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ROBERTO AMARAL DE CASTRO PRADO SANTOS

NATURAL GAS VEHICLES IN BRAZIL: CONSEQUENCES TO FUEL MARKETS

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Dissertação apresentada à Escola de Economia de São Paulo da Fundação Getúlio Vargas como requisito para obtenção do título de Mestre em Economia de Empresas

Campo de Conhecimento:
Microeconomia – Organização Industrial

Orientador: Prof. Dr. João Paulo Cordeiro de Noronha Pessoa
Co-orientador: Prof. Dr. Ariaster Baumgratz Chimeli

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To my grandparents Vera and Antônio de Pádua, who for a few years were unable to see my master completed.

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ABSTRACT

This Master Thesis consists of one empirical article on the field of Microeconomy.

Natural Gas Vehicles (NGVs) are very popular in many countries around the world, including Brazil. The Brazilian State of Rio de Janeiro has the largest NGV fleet of the country. Using a panel database extending for 15 years, we evaluate the impact of the NGV fleet penetration growth in Rio de Janeiro on the retailers's prices and margins of gasoline and sugarcane ethanol. By correcting for endogeneity, we are able to identify a negative impact of the former variables on the last ones. The result is generally robust to different specifications of our model and instrument, as well as to data adjustment. We also calculate that the NGV fleet growth has benefited the environment through lower pollutant emissions. Hence, the increase in the NGV fleet is benefitial to society not only through less polution, but also by lowering the prices of gasoline and ethanol, therefore benefiting its consumers.

Key-words: Empirical Microeconomy, Industrial Organization, Environmental Economics, Istrumental Variables, Fuel Markets, Natural Gas Vehicles, Rio de Janeiro.

RESUMO

Esta dissertação de mestrado consiste em um artigo empírico no campo da Microeconomia.

Veículos movido a gás natural são populares em diversos países do mundo, incluindo o Brasil. O estado brasileiro do Rio de Janeiro tem a maior frota desse tipo de veículos no Brasil. Usando 15 anos de dados em painel, nós avaliamos o impacto do crescimento da penetração dos veículos movidos a gás natural no Rio de Janeiro sobre os preços e margens da gasolina e do etanol de cana-de-açúcar nos postos de gasolina fluminenses. Ao corrigir pela endogeneidade, identificamos um impacto negativo da primeira variável nas posteriores. Tal resultado é geralmente robusto a diferentes especificações do nosso modelo e instrumento, além de a ajustes nos dados. Além disso, calculamos que o crescimento da frota de veículos movidos a gás natural foi benéfico para o meio-ambiente por meio de menores emissões de poluentes. Assim, um aumento da frota de veículos movidos a gás natural beneficiou a sociedade não apenas através de uma menor poluição, mas também por diminuir o preço da gasolina e etanol, beneficiando, consequentemente, seus consumidores.

Palavras-chaves: Microeconomia Empírica, Organização Industrial, Economia do Meio Ambiente, Variáveis Instrumentais, Mercados de Combustíveis, Veículos Movidos a Gás Natural, Rio de Janeiro.

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1 Introduction

Natural Gas Vehicles[1] (NGVs) are a popular phenomenon in many developing countries. The technology enabling automobiles to work on compressed natural gas was first introduced in Italy in the 1930s. For many years, it remained more a curiosity than a real fuelling solution. However, it was rediscovered in the 1970s and 1980s, as oil prices surged. Since then, NGV's popularity rose in many countries, specially non-developed ones. Compressed natural gas (CNG) being generally cheaper than other fuel options was probably the major reason for the mounting sucess of NGV's among drivers that use their cars intensively in spite of the lower power of CNG engines in comparison to their substitutes.

Brazil is one of the countries in which NGVs numbers grew considerably[2]. In the beginning of the 2000s they rose in popularity, becoming ubiquitous among constant drivers in large cities. The growth of the NGV fleet has had some major consequences to both vehicles and fuel markets, as well as to the environment. In this work, we study whether the growth of the NGV fleet has had an impact on the price and retailer's margin of the two other popular fuels for touring vehicles: gasoline and sugarcane ethanol.

In principle, owners of vehicles running on natural gas will demand less ethanol, or gasoline, as compressed natural gas is a cheaper fuel[3]. Hence, there will be a demand shift as car drivers change to vehicles running on CNG from automobiles running on other fuels[4].

Our analysis makes use of a detailed panel database of fuel prices by station and fleet size by fuel type considering a sample of municipalities of the Rio de Janeiro state in Brazil. We also employ an instrumental variable strategy in order to deal with the potential simultaneity arising from the impact of gasoline and ethanol prices on the incentive to convert one's vehicle to run on CNG[5].

Our results show that an increase of 1 p.p. in the NGV fleet decreased gas prices and margins by approximately 2 and 1,5 Brazilian cents, respectively. An increase of the same magnitude in the NGV fleet had an estimated negative impact on ethanol prices and margins of approximately 1 and 3 Brazilian cents, respectively. The results are robust to different specifications, but are not robust to First-Difference estimation and are partially robust to sccrapping adjustment of the fleets by fuel type[6].

We also briefly explore some environmental consequences of the NGV fleet growth. Car

[1] Vehicles that can run on compressed natural gas.

[2] Actually, NGVs are particularly popular among Brazilian drivers in certain states of its Southeastern region, namely: Rio de Janeiro, São Paulo and Minas Gerais.

[3] Both in absolute terms and when comparing the price of fuels given their energetic content.

[4] It should be noted that, with rare exceptions, NGVs are gasoline, ethanol or flex fuel vehicles converted to run on both natural gas and their original fuel.

[5] Whenever the price of gasoline or ethanol is higher one would expect the incentives to pay for the conversion costs to rise.

[6] For this robustness checks we make some strong assumptions regarding the depreciation rate of vehicles. These assumptions are detailed in Section5.1.

owners converting their vehicles to run on CNG expect to benefit from lower fuel expenditures. Nevertheless, as CNG is usually considered a cleaner fuel (in terms of pollutant emissions[7]) than gasoline, NGV owners may be generating a positive externality[8]. Under some simplifying assumptions we calculate that the growth of the NGV fleet in the state of Rio de Janeiro was beneficial to the environment. Hence, we contribute to the current literature by describing two channels through which the choice of CNG as fuel may generate benefits (for a group of individuals or for the whole society): (i) the prices' decreases of both gasoline and ethanol benefiting consumers of these other fuels and (ii) the lower aggregated impacts of the automobile fleet on the environment.

Our work contributes to the existing literature by estimating causal effects of NGV adoption on fuel markets in Brazil. Although there are some works on the consequences of the flex fuel[9] fleet growth to the fuel and vehicles markets that explicitly deal with endogeneity issues, we could not find studies with a similar preocupation for the NGV phenomenon. Therefore, we further contribute by employing an instrumental variable strategy in order to deal with the endogeneity arising from the choice to convert a car to run on CNG.

Previous literature on the topic of NGV fleet and infrastructure growth and development is mostly qualitative. For example, Yeh (2007) qualitatively compares the experiences of CNG in Argentina, Brazil, China, India, Italy, New Zealand, Pakistan, and the United States. On the other hand, Flynn (2002), Janssen et al. (2006) and Collantes e Melaina (2011) focus on the development of the NGV fleet in Canada, Switzerland and Argentina, respectively. Contrastingly to the aforementioned papers, our study adopts an econometric approach. Also, instead of considering and trying to disentangle the factors causing the development of both the NGV fleet and its refuelling infrastructure, as the previous literature on NGVs does, we take the growth of the NGV fleet as a given, in order to focus on studying its effects on gasoline and ethanol retail markets.

Studies similarly exploring effects of the Brazilian fleet composition changes on fuel markets are Ferreira, Prado e Silveira (2009), Salvo e Huse (2011), Salvo e Huse (2013) and Pessoa, Rezende e Assunção (2018). All these works explore the consequences of the flex fuel fleet rise. We believe the focus on the flex fuel fleet, instead of the NGV one, on the economic literature regarding Brazil to be a consequence of this country having the largest flex-fuel fleet in the world[10]. However, it should be highlighted that this is in spite of the effects of the NGV and flex fuel fleets' growth operating through different channels.

Furthermore, prior studies for Brazil have also focused in estimating price-demand and

[7] According to MMA (2011) the CO_2 (carbon dioxide) emissions of a NGV are lower than the ones for a gasoline vehicle. For other pollutants this may not hold, as described in Section 6.

[8] Actually, they are diminishing the negative externalities generated by their decision to drive a car running on fossil fuels.

[9] Flex fuel vehicles are the ones that can run on both gasoline, ethanol or a mixture in any proportion of these two fuels.

[10] Partly thanks to the previously developed sugarcane ethanol production and distribution infrastructure.

price-income elasticities for CNG making use of yearly price and quantities data. Following this approach, Iootty, Pinto Jr. e Ebeling (2009) employ time-series data in both a static and a dynamic approximation of an Almost Ideal Demand System (LA-AIDS) to estimate elasticities for CNG and other fuels. Santos (2013) studies a similar problem by employing panel data and panel cointegration to estimate, not only price-demand and price-income elasticicites, but also cross-price elasticities for CNG, as well as for other fuels. Although Santos (2013) uses the same database as us, we are able to make use of the data in a more granular form[11], as we do not need information on quantities, which are usually available only in more aggregated form (quarterly). Also, as highlighted before, our instrumental variables strategies allows us to establish a causal link between the NGV Fleet penetration and the change in the prices/margins of gasoline and ethanol.

This paper is organized as follows: section 2 provides a brief summary of the general characteristics of NGVs and its history. Section 3 describes and analyzes the data employed. Section 4 provides an empirical model and describes our estimation strategies. Section 5 presents and discusses the main results, as well as some robustness checks. Section 6 calculates the environmental impacts of the NGV fleet growth considering its impact on the price of ethanol and gasoline. Finally, Section 7 shows our concluding remarks.

2 NGV Techonology and History

The NGVs were first introduced in Italy in the 1930s. They lacked popularity for decades until their fleet started to increase in the 1970s in Italy and, one decade later, in New Zealand. In order to run on natural gas (actually, on CNG), a vehicle should be modified. A special tank consisting of an armored cylinder is installed in the car, as well as a special fuel injection system with a control unit. Some other minor modifications are also carried on the vehicle. After the conversion to run on CNG, a car can still run on its original fuel. Actually, it is mostly recommended that these vehicles are cold started with their original fuel. Only after their engine has heated should they be run on natural gas. Although the conversion of vehicles to run on natural gas was first authorized in Brazil in 1996, it was not until the beginning of the 2000s that these vehicles became a noticeable phenomenum. In 2007, approximately, the penetration of the NGV fleet had roughly stagnated.[12]

The conversion of vehicles to run on CNG is not the only challenge in building a NGV fleet. In order to fuel automobiles with natural gas, fuel stations should have a special

[11] We have weekly data, although our time fixed effects are for months.

[12] Our database provides evidence on this for the Rio de Janeiro state. Also, though we lack the data, there is anecdotal evidence that the same happened around the same period in other Brazilian states where the growth of the NGV fleet had, until recently, been a noticeable phenomenum. Several factors may explain this dynamic, including the Bolivian-Brazilian quarrel over the nationalization of Petrobras' natural gas installations in Bolivia, the drought period that impacted Brazilian hydroeletric energy production leading to higher energy demand by natural gas thermoelectric facilities and the saturation of the NGV market.

infrastructure including a compressor[13], special fuelling pumps and a tank. The installation of these equipaments and the adaption of the fuelling station facilities is costly. If the owner of a given fuel station does not want to invest his own money in such infrastructure, he may have them financed by the station's fuel distributor. The counterpart of this deal is usually the compromise of the station to buy natural gas exclusively from the distributor that financed its natural gas facilities. On the other hand, a station not subject to this kind of agreement could, instead, buy its natural gas directly from the natural gas distribution monopolists[14]. Another important feature of natural gas offer in fuel stations is how this fuel is supplied for the station. This can be done in one of the two following ways: via piped natural gas or with tank trucks. The former option is cheaper than the later.

Although NGVs have been manufactured by some of the leading automakers[15] in Brazil during the period contemplated in our database, the overwhelming majority of the NGVs were originally sold as gasoline, ethanol or flex fuel vehicles which were later converted to also run on CNG. The conversion of a car to run on CNG can be costly[16]. Hence, it is mostly sought by constant and long distance drivers. Anecdotal evidence points out to the ubiquity of converted cars among taxi drivers and lightweight freight transporters[17].

Brazil currently[18] has the sixth largest NGV fleet in the world. However, during most of the period of our analysis Brazil had up to the third largest NGV fleet in the world. Table 1 illustrates this fact, and provides the rank of biggest NGV fleets both in 2008 and 2016. Within Brazil, São Paulo and Rio de Janeiro stand out for the size of its NGV fleets both in absolute numbers, as well as in relation to the whole fleet.

The Rio de Janeiro state has the largest NGV fleet among Brazilian states probably due to its proximity to natural gas production fields and a friendly legislation for NGVs. Contrastingly to other Brazilian states, the Rio de Janeiro state gives a 75% discount on its vehicles' property tax to cars converted to run on CNG and properly registered[19]. This subsidy has helped Rio de

[13] Note that the vehicles actually run on CNG, not natural gas (which lacks comprension).

[14] In Brazil these are publicly or privately owned firms that hold the rights to distribute natural gas as monopolists on a certain region. This makes sense from an economic standpoint as natural gas distribution is believed to be a Natural Monopoly. These firms are regulated by a government agency. In the case of the Rio de Janeiro state there are two such distribution firms: Ceg and Ceg-Rio. Both are privately owned and have acquired their distribution rights in the state privatization program of the 1990s. The regulator is named Agernesa (Regulation Agency for Energy and Sanitation of Rio de Janeiro).

[15] However, even in this case the vehicles were gasoline, ethanol or flex fuel cars converted to run on CNG. Indeed, their conversion was performed just after the assembly process, still in the automakers facilities, or in authorized conversion workshops. In both cases, the vehicles were sold only after the modifications.

[16] In 2017, it costed approximately R$ 3,500.00 to convert a four cylinders' car in the retail conversion market. For vehicles with bigger engines, the conversion price is usually above this value.

[17] During our sample period, this kind of service was mostly provided by Volkswagen Kombis, a sort of small van designed as a complement to the Volkswagen Beetle model line and sold on gasoline, ethanol and flex fuel options.

[18] Data for 2016.

[19] A conversion is only lawful when done in a officially trusted mechanical shop. After the conversion, the car owner should properly register the fuel change of its car in the Traffic Departament. This process needs to be repeated every year.

Table 1 – Rank of Largest NGV's Fleets

Rank 2016	Country	Rank 2008	% NGV Population 2008	% NGV Population 2016
1	China	7	4.16%	20.45%
2	Iran	4	10.39%	16.36%
3	India	5	6.76%	12.45%
4	Pakistan	1	20.8%	12.27%
5	Argentina	2	18.15%	9.39%
6	Brazil	3	16.51%	7.28%
7	Italy	6	6.03%	4.1%
8	Colombia	8	2.91%	2.28%
9	Thailand	9	1.33%	1.94%
10	Uzbekistan	20	0.49%	1.84%

NOTES: The table provides information on the largest NGV fleets by country in 2016 (first column). There is also the position of these countries in this very rank in 2018 (third column). The last two columns show the penetration of the NGV fleet in the shown countries for 2008 and 2016, respectively. Source: iangv.org.

Janeiro avoiding illegal conversions, as owners of such vehicles would not enjoy the lower taxes. During the period of our analysis there was also a law[20] obliging new fuel stations to offer natural gas whenever they had technological conditions to do so, and giving older stations 5 years to comply with mandatory natural gas supply[21]. In addition to this, in the final years of our dataset legislation was passed dictating that taxi drivers should run on at least one clean fuel[22].

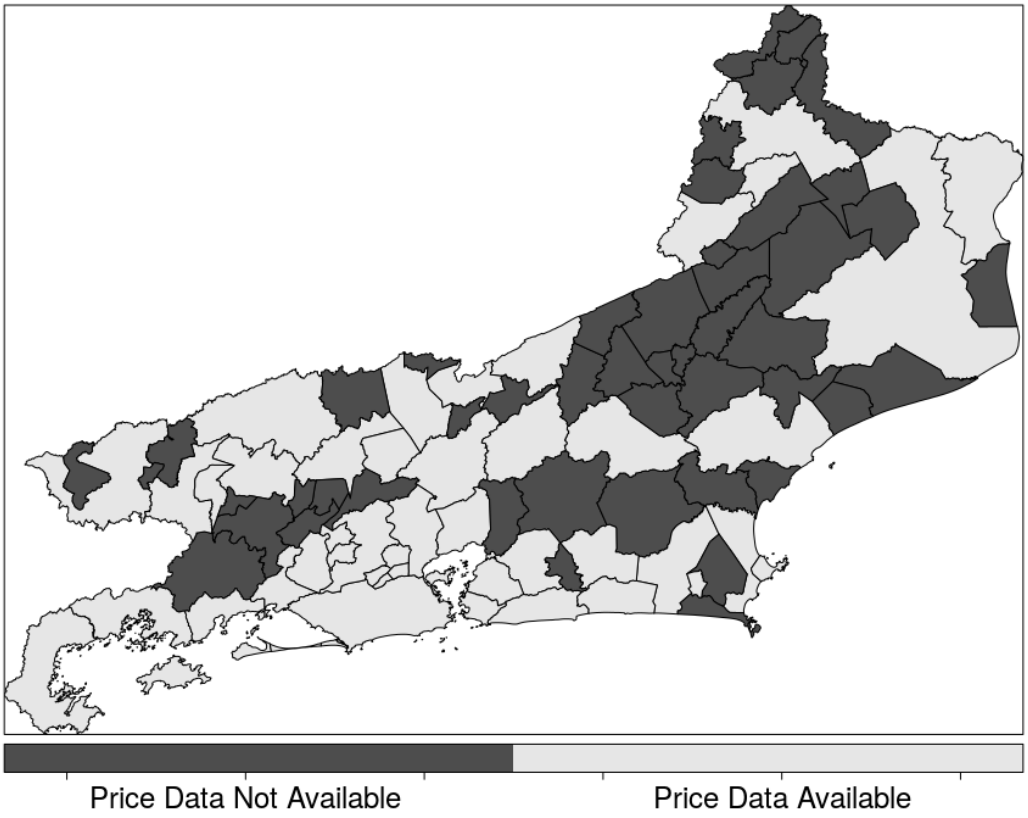
3 Data

We employ an unbalanced panel database following from the combination of different datasets. The first of them comes from the Brazilian National Oil Agency (ANP). This database has weekly acquisition[23] and retail sell prices for gasoline, sugarcane ethanol and CNG[24]. Most observations have gasoline and ethanol retail prices (609.357 and 582.283 observations out of 617.344), but gasoline and ethanol acquisition prices are far less common (385.306 and 320.588 observations out of the same 617.344). Hence, our estimations for margins will be based on a much smaller dataset than the ones for prices, even though in both cases we have a large dataset. We work with real fuel prices, obtained by adjusting the original nominal prices by the Brazilian monthly CPI[25]. The dataset covers the period from July 2001 to December 2016 for 44 out of 91 Rio de Janeiro's municipalities. It also has data on fuel station characteristics. Most importantly, it has their addresses, brands and an unique station identifier[26]. One important feature of this

[20] This law was cancelled in the final years of our database.
[21] We do not have evidence on this law being enforced.
[22] Here understood as natural gas, sugarcane ethanol or electricity. As most cars in Brazil are now flex fuel, this law was probably not binding for the great majority of drivers.
[23] The price paid by the fuel station owner.
[24] We deflate, or inflate, these prices by the monthly Brazilian CPI (IPCA) to December 2010 prices.
[25] IPCA (Índice de Preços ao Consumidor) from the Brazilian Geography and Statistics Institute (IBGE).
[26] The station identifier is called CNPJ (Cadastro Nacional da Pessoa Jurídica) and is an unique government-endorsed firm identifier.

database is that the weekly survey conducted to collect the fuel prices does not comprehend, in a given week, all the stations in the larger surveyed municipalities. Hence, each fuel station in these towns will be surveyed every few weeks[27]. Figure 1 shows the municipalities for which we have data on fuel prices[28].

Figure 1 – Municipalities in the Database



NOTES: The figure shows municipalities for which data on fuel prices is available for some (or the whole) period between January 2001 and December 2016.

Additionally, our dataset has information on the monthly size of vehicles' fleet by fuel type and municipality for the same extent as the previous dataset. This data was obtained from the Rio de Janeiro State Traffic Department (Detran-RJ) website. Furthermore, our database contains information on the existence of piped gas in each Rio de Janeiro municipality by year (2001-2016)[29] from the annual reports of Ceg and Ceg-Rio, the natural gas concessionaires of Rio de Janeiro between 2001-2016. Finally, our data on nominal GDP[30] and population by

[27] The number of weeks may depend on the size of the municipality.

[28] Prices for all the 44 municipalities are not available for the entire sample.

[29] There are some missing years. We do not have the annual reports neither for 2009, nor for 2011 and 2012. In both cases, we consider the municipalities with piped gas to be the same as the ones in the previous year. However, the municipalities offering this kind of infrastructure are the same in 2010 and 2013, while they differ in 2008 and 2010.

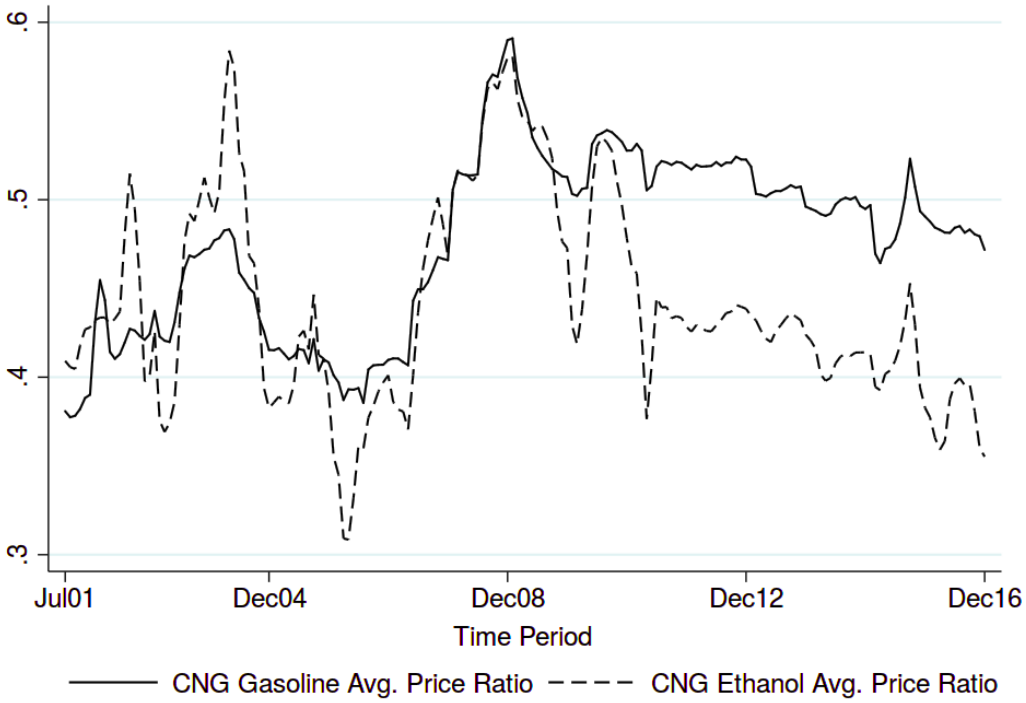
[30] We deflate, and inflate, it by the yearly national GDP deflator (from the Brazilian Geography and Statistics Institute (IBGE) in order to obtain the real GDP by municipality. This series is divided by the population series

municipality, available, respectively, for 2001-2014 and 2001-2016, comes from the Brazilian Geography and Statistics Institute (IBGE).

3.1 Descriptive Analysis

One important feature of CNG is that it is a cheaper fuel by energy unit than gasoline or sugarcane ethanol. This price differential creates an incentive for the driver of a NGV to run on CNG whenever possible. Also, the high conversion costs for a vehicle to be able to run on CNG tends to select those consumers that are most likely to fuel their cars with CNG after the conversion. Figure 2 shows the average relative price between CNG and gasoline and between CNG and ethanol at the station per energy unit throughout our sample. It is clear from the data that CNG is considerably cheaper than gasoline during our whole analysis.

Figure 2 – Fuel Relative Prices



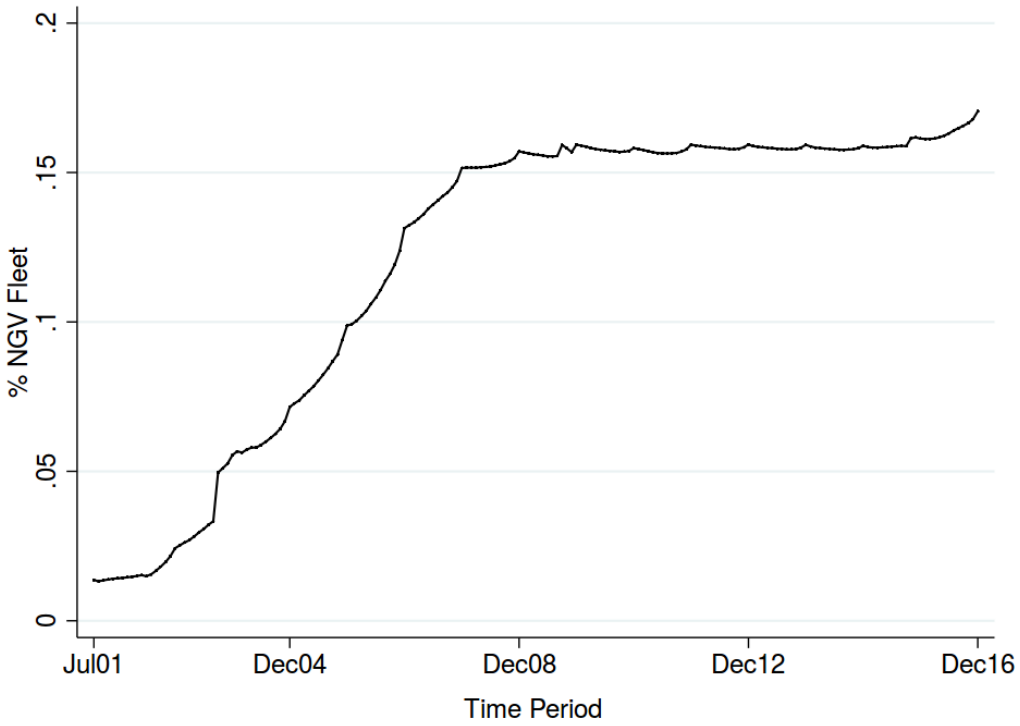
NOTES: The figure shows the price ratio of CNG and gasoline and CNG and ethanol on a monthly basis.

