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VAT pass-through and competition: Evidence from the Greek Islands

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Abstract
We examine how competition affects VAT pass-through in isolated oligopolistic markets as defined by the Greek islands. Using daily gasoline prices and a difference-in-differences methodology, we investigate how changes in VAT rates are passed through to consumers in islands with different market structure. We show that pass-through increases with competition, going from 50% in monopoly to around 80% in more competitive markets, but remains incomplete. We also discover a rapid rate of adjustment for VAT changes, as well as a positive relationship between competition and the rate of price adjustment. Finally, we document higher pass-through for products with more inelastic demand.

Keywords: pass-through, tax incidence, gasoline, value added tax (VAT), market structure, competition, Greek Islands
JEL: H22; L1

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1. Introduction

Value added taxes (VAT) are among the most widely used taxes across developed and developing countries.[6] VAT is also an important source of government revenue, raising about a fifth of total tax revenues among OECD countries (OECD, 2020). Given VAT's magnitude and importance, it is no wonder that it is frequently used as a policy tool. Whether the target is to raise more revenue[7], or provide a fiscal stimulus,[8] or dealing with the Covid19 pandemic[9] governments around the world have been modifying those rates. However, how the impact of a VAT change will be divided between firms and consumers is critical for policymakers aiming to target their support or to minimize the tax burden.

Economic theory suggests that the impact of a VAT change on final consumer prices is governed by the key parameter of "pass-through" (the elasticity of consumer prices with respect to the VAT rate) and a full pass-through cannot simply be assumed. Particularly, in differentiated product oligopolistic markets a key determinant of pass-through is competition (Delipalla and Keen, 1992; Anderson, De Palma and Kreider, 2001; Weyl and Fabinger, 2013; Miklós-Thal and Shaffer, 2021; Adachi and Fabinger, 2022). Yet, despite the large literature estimating the VAT pass-through across different countries and markets, there is limited evidence on the relation between competition and pass-through. Moreover, competition is typically measured by the number of competitors within a relevant geographic market based on geographical or driving distance between sellers. While realistic, this approach cannot guarantee the absence of substitution effects from firms outside the geographical area considered.

[6] With the notable exception of the United States.
[7] As in the case of Greece in 2010 (Matsaganis and Leventi, 2013).
[8] As in the case of China (Liu and Mao, 2019) or France (Benzarti and Carloni, 2019) or the UK in 2009 (Crossley, Low and Wakefield, 2009).
[9] Temporary cuts in Germany (Fuest, Neumeier and Stöhlker, 2020) and elsewhere for specific products.

Furthermore, because VAT is typically applied nationally, it is difficult for researchers to find a good comparison group. Two approaches to study VAT pass-through have been used in the literature. The first one looks at the same product and compares countries that experience a change in VAT with countries that did not.[10] One potential limitation of this approach is that there could be a variety of reasons why the tax changed in one country but not in others, and these factors could also affect consumer behavior differently across countries. The second approach compares products whose tax change with other products that did not, within the same country.[11] This comparison, however, may also be problematic, especially if there are significant substitution effects between the two groups of products. In such a case, the estimates will understate pass through if the goods are substitutes and overstate it if they are complements.

In this paper we tackle these two empirical challenges in two steps. First, we measure how VAT pass-through varies for the same products, within the same country, across independent, isolated oligopolistic markets. We exploit a unique natural experiment in which the Greek government decided to equalize VAT rates across islands in January 2018. We concentrate on the retail market for petroleum products, and we calculate VAT pass-through by comparing prices for unleaded gasoline and diesel on the affected islands to similar islands where the rates remained unchanged. Second, we use the cross-island variation in market structure to study the impact of competition on pass-through. Islands clearly define local markets and there is no substitutability among them.[12] Some islands are so small that they only have one gas station, while others can have two, or more, depending on their size. This naturally occurring variability in land mass across those islands generates

[10] For example, see Benedek et al., 2020; Fuest, Neumeier and Stöhlke, 2020; Buettner and Madzgarova, 2021; Montag et al., 2020; Konsonen et al., 2015; Bellon and Copestake and Daniel, 2021.
[11] For example, see Benzarti and Carloni, 2019; Shiraishi, 2022.
[12] Refueling a car by traveling to a different island is prohibitively expensive, and privately importing fuel in tanks or similar containers is dangerous and illegal.

exogenous variation in the retail gas station market structure allowing us to empirically measure the relationship between competition and VAT pass-through.

Using daily gas station data, we investigate how VAT pass-through for unleaded gasoline and diesel differed across markets with varying numbers of competitors, while using the same products in unaffected islands as a control group. We account for unobserved heterogeneity across islands and gas stations, and we control for common aggregate price fluctuations by using the control group. We find four key results. First, we estimate an average overall VAT pass-through of 0.7, that in all specifications remains incomplete, i.e., significantly lower than 1. Second, we show that pass-through increases with competition, ranging from around 0.5 in monopoly to 0.8 in markets with more than eight competitors. Third, we find that the rate of adjustment for VAT changes is faster than for specific taxes, and that it is faster in more competitive markets. Fourth, we find higher pass-through for products with more inelastic demand.

Our results contribute to several strands of the literature. First, our findings add to the empirical literature on estimating the VAT pass-through. There is a great variation of the pass-through rates in different studies, ranging from 9.7% in Benzarti and Carloni (2019) to 100% in Gaarder (2019) and Fuest, Neumeier and Stöhlker (2020), with many studies finding that the VAT pass-through is incomplete (Carbonnier, 2007; Andrade, Carré and Benassy-Quere, 2010; Kosonen, 2015; Benzarti and Carloni, 2019; Montag, Sagimuldina and Schnitzer, 2020; Ardalan and Kessing, 2021). We find a high (70%) average degree of VAT pass-through that also remains incomplete, while credibly controlling for market structure.

Second, we contribute to the literature comparing the pass-through between ad valorem (for example, VAT) and specific taxes (for example, excise duties). Theory predicts that under imperfect competition the pass-through of excise taxes should exceed those of ad valorem taxes (Stern, 1987; Delipalla and Keen, 1992; Anderson, De Palma and Kreider, 2001; Weyl and Fabinger, 2013; Miklós-Thal and Shaffer, 2021; Adachi and Fabinger, 2022). Our findings of incomplete VAT pass-through, together with the results from Genakos and Pagliero (2022) of complete excise duty pass-through, provide empirical confirmation for these theoretical predictions.

Third, we add to the small but growing literature that examines the impact of competition on pass-through. Existing evidence is somehow mixed with Doyle and Samphantharak (2008), Miller, Osborne and Sheu (2017) and Stolper (2018) finding that pass-through is decreasing in competition, while Cabral, Geruso and Mahoney (2018), Montag Sagimuldina and Schnitzer (2020), Fuest, Neumeier and Stöhlker (2020) and Genakos and Pagliero (2022) conclude the opposite. We provide new evidence that VAT pass-through increases with competition, though the positive correlation appears to be much more compressed than in the case of specific taxes.

