Does Petrobras' change in IPP policy really lead to positive economic effects? Assessing income redistribution and the reduction in emissions from fuel use[1]

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Abstract

Since 2016, Brazil has implemented the Internal Price Parity (IPP) Policy for fossil fuels, partially indexing prices to international rates. This policy has broadened the tax base, leading to increased household and production costs. However, in 2023, Petrobras discontinued this policy, particularly for diesel and gasoline, redirecting resources and bolstering household spending. This article contributes to the assessment of the impacts of this change in Brazil. The main results show intensified economic growth versus environmental concerns, increased production and improved utility for families of all income levels. However, higher-income families, dependent on private transportation, face greater effects, perpetuating income concentration.

Keywords: Fuels. Price policy. Computable General Equilibrium.

Thematic area: Public policies: gender, race, inclusion

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1. Introduction

Industries in the fuel sector present a complex, systemic chain with a high degree of maturity in the Brazilian economy. These economic activities are characteristically capital-intensive, relying on extensive infrastructure for fuel storage and distribution. Their processing units are strategically located between raw material sources and consumer markets. To optimize costs across the supply chain, industrial processing, and distribution within a country (CADE, 2022; do Amaral Mendes et al., 2018; Wagner et al., 2014). It is a sector susceptible to cyclical shocks capable of absorbing or transmitting systemic effects through the interaction of intermediate input demand (upstream) and fuel supply (downstream) (Baumeister & Kilian, 2016; EPE, 2021). In Brazil, the fuel sector is classified as a key sector due to its potential to generate upstream and downstream effects leading to above-average production(Betarelli Junior, 2022; IBGE, 2023).

On average, between 2018 and 2019, over half (about 58%) of Brazil's total fuel supply was used as intermediate input in economic activities, according to IBGE (2023). This places fuels as the second most important input in the national economy. In 2019, IBGE data shows that gasoline, fuel oil, diesel, and biofuels jointly accounted for 4.22% of the country's intermediate consumption, ranking behind only electricity (4.36%) and financial services (6.69%). Fuels represent 42% of the total supply, with 13.20% allocated to the external market and 28.52% to Brazilian households (IBGE, 2023). Generally, higher-income families demand more private transportation, while lower-income ones rely more on public transport, mostly fueled by diesel and biofuels for services (Peng et al., 2008). This discrepancy directly impacts household budgets, varying according to income distribution and transportation expenses.

Policy instruments directly affecting fuel market prices impact on relative price structures, production operations—especially in sectors intensive in fuel use—and the typical households' budget constraints, income flow composition, and payments among economic institutions (i.e., firms, households, and public administration). In this context, until 2023, fuel pricing in the Brazilian market was influenced by three main factors. First, the market structure stands out, characterized by a state-controlled monopoly. Second, the high density of oil extracted from Brazilian basins makes domestic refining more challenging, requiring the import of lighter oil for suitable composition. Although lighter oil exists in the pre-salt reserves, the country remains highly dependent on imports for refining (Lourenço, 2022). Lastly, the Import Parity Policy (IPP) implemented in 2016.

The IPP was a policy instrument implemented to generate profits for Petrobras and prevent distortions in the Brazilian fuel market. However, an unintended consequence was the increase in domestic prices in response to international market hikes, benefiting oil importers and affecting the competitiveness of the Brazilian state-owned company. This occurred due to a hypothetical scenario in which Brazil does not produce oil, resulting in companies acting as importers and incorporating additional costs to distributors. In this perspective, the policy adoption led to increased fuel and oil refining product prices' susceptibility to price asymmetries. Initially, policy adjustments were made monthly. However, in July 2016, prices started being adjusted daily, within a range of -7% to +7%. The rationale presented was that past changes could not keep up with international market volatility. In practice, adjustments did not occur daily but had higher frequency than before (Lourenço, 2022). There was then a gradual increase in final fuel prices, leading to a negative impact on people's cost of living and contributing to economic activity slowdown. This price policy impacted gasoline and diesel until 2023.

The transmission of these various economic and redistributive effects through direct and indirect channels among the production system, income and payment flows of economic institutions, and fuel price policies has been underexplored by applied research (e.g., Bhuvandas & Gundimeda, 2020;

Proque, 2019), especially for Brazil. Hence, this is a gap our study aims to fill. Therefore, this article contributes to analyzing the economic, distributive, and environmental effects resulting from the end of IPP. To accommodate the main objective, we used a Computable General Equilibrium (CGE) model, which incorporates flows from the Brazilian Social Accounting Matrix (SAM). The model also intricately recognizes private and public transport markets and fuel markets, which were affected by changes in fuel pricing policies.

Furthermore, the model we employed incorporates an emission accounting module, capturing how policies impact Greenhouse Gas Emissions (GGE) reduction or increase. Previous studies also assess the relationship between fuel policies and their impacts on the economy (e.g., Arndt et al., 2008; Henseler & Maisonnave, 2018; Proque et al., 2022; Rahiminia et al., 2015; Yusuf & Resosudarmo, 2008) others relate them to greenhouse gas emissions (e.g., Guo et al., 2014; Kulmer & Seebauer, 2019; Li & Yao, 2020). Therefore, the methodology allows capturing the main secondary effects of fuel policies on households, firms, and investors, as well as analyzing the interaction of different taxes.

1.1 Fuel Policies: Methodological Approaches

Changes in gasoline and diesel prices have an impact on household demand, prices, income, and well-being. For instance, increases in urban bus fares tend to exacerbate inequality, especially in urban areas, due to households' budget constraints. Given the complexity and diversity of economic issues related to fuel policy, some studies employ methodologies such as econometrics, input-output analysis, and panel data (e.g., Bakhat et al., 2017; Jiang & Ouyang, 2017; Liddle & Huntington, 2020; Wang et al., 2013) to yield results. However, the Computable General Equilibrium (CGE) model offers a consistent and comprehensive framework for examining the economic and sectoral impacts of a specific fuel policy. Aligned with the applied methodology, CGE models can integrate the SAM into the database structure, enabling the model to detail income generation and appropriation through various sources and expenditure structures.

