On the tax incidence of fuel taxes in developing countries: evidence from a natural experiment in Argentina *

Guillermo Falcone Francisco Pizzi Jorge Puig

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Abstract

We exploited an exogenous reform in the fuel tax that implied a tax reduction close to 35 percent on the tax burden of gasoline. Interestingly, given that the bulk of the available evidence is for developed countries, the case study is Argentina. Using a difference-in-differences approach answer how much of the tax reduction was shifted to consumers (i.e. the pass-through) and how consumption responded. Results indicate that the pass-through, although considerable, is not full (i.e., around 73 percent in gasoline and 86 percent in diesel). The increase in consumption due to lower prices ranges between 15 and 18 percent depending on the type of fuel. Interestingly the effects are immediate (i.e., they take place in the month of the reform and remain stable in the following months). The brand of fuel does not seem to be a key factor for the pass-through despite the fact that two brands account for 75 percent of the fuel market. Cross-border shopping does not seem to play a significant role in the shifting of the tax on fuel prices. Neither in the reaction of consumption. The results are robust to a battery of sensitivity analyses and contribute for a better understanding on the incidence of fuel taxation which is fundamental to assess political, budgetary, welfare and other (health, environmental, etc.) implications of tax reforms.

JEL Codes: H2, H22, H32.

Keywords: Taxation, fuel consumption, Pass-through, Difference in differences.

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1 Introduction

In November 2015, Argentine government expanded a tax exemption zone on the fuel tax. Interestingly, this tax change established a tax border: gas stations located south of the border were fuel tax exempt, experimenting a tax reduction on gasoline and diesel. Before the exemption, these gas stations taxed gasoline at an ad valorem rate of 55.8 percent, and diesel at 17.1 percent. A remarkable feature of this tax reduction is that it was not due to a reaction in market conditions. That is, it was purely exogenous. The government pointed out that this decision "[w]ill help offset the high production costs in the oil basins, from where 90% of the country's hydrocarbons are extracted, including non-conventional ones, which require large transfers of materials". Taking advantage of the size and the exogeneity of this tax change, in this paper we analyze both the tax pass-through of fuel taxes, and changes in total consumption by using a rich database at the gas station level.

The tax reform differentially affected gas stations that were located south of the border ("treated") and gas stations that were north of the border ("control"), allowing for a pre–post comparison between them. The tax reform implied significant price changes. Before the reform, a liter of gasoline cost -on average- of 15.6 pesos on both sides of the tax border. After December 2015, the retail price of a liter of gasoline in the north was 15.0 pesos, while in the south was 11.4 pesos. This implies a price reduction of near 25 percent in gasoline retail prices at stations in the south. Similarly, the retail price of diesel was reduced by approximately 7 percent. In terms of the tax burden in the retail price of fuels, it was reduced by 35.8 (11.0) percent in the case of gasoline (diesel). In this context, the Argentine tax reduction allows for price and sales responses that are large enough to be detectable with firm level data. Specifically, in this paper we ask how much of the lower prices -due to lower taxes- was shifted to consumers (i.e. the pass-through). We also inquire about the responses of the consumed quantities.

For identification, we use a difference-in-differences approach and compare exempted and non-exempted gas stations. Our empirical setting has the advantage of using firm-level (i.e., gas stations) data, which can capture the true impact of an exogenous tax change on domestic consumer prices and sales more accurately. The rich nature of the database allows us to capture differential effects across gas stations within a given province or state, thus avoiding potential confounding effects when using aggregate-level data. As we also count with gas stations' locations and their distance to the tax border, we study spatial heterogeneity in tax incidence across geographical areas, which is relevant given that this type of tax change may affect the incentives of consumers located in the north to cross-border shopping. Finally, as the monthly database covers the period

between January 2015 and December 2016, we also checks for the evolution of prices and sales over each month after the tax exemption and tests whether the changes in those outcomes are permanent or just temporary.

The main findings of the paper can be summarized as follows. The pass-through of lower taxes, although considerable, is not full. The pass-through to consumers is of the order of 73 percent in gasoline and 86 percent in diesel. The increase in consumption due to lower prices ranges between 15 and 18 percent depending on the type of fuel. Interestingly the effects are immediate. That is, they take place in the month of the reform and remain stable in the following months. The brand of fuel does not seem to be a key factor for the pass-through despite the fact that two brands account for 75 percent of the fuel market in Argentina. Cross-border shopping does not seem to play a significant role in the shifting of the tax on fuel prices. Neither in the reaction of consumption. The results are robust to a battery of sensitivity analyses and contribute for a better understanding on the incidence of fuel taxation which is fundamental to assess political, budgetary, welfare and other (health, environmental, etc.) implications of tax reforms (Bajo-Buenestado & Borrella-Mas, 2019). This is also important to identify how the tax burden is distributed in the population (Hindriks & Serse, 2019).

Our study contributes to the empirical literature on the tax incidence of fuel taxes. As in Bajo-Buenestado & Borrella-Mas (2019) the evidence applies to a specific context: an industry with geographically differentiated firms selling a homogeneous product. Within the existing literature, we believe that the analysis is valuable and contributes in several dimensions given the rich nature of the data and the country under analysis. First, the data allows us to look at gas stations on both sides of the tax border. Second, we have data on sales at the firm level, which allows us to perform an analysis on quantities. Interestingly, this was not possible in closely related contributions. For example, Bajo-Buenestado & Borrella-Mas (2019) analyze the incidence of a change in the Portuguese fuel tax on Spanish fuel prices using firm level data from Spanish gas station on fuel prices, their locations, and their distance to the Portuguese border. This paper does not count with information on gas stations in Portugal. In addition, although having data on sales in Spain, this information is at the province level. Doyle & Samphantharak (2008) use data of daily prices at the gas station level to estimate the impact of a temporary fuel tax change in Illinois and Indiana on the retail price of fuel. This paper observes gas stations on both sides of the border, but it does not have data on fuel sales. A similar observation on data limitation applies to Coyne (2017) that compares how prices respond to changes in fuel taxes conditional on distance to an out-of-state competitor for a sample of over 137,000 stations in the United States. Third, most of the contributions are made to the United States or European countries, including those papers that use more aggregate data at the state-level (Chouinard & Perloff, 2004; Alm *et al.*,

2009; Marion & Muehlegger, 2011). In this sense, our paper represents a unique opportunity to obtain estimates for developing countries, like Argentina, where the empirical evidence is null.

The rest of the paper is organized as follows. In Section 2, we provide a review of the relevant empirical literature and identify our contribution. In Section 3, we introduce the tax change that we exploit in this paper and we describe the data. In Section 4 we describe the methodological framework, while in Section 5 we report the main results, and several robustness tests. Extensions incorporating context conditional results are presented in Section **??**. Section 6 concludes.

2 Related literature

This paper contributes to the empirical literature on sales tax incidence. Given the studied commodity (i.e., fuel), the nature of the data (i.e., firm-level data), and the type of experiment used for identification, the paper is directly related to three previous contributions. First, to Doyle & Samphantharak (2008) that study the effects of cross-border competition on the gasoline tax shifting to retail prices. Using data of daily prices at the gas station level this paper estimates the impact of a temporary suspension, and subsequent reinstatement, of the gasoline sales tax in Illinois and Indiana on the retail price of gasoline, which followed a price spike in the spring of 2000. As we do in this paper, Doyle & Samphantharak (2008) adopt a difference-in-differences approach by using the gasoline retail price of neighboring states as a control group. They find that pass-through rates are between 60 to 80 percent in general, and suggest a smaller tax shift for gas stations close to the border, especially for the tax reinstatement. Second, to Coyne (2017) that compare how prices respond to changes in fuel taxes in the United States, conditional on the distance to an out-of-state competitor. Using retail price data at the gas station level and their corresponding location, shows that gas stations do indeed pass through a different proportion of a tax hike depending on how close they are located to a state border. In particular, stations within 10 miles of an out-of-state competitor pass about 93 percent of a tax through to prices. This pass-through increases with distance to an out-of-state competitor. Third, to Bajo-Buenestado & Borrella-Mas (2019) that study the effect of a change in the Portuguese fuel (in February 2016) tax on Spanish fuel prices. This paper uses data on prices for Spanish gas station only, their location, and their distances to the Portuguese border, and also adopt a difference-in-differences strategy.[1] Results show that the tax increase in the Portuguese fuel excise duty had an impact on Spanish

[1]They define "treated" gas stations – as those that are "close to the border" – and "control" gas stations — as those that are not "close to the border".

fuel prices across the border. In particular, a 20.5 (8.33) percent cross-border pass-through rate for diesel (gasoline) prices. This impact tends to vanish as gas stations are located further away from the Portuguese–Spanish border. Intuitively, gas stations that are close to the border are those that Portuguese citizens may use to arbitrage fuels across countries.