Lastly, our findings on the quick response to VAT changes and on the positive correlation between speed of adjustment and competition contributes to the literature on the transmission of cost shocks to prices, such as the large exchange shock studied in Bonadio, Fisher and Sauré (2020) and the reduction of VAT rate studied in Fuest, Neumeier and Stöhlker (2020).

2. Theoretical background

Economic theory provides us with two general guiding results related to the tax incidence and competition in differentiated oligopoly markets (Stern, 1987; Delipalla and Keen, 1992; Anderson, De Palma and Kreider, 2001; Weyl and Fabinger, 2013; Miklós-Thal and Shaffer, 2021; Adachi and Fabinger, 2022). First, for a given degree of market power, we should expect the level of pass-through for ad valorem (percentage) taxes to be lower compared to per unit specific taxes (such as the excise duty taxes). The intuition is that with ad valorem taxes (like the VAT) the government receives a share of a firm's gross revenue. Thus, the ability of firms to raise prices under imperfect competition also benefits the government. This reduces firms' incentives to increase prices in comparison with the case of a specific tax, such as excise duties, which results in lower pass-through.

Second, the intensity of competition among firms, typically captured by the conduct parameter θ (varying from zero in perfect competition to one in a monopoly market), interacts in a non-linear way with four key elasticities[13] to determine the level of pass-through, denoted by ρ (Weyl and Fabinger, 2013; Miklós-Thal and Shaffer, 2021; Adachi and Fabinger, 2022). Hence, in general, the sign and magnitude of the relationship between pass-through and intensity of competition is ambiguous and open for empirical research.

To focus ideas and guide our reading of the empirical results in this paper, it is worth noting that the relationship between ad valorem pass-through and intensity of competition greatly simplifies under a set of assumptions that seem realistic in our environment. If the marginal cost is constant, θ is constant, and demand is assumed linear, then $\rho = \frac{\epsilon_D - \theta}{\epsilon_D} \frac{1}{1+\theta}$ and an increase in the conduct parameter (less competition) would lead to lower pass-through. As we will argue in Section 4, assuming that the marginal cost is constant at the firm level is realistic in our environment, at least in the short run, and for the range of quantities typically sold by gas stations in our sample. We also assume the conduct parameter to be constant, given that we investigate a small-time window around the policy change, without putting any restrictions on its magnitude. Demand linearity is clearly a

[13] These elasticities are: the elasticity of demand (ϵ_D), the elasticity of the inverse marginal cost curve (or the elasticity of *competitive* supply, ϵ_S), the elasticity of the conduct parameter (ϵ_θ) and the elasticity of the inverse marginal consumer surplus (or the curvature of the demand function, ϵ_{ms}).

restrictive assumption (Mrazova and Neary, 2017; Miravete, Seim and Thurk, 2023), although we will provide some supportive empirical evidence later on. Hence, in general, the impact of an increase in competition on pass-through remains largely an empirical issue and there is very little credible evidence in the literature, particularly for ad valorem (percentage) taxes.

3. Institutional and policy change background

In 2010 the inability of the Greek government to borrow funds from the international markets led to a €110 billion bailout loan from the European Commission, the European Central Bank, and the International Monetary Fund. As part of the loan agreement, the Greek government agreed and implemented a series of austerity measures. The third and last economic adjustment programme was signed by the Greek government in July 2015. One of the measures agreed with the creditors was the equalization of VAT rates across Greece. Until then, VAT rates were lower in some islands compared to the mainland, as a social welfare policy to provide incentives for people to stay in remote islands and to make those destinations more competitive in the international tourism market.

The VAT equalization was implemented gradually at three different points in time (Oct 2015, Jun 2016 and Jan 2018). The timing for each of these changes was not predetermined, but rather chosen by the government and swiftly implemented. In this paper we exploit the last VAT increase (from 17% to 24%) on January 1st, 2018, that affected islands that are close to the borders of Greece with Turkey (see black dots in Figure 1).[14] We select this VAT incident for two main reasons. First, those islands located near the borders of Greece are not fundamentally different from other nearby islands (as we will document later) and

[14] Islands with refugee camps were excluded from the VAT increase.

hence their selection can be considered quasi-random.[15] Second, there is significant variation in the retail gasoline market structure of these islands (we observe islands that are monopolies, duopolies and with more than eight gas stations) that provide us with the natural variability to study the impact of competition on VAT pass-through.

We focus on unleaded gasoline and diesel, which are the main oil products in Greece, accounting for 62% of the total oil consumption. Due to the large number of islands and the population living in isolated regions, there are more gas stations per capita in Greece than the EU's average. Each gas station in Greece provides service to approximately 1,400 consumers, on average, while in the rest of Europe a gas station covers about 3,800 consumers.[16] The refilling process for the gas stations located in islands is conducted by ships that leave from the port of Piraeus (in Attica, near the capital of Athens) to reach each island. The retail gasoline price is affected by the refinery cost, as well as taxes (both per unit and percentage) and is calculated as follows: $P_{retail} = \left(P_{refinery} + excise\ duty\ \&\ fees + profit\ margin\right) \times (1 + VAT)$. The marginal cost of petroleum products depends on long-term contracts between gas stations and trade companies. Within the time window of this study, we can safely assume the marginal cost of retailers is constant. Taxes account for almost two-thirds of the gasoline price in Greece. In this paper, we focus on the change in the VAT, which is a percentage tax.

[15] Even the criterion of "being close to the borders" does not exclusively characterize the islands included in the change, as there are islands within the control group, as we will show later, that are closer to Turkey. For example, the island of Kos is closer to Turkey than most of the islands included in the change, highlighting again the quasi-randomness of the selection process.

[16] International Energy Agency, Energy Policies of IEA Countries, 2017 review.

4. Data

We combined two main datasets for our analysis. First, we use daily prices for each gas station in the islands of interest for unleaded 95 and diesel products. This data is reported daily from the gas station owners to an online platform of the Greek Ministry of Development and Competitiveness. The aim of the platform is to inform consumers and to facilitate comparisons by reducing search costs. Through this platform we also identified the number of retailers in each island, and we utilized Google maps to verify location and other station characteristics. Second, we obtained socioeconomic (e.g., population, education, income, number of tourist arrivals) and geographic characteristics (e.g., size, distance from Piraeus, number of ports etc.) of each island from the Hellenic Statistical Authority.