CGE modeling, then, has become a popular tool in investigating price impacts resulting from fuel taxes and production subsidies. Some studies specifically focus on investigating the distributive impacts of fuel price increases, such as the work of Yusuf & Resosudarmo (2008), which analyzes the distributive impact of fuel price hikes implemented by the Indonesian government in October 2005. The authors noted that such fuel price increases led to heightened inequality, especially in urban areas. Other researchers, like Arndt et al. (2008), examine the macroeconomic and sectoral implications of global fuel and food price increases on Mozambique's economy. They demonstrate that these price hikes were transmitted to the domestic economy, resulting in a significant negative impact on the country's terms of trade.

Given the potential economic development impacts of such policies, studies have paid special attention to climate policies and alternative fuel production, such as biofuels. Chanthawong et al. (2020) analyze the impact of biofuel policies on Thailand's economy and find that promoting biofuels could have a positive impact by boosting production and employment in renewable energy-related sectors. Meanwhile, Wianwiwat & Asafu-Adjaye (2013) investigate the macroeconomic and sectoral implications resulting from the implementation of biofuel promotion measures outlined in the Thai government's alternative energy development plan over a 10-year period. They conclude that developing biofuels in Thailand has the potential to contribute to the country's economic advancement and enhance energy security without compromising food security.

The CGE methodology, with SAM, has also been employed to assess the impacts of fuel subsidies. In their work, Henseler & Maisonnave (2018) investigate the effect of reallocating subsidies from fossil fuels to the public transport sector in South Africa. They conclude that both subsidies they analyzed would benefit the South African economy. The reallocations made could promote and develop public transportation, preempting global oil price increases. Thus, such measures could contribute to sustainable economic growth.

In Iran, (Rahiminia et al. (2015) examine the effects of redirecting fuel subsidies. Simulated scenarios reveal stagflation resulting from economic conditions and potential inflation rate increases induced by the policy. Still in the Persian nation, AlShehabi (2012) analyzes the effects of phasing out crude oil and fuel subsidies on the labor market. It is concluded that merely redistributing additional income to households is insufficient to address the distortions created by the policy. The labor market would continue to suffer even with real GDP and household consumption increases. However, directing this income toward investments can significantly improve the labor market in the long term by increasing capital accumulation. Hence, a gradual implementation of subsidy elimination offers a smoother transition, minimizing short-term adverse effects on the labor market.

Moreover, some studies focus on tax policies related to fuels. In Brazil, Proque et al. (2022) utilize dynamic CGE methodology to evaluate the effects of fuel taxation and cross-subsidization on income distribution and consumption in the country. They develop an SAM (2010) for the Brazilian economy as a database and divide representative households by income bracket. Two scenarios are created for the model: (1) an overall cut in fuel taxes to assess its role in the economy; (2) the tax burden on gasoline and reduction in diesel tax to subsidize urban public transportation services. The research results indicate that lowering fuel prices and adopting cross-subsidies in the urban collective transport sector have the potential to produce a beneficial effect on the Brazilian economy, amplifying real GDP and mitigating income disparity.

In China, Guo et al. (2014) employ the methodology to investigate the impacts of a carbon tax on the economy and carbon emissions. Meanwhile, in a more recent study, (Shao et al., 2022) use the same methodology to understand how fuel taxes can be used as a policy tool to reduce vehicle pollution and minimize negative impacts on economic growth and industrial structure. The authors conclude that such taxation can be effective in reducing vehicular pollution. However, higher taxes on production and imports may lead Beijing to stagflation, increasing unemployment and inflation rates. Conversely, higher consumption taxes could cause an economic depression, reducing the production and consumption of goods.

The aforementioned studies comprehensively address fuel-related policies, with an emphasis on disaggregated analysis by family groups. This approach allows for comparing the diverse impacts of these policies across different income strata, as well as evaluating the economic feasibility of these measures for less privileged socioeconomic groups. The computable general equilibrium model provides a consistent framework for analyzing new fuel policies, while also offering a comprehensive description of the economy, including the incorporation of an SAM that covers both direct and indirect effects of policy changes. In this regard, our study adopts a dynamic CGE model that enables exploration of potential changes in fuel policy, analyzing resulting impacts in terms of macroeconomic, sectoral, greenhouse gas emissions, and family-related aspects.

2. The Model

The Computable General Equilibrium (CGE) model traces back to discussions about the feasibility of calculating an optimally efficient allocation of resources. Scholars in this field sought solutions for the Walrasian system of equations governing market behavior in an economy. This methodology views the economy as a complex system comprising interconnected markets, where the equilibrium of all variables must be determined concurrently (Perobelli, 2004). Essentially, it functions as a set of simultaneous equations derived from the optimizing behavior of all economic agents (Lin & Jia, 2018). Thus, it serves as a comprehensive tool for examining the overall impacts of fluctuations in fuel prices on the Brazilian economy.

The CGE model used in our study is based on the Brazilian Input-Output Matrix (IOM) of 2015, comprising 67 sectors and 127 products, utilizing 3 primary factors for production: land, capital, and labor (IBGE, 2023). Incorporates a Social Accounting Matrix (SAM), constructed from the input-output matrix and based on the double-entry accounting principle. It encompasses revenues and expenditures, allowing for the interpretation of economic flows among different institutional sectors such as firms, households, government, and the rest of the world (Fochezatto, 2011). Models with a fiscal module and payment flow provide a detailed analysis of the origin, allocation, and transfer of income among important economic agents (Cardoso, 2016; Martins, 2021). Including the fiscal module allows for simulating variations in fuel tax rates and different fiscal closures to assess economic effects.