Our dataset can be roughly divided in two main periods: one when the penetration of the NGV fleet was growing, which lasts, roughly, from July 2001 to June 2008, and a second one, following the previous one, when the penetration of NGV was stagnant. Figure 3 illustrates this dynamic. Albeit it is not our objective to describe this trajectory in our work, we believe that the distinct trend after 2008 can be related to the Bolivian-Brazilian quarrel over the nationalization

to get the yearly municipal real GDP per capita numbers.

of Petrobras' natural gas installation in Bolivia[31,32], the drought period that impacted Brazilian Hydroeletric energy production leading to higher energy demand by natural gas thermoelectric facilities[33,34] and the saturation of the NGV market.

Figure 3 – NGV Fleet Penetration



NOTES: The figure shows penetration of the NGV Fleet in the state of Rio de Janeiro weighted by the size (in number of inhabitants) of municipalities.

The fact that our data seems to come from two heterogeneous periods is not without implications for this work, as the lack of variability for the second period makes the identification weak. This effect also holds when we consider the evolution of the NGV fleet by municipality, as most cities face nearly constant ratios between their NGV and total fleets from 2008 on. Table 2[35] shows the standard deviation for each of the cities in our database both before, and after June 2008. From it, we can see the drop in the variance of the second period, making identification for this subsample fragile. Therefore, we will focus our results on the period from January 2002 to June 2008.

[31] EFE (2007).
[32] Pamplona (2009).
[33] Filho (2007).
[34] Lima (2008).
[35] Table 15 in the appendix shows the standard deviation of the error terms in the linear regression of penetration of NGV by municipality on a municipality fixed effect. The results are similar to the ones shown in Table 2.

Table 2 – Standard Deviation of the NGV to Total Fleet Ratio

Municipality	Until June 2008	After June 2008	Municipality (continuation)	Until June 2008	After June 2008
Angra dos Reis	1.42%	0.39%	Nova Iguaçu	5.24%	0.93%
Araruama	4.3%	0.23%	Paraíba do Sul	0.92%	0.49%
Armação dos Búzios	3.08%	0.78%	Paraty	0.61%	0.22%
Barra do Piraí	4.63%	0.46%	Paty do Alferes	0.53%	-
Barra Mansa	4.83%	0.75%	Petrópolis	3.12%	0.16%
Belford Roxo	7.59%	0.33%	Queimados	6.71%	0.79%
Cabo Frio	6.33%	0.37%	Resende	5.43%	0.29%
Campos dos Goytacazes	4.77%	0.41%	Rio Bonito	4.48%	0.18%
Duque de Caxias	4.45%	0.96%	Rio de Janeiro	4.49%	0.2%
Iguaba Grande	0.19%	-	Santo Antônio de Pádua	0.22%	0.6%
Itaboraí	5.72%	1.14%	São Francisco de Itabapoana	1.17%	0.46%
Itaguaí	4.4%	1.05%	São Gonçalo	5.98%	0.65%
Itaperuna	0.37%	0.05%	São João de Meriti	5.57%	1.07%
Japeri	2.11%	-	São José de Ubá	0.09%	-
Macaé	4.1%	0.61%	Sapucaia	0.43%	0.53%
Magé	6.26%	0.28%	Saquarema	2.67%	0.38%
Mangaratiba	5.81%	1.3%	Seropédica	1.96%	-
Maricá	5.57%	0.24%	Teresópolis	1.45%	0.55%
Mesquita	4.46%	-	Três Rios	1.13%	0.5%
Nilópolis	6.85%	0.22%	Valença	2.63%	0.76%
Niterói	3.18%	0.29%	Vassouras	2.5%	0.42%
Nova Friburgo	0.85%	0.37%	Volta Redonda	6.27%	0.3%

NOTES: The table shows the standard deviation of the penetration of the NGV fleet by municipality for two periods: January 2001 to June 2008 and July 2008 to December 2016. Source: Detran-RJ.

4 Empirical Model

When a driver converts his car to run on CNG he will start demanding natural gas instead of gasoline or ethanol whenever possible. Hence, the growth of the NGV fleet may have an impact on the demanded quantities of gas and sugarcane ethanol. We try to estimate what, if any, was the impact of the NGV fleet growth on the prices of the other fuels. Our hypothesis is that, as the NGV fleet expanded, the demanded quantities of other fuels fell, resulting in a negative price adjustment of such fuels. Furthermore, we verify that fuel stations have absorbed some of these price changes in their margins[36]. This adjustment mechanism is possible in the Brazilian fuel retail market as it is not perfectly competitive[37]. For intuition, please see Section 8.1, where a theoretical model illustrating the mechanism described above is shown.

In order to test our hypothesis, we use an econometric model described, in its fully specified form, in equation 1.1.

$$Y_{smt} = \beta_1 \textit{NGV Share}_{mt} + \beta_2 X_{smt} + \epsilon_{smt} \tag{1.1}$$

Where *s* indexes the station, *m* indexes the municipality and *t* indexes the time period[38]. Y_{smt} can refer to gas prices, gas margins, ethanol prices or ethanol margins, depending on the effect considered, at a given station, month and municipality, $NGVShare_{mt}$ is the relative size of the NGV fleet to the total fleet for a given municipality and month[39], X_{smt} is a set of controls including municipality, market and fleet composition characteristics, as well as station, time and station brand fixed effects. Finally, ϵ_{smt} is an error term for a given station, time period and municipality.

4.1 Instruments

As has already been mentioned, the rise of the NGV fleet is due to CNG being a cheaper fuel than the other available options for touring vehicles in Brazil (i.e. gasoline and sugarcane ethanol). The price differential between CNG and the other fuels creates an incentive for the driver to convert her car. Therefore, when the price of gasoline or sugarcane ethanol goes up, we would expect a greater incentive for car owners to convert their automobiles making the error terms of our model correlated with our variable of interest. This raises endogeneity concerns in our estimation. To deal with this simultaneity issue, we employ an instrumental variable strategy.

[36] In our study, we consider as fuel stations' margins for a given fuel the difference between the selling price of this fuel and the price paid for it by the station.

[37] As shown, for example, in Fetter (2016) and Merenstein (2016).

[38] We consider month-year as time periods for the fixed effects. Nevertheless, our dataset is more detailed than this, as we can know the day a given observation was collected. Hence, there may be more than one price observation for a station in a given month.

[39] This is the coefficient we are interested in.

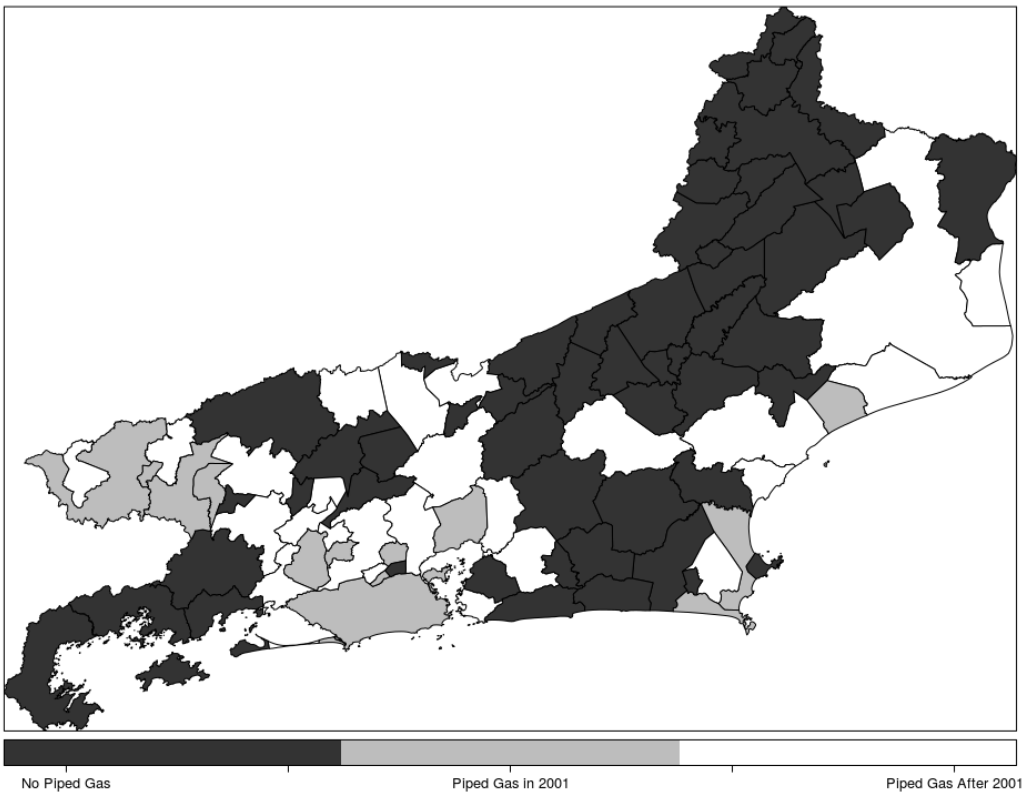
Our instrument is an interaction between two variables described in equation 1.2.

$$IV_{mt}^{NGV\,Fleet} = Fleet_t^{RJ}.I_m^{PipedGas} \tag{1.2}$$

Where $Fleet_t^{RJ}$ is the contemporaneous overall fleet of the Rio de Janeiro municipalities not included in our fuel prices database and $I_m^{PipedGas}$ is a dummy indicating if a municipality had access to piped gas in 2001. The first term captures a non-local tendency of growth for the NGV fleet. The concept behind it is that the growth of the NGV fleet in the municipalities in our database (both the ones included and not included) will only be commonly affected by a state or national tendency in the NGV growth, but not by local changes in the prices or margins of other fuels.

Figure 4 shows the municipalities with piped natural gas in 2001, the ones where this infrastructure was built between 2002 and 2016, and the ones without piped natural gas as of December 2016. The second term of the interaction acts via a cost channel. Stations in municipalities with access to piped natural gas will offer CNG supplied by this network. On the other hand, stations in municipalities without this infrastructure will face a more expensive process to obtain natural gas, as it will have to be transported to them by truck. The lower cost of natural gas in the first set of municipalities should be reflected in lower average prices of CNG and, consequently, in further incentives for the rise of the NGV fleet.

Figure 4 – Municipalities with Piped Gas Infrastructure



NOTES: The figure shows municipalities that had piped gas infrastructure in the state of Rio de Janeiro in 2001, municipalities that developed a piped gas infrastructure at some point between 2001 and 2016 and municipalities that never had access to piped gas during this period.

Our instrument is inspired in Bartik instruments[40], a kind of instrument, usually used in the international trade literature, that acts via non-local variation avoiding, therefore, endogeneities in the local components. We also employ other specifications of the instrument as robustness checks[41].

5 Results

We provide reduced form estimated impacts of the NGV fleet growth on the gasoline and ethanol prices and margins both by OLS and 2SLS. We use the instrumental variables strategy in order to deal with differential conversion incentives due to higher/lower fuel prices and margins. We use four different dependent variables: gasoline prices, gasoline margins, ethanol prices and ethanol margins. Also, we focus our results on the period from January 2002 to June 2008. Nevertheless, estimations for July 2008 to December 2016, as well as for the whole period of our sample, are available in the appendix[42].

[40] These are instruments that date back to Bartik (1991).
[41] These specifications will be detailed in the Section 5.1.
[42] Please see tables 16- 23 in Section 8.2.

Table 3 shows the results for gasoline prices as the dependent variable. The first two specifications are estimated by OLS, while the five next ones use our IV strategy[43]. Fixed effects and controls are gradually added to the specifications without significant changes to the results. Specification (1) of Table 3 is estimated by an univariate OLS with a constant. Specification (2) substitutes the constant from (1) for station and month-year fixed effects. These fixed effects have been shown to be capture essential dynamics of fuel prices and margins in Pessoa, Rezende e Assunção (2018). From specification (3) on, the coefficients are estimated using our IV strategy. Specification (3) is similar to (2) as it considers only station and month-year fixed effects. In the next specification, a brand fixed effect is added. In (5), while keeping the three aforementioned fixed effects, the percentage of ethanol and gas vehicles in the total fleet are used as controls. Specification (6) substitutes the prior controls for municipal GDP per capita, the fleet size to station ratio by municipality and the monthly number of station by municipality as controls. Finally, (7) combines the set of controls used in (5) and (6).

The result for specification (1) is not statistically significant. However, once we include our main fixed effects (month-year and station fixed effects), we get the expected negative result. In specification (3) the coefficient for the NGV fleet share remains negative and statistically significant once we deal with the endogeneity. Nevertheless, its magnitude changes, as it becomes even more negative in comparison to the estimate in (2). The results for specifications (3) - (7) are always negative and significant, even though its magnitude changes whether we control for the share of other fuel types' fleets. The result for specification (7), the one including the complete set of controls and fixed effects and estimated correcting for endogeneity, shows that an increase of 1 p.p. in the NGV fleet decreased gas prices by, approximately, 2 Brazilian cents. Also, the drop in gasoline prices for a city going from 40th to the 60th percentile of NGV fleet as percent of the total fleet in June 2008 would be, approximately, 9 Brazilian cents.

Table 4, Table 5 and Table 6 show, respectively, the results when gasoline margins, ethanol prices and ethanol margins are used as dependent variables. In all this three tables, the first two specifications are estimated by OLS, while the five next ones use our IV strategy[44]. The specifications going from (1) to (7) are the same as the ones in Table 3. The NGV fleet share coefficient estimates in the tables are analogous to the ones in Table 3: in (1) the results may not be statistically significant, but once we include the two first fixed effects the estimate becomes negative and statistically significant; employing the IV strategy does not change this fact, but, as the inclusion of certain controls, changes the magnitude of the results. From specification (7), again the one including the complete set of controls and fixed effects and estimated correcting for endogeneity, we see that an increase of 1 p.p. in the NGV fleet decreased gasoline margins, ethanol

[43] For the first stage regressions, please see table 24 in the appendix. The first stage results are also available for the whole period of our sample (January 2002 to December 2016) and for the subperiod going from July 2008 to December 2016. For these, please see tables 25 and 26

[44] For the first stage regressions, please see Tables 27- 29 in the appendix. The first stage results are also available for the whole period of our sample (January 2002 to December 2016) and for the subperiod going from July 2008 to December 2016. For these, please see Tables 30- 35

Table 3 – Gasoline Prices 2002-2008

	(1) OLS	(2) OLS	(3) 2SLS	(4) 2SLS	(5) 2SLS	(6) 2SLS	(7) 2SLS
% NGV Fleet	0.0338	-0.387***	-1.085***	-1.095***	-2.093***	-1.022***	-2.068***
	(0.36)	(-5.93)	(-8.94)	(-9.02)	(-4.62)	(-8.66)	(-4.33)
% Gas Fleet					-1.483***		-1.444**
					(-3.52)		(-3.13)
% Ethanol Fleet					-2.252***		-2.279***
					(-3.41)		(-3.58)
% Flex Fleet					-2.057***		-1.887***
					(-4.61)		(-4.04)
GDP per Capita						0.0958***	0.0362*
						(6.55)	(2.13)
Fleet/Station						0.0000137	0.00000856
						(0.77)	(0.49)
Stations City-month						0.00000220*	0.00000406*
						(2.26)	(2.52)
Observations	297522	297489	297489	297489	297489	297489	297489
Instrumentalized Fleet	No	No	Yes	Yes	Yes	Yes	Yes
Station Fixed Effect	No	Yes	Yes	Yes	Yes	Yes	Yes
Time Fixed Effect	No	Yes	Yes	Yes	Yes	Yes	Yes
Brand Fixed Effect	No	No	No	Yes	Yes	Yes	Yes
Kleibergen-Paap LM statistic			317.0	319.9	102.1	326.7	138.0
Kleibergen-Paap LM p-value			6.38e-71	1.55e-71	5.22e-24	4.94e-73	7.19e-32

NOTES: Table displays the estimated effects of shares of NGVs on gasoline retail prices. Regressions consider a station *i* located in municipality *m* in week *t* as the unit of analysis, and the sample period goes from January 2002 to June 2008. All prices are expressed in BRL real terms, deflated by the monthly Brazilian CPI (Índice de Preços ao Consumidor Amplo – IPCA). Columns 1-2 are estimated by OLS and columns 3-7 by 2SLS. Columns 2-7 include station and monthly fixed effects and columns 3-7 include station-brand fixed effects as controls. Columns 5 and 7 also include shares of gasoline, ethanol and flex fleet as controls. Finally, column 6 and 7 add yearly municipal GDP per capita (available only until 2015), the NGV fleet divided by the monthly number of stations at the municipality level, and the monthly number of stations at each municipality as controls. Instrument for the share of NGVs is the interaction between a dummy reflecting the availability of piped gas at a given municipality in 2001 and the share of the NGV fleet in the Rio de Janeiro state municipalities not included in our prices database. Standard errors are clustered by city-month. Shown in parentheses are the t-stats for the coefficients. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

prices and ethanol margins by, approximately, 1,5, 0,7 and 2,7 Brazilian cents, respectively. Also, the drop in gasoline margins, ethanol prices and ethanol margins for a city going from 40th to the 60th percentile of NGV fleet as percent of the total fleet in June 2008 would be, approximately, 6,5, 3 and 11 Brazilian cents, respectively.

Table 4 – Gasoline Margins 2002-2008

	(1) OLS	(2) OLS	(3) 2SLS	(4) 2SLS	(5) 2SLS	(6) 2SLS	(7) 2SLS
% NGV Fleet	-0.543***	-0.329***	-0.949***	-0.953***	-1.503***	-0.900***	-1.528***
	(-14.23)	(-5.42)	(-8.30)	(-8.32)	(-4.04)	(-7.84)	(-3.80)
% Gas Fleet					-1.011**		-0.990**
					(-2.97)		(-2.60)
% Ethanol Fleet					-1.875***		-2.000***
					(-3.31)		(-3.57)
% Flex Fleet					-1.610***		-1.510***
					(-4.48)		(-3.84)
GDP per Capita						0.0827***	0.0313*
						(7.55)	(2.42)
Fleet/Station						0.0000845*	0.0000700*
						(2.55)	(2.20)
Stations City-month						0.00000431***	0.00000436**
						(3.51)	(2.61)
Observations	206477	206442	206442	206442	206442	206442	206442
Instrumentalized Fleet	No	No	Yes	Yes	Yes	Yes	Yes
Station Fixed Effect	No	Yes	Yes	Yes	Yes	Yes	Yes
Time Fixed Effect	No	Yes	Yes	Yes	Yes	Yes	Yes
Brand Fixed Effect	No	No	No	Yes	Yes	Yes	Yes
Kleibergen-Paap LM statistic			303.4	306.6	111.8	341.2	149.9
Kleibergen-Paap LM p-value			6.01e-68	1.18e-68	3.94e-26	3.48e-76	1.79e-34

NOTES: Table displays the estimated effects of shares of NGVs on gasoline retail margins. Regressions consider a station *i* located in municipality *m* in week *t* as the unit of analysis, and the sample period goes from January 2002 to June 2008. All prices are expressed in BRL real terms, deflated by the monthly Brazilian CPI (Índice de Preços ao Consumidor Amplo – IPCA). Columns 1-2 are estimated by OLS and columns 3-7 by 2SLS. Columns 2-7 include station and monthly fixed effects and columns 3-7 include station-brand fixed effects as controls. Columns 5 and 7 also include shares of gasoline, ethanol and flex fleet as controls. Finally, column 6 and 7 add yearly municipal GDP per capita (available only until 2015), the NGV fleet divided by the monthly number of stations at the municipality level, and the monthly number of stations at each municipality as controls. Instrument for the share of NGVs is the interaction between a dummy reflecting the availability of piped gas at a given municipality in 2001 and the share of the NGV fleet in the Rio de Janeiro state municipalities not included in our prices database. Standard errors are clustered by city-month. Shown in parentheses are the t-stats for the coefficients. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table 5 – Ethanol Prices 2002-2008

	(1) OLS	(2) OLS	(3) 2SLS	(4) 2SLS	(5) 2SLS	(6) 2SLS	(7) 2SLS
% NGV Fleet	0.547***	-0.417***	-1.286***	-1.334***	-0.773	-1.208***	-0.782
	(3.98)	(-4.68)	(-6.17)	(-6.39)	(-1.28)	(-6.44)	(-1.22)
% Gas Fleet					0.00955		0.00958
					(0.02)		(0.02)
% Ethanol Fleet					-1.849*		-1.878*
					(-2.01)		(-2.12)
% Flex Fleet					-1.395*		-1.271*
					(-2.25)		(-1.98)
GDP per Capita						0.0486	0.0265
						(1.72)	(0.94)
Fleet/Station						0.0000348	0.0000224
						(0.86)	(0.58)
Stations City-month						0.00000971***	0.00000493
						(4.81)	(1.85)
Observations	277246	277201	277201	277201	277201	277201	277201
Instrumentalized Fleet	No	No	Yes	Yes	Yes	Yes	Yes
Station Fixed Effect	No	Yes	Yes	Yes	Yes	Yes	Yes
Time Fixed Effect	No	Yes	Yes	Yes	Yes	Yes	Yes
Brand Fixed Effect	No	No	No	Yes	Yes	Yes	Yes
Kleibergen-Paap LM statistic			332.2	335.9	109.3	343.8	145.4
Kleibergen-Paap LM p-value			3.27e-74	5.02e-75	1.42e-25	9.60e-77	1.78e-33

NOTES: Table displays the estimated effects of shares of NGVs on ethanol retail prices. Regressions consider a station *i* located in municipality *m* in week *t* as the unit of analysis, and the sample period goes from January 2002 to June 2008. All prices are expressed in BRL real terms, deflated by the monthly Brazilian CPI (Índice de Preços ao Consumidor Amplo – IPCA). Columns 1-2 are estimated by OLS and columns 3-7 by 2SLS. Columns 2-7 include station and monthly fixed effects and columns 3-7 include station-brand fixed effects as controls. Columns 5 and 7 also include shares of gasoline, ethanol and flex fleet as controls. Finally, column 6 and 7 add yearly municipal GDP per capita (available only until 2015), the NGV fleet divided by the monthly number of stations at the municipality level, and the monthly number of stations at each municipality as controls. Instrument for the share of NGVs is the interaction between a dummy reflecting the availability of piped gas at a given municipality in 2001 and the share of the NGV fleet in the Rio de Janeiro state municipalities not included in our prices database. Standard errors are clustered by city-month. Shown in parentheses are the t-stats for the coefficients. $^{*}\ p < 0.05$, $^{**}\ p < 0.01$, $^{***}\ p < 0.001$.

Table 6 – Ethanol Margins 2002-2008

	(1) OLS	(2) OLS	(3) 2SLS	(4) 2SLS	(5) 2SLS	(6) 2SLS	(7) 2SLS
% NGV Fleet	-0.697***	-0.394***	-1.179***	-1.178***	-2.554***	-1.020***	-2.662***
	(-19.17)	(-5.03)	(-6.76)	(-6.74)	(-4.57)	(-6.56)	(-4.80)
% Gas Fleet					-1.989***		-2.041***
					(-3.86)		(-3.79)
% Ethanol Fleet					-2.931***		-3.102***
					(-3.37)		(-3.92)
% Flex Fleet					-2.599***		-2.227***
					(-4.63)		(-4.04)
GDP per Capita						0.124***	0.0491*
						(6.46)	(1.99)
Fleet/Station						0.000232**	0.000215**
						(2.97)	(2.67)
Stations City-month						0.0000190***	0.0000226***
						(6.45)	(6.23)
Observations	159334	159286	159286	159286	159286	159286	159286
Instrumentalized Fleet	No	No	Yes	Yes	Yes	Yes	Yes
Station Fixed Effect	No	Yes	Yes	Yes	Yes	Yes	Yes
Time Fixed Effect	No	Yes	Yes	Yes	Yes	Yes	Yes
Brand Fixed Effect	No	No	No	Yes	Yes	Yes	Yes
Kleibergen-Paap LM statistic			301.6	305.2	110.6	329.2	144.1
Kleibergen-Paap LM p-value			1.44e-67	2.40e-68	7.27e-26	1.46e-73	3.32e-33

NOTES: Table displays the estimated effects of shares of NGVs on ethanol retail margins. Regressions consider a station *i* located in municipality *m* in week *t* as the unit of analysis, and the sample period goes from January 2002 to June 2008. All prices are expressed in BRL real terms, deflated by the monthly Brazilian CPI (Índice de Preços ao Consumidor Amplo – IPCA). Columns 1-2 are estimated by OLS and columns 3-7 by 2SLS. Columns 2-7 include station and monthly fixed effects and columns 3-7 include station-brand fixed effects as controls. Columns 5 and 7 also include shares of gasoline, ethanol and flex fleet as controls. Finally, column 6 and 7 add yearly municipal GDP per capita (available only until 2015), the NGV fleet divided by the monthly number of stations at the municipality level, and the monthly number of stations at each municipality as controls. Instrument for the share of NGVs is the interaction between a dummy reflecting the availability of piped gas at a given municipality in 2001 and the share of the NGV fleet in the Rio de Janeiro state municipalities not included in our prices database. Standard errors are clustered by city-month. Shown in parentheses are the t-stats for the coefficients. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Hence, Tables 3- 6 provide evidence on the negative impact of gasoline and ethanol prices/margins on the growth of the NGV fleet. These results are in line with the positive cross-price elasticity for gasoline and CNG as well as for ethanol and CNG estimated by Santos (2013). Furthermore, as a robustness check we provide the results when using CNG prices and margins as dependent variables. The idea is that, if the NGV fleet growth is causing gasoline and ethanol prices and margins to fall via a demand channel, it may as well be leading CNG prices and margins upward by the opposite effect. The results for these estimations are available in Section 8.6. In line with what was expected, the estimates for the NGV fleet penetration for most specifications are positive and significant[45].

[45] The two exceptions are specifications (6) and (7) for CNG margins. For more details please refer to Table 49 in Section 8.6.

5.1 Robustness Checks

We test the robustness of the results obtained in Section 5 to different specifications of our baseline model, its variables and the instruments. We try different versions of our fleet instrument, including (i) an interaction between the dummy for municipalities with a piped gas infrastructure in 2001 and the number of stations supplying natural gas in the Southeast region of Brazil excluding the Rio de Janeiro State and (ii) an interaction between the dummy for municipalities with a piped gas infrastructure in 2001 and the fleet of spatially-lagged municipalities of Rio de Janeiro[46]. Also, we estimate our model with different especifications such as one (iii) including a dummy indicating if CNG was available at the station at that period of time as a control and (iv) using Driscoll-Kraay standard errors[47], which somewhat correct for spatial autocorrelation. The results for specifications (i), (ii), (iii) and (iv) are available in the Sections 8.7, 8.8, 8.3 and 8.4, respectively.