We designate as the treatment group those islands for which the VAT increased on January 1, 2018. Measuring the number of gas stations in each of these islands, we can naturally split the treatment group into three subgroups (Table A1) of monopoly, duopoly and more competitive (more than eight competitors) market structures. We then selected as control group Greek islands with similar market structure and socioeconomics and geographic characteristics for which the VAT did not change. More specifically, as you can see in Tables A1 and A2, for the monopoly and duopoly treated subgroups, we selected other islands with exactly the same number of gas stations. For the last treated subgroup of more than eight competitors, we could not match them with other islands with exactly the same number of gas stations, so we selected islands with similar characteristics (population, size, ports, tourists arrivals, education, income) and the same (statistically speaking) number of competitors on average (Table A2, Panel D). Finally, as a robustness exercise, we matched each island in the treatment group one-to-one with its closest geographically island from the control group (Table A1, Panel B). Table 1 reports summary statistics for the 27 islands used and a period of fifteen days before and after the change in VAT.

The Greek islands environment is an ideal setup to measure VAT pass-through and its relation to market structure. First, islands clearly define local markets, as there is no substitutability between them. Arbitrage across islands is not possible, as the cost of transporting a car by ferry outweighs any potential fuel cost savings. Second, our difference in difference framework essentially will compare the pass-through behavior for the same product across islands, within the same country. Such variation is rarely observable in VAT studies, precisely because this tax often applies nationwide. Moreover, we can safely assume that there are no substitution effects in our case, as it is impossible to use anything else other than gasoline or diesel to move your car. Third, islands vary in size exogenously and that affects the number of inhabitants and, of course, the number of gas stations through a long-run entry game that we assume is not affected, in the short run at least, by the VAT changes.[17] Figure 2, panel A shows that the larger the island, either in terms of land area or population, the larger the number of gas stations in our sample. At the same time, in Figure 2 panel B, we can see a negative correlation between the number of competitors and prices for both unleaded 95 and diesel. Taken together, Figure 2 shows that, as expected, larger islands tend to support more competitive markers that lead to lower prices. In other words, the Greek island environment provides us with exogenous variation in market size that allows us to study empirically the effect of competition on pass-through. Bresnahan and Reiss (1991) were the first to explore how entry is affected across multiple isolated markets, finding that the most variation in conduct occurs with the entry of the second or third firm.

[17] All stations in our sample are either dealer owned or independent, so we have no vertically integrated stations (Bajo-Buenestado and Borrella-Mas, 2022) and no retail chains.

Overall, the quasi-random selection of islands for which the VAT rates increased, together with the inherent variation in land mass that generates exogenous variation in the retail gas station market structure of these islands creates an ideal setup to measure VAT pass-through and its relation to market structure.

5. Empirical Methodology

To estimate the mean impact of VAT change, we use the following difference-in-differences empirical specification:

$$ln(P_{jigt}) = \lambda_0 + \rho VAT_{it} + \lambda_t + \lambda_{jg} + \varepsilon_{jigt} \qquad (1)$$

where P_{jigt} denotes the retail price of gasoline product *j* on island *i*, in gas station *g*, on day $t \in \{\tau - 1, \tau + \delta\}$, where τ is the day of VAT change and δ = 1, … ,15 represents the length of the adjustment period considered. VAT_{it} is the VAT rate of each island at different points in time, while the coefficient ρ captures the pass-through. Finally, the model includes product-gas station (λ_{jg}) and day (λ_t) fixed effects. In all specifications, the standard errors are clustered at the island level, as this is considered to be the relevant geographic market and also the unit at which policy randomization occurs.

This specification follows a long literature on difference in difference estimators and is based on the comparison of prices of the same type of gasoline products before and after the policy change for a treatment group of islands compared to a control group of islands that were unaffected by the VAT change.[18] The identifying assumption of our difference in

[18] Early applications of this methodology are found in Ashenfelter and Card (1985), Card (1992), and Card and Krueger (1994, 2000); more recent applications in industrial economics include, for example, Ashenfelter, Hosken and Weinberg (2013) and Genakos, Koutroumpis and Pagliero (2018).

difference framework is that for both gasoline products the evolution of prices in the treatment and control islands were the same before the event. As the VAT increase was not anticipated, prices seem to visually follow the same trend before the policy change and to sharply change after the announcement (Figure A1).

Following Ashenfelter, Hosken and Weinberg (2013), we also conduct two formal tests of the parallel trend assumption. First, we estimate the equation:

$$ln(P_{jigt}) = \gamma_0 + \gamma_1 Trend_t + \gamma_T Trend_t \times Treat_i + \lambda_j + \lambda_g + \varepsilon_{jigt} \qquad (2)$$

where $Treat_i$ is an indicator variable that equals one for islands which were affected by the change and zero otherwise. We estimate (2) separately using data for the 15 days before the VAT change. We then test and cannot reject the null hypothesis that the coefficient γ_T is equal to zero for either the whole data or each gasoline product separately (Table A3). Second, we replace the trend variable in (2) with day specific indicators (γ_t) and interact them with $Treat_i$. All the estimated day specific interactions are equal to zero both individually and jointly (Table A4), which indicates that the parallel trends assumption is satisfied.[19]

We then extend the baseline specification to examine the interaction between the VAT pass-through and competition in the following way:

$$ln(P_{jigt}) = \lambda_0 + \rho(n_i, Z_i) VAT_{it} + \lambda_t + \lambda_{jg} + \varepsilon_{jigt} \qquad (3)$$

where we estimate the pass-through as a linear function of the number of competitors (n_i) and other island characteristics (Z_i). Finally, we estimate the relation between pass-

[19] We also estimated the specifications using longer time windows (20 and 30 days) before the policy change, but the results remain unchanged (results not reported here, available on request).

through and the number of stations non-parametrically, allowing for separate coefficients for monopoly, duopoly and more competitive islands. Islands with more than eight competitors are grouped together as we do not observe treated islands with the same number of competitors above this number. This grouping is also justified based on the literature. Bresnahan and Reiss (1991) show that after two or three firms, any additional entrant does not significantly affect entry thresholds and, more recently, Genakos and Pagliero (2022) show that the pass-through for excise duty changes does not significantly change after the fourth competitor.

To test the robustness of the relation between pass-through and the number of stations, we also run specifications where we include various other island characteristics (Z_i). We will also report IV estimates of model (3), where exogenous variability in market size is used to estimate the impact of the number of competitors on pass-through. Following an extensive literature on equilibrium entry in oligopoly markets (Bresnahan and Reiss, 1991; Berry, 1992; Mazzeo, 2002; Toivanen and Waterson, 2005, among others), the rationale for the IV approach is that market size is a crucial determinant of entry and competition, while it is arguably uncorrelated with unobservable determinants of the pass-through. Hence, the IV approach assumes that market size can be excluded from Z, while being correlated with measures of competition. This second assumption can be tested, and it is verified in our results described next.