The demand of economic agents is modeled by a system of equations, assuming they are cost minimizers and price takers (Horridge, 2000, 2003). Economic sectors are structured into a production function that relates to the composition of manufactured products, demand for intermediate inputs, and factors of production, interconnected by sectoral activity levels. Producers' demand structure is represented by Leontief and CES-type functions, as evidenced by Dixon (1982)

In the first level of the production structure, industries produce one or more goods that combine intermediate inputs (X_i) and primary factors (VA) in fixed proportions, defined by a Leontief function. At the second hierarchical level, each composite derives from a CES function. Using this function implies imperfect substitution between inputs or production factors due to their different characteristics Armington (1969), which depend on the relative prices of domestic (Dom) and imported (Imp) inputs. This applies to both production and investment. On the other hand, value added in production results from imperfect combinations of production factors: labor (L), land (L_D), physical capital (K_P), and knowledge capital (K_H). The nested structure of production at two levels is defined by Betarelli Junior et al. (2020) as:

$$Z_i = min\left(\frac{X_i}{a_i^X}, \frac{V_i}{a_i^V}\right) \quad (1)$$

The variable Z_i represents the product; the terms a_i^X and a_i^V represent the productive efficiency of each factor; X_i denotes intermediate inputs, and V_i represents value added, respectively characterized as:

$$X_i = \left[\sum_{i=1}^{s} \delta_{s,i} X_{s,i}^{-\rho^X}\right]^{\frac{-1}{\rho^X}} \forall \; s = (D, I) \quad (2)$$

such that:

$$V_i = \left[\sum_{i=1}^{f} \delta_{f,i} V_{f,i}^{-\rho^V}\right]^{\frac{-1}{\rho^V}} \forall \; f = (L_D, \mathrm{L}, K_P, K_H) \quad (3)$$

The parameter δ satisfies $\sum_{i=1}^{f} \delta_{f,i} = 1$ or $\sum_{i=1}^{s} \delta_{s,i} = 1$ and ρ represents a substitution parameter between the factors X_i and V_i in the industry. The theoretical formulation is uniform across all sectors, with variations only in substitution elasticities and input and primary factor proportions (Betarelli Junior et al., 2020).

The household demand behavior follows a nested structure, similar to investment demand, but it employs the Klein-Rubin or Stone-Geary function to consolidate commodity compounds, resulting in the Linear Expenditure System (LES) (Proque, 2019). In this system, a fixed portion of household expenditures is allocated to basic needs, while the remainder is flexible, referred to as "luxury spending," varying with income and resulting in different combinations of consumer goods. The LES function is characterized as non-homothetic, as only the quantities demanded of goods exceeding subsistence levels vary proportionally with income. The shares of spending on essential goods increase in response to income reduction and decrease when income rises (Betarelli Junior et al., 2020; Burfisher, 2021).

Moreover, our model allows for analyzing the impact of policies on CO2 emissions, an increasingly utilized approach in environmental policy assessment (Magalhães, 2013). The significance of this topic is underscored by the growing prominence of environmental issues, driven by events such as heatwaves and natural disasters. The environmental module is based on Adams, Horridge, and Parmenter's (2000) MMRF-GREEN, which converts prices or taxes derived from carbon taxation into ad-valorem rates, integrating them into the core of the model. This module calculates changes in emissions based on variables such as fuel consumption, activity levels, and household consumption (Adams et al., 2002; Magalhães, 2013). The sectoral emissions data utilized in our study originates from the Greenhouse Gas Emissions Estimates System (SEEG, 2022). A comprehensive assessment of all emission sources is conducted, including Agriculture, Energy, Land Use Change, Industrial Processes, and Waste, mirroring the detailed approach found in emissions inventories.

2.1 Closures and Simulation

The baseline scenario's closure encompasses real variations in final demand up to 2022 and extends with projections until 2040. The simulation process unfolds in two stages: initially, it replicates the reference scenario (business-as-usual) from 2016 to 2040, as detailed by Betarelli Junior et al. (2021). Starting from 2022, a GDP growth rate of 2.2% is forecasted, aligning with the projections set forth in the Federal Development Strategy for Brazil spanning 2020 to 2031 (Brasil, 2020), with a concurrent population growth rate of 0.8%. Subsequent to this phase, policy shocks are implemented in accordance with the aforementioned projections.

Between 2016 and 2018, Brazil experienced an increase in economic growth, with exports rising from 0.9% in 2016 to 4.1% in 2018, and household consumption from -3.8% to 2.4% in the same period, along with an increase in investment, from -12.1% in 2016 to 5.2% in 2018 (IBGE, 2023). Although macroeconomic data show a slight improvement from 2017 onwards, the COVID-19 pandemic in 2020 resulted in a negative variation, as predicted by the government, with a potential reduction of 5%. Government extraordinary expenditures increased due to the pandemic, surpassing previous forecasts.

The underlying premise is based on macroeconomic stability, ensured by the balance of trade relative to GDP and the influence of income on household expenditures. The scenario considers the end of the spending ceiling and the implementation of PLP 93/2023, known as the New Fiscal Framework, which manages the primary surplus with a margin of 0.25 percentage points. Article 9 of PLP establishes that from 2024 to 2027, real expenditure growth is limited to 70% of the real revenue variation, with expenditure increases ranging from 0.6% to 2.5% per year, even if revenue increases by 4% or more. Simulating changes in fuel prices is also expected to affect government revenue. To address this issue, we adopt the balanced budget hypothesis. The adoption of this hypothesis implies that government demand is determined by tax revenue. Additionally, we use the exchange rate as our numeraire.