The results are robust to (i), (ii) and (iii). However, (iv) generates mixed results, which, sometimes, are not in line with our previous results[48]. This may be due to the existence of spatial dependence in our model[49], but may as well be due to the lack of treatment of the endogeneity arising from our dependent variable and our variable of interest[50].

We also test for robustness of our results to First-Difference estimation. First-Difference (FD) can be seen in our context as an alternative to the use of Fixed Effects (FE). Hence, if we aggregate our data to month[51] we are able to first-difference with respect to station and, thus, avoid the employment of station fixed effects[52]. The results obtained from this exercise (available in Section 8.5) differ considerably from our previous results. Actually, we lose significance for almost all especifications. Our results also change when we employ FE to the same dataset. For more details, please refer to Tables 45 to 48, in which the estimates for both FD and FE in the aggregate dataset are shown. The reason why this happens is not entirely clear. Such differences

[46] In this case, in the construction of the instrument for a given municipality, we consider all Rio de Janeiro municipalities (both the ones in our fuel prices database and the ones not) that are within at least two spatial lags from this municipality.

[47] For reference please see Driscoll e Kraay (1998).

[48] The results are usually negative and statistically significant for estimates with gasoline prices and margins and ethanol margins as dependent variables. However, we lose statistical significance for most specifications once we use ethanol prices as the dependent variable. For more details please refer to Tables 41 to 44 in Section 8.4.

[49] There are more robust methods that could have been employed in order to check if our result holds or not. Nevertheless, due to the structure of our data (clustered in mainly three regions and the mountainous geography of the Rio de Janeiro city) we have not been able to employ other commonly used spatial econometric methods such as Krigging.

[50] When estimating with Driscoll-Kraay standard errors we have not been able to use our instrumental variable strategy. Actually, controlling for spatial dependency usually makes it difficult to use instruments.

[51] Remember that our database, although unbalanced, may have up to weekly observations for a given station. Hence, in order to aggregate for monthly data we have selected only the first observation for each station in a given month. Also, our database does not contain observations that are not matched by an observation by the same station in a previous or following adjacent month. This process has caused our dataset to shrink to less than half its original size.

[52] We still consider a modified version (the term resulting from differencing the observations) the other two fixed effects, namely, month-year and brand.

deserve a deeper future investigation.

Furthermore, the datasource used in this research has data on vehicles registered at least once in their lifetime, and not only on cars properly registered for the year considered[53]. This may overestimate the real number of vehicles from a certain kind in the fleet. This issue is specially acute for ethanol vehicles. These vehicles were first produced in 1979, in the wake of the Proálcool Program[54]. Their production peaked in 1986, and from 1996 onwards the number of ethanol run vehicles assembled in Brazil was negligible. In the period considered in our research, these cars were mostly old and rapidly depreciating. Hence, the fleets' figures in the Detran-RJ database may be overestimated.

Independent variables with measurement errors as the ones considered in our study leads to biased estimated coefficients. If the measurement errors are of the classic type, then our coefficients will suffer from attenuation bias. As our results in Section 5 are significant, despite the incorrect estimated impacts we are still able to provide evidence on the mechanism studied. This is true even whether our measurement errors are serially correlated. However, if the measurement error observed in our database is not of the classic type (i.e. if the measurement error is correlated to the non-observed true size of the observation)[55], then our coefficients could be both attenuated or amplified. In order to verify whether our results are robust to correction for the measurement error, we adjust our data on the size of fleets for a scrapping curve following from a Gompertz curve[56] shown in equation 1.3[57].

$$F(t) = e^{-e^{(1,798-0,137t)}} \tag{1.3}$$

Where *F(t)* refers to the correction term between 0 and 1 to be applied to a given fleet at a moment *t* in time. Using the function in equation 1.3, we can approximate the true size of the different fleets (by fuel) in a given moment. In order to correct the fleet data from Detran-RJ for scrapping (which is a kind of depreciation), we have to make some assumptions which are described below.

(i) We calculate the number of vehicles joining the fleet in each month between February 2001 and December 2016. This number is just the difference between the number of vehicles

[53] For example, if a flex vehicle was registered when sold, then it will appear in our database for the years to come, independently of it being lawfully registered again after its first year. A vehicle may be removed whether it officially changes its fuel type (for instance, a flex fuel vehicle could convert to run on CNG to become a flex-CNG vehicle) or if it is officially stated as destroyed, which may not always be a simple thing to oficialize.

[54] The Proálcool Program was a Brazilian governamental initiative lasting from 1975 to the 1990s. Its objective was to develop the production and use of ethanol as a fuel for lighweight vehicles in Brazil.

[55] The measurement error in the size of the fleet provided by Detran seem not to be of the classic type (as already discussed, all fleets' sizes will be overestimated). However, it is not clear how the measurement error will be correlated to the true non-observed values when we consider the penetration of fleets of distinct fuels.

[56] Following from MCT (2006).

[57] The values 1.798 and -0,137 in the equation are the ones provided for lightweight vehicles in MCT (2006).

in the fleet in a given month and the same value in the previous month net of vehicles converting to some other fuel category[58].

(ii) We calculate the scrapping function for the vehicles joining the fleet in a given month and apply it in order to project their future number until December 2016. For instance, whether 10 vehicles joined the flex fuel fleet in the beginning of 2005 in a given municipality, then by applying the scrapping correction term *F(t)* (following from equation 1.3) we can calculate the predicted number of lasting units of these vehicles for future months.

(iii) Vehicles already existing in January 2001, as we cannot be sure about their ages, are divided by age according to the probability given by the scrapping function. For instance, if there were 1000 vehicles running on gas on January 2001, from the scrapping function we can get the proportions between new vehicles and one year old vehicles or between new vehicles and two year old vehicles and so on and so forth. Therefore, we can predict how many of the vehicles showing in 2001 will have a given age in January 2001, allowing us to calculate the number of already existing vehicles in January 2001 in any given month in the future.

(iv) We sum the predicted number of vehicles of all ages in a given month in order to obtain the scrapping adjusted size of the fleet in a given municipality for that month.

It is important to notice that in our scrapping adjustment framework we have assumed that vehicles running on CNG were one year old when converted. This assumption follows from the fact that converting a car to run on natural gas would make the owner lose its warranty. As the warranty time in Brazil for vehicles was, for most automobile brands, one year during our sample period, we have decided to choose one year as the threshold for a car being converted to run on CNG. This implies that all NGVs were projected using the scrapping function as if they were one year old when first observed in our sample.

In order to check the robustness of our results, we estimate our model (i) when the gasoline, ethanol and flex fleet data are adjusted by the scrapping function, but not the NGV fleet; (ii) when all the four fleets (gasoline, ethanol, flex and NGV) are adjusted. The NGV fleet has the peculiarity that its vehicles should be inspected every year in order to be registered. Hence, they may be more prone to be taken out from fleet size statistics if they fail to comply with this law. We understand that it is important to estimate our model both with the adjusted and non-adjusted NGV fleets, as the original data on NGVs may not have measurement error if these vehicles are excluded from the database whenever they fail to comply with the aforementioned regulation.

[58] As the sale of brand new vehicles running on CNG was very restricted in Brazil during our sample, we can assume that all vehicles running on CNG were converted vehicles from some other fuel category. Hence, whenever the fleet of NGVs rises by a certain amount, this very number of vehicles should be subtracted from the gasoline, ethanol or flex fleets. For example, if the fleet of vehicles running on both gasoline and CNG rises by three units in a given month, them we will subtract 3 vehicles from the gasoline fleet in this very month.

Tables 7 and 8 present, respectively, the results for the regressions of gasoline prices and margins and the analogous variables for ethanol on the non adjusted NGV fleet. The first two columns (specifications (1) and (2)) of both these tables show the results for specifications in which prices are the dependent variables, while the last two columns (specifications (3) and (4)) hold the results when the dependent variables are margins. The odd and even numbered specifications correspond, respectively, to specifications (5) and (7)[59] described in Section 5. It should be noticed that when scrapping adjusted gasoline, ethanol and flex fleet, but the non-adjusted NGV fleet, are used, then the only specifications in Tables 3- 6 for which the estimates would change are the fifth and seventh ones, as the other ones do not include gasoline, ethanol and flex fleet as controls and, hence, remain the same as in Tables 3- 6. The instrument employed is the one previously defined in equation 1.2.

In its turn, Tables 9 - 12 show, respectively, the results for the regressions of gasoline prices, gasoline margins, ethanol prices and ethanol margins on the adjusted NGV fleet[60]. In this case, as our variable of interest, the NGV fleet penetration, has been modified (it is now scrapping adjusted), we show the whole set of specifications ((1) to (7)) described in Section 5. Due to the employment of the adjusted data for NGV fleet size in these tables, the instrument had to be modified to consider an adjusted analogue of the NGV fleet considered in the instrument shown in equation 1.2. Hence, the new instrument is the intersection between the availability of piped natural gas in a given municipality in 2001 and the size of the adjusted NGV fleet in Rio de Janeiro's state municipalities that were not present in our dataset. Both for Tables 7 and 8, as for Tables 9 and 12, only the scrapping adjusted version of the ethanol, gasoline and flex fleets are used as controls.

It should be highighted that the adjustment is made on strong assumptions about the fleet depreciation. Such assumptions may not be correct. From the results for the non-adjusted NGV fleet data (Tables 7 and 8), the coefficients on the percentage of the NGV fleet have, except for the estimates on gasoline prices and specification (1) of ethanol prices, lost significance.

When we consider the adjusted NGV fleet estimates little changes in relation to the previous result. In this case, we also lose significance for the especification including the adjusted ethanol, gasoline and flex fleets as controls[61]. For all the other specifications, we still get the significant negative results for the NGV fleet coefficient. Hence, if not from the strong depreciation assumptions made, the loss of significance in specifications (5) and (7) may be coming from endogeneity between price/margins independent variables and the fleets' penetration used as

[59] All these specifications have station, month-year and brand fixed effects and use gasoline, ethanol and flex fleets sizes as controls. Additionally, specifications (2) and (4) employ municipal GDP per capita, fleet size to station ratio by municipality and the monthly number of station by municipality as controls.

[60] Results for July 2008 to December 2016, for January 2002 to December 2016 and for the first stage regressions are available upon request for both the case in which the non adjusted NGV Fleet and the adjusted NGV Fleet are employed.

[61] In specifications (7) for gasoline prices and (5) for ethanol margins we get significance. However, the coefficient has the opposite sign of what would be expected.

Table 7 – Gasoline Prices and Margins 2002-2008 with Adjusted Control Fleets

	(1) 2SLS Prices	(2) 2SLS Prices	(3) 2SLS Margins	(4) 2SLS Margins
% NGV Fleet	-0.665*	-0.938**	-0.301	-0.516
	(-2.05)	(-2.98)	(-1.16)	(-1.96)
% Gas Fleet	-0.1000	-0.133*	-0.0259	-0.0495
	(-1.79)	(-2.37)	(-0.58)	(-1.03)
% Ethanol Fleet	0.632***	0.720***	0.291**	0.344**
	(5.80)	(5.97)	(3.07)	(3.13)
% Flex Fleet	-0.192**	-0.274***	-0.147**	-0.210***
	(-3.13)	(-4.34)	(-3.16)	(-4.05)
GDP per Capita		0.0138		0.0194
		(0.74)		(1.41)
Fleet/Station		-0.000163***		-0.000125**
		(-3.94)		(-3.10)
Stations City-month		-0.00000230**		-0.00000254***
		(-2.61)		(-3.64)
Observations	297489	297489	206442	206442
Kleibergen-Paap LM statistic	106.7	117.7	125.7	136.2
Kleibergen-Paap LM p-value	5.17e-25	2.05e-27	3.55e-29	1.82e-31

NOTES: Table displays the estimated effects of shares of NGVs on gasoline retail prices (second and third columns) and margins (last two columns). Regressions consider a station *i* located in municipality *m* in week *t* as the unit of analysis, and the sample period goes from January 2002 to June 2008. All prices are expressed in BRL real terms, deflated by the monthly Brazilian CPI (Índice de Preços ao Consumidor Amplo – IPCA). All columns are estimated by 2SLS and include station, monthly and station-brand fixed effects. All columns also include shares of scrapped adjusted gasoline, ethanol and flex fleet as controls, nut columns 2 and 4 add yearly municipal GDP per capita (available only until 2015), the NGV fleet divided by the monthly number of stations at the municipality level, and the monthly number of stations at each municipality as controls. Instrument for the share of NGVs is the interaction between a dummy reflecting the availability of piped gas at a given municipality in 2001 and the share of the NGV fleet in the Rio de Janeiro state municipalities not included in our prices database. Standard errors are clustered by city-month. Shown in parentheses are the t-stats for the coefficients. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table 8 – Ethanol Prices and Margins 2002-2008 with Adjusted Control Fleets

	(1) 2SLS Prices	(2) 2SLS Prices	(3) 2SLS Margins	(4) 2SLS Margins
% NGV Fleet	-1.037	-0.777	-1.188**	-0.243
	(-1.94)	(-1.60)	(-2.87)	(-0.65)
% Gas Fleet	-0.119	-0.0788	-0.183*	-0.0125
	(-1.32)	(-0.92)	(-2.46)	(-0.17)
% Ethanol Fleet	-0.00297	-0.00144	0.743***	0.421*
	(-0.02)	(-0.01)	(4.65)	(2.36)
% Flex Fleet	-0.409***	-0.350***	-0.284***	-0.00235
	(-3.76)	(-3.55)	(-3.48)	(-0.03)
GDP per Capita		-0.0215		0.0735**
		(-0.74)		(2.94)
Fleet/Station		-0.0000321		0.000167**
		(-0.73)		(2.89)
Stations City-month		0.00000443**		0.0000123***
		(2.80)		(7.35)
Observations	277201	277201	159286	159286
Kleibergen-Paap LM statistic	114.5	126.0	138.5	152.8
Kleibergen-Paap LM p-value	1.03e-26	3.07e-29	5.53e-32	4.29e-35

NOTES: Table displays the estimated effects of shares of NGVs on ethanol retail prices (second and third columns) and margins (last two columns). Regressions consider a station *i* located in municipality *m* in week *t* as the unit of analysis, and the sample period goes from January 2002 to June 2008. All prices are expressed in BRL real terms, deflated by the monthly Brazilian CPI (Índice de Preços ao Consumidor Amplo – IPCA). All columns are estimated by 2SLS and include station, monthly and station-brand fixed effects. All columns also include shares of scrapped adjusted gasoline, ethanol and flex fleet as controls, nut columns 2 and 4 add yearly municipal GDP per capita (available only until 2015), the NGV fleet divided by the monthly number of stations at the municipality level, and the monthly number of stations at each municipality as controls. Instrument for the share of NGVs is the interaction between a dummy reflecting the availability of piped gas at a given municipality in 2001 and the share of the NGV fleet in the Rio de Janeiro state municipalities not included in our prices database. Standard errors are clustered by city-month. Shown in parentheses are the t-stats for the coefficients. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

controls[62]. The results from Tables 9 to 12 are smaller, in magnitude, than the ones from Tables 3 to 6.

Nevertheless, considering adjusted ethanol, gasoline and flex fleet size data instead of the non-adjusted one brings an unexpected result. Even though we lose significance when we adjust fleets' sizes and estimate for the period January 2002 and June 2008, we get a negative significant result for all our choices of controls and dependent variables[63] if we consider the whole sample (January 2002 – December 2016). Close inspection shows that these results are coming mostly from the period extending from July 2008 to December 2016[64], in clear contrast to what has been observed in the section 5.

Table 9 – Gasoline Prices 2002-2008 with Adjusted Fleets

	(1) OLS	(2) OLS	(3) 2SLS	(4) 2SLS	(5) 2SLS	(6) 2SLS	(7) 2SLS
% NGV Fleet	0.0228	-0.0638***	-0.182***	-0.183***	0.631	-0.211***	0.988**
	(1.08)	(-5.86)	(-7.91)	(-7.93)	(1.96)	(-7.03)	(2.80)
% Gas Fleet					0.574*		0.915**
					(1.98)		(2.88)
% Ethanol Fleet					1.351**		1.810***
					(3.04)		(3.73)
% Flex Fleet					0.547		0.866*
					(1.74)		(2.53)
GDP per Capita						0.117***	0.0592***
						(6.34)	(4.35)
Fleet/Station						-0.000124**	-0.000157***
						(-3.11)	(-4.03)
Stations City-month						-0.000000905	-0.00000451***
						(-1.10)	(-4.18)
Observations	297522	297489	297489	297489	297489	297489	297489
Instrumentalized Fleet	No	No	Yes	Yes	Yes	Yes	Yes
Station Fixed Effect	No	Yes	Yes	Yes	Yes	Yes	Yes
Time Fixed Effect	No	Yes	Yes	Yes	Yes	Yes	Yes
Brand Fixed Effect	No	No	No	Yes	Yes	Yes	Yes
Kleibergen-Paap LM statistic			147.6	147.2	79.03	87.36	82.03
Kleibergen-Paap LM p-value			5.74e-34	7.23e-34	6.11e-19	9.05e-21	1.34e-19

NOTES: Table displays the estimated effects of shares of NGVs on gasoline retail prices. Regressions consider a station *i* located in municipality *m* in week *t* as the unit of analysis, and the sample period goes from January 2002 to June 2008. All prices are expressed in BRL real terms, deflated by the monthly Brazilian CPI (Índice de Preços ao Consumidor Amplo – IPCA). Columns 1-2 are estimated by OLS and columns 3-7 by 2SLS. Columns 2-7 include station and monthly fixed effects and columns 3-7 include station-brand fixed effects as controls. Columns 5 and 7 also include shares of scrapped adjusted gasoline, ethanol and flex fleet as controls. Finally, column 6 and 7 add yearly municipal GDP per capita (available only until 2015), the scrapped adjusted NGV fleet divided by the monthly number of stations at the municipality level, and the monthly number of stations at each municipality as controls. Instrument for the share of scrapped adjusted NGVs is the interaction between a dummy reflecting the availability of piped gas at a given municipality in 2001 and the share of the scrapped adjusted NGV fleet in the Rio de Janeiro state municipalities not included in our prices database. Standard errors are clustered by city-month. Shown in parentheses are the t-stats for the coefficients. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

[62] As the NGV fleet penetrations has been described to be an endogenous variable with respect to gasoline/ethanol prices/margins, one can imagine that the other fleets are also endogenous to the former variables. For instance, if the price of gasoline rises, this does not only create an incentive for consumers to drive vehicles running on CNG, but also on ethanol. It also disincentivizes the use of gasoline run cars.

[63] Tables available upon request.

[64] Tables available upon request.

Table 10 – Gasoline Margins 2002-2008 with Adjusted Fleets

	(1) OLS	(2) OLS	(3) 2SLS	(4) 2SLS	(5) 2SLS	(6) 2SLS	(7) 2SLS
% NGV Fleet	-0.0869***	-0.0492***	-0.162***	-0.164***	0.339	-0.167***	0.599
	(-9.58)	(-5.00)	(-7.09)	(-7.11)	(1.14)	(-5.37)	(1.90)
% Gas Fleet					0.327		0.577*
					(1.23)		(2.03)
% Ethanol Fleet					0.709		1.044*
					(1.67)		(2.31)
% Flex Fleet					0.239		0.476
					(0.82)		(1.54)
GDP per Capita						0.0995***	0.0435***
						(6.18)	(4.32)
Fleet/Station						-0.0000679	-0.000112**
						(-1.41)	(-2.84)
Stations City-month						-0.000000138	-0.00000347***
						(-0.18)	(-3.99)
Observations	206477	206442	206442	206442	206442	206442	206442
Instrumentalized Fleet	No	No	Yes	Yes	Yes	Yes	Yes
Station Fixed Effect	No	Yes	Yes	Yes	Yes	Yes	Yes
Time Fixed Effect	No	Yes	Yes	Yes	Yes	Yes	Yes
Brand Fixed Effect	No	No	No	Yes	Yes	Yes	Yes
Kleibergen-Paap LM statistic			128.7	127.9	71.96	103.3	77.62
Kleibergen-Paap LM p-value			7.96e-30	1.16e-29	2.20e-17	2.90e-24	1.25e-18

NOTES: Table displays the estimated effects of shares of NGVs on gasoline retail margins. Regressions consider a station *i* located in municipality *m* in week *t* as the unit of analysis, and the sample period goes from January 2002 to June 2008. All prices are expressed in BRL real terms, deflated by the monthly Brazilian CPI (Índice de Preços ao Consumidor Amplo – IPCA). Columns 1-2 are estimated by OLS and columns 3-7 by 2SLS. Columns 2-7 include station and monthly fixed effects and columns 3-7 include station-brand fixed effects as controls. Columns 5 and 7 also include shares of scrapped adjusted gasoline, ethanol and flex fleet as controls. Finally, column 6 and 7 add yearly municipal GDP per capita (available only until 2015), the scrapped adjusted NGV fleet divided by the monthly number of stations at the municipality level, and the monthly number of stations at each municipality as controls. Instrument for the share of scrapped adjusted NGVs is the interaction between a dummy reflecting the availability of piped gas at a given municipality in 2001 and the share of the scrapped adjusted NGV fleet in the Rio de Janeiro state municipalities not included in our prices database. Standard errors are clustered by city-month. Shown in parentheses are the t-stats for the coefficients. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table 11 – Ethanol Prices 2002-2008 with Adjusted Fleets

	(1) OLS	(2) OLS	(3) 2SLS	(4) 2SLS	(5) 2SLS	(6) 2SLS	(7) 2SLS
% NGV Fleet	0.118***	-0.0195	-0.206***	-0.213***	1.059	-0.160***	0.878
	(3.70)	(-1.32)	(-4.55)	(-4.67)	(1.85)	(-3.49)	(1.53)
% Gas Fleet					0.998		0.841
					(1.96)		(1.63)
% Ethanol Fleet					1.245		0.999
					(1.58)		(1.28)
% Flex Fleet					0.816		0.651
					(1.48)		(1.17)
GDP per Capita						0.0495	0.0181
						(1.47)	(0.68)
Fleet/Station						0.0000313	-0.0000274
						(0.54)	(-0.59)
Stations City-month						0.00000740***	0.00000267
						(4.93)	(1.75)
Observations	277246	277201	277201	277201	277201	277201	277201
Instrumentalized Fleet	No	No	Yes	Yes	Yes	Yes	Yes
Station Fixed Effect	No	Yes	Yes	Yes	Yes	Yes	Yes
Time Fixed Effect	No	Yes	Yes	Yes	Yes	Yes	Yes
Brand Fixed Effect	No	No	No	Yes	Yes	Yes	Yes
Kleibergen-Paap LM statistic			156.2	155.3	72.80	93.88	74.84
Kleibergen-Paap LM p-value			7.59e-36	1.19e-35	1.44e-17	3.35e-22	5.11e-18

NOTES: Table displays the estimated effects of shares of NGVs on ethanol retail prices. Regressions consider a station *i* located in municipality *m* in week *t* as the unit of analysis, and the sample period goes from January 2002 to June 2008. All prices are expressed in BRL real terms, deflated by the monthly Brazilian CPI (Índice de Preços ao Consumidor Amplo – IPCA). Columns 1-2 are estimated by OLS and columns 3-7 by 2SLS. Columns 2-7 include station and monthly fixed effects and columns 3-7 include station-brand fixed effects as controls. Columns 5 and 7 also include shares of scrapped adjusted gasoline, ethanol and flex fleet as controls. Finally, column 6 and 7 add yearly municipal GDP per capita (available only until 2015), the scrapped adjusted NGV fleet divided by the monthly number of stations at the municipality level, and the monthly number of stations at each municipality as controls. Instrument for the share of scrapped adjusted NGVs is the interaction between a dummy reflecting the availability of piped gas at a given municipality in 2001 and the share of the scrapped adjusted NGV fleet in the Rio de Janeiro state municipalities not included in our prices database. Standard errors are clustered by city-month. Shown in parentheses are the t-stats for the coefficients. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table 12 – Ethanol Margins 2002-2008 with Adjusted Fleets

	(1) OLS	(2) OLS	(3) 2SLS	(4) 2SLS	(5) 2SLS	(6) 2SLS	(7) 2SLS
% NGV Fleet	-0.138***	-0.0776***	-0.247***	-0.249***	1.483**	-0.101*	0.303
	(-17.70)	(-5.60)	(-5.81)	(-5.83)	(2.69)	(-2.38)	(0.64)
% Gas Fleet					1.337**		0.301
					(2.73)		(0.72)
% Ethanol Fleet					2.654**		0.786
					(3.27)		(1.13)
% Flex Fleet					1.378*		0.342
					(2.57)		(0.74)
GDP per Capita						0.109***	0.0859***
						(5.27)	(4.34)
Fleet/Station						0.000164*	0.000179**
						(2.56)	(3.16)
Stations City-month						0.0000123***	0.0000119***
						(8.13)	(7.14)
Observations	159334	159286	159286	159286	159286	159286	159286
Instrumentalized Fleet	No	No	Yes	Yes	Yes	Yes	Yes
Station Fixed Effect	No	Yes	Yes	Yes	Yes	Yes	Yes
Time Fixed Effect	No	Yes	Yes	Yes	Yes	Yes	Yes
Brand Fixed Effect	No	No	No	Yes	Yes	Yes	Yes
Kleibergen-Paap LM statistic			137.6	136.6	71.19	104.6	78.90
Kleibergen-Paap LM p-value			9.02e-32	1.48e-31	3.24e-17	1.48e-24	6.53e-19

NOTES: Table displays the estimated effects of shares of NGVs on ethanol retail margins. Regressions consider a station *i* located in municipality *m* in week *t* as the unit of analysis, and the sample period goes from January 2002 to June 2008. All prices are expressed in BRL real terms, deflated by the monthly Brazilian CPI (Índice de Preços ao Consumidor Amplo – IPCA). Columns 1-2 are estimated by OLS and columns 3-7 by 2SLS. Columns 2-7 include station and monthly fixed effects and columns 3-7 include station-brand fixed effects as controls. Columns 5 and 7 also include shares of scrapped adjusted gasoline, ethanol and flex fleet as controls. Finally, column 6 and 7 add yearly municipal GDP per capita (available only until 2015), the scrapped adjusted NGV fleet divided by the monthly number of stations at the municipality level, and the monthly number of stations at each municipality as controls. Instrument for the share of scrapped adjusted NGVs is the interaction between a dummy reflecting the availability of piped gas at a given municipality in 2001 and the share of the scrapped adjusted NGV fleet in the Rio de Janeiro state municipalities not included in our prices database. Standard errors are clustered by city-month. Shown in parentheses are the t-stats for the coefficients. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

6 Enviromental Consequences

CNG is commonly marketed as a cleaner fuel than gasoline. Actually, data on CO_2 (carbon dioxide) emissions for vehicles running on different kinds of fuel corroborate this notion[65]. For instance, according to MMA (2011)[66], a 2008 new vehicle converted to run on CNG emits, approximately, 167 g/km of carbon dioxide, compared to the 233 g/km of a gasoline car and 171 g/km of an ethanol[67] one of the same age[68]. Hence, the growth of NGVs may have entailed in

[65] The same cannot be said about other pollutants according to MMA (2011). For example, *CO* (carbon monoxide), CH_4 (methane), aldehydes, non-methane hydrocarbons and NO_x (nitrogen oxides) are higher per kilometer for new 2008 NGVs than for new 2008 gasoline cars. However, CNG does not emit particulate matter as gasoline does.

