistent with what was expected, since the presence of subsidies in passenger transport generates a positive impact on household income, by contributing to the reduction of fares and the reduction of the price of urban public transport in general. It is important to point out that a higher percentage growth is observed in the income of the poorest households, mainly for the group between four and six, and between seven and ten minimum wages, given that the poorest groups are those that demand greater public transport. The direct and indirect effects on the income of typical households could contribute to an increase in purchasing power and, consequently, in the real consumption of households.

Table 4 – Effects on real household disposable income (Var.%)

	Households	2021-2025	2021-2030	2021-2040
H1	Até 3 sm	0.16	0.37	0.84
H2	4 a 6 sm	0.23	0.50	1.08
H3	7 a 10 sm	0.22	0.47	1.02
H4	11 a 20 sm	0.16	0.37	0.84
H5	Acima de 20 sm	0.12	0.29	0.73

Source: Search results.

Note: sm (minimum wages).

With regard to utility, this can be considered as a function of the variation in household consumption that is above the subsistence portion and is a hypothesis of the impact on the economic welfare of households (Proque et al., 2022). The public transport subsidy policy induces an increase in welfare by contributing to the price of fares being below the cost of providing services. Table 5 presents the impact of the policy on the utility of household groups.

Table 5 – Effects on household utility (Var.%)

	Households	2021-2025	2021-2030	2021-2040
H1	Até 3 sm	0.35	0.81	1.66
H2	4 a 6 sm	0.51	1.12	2.21
H3	7 a 10 sm	0.48	1.04	2.03
H4	11 a 20 sm	0.36	0.79	1.64
H5	Acima de 20 sm	0.27	0.62	1.40

Source: Search results.
Note: sm (minimum wages).

It is observed that all income strata show utility gains for the three scenarios. The classes that are at the beginning of the distributive structure show the greatest gains, with a focus again on groups of four to six and seven to ten minimum wages. The group with income above twenty minimum wages presents the lowest utility gains in the three periods, since this group comprises the largest share of spending on luxury goods. As individuals/households show utility gains with an increase in the consumption basket, this scenario contributes to an increase in the welfare of households. The subsidy policy for public transport activities contributes to the reduction of the fare price and, consequently, the increase in demand for these sectors. Tables 6 and 7 presents, respectively, the demand for public transport and the demand for private transport by groups of households.

Table 6 – Demand for public transport by household group (Var.%)

	Households	2021-2025	2021-2030	2021-2040
H1	Até 3 sm	0.65	1.28	2.15
H2	4 a 6 sm	1.21	2.34	3.90
H3	7 a 10 sm	1.13	2.16	3.47
H4	11 a 20 sm	0.98	1.85	2.85
H5	Acima de 20 sm	0.80	1.51	2.23

Source: Search results.
Note: sm (minimum wages).

For all income strata, increases in demand for public transport are again to be seen, mainly by households in the lower strata, who are the ones who consume the most this category of service. In relation to the demand for private transport, it shows an increase in the three periods, but in a more discreet way. In this case, it is the households with the highest income strata that have the greatest gain in demand, since they are the ones that most demand private transport, such as cars.

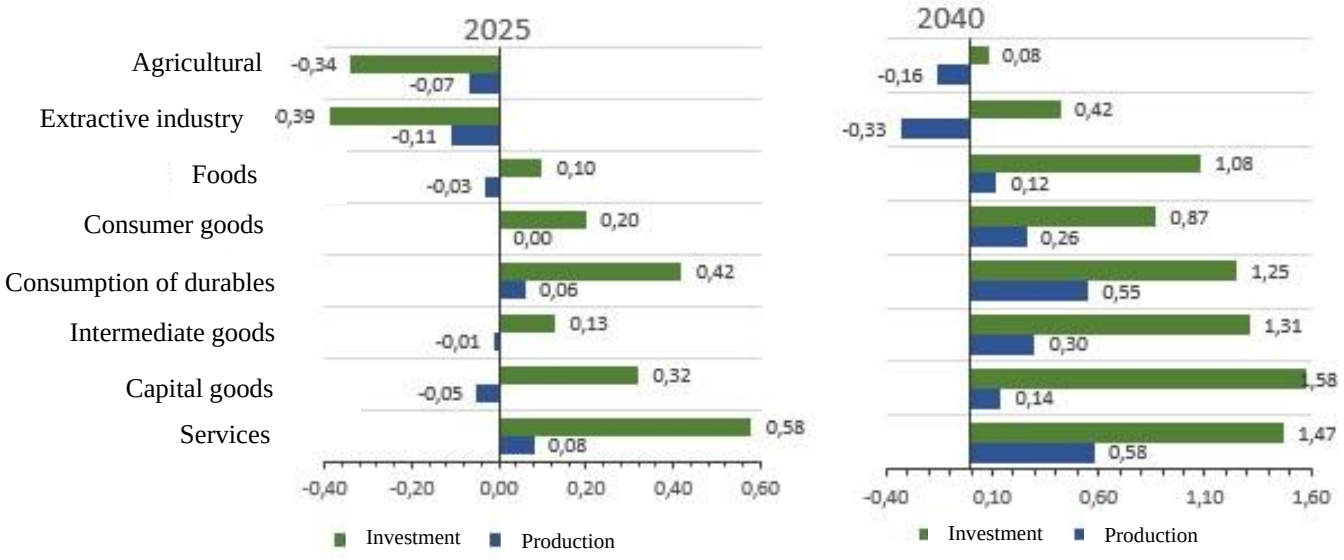
Table 7 – Demand for private transport by household group (Var.%)