6. Results

6.1. Baseline pass-through estimates

Figure 3 plots the average price difference between treated and control islands for fifteen days before and after the announcement, separately for each of the two gas products. The solid lines represent linear regressions separately estimated before and after the VAT change. There does not seem to be any anticipation or reaction prior to the VAT change announcement for both products. There is a significant jump on prices on the day after the announcement. The price adjustment seems to be "completed" very quickly, as prices seem to stabilize after day three. Around 70% of the gas stations adjusted their prices within the first two days of the tax change.[20] Although this is slower than Knittel, Meiselman and Stock (2017), who find 98% price adjustment after two business days, remember that the VAT change in this case occurred on January 1st and both that day and the next are public holidays.

The estimated pass-through rate on a given date depends on the number of gas stations that have adjusted their prices (extensive margin), as well as the magnitude of the price change of the gas stations that have already adjusted their prices (intensive margin). Accordingly, we estimate separately the "average" and the "conditional" pass-through, where the former considers all the gas stations, while the later only the ones that have adjusted their prices (at least once) after the policy change. Obviously, for long enough time windows, the two definitions will converge, as almost all stations have adjusted their prices. However, in shorter time windows the two definitions may differ substantially. We run our baseline model (1) for a time window of fifteen days (94% of gas stations had

[20] This is significantly faster than Genakos and Pagliero (2022) that observe an average response of 59% product-station prices adjusted within the first three days.

adjusted their prices), but we also explore the convergence evolution path by comparing the average and conditional pass-through over time.

Table 2 reports the baseline results from model (1). The conditional pass-through is about 0.76 (column 1), while the average is about 0.7 (column 3). Both are significantly lower than 1,[21] indicating incomplete VAT pass-through. Several recent empirical studies also find incomplete VAT pass-through.[22] Therefore, both the pass-through magnitude and the resulting undershifting of the VAT suggest that the retail gas market in the Greek islands does not operate very differently from other market studies in the literature, enhancing the external validity of our results.

As a robustness exercise, we also matched one-to-one each island in the treatment group with its closest in geography island from the control group (see Table A1, Panel B). The idea is similar to the literature that uses geographic variation in markets (for example, Hastings, 2004; Aguzzoni et al., 2016; Allain et al., 2017; Argentesi et al., 2021) to control for any unobserved characteristics that might affect demand or the cost conditions, such as the climate conditions, or the distance from the main port of Piraeus in our case. Both the conditional (column 2) and the average (column 4) pass-through in Table 2 are very similar to the estimates obtained from the full sample, which is reassuring.[23]

6.2. Pass-through and competition

To study how pass-through varies with competition, in Table 3, column 1, we first estimate model (3) allowing for an interaction between the VAT change and the number of

[21] The P-values are 0.003 and 0.0002 respectively.
[22] For example, see Carbonnier (2007), Andrade, Carré and Bénassy-Quéré (2010), Benzarti and Carloni, (2019), Montag, Sagimuldina and Schnitzer (2020), Ardalan and Kessing (2021) and Fuest, Neumeier and Stöhlke, (2020).
[23] This also indicates that there are no supply-side spillovers between islands. Moreover, we find no significant differences in pass-through for franchisees and independent gas stations.

competitors. In column 2, we add controls for the interaction of VAT with island characteristics, such as income, education, number of ports and number of tourists arrivals. Both the conditional (Panel A) and the average (Panel B) pass-through increase with competition. Column 3 shows that the relation between competition and pass-through is linear in our sample. In column 4 we also report the IV estimates, where the excluded instrument is island population. First stage results (F-tests in column 4 below coefficients) are highly significant, showing a strong correlation between market size and the number of competitors. Overall, there seems to be a strong and robust positive relation between competition and pass-through.

In Table 4 we explore the impact of competition in more detail using a non-parametric specification of model (3). Figure 4 plots the estimated coefficients to ease exposition. Both the conditional (column 1) and the average (column 2) pass-through is statistically indistinguishable from 0.5 in monopoly islands. This is in line with the (absolute) pass-through prediction from a monopoly model with linear demand. The pass-through increases for duopoly and the more competitive islands,[24] but remains statistically less than 1, i.e., less than full pass-through. Results remain unchanged in columns 3 and 4 when we look at the matched sample.

The increase in the pass-through as competition intensifies is in line with the findings of Genakos and Pagliero (2022) on the pass-through of excise duty. However, results here also differ in that, even in highly competitive markets, the pass-through remains incomplete. This finding is in line with the theoretical literature that predicts that under imperfect competition the pass-through of excise taxes should exceed those of ad valorem

[24] Although estimated coefficients increase across island subgroups, most of the differences are not statistically significant, most likely due to the small sample size. The only notable exception are monopoly islands that seem to be different from the competitive subgroup at 10% significance level.

taxes (Stern, 1987; Delipalla and Keen, 1992; Anderson, De Palma and Kreider, 2001). Bonnet and Réquillart (2013) use a structural model and simulate the response of French soft drink producers to show that excise tax is over-shifted to consumer prices, while an VAT is under-shifted, and Ardalan and Kessing (2021), using beer prices responses to changes on VAT and excise duty taxes across EU countries, document empirically that the VAT pass-through is around 70%, while for excise taxes is almost 100%. Our study complements the existing literature by empirically documenting both the increase in pass-through as competition intensifies and the overall lower level of pass-through for ad valorem taxes in oligopolistic markets.

6.3. Pass-through and speed of adjustment

Table 5 reports the estimated average (column 1) or conditional (column 2) pass-through for different time windows. Figure 5 plots the estimated coefficients to ease comparisons. The conditional pass-through does not significantly vary over time. In contrast, the average pass-through quickly increases and converges to the conditional, as more and more stations adjust their prices after the policy change. The speed of convergence of the average and the conditional pass-through is in line with the relatively fast exchange rate pass-through measured by Bonadio, Fischer and Sauré (2016) and is faster than the one observed for excise duty in Genakos and Pagliero (2022).

This fast speed of convergence is a new and interesting fact in itself, as we have no theory guidance as to what we should expect. We conjecture that there are at least two reasons why the speed of adjustment for VAT is faster than that of excise duty. First, the VAT applies only and is paid directly by the final consumer. In contrast, the excise duty is paid at the refinery level and has to be transmitted through the whole vertical supply chain (refinery to wholesaler to retailer) to reach the gas stations in remote islands.[25] Second, VAT changes, precisely because they apply to consumers directly, get much more publicity and they are easier to detect in final consumer prices. In contrast, excise duty taxes are intertwined with the refinery price and the wholesale and retailers' margin and are difficult to isolate in final prices. We believe that both of these reasons lead to faster price adjustment for VAT changes.