Therefore, in order to simulate the end of the International Price Parity (IPP) policy in 2023, we incorporated the domestic consumer price variable endogenously, replacing the exogenous variable that reflects the effect of domestic tax transfers. This adjustment was implemented to prevent inconsistencies in the model, given that the modification had a direct impact on retail fuel prices. Consequently, the resulting fluctuation was integrated into the model through a direct shock to the domestic price variable. This modification had an immediate effect, leading to a reduction of 12.8% in the average selling price of Diesel (BRL 0.44 per liter) and 12.6% in Gasoline (BRL 0.40 per liter). These reductions were reported solely by Petrobras in 2023 and will be analyzed until 2040. In summary, the shock will be applied to the price variable for both fuels in accordance with the aforementioned reductions.

3. Results

Our study analyzes the impact of ending the IPP policy on the Brazilian economy. The results are in terms of the accumulated deviations (%) caused by the policy of reducing gasoline and diesel prices on aggregate macroeconomic variables. This direct reduction in consumption costs and final demand in the economy would lead to a decrease in fuel costs, spreading systematically through economic channels and promoting a generalized reduction in internal costs and prices, known as the price effect. The overall price reduction would boost demand in various markets, increasing real income for families and the competitiveness of domestic products, both domestically and internationally. This would result in higher production, raising remuneration for primary factors and generating additional revenue for the public budget, which could offset part of the decline in tax revenue, reducing the need for government spending adjustments to maintain budget balance.

According to Table 1, the implicit GDP deflator, which reflects internal costs and prices, would decrease compared to the baseline scenario of the Brazilian economy by 2040 (business-as-usual). However, in the year the policy ends, 2023, the market price drop was consistent with shock values in the simulation. This resulted in a more intense transmission of fuel price reduction in economic transactions, amplifying the activity effect with increased production and remuneration for primary factors. If the activity effect outweighs the price effect, the GDP deflator will have a positive deviation from the baseline scenario. In the short term, we observe this effect; however, in the long term, the deflator would show a negative trend, suggesting an increase in competitiveness of domestic products.

The policy would promote a gradual increase in GDP, with an accumulated addition of about 0.64% by 2040 compared to the baseline scenario. As observed in Graph 1, the GDP growth would be driven primarily by capital, followed by labor from an income perspective. In the short term, the impact of capital would be limited but would increase after 2030 due to rising investments between 2023 and 2025. From the expenditure perspective, changes in GDP would be primarily driven by household consumption and investment, while initially, negative variations are related to a trade deficit. Thus, it is noted that the outcome on household consumption would be positive for all years of the policy. By 2040, household consumption would show a positive variation of 0.84% compared to the baseline scenario.

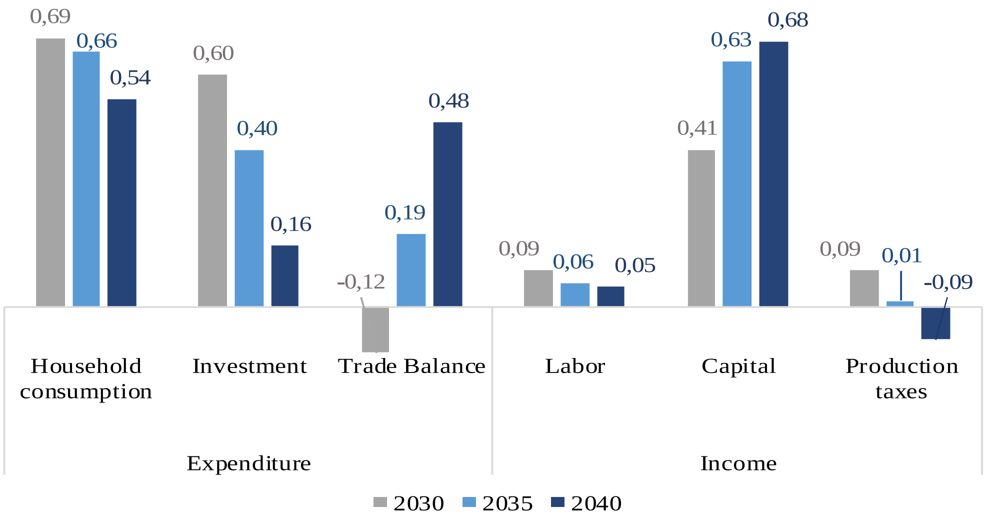
Table 1 – Effects of policy on the main macroeconomic variables (Baseline = 2023)

Variables	Unit	2030	2035	2040
GDP	Var.%	0,55	0,67	0,64
Investment	Var.%	2,83	1,88	0,53
Household consumption	Var.%	1,14	1,07	0,84
Household utility	Var.%	2,31	2,11	1,64
Aggregate employment	Var.%	0,13	-0,01	-0,08
Real wages	Var.%	1,24	1,38	1,18
Capital stock	Var.%	0,77	1,25	1,34
Total government income	Var.%	-0,12	-1,59	-2,41
Total government expenditure	Var.%	-0,50	-1,92	-0,76
Government tax revenue	Var.%	-1,37	-2,71	-3,46
GDP deflator	Var.%	0,33	-1,32	-2,12
Terms of trade	Var.%	0,14	-0,90	-1,44
Exports	Var.%	-0,17	0,95	1,56
Imports	Var.%	1,25	0,75	0,40
Balance of trade	Var.%	-1,42	0,20	1,17
Total taxes	Var. R$ Bi.	-15,23	-25,77	-28,81

Source: Survey results.
Note: *accumulated % deviation from the base scenario.