[66] All the pollutant emission data from MMA (2011) considers vehicles on road use.

[67] Note that this is the emission level of an engine running on ethanol. This number does not take into account the fact that sugarcane, from which Brazil's ethanol comes from, is a renewable resource and one that sequesters carbon while growing.

[68] MMA (2011) also states that a 2008 new flex fuel vehicle emits 160g/km of CO_2 when running on ethanol and 191g/km of the same pollutant when running on gasoline.

lesser emmissions of carbon dioxide, benefiting the environment.

From Section 5, we have that the growth in the NGV fleet caused the prices of ethanol and gasoline in Rio de Janeiro to fall. Although this effect has benefited the owners of cars running on the former two fuels, it has created, in this case, an incentive for further fuel consumption by drivers. This implies in longer distances travelled and, consequently, higher emissions of pollutants. Therefore, it is not clear at first sight if the rise of NGVs has proven benefitial to the environment or not.

In order to investigate this question, we calculate the pollutants' emissions jointly avoided, or jointly increased, by the two opposite effects described in the previous paragraph. On one hand, we have the emissions generated by the converted NGVs[69] and by the increased use of the gasoline and ethanol run vehicles. On the other hand, if gasoline, ethanol and flex fuel had never been converted to NGVs, we would have had greater pollutants emissions from the larger uncoverted fleets. Hence, we calculate this counterfactual avoided pollution. The difference between the increased emissions and the avoided ones provides the net pollutants' emissions effect of the NGV phenomenon in Rio de Janeiro.

In order to calculate the enviromental consequences of the NGV fleet expansion in the state of Rio de Janeiro we employ data from various sources. Our data on the circulating fleet of vehicles in Brazil comes from Guimarães e Lee (2010) and goes from 1960 to 2008. The size of the Rio de Janeiro State fleet by fuel on June 2008 was obtained in our main database. The data on the number of new vehicles manufactured by fuel type[70] by year[71] is from Anfavea[72]. From it, we can calculate the percentage of new vehicles by fuel type in each year. The data on pollutants' emissions constants[73] by fuel type[74] and year[75] and the data on the average fuel efficiency of vehicles by fuel type and year from MMA (2011). Finally, we have data on vehicle's

[69] For simplification, we assume that the NGVs are always fuelled only with CNG. This is not fully accurate, as the residual demand for ethanol and/or gasoline of converted vehicles exists, as described in Section 2.

[70] Gasoline, ethanol or flex fuel.

[71] From 1957 to 2017.

[72] Automotive Vehicles Manufacturers National Association.

[73] For instance, how many grammes per kilometer of aldehydes does an ethanol car produced in 2001 emit.

[74] The fuel types considered in this case are: gasoline, ethanol, CNG, ethanol and gasoline when used by flex fuel vehicles. It should be noted that the constants are usually for the vehicles when new, as mileage increases the emissions by a car. Hence, whenever possible, adjustment factors for mileage (as suggested in MMA (2011)) were applied to the constants for new cars. NGVs were the only kind of vehicles for which the mileage adjustments were not done in our exercise, as there was no mention about them in the literature. This may be biasing our results downwards, as NGVs have the highest average intensity of use among the different kinds of fuel types considered. Nevertheless, the emissions' constant for NGVs is probably taking into account that these vehicles were not converted when new.

[75] We have yearly data for gasoline and ethanol vehicles spanning from 1988 to 2006. For any vehicles produced before and in 1983 the constants are the same. Also, vehicles produced in (i) 1984 and 1985; (ii) 1986 and 1987 are considered to have the same constants. Finally, we have yearly constants for gasoline in 2007 and 2008 too. For flex fuel vehicles running on ethanol or gasoline yearly data is available from 2003 on.

annual mileage by fuel type[76] and age[77] from Bruni e Bales (2013)[78]. The last piece of data used are estimated price-demand elasticities for both ethanol and gasoline. In our calculations we have considered the estimated price-demand elasticities by Iootty, Pinto Jr. e Ebeling (2009)[79] as they were the greatest in absolute value (i.e. most elastic ones) in the literature[80] and, therefore, the ones leading to the most conservative calculations of pollutants emissions[81].

In order to calculate the differential pollutant emissions arising from the growth of the NGV fleet, we consider the circulating fleet size by year of production in 2008 and the distribution of vehicles by year and fuel type. Hence, we can obtain the age distribution by fuel type for the fleet stated in our main database for June 2008[82]. It should be noticed that the fleet in our main database is greater than the circulating fleet, as it may include cars once registered that are no longer circulating. Hence, our division of the fleet in Rio de Janeiro in 2008 by age is set proportionally to the distribution of vehicles by age for the Brazilian circulating fleet considering the ubiquity of a certain fuel type among the vehicles produced in a given year[83].

Using the data on intensity of use of vehicles by fuel type and age and the estimated price-demand elasticities for gasoline and ethanol from Iootty, Pinto Jr. e Ebeling (2009), we are able to calculate how the estimated gasoline and ethanol prices shifts[84] in Section 5, given the average gasoline and ethanol prices in our database for June 2008, affect the consumption of gasoline and ethanol by drivers of gasoline, ethanol and flex fuel cars. We can apply the pollutants emissions constants from MMA (2011) to these calculated incremental demands of fuels considering the fuel efficiency of a vehicle of a given fuel type and age. Finally, we multiply

[76] The fuel type cathegories are gasoline, ethanol, flex fuel, gasoline converted to run on CNG and flex fuel converted to run on CNG.

[77] For gasoline vehicles, we have estimated data for vehicles aged 0 to 48 years old (implying they were produced from 1960 to 2008). However, for ethanol run vehicles we only have data for cars produced between 1979 and 2002. Hence, for newer vehicles (those produced between 2003 and 2006) we assume the mileage to be the same as the one for cars produced in 2002. For flex fuel vehicles, as well as for NGVs previously run on gasoline or on both ethanol and gasoline (flex fuel), we have a similar situation. For flex fuel cars, we have data on vehicles produced from 2003 to 2007 (2008 cars assumed to have the same intensity of use as vehicles one year older). For NGVs that can also run only on gasoline we have data for vehicles aged 20 to 3 years old. For flex fuel vehices converted to run on CNG we have data for cars aged 5 to 2 years old. Newer NGVs of both kinds are assumed to have the same intensity of use as the last available year.

[78] The study estimates the annual mileage for vehicles of distinct fuel types from the city of São Paulo. We assume that these values are reasonable for vehicles on the Rio de Janeiro State.

[79] The elasticities used for gasoline and ethanol were, respectively, -3,848 and -3,583.

[80] The following works, besides Iootty, Pinto Jr. e Ebeling (2009), were considered for price-demand elasticities for fuels in Brazil: Schünemann (2007), Azevedo (2007), Pontes (2009), Freitas e Kaneko (2011)), Orellano, Souza e Azevedo (2013) and Santos (2013).

[81] If one considers not finding an environmental benefit the conservative result.

[82] The NGV fleet is an exception in this case, as we cannot apply the described process to estimate its circulating fleet because the manufacturing of NGVs was negligible. Hence, we use the NGV fleet size data from our main database to calculate the NGV size by year, considering that the vehicles were produced in the same year they have been converted. For simplification, we further assume that there was no NGV fleet before 2001. As we have no date on incremental emissions by NGVs from high mileage, this last assumption has lesser consequences to our calculations than one might imagine.

[83] Implicitly, this implies that we are assuming that gasoline, ethanol and flex fuel fleets will depreciate at the same rate.

[84] We take these estimated impacts from specification (7) in Tables 3 and 5, respectively.

these individual emissions by the data on fleets' sizes to obtain the values shown in Tables 13 and 14.

Table 13 shows the calculated net[85] CO_2 emmissions[86] in June 2008 in the Rio de Janeiro State, accounting for the ethanol and gasoline price effects estimated in Section 5. The four different values shown in the table represent, respectively, cases in which it is assumed that: all NGVs were originally gasoline run vehicles and all flex fuel cars are run on gasoline only, all NGVs were originally gasoline run vehicles and all flex fuel cars are run on ethanol only, all NGVs were originally flex fuel vehicles and all flex fuel cars are run on gasoline only and all NGVs were originally flex fuel vehicles and all flex fuel cars are run on ethanol only. In all the four aforementioned cases there is a decrease in carbon dioxide emissions.

Table 13 – Emissions of CO_2

(1)	(2)	(3)	(4)
-18.340.743	-18.617.242	-1.632.626	-1.909.124

NOTES: Calculated decreased emissions of CO_2 from the growth of the NGV fleet in the Rio de Janeiro State. Specification (1) assumes that all NGVs were previously gasoline run vehicles and that all flex fuel cars run solely on gasoline. Specification (2) differs from (1) by assuming that flex fuel are run only on ethanol. Specification (3) assumes that all NGVs were previously flex fuel vehicles and that all flex fuel cars run solely on gasoline. Specification (2) differs from (1) by assuming that flex fuel are run only on ethanol. All values are in tonnes.

Even though the CO_2 emissions are calculated to have decreased with the advent of NGVs, the same cannot be said about other pollutants emitted by combustion engines[87] as shown in Table 14. This follows from CNG not necessarily being "cleaner"than ethanol or gasoline regarding other pollutants, namely *CO*, CH_4, aldehydes, non-methane hydrocarbons, NO_x and particulate matter[88]. The consequences of this can be seen in Table 14. The results shown are under the assumption that NGVs were originally gasoline run vehicles and all flex fuel cars are run on gasoline only[89]. The table shows that there was an increase in the *CO*, NO_x, non-Methane

[85] The term "net" here refers to the fact that we are subtracting the emissions that would have happened, based on our assumptions, had the vehicles then running on CNG had never been converted.

[86] Values in tonnes.

[87] The engines employed in non-eletric cars are known as combustion engines after the combustion of fuel happening inside them when they are put to work.

[88] According to MMA (2011), for a new 2008 touring car the CO emissions were greater for ethanol than for CNG and greater for CNG than for gasoline, the NO_x emissions were greater for CNG than for ethanol and greater for ethanol than for gasoline, the non-methane hydrocarbons emissions were lower for CNG than for both gasoline and ethanol, the aldehydes emissions were greater for ethanol than for CNG and greater for CNG than for gasoline. Finally, the CH_4 emissions were greater for CNG than for both gasoline and ethanol. The particulate matter emissions of both ethanol and CNG were negligible.

[89] The results are similar in sign (but not necessarily in order of magnitude) for the following assumptions: all NGVs were originally gasoline run vehicles and all flex fuel cars are run on ethanol only, all NGVs were originally flex

hydrocarbons, aldehydes, CH_4 and particulate matter emissions[90], respectively.

Table 14 – Emissions of Other Pullutants

(1) CO	(2) NO_x	(3) NMHC*	(4) Aldehydes	(5) CH_4	(6) PM**
14924	4955	362	644	3848	157

* Non-Methane Hydrocarbons
** Particulate Matter
NOTES: Calculated increased emissions of various pollutants from the growth of the NGV fleet in the Rio de Janeiro State, namely: *CO* (Carbon Monoxide), NO_x (Nitrogen Oxides), NMHC (Non-Methane Hydrocarbons), Aldehydes and PM (Particulate Matter). For the calculations it is assumed that all NGVs were previously gasoline run vehicles and that all flex fuel cars run solely on gasoline. All values are in tonnes.

Carbon dioxide is surely the best known greenhouse gas, the gases responsible for the Greenhouse Effect[91] and Global Warming[92]. However, other pollutants, such as the ones shown in Table 14, have its share on these phenomena. Carbon monoxide, for instance, though not a direct agent of Global Warming, is related to the latter through the formation of methane and carbon dioxide[93]. On the other hand, methane is a Greenhouse gas whose power to trap heat in the atmosphere while lingering in it is much greater than that of carbon dioxide[94]. Even more damaging[95] than methane emissions are the N_2O (nitrous oxide) ones, a kind of nitrogen oxide.

Tables 13 and 14 show environmental impacts of the NGV fleet growth that go on opposite directions. To verify which effect, the decreased pollution from the diminished CO_2 emissions or the increased pollution from methane and nitrous oxide higher emissions, is the greatest, we calculate the aggregate impact in the environment of the NGV fleet by considering the Climate Change heterogeneous power of CO_2, CH_4 and NO_x emissions[96]. For example, a decrease of 4 tonnes of carbon dioxide does not compensate for a increase of 2 tonnes of methane, as the latter is equivalent to 50 tonnes of CO_2. In other words, if a vehicle emits 1

fuel vehicles and all flex fuel cars are run on gasoline only and all NGVs were originally flex fuel vehicles and all flex fuel cars are run on ethanol only. Results available upon request.

90 As before, the values shown are in tonnes.

91 Greenhouse Effect refers to the heating of the Earth surface above the temperature that woul be reached without the accumulated gases in its atmosphere. This effect is not necessarily an environmental issue. Actually, it happens naturally.

92 Global Warming is the heating of Earth's surface caused by men's emissions of pollutant. This phenomenon is widely regarded as a serious environmental issue.

93 Voiland (2015).

94 Actually, over a 100 years period that power is more than 25 times greater than that of CO_2 according to EPA ([ca. 2018]). Furthermore, this pollutant decays to carbon dioxide, which lasts longer in the atmosphere.

95 According to EPA ([ca. 2018]), it may be up to 298 times more damaging (in terms of Climate Change power) than the carbon dioxide emissions.

96 We assume that all NO_x emissions are N_2O ones.

tonne of methane, it is emiting 50 carbon dioxide equivalent (CO_2eq)[97]. Using this equivalency scale between pollutants, we find an aggregate environmental benefit of the NGV fleet growth for the case assumed for Table 14 results[98] corroborating the generally held view that NGVs are "good"for the environment. Nevertheless, this result follows from several strong assumptions. Therefore, it should be approached with caution.

7 Conclusion

We have found evidence that the increasing penetration of NGVs in Rio de Janeiro's automobile fleet has caused retail prices of both ethanol and gasoline to decrease. This result is robust to most specification changes and data adjustments. Furthermore, prices' decreases for these fuels can be explained, at least in part, by the reduction of fuel retail margins.

One consequence of the effect described above is that not only has the higher penetration of NGVs in the fleet benefited NGV owners (as they are consuming a cheaper fuel), but also the owners of gasoline, ethanol and flex fuel cars. From this perspective, the NGV fleet rise was a win-win phenomenon. In addition to this, the growth of the NGV fleet has also led to lower CO_2 emissions, as CNG is less pollutant than gasoline regarding this gas. Nevertheless, although NGVs emit lesser quantities of some pollutants (for instance, particulate matter or non-methane hydrocarbons) than gasoline (or ethanol), the NGV phenomenon has been calculated to be responsible for greater emissions of most pollutants other than carbon dioxide in the Rio de Janeiro State.

The consequences of the NGV fleet growth described here suggest a distributional and a welfare-improving channel through which incentives to the NGV fleet expansion may operate. In other words, we identify a pecuniary[99] and a technological externality[100] arising from the NGV fleet growth. Better comprehension of these channels, as well as better qualification of the pros and cons arising from the NGV fleet expansion, demand further research. One possible extension would be to build and structurally estimate a model of price formation taking into consideration potential environmental externalities. This would allow for a more precise welfare calculation of

[97] CO_2eq is a measure supported by the Intergovernmental Panel on Climate Change (IPCC) to quantify the global warming potential over a specified timescale of a pollutant.

[98] However, even though this conclusion holds if all NGVs are assumed to have originally been gasoline run vehicles and all flex fuel cars are assumed to have been run on ethanol only, the results change in sign when we assume that all NGVs were originally flex fuel vehicles and all flex fuel cars are run on gasoline only or that all NGVs were originally flex fuel vehicles and all flex fuel cars are run on ethanol only. Nevertheless, the increased emission resulting from the later two assumptions are small in absolute value if compared to the decreased emissions from asumming the other two assumptions. In reality, some drivers will convert gasoline cars to run on CNG while others will convert their flex fuel vehicles. Also, some owners of flex fuel vehicles will run their cars on ethanol while other will fuel them with gasoline. Furthermore, this may change over time. Hence, reality should be somewhere in between the extreme assumptions we have made. In this case, we can calculate that if the NGV fleet composition has less than 93% of its vehicles converted from flex fuel, then the NGV fleet growth has benefited the environment in terms of global warming potential of the pollutants' emissions.

[99] Externalities that have no impact in terms of efficiency.

[100] Externalities that have an impact in terms of efficiency.

the impact of the rise of NGV's in the state of Rio de Janeiro.

8 Appendices

8.1 Appendix A. Theoretical Model

Assume that there is a continuous between 0 and 1 of car owners (from here on called consumers). Each consumer owns exactly one car. We assume, without loss of generality, that this car can run on both ethanol or gas. Furthermore, assume that a station is faced with the aggregate demand $D(p, \theta) = (1 - \theta)a - p$, with $p = min\{p_e, p_g\}$, where p_e and p_g are, respectively, the prices for ethanol and gasoline in this station, θ is the share of NGVs owners among consumers of fuels and a is an exogenous demand component. The station maximizes its profit $(p - c)q$, where c is the marginal cost of the cheapest fuel between ethanol and gasoline and q is the number of liters of that fuel sold. Assume further that $p > c$.

$$\underset{p}{Max}\ [(1 - \theta)a - p](p - c) \tag{1.4}$$

Maximizing the profit of the station (equation 1.4) when $q = D(p, \theta)$, defining $\theta = \theta(p)$[101] and rearranging we get:

$$p(a\theta' + 2) = a(1 - \theta) + c(1 + a\theta') \tag{1.5}$$

From (1.5) and the Implicit Function Theorem we have that:

$$\frac{\partial p}{\partial \theta}(a\theta' + 2) + ap\frac{\partial \theta'}{\partial \theta} = -a + ac\frac{\partial \theta'}{\partial \theta} \tag{1.6}$$

We know $\theta'^{-1} \circ \theta'(p) = p$[102]. Hence, by differentiating both sides with respect to θ we get $\frac{\partial \theta'}{\partial \theta} = \frac{\partial p}{\partial \theta}\theta'$. Substituting this last term in equation 1.6 and rearranging we have:

$$\frac{\partial p}{\partial \theta} = \frac{-a}{a\theta' + 2 + a\theta'(p - c)} < 0 \tag{1.7}$$

From this, we have that the price of ethanol and gasoline vary negatively with the growth of the NGV fleet.

8.2 Appendix B. Additional Tables for Main Results

[101] This follows from the fact that the decision to convert a car to run on natural gas will depend on the price of the alternative fuels. Hence, the higher the price of gas or ethanol, the higher the incentive to convert one's vehicle. This dynamics reflect the source of endogeneity in our estimation.

[102] As from the Implicit Function Theorem, we are again implicitly assuming that the inverse of θ exists.

Table 15 – Standard Deviation of OLS Errors of the NGV to Total Fleet Ratio

Municipality	Until June 2008	After June 2008	Municipality (continuation)	Until June 2008	After June 2008
Angra dos Reis	2.97%	0.2%	Nova Iguaçu	0.94%	0.72%
Araruama	0.56%	0.2%	Paraíba do Sul	2.19%	0.36%
Armação dos Búzios	0.31%	0.92%	Paraty	2.47%	0.11%
Barra do Piraí	0.36%	0.24%	Paty do Alferes	0.98%	-
Barra Mansa	0.79%	0.53%	Petrópolis	1.06%	0.34%
Belford Roxo	3.28%	0.28%	Queimados	2.16%	0.64%
Cabo Frio	2.09%	0.49%	Resende	1.13%	0.28%
Campos dos Goytacazes	0.46%	0.56%	Rio Bonito	1.48%	0.33%
Duque de Caxias	0.22%	0.75%	Rio de Janeiro	0.5%	0.27%
Iguaba Grande	0.09%	-	Santo Antônio de Pádua	2.8%	0.47%
Itaboraí	1.4%	0.95%	São Francisco de Itabapoana	1.89%	0.26%
Itaguaí	0.36%	0.83%	São Gonçalo	1.75%	0.43%
Itaperuna	4.07%	0.24%	São João de Meriti	1.3%	0.87%
Japeri	0.66%	-	São José de Ubá	0.75%	-
Macaé	0.72%	0.78%	Sapucaia	2.68%	0.35%
Magé	2.04%	0.26%	Saquarema	0.43%	0.17%
Mangaratiba	2.73%	1.47%	Seropédica	1.09%	-
Maricá	1.51%	0.37%	Teresópolis	2.97%	0.38%
Mesquita	2.61%	-	Três Rios	3.23%	0.31%
Nilópolis	2.38%	0.24%	Valença	1.79%	0.57%
Niterói	1.33%	0.44%	Vassouras	0.65%	0.24%
Nova Friburgo	3.49%	0.27%	Volta Redonda	2.02%	0.42%

NOTES: The table shows the standard deviation of the error terms of the linear regression of penetration of the NGV fleet by municipality on a municipality fixed effect for two periods: January 2001 to June 2008 and July 2008 to December 2016. Source: Detran-RJ.

Table 16 – Gasoline Prices 2008-2016

	(1) OLS	(2) OLS	(3) 2SLS	(4) 2SLS	(5) 2SLS	(6) 2SLS	(7) 2SLS
% NGV Fleet	-0.422***	0.267*	-7.504***	-7.561***	-6.658***	-2.791*	-2.967*
	(-11.27)	(2.15)	(-4.46)	(-4.46)	(-6.81)	(-2.19)	(-2.38)
% Gas Fleet					-4.299***		-1.661*
					(-6.89)		(-2.16)
% Ethanol Fleet					-10.75***		-6.499***
					(-8.63)		(-4.03)
% Flex Fleet					-4.791***		-2.284**
					(-7.94)		(-2.92)
GDP per Capita						-0.0856*	0.00498
						(-2.47)	(0.45)
Fleet/Station						0.000249***	0.0000444
						(6.09)	(0.71)
Stations City-month						0.0000375*	-0.00000748
						(2.41)	(-0.69)
Observations	293492	293420	293420	293420	293420	243121	243121
Instrumentalized Fleet	No	No	Yes	Yes	Yes	Yes	Yes
Station Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Brand Fixed Effect	No	No	Yes	Yes	Yes	Yes	Yes
Kleibergen-Paap LM statistic			24.86	24.70	38.42	23.15	49.38
Kleibergen-Paap LM p-value			0.000000616	0.000000670	5.71e-10	0.00000150	2.11e-12

NOTES: Table displays the estimated effects of shares of NGVs on gasoline retail prices. Regressions consider a station *i* located in municipality *m* in week *t* as the unit of analysis, and the sample period goes from July 2008 to December 2016. All prices are expressed in BRL real terms, deflated by the monthly Brazilian CPI (Índice de Preços ao Consumidor Amplo – IPCA). Columns 1-2 are estimated by OLS and columns 3-7 by 2SLS. Columns 2-7 include station and monthly fixed effects and columns 3-7 include station-brand fixed effects as controls. Columns 5 and 7 also include shares of gasoline, ethanol and flex fleet as controls. Finally, column 6 and 7 add yearly municipal GDP per capita (available only until 2015), the NGV fleet divided by the monthly number of stations at the municipality level, and the monthly number of stations at each municipality as controls. Instrument for the share of NGVs is the interaction between a dummy reflecting the availability of piped gas at a given municipality in 2001 and the share of the NGV fleet in the Rio de Janeiro state municipalities not included in our prices database. Standard errors are clustered by city-month. Shown in parentheses are the t-stats for the coefficients. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table 17 – Gasoline Margins 2008-2016

	(1) OLS	(2) OLS	(3) 2SLS	(4) 2SLS	(5) 2SLS	(6) 2SLS	(7) 2SLS
% NGV Fleet	-0.245***	0.234*	-6.104***	-6.059***	-6.245***	0.122	0.232
	(-13.32)	(2.16)	(-4.52)	(-4.50)	(-6.75)	(0.17)	(0.21)
% Gas Fleet					-4.523***		0.234
					(-6.53)		(0.28)
% Ethanol Fleet					-9.323***		-1.454
					(-7.86)		(-1.00)
% Flex Fleet					-4.776***		-0.261
					(-7.38)		(-0.32)
GDP per Capita						0.0370	0.0551***
						(1.67)	(5.14)
Fleet/Station						0.000187***	0.0000803
						(7.23)	(1.70)
Stations City-month						-0.00000452	-0.0000258**
						(-0.47)	(-3.05)
Observations	164819	164737	164737	164737	164737	136301	136301
Instrumentalized Fleet	No	No	Yes	Yes	Yes	Yes	Yes
Station Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Brand Fixed Effect	No	No	Yes	Yes	Yes	Yes	Yes
Kleibergen-Paap LM statistic			28.51	28.48	36.44	27.92	41.23
Kleibergen-Paap LM p-value			9.30e-08	9.48e-08	1.58e-09	0.000000126	1.35e-10

NOTES: Table displays the estimated effects of shares of NGVs on gasoline retail margins. Regressions consider a station *i* located in municipality *m* in week *t* as the unit of analysis, and the sample period goes from July 2008 to December 2016. All prices are expressed in BRL real terms, deflated by the monthly Brazilian CPI (Índice de Preços ao Consumidor Amplo – IPCA). Columns 1-2 are estimated by OLS and columns 3-7 by 2SLS. Columns 2-7 include station and monthly fixed effects and columns 3-7 include station-brand fixed effects as controls. Columns 5 and 7 also include shares of gasoline, ethanol and flex fleet as controls. Finally, column 6 and 7 add yearly municipal GDP per capita (available only until 2015), the NGV fleet divided by the monthly number of stations at the municipality level, and the monthly number of stations at each municipality as controls. Instrument for the share of NGVs is the interaction between a dummy reflecting the availability of piped gas at a given municipality in 2001 and the share of the NGV fleet in the Rio de Janeiro state municipalities not included in our prices database. Standard errors are clustered by city-month. Shown in parentheses are the t-stats for the coefficients. $^{*}\ p < 0.05$, $^{**}\ p < 0.01$, $^{***}\ p < 0.001$.