Given that Doyle & Samphantharak (2008), Coyne (2017), and Bajo-Buenestado & Borrella-Mas (2019) focus on developed countries (i.e., United States and Spain, respectively) our paper complements them with evidence for a developing country like Argentina. To the best of our knowledge, our paper is the first contribution with causal evidence for a developing country. More importantly, our paper analyzes the effects on both prices and sales. This is not the norm in previous papers due data limitations. In the case of Doyle & Samphantharak (2008), they do not have quantity data at the station level (see footnote 7 in this paper), while Bajo-Buenestado & Borrella-Mas (2019) has data on monthly sales at the province level (see page 6 in this paper).

Other contributions -mostly focused on the United States- provide evidence regarding the incidence of gasoline taxes on retail prices but using state-level variation in taxes and prices. Chouinard & Perloff (2004) find that 50 (75) percent of the federal excise (ad-valorem) tax is passed through to prices. Alm *et al.* (2009) indicate full shifting of gasoline taxes to the final consumer. Marion & Muehlegger (2011) indicate that state taxes are fully (and rapidly) passed on to consumers but the pass-through rate of fuel taxes declines in periods of time when the supply chain is constrained. Louis & Taylor (2016) fails to reject full pass-through of the amount of the tax increase to retail prices in both products.[2] Regarding this body of evidence our paper has the advantage of using firm-level data that avoid potential confounding effects when using aggregate-level data.

Despite not analyzing the same commodity as we do, two recent contributions are closely related with our paper. Hindriks & Serse (2019), which analyzes the excise tax increase on alcoholic beverages in Belgium during November 2015. Using data at the store level on the retail price of six major brands of spirits and a difference-in-differences method, the paper shows that the alcohol tax reform was mostly over-shifted to the retail price. In addition, since the authors have data on each store location, they show spatial variations in the tax pass-through for homogeneous products. These variations are strongly related to the intensity of local competition and to a lesser extent to the proximity to the borders (mainly with Luxembourg). Like this contribution we also test if not only the pass-through but also the reaction of sales are related to the intensity of local competition

[2]This paper also finds no significant sensitivity of retail pass-through to station locations relative to state borders or to retail competitive conditions as measured by local station density. The expansion of hypermarkets in Washington State during the period was a confounding factor in estimating tax pass-through effects.

and to the proximity to the borders. Gehrsitz *et al.* (2021), which derive causal estimates from a natural experiment in Illinois where spirits and wine taxes were raised sharply and unexpectedly in 2009. Using several difference-in-differences models, this paper is one of the few that looks at both the effects of a tax change on prices and sales with firm-level data. Results show that alcohol excise taxes are instantly over-shifted and that consumers react by switching to less expensive products.

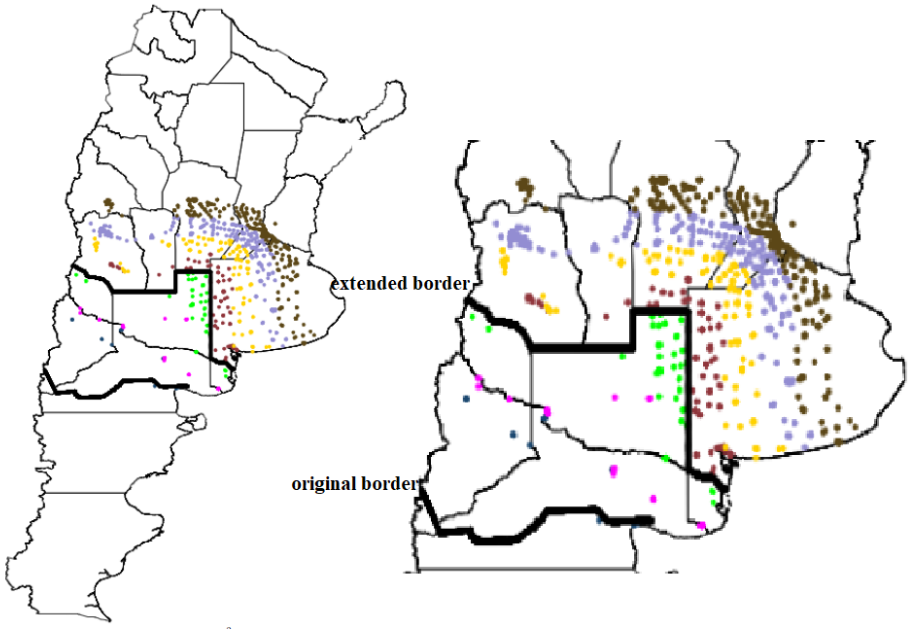
3 Background and data description

3.1 The tax change: expansion of a tax exemption zone on the fuel tax in Argentina.

Argentina is a federal country, with three levels of government: the National; the subnational including 23 provinces and the Autonomous City of Buenos Aires (CABA); and more than 2300 local governments. Historically, fuels have been mainly taxed through an excise tax at the national level. This tax is known as Tax on the Transfer of Liquid Fuels (i.e., TTLF). Prior to November 2015, gasoline throughout the country was taxed at an ad valorem rate of 63.0 percent per liter. The tax rate for diesel was 17.1 percent per liter. In each case the tax base was the wholesale price, without taxes. At that time the TTLF presented an exemption zone, in place since 1998, that was historically known as the "42nd parallel zone". This zone covered the Patagonian areas in the south of the Argentine. Specifically, the provinces of Tierra del Fuego, Santa Cruz, Chubut and some towns of Río Negro and Neuquén (see Figure 1, original border). However, in November 25, 2015 -and becoming in December 1, 2015-, the exemption zone was extended to the entire province of Río Negro, Neuquén, La Pampa, and the towns of Patagones -located in the south of the Province of Buenos Aires- and Malargüe -at the Province of Mendoza- (see Figure 1, extended border). Thus, gas stations located south of the extended border experienced a tax reduction on gasoline and diesel. This expansion on the tax exemption zone on the fuel tax is the quasi-experimental design that we exploit in this paper to obtain causal evidence on the effects of fuel taxes on prices and sales. As stated in the Introduction, a remarkable feature of this tax change is that it was not due to a reaction in market conditions. That is, it was purely exogenous. In addition, such a change in fuel taxes was unanticipated by consumers, as details had not been previously specified. This rules out a potential anticipation effect on consumption patterns, as

discussed by Coglianese *et al.* (2017).[3] In addition to being taxed with the TTLF, during the analyzed period there were other taxes on gasoline and diesel. Specifically, these commodities were taxed with three additional national taxes: i) the value added tax with a rate of 21 percent; ii) an additional excise tax on gasoline to finance the hydric infrastructure fund with a rate of 4 percent; and iii) an additional excise tax on diesel to finance the infrastructure projects with a rate of 22 percent. At the subnational level, there was a turn over tax with a rate that ranges between 2 and 3.5 percent depending on the province. An important point is that during the period of time analyzed in this paper, none of the other taxes on fuels were modified.