The reduction in domestic fuel prices would boost Brazilian exports due to increased competitiveness in the global market. This would result in a surplus in the trade balance by 2040, with a 1.17% increase compared to the counterfactual scenario. Furthermore, the activity effect could be observed in the labor market, where policies would stimulate employment above the trend level. This is because, as the capital stock lags behind current investments by one-year, economic activity expansion primarily occurs through additional hiring in the year of policy implementation. Demand expansion induces increases in nominal wages in the economy, leading to higher production costs.

Graph 1 – Effects of policy on GDP



Source: Survey results.
Note: *accumulated % deviation from the base scenario.

However, the increase in employment in the initial period influences wages at a later stage. In the trajectories of real wages, expansions indicate an increase in labor costs per unit produced, discouraging demand for labor in subsequent years. Nonetheless, negative deviations in real wages would again stimulate employment. In the long term, the activity effect is partially offset by increases in real wages. This is because workers have more bargaining power when labor demand is high. The rise in real wages, in turn, increases production costs, which can lead to reduced labor demand. Thus, there is an explicit lagged adjustment mechanism in the labor market, where there is a negative relationship between employment and real wages, resulting in the convergence of current national employment to the trend (Proque, 2019). We can observe that the policy instrument would have a positive impact on real wages with a variation of 1.18% compared to the reference wage, while employment would decrease by 0.08% in 2040.

Investments, on the other hand, would experience a higher growth rate in the short term (2.83% by 2030) due to increased capital supply, while capital stock growth would only be observed in the long term. However, government tax revenue would decrease by 2040 due to reduced fuel prices and consequently, the tax base. By 2030, there would be a reduction of BRL 15.23 billion in total revenue, while by 2040, this loss would widen to BRL 28.81 billion. This reduction in revenue would lead to a decrease in public spending, affecting long-term economic activity.

Moreover, the end of the IPP policy would bring about changes in economic sectors. Table 2 shows how production and employment are impacted in eight major sectors, with details for the fifteen products with the largest production variations. The simulation suggests a positive impact on the agricultural sector, as the reduction in fuel prices would lower production costs, making agricultural products more competitive in the international market. This could boost exports of agricultural products, which represent about 15% of Brazilian exports. Production in the food sector would increase by 1.08% by 2040, while the extractive industry, especially in oil and natural gas, would see growth of 2.20% compared to the reference scenario. The capital goods sector, including extraction machines, would also experience growth, notably with a 1.74% increase by 2040.

On the other hand, the reduction in fuel prices would directly impact the intermediate goods sector, resulting in increased production of these goods. By 2040, gasoline would show a variation of 5.34%, while diesel would increase by 1.50%. However, the services sector would have lower production growth, with a variation of just 0.39%, being the only one with a negative impact on employment. Additionally, transport sectors would be positively impacted, with three long-term favored sectors: collective road transport (positive variation of 2.17%), metro-rail transport (2.16%), and pipeline transport (1.69%).

Table 2 – Sectoral effects of the policy instrument (Baseline = 2023)

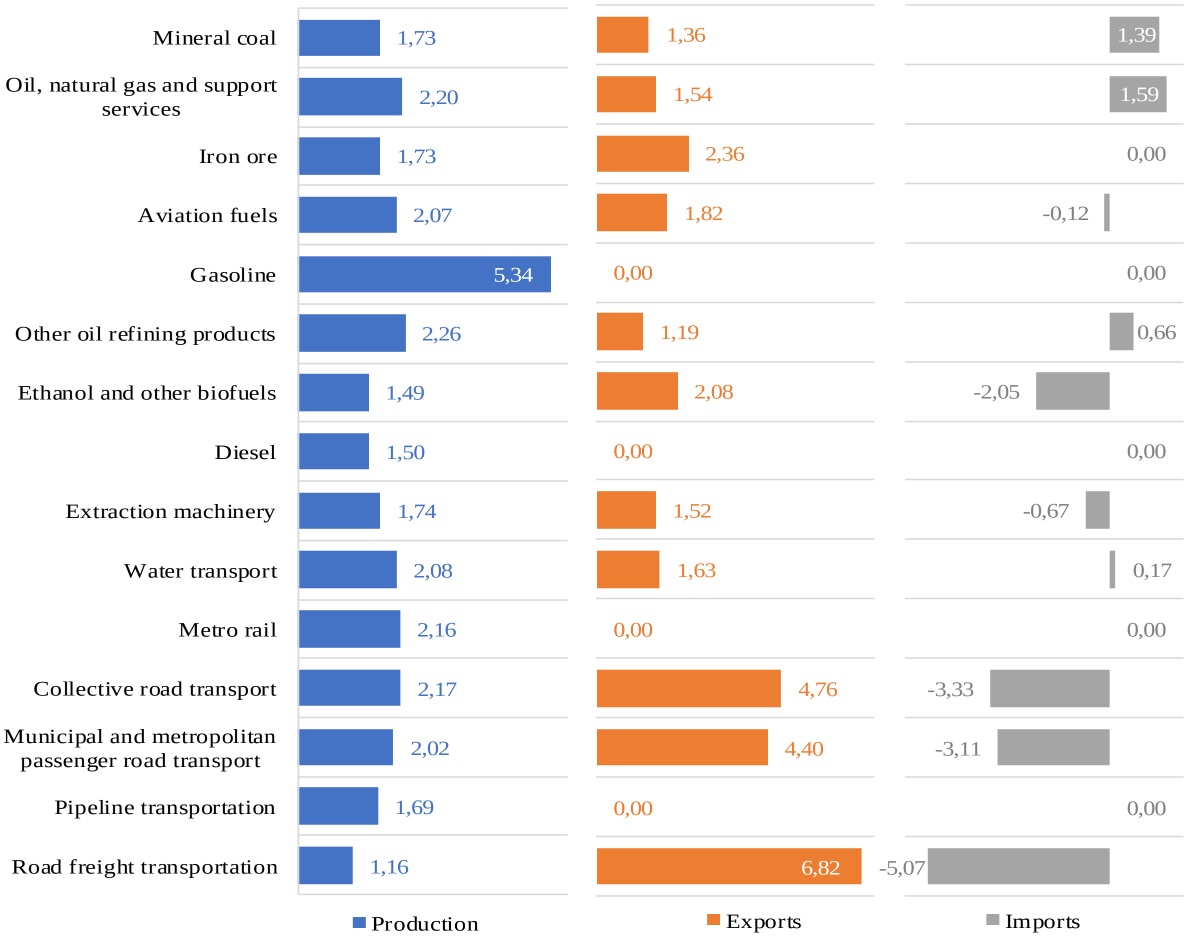
Sectors	2030	2035	2040
Production			
Agriculture	0,36	0,97	1,31
Extractive industry	0,84	1,54	1,98
Oil, natural gas and support services	1,98	2,22	2,20
Mineral coal	1,08	1,65	1,80
Iron ore	0,71	1,40	1,73
Foodstuffs	0,56	0,93	1,08
Consumer goods	0,54	0,70	0,65
Durable consumer goods	1,48	1,13	0,59
Intermediate goods	1,19	1,54	1,61
Gasoline[4]	5,52	5,55	5,34
Other oil refining products	1,99	2,30	2,26
Aviation fuels	1,42	1,97	2,07
Diesel	1,22	1,46	1,50
Ethanol and other biofuels	1,44	1,55	1,49
Capital goods	1,10	1,37	1,33
Extraction machinery	2,09	2,13	1,74
Services	0,47	0,51	0,39
Water transport	0,84	1,62	2,08
Metro rail	2,06	2,20	2,16
Collective road transport	2,09	2,22	2,17
Munic and metropolitan passenger road transport	1,96	2,08	2,02
Pipeline transportation	1,23	1,55	1,69
Road freight transportation	0,96	1,16	1,16
Employment			
Agriculture	0,55	1,04	1,35
Extractive industry	0,94	1,43	1,49
Foodstuffs	0,60	0,79	0,89
Consumer goods	0,59	0,54	0,44
Durable consumer goods	1,52	1,05	0,51
Intermediate goods	1,18	1,15	1,07
Capital goods	1,23	1,38	1,23
Services	-0,09	-0,30	-0,40