Table 18 – Ethanol Prices 2008-2016

	(1) OLS	(2) OLS	(3) 2SLS	(4) 2SLS	(5) 2SLS	(6) 2SLS	(7) 2SLS
% NGV Fleet	-0.100*	0.451**	-7.154***	-7.265***	-8.281***	-1.122	-1.556
	(-2.45)	(3.26)	(-4.21)	(-4.23)	(-4.90)	(-0.85)	(-1.02)
% Gas Fleet					-5.070***		-0.816
					(-4.60)		(-0.84)
% Ethanol Fleet					-10.06***		-1.817
					(-4.80)		(-0.93)
% Flex Fleet					-4.739***		-0.626
					(-4.49)		(-0.64)
GDP per Capita						-0.0387	-0.0305
						(-1.04)	(-1.92)
Fleet/Station						-0.0000914	-0.000118
						(-1.75)	(-1.32)
Stations City-month						-0.0000351	-0.0000370*
						(-1.90)	(-2.29)
Observations	287516	287445	287445	287445	287445	238414	238414
Instrumentalized Fleet	No	No	Yes	Yes	Yes	Yes	Yes
Station Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Brand Fixed Effect	No	No	Yes	Yes	Yes	Yes	Yes
Kleibergen-Paap LM statistic			29.01	28.89	41.42	25.03	50.34
Kleibergen-Paap LM p-value			7.19e-08	7.65e-08	1.23e-10	0.000000566	1.29e-12

NOTES: Table displays the estimated effects of shares of NGVs on ethanol retail prices. Regressions consider a station *i* located in municipality *m* in week *t* as the unit of analysis, and the sample period goes from July 2008 to December 2016. All prices are expressed in BRL real terms, deflated by the monthly Brazilian CPI (Índice de Preços ao Consumidor Amplo – IPCA). Columns 1-2 are estimated by OLS and columns 3-7 by 2SLS. Columns 2-7 include station and monthly fixed effects and columns 3-7 include station-brand fixed effects as controls. Columns 5 and 7 also include shares of gasoline, ethanol and flex fleet as controls. Finally, column 6 and 7 add yearly municipal GDP per capita (available only until 2015), the NGV fleet divided by the monthly number of stations at the municipality level, and the monthly number of stations at each municipality as controls. Instrument for the share of NGVs is the interaction between a dummy reflecting the availability of piped gas at a given municipality in 2001 and the share of the NGV fleet in the Rio de Janeiro state municipalities not included in our prices database. Standard errors are clustered by city-month. Shown in parentheses are the t-stats for the coefficients. $^{*}\ p < 0.05$, $^{**}\ p < 0.01$, $^{***}\ p < 0.001$.

Table 19 – Ethanol Margins 2008-2016

	(1) OLS	(2) OLS	(3) 2SLS	(4) 2SLS	(5) 2SLS	(6) 2SLS	(7) 2SLS
% NGV Fleet	-0.0213	0.0297	-5.489***	-5.523***	-7.227***	0.270	0.766
	(-1.05)	(0.23)	(-4.77)	(-4.77)	(-5.20)	(0.27)	(0.42)
% Gas Fleet					-5.523***		0.111
					(-5.05)		(0.08)
% Ethanol Fleet					-8.498***		1.788
					(-4.78)		(0.75)
% Flex Fleet					-5.321***		0.127
					(-5.23)		(0.09)
GDP per Capita						0.0333	0.0398*
						(1.06)	(2.28)
Fleet/Station						0.00000765	0.0000363
						(0.21)	(0.49)
Stations City-month						-0.0000162	-0.0000121
						(-1.40)	(-1.16)
Observations	148917	148829	148829	148829	148829	123201	123201
Instrumentalized Fleet	No	No	Yes	Yes	Yes	Yes	Yes
Station Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Brand Fixed Effect	No	No	Yes	Yes	Yes	Yes	Yes
Kleibergen-Paap LM statistic			36.08	35.91	41.71	30.93	42.78
Kleibergen-Paap LM p-value			1.89e-09	2.07e-09	1.06e-10	2.68e-08	6.12e-11

NOTES: Table displays the estimated effects of shares of NGVs on ethanol retail margins. Regressions consider a station *i* located in municipality *m* in week *t* as the unit of analysis, and the sample period goes from July 2008 to December 2016. All prices are expressed in BRL real terms, deflated by the monthly Brazilian CPI (Índice de Preços ao Consumidor Amplo – IPCA). Columns 1-2 are estimated by OLS and columns 3-7 by 2SLS. Columns 2-7 include station and monthly fixed effects and columns 3-7 include station-brand fixed effects as controls. Columns 5 and 7 also include shares of gasoline, ethanol and flex fleet as controls. Finally, column 6 and 7 add yearly municipal GDP per capita (available only until 2015), the NGV fleet divided by the monthly number of stations at the municipality level, and the monthly number of stations at each municipality as controls. Instrument for the share of NGVs is the interaction between a dummy reflecting the availability of piped gas at a given municipality in 2001 and the share of the NGV fleet in the Rio de Janeiro state municipalities not included in our prices database. Standard errors are clustered by city-month. Shown in parentheses are the t-stats for the coefficients. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table 20 – Gasoline Prices

	(1) OLS	(2) OLS	(3) 2SLS	(4) 2SLS	(5) 2SLS	(6) 2SLS	(7) 2SLS
% NGV Fleet	-1.525***	0.455***	0.533***	0.493***	-2.166	-0.590***	-4.335***
	(-27.01)	(11.65)	(3.64)	(3.41)	(-1.05)	(-3.98)	(-5.11)
% Gas Fleet					-2.304		-4.011***
					(-1.40)		(-5.46)
% Ethanol Fleet					-3.131		-5.640***
					(-1.18)		(-5.73)
% Flex Fleet					-2.606		-4.520***
					(-1.39)		(-5.70)
GDP per Capita						0.00549	-0.0416**
						(0.52)	(-2.70)
Fleet/Station						0.000301**	0.000165**
						(3.20)	(3.14)
Stations City-month						0.00000514	0.00000870**
						(1.20)	(2.69)
Observations	591014	590971	590971	590971	590971	540669	540669
Instrumentalized Fleet	No	No	Yes	Yes	Yes	Yes	Yes
Station Fixed Effect	No	Yes	Yes	Yes	Yes	Yes	Yes
Time Fixed Effect	No	Yes	Yes	Yes	Yes	Yes	Yes
Brand Fixed Effect	No	No	No	Yes	Yes	Yes	Yes
Kleibergen-Paap LM statistic			273.9	276.2	6.560	335.6	77.68
Kleibergen-Paap LM p-value			1.64e-61	5.14e-62	0.0104	5.78e-75	1.21e-18

NOTES: Table displays the estimated effects of shares of NGVs on gasoline retail prices. Regressions consider a station *i* located in municipality *m* in week *t* as the unit of analysis, and the sample period goes from January 2002 to December 2016. All prices are expressed in BRL real terms, deflated by the monthly Brazilian CPI (Índice de Preços ao Consumidor Amplo – IPCA). Columns 1-2 are estimated by OLS and columns 3-7 by 2SLS. Columns 2-7 include station and monthly fixed effects and columns 3-7 include station-brand fixed effects as controls. Columns 5 and 7 also include shares of gasoline, ethanol and flex fleet as controls. Finally, column 6 and 7 add yearly municipal GDP per capita (available only until 2015), the NGV fleet divided by the monthly number of stations at the municipality level, and the monthly number of stations at each municipality as controls. Instrument for the share of NGVs is the interaction between a dummy reflecting the availability of piped gas at a given municipality in 2001 and the share of the NGV fleet in the Rio de Janeiro state municipalities not included in our prices database. Standard errors are clustered by city-month. Shown in parentheses are the t-stats for the coefficients. $^{*}\ p < 0.05$, $^{**}\ p < 0.01$, $^{***}\ p < 0.001$.

Table 21 – Gasoline Margins

	(1) OLS	(2) OLS	(3) 2SLS	(4) 2SLS	(5) 2SLS	(6) 2SLS	(7) 2SLS
% NGV Fleet	-0.310***	0.286***	0.137	0.153	-1.290	-0.856***	-2.983***
	(-14.62)	(7.73)	(1.05)	(1.16)	(-1.27)	(-6.42)	(-5.86)
% Gas Fleet					-1.491		-2.729***
					(-1.77)		(-5.98)
% Ethanol Fleet					-1.925		-4.375***
					(-1.38)		(-6.86)
% Flex Fleet					-1.719		-3.057***
					(-1.87)		(-6.45)
GDP per Capita						0.0467***	0.0228**
						(5.79)	(2.67)
Fleet/Station						0.000414***	0.000226***
						(11.47)	(9.41)
Stations City-month						0.0000151***	0.0000114***
						(8.62)	(7.14)
Observations	371296	371247	371247	371247	371247	342812	342812
Instrumentalized Fleet	No	No	Yes	Yes	Yes	Yes	Yes
Station Fixed Effect	No	Yes	Yes	Yes	Yes	Yes	Yes
Time Fixed Effect	No	Yes	Yes	Yes	Yes	Yes	Yes
Brand Fixed Effect	No	No	No	Yes	Yes	Yes	Yes
Kleibergen-Paap LM statistic			198.3	199.4	14.18	313.0	106.5
Kleibergen-Paap LM p-value			5.02e-45	2.84e-45	0.000166	4.97e-70	5.80e-25

NOTES: Table displays the estimated effects of shares of NGVs on gasoline retail margins. Regressions consider a station *i* located in municipality *m* in week *t* as the unit of analysis, and the sample period goes from January 2002 to December 2016. All prices are expressed in BRL real terms, deflated by the monthly Brazilian CPI (Índice de Preços ao Consumidor Amplo – IPCA). Columns 1-2 are estimated by OLS and columns 3-7 by 2SLS. Columns 2-7 include station and monthly fixed effects and columns 3-7 include station-brand fixed effects as controls. Columns 5 and 7 also include shares of gasoline, ethanol and flex fleet as controls. Finally, column 6 and 7 add yearly municipal GDP per capita (available only until 2015), the NGV fleet divided by the monthly number of stations at the municipality level, and the monthly number of stations at each municipality as controls. Instrument for the share of NGVs is the interaction between a dummy reflecting the availability of piped gas at a given municipality in 2001 and the share of the NGV fleet in the Rio de Janeiro state municipalities not included in our prices database. Standard errors are clustered by city-month. Shown in parentheses are the t-stats for the coefficients. $^{*}\ p < 0.05$, $^{**}\ p < 0.01$, $^{***}\ p < 0.001$.

Table 22 – Ethanol Prices

	(1) OLS	(2) OLS	(3) 2SLS	(4) 2SLS	(5) 2SLS	(6) 2SLS	(7) 2SLS
% NGV Fleet	0.136*	0.467***	0.372*	0.295	0.285	-0.219	-1.854*
	(2.05)	(8.88)	(2.22)	(1.79)	(0.15)	(-1.45)	(-2.31)
% Gas Fleet					-0.136		-1.834**
					(-0.09)		(-2.61)
% Ethanol Fleet					-0.000737		-2.549**
					(-0.00)		(-2.84)
% Flex Fleet					-0.294		-2.245**
					(-0.17)		(-2.97)
GDP per Capita						-0.0137	-0.0242
						(-1.17)	(-1.58)
Fleet/Station						0.000150*	0.0000870*
						(2.51)	(2.19)
Stations City-month						0.00000464	0.00000462
						(1.57)	(1.59)
Observations	564762	564705	564705	564705	564705	515673	515673
Instrumentalized Fleet	No	No	Yes	Yes	Yes	Yes	Yes
Station Fixed Effect	No	Yes	Yes	Yes	Yes	Yes	Yes
Time Fixed Effect	No	Yes	Yes	Yes	Yes	Yes	Yes
Brand Fixed Effect	No	No	No	Yes	Yes	Yes	Yes
Kleibergen-Paap LM statistic			284.7	288.1	9.706	359.0	83.80
Kleibergen-Paap LM p-value			7.24e-64	1.29e-64	0.00184	4.62e-80	5.47e-20

NOTES: Table displays the estimated effects of shares of NGVs on ethanol retail prices. Regressions consider a station *i* located in municipality *m* in week *t* as the unit of analysis, and the sample period goes from January 2002 to December 2016. All prices are expressed in BRL real terms, deflated by the monthly Brazilian CPI (Índice de Preços ao Consumidor Amplo – IPCA). Columns 1-2 are estimated by OLS and columns 3-7 by 2SLS. Columns 2-7 include station and monthly fixed effects and columns 3-7 include station-brand fixed effects as controls. Columns 5 and 7 also include shares of gasoline, ethanol and flex fleet as controls. Finally, column 6 and 7 add yearly municipal GDP per capita (available only until 2015), the NGV fleet divided by the monthly number of stations at the municipality level, and the monthly number of stations at each municipality as controls. Instrument for the share of NGVs is the interaction between a dummy reflecting the availability of piped gas at a given municipality in 2001 and the share of the NGV fleet in the Rio de Janeiro state municipalities not included in our prices database. Standard errors are clustered by city-month. Shown in parentheses are the t-stats for the coefficients. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table 23 – Ethanol Margins

	(1) OLS	(2) OLS	(3) 2SLS	(4) 2SLS	(5) 2SLS	(6) 2SLS	(7) 2SLS
% NGV Fleet	-0.403***	0.134**	-0.139	-0.146	-3.740**	-0.504***	-2.623***
	(-20.58)	(2.84)	(-0.89)	(-0.93)	(-2.81)	(-3.57)	(-5.02)
% Gas Fleet					-3.512**		-2.555***
					(-3.16)		(-5.36)
% Ethanol Fleet					-4.584*		-2.885***
					(-2.47)		(-4.26)
% Flex Fleet					-3.819**		-2.568***
					(-3.15)		(-5.29)
GDP per Capita						0.0659***	0.0353**
						(6.72)	(3.20)
Fleet/Station						0.000330***	0.000211***
						(8.54)	(6.96)
Stations City-month						0.0000186***	0.0000204***
						(8.68)	(8.92)
Observations	308251	308187	308187	308187	308187	282558	282558
Instrumentalized Fleet	No	No	Yes	Yes	Yes	Yes	Yes
Station Fixed Effect	No	Yes	Yes	Yes	Yes	Yes	Yes
Time Fixed Effect	No	Yes	Yes	Yes	Yes	Yes	Yes
Brand Fixed Effect	No	No	No	Yes	Yes	Yes	Yes
Kleibergen-Paap LM statistic			205.4	205.9	19.57	330.6	102.5
Kleibergen-Paap LM p-value			1.41e-46	1.08e-46	0.00000972	7.22e-74	4.29e-24

NOTES: Table displays the estimated effects of shares of NGVs on ethanol retail margins. Regressions consider a station *i* located in municipality *m* in week *t* as the unit of analysis, and the sample period goes from January 2002 to December 2016. All prices are expressed in BRL real terms, deflated by the monthly Brazilian CPI (Índice de Preços ao Consumidor Amplo – IPCA). Columns 1-2 are estimated by OLS and columns 3-7 by 2SLS. Columns 2-7 include station and monthly fixed effects and columns 3-7 include station-brand fixed effects as controls. Columns 5 and 7 also include shares of gasoline, ethanol and flex fleet as controls. Finally, column 6 and 7 add yearly municipal GDP per capita (available only until 2015), the NGV fleet divided by the monthly number of stations at the municipality level, and the monthly number of stations at each municipality as controls. Instrument for the share of NGVs is the interaction between a dummy reflecting the availability of piped gas at a given municipality in 2001 and the share of the NGV fleet in the Rio de Janeiro state municipalities not included in our prices database. Standard errors are clustered by city-month. Shown in parentheses are the t-stats for the coefficients. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table 24 – Gasoline Prices 2002-2008 - First Stage

	(1)	(2)	(3)	(4)	(5)
Instrument Piped Gas x Bartik RJ	0.324***	0.323***	0.110***	0.337***	0.102***
	(18.04)	(18.06)	(12.92)	(19.97)	(15.41)
% Gas Fleet			-0.835***		-0.879***
			(-86.77)		(-101.82)
% Ethanol Fleet			-1.439***		-1.301***
			(-45.21)		(-42.85)
% Flex Fleet			-1.019***		-1.007***
			(-71.42)		(-83.19)
GDP per Capita				0.0337***	-0.0211***
				(8.54)	(-12.03)
Fleet/Station				0.0000254*	0.00000569
				(2.41)	(1.80)
Stations City-month				0.00000361***	0.00000275***
				(8.83)	(16.42)
Observations	297489	297489	297489	297489	297489
Station Fixed Effect	Yes	Yes	Yes	Yes	Yes
Time Fixed Effect	Yes	Yes	Yes	Yes	Yes
Brand Fixed Effect	No	Yes	Yes	Yes	Yes

NOTES: Table displays the first stage for the regression on the estimated effects of shares of NGVs on gasoline retail prices. The dependent variable is the share of NGVs in the total automobile's fleet. The instrument, here shown as an independent regressor, is the interaction between a dummy reflecting the availability of piped gas at a given municipality in 2001 and the share of the NGV fleet in the Rio de Janeiro state municipalities not included in our prices database. Regressions consider a station *i* located in municipality *m* in week *t* as the unit of analysis, and the sample period goes from January 2002 to June 2008. All prices are expressed in BRL real terms, deflated by the monthly Brazilian CPI (Índice de Preços ao Consumidor Amplo – IPCA). All Columns include station and monthly fixed effects and columns 2-5 include station-brand fixed effects as controls. Columns 3 and 5 also include shares of gasoline, ethanol and flex fleet as controls. Finally, column 4 and 5 add yearly municipal GDP per capita (available only until 2015), the NGV fleet divided by the monthly number of stations at the municipality level, and the monthly number of stations at each municipality as controls. Standard errors are clustered by city-month. Shown in parentheses are the t-stats for the coefficients. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table 25 – Gasoline Prices 2008-2016 - First Stage

	(1)	(2)	(3)	(4)	(5)
Instrument Piped Gas x Bartik RJ	-0.602***	-0.599***	-0.594***	-0.868***	-0.771***
	(-5.03)	(-5.02)	(-7.33)	(-5.03)	(-7.92)
% Gas Fleet			-0.618***		-0.620***
			(-38.43)		(-35.71)
% Ethanol Fleet			-1.243***		-1.273***
			(-34.73)		(-33.56)
% Flex Fleet			-0.613***		-0.640***
			(-43.87)		(-40.95)
GDP per Capita				-0.0270***	-0.00599***
				(-23.92)	(-7.20)
Fleet/Station				-0.0000111*	-0.0000456***
				(-2.33)	(-8.95)
Stations City-month				0.00000461*	-0.00000230
				(2.00)	(-1.43)
Observations	293420	293420	293420	243121	243121
Station Fixed Effect	Yes	Yes	Yes	Yes	Yes
Time Fixed Effect	Yes	Yes	Yes	Yes	Yes
Brand Fixed Effect	Yes	Yes	Yes	Yes	Yes

NOTES: Table displays the first stage for the regression on the estimated effects of shares of NGVs on gasoline retail prices. The dependent variable is the share of NGVs in the total automobile's fleet. The instrument, here shown as an independent regressor, is the interaction between a dummy reflecting the availability of piped gas at a given municipality in 2001 and the share of the NGV fleet in the Rio de Janeiro state municipalities not included in our prices database. Regressions consider a station *i* located in municipality *m* in week *t* as the unit of analysis, and the sample period goes from July 2008 to December 2016. All prices are expressed in BRL real terms, deflated by the monthly Brazilian CPI (Índice de Preços ao Consumidor Amplo – IPCA). All Columns include station and monthly fixed effects and columns 2-5 include station-brand fixed effects as controls. Columns 3 and 5 also include shares of gasoline, ethanol and flex fleet as controls. Finally, column 4 and 5 add yearly municipal GDP per capita (available only until 2015), the NGV fleet divided by the monthly number of stations at the municipality level, and the monthly number of stations at each municipality as controls. Standard errors are clustered by city-month. Shown in parentheses are the t-stats for the coefficients. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table 26 – Gasoline Prices - First Stage

	(1)	(2)	(3)	(4)	(5)
Instrument Piped Gas x Bartik RJ	0.231***	0.230***	0.0191**	0.308***	0.0636***
	(16.52)	(16.54)	(2.68)	(19.67)	(11.23)
% Gas Fleet			-0.789***		-0.840***
			(-96.43)		(-112.15)
% Ethanol Fleet			-1.306***		-1.151***
			(-51.01)		(-45.01)
% Flex Fleet			-0.908***		-0.923***
			(-96.90)		(-112.32)
GDP per Capita				-0.0202***	-0.0151***
				(-5.90)	(-15.74)
Fleet/Station				0.0000504***	-0.0000170**
				(3.96)	(-3.11)
Stations City-month				0.00000784***	0.00000261***
				(12.74)	(10.41)
Observations	590971	590971	590971	540669	540669
Station Fixed Effect	Yes	Yes	Yes	Yes	Yes
Time Fixed Effect	Yes	Yes	Yes	Yes	Yes
Brand Fixed Effect	No	Yes	Yes	Yes	Yes

NOTES: Table displays the first stage for the regression on the estimated effects of shares of NGVs on gasoline retail prices. The dependent variable is the share of NGVs in the total automobile's fleet. The instrument, here shown as an independent regressor, is the interaction between a dummy reflecting the availability of piped gas at a given municipality in 2001 and the share of the NGV fleet in the Rio de Janeiro state municipalities not included in our prices database. Regressions consider a station *i* located in municipality *m* in week *t* as the unit of analysis, and the sample period goes from January 2002 to December 2016. All prices are expressed in BRL real terms, deflated by the monthly Brazilian CPI (Índice de Preços ao Consumidor Amplo – IPCA). All Columns include station and monthly fixed effects and columns 2-5 include station-brand fixed effects as controls. Columns 3 and 5 also include shares of gasoline, ethanol and flex fleet as controls. Finally, column 4 and 5 add yearly municipal GDP per capita (available only until 2015), the NGV fleet divided by the monthly number of stations at the municipality level, and the monthly number of stations at each municipality as controls. Standard errors are clustered by city-month. Shown in parentheses are the t-stats for the coefficients. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table 27 – Gasoline Margins 2002-2008 - First Stage

	(1)	(2)	(3)	(4)	(5)
Instrument Piped Gas x Bartik RJ	0.324***	0.323***	0.123***	0.339***	0.114***
	(17.75)	(17.80)	(14.26)	(19.78)	(16.87)
% Gas Fleet			-0.825***		-0.870***
			(-82.38)		(-97.06)
% Ethanol Fleet			-1.478***		-1.341***
			(-47.60)		(-44.66)
% Flex Fleet			-1.024***		-1.021***
			(-71.12)		(-83.34)
GDP per Capita				0.0419***	-0.0203***
				(10.92)	(-12.42)
Fleet/Station				0.0000605***	0.0000113
				(4.38)	(1.82)
Stations City-month				0.00000472***	0.00000285***
				(10.39)	(12.28)
Observations	206442	206442	206442	206442	206442
Station Fixed Effect	Yes	Yes	Yes	Yes	Yes
Time Fixed Effect	Yes	Yes	Yes	Yes	Yes
Brand Fixed Effect	No	Yes	Yes	Yes	Yes

NOTES: Table displays the first stage for the regression on the estimated effects of shares of NGVs on gasoline retail margins. The dependent variable is the share of NGVs in the total automobile's fleet. The instrument, here shown as an independent regressor, is the interaction between a dummy reflecting the availability of piped gas at a given municipality in 2001 and the share of the NGV fleet in the Rio de Janeiro state municipalities not included in our prices database. Regressions consider a station *i* located in municipality *m* in week *t* as the unit of analysis, and the sample period goes from January 2002 to June 2008. All prices are expressed in BRL real terms, deflated by the monthly Brazilian CPI (Índice de Preços ao Consumidor Amplo – IPCA). All Columns include station and monthly fixed effects and columns 2-5 include station-brand fixed effects as controls. Columns 3 and 5 also include shares of gasoline, ethanol and flex fleet as controls. Finally, column 4 and 5 add yearly municipal GDP per capita (available only until 2015), the NGV fleet divided by the monthly number of stations at the municipality level, and the monthly number of stations at each municipality as controls. Standard errors are clustered by city-month. Shown in parentheses are the t-stats for the coefficients. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table 28 – Ethanol Prices 2002-2008 - First Stage

	(1)	(2)	(3)	(4)	(5)
Instrument Piped Gas x Bartik RJ	0.332***	0.330***	0.112***	0.343***	0.105***
	(18.31)	(18.35)	(13.42)	(20.14)	(15.92)
% Gas Fleet			-0.835***		-0.875***
			(-86.21)		(-99.91)
% Ethanol Fleet			-1.418***		-1.288***
			(-44.79)		(-42.02)
% Flex Fleet			-1.029***		-1.014***
			(-71.43)		(-81.41)
GDP per Capita				0.0327***	-0.0211***
				(8.19)	(-11.52)
Fleet/Station				0.0000254*	0.00000613
				(2.48)	(1.83)
Stations City-month				0.00000359***	0.00000266***
				(8.71)	(15.49)
Observations	277201	277201	277201	277201	277201
Station Fixed Effect	Yes	Yes	Yes	Yes	Yes
Time Fixed Effect	Yes	Yes	Yes	Yes	Yes
Brand Fixed Effect	No	Yes	Yes	Yes	Yes

NOTES: Table displays the first stage for the regression on the estimated effects of shares of NGVs on ethanol retail prices. The dependent variable is the share of NGVs in the total automobile's fleet. The instrument, here shown as an independent regressor, is the interaction between a dummy reflecting the availability of piped gas at a given municipality in 2001 and the share of the NGV fleet in the Rio de Janeiro state municipalities not included in our prices database. Regressions consider a station *i* located in municipality *m* in week *t* as the unit of analysis, and the sample period goes from January 2002 to June 2008. All prices are expressed in BRL real terms, deflated by the monthly Brazilian CPI (Índice de Preços ao Consumidor Amplo – IPCA). All Columns include station and monthly fixed effects and columns 2-5 include station-brand fixed effects as controls. Columns 3 and 5 also include shares of gasoline, ethanol and flex fleet as controls. Finally, column 4 and 5 add yearly municipal GDP per capita (available only until 2015), the NGV fleet divided by the monthly number of stations at the municipality level, and the monthly number of stations at each municipality as controls. Standard errors are clustered by city-month. Shown in parentheses are the t-stats for the coefficients. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table 29 – Ethanol Margins 2002-2008 - First Stage