Figure 1: Gas stations, provinices, and the tax border used in the empirical analysis. Argentina.



Source:Authors' elaboration based on Argentine Ministry of Energy. *Note*: Black lines denotes the original tax border before December 2015, and extended tax border after December 2015. Colored dots indicate the location of gas stations considering intervals of 100 kilometers away from the extended border.

3.2 Data description

To study the effects of the tax exemption we construct a rich database on prices, sales, and gas station characteristics (i.e., localization, brand, etc.). The main unit of observation in these data is the station-month. The data are derived from the Argentine Ministry of Energy which has an open database at the gas station level that details the average monthly prices before and after taxes, the total amount of sales for different types of fuel, and the geographic coordinates (i.e.,

[3]In this sense our tax change is similar to Bajo-Buenestado & Borrella-Mas (2019). For the case of an anticipated tax change, see Gehrsitz *et al.* (2021).

GPS location coordinates) and brand of each gas stations. The database contains information from over 3,000 gas stations in the Argentine for 10 types of fuels.

In this paper we focus on monthly price and sales data for retail diesel and gasoline (i.e., the most popular transportation fuels in Argentina). We focus on all the gas stations located at 125 check km at each side of the tax border. To study the differential impact of the tax exemption, we define "treated" gas stations as those that are located south up to 125 km of the tax border. Analogously "control" gas stations are those located north up to 125 km of the tax border.[4] As will be appreciated this does not alter our main findings. The distance to the border is calculated in two ways: i) by computing the linear Euclidean distance; and ii) by computing distance via GPS coordinate route. For the first, the GEODIST package -developed in Picard (2010) - is used. As the linear distance may not be representative of the true driving distance, we then calculated with the "osrmtime" package -developed in Huber & Rust (2016)- the distance in kilometers per route and in seconds of time that the route takes with the free Open Street Map OSRM software.[5] Having GPS distance remove a potential concern on that distance-to-the-border variable does not take into account topography when calculating the distance to the border and, as a consequence, that it may not accurately reflect the actual driving distance to the border.

Our sample contains a total of 215 gas station, of which 70 (145) are assigned to treatment (control).[6] To avoid issues related to selective attrition, we only use stations that are observed in every single month between the beginning of January 2015 and the end of December 2016. Panel A in Figure 2 presents the evolution of retail prices for regular gasoline. Since January 2015 up to November 2015, the average retail price per liter of gasoline was around $15.6 on both sides of the border. Since December 2015 (i.e., the month in which the tax exemption became effective) up to December 2016, the average retail price per liter of gasoline was around $11.4 for gas stations located south and $14.8 for located north. Since January 2015 up to November 2015, the average retail price per liter of gasoline was around $15.6 on both sides of the border. Since December 2015

[4]See Figure 1. In the robustness checks we consider also gas stations located at alternative distances at each side of the tax border.

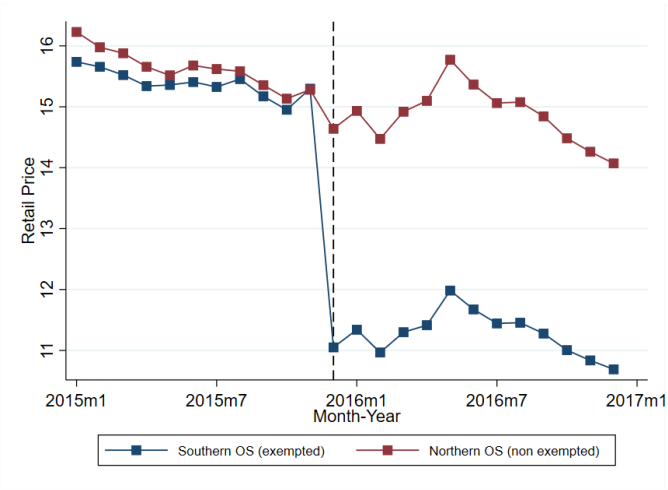
[5]The package has advantages over packages that use the distance by route online since, on the one hand, the georeferenced data cannot always be used on the Internet, since it may contain sensitive information. In addition, the routines that use offline free software do not run the risk of becoming obsolete due to online software updates. Finally, in contrast to online mapping routines, since the results do not depend on time-specific real-time data, they can be replicated at any time.

[6]A potential concern about this empirical strategy is that, due to changes in demand conditions, some gas stations may have opened and/or closed in the period of the study (Bajo-Buenestado & Borrella-Mas, 2019). However, as the period is quite narrow we do not observe reallocation or newer gas stations entrance.

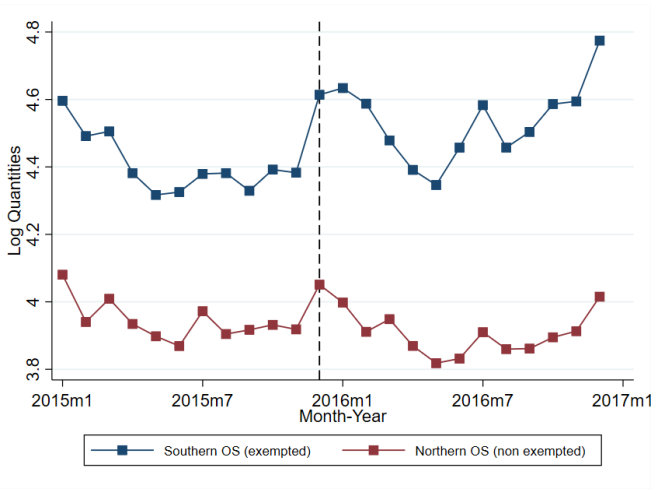
(i.e., the month in which the tax exemption became effective) up to December 2016, the average retail price per liter of gasoline was around $11.4 for gas stations located south and $14.8 for located north.Note that the tax reduction for stations located south was around 27.1 percent in the case of gasoline. Given the tax structure, described in previous subsection, total fuel taxes represent around 39.9 percent of the final consumer price for gasoline and approximately percent for diesel. The TTLF, by itself, explains around 31.5 (10.9) percent of the gasoline (diesel) price. Panel B present the evolution of sales. Panel C and D, with similar stylized facts, present the evolution of prices and sales for diesel. The graphical analysis suggests that Argentine tax reduction allows for price and sales responses that are large enough to be detectable with firm level data.

Figure 2: Trends in Fuel Prices and Sales. Argentina

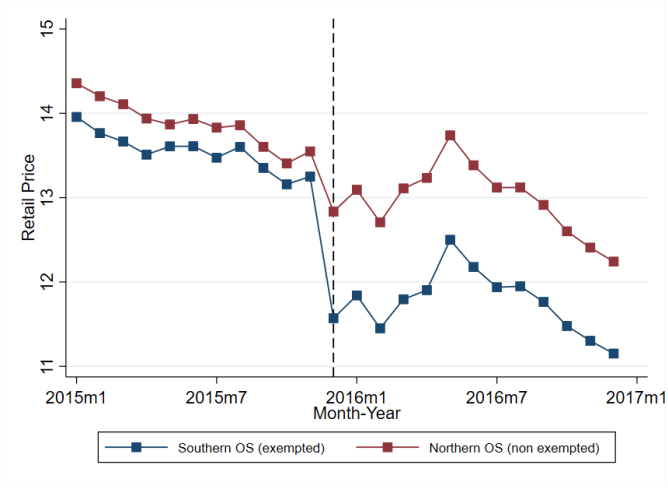
(a) Gasoline Prices



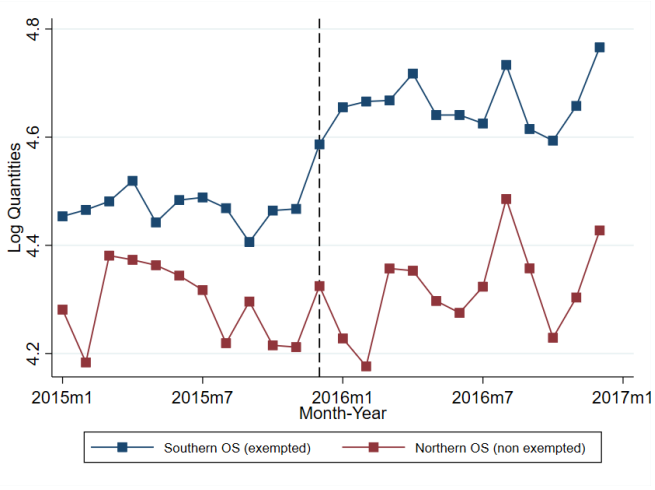
(b) Gasoline Quantities



(c) Diesel Prices



(d) Diesel Quantities



Source: Authors' elaboration based on Argentine Ministry of Energy. *Notes*: Prices are expressed in constant pesos of 2015. At that time the nominal exchange rate between the Argentine Peso and the U.S. dollar was XXXX. Quantities are expressed in thousand of liters.