	Households	2021-2025	2021-2030	2021-2040
H1	Até 3 sm	0.00	0.01	0.02
H2	4 a 6 sm	0.02	0.04	0.10
H3	7 a 10 sm	0.02	0.05	0.13
H4	11 a 20 sm	0.03	0.07	0.17
H5	Acima de 20 sm	0.03	0.07	0.20

Source: Search results.
Note: sm (minimum wages).

So far, the impacts of subsidies on passenger transport activities at the macroeconomic level and the consequences on typical households' groups have been evaluated. In this section, the impacts on the sectors of the economy will also be evaluated. Graph 2, in turn, presents the impacts of sectorial production and investment. Eight sectors are recognized in the model in the short-, medium- and long-term periods, namely: agriculture, extractive industry, food, consumer goods, consumption of durables, intermediate goods, capital goods and services.

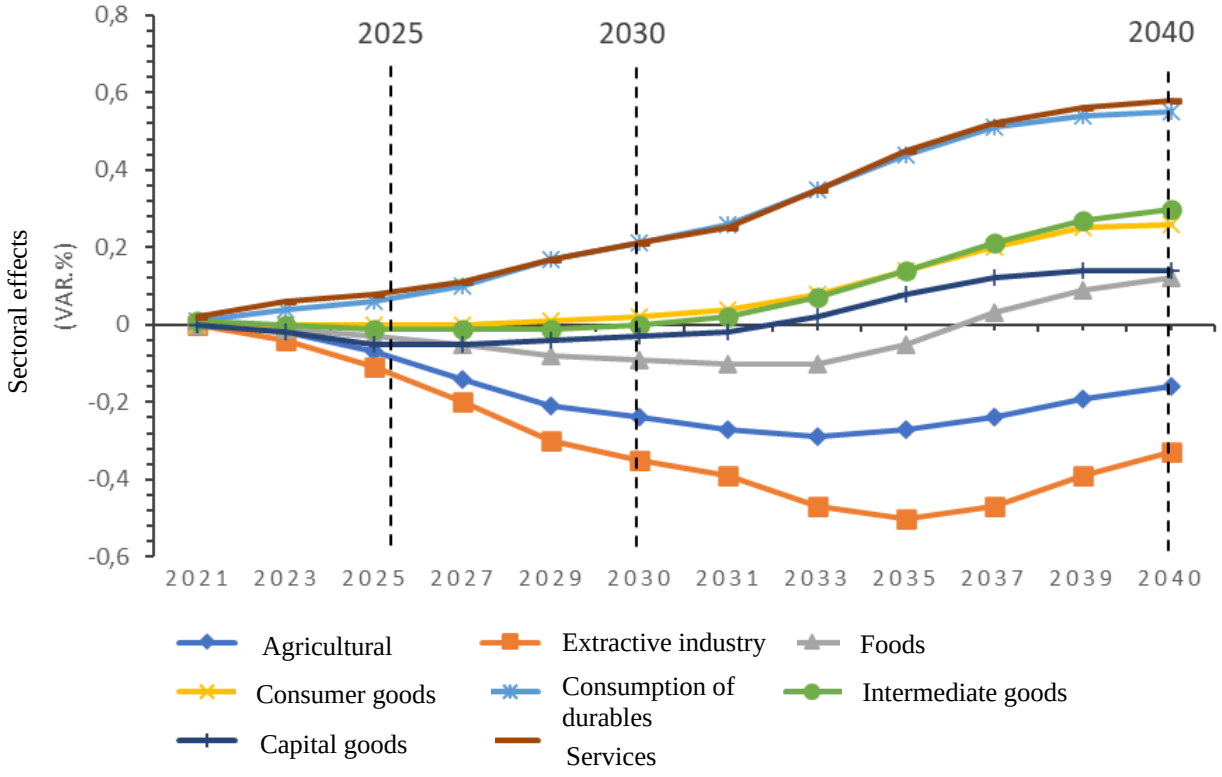
Graph 2 – Sectoral effects of subsidy policy from the perspective of production and employment and investment (Var.%)



Source: Search results.