Source: Survey results.

Graph 2 presents the cumulative variations of the policy on production, export, and import. Overall, we can conclude that the policy of reducing fuel demand prices has contributed to the industrialization process of the Brazilian economy, diversifying the export agenda by increasing the share of manufactured goods and mitigating the trend towards primary production and specialization in the short term, a concern that has been recurrent in the debate on the country's productive structure in the last 10 years. For instance, this diagnosis had already been made by the Greater Brazil Plan 2011-2014 (GBP), which foresaw the implementation of export tax breaks to counteract the increase in imports and the decline in competitiveness of the industrial sector, whose context indicated deindustrialization of the economy.

[4] Gasoline refers to the standardized blend of pure gasoline and anhydrous ethanol, according to the regulatory standards established in Brazil to meet vehicle performance and environmental requirements.

Graph 2 – Cumulative impacts on sector indicators in 2040 (Baseline = 2023)



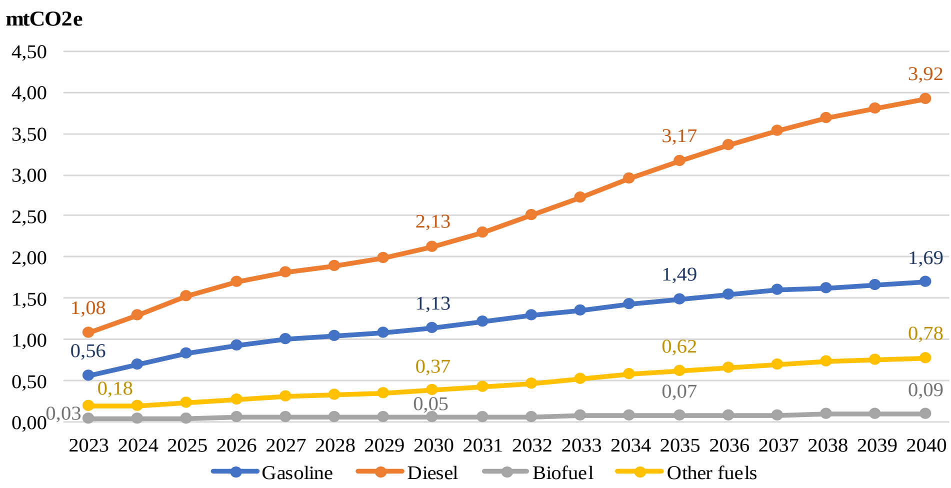
Source: Survey results.
Note: *accumulated % deviation from the base scenario.

The industrial sector in the country is strategic for several reasons. Firstly, its higher capital intensity allows for greater potential for production gains due to the absorption of technology incorporated into new machinery and equipment. Secondly, industrial activities are seen as a key source of innovations for the productivity of other sectors, despite the growth of certain services as sources of innovation. Finally, this type of sector is traditionally perceived as a source of higher-quality jobs with lower turnover, which enables the development of specific human capital with a positive impact on productivity (Messa, 2015).

On the other hand, the increase in production and demand for fossil fuels, given the end of the IPP policy, would result in significant increases in emissions of the three main fuels: other fuels – aviation fuel and fuel oil – (2.461%), biofuel (1.701%) and diesel (1.501%). The incentive to fossil fuels led to higher emissions, with diesel being responsible for 3.92 Million Tonnes of CO2 Equivalent (mtCO2e), followed by gasoline (1.69 mtCO2e) and other fuels[5] (0.78 mtCO2). Therefore, the policy would not be able to reduce emissions, mainly due to the increase in demand for gasoline and diesel. It is important to note that the emissions analyzed in this section are only from use, i.e., the burning of fuels by demand. However, in summary, the incentive to fuels resulted in an increase in Greenhouse Gas Emissions (GGE) due to increased demand.