4 Methodology

We use the difference-in-differences approach to analyze the effect of the fuel tax reform on prices and sales. We use the following general specification:

$$Y_{i,t} = \alpha + \beta \times South_i \times Post_t + \delta \times X'_{i,t} + \eta_t + \psi_i + \epsilon_{i,t} \quad (1)$$

where $Y_{i,t}$ is price or sales outcome in gas station i during month t. Prices are measured in real terms (i.e., constant 2015). Sales are measured as sold quantities in liters, and are expressed in logarithms. Each model is estimated separately for prices and sales of gasoline and diesel. $South_i$ is a dummy variable equal to 1 if the station i is located at the south of the border (i.e., treatment group) and 0 otherwise. The variable $Post_t$ is a dummy variable equal to 1 during the period of tax exemption (post-November 2015) and 0 otherwise. $X'_{i,t}$ is a vector of time-varying control variables (wholesale prices, dummies indicating gas stations' brand and the interaction between wholesale prices and the brand dummies), controlling for gas station specific costs. ψ_i are a gas station fixed effect, controlling for any time-invariant characteristic that may have an influence both on outcomes and stations' locations. η_t are monthly fixed effect, controlling for the growth of fuel prices or sales common to all gas stations. $\epsilon_{i,t}$ is the unobserved error term. The treatment effect is captured by the parameter β, which is the difference in the outcome variables averaged across all treated gas stations relative to the control group after the tax reform was implemented.

A main concern in the difference-in-difference literature is that errors can be correlated across different groups of observations. In that case, assuming that errors are independent across observations can lead to an incorrect estimation of the standard errors for the treatment effect (Bertrand *et al.*, 2004). In our context, the potential sources of correlation are (i) serial correlation of errors for each station; and (ii) spatial correlation of errors across stations. The first one is standard when observing the same individual/firm over multiple periods and it can be produced by unobserved characteristics that are constant overtime. The second one can be produced by local shocks that affect stores in the same area similarly. This source of correlation is quite relevant in our case since stations set their prices by matching the lowest price of any competitors within a certain radius. To account for these two possible sources of error correlation, we cluster errors at the arrondissement level (Hindriks & Serse, 2019). In the robustness checks we will also estimate the models clustering at the gas station level.

Our identification strategy is based on the assumption that the outcome variables for the treated and control groups would have evolved in parallel in the absence of treatment. We test this

assumption using the event study methodology. We also use this method to evaluate the speed with which the reform affects our outcome variables. For this purpose, we estimate Equation 2:

$$Y_{i,t} = \alpha + \sum_{k=1/2015}^{12/2016} \beta_{i,k} 1[t = k] \times South_i + \delta \times X_{i,t}^{'} + \eta_t + \psi_i + \epsilon_{i,t} \quad (2)$$

where $1[t = k]$ is a set of dummy variables that equals to 1 in the k months relative to the reform month for gas station i. The coefficient on each of those dummies indicates the difference in each outcome variable between the two groups in that month relative to month t-1, which is the benchmark. We continue to control for additional variables, gas station-specific fixed effect, and month fixed effects.

5 Results

5.1 Baseline results

We begin by presenting in Table 1 the effects of the tax change on the prices of gasoline and diesel. Column 1 shows the estimate of equation 1 for gasoline's retail price, including only fixed effects at the gas station level. In Column 2 monthly fixed effects are added while in Column 3 control variables are also included. We consider the latter as our fully controlled specification. It can be appreciated that the tax change reduced, in a statistically significant way, the price of gasoline by about 3.38 pesos. Given that the total reduction of the tax represented 4.62 pesos, the pass-through was around 73.14 percent. That is, consumers benefited from about three quarters of the tax reduction on gasoline. Given the standard error of the pass-through estimate, we can reject the hypothesis of a full pass-through of the tax reduction to gasoline prices. Columns 4 to 6 replicate the results for diesel. Column 6 indicates that the tax change reduced, in a statistically significant way, the price of gas oil by about one peso. Given that the total reduction of the tax represented 1.16 pesos, the pass-through was around 86.33 percent. Again, we can reject the hypothesis of a full pass-through of the tax reduction to diesel prices.

Figure 3 illustrates the results of the event-study specification outlined by equation 2. The reference period here is December 2015. Panel A presents the results for gasoline's retail prices. Two features stand out. First, the pre-period coefficients and 95% confidence intervals all hover around 16 pesos. This further bolsters the common-time trend assumption and thus adds credibility to a causal interpretation of our results. Second, prices appear to adjust almost

immediately and remain at a lower level for the full post-period. This suggests that the tax reduction led to a permanent price reduction. Also note that dotted lines indicate the price level for full pass-through. Thus, the hypothesis of a full pass-through of the tax reduction to gasoline prices seems not to be true in the case of Argentina. Panels C shows the analogous effects for diesel. Similar conclusions regarding price behavior can be supported.

Table 2 presents the effect on sales (in logs). As can be appreciated in Columns 3 (6), the lower prices increased the consumption of gasoline (diesel) by 18 (15) percent. Panel B in Figure 3 shows the event-study for gasoline's sales, which seem to be noisier than retail rices. Nonetheless, the lagged interaction coefficients hover around 4.1 for the vast majority of the period leading up to December 2015. Sales spiked in the south region, relative to the north, in the same month of the tax reduction. Although there do not seem to be any statistical differences between the months after the reform, there is a slight upward trend in sales. Panels D shows the analogous effects for diesel.

Overall, these event-studies point out that the timing of the reform was immediate. Both prices and quantities reacted immediately after the tax cut was introduced.

Table 1: Baseline Panel Regressions: Results on gasoline and diesel retail prices