	(1)	(2)	(3)	(4)	(5)
Instrument Piped Gas x Bartik RJ	0.344***	0.343***	0.127***	0.363***	0.121***
	(18.28)	(18.36)	(14.40)	(20.91)	(17.22)
% Gas Fleet			-0.815***		-0.857***
			(-78.09)		(-89.42)
% Ethanol Fleet			-1.508***		-1.374***
			(-46.33)		(-42.91)
% Flex Fleet			-1.008***		-1.001***
			(-70.29)		(-77.99)
GDP per Capita				0.0461***	-0.0183***
				(11.47)	(-10.86)
Fleet/Station				0.0000476**	0.0000106
				(3.29)	(1.37)
Stations City-month				0.00000453***	0.00000283***
				(9.70)	(10.55)
Observations	159286	159286	159286	159286	159286
Station Fixed Effect	Yes	Yes	Yes	Yes	Yes
Time Fixed Effect	Yes	Yes	Yes	Yes	Yes
Brand Fixed Effect	No	Yes	Yes	Yes	Yes

NOTES: Table displays the first stage for the regression on the estimated effects of shares of NGVs on ethanol retail margins. The dependent variable is the share of NGVs in the total automobile's fleet. The instrument, here shown as an independent regressor, is the interaction between a dummy reflecting the availability of piped gas at a given municipality in 2001 and the share of the NGV fleet in the Rio de Janeiro state municipalities not included in our prices database. Regressions consider a station *i* located in municipality *m* in week *t* as the unit of analysis, and the sample period goes from January 2002 to June 2008. All prices are expressed in BRL real terms, deflated by the monthly Brazilian CPI (Índice de Preços ao Consumidor Amplo – IPCA). All Columns include station and monthly fixed effects and columns 2-5 include station-brand fixed effects as controls. Columns 3 and 5 also include shares of gasoline, ethanol and flex fleet as controls. Finally, column 4 and 5 add yearly municipal GDP per capita (available only until 2015), the NGV fleet divided by the monthly number of stations at the municipality level, and the monthly number of stations at each municipality as controls. Standard errors are clustered by city-month. Shown in parentheses are the t-stats for the coefficients. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table 30 – Gasoline Margins 2008-2016 - First Stage

	(1)	(2)	(3)	(4)	(5)
Instrument Piped Gas x Bartik RJ	-0.676***	-0.676***	-0.559***	-1.064***	-0.668***
	(-5.39)	(-5.38)	(-7.81)	(-5.65)	(-7.60)
% Gas Fleet			-0.734***		-0.729***
			(-46.62)		(-41.02)
% Ethanol Fleet			-1.231***		-1.253***
			(-41.72)		(-39.45)
% Flex Fleet			-0.697***		-0.714***
			(-57.75)		(-49.68)
GDP per Capita				-0.0281***	-0.00429***
				(-19.85)	(-5.26)
Fleet/Station				-0.000000137	-0.0000349***
				(-0.03)	(-8.91)
Stations City-month				0.00000357	-0.000000697
				(1.55)	(-0.54)
Observations	164737	164737	164737	136301	136301
Station Fixed Effect	Yes	Yes	Yes	Yes	Yes
Time Fixed Effect	Yes	Yes	Yes	Yes	Yes
Brand Fixed Effect	Yes	Yes	Yes	Yes	Yes

NOTES: Table displays the first stage for the regression on the estimated effects of shares of NGVs on gasoline retail margins. The dependent variable is the share of NGVs in the total automobile's fleet. The instrument, here shown as an independent regressor, is the interaction between a dummy reflecting the availability of piped gas at a given municipality in 2001 and the share of the NGV fleet in the Rio de Janeiro state municipalities not included in our prices database. Regressions consider a station *i* located in municipality *m* in week *t* as the unit of analysis, and the sample period goes from July 2008 to December 2016. All prices are expressed in BRL real terms, deflated by the monthly Brazilian CPI (Índice de Preços ao Consumidor Amplo – IPCA). All Columns include station and monthly fixed effects and columns 2-5 include station-brand fixed effects as controls. Columns 3 and 5 also include shares of gasoline, ethanol and flex fleet as controls. Finally, column 4 and 5 add yearly municipal GDP per capita (available only until 2015), the NGV fleet divided by the monthly number of stations at the municipality level, and the monthly number of stations at each municipality as controls. Standard errors are clustered by city-month. Shown in parentheses are the t-stats for the coefficients. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table 31 – Ethanol Prices 2008-2016 - First Stage

	(1)	(2)	(3)	(4)	(5)
Instrument Piped Gas x Bartik RJ	-0.656***	-0.652***	-0.624***	-0.899***	-0.787***
	(-5.45)	(-5.44)	(-7.66)	(-5.23)	(-7.98)
% Gas Fleet			-0.610***		-0.610***
			(-37.80)		(-34.98)
% Ethanol Fleet			-1.207***		-1.242***
			(-33.48)		(-32.61)
% Flex Fleet			-0.603***		-0.627***
			(-42.77)		(-39.78)
GDP per Capita				-0.0269***	-0.00634***
				(-23.52)	(-7.47)
Fleet/Station				-0.0000143**	-0.0000462***
				(-2.98)	(-8.77)
Stations City-month				0.00000397	-0.00000240
				(1.75)	(-1.47)
Observations	287445	287445	287445	238414	238414
Station Fixed Effect	Yes	Yes	Yes	Yes	Yes
Time Fixed Effect	Yes	Yes	Yes	Yes	Yes
Brand Fixed Effect	Yes	Yes	Yes	Yes	Yes

NOTES: Table displays the first stage for the regression on the estimated effects of shares of NGVs on ethanol retail prices. The dependent variable is the share of NGVs in the total automobile's fleet. The instrument, here shown as an independent regressor, is the interaction between a dummy reflecting the availability of piped gas at a given municipality in 2001 and the share of the NGV fleet in the Rio de Janeiro state municipalities not included in our prices database. Regressions consider a station *i* located in municipality *m* in week *t* as the unit of analysis, and the sample period goes from July 2008 to December 2016. All prices are expressed in BRL real terms, deflated by the monthly Brazilian CPI (Índice de Preços ao Consumidor Amplo – IPCA). All Columns include station and monthly fixed effects and columns 2-5 include station-brand fixed effects as controls. Columns 3 and 5 also include shares of gasoline, ethanol and flex fleet as controls. Finally, column 4 and 5 add yearly municipal GDP per capita (available only until 2015), the NGV fleet divided by the monthly number of stations at the municipality level, and the monthly number of stations at each municipality as controls. Standard errors are clustered by city-month. Shown in parentheses are the t-stats for the coefficients. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table 32 – Ethanol Margins 2008-2016 - First Stage

	(1)	(2)	(3)	(4)	(5)
Instrument Piped Gas x Bartik RJ	-0.769***	-0.767***	-0.562***	-1.131***	-0.644***
	(-6.02)	(-6.01)	(-8.52)	(-5.94)	(-7.66)
% Gas Fleet			-0.735***		-0.739***
			(-46.21)		(-42.33)
% Ethanol Fleet			-1.251***		-1.275***
			(-44.29)		(-41.45)
% Flex Fleet			-0.704***		-0.729***
			(-58.98)		(-53.04)
GDP per Capita				-0.0282***	-0.00299***
				(-19.42)	(-3.81)
Fleet/Station				-0.00000804	-0.0000342***
				(-1.59)	(-8.82)
Stations City-month				0.00000193	-0.000000793
				(0.85)	(-0.65)
Observations	148829	148829	148829	123201	123201
Station Fixed Effect	Yes	Yes	Yes	Yes	Yes
Time Fixed Effect	Yes	Yes	Yes	Yes	Yes
Brand Fixed Effect	Yes	Yes	Yes	Yes	Yes

NOTES: Table displays the first stage for the regression on the estimated effects of shares of NGVs on ethanol retail margins. The dependent variable is the share of NGVs in the total automobile's fleet. The instrument, here shown as an independent regressor, is the interaction between a dummy reflecting the availability of piped gas at a given municipality in 2001 and the share of the NGV fleet in the Rio de Janeiro state municipalities not included in our prices database. Regressions consider a station *i* located in municipality *m* in week *t* as the unit of analysis, and the sample period goes from July 2008 to December 2016. All prices are expressed in BRL real terms, deflated by the monthly Brazilian CPI (Índice de Preços ao Consumidor Amplo – IPCA). All Columns include station and monthly fixed effects and columns 2-5 include station-brand fixed effects as controls. Columns 3 and 5 also include shares of gasoline, ethanol and flex fleet as controls. Finally, column 4 and 5 add yearly municipal GDP per capita (available only until 2015), the NGV fleet divided by the monthly number of stations at the municipality level, and the monthly number of stations at each municipality as controls. Standard errors are clustered by city-month. Shown in parentheses are the t-stats for the coefficients. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table 33 – Gasoline Margins - First Stage

	(1)	(2)	(3)	(4)	(5)
Instrument Piped Gas x Bartik RJ	0.200***	0.199***	0.0302***	0.262***	0.0822***
	(14.27)	(14.29)	(4.12)	(16.29)	(14.96)
% Gas Fleet			-0.809***		-0.858***
			(-100.37)		(-119.98)
% Ethanol Fleet			-1.384***		-1.243***
			(-66.17)		(-57.76)
% Flex Fleet			-0.902***		-0.925***
			(-107.88)		(-122.21)
GDP per Capita				-0.00882*	-0.0118***
				(-2.46)	(-13.25)
Fleet/Station				0.0000973***	-0.0000230***
				(10.01)	(-7.58)
Stations City-month				0.00000940***	0.00000237***
				(17.05)	(13.46)
Observations	371247	371247	371247	342812	342812
Station Fixed Effect	Yes	Yes	Yes	Yes	Yes
Time Fixed Effect	Yes	Yes	Yes	Yes	Yes
Brand Fixed Effect	No	Yes	Yes	Yes	Yes

NOTES: Table displays the first stage for the regression on the estimated effects of shares of NGVs on gasoline retail margins. The dependent variable is the share of NGVs in the total automobile's fleet. The instrument, here shown as an independent regressor, is the interaction between a dummy reflecting the availability of piped gas at a given municipality in 2001 and the share of the NGV fleet in the Rio de Janeiro state municipalities not included in our prices database. Regressions consider a station *i* located in municipality *m* in week *t* as the unit of analysis, and the sample period goes from January 2002 to December 2016. All prices are expressed in BRL real terms, deflated by the monthly Brazilian CPI (Índice de Preços ao Consumidor Amplo – IPCA). All Columns include station and monthly fixed effects and columns 2-5 include station-brand fixed effects as controls. Columns 3 and 5 also include shares of gasoline, ethanol and flex fleet as controls. Finally, column 4 and 5 add yearly municipal GDP per capita (available only until 2015), the NGV fleet divided by the monthly number of stations at the municipality level, and the monthly number of stations at each municipality as controls. Standard errors are clustered by city-month. Shown in parentheses are the t-stats for the coefficients. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table 34 – Ethanol Prices - First Stage

	(1)	(2)	(3)	(4)	(5)
Instrument Piped Gas x Bartik RJ	0.237***	0.236***	0.0226***	0.315***	0.0655***
	(16.71)	(16.76)	(3.30)	(19.97)	(11.83)
% Gas Fleet			-0.794***		-0.840***
			(-98.09)		(-112.90)
% Ethanol Fleet			-1.269***		-1.131***
			(-53.04)		(-46.44)
% Flex Fleet			-0.920***		-0.932***
			(-101.05)		(-115.46)
GDP per Capita				-0.0238***	-0.0141***
				(-7.13)	(-14.70)
Fleet/Station				0.0000498***	-0.0000151**
				(3.95)	(-2.95)
Stations City-month				0.00000790***	0.00000256***
				(12.76)	(10.66)
Observations	564705	564705	564705	515673	515673
Station Fixed Effect	Yes	Yes	Yes	Yes	Yes
Time Fixed Effect	Yes	Yes	Yes	Yes	Yes
Brand Fixed Effect	No	Yes	Yes	Yes	Yes

NOTES: Table displays the first stage for the regression on the estimated effects of shares of NGVs on ethanol retail prices. The dependent variable is the share of NGVs in the total automobile's fleet. The instrument, here shown as an independent regressor, is the interaction between a dummy reflecting the availability of piped gas at a given municipality in 2001 and the share of the NGV fleet in the Rio de Janeiro state municipalities not included in our prices database. Regressions consider a station *i* located in municipality *m* in week *t* as the unit of analysis, and the sample period goes from January 2002 to December 2016. All prices are expressed in BRL real terms, deflated by the monthly Brazilian CPI (Índice de Preços ao Consumidor Amplo – IPCA). All Columns include station and monthly fixed effects and columns 2-5 include station-brand fixed effects as controls. Columns 3 and 5 also include shares of gasoline, ethanol and flex fleet as controls. Finally, column 4 and 5 add yearly municipal GDP per capita (available only until 2015), the NGV fleet divided by the monthly number of stations at the municipality level, and the monthly number of stations at each municipality as controls. Standard errors are clustered by city-month. Shown in parentheses are the t-stats for the coefficients. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table 35 – Ethanol Margins - First Stage

	(1)	(2)	(3)	(4)	(5)
Instrument Piped Gas x Bartik RJ	0.211***	0.209***	0.0366***	0.285***	0.0864***
	(14.62)	(14.63)	(5.00)	(16.97)	(15.10)
% Gas Fleet			-0.810***		-0.853***
			(-97.45)		(-112.39)
% Ethanol Fleet			-1.411***		-1.276***
			(-67.76)		(-58.61)
% Flex Fleet			-0.903***		-0.915***
			(-110.52)		(-117.87)
GDP per Capita				-0.0121***	-0.00928***
				(-3.35)	(-10.71)
Fleet/Station				0.0000741***	-0.0000220***
				(8.20)	(-7.31)
Stations City-month				0.00000897***	0.00000238***
				(16.51)	(13.54)
Observations	308187	308187	308187	282558	282558
Station Fixed Effect	Yes	Yes	Yes	Yes	Yes
Time Fixed Effect	Yes	Yes	Yes	Yes	Yes
Brand Fixed Effect	No	Yes	Yes	Yes	Yes

NOTES: Table displays the first stage for the regression on the estimated effects of shares of NGVs on ethanol retail margins. The dependent variable is the share of NGVs in the total automobile's fleet. The instrument, here shown as an independent regressor, is the interaction between a dummy reflecting the availability of piped gas at a given municipality in 2001 and the share of the NGV fleet in the Rio de Janeiro state municipalities not included in our prices database. Regressions consider a station *i* located in municipality *m* in week *t* as the unit of analysis, and the sample period goes from January 2002 to December 2016. All prices are expressed in BRL real terms, deflated by the monthly Brazilian CPI (Índice de Preços ao Consumidor Amplo – IPCA). All Columns include station and monthly fixed effects and columns 2-5 include station-brand fixed effects as controls. Columns 3 and 5 also include shares of gasoline, ethanol and flex fleet as controls. Finally, column 4 and 5 add yearly municipal GDP per capita (available only until 2015), the NGV fleet divided by the monthly number of stations at the municipality level, and the monthly number of stations at each municipality as controls. Standard errors are clustered by city-month. Shown in parentheses are the t-stats for the coefficients. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

8.3 Appendix C. Further Analysis - CNG Dummy

Not only can the penetration of the NGV fleet impact the prices and margins of gasoline and ethanol, but the decision of the station to offer CNG, one may conjecture, may have an effect on the prices and margins of other fuels sold at that station. The effect would arise from the residual demand for ethanol or gasoline among NGV owners. For the engine to last longer, a driver should cold start her car on gasoline or ethanol and, only after having heated the engine, should she change to operation on natural gas. Albeit owners of vehicles converted to run on CNG will, whenever possible, run their cars on natural gas, there is still the aforementioned technological restriction which creates a residual demand for gasoline or ethanol by the drivers[103]. This fact may give the opportunity to stations supplying natural gas to charge a higher price for

[103] The technology of the conversion kits for cars to run on natural gas has developed from 2001 to 2016. Hence, older conversion kits came with a fuel shift button. Hence, the driver may press the button in order to change from gasoline/ethanol to natural gas and vice-versa. Newer kits had an eletronic system that would choose gasoline/ethanol whenever the car was cold, shifting to natural gas automatically as soon as the engine heated.

other fuels (gasoline or ethanol), as consumers of natural gas would prefer to fill their tanks with gasoline or ethanol in these stations, even though they are more expensive there than elsewhere, instead of facing travel costs to stations offering cheaper fuel[104].

To evaluate this second effect, we modify our main empirical model to include a dummy indicating if a station was offering natural gas at a given moment[105]. We also need an additional instrument for this new dummy. Hence, in addition to the instrument in equation 1.2, we use an instrument given by the interaction between the two variables described in equation 1.8.

$$IV_{st}^{DummyNGV} = Stations_{t}^{SWex-RJ}.I_{s}^{DistancetoPipelines} \tag{1.8}$$

Where $Stations_{SWex-RJ}$ is the monthly number of stations offering natural gas in the Southeast of Brazil ex-Rio de Janeiro State and $I_{\{DistancetoPipelines\}}$ is a dummy equal to 1 if an station is less than 20 kilometers from one of Rio de Janeiro's main gas pipelines[106]. Again, the first term of the interaction reflects a non-local growth tendency, but this time for the supply of natural gas for vehicles. The second term reflects the fact that Ceg and Ceg-Rio will expand their piped natural gas network to serve stations within 20 kilometers of an already existing piped gas infrastructure. Therefore, stations within this distance of gas pipelines[107] built before the expansion of the piped gas network[108] may have a greater chance of having access to piped gas after the later phenomenon. It should be noted that we do not have access to the real distance between stations and the gas pipelines, but only to a proxy distance calculated considering a straight line between the initial and final points of the gas pipelines. Table 36 shows the pipelines considered in the dummy construction and the proxy length, as well as the real length of the gas pipelines. As before, this instrument also has Bartik instruments characteristics.

We could not find evidence of this effect neither in our main specifications shown in Tables 37 - 40, nor in some robustness checks[109]. Nevertheless, our results for the impact of the NGV fleet on the price of gasoline and ethanol still hold. As in the Results section, the two first specifications shown in the tables are estimated with OLS, while the other five are by 2SLS. The

[104] The NGV driver would plausibly only move from one station to another in order to fuel with gasoline or ethanol if the price difference between gasoline/ethanol in the more expensive and the cheaper station is great enough to compensate the travel costs (for example: the opportunity cost of the time) associated with going from on station to another.

[105] Our dummy is 1 for stations supplying natural gas, and 0 otherwise. It is constructed by observing if a given station had CNG prices registered for a given moment in time or not.

[106] We call gas pipelines the pipe structures used to transport natural gas over long distances and/or being part of a national infrastructure of natural gas transportation. On the other hand, we use piped gas infrastructure to refer to the network within a municipality used to supply consumers with natural gas. In Rio de Janeiro it is easy to separate one from another as gas pipelines are operated by Transpetro and the piped natural gas infrastructure is granted to Ceg and Ceg-Rio.

[107] We only consider gas pipelines completed until 1996.

[108] Before the privatization of the natural gas concessionaires, in 1997, only Rio de Janeiro city had access to piped gas. After the privatization, both Ceg and Ceg-Rio began an expansion of their respective piped gas networks.

[109] As a robustness check, we reestimate excluding the city of Rio de Janeiro, as its piped gas infrastructure was possibly in spite of the location of the intermunicipal gas pipelines Melo Filho (2005) points that Rio de Janeiro has historically had a piped gas system).

Table 36 – Gas Pipelines in Rio de Janeiro

Name	Extension	Calculated Extension	In Operation Since	Start	End
GASDUC I	184 km	169 km	1982	Macaé - RJ	Duque de Caxias - RJ
GASDUC II	182 km	169 km	1996	Macaé - RJ	Duque de Caxias - RJ
GASBEL	357 km	316 km	1996	Duque de Caxias - RJ	Betim - MG
GASPAL	325 km	-	1988	Volta Redonda - RJ	Capuava - SP
GASVOL	6 km	-	1986	Volta Redonda - RJ	Volta Redonda - RJ
GASVOL I	95 km	85 km	1986	Duque de Caxias - RJ	Volta Redonda - RJ
GASCAB I	67 km	-	1982	Macaé - RJ	Macaé - RJ

NOTES: The table shows the gas pipelines existing in the Rio de Janeiro State before the beginning of our sample. The seocnd column shows the real extension of the pipeline, while the third column shows what would be the extension of it whether it was a straight line going from its beginning to its ending point, when available (it is available only for the intermunicipal pipelines). The extreme points of the gas pipelines were obtained in the Petrobras website. The last two columns show, respectively, the municipalities where the starting and ending pooints of the pipelines are located. Source: Gasnet and Petrobras.

estimation period was from January 2002 to June 2008[110]. The specifications going from (1) to (7) are the same as the ones in Table 3.

[110] Estimated results when considering our whole sample or the period from July 2008 to December 2016 are available upon request. First stage regressions for the 2SLS specifications are also available upon request.

Table 37 – Gasoline Prices 2002-2008 with CNG Offer Dummy

	(1) OLS	(2) OLS	(3) 2SLS	(4) 2SLS	(5) 2SLS	(6) 2SLS	(7) 2SLS
% NGV Fleet	0.105	-0.403***	-1.032***	-1.021***	-2.788***	-0.978***	-2.941***
	(1.10)	(-6.15)	(-6.97)	(-6.71)	(-6.34)	(-6.30)	(-6.21)
NG Supply Indicator	-0.0468***	0.0130***	-0.0893	-0.122	-0.279***	-0.0582	-0.308***
	(-7.59)	(7.23)	(-1.17)	(-1.51)	(-3.61)	(-0.77)	(-4.16)
% Gas Fleet					-2.639***		-2.870***
					(-7.49)		(-6.82)
% Ethanol Fleet					-2.529***		-2.541***
					(-3.33)		(-3.51)
% Flex Fleet					-3.222***		-3.202***
					(-8.19)		(-7.11)
GDP per Capita						0.103***	0.0174
						(6.41)	(1.03)
Fleet/Station						0.0000143	0.0000178
						(0.78)	(0.77)
Stations City-month						0.00000256*	0.0000100***
						(2.39)	(5.83)
Observations	297522	297489	297489	297489	297489	297489	297489
Instrumentalized Fleet	No	No	Yes	Yes	Yes	Yes	Yes
Instrumentalized NGV Dummy	No	No	Yes	Yes	Yes	Yes	Yes
Station Fixed Effect	No	Yes	Yes	Yes	Yes	Yes	Yes
Time Fixed Effect	No	Yes	Yes	Yes	Yes	Yes	Yes
Brand Fixed Effect	No	No	No	Yes	Yes	Yes	Yes
Kleibergen-Paap LM statistic			121.2	115.3	185.5	129.6	236.1
Kleibergen-Paap LM p-value			3.52e-28	6.86e-27	2.98e-42	5.07e-30	2.78e-53

NOTES: Table displays the estimated effects of shares of NGVs and NG offer by the station on gasoline retail prices. Regressions consider a station *i* located in municipality *m* in week *t* as the unit of analysis, and the sample period goes from January 2002 to June 2008. All prices are expressed in BRL real terms, deflated by the monthly Brazilian CPI (Índice de Preços ao Consumidor Amplo – IPCA). Columns 1-2 are estimated by OLS and columns 3-7 by 2SLS. Columns 2-7 include station and monthly fixed effects and columns 3-7 include station-brand fixed effects as controls. Columns 5 and 7 also include shares of gasoline, ethanol and flex fleet as controls. Finally, column 6 and 7 add yearly municipal GDP per capita (available only until 2015), the NGV fleet divided by the monthly number of stations at the municipality level, and the monthly number of stations at each municipality as controls. The instrument for the share of NGVs is the interaction between a dummy reflecting the availability of piped gas at a given municipality in 2001 and the share of the NGV fleet in the Rio de Janeiro state municipalities not included in our prices database. The instrument for the NG offer by the station dummy is the interaction between the monthly number of stations offering natural gas in the Southeast of Brazil ex-Rio de Janeiro State and a dummy whether a station is less than 20 kilometers from one of Rio de Janeiro's main gas pipelines. Standard errors are clustered by city-month. Shown in parentheses are the t-stats for the coefficients. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table 38 – Gasoline Margins 2002-2008 with CNG Offer Dummy

	(1) OLS	(2) OLS	(3) 2SLS	(4) 2SLS	(5) 2SLS	(6) 2SLS	(7) 2SLS
% NGV Fleet	-0.508***	-0.342***	-0.845***	-0.842***	-2.186***	-0.832***	-2.359***
	(-13.36)	(-5.64)	(-5.50)	(-5.33)	(-5.86)	(-5.04)	(-5.83)
NG Supply Indicator	-0.0212***	0.0103***	-0.144	-0.153	-0.335***	-0.0756	-0.355***
	(-7.23)	(5.92)	(-1.86)	(-1.85)	(-4.21)	(-0.98)	(-4.57)
% Gas Fleet					-2.335***		-2.537***
					(-8.00)		(-6.98)
% Ethanol Fleet					-1.965**		-2.084**
					(-2.86)		(-3.20)
% Flex Fleet					-2.937***		-2.933***
					(-9.07)		(-7.51)
GDP per Capita						0.0939***	0.0166
						(7.15)	(1.12)
Fleet/Station						0.0000908**	0.000101**
						(2.83)	(2.79)
Stations City-month						0.00000491***	0.0000113***
						(3.77)	(5.87)
Observations	206477	206442	206442	206442	206442	206442	206442
Instrumentalized Fleet	No	No	Yes	Yes	Yes	Yes	Yes
Instrumentalized NGV Dummy	No	No	Yes	Yes	Yes	Yes	Yes
Station Fixed Effect	No	Yes	Yes	Yes	Yes	Yes	Yes
Time Fixed Effect	No	Yes	Yes	Yes	Yes	Yes	Yes
Brand Fixed Effect	No	No	No	Yes	Yes	Yes	Yes
Kleibergen-Paap LM statistic			92.65	83.72	133.5	92.86	165.6
Kleibergen-Paap LM p-value			6.23e-22	5.70e-20	7.00e-31	5.60e-22	6.61e-38

NOTES: Table displays the estimated effects of shares of NGVs and NG offer by the station on gasoline retail margins. Regressions consider a station *i* located in municipality *m* in week *t* as the unit of analysis, and the sample period goes from January 2002 to June 2008. All prices are expressed in BRL real terms, deflated by the monthly Brazilian CPI (Índice de Preços ao Consumidor Amplo – IPCA). Columns 1-2 are estimated by OLS and columns 3-7 by 2SLS. Columns 2-7 include station and monthly fixed effects and columns 3-7 include station-brand fixed effects as controls. Columns 5 and 7 also include shares of gasoline, ethanol and flex fleet as controls. Finally, column 6 and 7 add yearly municipal GDP per capita (available only until 2015), the NGV fleet divided by the monthly number of stations at the municipality level, and the monthly number of stations at each municipality as controls. The instrument for the share of NGVs is the interaction between a dummy reflecting the availability of piped gas at a given municipality in 2001 and the share of the NGV fleet in the Rio de Janeiro state municipalities not included in our prices database. The instrument for the NG offer by the station dummy is the interaction between the monthly number of stations offering natural gas in the Southeast of Brazil ex-Rio de Janeiro State and a dummy whether a station is less than 20 kilometers from one of Rio de Janeiro's main gas pipelines. Standard errors are clustered by city-month. Shown in parentheses are the t-stats for the coefficients. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table 39 – Ethanol Prices 2002-2008 with CNG Offer Dummy