Next, we examine whether the speed of adjustment is related to competition. The literature both at the aggregate level (Gopinath and Itskhoki, 2010) and at the micro level (Genakos and Pagliero, 2022) has shown that the level of competition seems to matter for how quickly prices adjust to cost shocks. To investigate this in our environment we split the treated islands into two groups: the low competition group, which includes monopolies and duopolies and the high competition group, which includes the rest. Figure 6 plots the cumulative frequency of price changes for each of the two groups for the fifteen days adjustment period. The differences are stark. By the third day since the policy change 84% of the retailers in the more competitive islands have adjusted their prices, compared to only 40% in the low competition markets. The differences continue to be significant up to the 9th day, before the low competition markets catch up. This implies a positive correlation between competition and the speed of price adjustment.

Using model (3), we estimated both the conditional and the average pass-through for the two groups of islands. Table 6 reports the estimated coefficients for each day within our time window and Figure 7 plots the four sets to ease comparisons. The conditional estimates start similar, but they diverge over time, leading to a 0.2 difference at $\tau+15$ (significant at 10%). The average pass-through is higher in more competitive islands, although not very

[25] Gas stations in islands are restocked on a weekly or by-weekly basis depending on demand, hence it takes more time for a new excise duty tax to be transmitted to final consumer prices.

strong statistically.[26] At τ+3, the pass-through in more competitive islands (0.717) is more than twice as large than in less competitive markets (0.326), while even at τ+10 the difference between the two is 0.2 (or 37% higher). Combining the information from Figures 6 and 7, we can conclude that, for ad valorem taxes, more competitive markets seem to adjust faster to cost shocks, partly because the conditional pass-through is higher and partly due to the faster price reaction. Our results are in line with Gopinath and Itskhoki (2010), who conclude that firms which infrequently adjust prices are the ones which pass smaller amounts of the tax to consumers and Genakos and Pagliero (2022), who find similar results for excise duty taxes. Therefore, although the level of pass-through and the speed of adjustment behavior seem to be different for ad valorem versus specific taxes, their adjustment behavior with respect to competition looks similar across the two types of taxes.

6.4. Pass-through and product heterogeneity

Finally, we test if there is any heterogeneity on the results in the two gasoline products. We run the empirical specification of equation (1) separately for diesel and unleaded 95. The results are presented on Table 7. The average pass-through is higher for diesel (0.757) than for unleaded 95 (0.641), with the difference being statistically significant at 1%. Similar results hold for the conditional pass-through in column 3. In addition, we also interacted the product coefficients with the indicators for low or high competitive markets in columns 2 (average) and 4 (conditional). In all cases, as we can see at the equality tests at the bottom of Table 7, the effect on diesel is significantly higher than unleaded 95. Worth noting that these results are in contrast to the findings in Genakos and Pagliero (2022), who did not detect any significant differences in excise duty pass-through across products. From

[26] The trend is very clear from the graph (most of the differences are significant at the 10% level up to day six), but the estimates are quite noisy, most likely due to the small sample size.

a theory perspective this result is consistent with the demand for diesel being more inelastic than the demand for unleaded 95. Given that, apart from consumers, diesel is used mainly by commercial vehicles (tractors and other agriculture vehicles, military vehicles, buses, etc.) for business purposes, we conjecture that it has greater compression resistance. This is also confirmed in the literature that finds a more inelastic demand for diesel (for example, see Ajanovic, Dahl and Schipper, 2012; Karagiannis, Panagopoulos and Vlamis, 2015; Labandeira, Labeaga and Lopez-Otero, 2017; Fridstrøm and Østli, 2021).

7. Conclusion

The quasi-random policy selection of Greek islands for which the VAT rates increased, together with the natural variation in land mass that generates exogenous variation in the retail gas station market structure of these islands, creates an ideal setup to measure VAT pass-through and its relation to competition. We contribute to the growing literature on pass-through by showing that pass-through increases with competition, but also that the level of VAT pass-through remains incomplete. Furthermore, we find that the rate of adjustment for VAT changes is faster than for specific taxes, that it is faster in more competitive markets, and that it is higher in products with more inelastic demand.

We acknowledge that Greek islands are not necessarily representative of oligopolistic markets for other products. However, we selected this environment precisely because it provides clean variation in the competitive environment and allows us to compare the same products across different markets within the same country. We believe that the results contribute to our understanding on VAT pass-through, in case of an increase, by showing new evidence on relationships that may be present in other settings and in larger markets.

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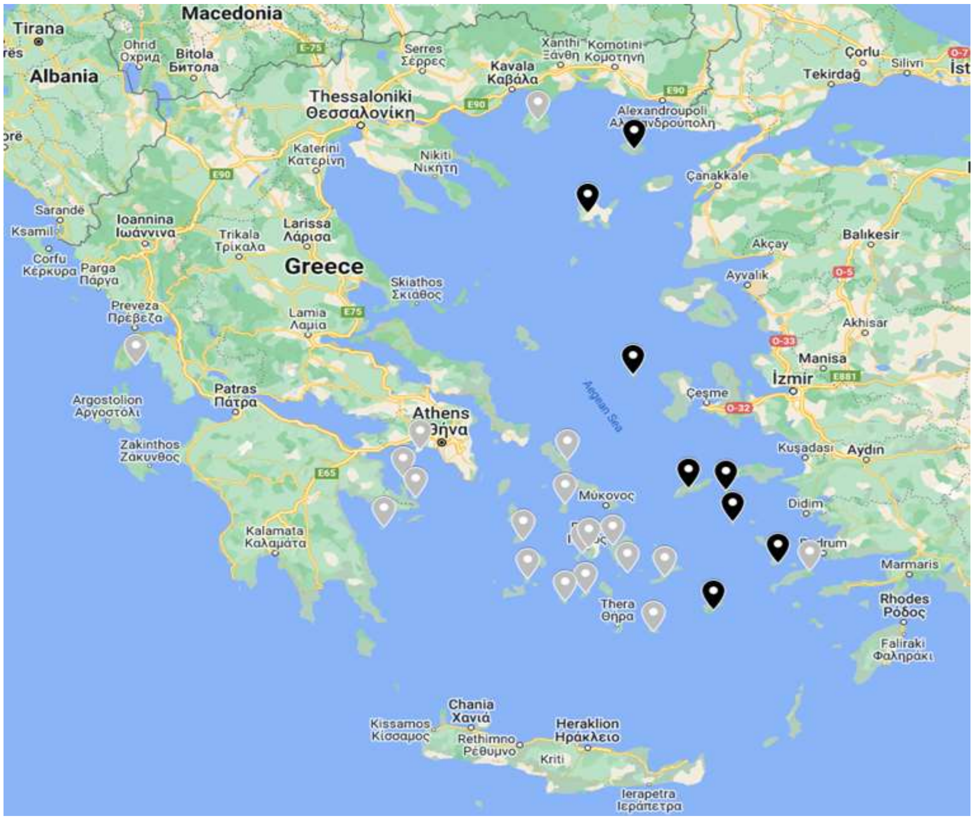
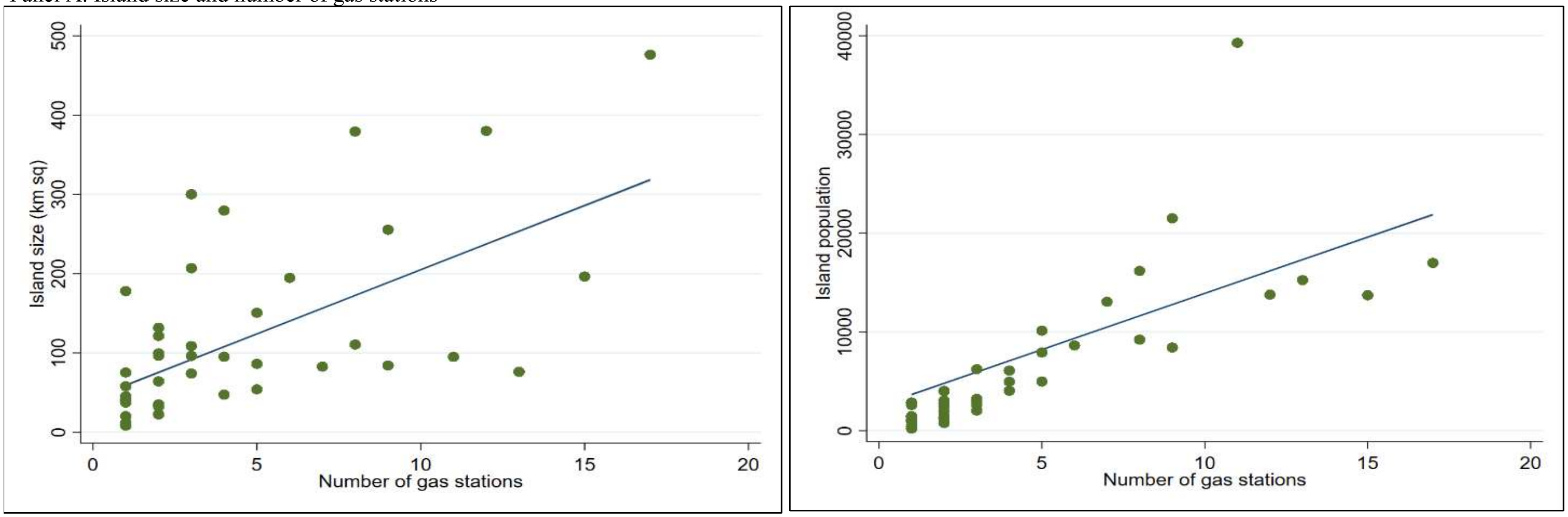
FIGURE 1 - VAT CHANGES ACROSS GREEK ISLANDS