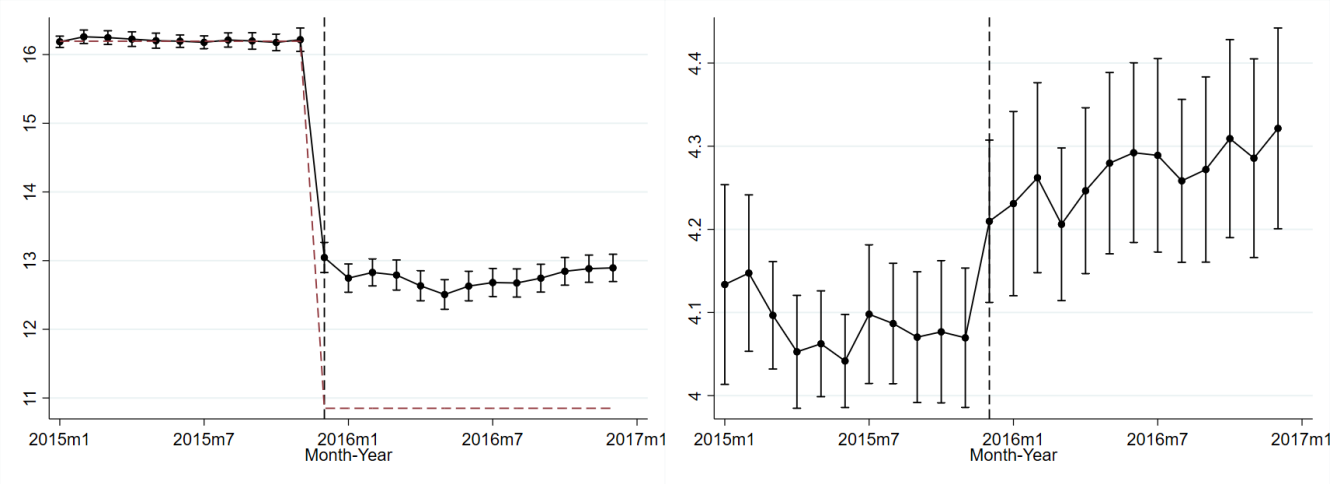
	(1)	(2)	(3)	(4)	(5)	(6)
$South_i \# Post_{i,t}$	-3.447***	-3.447***	-3.381***	-1.004***	-1.004***	-1.002***
	(0.0827)	(0.0829)	(0.0626)	(0.0600)	(0.0602)	(0.0495)
Constant	15.67***	16.19***	14.01***	13.92***	14.35***	11.61***
	(0.0198)	(0.0340)	(0.527)	(0.0153)	(0.0303)	(0.609)
Observations	5,160	5,160	5,160	4,584	4,584	4,584
R-squared	0.876	0.943	0.955	0.680	0.837	0.875
Number of Stations	215	215	215	191	191	191
Pass-trough (%)	66.64	64.52	73.14	72.12	69.94	86.33
Pass-trough (s.e.)	1.58	1.57	3.49	4.31	4.19	5.58
Delta Tax ($)	-5.17	-5.34	-4.62	-1.39	-1.44	-1.16
Time Fixed Effect	NO	YES	YES	NO	YES	YES
Station Fixed Effect	YES	YES	YES	YES	YES	YES
Controls	NO	NO	YES	NO	NO	YES
Fuel Type	Gasoline	Gasoline	Gasoline	Diesel	Diesel	Diesel

Source: Authors' elaboration. *Notes*: Robust cluster standard errors at the arrondissement level in parentheses. Statistical significance *** p<0.01, ** p<0.05, * p<0.1.

Figure 3: Baseline Panel Regressions: Event-study results. Estimations with time interactions

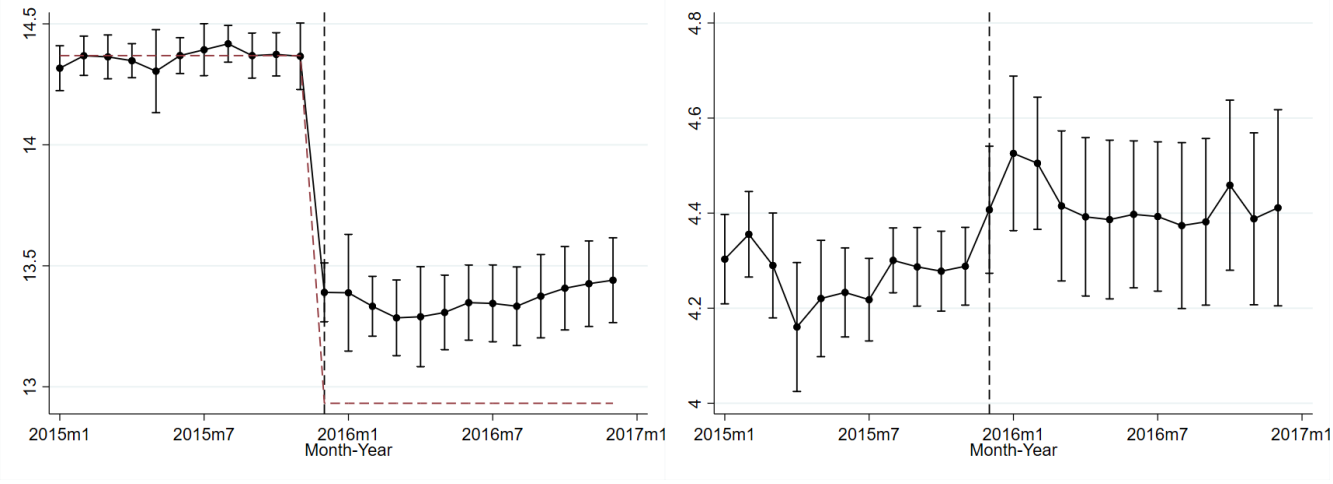
(a) Gasoline Prices

(b) Gasoline Sales



(c) Diesel Prices

(d) Diesel Sales



Source: Authors' elaboration. *Notes*: Robust cluster standard errors at the arrondissement level. Bands indicate a 95 percent confidence interval

Table 2: Baseline Panel Regressions: Results on gasoline and diesel (log) sales

	(1)	(2)	(3)	(4)	(5)	(6)
$South_i \# Post_{i,t}$	0.181***	0.181***	0.168***	0.151***	0.151***	0.151***
	(0.0406)	(0.0407)	(0.0371)	(0.0565)	(0.0567)	(0.0565)
Constant	3.933***	4.073***	4.393***	4.304***	4.258***	5.147***
	(0.00892)	(0.0251)	(0.196)	(0.0146)	(0.0297)	(0.405)
Observations	5,160	5,160	5,160	4,584	4,584	4,584
R-squared	0.047	0.135	0.164	0.026	0.073	0.105
Number of Stations	215	215	215	191	191	191
Time Fixed Effect	NO	YES	YES	NO	YES	YES
Station Fixed Effect	YES	YES	YES	YES	YES	YES
Controls	NO	NO	YES	NO	NO	YES
Fuel Type	Gasoline	Gasoline	Gasoline	Diesel	Diesel	Diesel

Source: Authors' elaboration. *Notes*: Robust cluster standard errors at the arrondissement level in parentheses. Statistical significance *** p<0.01, ** p<0.05, * p<0.1.

5.2 Robustness Tests

We test the sensitivity of baseline results to a series of robustness checks. First, we replicate the estimates but clustering the standard errors alternatively. Punctually at gas station level. Table A1 and Table A2 show these estimates. In all these checks, the baseline results remain unchanged.

Second, the fact that our sample includes all gas stations located at a distance of 125 kilometers from the border, may contain some arbitrary. To tackle this, we modify this parameter to validate the results. Specifically, we redefine the sample by taking alternative distances to the border : 60 km, 75 km, 90 km, 105 km, and 120 km. Table 3 shows these validations for the effects on gasoline prices, while Table 4 does so for sales. Tables 5 and 6 do the same for diesel. Although differences in the magnitude of the effects, something that would lead us to condition the results on the distance to the border (see Sub-section **??**), in all cases our main conclusions remain valid.

Finally, we exclude from the sample one arrondissement at a time, to ensure that our results are not driven by any of them in particular. Figure A1 shows that both the effect found on prices (i.e., pass-trough) and quantities is maintained for both gasoline and diesel.

Table 3: Robustness checks on baseline results: alternative samples for gasoline retail prices regression

	(1)	(2)	(3)	(4)	(5)
$South_i \# Post_{i,t}$	-3.286***	-3.320***	-3.347***	-3.361***	-3.344***
	(0.0767)	(0.0752)	(0.0570)	(0.0575)	(0.0563)
Constant	14.02***	14.22***	14.34***	14.39***	14.58***
	(0.473)	(0.351)	(0.255)	(0.198)	(0.190)
Observations	2,256	2,472	3,312	4,608	4,920
R-squared	0.964	0.965	0.969	0.959	0.959
Number of Stations	94	103	138	192	205
Pass-trough (%)	71.04	70.73	70.73	70.79	69.52
Pass-trough (s.e.)	2.93	2.56	1.79	1.36	1.44
Delta Tax ($)	-4.63	-4.69	-4.73	-4.75	-4.81
Time Fixed Effect	YES	YES	YES	YES	YES
Station Fixed Effect	YES	YES	YES	YES	YES
Controls	YES	YES	YES	YES	YES
Distance to frontier	60 km	75 km	90 km	105 km	120 km

Source: Authors' elaboration. *Notes*: Robust cluster standard errors at the arrondissement level in parentheses. Statistical significance *** p<0.01, ** p<0.05, * p<0.1.