It is observed that with the policy there is an increase in production and investment in the sectors of the economy in both policy scenarios, with the exception of the agricultural and extractive industry sectors. This can be explained by the fact that both sectors are representative in the composition of Brazilian exports and, according to Table 3, there is a reduction in the country's exports in the three periods. On the other hand, there is an increase in production and investment in the sectors of consumer goods, consumer durables, food and services. The increase in household income contributes to an increase in the production of those sectors that are more related to household consumption, mainly due to the consumption profile of households in lower income strata. Graph 3 presents the production of the sectors in the three periods. It can be noted that the sectors that showed the greatest growth are consumption of durable goods and services, reaching 0.55% and 0.58% in the long term.

Graph 3 – Sectoral effects of the subsidy policy from the perspective of production (Var.%)



7 Conclusion and Policy Implications

Household budget surveys by the Brazilian Institute of Geography and Statistics (IBGE) show evidence that Brazilian households already spend practically the same amount on transport and food, and in some metropolitan regions there are indications that spending on transport exceeds food. In the latest edition of this survey, spending on transportation exceeded spending on food. Thus, changes in the price of urban public transport (UPT) fares directly affect the cost of living and the household budget. Despite the importance of urban public transport as a guarantee of accessibility and mobility for a large part of the

population, it has become increasingly expensive for users, with fare increases and quality reductions, which reduces the demand for the service on the part of citizens. users, reduced ability to pay the minimum wage and compromised access to public transport services, especially for the poorest households. Public policies such as the Urban Mobility Law are unable to contain the effects of rising public transport costs.

This scenario opens the discussion on the role of subsidies for urban public passenger transport, as an important option for reducing ticket prices and improving the quality of the service provided. For the specific case of public transport, the government concession aims to maintain tariffs at prices that are accessible to the population. In addition, it is necessary to evaluate the impact of the subsidy policy on the redistribution of household income, taking into account the peculiarities of different groups by income level. Thus, the present paper aimed to analyze and project the economic effects of subsidies granted to passenger transport activities on the Brazilian economy, as well as the redistributive effects on consumption and income of typical households. To fulfill the objective, the BIG-TP model was used, which is a Computable General Equilibrium (CGE) model that presents flexibility for the creation of scenarios based on economic fundamentals for the Brazilian economy. Within the innovations proposed by the model, the present paper contributes to filling gaps in the analysis of the redistributive effects of income with the introduction of subsidies to the transport of passengers.

The macroeconomic results show that the subsidy policy for public passenger transport generates effects on the growth of the Brazilian GDP and contributes to the increase in the flow of expenditure and income, generating positive impacts for the Brazilian economy. This positive effect is mainly due to the increase in household consumption and investments and the reduction in the trade balance. Regarding the results observed by groups of households, it can be concluded that the analyzed policy generally benefits all income strata, but mainly the poorest households, which have greater percentage gains in real income, utility and consumption. There is a greater demand for public transport mainly by the poorest households and a more expressive increase in the demand for private transport by the richest households. Regarding the sectoral impacts, the increase in household income contributes to an increase in the production of those sectors that are more related to household consumption, mainly due to the consumption profile of households from lower income strata, contributing to the increase in sectoral production and investment. In sectors such as agriculture and extractive industry, however, there are difficulties in expanding production in the short and medium term. These projections are in line with the reflections and proposals of the National Association of Urban Transport Companies (NTU) and the National Transport Confederation (CNT), which seek ways for sectors such as public passenger transport, essential services that benefit from these policies. specific for inputs such as diesel and which, on the other hand, suffer from recurrent crises resulting from the loss of demand, high tariffs, the absence of economic subsidies, the current sector financing model, among others.

In a final assessment, there is no doubt that any movement towards a search for improvements in the public passenger transport sector that includes tax exemptions and/or economic subsidies, in principle, is beneficial for Brazil. And the search for segments of society, beneficiaries of public transport, that can contribute to its financing, without safeguards, will bring gains to the Brazilian economy, although with greater incentives for specific groups, such as the poorest households. Such incentives should favor the greatest demanders of public transport, since the access of these users to the service is costly due to the higher tariffs. In other countries (e.g., United Kingdom, France) funding for the sector is already a reality, whose subsidies account for almost half of the resources allocated to finance the operation of these services. The sector's tariff regulation model and the government's private interests constitute the greatest obstacle to public transport financing in Brazil. Tariff systems feed a vicious cycle of loss of demand for public passenger transport, while private transport gains strength due to government policies in its favor.

As for further research issues, it would be interesting to use the microsimulation module to capture inequality issues. Another avenue of research could be developing the interregional model to address issues such as public transport tariff policies, gratuities granted to the elderly, and the consequent increase in this with the aging population. Finally, we are calibrating the CGE model for 2015, whose data are the most recent available from the IBGE.

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