	(1) OLS	(2) OLS	(3) 2SLS	(4) 2SLS	(5) 2SLS	(6) 2SLS	(7) 2SLS
% NGV Fleet	0.540***	-0.435***	-1.322***	-1.363***	-1.422**	-1.218***	-1.580**
	(3.88)	(-4.86)	(-5.26)	(-5.35)	(-2.62)	(-5.05)	(-2.62)
NG Supply Indicator	0.00462	0.0146***	0.0671	0.0515	-0.226*	0.0151	-0.255*
	(0.47)	(4.98)	(0.57)	(0.43)	(-2.24)	(0.14)	(-2.53)
% Gas Fleet					-1.013*		-1.242*
					(-2.06)		(-2.08)
% Ethanol Fleet					-2.153*		-2.177*
					(-2.35)		(-2.47)
% Flex Fleet					-2.433***		-2.427***
					(-4.27)		(-3.82)
GDP per Capita						0.0461	0.0147
						(1.50)	(0.52)
Fleet/Station						0.0000346	0.0000309
						(0.86)	(0.71)
Stations City-month						0.00000960***	0.0000101***
						(4.92)	(3.65)
Observations	277246	277201	277201	277201	277201	277201	277201
Instrumentalized Fleet	No	No	Yes	Yes	Yes	Yes	Yes
Instrumentalized NGV Dummy	No	No	Yes	Yes	Yes	Yes	Yes
Station Fixed Effect	No	Yes	Yes	Yes	Yes	Yes	Yes
Time Fixed Effect	No	Yes	Yes	Yes	Yes	Yes	Yes
Brand Fixed Effect	No	No	No	Yes	Yes	Yes	Yes
Kleibergen-Paap LM statistic			122.5	119.4	192.4	134.3	240.3
Kleibergen-Paap LM p-value			1.80e-28	8.54e-28	9.45e-44	4.63e-31	3.33e-54

NOTES: Table displays the estimated effects of shares of NGVs and NG offer by the station on ethanol retail prices. Regressions consider a station *i* located in municipality *m* in week *t* as the unit of analysis, and the sample period goes from January 2002 to June 2008. All prices are expressed in BRL real terms, deflated by the monthly Brazilian CPI (Índice de Preços ao Consumidor Amplo – IPCA). Columns 1-2 are estimated by OLS and columns 3-7 by 2SLS. Columns 2-7 include station and monthly fixed effects and columns 3-7 include station-brand fixed effects as controls. Columns 5 and 7 also include shares of gasoline, ethanol and flex fleet as controls. Finally, column 6 and 7 add yearly municipal GDP per capita (available only until 2015), the NGV fleet divided by the monthly number of stations at the municipality level, and the monthly number of stations at each municipality as controls. The instrument for the share of NGVs is the interaction between a dummy reflecting the availability of piped gas at a given municipality in 2001 and the share of the NGV fleet in the Rio de Janeiro state municipalities not included in our prices database. The instrument for the NG offer by the station dummy is the interaction between the monthly number of stations offering natural gas in the Southeast of Brazil ex-Rio de Janeiro State and a dummy whether a station is less than 20 kilometers from one of Rio de Janeiro's main gas pipelines. Standard errors are clustered by city-month. Shown in parentheses are the t-stats for the coefficients. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table 40 – Ethanol Margins 2002-2008 with CNG Offer Dummy

	(1) OLS	(2) OLS	(3) 2SLS	(4) 2SLS	(5) 2SLS	(6) 2SLS	(7) 2SLS
% NGV Fleet	-0.707***	-0.404***	-1.231***	-1.219***	-2.960***	-1.068***	-3.297***
	(-19.26)	(-5.16)	(-5.78)	(-5.64)	(-6.01)	(-5.33)	(-6.14)
NG Supply Indicator	0.00578	0.00754*	0.0871	0.0679	-0.153	0.0661	-0.220*
	(1.84)	(2.22)	(0.83)	(0.62)	(-1.41)	(0.70)	(-2.10)
% Gas Fleet					-2.702***		-3.133***
					(-5.59)		(-5.32)
% Ethanol Fleet					-3.052***		-3.256***
					(-3.43)		(-4.05)
% Flex Fleet					-3.338***		-3.272***
					(-6.18)		(-5.39)
GDP per Capita						0.110***	0.0428
						(4.45)	(1.67)
Fleet/Station						0.000218**	0.000250**
						(3.04)	(2.80)
Stations City-month						0.0000182***	0.0000276***
						(6.66)	(6.79)
Observations	159334	159286	159286	159286	159286	159286	159286
Instrumentalized Fleet	No	No	Yes	Yes	Yes	Yes	Yes
Instrumentalized NGV Dummy	No	No	Yes	Yes	Yes	Yes	Yes
Station Fixed Effect	No	Yes	Yes	Yes	Yes	Yes	Yes
Time Fixed Effect	No	Yes	Yes	Yes	Yes	Yes	Yes
Brand Fixed Effect	No	No	No	Yes	Yes	Yes	Yes
Kleibergen-Paap LM statistic			98.46	92.00	134.2	111.8	153.9
Kleibergen-Paap LM p-value			3.31e-23	8.68e-22	4.93e-31	3.97e-26	2.49e-35

NOTES: Table displays the estimated effects of shares of NGVs and NG offer by the station on ethanol retail margins. Regressions consider a station *i* located in municipality *m* in week *t* as the unit of analysis, and the sample period goes from January 2002 to June 2008. All prices are expressed in BRL real terms, deflated by the monthly Brazilian CPI (Índice de Preços ao Consumidor Amplo – IPCA). Columns 1-2 are estimated by OLS and columns 3-7 by 2SLS. Columns 2-7 include station and monthly fixed effects and columns 3-7 include station-brand fixed effects as controls. Columns 5 and 7 also include shares of gasoline, ethanol and flex fleet as controls. Finally, column 6 and 7 add yearly municipal GDP per capita (available only until 2015), the NGV fleet divided by the monthly number of stations at the municipality level, and the monthly number of stations at each municipality as controls. The instrument for the share of NGVs is the interaction between a dummy reflecting the availability of piped gas at a given municipality in 2001 and the share of the NGV fleet in the Rio de Janeiro state municipalities not included in our prices database. The instrument for the NG offer by the station dummy is the interaction between the monthly number of stations offering natural gas in the Southeast of Brazil ex-Rio de Janeiro State and a dummy whether a station is less than 20 kilometers from one of Rio de Janeiro's main gas pipelines. Standard errors are clustered by city-month. Shown in parentheses are the t-stats for the coefficients. $^{*}\ p < 0.05$, $^{**}\ p < 0.01$, $^{***}\ p < 0.001$.

8.4 Appendix D. Spatial Analysis

Table 41 – OLS with Driscoll-Kraay Standard Errors: Gasoline Prices 2002-2008

	(1) OLS	(2) OLS	(3) OLS	(4) OLS	(5) OLS	(6) OLS
% NGV Fleet	0.0746	-0.480***	-0.490***	-0.491*	-0.431***	0.132
	(0.19)	(-4.22)	(-4.25)	(-2.29)	(-3.59)	(0.55)
% Gas Fleet				0.0414		0.686*
				(0.16)		(2.42)
% Ethanol Fleet				0.0288		0.455
				(0.06)		(0.84)
% Flex Fleet				-0.624*		0.136
				(-2.35)		(0.43)
GDP per Capita					0.114***	0.113***
					(5.75)	(5.35)
Fleet/Station					-0.0000203*	-0.0000147*
					(-2.59)	(-2.58)
Stations City-month					-0.00000180	-0.00000480***
					(-1.28)	(-3.49)
Observations	116559	116559	116559	116559	107943	107943
Station Fixed Effect	No	Yes	Yes	Yes	Yes	Yes
Time Fixed Effect	No	Yes	Yes	Yes	Yes	Yes
Brand Fixed Effect	No	No	Yes	Yes	Yes	Yes

NOTES: Table displays the estimated effects of shares of NGVs on gasoline retail prices. Regressions consider a station *i* located in municipality *m* in week *t* as the unit of analysis, and the sample period goes from January 2002 to June 2008. All prices are expressed in BRL real terms, deflated by the monthly Brazilian CPI (Índice de Preços ao Consumidor Amplo - IPCA). All coefficients are estimated by a Regression with Driscoll-Kraay standard errors. Columns 1-6, 2-6 and 3-6 include, respectively, station, month and station-brand fixed effects as controls. Columns 4 and 6 also include shares of gasoline, ethanol and flex fleet as controls. Finally, columns 5 and 6 add yearly municipal GDP per capita (available only until 2015), the NGV fleet divided by the monthly number of stations at the municipality level, and the monthly number of stations at each municipality as controls. Shown in parentheses are the t-stats for the coefficients. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table 42 – OLS with Driscoll-Kraay Standard Errors: Gasoline Margins 2002-2008

	(1) OLS	(2) OLS	(3) OLS	(4) OLS	(5) OLS	(6) OLS
% NGV Fleet	-0.420***	-0.366***	-0.366***	-0.529	-0.317**	-0.267
	(-4.47)	(-3.62)	(-3.56)	(-1.86)	(-3.03)	(-0.80)
% Gas Fleet				-0.136		0.126
				(-0.45)		(0.35)
% Ethanol Fleet				-0.268		-0.220
				(-0.47)		(-0.37)
% Flex Fleet				-0.733*		-0.323
				(-2.13)		(-0.73)
GDP per Capita					0.0869***	0.0716***
					(4.77)	(5.42)
Fleet/Station					-0.0000406	-0.00000276
					(-1.05)	(-0.08)
Stations City-month					-0.000000648	-0.00000105
					(-0.48)	(-1.07)
Observations	81188	81188	81188	81188	74580	74580
Station Fixed Effect	No	Yes	Yes	Yes	Yes	Yes
Time Fixed Effect	No	Yes	Yes	Yes	Yes	Yes
Brand Fixed Effect	No	No	Yes	Yes	Yes	Yes

NOTES: Table displays the estimated effects of shares of NGVs on gasoline margins. Regressions consider a station *i* located in municipality *m* in week *t* as the unit of analysis, and the sample period goes from January 2002 to June 2008. All prices are expressed in BRL real terms, deflated by the monthly Brazilian CPI (Índice de Preços ao Consumidor Amplo - IPCA). All coefficients are estimated by a Regression with Driscoll-Kraay standard errors. Columns 1-6, 2-6 and 3-6 include, respectively, station, month and station-brand fixed effects as controls. Columns 4 and 6 also include shares of gasoline, ethanol and flex fleet as controls. Finally, columns 5 and 6 add yearly municipal GDP per capita (available only until 2015), the NGV fleet divided by the monthly number of stations at the municipality level, and the monthly number of stations at each municipality as controls. Shown in parentheses are the t-stats for the coefficients. $^{*}\ p < 0.05$, $^{**}\ p < 0.01$, $^{***}\ p < 0.001$.

Table 43 – OLS with Driscoll-Kraay Standard Errors: Ethanol Prices 2002-2008

	(1) OLS	(2) OLS	(3) OLS	(4) OLS	(5) OLS	(6) OLS
% NGV Fleet	0.854	-0.488*	-0.524*	-0.241	-0.479	-0.506
	(1.42)	(-2.43)	(-2.54)	(-0.52)	(-1.93)	(-0.88)
% Gas Fleet				0.738		0.272
				(1.23)		(0.41)
% Ethanol Fleet				-1.486		-1.436
				(-1.87)		(-1.70)
% Flex Fleet				-0.723		-1.163
				(-1.09)		(-1.60)
GDP per Capita					0.0797*	0.0506
					(2.13)	(1.50)
Fleet/Station					-0.0000219	-0.00000442
					(-1.26)	(-0.14)
Stations City-month					0.00000543	0.00000149
					(1.63)	(0.42)
Observations	108385	108385	108385	108385	100151	100151
Station Fixed Effect	No	Yes	Yes	Yes	Yes	Yes
Time Fixed Effect	No	Yes	Yes	Yes	Yes	Yes
Brand Fixed Effect	No	No	Yes	Yes	Yes	Yes

NOTES: Table displays the estimated effects of shares of NGVs on ethanol retail prices. Regressions consider a station *i* located in municipality *m* in week *t* as the unit of analysis, and the sample period goes from January 2002 to June 2008. All prices are expressed in BRL real terms, deflated by the monthly Brazilian CPI (Índice de Preços ao Consumidor Amplo - IPCA). All coefficients are estimated by a Regression with Driscoll-Kraay standard errors. Columns 1-6, 2-6 and 3-6 include, respectively, station, month and station-brand fixed effects as controls. Columns 4 and 6 also include shares of gasoline, ethanol and flex fleet as controls. Finally, columns 5 and 6 add yearly municipal GDP per capita (available only until 2015), the NGV fleet divided by the monthly number of stations at the municipality level, and the monthly number of stations at each municipality as controls. Shown in parentheses are the t-stats for the coefficients. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table 44 – OLS with Driscoll-Kraay Standard Errors: Ethanol Margins 2002-2008

	(1) OLS	(2) OLS	(3) OLS	(4) OLS	(5) OLS	(6) OLS
% NGV Fleet	-0.729***	-0.507***	-0.507***	-0.556	-0.573***	-1.454**
	(-7.14)	(-3.92)	(-3.92)	(-1.26)	(-3.83)	(-3.25)
% Gas Fleet				-0.0132		-0.907
				(-0.03)		(-1.61)
% Ethanol Fleet				-0.123		-1.420
				(-0.14)		(-1.81)
% Flex Fleet				-0.779		-1.258*
				(-1.55)		(-2.10)
GDP per Capita					0.127***	0.0860*
					(4.47)	(2.18)
Fleet/Station					0.0000633	0.000124
					(0.68)	(1.33)
Stations City-month					0.0000133**	0.0000164**
					(2.83)	(3.18)
Observations	63269	63269	63269	63269	57506	57506
Station Fixed Effect	No	Yes	Yes	Yes	Yes	Yes
Time Fixed Effect	No	Yes	Yes	Yes	Yes	Yes
Brand Fixed Effect	No	No	Yes	Yes	Yes	Yes

NOTES: Table displays the estimated effects of shares of NGVs on ethanol margins. Regressions consider a station *i* located in municipality *m* in week *t* as the unit of analysis, and the sample period goes from January 2002 to June 2008. All prices are expressed in BRL real terms, deflated by the monthly Brazilian CPI (Índice de Preços ao Consumidor Amplo - IPCA). All coefficients are estimated by a Regression with Driscoll-Kraay standard errors. Columns 1-6, 2-6 and 3-6 include, respectively, station, month and station-brand fixed effects as controls. Columns 4 and 6 also include shares of gasoline, ethanol and flex fleet as controls. Finally, columns 5 and 6 add yearly municipal GDP per capita (available only until 2015), the NGV fleet divided by the monthly number of stations at the municipality level, and the monthly number of stations at each municipality as controls. Shown in parentheses are the t-stats for the coefficients. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

8.5 Appendix E. First-Difference

Table 45 – First-Difference - Piped Gas x Bartik RJ: Gasoline Prices 2002-2008

	(1) OLS	(2) 2SLS	(3) 2SLS	(4) 2SLS	(5) 2SLS	(6) 2SLS
% NGV Fleet FD	-0.188	0.0394	0.124	0.301	0.126	0.325
	(-0.46)	(0.05)	(0.17)	(0.38)	(0.17)	(0.41)
% NGV Fleet FE	-0.187	49.77***	50.03***	35.38***	48.58***	31.12***
	(-0.75)	(4.69)	(4.70)	(3.59)	(4.49)	(3.43)
Observations FD	103239	103239	103217	103217	103217	103217
Observations FE	105416	105416	105416	105416	105416	105416
Instrumentalized Fleet	No	Yes	Yes	Yes	Yes	Yes
Time Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes
Brand Fixed Effect	No	No	Yes	Yes	Yes	Yes
Kleibergen-Paap LM statistic FD		10.16	10.15	8.039	10.15	7.962
Kleibergen-Paap LM p-value FD		0.00144	0.00145	0.00458	0.00145	0.00478
Kleibergen-Paap LM statistic FE		32.18	32.53	31.37	29.26	31.32
Kleibergen-Paap LM p-value FE		1.41e-08	1.18e-08	2.13e-08	6.33e-08	2.19e-08

NOTES: Table displays the estimated effects of the shares of NGVs on gasoline retail prices for both First-Difference (FD) and Fixed Effects (FE) for a monthly aggregated dataset. In the case of the FD estimates all variables are first-differenced by month. We only consider first-difference obtained from subsequent months. Regressions consider a station *i* located in municipality *m* in week *t* as the unit of analysis, and the sample period goes from January 2002 to June 2008. All prices are expressed in BRL real terms, deflated by the monthly Brazilian CPI (Índice de Preços ao Consumidor Amplo - IPCA). Column 1 is estimated by OLS and columns 2-6 by 2SLS. Columns 2-6 include monthly fixed effects (or their first-differenced analogue) and columns 3-6 include first-differenced station-brand fixed effects as controls. Columns 2-6 also include station fixed effects for FE estimates. Columns 4 and 6 include shares of gasoline, ethanol and flex fleet (or their first-differenced analogues) as controls. Finally, column 5 and 6 add the yearly municipal GDP per capita (available only until 2015), the NGV fleet divided by the monthly number of stations at the municipality level, and the monthly number of stations at each municipality (or their first-differenced analogues) as controls. The instrument for the share of NGVs is the first-differenced interaction between a dummy reflecting the availability of piped gas at a given municipality in 2001 and the share of the NGV fleet in the Rio de Janeiro state municipalities not included in our prices database. Standard errors are clustered by city-month. Shown in parentheses are the t-stats for the coefficients. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table 46 – First-Difference - Piped Gas x Bartik RJ: Gasoline Margins 2002-2008

	(1) OLS	(2) 2SLS	(3) 2SLS	(4) 2SLS	(5) 2SLS	(6) 2SLS
% NGV Fleet FD	0.182	0.416	0.630	0.682	0.632	0.696
	(0.40)	(0.44)	(0.68)	(0.69)	(0.69)	(0.70)
% NGV Fleet FE	-0.464	38.01***	38.48***	22.07**	39.65***	22.04*
	(-1.72)	(4.28)	(4.29)	(2.77)	(3.62)	(2.44)
Observations FD	58672	58672	58645	58645	58645	58645
Observations FE	72915	72915	72915	72915	72915	72915
Instrumentalized Fleet	No	Yes	Yes	Yes	Yes	Yes
Time Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes
Brand Fixed Effect	No	No	Yes	Yes	Yes	Yes
Kleibergen-Paap LM statistic FD		9.382	9.393	7.078	9.403	7.030
Kleibergen-Paap LM p-value FD		0.00219	0.00218	0.00780	0.00217	0.00802
Kleibergen-Paap LM statistic FE		32.05	32.34	34.73	24.80	28.57
Kleibergen-Paap LM p-value FE		1.51e-08	1.30e-08	3.80e-09	0.000000635	9.04e-08

NOTES: Table displays the estimated effects of the shares of NGVs on gasoline retail marginsfor both First-Difference (FD) and Fixed Effects (FE) for a monthly aggregated dataset. In the case of the FD estimates all variables are first-differenced by month. We only consider first-difference obtained from subsequent months. Regressions consider a station *i* located in municipality *m* in week *t* as the unit of analysis, and the sample period goes from January 2002 to June 2008. All prices are expressed in BRL real terms, deflated by the monthly Brazilian CPI (Índice de Preços ao Consumidor Amplo - IPCA). Column 1 is estimated by OLS and columns 2-6 by 2SLS. Columns 2-6 include monthly fixed effects (or their first-differenced analogue) and columns 3-6 include first-differenced station-brand fixed effects as controls. Columns 2-6 also include station fixed effects for FE estimates. Columns 4 and 6 include shares of gasoline, ethanol and flex fleet (or their first-differenced analogues) as controls. Finally, column 5 and 6 add the yearly municipal GDP per capita (available only until 2015), the NGV fleet divided by the monthly number of stations at the municipality level, and the monthly number of stations at each municipality (or their first-differenced analogues) as controls. The instrument for the share of NGVs is the first-differenced interaction between a dummy reflecting the availability of piped gas at a given municipality in 2001 and the share of the NGV fleet in the Rio de Janeiro state municipalities not included in our prices database. Standard errors are clustered by city-month. Shown in parentheses are the t-stats for the coefficients. $^{*}\ p < 0.05$, $^{**}\ p < 0.01$, $^{***}\ p < 0.001$.

Table 47 – First-Difference - Piped Gas x Bartik RJ: Ethanol Prices 2002-2008

	(1) OLS	(2) 2SLS	(3) 2SLS	(4) 2SLS	(5) 2SLS	(6) 2SLS
% NGV Fleet FD	0.629	0.233	0.247	0.481	0.210	0.295
	(1.00)	(0.17)	(0.19)	(0.37)	(0.16)	(0.23)
% NGV Fleet FE	0.976*	65.93***	68.12***	9.513	62.66***	7.855
	(2.21)	(5.02)	(5.10)	(0.92)	(4.57)	(0.75)
Observations FD	95020	95020	94997	94997	94997	94997
Observations FE	97779	97779	97779	97779	97779	97779
Instrumentalized Fleet	No	Yes	Yes	Yes	Yes	Yes
Time Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes
Brand Fixed Effect	No	No	Yes	Yes	Yes	Yes
Kleibergen-Paap LM statistic FD		10.77	10.75	8.153	10.74	8.065
Kleibergen-Paap LM p-value FD		0.00103	0.00104	0.00430	0.00105	0.00451
Kleibergen-Paap LM statistic FE		33.47	33.85	32.17	30.02	32.42
Kleibergen-Paap LM p-value FE		7.25e-09	5.95e-09	1.42e-08	4.27e-08	1.24e-08

NOTES: Table displays the estimated effects of the shares of NGVs on ethanol retail pricesfor both First-Difference (FD) and Fixed Effects (FE) for a monthly aggregated dataset. In the case of the FD estimates all variables are first-differenced by month. We only consider first-difference obtained from subsequent months. Regressions consider a station *i* located in municipality *m* in week *t* as the unit of analysis, and the sample period goes from January 2002 to June 2008. All prices are expressed in BRL real terms, deflated by the monthly Brazilian CPI (Índice de Preços ao Consumidor Amplo - IPCA). Column 1 is estimated by OLS and columns 2-6 by 2SLS. Columns 2-6 include monthly fixed effects (or their first-differenced analogue) and columns 3-6 include first-differenced station-brand fixed effects as controls. Columns 2-6 also include station fixed effects for FE estimates. Columns 4 and 6 include shares of gasoline, ethanol and flex fleet (or their first-differenced analogues) as controls. Finally, column 5 and 6 add the yearly municipal GDP per capita (available only until 2015), the NGV fleet divided by the monthly number of stations at the municipality level, and the monthly number of stations at each municipality (or their first-differenced analogues) as controls. The instrument for the share of NGVs is the first-differenced interaction between a dummy reflecting the availability of piped gas at a given municipality in 2001 and the share of the NGV fleet in the Rio de Janeiro state municipalities not included in our prices database. Standard errors are clustered by city-month. Shown in parentheses are the t-stats for the coefficients. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table 48 – First-Difference - Piped Gas x Bartik RJ: Ethanol Margins 2002-2008

	(1) OLS	(2) 2SLS	(3) 2SLS	(4) 2SLS	(5) 2SLS	(6) 2SLS
% NGV Fleet FD	0.571	-0.838	-0.598	-0.453	-0.595	-0.426
	(0.65)	(-0.50)	(-0.37)	(-0.25)	(-0.37)	(-0.24)
% NGV Fleet FE	0.0155	69.24***	69.11***	52.25***	77.41***	65.39***
	(0.03)	(4.90)	(4.90)	(3.87)	(3.48)	(3.42)
Observations FD	41267	41267	41239	41239	41239	41239
Observations FE	56105	56105	56105	56105	56105	56105
Instrumentalized Fleet	No	Yes	Yes	Yes	Yes	Yes
Time Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes
Brand Fixed Effect	No	No	Yes	Yes	Yes	Yes
Kleibergen-Paap LM statistic FD		9.865	9.842	6.495	9.928	6.499
Kleibergen-Paap LM p-value FD		0.00168	0.00171	0.0108	0.00163	0.0108
Kleibergen-Paap LM statistic FE		33.12	33.20	31.30	17.55	20.88
Kleibergen-Paap LM p-value FE		8.67e-09	8.34e-09	2.21e-08	0.0000280	0.00000489

NOTES: Table displays the estimated effects of the shares of NGVs on ethanol retail marginsfor both First-Difference (FD) and Fixed Effects (FE) for a monthly aggregated dataset. In the case of the FD estimates all variables are first-differenced by month. We only consider first-difference obtained from subsequent months. Regressions consider a station *i* located in municipality *m* in week *t* as the unit of analysis, and the sample period goes from January 2002 to June 2008. All prices are expressed in BRL real terms, deflated by the monthly Brazilian CPI (Índice de Preços ao Consumidor Amplo - IPCA). Column 1 is estimated by OLS and columns 2-6 by 2SLS. Columns 2-6 include monthly fixed effects (or their first-differenced analogue) and columns 3-6 include first-differenced station-brand fixed effects as controls. Columns 2-6 also include station fixed effects for FE estimates. Columns 4 and 6 include shares of gasoline, ethanol and flex fleet (or their first-differenced analogues) as controls. Finally, column 5 and 6 add the yearly municipal GDP per capita (available only until 2015), the NGV fleet divided by the monthly number of stations at the municipality level, and the monthly number of stations at each municipality (or their first-differenced analogues) as controls. The instrument for the share of NGVs is the first-differenced interaction between a dummy reflecting the availability of piped gas at a given municipality in 2001 and the share of the NGV fleet in the Rio de Janeiro state municipalities not included in our prices database. Standard errors are clustered by city-month. Shown in parentheses are the t-stats for the coefficients. $^{*}\ p < 0.05$, $^{**}\ p < 0.01$, $^{***}\ p < 0.001$.

