*Natural Gas Vehicles: Consequences to Fuel Markets and the Environment*

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# Overview

The search for alternative and more efficient energy sources has taken center stage in response to recurrent wars, oil price shocks, geopolitical concerns, and, more recently, climate change. Part of the solution relies on new technologies, which are capable of transforming market structures and the environment. As a pressing issue, governments worldwide have promoted policies to foster technology adoption that augment fuel efficiency and reduce fuel consumption and emissions, with mixed implications for welfare. Among the initiatives to promote fuel substitution, the expansion of markets for natural gas vehicles (NGVs) deserves attention.

Natural gas is deemed a realistic fuel option for economic and environmental reasons: its price is relatively low, it is simple and affordable to convert cars to run on natural gas, and NGVs emit less CO2 when compared to gasoline-powered vehicles. Despite the extensive literature on alternative fuels, the implications of the growth of the market for NGVs are relatively under-explored.

We use an instrumental variables (IV) strategy to estimate how the expansion of the NGV fleet promoted by past Brazilian governments has affected the prices of gasoline and ethanol, the two main competitors of natural gas for vehicles, and the consequences of these price shifts on greenhouse gas emissions and other air pollutants. We focus on Rio de Janeiro, the Brazilian state with the largest NGV fleet in the country. The analysis can provide insights into local market power, which affects total fuel consumption and emissions and may need to be anticipated in the design of policies.

If a driver converts her car to run on natural gas, a generally cheaper fuel, she will demand less gasoline or ethanol. However, increased

competition may lower gasoline and ethanol prices, leading to higher fuel consumption in the intensive margin. Furthermore, lower natural gas prices may incentivize NGV drivers to use their cars more intensively. Therefore, the final impact of CNG on prices and margins of other fuels, and the contribution of these effects to emissions, is an empirical question that depends on dynamic adjustments in supply and market power by fuel stations.

This paper contributes to an extensive and growing literature on the effects of policies to stimulate the adoption of cleaner vehicles and how these policies interact with market characteristics. To the best of our knowledge, this is the first paper to causally estimate the linkages between NGVs, competition between alternative fuels, and the environment.

**Methods**

Our primary source of identification is the variation of fuel prices and margins at the fuel station level. We use a detailed panel database of weekly fuel prices between 2001 and 2016 for a large sample of municipalities in Rio de Janeiro, the Brazilian state with the largest NGV fleet. We complement the data with monthly information on fleet size by fuel type at the municipality level.

Our regression specification is the following: Ysmw = β1*NGV Share*mt + β2Xsmt + πs + πt + λb + εsmw. Where *s* indexes the station, *m* indexes the municipality, *w* indexes the week-year period, and *t* indexes the month-year period. Ysmw is the outcome of interest, which can be gas prices, gas margins, ethanol prices, or ethanol margins at a given station, month, and municipality. *NGV Share*mt is the relative size of the monthly NGV fleet to the total fleet in a given municipality at time t (changing at monthly frequency), so $\beta\_1$ is our coefficient of interest. Xsmt is a set of controls including municipality, market, and fleet composition characteristics. πs, πt and λb are, respectively, station, time, and station's brand fixed effects. εsmw is an error term.

In order to deal with the potential simultaneity arising from the impact of gasoline and ethanol prices on the incentive to convert vehicles to run on CNG, we employ an IV strategy. Our instrument is given by the following equation: IVmt = *Fleet RJ*t . *I{Piped Gas}*m. Where *Fleet RJ*t is the contemporaneous share of NGVs among out-of-sample municipalities and *I{Piped Gas}*m is a dummy indicating if a municipality in our sample had access to piped gas in 2002. The first term captures a non-local component of the growth of the NGV fleet that is driven, for example, by the discovery of new technologies that make engine conversion to CNG cheaper and more efficient but are not influenced by local fuel price shocks. The second term of the interaction acts as a supply shifter. While stations in municipalities with access to piped natural gas will offer CNG supplied by this network, 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 a larger NGV fleet. We believe the dummy for municipalities with access to piped gas in 2002 does not suffer from reverse causality for two reasons. First, we consider municipalities' access to piped natural gas in the beginning of our period of analysis (2002), we expect these concerns to be attenuated. Second, distribution services of natural gas in Rio de Janeiro were privatized in 1997, and future expansions of the piped natural gas infrastructure were set by contract in that year. Privatization happened little after NGVs were approved in Brazil (1996) when they were still uncommon (and remained like this until the early 2000s)

# Results

We hypothesize that as the NGV fleet expanded, the demand for gasoline and ethanol dropped, leading to lower prices. We expect the price adjustment to happen via fuel station margins, given that fuel prices set by upstream distribution and production companies might not have been entirely responsive to market incentives. We show that an increase in the NGV fleet led to a fall in the prices and margins of gasoline and ethanol. The results are robust to several different specifications. In particular, our baseline specification shows that a one p.p. increase in the NGV fleet led to a fall in gasoline and ethanol prices of 1.2 and 0.5 cents of Brazilian Reais, respectively. Retail margins also fell significantly, suggesting some degree of market power by local fuel retailers. The results are robust to several specifications and robustness checks.

We also provide evidence of the environmental consequences of the NGV fleet growth motivated by changes in the prices of gasoline and ethanol. Because information on fuel sales at the station level is not available, we use a wide range of elasticities from the literature

and simplifying assumptions to produce back-of-the-envelope calculations for the resulting emissions of GHGs and other air pollutants in the state of Rio de Janeiro in 2008. The decrease in gasoline and ethanol prices due to the expanding NGV fleet should boost the consumption of these fuels. Our calculations for GHGs suggest that emissions increased between 12,759 and 193,614 tonnes of carbon dioxide equivalent over 2008, challenging the view that they are beneficial to the environment. Considering a social cost of carbon (SCC) of USD 51 per tonne of CO2 , this corresponds to an aggregate SCC between USD 0.6 MM and USD 9 MM (in 2008 dollars). Emissions of other air pollutants affecting human health have also increased. Hence, we describe two counteracting channels through which the growth of NGVs and competition in the fuel market impacted welfare: (i) the decrease in fuel prices benefits consumers, and (ii) the increase in emissions brings down welfare.

**Conclusions**

Our results underscore the importance of market forces and market power in designing policies to reduce emissions, a topic gaining momentum worldwide. In a broadly related subject, the European Commission is currently considering promoting environmental sustainability by relaxing anti-competitive policies in Article 101(3) of the Treaty on the Functioning of the European Union. The literature on how alternative cleaner fuels affect equilibrium prices and quantities of incumbent energy sources is still developing, and we bring new insights from a large CNG market.

# References

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