[5] Other fuels represent the sum of emissions from aviation fuels and fuel oil.

Graph 3 – Variations in GGE emissions by type of fuel burned



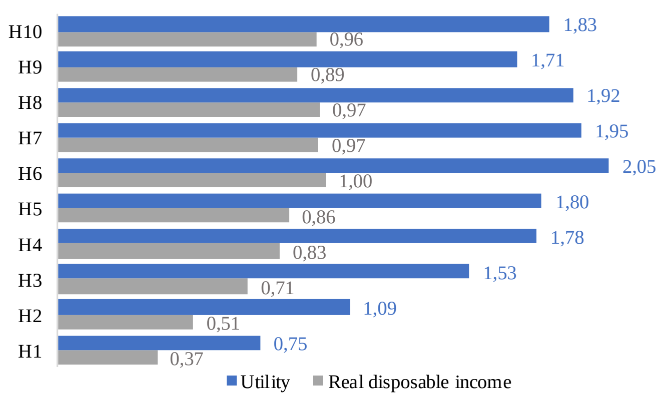
Source: Survey results.

Note: *accumulated % deviation from the base scenario.

Finally, the end of the International Price Parity policy would have effects on typical families in the Brazilian economy. Graph 4 illustrates the aggregate effects on real income for families, revealing real gains across all income range and the utility of families. It is expected that wealthier families would tend to use more fuel for private transport, while poorer ones rely more on public transportation, which primarily consumes diesel and biofuels. However, a decrease in diesel prices also raises the cost of food as the machinery used for production, as well as the transport of these inputs, is directly dependent on diesel. Thus, when there is an increase in fuel prices, this cost is passed on to the population.

However, the policy instrument would lead to an increase of 2.73% in the real income of less privileged families by the year 2030, and 1.58% by 2040. On the other hand, families representing the middle and upper classes (H4-H10) would benefit the most from the IPP. This can be explained by the fact that they are the main owners of cars and trucks, which typically consume more gasoline and diesel for private transportation. In 2030, middle-income families would see a real income increase of 4.96%, and 3.65% by 2040. Higher-income families, on the other hand, would experience a 3.51% increase in real income by 2030 and 2.83% by 2040. From this perspective, it can be inferred that the policy in question will not lead to an improvement in income deconcentration, as it is mainly middle-class families that receive the greatest benefits.

Graph 4 – Cumulative impacts on real household income and utility (2040)



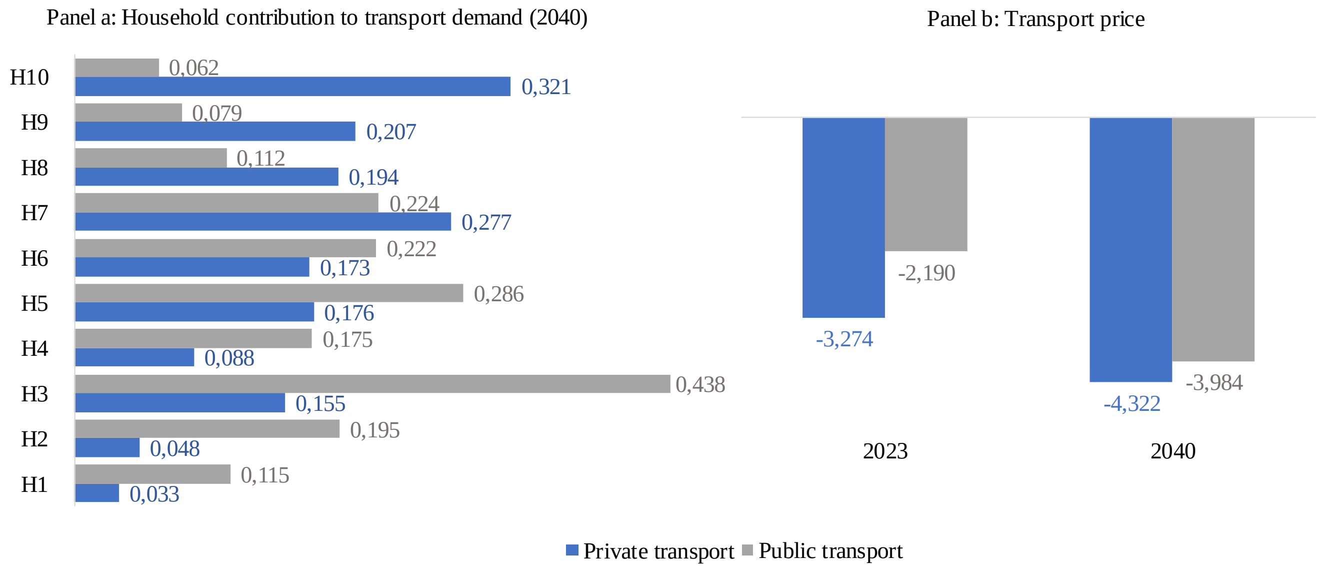
Source: Survey results.

Note: *accumulated % deviation from the base scenario.

According to the Linear Expenditure System (LES) specification, expanding the consumption set increases the level of utility[6] for families, so changes in fuel prices associated with the policy would enhance the well-being of all family groups. Utility would be higher in 2030 with a variation of 2.31% compared to the reference scenario and would remain positive until 2040 (1.64%). In other words, the policy of reducing gasoline and diesel prices would produce a gain in well-being for the Brazilian economy. It is noted that families with incomes from H6 to H10 would have significant gains in utility and real disposable income, with an average increase of about 2% by 2040. Conversely, lower-income families (H1-H3) would experience the smallest increase in well-being.