8.6 Appendix F. CNG Results

Table 49 – IV - Piped Gas x Bartik RJ: CNG Prices 2002-2008

	(1) OLS	(2) OLS	(3) 2SLS	(4) 2SLS	(5) 2SLS	(6) 2SLS	(7) 2SLS
% NGV Fleet	0.714***	0.555**	3.640***	3.373***	9.831**	3.127*	11.92*
	(6.01)	(2.81)	(5.16)	(5.10)	(3.18)	(2.26)	(2.39)
% Gas Fleet					2.313		4.686
					(1.65)		(1.74)
% Ethanol Fleet					21.69***		20.29**
					(4.22)		(3.00)
% Flex Fleet					3.403		5.629
					(1.66)		(1.67)
GDP per Capita						0.286***	0.332***
						(12.73)	(4.47)
Fleet/Station						0.0000422	-0.000115
						(0.54)	(-1.06)
Stations City-month						-0.00000160	-0.0000199
						(-0.58)	(-1.82)
Observations	57533	57426	57426	57426	57426	57426	57426
Instrumentalized Fleet	No	No	Yes	Yes	Yes	Yes	Yes
Station Fixed Effect	No	Yes	Yes	Yes	Yes	Yes	Yes
Time Fixed Effect	No	Yes	Yes	Yes	Yes	Yes	Yes
Brand Fixed Effect	No	No	No	Yes	Yes	Yes	Yes
Kleibergen-Paap LM statistic			39.14	40.55	16.52	10.28	11.23
Kleibergen-Paap LM p-value			3.94e-10	1.92e-10	0.0000481	0.00135	0.000806

NOTES: Table displays the estimated effects of shares of NGVs on CNG retail prices. Regressions consider a station *i* located in municipality *m* in week *t* as the unit of analysis, and the sample period goes from January 2002 to June 2008. All prices are expressed in BRL real terms, deflated by the monthly Brazilian CPI (Índice de Preços ao Consumidor Amplo – IPCA). Columns 1-2 are estimated by OLS and columns 3-7 by 2SLS. Columns 2-7 include station and monthly fixed effects and columns 3-7 include station-brand fixed effects as controls. Columns 5 and 7 also include shares of gasoline, ethanol and flex fleet as controls. Finally, column 6 and 7 add yearly municipal GDP per capita (available only until 2015), the NGV fleet divided by the monthly number of stations at the municipality level, and the monthly number of stations at each municipality as controls. Instrument for the share of NGVs is the interaction between a dummy reflecting the availability of piped gas at a given municipality in 2001 and the share of the NGV fleet in the Rio de Janeiro state municipalities not included in our prices database. Standard errors are clustered by city-month. Shown in parentheses are the t-stats for the coefficients. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table 50 – IV - Piped Gas x Bartik RJ: CNG Margins 2002-2008

	(1) OLS	(2) OLS	(3) 2SLS	(4) 2SLS	(5) 2SLS	(6) 2SLS	(7) 2SLS
% NGV Fleet	0.581***	0.958***	19.53	15.81*	3.251**	-2.530	1.521
	(7.49)	(3.75)	(1.90)	(2.20)	(2.63)	(-0.85)	(1.02)
% Gas Fleet					-1.029		-0.732
					(-1.73)		(-0.85)
% Ethanol Fleet					13.33***		7.056**
					(6.36)		(3.20)
% Flex Fleet					-1.417		-0.759
					(-1.76)		(-0.75)
GDP per Capita						0.454***	0.362***
						(15.01)	(10.38)
Fleet/Station						-0.000140	0.0000241
						(-0.79)	(0.21)
Stations City-month						0.00000737	0.00000285
						(1.51)	(0.49)
Observations	29437	29396	29396	29396	29396	29396	29396
Instrumentalized Fleet	No	No	Yes	Yes	Yes	Yes	Yes
Station Fixed Effect	No	Yes	Yes	Yes	Yes	Yes	Yes
Time Fixed Effect	No	Yes	Yes	Yes	Yes	Yes	Yes
Brand Fixed Effect	No	No	No	Yes	Yes	Yes	Yes
Kleibergen-Paap LM statistic			3.339	4.255	44.15	5.953	67.26
Kleibergen-Paap LM p-value			0.0677	0.0391	3.04e-11	0.0147	2.38e-16

NOTES: Table displays the estimated effects of shares of NGVs on CNG retail margins. Regressions consider a station *i* located in municipality *m* in week *t* as the unit of analysis, and the sample period goes from January 2002 to June 2008. All prices are expressed in BRL real terms, deflated by the monthly Brazilian CPI (Índice de Preços ao Consumidor Amplo – IPCA). Columns 1-2 are estimated by OLS and columns 3-7 by 2SLS. Columns 2-7 include station and monthly fixed effects and columns 3-7 include station-brand fixed effects as controls. Columns 5 and 7 also include shares of gasoline, ethanol and flex fleet as controls. Finally, column 6 and 7 add yearly municipal GDP per capita (available only until 2015), the NGV fleet divided by the monthly number of stations at the municipality level, and the monthly number of stations at each municipality as controls. The instrument for the share of NGVs is the interaction between a dummy reflecting the availability of piped gas at a given municipality in 2001 and the share of the NGV fleet in the Rio de Janeiro state municipalities not included in our prices database. Standard errors are clustered by city-month. Shown in parentheses are the t-stats for the coefficients. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

8.7 Appendix G. Further Analysis - Southeast Fuel Stations Instrument

Table 51 – IV - Piped Gas x Number of Fuel Stations: Gasoline Prices 2002-2008

	(1) OLS	(2) OLS	(3) 2SLS	(4) 2SLS	(5) 2SLS	(6) 2SLS	(7) 2SLS
% NGV Fleet	0.0338	-0.387***	-1.144***	-1.156***	-2.295***	-1.093***	-2.463***
	(0.36)	(-5.93)	(-9.04)	(-9.13)	(-4.97)	(-8.78)	(-4.52)
% Gas Fleet					-1.665***		-1.814***
					(-3.88)		(-3.47)
% Ethanol Fleet					-2.555***		-2.806***
					(-3.75)		(-3.86)
% Flex Fleet					-2.251***		-2.264***
					(-4.97)		(-4.29)
GDP per Capita						0.0974***	0.0266
						(6.63)	(1.48)
Fleet/Station						0.0000176	0.0000125
						(0.91)	(0.64)
Stations City-month						0.00000245*	0.00000522**
						(2.44)	(2.93)
Observations	297522	297489	297489	297489	297489	297489	297489
Instrumentalized Fleet	No	No	Yes	Yes	Yes	Yes	Yes
Station Fixed Effect	No	Yes	Yes	Yes	Yes	Yes	Yes
Time Fixed Effect	No	Yes	Yes	Yes	Yes	Yes	Yes
Brand Fixed Effect	No	No	No	Yes	Yes	Yes	Yes
Kleibergen-Paap LM statistic			297.5	299.1	88.37	306.4	105.3
Kleibergen-Paap LM p-value			1.17e-66	5.15e-67	5.43e-21	1.30e-68	1.07e-24

NOTES: Table displays the estimated effects of shares of NGVs on gasoline retail prices. Regressions consider a station *i* located in municipality *m* in week *t* as the unit of analysis, and the sample period goes from January 2002 to June 2008. All prices are expressed in BRL real terms, deflated by the monthly Brazilian CPI (Índice de Preços ao Consumidor Amplo – IPCA). Columns 1-2 are estimated by OLS and columns 3-7 by 2SLS. Columns 2-7 include station and monthly fixed effects and columns 3-7 include station-brand fixed effects as controls. Columns 5 and 7 also include shares of gasoline, ethanol and flex fleet as controls. Finally, column 6 and 7 add yearly municipal GDP per capita (available only until 2015), the NGV fleet divided by the monthly number of stations at the municipality level, and the monthly number of stations at each municipality as controls. The instrument for the share of NGVs is the interaction between a dummy reflecting the availability of piped gas at a given municipality in 2001 and the number of fuel stations supplying CNG in the Southeastern region of Brazil except Rio de Janeiro. The number of stations was calculated smoothed from the data in our main database. Standard errors are clustered by city-month. Shown in parentheses are the t-stats for the coefficients. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table 52 – IV - Piped Gas x Number of Fuel Stations: Gasoline Margins 2002-2008

	(1) OLS	(2) OLS	(3) 2SLS	(4) 2SLS	(5) 2SLS	(6) 2SLS	(7) 2SLS
% NGV Fleet	-0.543***	-0.329***	-1.001***	-1.007***	-1.715***	-0.972***	-1.869***
	(-14.23)	(-5.42)	(-8.48)	(-8.50)	(-4.58)	(-8.09)	(-4.23)
% Gas Fleet					-1.200***		-1.308**
					(-3.51)		(-3.13)
% Ethanol Fleet					-2.205***		-2.472***
					(-3.80)		(-4.01)
% Flex Fleet					-1.810***		-1.838***
					(-5.03)		(-4.27)
GDP per Capita						0.0847***	0.0230
						(7.68)	(1.68)
Fleet/Station						0.0000959**	0.0000793*
						(2.82)	(2.40)
Stations City-month						0.00000478***	0.00000551**
						(3.81)	(3.08)
Observations	206477	206442	206442	206442	206442	206442	206442
Instrumentalized Fleet	No	No	Yes	Yes	Yes	Yes	Yes
Station Fixed Effect	No	Yes	Yes	Yes	Yes	Yes	Yes
Time Fixed Effect	No	Yes	Yes	Yes	Yes	Yes	Yes
Brand Fixed Effect	No	No	No	Yes	Yes	Yes	Yes
Kleibergen-Paap LM statistic			281.9	283.4	99.02	308.1	118.7
Kleibergen-Paap LM p-value			2.90e-63	1.37e-63	2.50e-23	5.81e-69	1.21e-27

NOTES: Table displays the estimated effects of shares of NGVs on gasoline retail margins. Regressions consider a station *i* located in municipality *m* in week *t* as the unit of analysis, and the sample period goes from January 2002 to June 2008. All prices are expressed in BRL real terms, deflated by the monthly Brazilian CPI (Índice de Preços ao Consumidor Amplo – IPCA). Columns 1-2 are estimated by OLS and columns 3-7 by 2SLS. Columns 2-7 include station and monthly fixed effects and columns 3-7 include station-brand fixed effects as controls. Columns 5 and 7 also include shares of gasoline, ethanol and flex fleet as controls. Finally, column 6 and 7 add yearly municipal GDP per capita (available only until 2015), the NGV fleet divided by the monthly number of stations at the municipality level, and the monthly number of stations at each municipality as controls. The instrument for the share of NGVs is the interaction between a dummy reflecting the availability of piped gas at a given municipality in 2001 and the number of fuel stations supplying CNG in the Southeastern region of Brazil except Rio de Janeiro. The number of stations was calculated smoothed from the data in our main database. Standard errors are clustered by city-month. Shown in parentheses are the t-stats for the coefficients. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table 53 – IV - Piped Gas x Number of Fuel Stations: Ethanol Prices 2002-2008

	(1) OLS	(2) OLS	(3) 2SLS	(4) 2SLS	(5) 2SLS	(6) 2SLS	(7) 2SLS
% NGV Fleet	0.547***	-0.417***	-1.342***	-1.407***	-1.235	-1.356***	-1.495
	(3.98)	(-4.68)	(-5.59)	(-5.83)	(-1.70)	(-5.90)	(-1.74)
% Gas Fleet					-0.405		-0.658
					(-0.62)		(-0.82)
% Ethanol Fleet					-2.531*		-2.824*
					(-2.30)		(-2.42)
% Flex Fleet					-1.841*		-1.956*
					(-2.51)		(-2.31)
GDP per Capita						0.0523	0.00909
						(1.85)	(0.29)
Fleet/Station						0.0000428	0.0000294
						(0.96)	(0.69)
Stations City-month						0.0000102***	0.00000693*
						(4.69)	(2.16)
Observations	277246	277201	277201	277201	277201	277201	277201
Instrumentalized Fleet	No	No	Yes	Yes	Yes	Yes	Yes
Station Fixed Effect	No	Yes	Yes	Yes	Yes	Yes	Yes
Time Fixed Effect	No	Yes	Yes	Yes	Yes	Yes	Yes
Brand Fixed Effect	No	No	No	Yes	Yes	Yes	Yes
Kleibergen-Paap LM statistic			312.7	315.2	95.00	323.0	114.1
Kleibergen-Paap LM p-value			5.51e-70	1.62e-70	1.90e-22	3.17e-72	1.26e-26

NOTES: Table displays the estimated effects of shares of NGVs on ethanol retail prices. Regressions consider a station *i* located in municipality *m* in week *t* as the unit of analysis, and the sample period goes from January 2002 to June 2008. All prices are expressed in BRL real terms, deflated by the monthly Brazilian CPI (Índice de Preços ao Consumidor Amplo – IPCA). Columns 1-2 are estimated by OLS and columns 3-7 by 2SLS. Columns 2-7 include station and monthly fixed effects and columns 3-7 include station-brand fixed effects as controls. Columns 5 and 7 also include shares of gasoline, ethanol and flex fleet as controls. Finally, column 6 and 7 add yearly municipal GDP per capita (available only until 2015), the NGV fleet divided by the monthly number of stations at the municipality level, and the monthly number of stations at each municipality as controls. The instrument for the share of NGVs is the interaction between a dummy reflecting the availability of piped gas at a given municipality in 2001 and the number of fuel stations supplying CNG in the Southeastern region of Brazil except Rio de Janeiro. The number of stations was calculated smoothed from the data in our main database. Standard errors are clustered by city-month. Shown in parentheses are the t-stats for the coefficients. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table 54 – IV - Piped Gas x Number of Fuel Stations: Ethanol Margins 2002-2008

	(1) OLS	(2) OLS	(3) 2SLS	(4) 2SLS	(5) 2SLS	(6) 2SLS	(7) 2SLS
% NGV Fleet	-0.697***	-0.394***	-1.260***	-1.249***	-2.805***	-1.212***	-3.553***
	(-19.17)	(-5.03)	(-6.70)	(-6.65)	(-4.47)	(-6.91)	(-5.28)
% Gas Fleet					-2.210***		-2.861***
					(-3.86)		(-4.45)
% Ethanol Fleet					-3.335***		-4.386***
					(-3.37)		(-4.59)
% Flex Fleet					-2.832***		-3.067***
					(-4.57)		(-4.64)
GDP per Capita						0.130***	0.0288
						(6.68)	(1.12)
Fleet/Station						0.000263**	0.000241**
						(3.19)	(2.76)
Stations City-month						0.0000203***	0.0000256***
						(6.62)	(6.50)
Observations	159334	159286	159286	159286	159286	159286	159286
Instrumentalized Fleet	No	No	Yes	Yes	Yes	Yes	Yes
Station Fixed Effect	No	Yes	Yes	Yes	Yes	Yes	Yes
Time Fixed Effect	No	Yes	Yes	Yes	Yes	Yes	Yes
Brand Fixed Effect	No	No	No	Yes	Yes	Yes	Yes
Kleibergen-Paap LM statistic			287.6	289.9	101.0	306.7	121.3
Kleibergen-Paap LM p-value			1.63e-64	5.21e-65	9.11e-24	1.17e-68	3.25e-28

NOTES: Table displays the estimated effects of shares of NGVs on ethanol retail margins. Regressions consider a station *i* located in municipality *m* in week *t* as the unit of analysis, and the sample period goes from January 2002 to June 2008. All prices are expressed in BRL real terms, deflated by the monthly Brazilian CPI (Índice de Preços ao Consumidor Amplo – IPCA). Columns 1-2 are estimated by OLS and columns 3-7 by 2SLS. Columns 2-7 include station and monthly fixed effects and columns 3-7 include station-brand fixed effects as controls. Columns 5 and 7 also include shares of gasoline, ethanol and flex fleet as controls. Finally, column 6 and 7 add yearly municipal GDP per capita (available only until 2015), the NGV fleet divided by the monthly number of stations at the municipality level, and the monthly number of stations at each municipality as controls. The instrument for the share of NGVs is the interaction between a dummy reflecting the availability of piped gas at a given municipality in 2001 and the number of fuel stations supplying CNG in the Southeastern region of Brazil except Rio de Janeiro. The number of stations was calculated smoothed from the data in our main database. Standard errors are clustered by city-month. Shown in parentheses are the t-stats for the coefficients. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

8.8 Appendix H. Further Analysis - No Neighbour's Instrument

Table 55 – IV - Piped Gas x Bartik RJ ex-Neighbours: Gasoline Prices 2002-2008

	(1) OLS	(2) OLS	(3) 2SLS	(4) 2SLS	(5) 2SLS	(6) 2SLS	(7) 2SLS
% NGV Fleet	0.0338	-0.387***	-1.178***	-1.185***	-3.171***	-1.102***	-2.996***
	(0.36)	(-5.93)	(-9.38)	(-9.44)	(-4.75)	(-9.10)	(-4.60)
% Gas Fleet					-2.449***		-2.315***
					(-4.00)		(-3.73)
% Ethanol Fleet					-3.862***		-3.517***
					(-4.03)		(-4.14)
% Flex Fleet					-3.087***		-2.773***
					(-4.77)		(-4.40)
GDP per Capita						0.0976***	0.0135
						(6.67)	(0.67)
Fleet/Station						0.0000181	0.0000178
						(0.92)	(0.79)
Stations City-month						0.00000248*	0.00000678**
						(2.43)	(3.22)
Observations	297522	297489	297489	297489	297489	297489	297489
Instrumentalized Fleet	No	No	Yes	Yes	Yes	Yes	Yes
Station Fixed Effect	No	Yes	Yes	Yes	Yes	Yes	Yes
Time Fixed Effect	No	Yes	Yes	Yes	Yes	Yes	Yes
Brand Fixed Effect	No	No	No	Yes	Yes	Yes	Yes
Kleibergen-Paap LM statistic			331.5	334.4	84.27	340.6	111.5
Kleibergen-Paap LM p-value			4.56e-74	1.07e-74	4.31e-20	4.69e-76	4.69e-26

NOTES: Table displays the estimated effects of shares of NGVs on gasoline retail prices. Regressions consider a station *i* located in municipality *m* in week *t* as the unit of analysis, and the sample period goes from January 2002 to June 2008. All prices are expressed in BRL real terms, deflated by the monthly Brazilian CPI (Índice de Preços ao Consumidor Amplo – IPCA). Columns 1-2 are estimated by OLS and columns 3-7 by 2SLS. Columns 2-7 include station and monthly fixed effects and columns 3-7 include station-brand fixed effects as controls. Columns 5 and 7 also include shares of gasoline, ethanol and flex fleet as controls. Finally, column 6 and 7 add yearly municipal GDP per capita (available only until 2015), the NGV fleet divided by the monthly number of stations at the municipality level, and the monthly number of stations at each municipality as controls. Instrument for the share of NGVs is the interaction between a dummy reflecting the availability of piped gas at a given municipality in 2001 and the share of the NGV fleet in the Rio de Janeiro state municipalities that have at least two spatial lags rom the instrumented municipality. Standard errors are clustered by city-month. Shown in parentheses are the t-stats for the coefficients. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table 56 – IV - Piped Gas x Bartik RJ ex-Neighbours: Gasoline Margins 2002-2008

	(1) OLS	(2) OLS	(3) 2SLS	(4) 2SLS	(5) 2SLS	(6) 2SLS	(7) 2SLS
% NGV Fleet	-0.543***	-0.329***	-0.995***	-1.000***	-2.062***	-0.938***	-2.025***
	(-14.23)	(-5.42)	(-8.57)	(-8.60)	(-4.12)	(-8.10)	(-3.96)
% Gas Fleet					-1.508***		-1.454**
					(-3.32)		(-3.02)
% Ethanol Fleet					-2.746***		-2.689***
					(-3.71)		(-3.88)
% Flex Fleet					-2.138***		-1.988***
					(-4.49)		(-4.02)
GDP per Capita						0.0837***	0.0192
						(7.63)	(1.29)
Fleet/Station						0.0000904**	0.0000836*
						(2.68)	(2.43)
Stations City-month						0.00000456***	0.00000603**
						(3.61)	(2.98)
Observations	206477	206442	206442	206442	206442	206442	206442
Instrumentalized Fleet	No	No	Yes	Yes	Yes	Yes	Yes
Station Fixed Effect	No	Yes	Yes	Yes	Yes	Yes	Yes
Time Fixed Effect	No	Yes	Yes	Yes	Yes	Yes	Yes
Brand Fixed Effect	No	No	No	Yes	Yes	Yes	Yes
Kleibergen-Paap LM statistic			318.3	321.6	98.26	350.8	126.3
Kleibergen-Paap LM p-value			3.40e-71	6.35e-72	3.67e-23	2.81e-78	2.70e-29

NOTES: Table displays the estimated effects of shares of NGVs on gasoline retail margins. Regressions consider a station *i* located in municipality *m* in week *t* as the unit of analysis, and the sample period goes from January 2002 to June 2008. All prices are expressed in BRL real terms, deflated by the monthly Brazilian CPI (Índice de Preços ao Consumidor Amplo – IPCA). Columns 1-2 are estimated by OLS and columns 3-7 by 2SLS. Columns 2-7 include station and monthly fixed effects and columns 3-7 include station-brand fixed effects as controls. Columns 5 and 7 also include shares of gasoline, ethanol and flex fleet as controls. Finally, column 6 and 7 add yearly municipal GDP per capita (available only until 2015), the NGV fleet divided by the monthly number of stations at the municipality level, and the monthly number of stations at each municipality as controls. Instrument for the share of NGVs is the interaction between a dummy reflecting the availability of piped gas at a given municipality in 2001 and the share of the NGV fleet in the Rio de Janeiro state municipalities that have at least two spatial lags rom the instrumented municipality. Standard errors are clustered by city-month. Shown in parentheses are the t-stats for the coefficients. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table 57 – IV - Piped Gas x Bartik RJ ex-Neighbours: Ethanol Prices 2002-2008

	(1) OLS	(2) OLS	(3) 2SLS	(4) 2SLS	(5) 2SLS	(6) 2SLS	(7) 2SLS
% NGV Fleet	0.547***	-0.417***	-1.411***	-1.447***	-1.525	-1.267***	-1.380
	(3.98)	(-4.68)	(-6.51)	(-6.66)	(-1.80)	(-6.60)	(-1.67)
% Gas Fleet					-0.665		-0.550
					(-0.87)		(-0.71)
% Ethanol Fleet					-2.959*		-2.670*
					(-2.38)		(-2.41)
% Flex Fleet					-2.121*		-1.845*
					(-2.52)		(-2.28)
GDP per Capita						0.0501	0.0119
						(1.77)	(0.39)
Fleet/Station						0.0000380	0.0000283
						(0.90)	(0.67)
Stations City-month						0.00000991***	0.00000661*
						(4.84)	(2.12)
Observations	277246	277201	277201	277201	277201	277201	277201
Instrumentalized Fleet	No	No	Yes	Yes	Yes	Yes	Yes
Station Fixed Effect	No	Yes	Yes	Yes	Yes	Yes	Yes
Time Fixed Effect	No	Yes	Yes	Yes	Yes	Yes	Yes
Brand Fixed Effect	No	No	No	Yes	Yes	Yes	Yes
Kleibergen-Paap LM statistic			344.1	348.1	92.27	356.4	119.3
Kleibergen-Paap LM p-value			8.08e-77	1.11e-77	7.55e-22	1.68e-79	8.98e-28

NOTES: Table displays the estimated effects of shares of NGVs on ethanol retail prices. Regressions consider a station *i* located in municipality *m* in week *t* as the unit of analysis, and the sample period goes from January 2002 to June 2008. All prices are expressed in BRL real terms, deflated by the monthly Brazilian CPI (Índice de Preços ao Consumidor Amplo – IPCA). Columns 1-2 are estimated by OLS and columns 3-7 by 2SLS. Columns 2-7 include station and monthly fixed effects and columns 3-7 include station-brand fixed effects as controls. Columns 5 and 7 also include shares of gasoline, ethanol and flex fleet as controls. Finally, column 6 and 7 add yearly municipal GDP per capita (available only until 2015), the NGV fleet divided by the monthly number of stations at the municipality level, and the monthly number of stations at each municipality as controls. Instrument for the share of NGVs is the interaction between a dummy reflecting the availability of piped gas at a given municipality in 2001 and the share of the NGV fleet in the Rio de Janeiro state municipalities that have at least two spatial lags rom the instrumented municipality. Standard errors are clustered by city-month. Shown in parentheses are the t-stats for the coefficients. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table 58 – IV - Piped Gas x Bartik RJ ex-Neighbours: Ethanol Margins 2002-2008

	(1) OLS	(2) OLS	(3) 2SLS	(4) 2SLS	(5) 2SLS	(6) 2SLS	(7) 2SLS
% NGV Fleet	-0.697***	-0.394***	-1.185***	-1.194***	-3.235***	-0.963***	-2.829***
	(-19.17)	(-5.03)	(-6.59)	(-6.62)	(-4.41)	(-6.18)	(-4.22)
% Gas Fleet					-2.588***		-2.194***
					(-3.87)		(-3.42)
% Ethanol Fleet					-4.028***		-3.342***
					(-3.58)		(-3.55)
% Flex Fleet					-3.231***		-2.384***
					(-4.47)		(-3.63)
GDP per Capita						0.122***	0.0453
						(6.38)	(1.73)
Fleet/Station						0.000222**	0.000220**
						(2.89)	(2.65)
Stations City-month						0.0000186***	0.0000232***
						(6.39)	(5.96)
Observations	159334	159286	159286	159286	159286	159286	159286
Instrumentalized Fleet	No	No	Yes	Yes	Yes	Yes	Yes
Station Fixed Effect	No	Yes	Yes	Yes	Yes	Yes	Yes
Time Fixed Effect	No	Yes	Yes	Yes	Yes	Yes	Yes
Brand Fixed Effect	No	No	No	Yes	Yes	Yes	Yes
Kleibergen-Paap LM statistic			316.4	320.4	97.72	339.9	123.0
Kleibergen-Paap LM p-value			8.91e-71	1.21e-71	4.83e-23	6.70e-76	1.36e-28

NOTES: Table displays the estimated effects of shares of NGVs on ethanol retail margins. Regressions consider a station *i* located in municipality *m* in week *t* as the unit of analysis, and the sample period goes from January 2002 to June 2008. All prices are expressed in BRL real terms, deflated by the monthly Brazilian CPI (Índice de Preços ao Consumidor Amplo – IPCA). Columns 1-2 are estimated by OLS and columns 3-7 by 2SLS. Columns 2-7 include station and monthly fixed effects and columns 3-7 include station-brand fixed effects as controls. Columns 5 and 7 also include shares of gasoline, ethanol and flex fleet as controls. Finally, column 6 and 7 add yearly municipal GDP per capita (available only until 2015), the NGV fleet divided by the monthly number of stations at the municipality level, and the monthly number of stations at each municipality as controls. Instrument for the share of NGVs is the interaction between a dummy reflecting the availability of piped gas at a given municipality in 2001 and the share of the NGV fleet in the Rio de Janeiro state municipalities that have at least two spatial lags rom the instrumented municipality. Standard errors are clustered by city-month. Shown in parentheses are the t-stats for the coefficients. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

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