Table 4: Robustness checks on baseline results: alternative samples for gasoline (log) sales regression

	(1)	(2)	(3)	(4)	(5)
$South_i \# Post_{i,t}$	0.237***	0.248***	0.193***	0.172***	0.163***
	(0.0447)	(0.0413)	(0.0436)	(0.0430)	(0.0405)
Constant	4.059***	4.243***	4.296***	4.337***	4.190***
	(0.270)	(0.224)	(0.173)	(0.135)	(0.132)
Observations	2,256	2,472	3,312	4,608	4,920
R-squared	0.158	0.165	0.148	0.140	0.144
Number of Stations	94	103	138	192	205
Time Fixed Effect	YES	YES	YES	YES	YES
Station Fixed Effect	YES	YES	YES	YES	YES
Controls	YES	YES	YES	YES	YES
Distance to frontier	60 km	75 km	90 km	105 km	120 km

Source: Authors' elaboration. *Notes*: Robust cluster standard errors at the arrondissement level in parentheses. Statistical significance *** p<0.01, ** p<0.05, * p<0.1.

Table 5: Robustness checks on baseline results: alternative samples for diesel retail prices regression

	(1)	(2)	(3)	(4)	(5)
$\text{South}_i \# Post_{i,t}$	-0.932***	-0.994***	-0.977***	-0.991***	-0.976***
	(0.0678)	(0.0759)	(0.0593)	(0.0478)	(0.0464)
Constant	10.67***	11.18***	11.64***	11.43***	11.68***
	(0.674)	(0.638)	(0.480)	(0.647)	(0.595)
Observations	1,920	2,184	2,904	4,056	4,368
R-squared	0.934	0.929	0.935	0.894	0.870
Number of Stations	80	91	121	169	182
Pass-trough (%)	87.39	88.92	83.94	86.75	83.58
Pass-trough (s.e.)	7.81	7.08	5.43	5.45	5.05
Delta Tax ($)	-1.07	-1.12	-1.16	-1.14	-1.17
Time Fixed Effect	YES	YES	YES	YES	YES
Station Fixed Effect	YES	YES	YES	YES	YES
Controls	YES	YES	YES	YES	YES
Distance to frontier	60 km	75 km	90 km	105 km	120 km

Source: Authors' elaboration. *Notes*: Robust cluster standard errors at the arrondissement level in parentheses. Statistical significance *** p<0.01, ** p<0.05, * p<0.1.

Table 6: Robustness checks on baseline results: alternative samples for diesel (log) sales regression

	(1)	(2)	(3)	(4)	(5)
$\text{South}_i \# Post_{i,t}$	0.113	0.164**	0.153**	0.190***	0.192***
	(0.0759)	(0.0749)	(0.0634)	(0.0622)	(0.0578)
Constant	5.713***	5.549***	5.328***	5.081***	5.108***
	(0.770)	(0.584)	(0.428)	(0.438)	(0.409)
Observations	1,920	2,184	2,904	4,056	4,368
R-squared	0.178	0.191	0.159	0.116	0.114
Number of Stations	80	91	121	169	182
Time Fixed Effect	YES	YES	YES	YES	YES
Station Fixed Effect	YES	YES	YES	YES	YES
Controls	YES	YES	YES	YES	YES
Distance to frontier	60 km	75 km	90 km	105 km	120 km

Source: Authors' elaboration. *Notes*: Robust cluster standard errors at the arrondissement level in parentheses. Statistical significance *** p<0.01, ** p<0.05, * p<0.1.

5.3 Extensions

We now explore whether the results are heterogeneous in dimensions that must be considered when thinking about economic policy on fuels.

First, we explore the effect of the tax reduction on cross-border shopping. Stations in the south are likely to compete with stations in the north, which were not directly affected by the tax exemption. Although in some cases, as was shown in Figure 1, the number of border stations in our sample is small, in others, such as the border between the provinces of Buenos Aires and La Pampa, the number of stations in both sides of the border is not negligible.

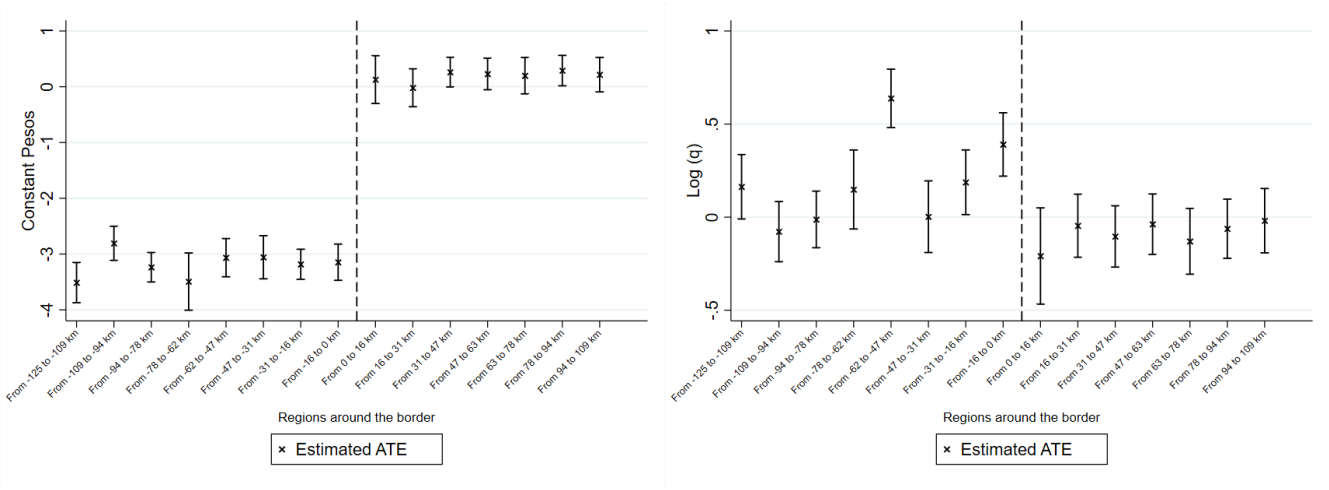
We, therefore, investigate the importance of cross-border shopping by including to the interaction between South and Post a dummy variable indicating whether station i is within a certain km distance to the border. The corresponding coefficient measures the difference in the treatment effect (tax shifting) for those stations that are within that certain distance to the border. In particular, we use different distances in steps of 15 km. The results are displayed in Figure 4 and show that tax shifting did not change with the proximity to any border. At any distance considered, those stations close to the border did not shift differently the tax exemption to the retail price compared to other stations. We obtain the same results for gasoline and diesel. This suggests that the threat of cross-border shopping does not seem to play a significant role in the shifting of the tax on fuel prices.

Second, we investigate whether the effects on prices and sales can be differential in the fuel brand. This is important and related to the structure of the fuel market in Argentina. Remember that two brands (i.e. Shell and YPF) account for 75 percent of the gas stations in our sample. For this purpose we include an interaction between South and Post and a dummy variable that indicates the brand of the gas station. As can be appreciated in Figure 5, the market structure does not seem to play a differential role in the effects of the tax exemption. The coefficients estimated in the base specification are statistically the same for all fuel brands. This is valid for gasoline and diesel, both in prices and in quantities.