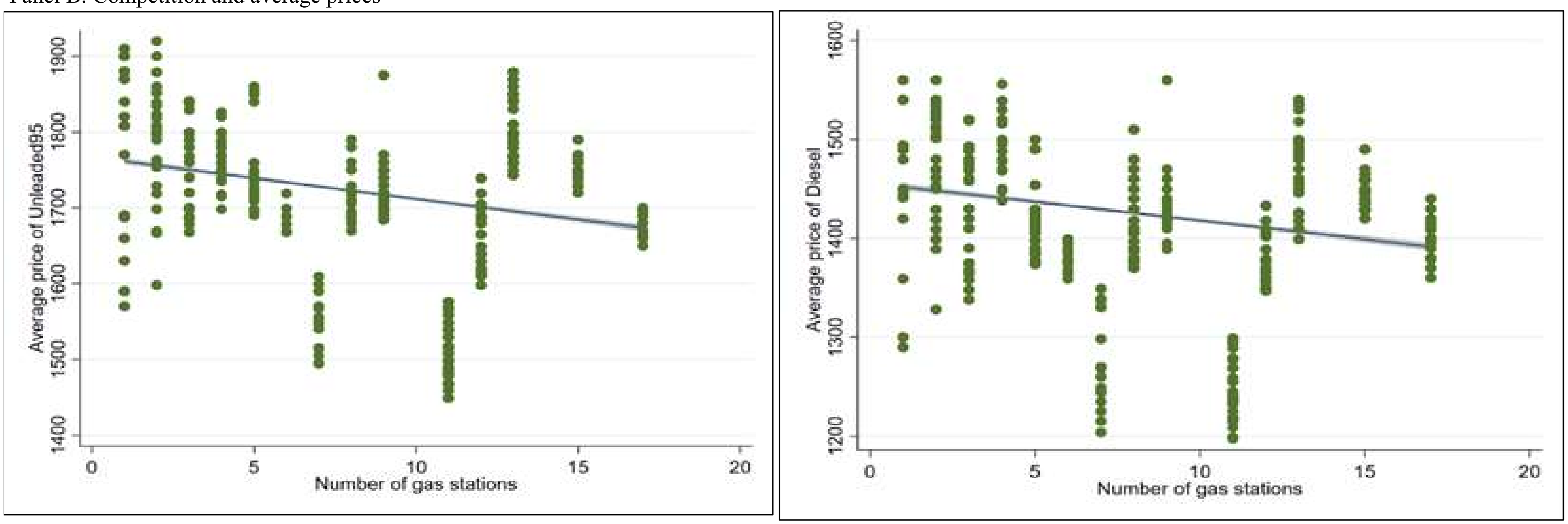
Notes: The figure marks the islands used in the analysis. The black dot indicates the group of treated islands, whereas the gray dot marks the islands used as control group.
Source: Authors' calculations based on data from the Greek Ministry of Development.