These changes in family incomes can disproportionately affect transportation demand, especially due to endogenous effects controlled by the LES specification. We can observe that the demand for both public and private transportation per family would increase compared to the reference scenario due to the end of the IPP, which directly influences gasoline and diesel prices. However, even with the increased demand for private transportation, low and middle-income families show a relative increase in demand for public transportation. Panel a of Figure 1 shows that middle-low-income families (H3, H5, H7, H4) contributed more to the growth in demand for public transportation, while wealthier families (H10, H7, H9, H8) were primarily responsible for the increase in demand for private transportation.

Figure 1 – Effect of policy on transport



Source: Survey results.
Note: *accumulated % deviation from the base scenario.

Panel b of Figure 1 demonstrates the projections of average prices reduction in both public and private transportation due to the analyzed policy. The simulation indicates a significant decrease in public transportation prices, with a negative variation of 4% by 2040. Between 2023 and 2040, there would be a decreasing trend in public transportation prices. Making public transportation even more attractive in the long run. However, the policy would result in a more pronounced and persistent reduction in private transportation prices compared to public transportation. In summary, the end of

[6] Traditionally, there are two ways to analyze welfare in CGE models: equivalent variation or changes in household utility. Equivalent variation is calculated based on changes in nominal variables in monetary terms, which depends on the price and quantity trajectories. This poses a problem in a recursive dynamic CGE model like ours. Operationally, we would have to construct a comparative static exercise within a dynamic model. To avoid errors in calculating the welfare effect, we chose to use the utility variable as a reference for welfare effects on households (Betarelli et al., 2021).

the policy would stimulate demand for both modes of transportation due to the decrease in prices in the family consumption set.

5. Conclusion and policy implications

Our study aimed to provide insights into the short, medium, and long-term effects of certain fuel price change policies on the Brazilian economy. There is limited emphasis in the ongoing debate or little academic exploration on how these policies impact the economy considering the transmissions of effects through established production and demand channels in the productive system, as well as the interactions among a country's economic institutions. Price adjustment policy instruments in fuels impact relative price structures, production operations—especially in fuel-intensive sectors—typical family consumption sets across income strata, and the income and payment flow among economic institutions (i.e., companies, households, and the public sector). However, despite altering production scale, demand, income, and payments, fuel price changes affect carbon dioxide (CO_2) emissions volume, derived both directly and indirectly from fuel combustion and sectoral activity levels. There's an expectation that certain fuel price change policies in Brazil may favor economic growth and international trade but may also negatively impact public budget revenues, generating redistributive and income concentration effects while increasing CO_2 emissions into the atmosphere. The benefits of such policies must be weighed against their costs.

Projections of these economic effects can aid in discussions of current and future fuel price change policies, whether stemming from tax rate adjustments or indirect changes in the tax base. This study, unique in its approach, aimed to fill this critical gap in fuel price policy discussions by projecting economic effects up to 2040. To address this research focus, we evaluated the International Price Parity (IPP) policy, ending in 2023, which directly impacts gasoline and diesel prices. Recent policies in the country have reduced market prices for certain fuels. Our analysis of the fuel sector underscores Brazil's economic dependence on these resources. Thus, our article stands out by addressing recent debates on fuel policies, which continue to have repercussions in the economy, while also examining changes in CO_2 emissions resulting from these measures, contributing to the understanding of sectoral policies' interactions and economic ramifications.

To be able to answer the research problem, we used a Dynamic Recursive Computable General Equilibrium (DRE) model, which incorporates a tax module derived from a Social Accounting Matrix (SAM) and a CO_2 emissions module into its theoretical framework. This approach makes it possible to analyze the effects of current taxes and make future projections, thus offering a robust and comprehensive methodological framework for analyzing the economic and sectoral impacts of fuel policies.

The findings reveal that the end of the policy would have significant effects on various macroeconomic variables. Firstly, the direct decrease in fuel prices would lead to a reduction in consumption costs and final demand in the economy, spreading systematically through economic channels and promoting a generalized reduction in internal costs and prices. This would have a positive impact on increasing demand in several markets, boosting production, primary factor remuneration, and competitiveness of domestic products, both in the domestic and external markets.

Additionally, the policy would have positive impacts on the industrial sector, driving production in various segments such as agriculture, food, extractive industries, and capital goods, while the service sector would show distinct variations in production and employment. In the short and long term, an increase in real income and utility of families could be observed. Especially for those in the middle and upper classes, who are the main owners of cars and pickups, consuming more gasoline and diesel for private transportation. However, it is safe to say that the end of the policy would not result in income deconcentration in the country. Furthermore, it is important to highlight that the increase in production and demand for fossil fuels would lead to a significant increase in greenhouse gas emissions, posing a challenge to environmental and sustainability policies.

In summary, the connection between fuel prices, production costs, aggregate demand, and product competitiveness offers insights for discussing policies aimed at boosting specific sectors of the economy and fostering sustainable growth. However, these policies must align not only with economic goals but also with environmental and climate concerns. The rise in fuel demand due to lower prices can harm the environment, necessitating a cautious and balanced approach that prioritizes sustainability. Additionally, targeted industrial policies like tax incentives, research and development investments, and improved access to global markets are pivotal in bolstering key economic sectors. These dynamics also prompt pertinent discussions on fairness and income distribution, influencing the shaping of social policies such as benefit programs and public service access. Thus, it's important to not just evaluate immediate impacts but also consider the long-term effects on economic sectors and the welfare of Brazilian families. A comprehensive analysis forms the basis for making political and strategic decisions that foster sustainable and equitable economic development.

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