Figure 4: Effects on prices and (log) sales of gasoline and diesel. Estimations by distance to border

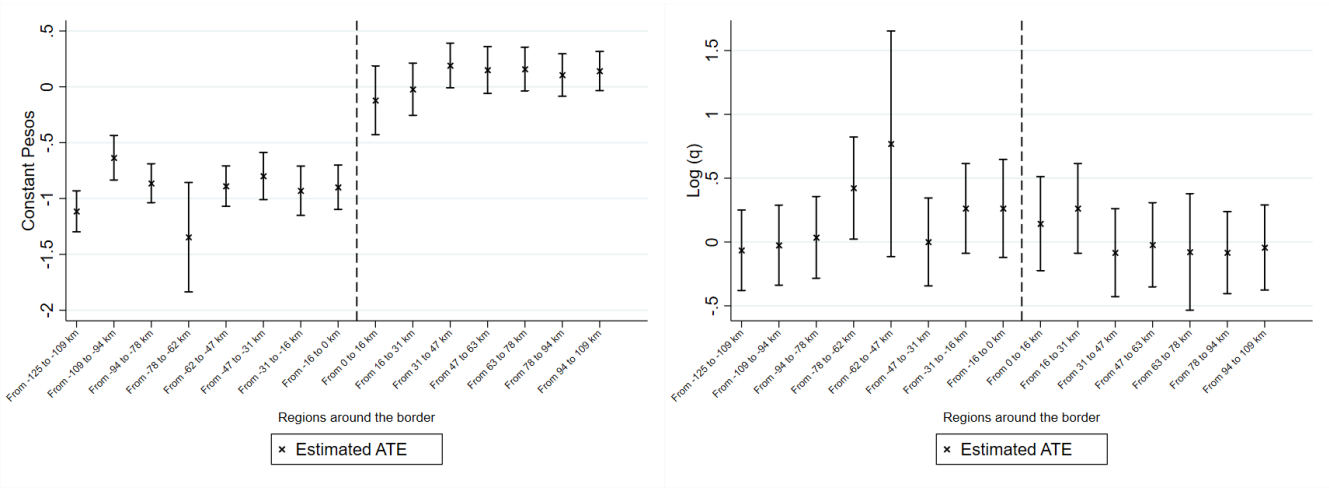
(a) Gasoline Pass-trhough

(b) Gasoline Beta Sales



(c) Diesel Pass-trhough

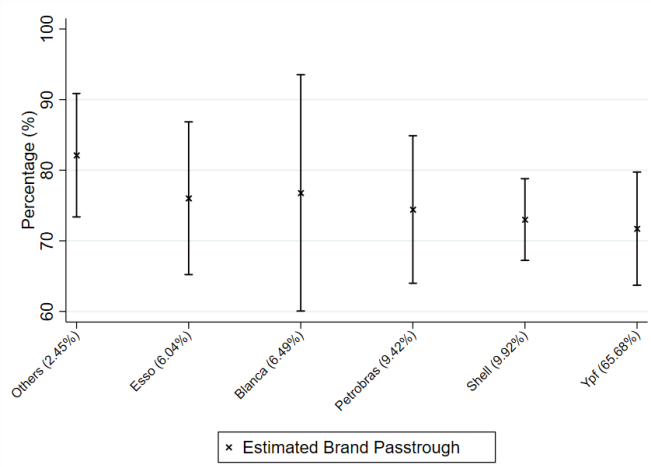
(d) Diesel Beta Sales



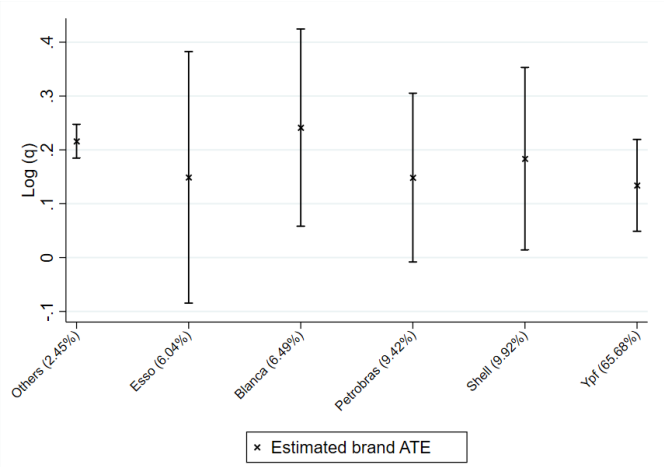
Source: Authors' elaboration. *Notes*: Robust cluster standard errors at the arrondissement level. Bands indicate a 95 percent confidence interval

Figure 5: Effects on prices and (log) sales of gasoline and diesel. Estimations by brand

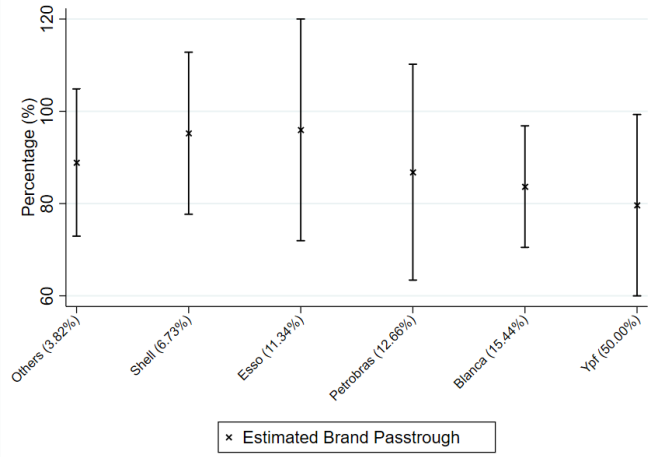
(a) Gasoline Pass-trhough



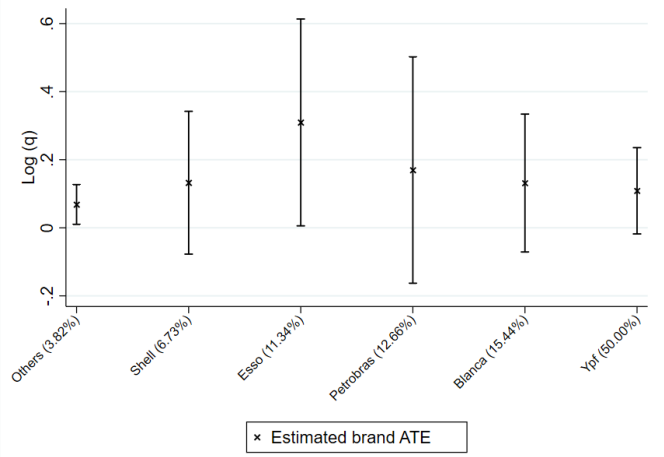
(b) Gasoline Beta Sales



(c) Diesel Pass-trhough



(d) Diesel Beta Sales



Source: Authors' elaboration. *Notes*: Robust cluster standard errors at the arrondissement level. Bands indicate a 95 percent confidence interval

6 Conclusions

In this paper we exploited an exogenous reform in the fuel tax that implied a tax reduction close to 35 percent on the tax burden of gasoline. Interestingly, given that the bulk of the available evidence is for developed countries, the case study is Argentina. Using a difference-in-differences approach answer how much of the tax reduction was shifted to consumers (i.e. the pass-through) and how consumption responded. Results indicate that the pass-through, although considerable, is not full (i.e., around 73 percent in gasoline and 86 percent in diesel). The increase in consumption due to lower prices ranges between 15 and 18 percent depending on the type of fuel. Interestingly the effects are immediate (i.e., they take place in the month of the reform and remain stable in the following months). The brand of fuel does not seem to be a key factor for the pass-through despite the fact that two brands account for 75 percent of the fuel market. Cross-border shopping does not seem to play a significant role in the shifting of the tax on fuel prices. Neither in the reaction of consumption. The results are robust to a battery of sensitivity analyses and contribute for a better understanding on the incidence of fuel taxation which is fundamental to assess political, budgetary, welfare and other (health, environmental, etc.) implications of tax reforms. Beyond its application to the case of Argentina, the evidence may be useful to think about the effect of transfers in other developing countries.