FIGURE 2 - COMPETITION AND ISLAND SIZE

Panel A. Island size and number of gas stations



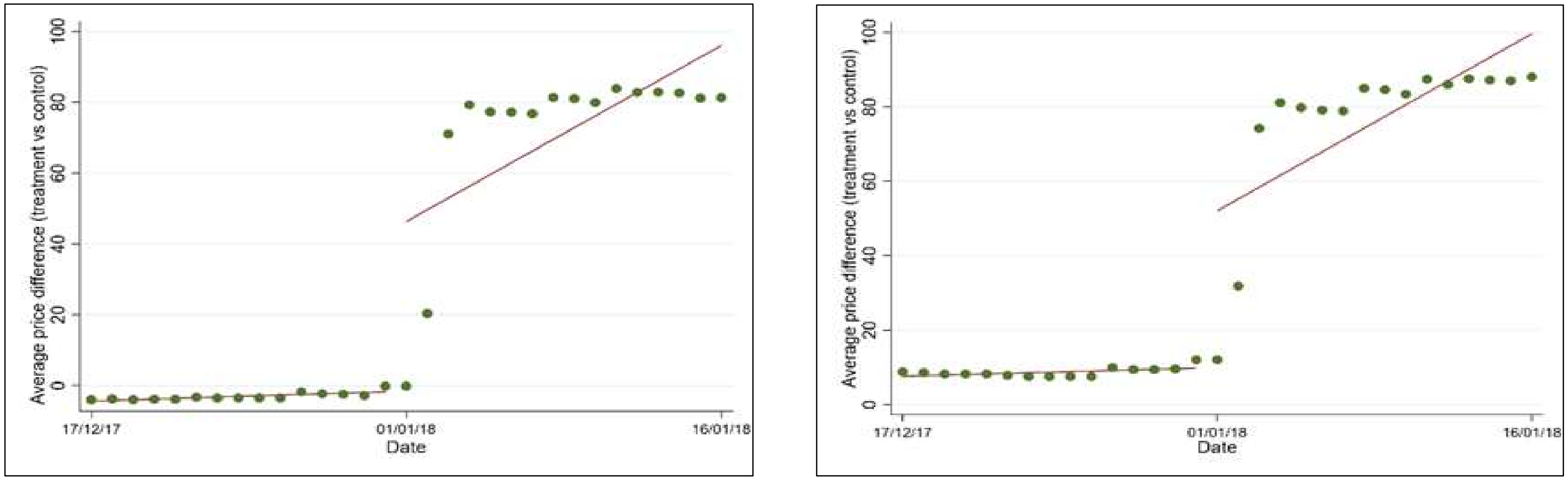
Panel B. Competition and average prices



Notes: Average values computed in November 2017.
Source: Authors' calculations based on data from the Greek Ministry of Development and the Hellenic Statistical Authority.

FIGURE 3 - AVERAGE PRICE DIFFERENCES BETWEEN TREATED AND CONTROL ISLANDS

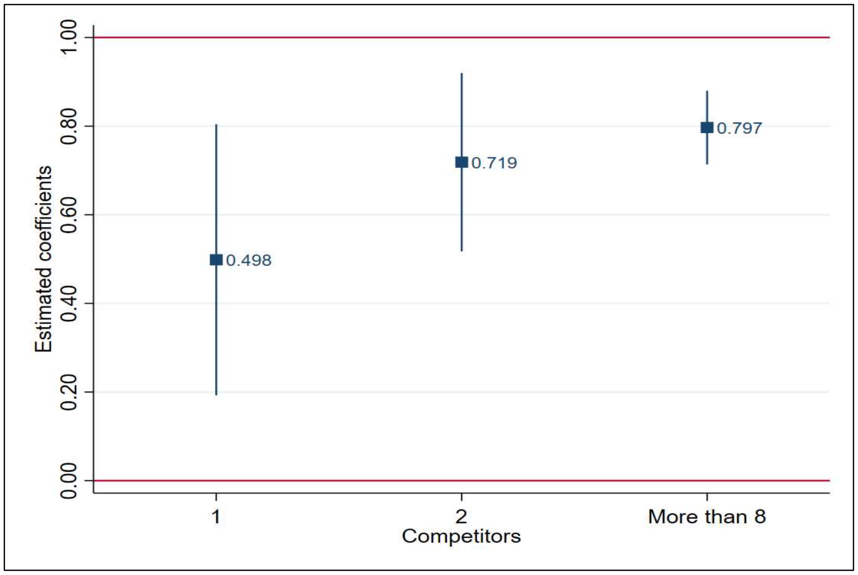
Unleaded 95 | Diesel



Notes: The two figures plot the average price difference between treated and control islands for the two products (unleaded 95 and diesel) for fifteen days before and after the VAT change, together with two linear regression lines for the period before and after the tax change separately for each product.
Source: Authors' calculations based on data from the Greek Ministry of Development.