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Appendix

Table A1: Robustness checks on baseline results: alternative standard errors for gasoline and diesel retail prices regression

	(1)	(2)	(3)	(4)	(5)	(6)
$South_i \# Post_{i,t}$	-3.447***	-3.447***	-3.381***	-1.004***	-1.004***	-1.002***
	(0.0713)	(0.0714)	(0.0480)	(0.0463)	(0.0464)	(0.0395)
Constant	15.67***	16.19***	14.01***	13.92***	14.35***	11.61***
	(0.0157)	(0.0276)	(0.506)	(0.0119)	(0.0243)	(0.588)
Observations	5,160	5,160	5,160	4,584	4,584	4,584
R-squared	0.876	0.943	0.955	0.680	0.837	0.875
Number of Stations	215	215	215	191	191	191
Pass-trough (%)	66.64	64.52	73.14	72.12	69.94	86.33
Pass-trough (s.e.)	1.35	1.31	3.11	3.33	3.23	5.19
Delta Tax ($)	-5.17	-5.34	-4.62	-1.39	-1.44	-1.16
Time Fixed Effect	NO	YES	YES	NO	YES	YES
Station Fixed Effect	YES	YES	YES	YES	YES	YES
Controls	NO	NO	YES	NO	NO	YES
Fuel Type	Gasoline	Gasoline	Gasoline	Diesel	Diesel	Diesel

Source: Authors' elaboration. *Notes*: Robust cluster standard errors at the station level in parentheses. Statistical significance *** p<0.01, ** p<0.05, * p<0.1.

Table A2: Robustness checks on baseline results: alternative standard errors for gasoline and diesel (log) sales regression

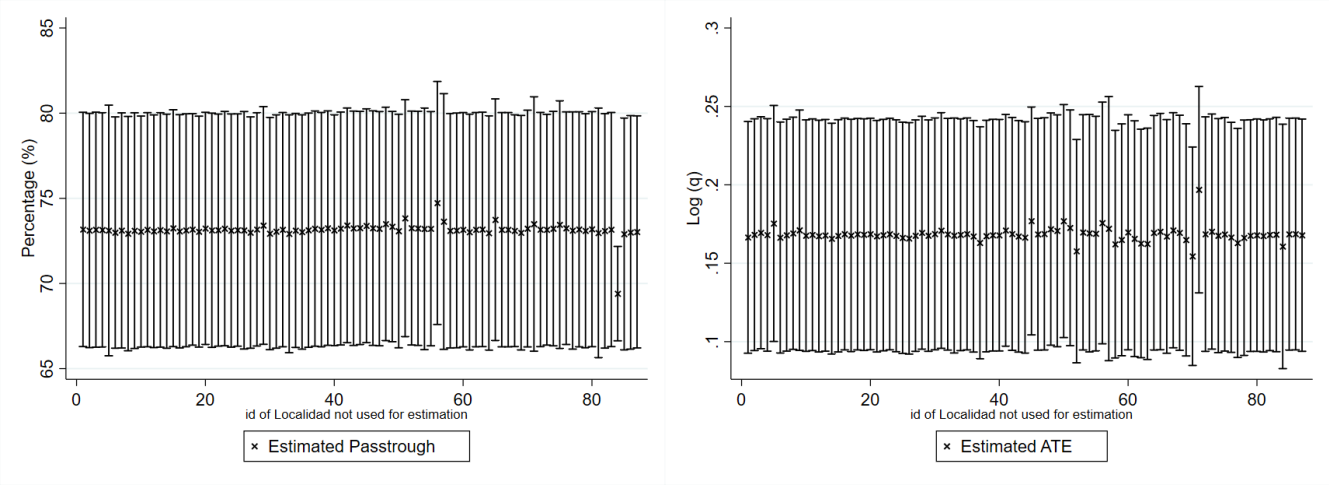
	(1)	(2)	(3)	(4)	(5)	(6)
$South_i \# Post_{i,t}$	0.181***	0.181***	0.168***	0.151***	0.151***	0.151***
	(0.0351)	(0.0352)	(0.0318)	(0.0478)	(0.0479)	(0.0482)
Constant	3.933***	4.073***	4.393***	4.304***	4.258***	5.147***
	(0.00790)	(0.0225)	(0.191)	(0.0127)	(0.0237)	(0.412)
Observations	5,160	5,160	5,160	4,584	4,584	4,584
R-squared	0.047	0.135	0.164	0.026	0.073	0.105
Number of Stations	215	215	215	191	191	191
Time Fixed Effect	NO	YES	YES	NO	YES	YES
Station Fixed Effect	YES	YES	YES	YES	YES	YES
Controls	NO	NO	YES	NO	NO	YES
Fuel Type	Gasoline	Gasoline	Gasoline	Diesel	Diesel	Diesel

Source: Authors' elaboration. *Notes*: Robust cluster standard errors at the station level in parentheses. Statistical significance *** p<0.01, ** p<0.05, * p<0.1.

Figure A1: Robustness checks on baseline results: additional checks on the samples for gasoline and diesel (log) sales and prices regressions. Estimations excluding arrondissement

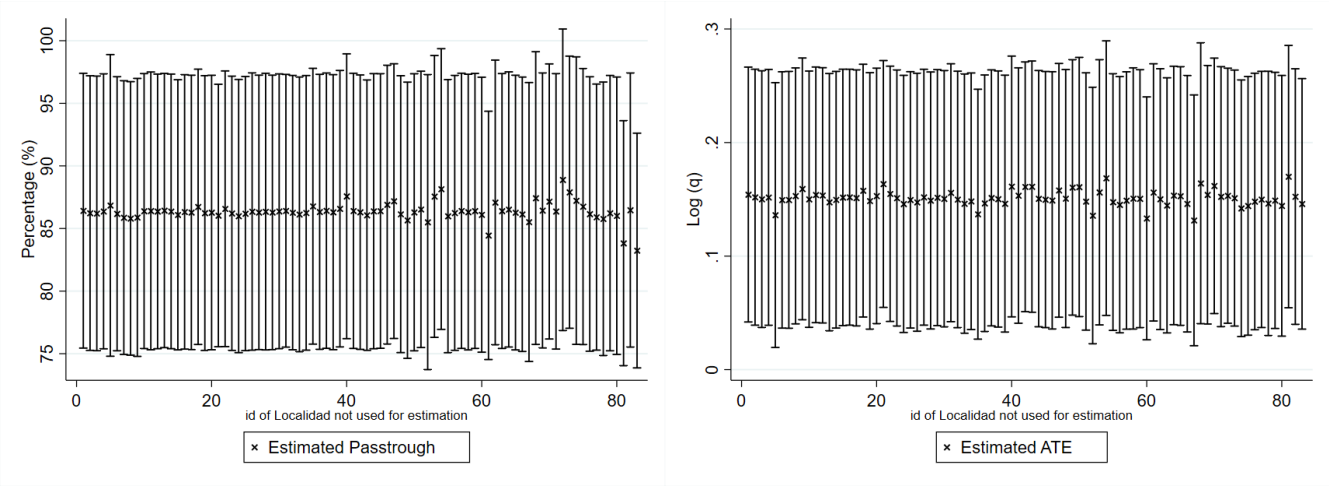
(a) Gasoline Passtrhough

(b) Gasoline Beta Quantities



(c) Diesel Passtrhough

(d) Diesel Beta Quantities



Source: Authors' elaboration. *Notes*: Robust cluster standard errors at the arrondissement level. Bands indicate a 95 percent confidence interval