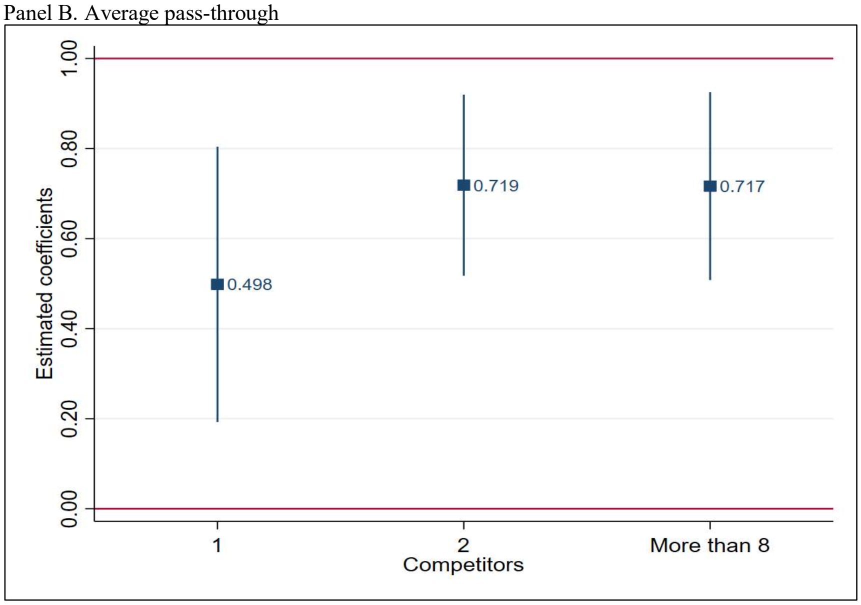
FIGURE 4 - PASS-THROUGH AND COMPETITION

Panel A. Conditional pass-through



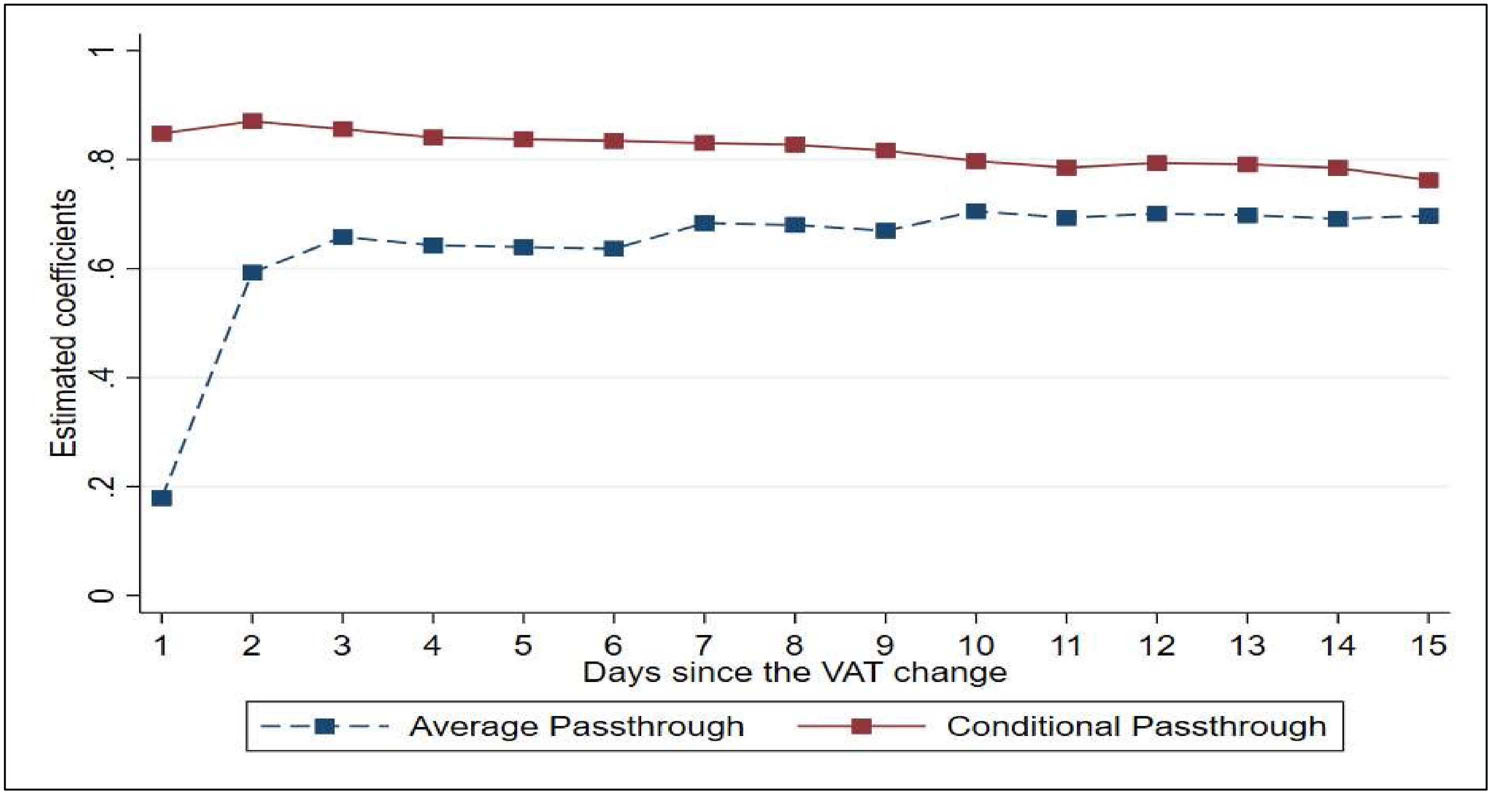
Notes: The figure plots the estimated coefficients from Table 4, column 1, together with the 95% confidence interval.
Source: Authors' calculations based on data from the Greek Ministry of Development.

Panel B. Average pass-through



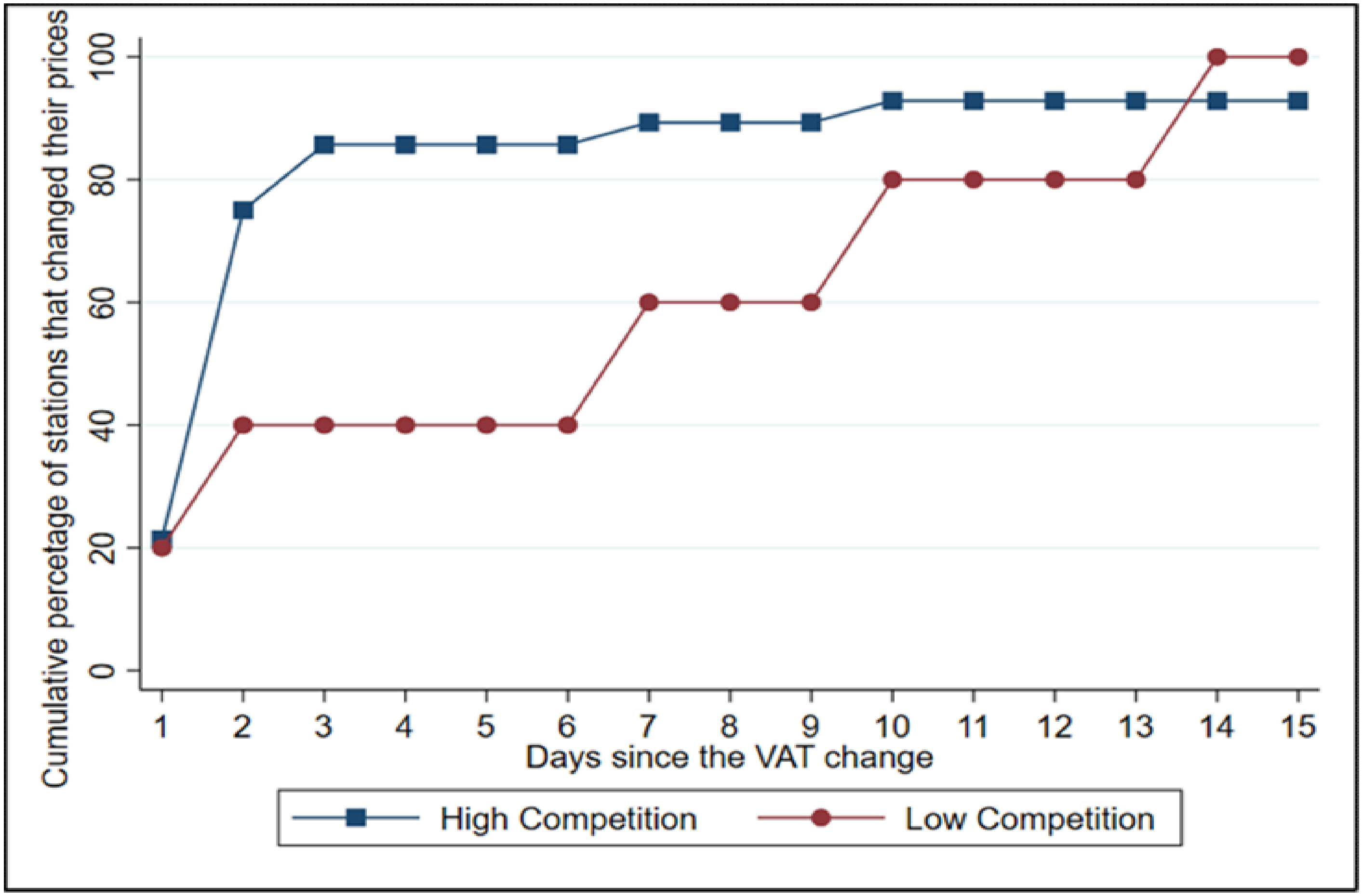
Notes: The figure plots the estimated coefficients from Table 4, column 2, together with the 95% confidence interval.
Source: Authors' calculations based on data from the Greek Ministry of Development.

FIGURE 5 - PASS-THROUGH AND SPEED OF ADJUSTMENT



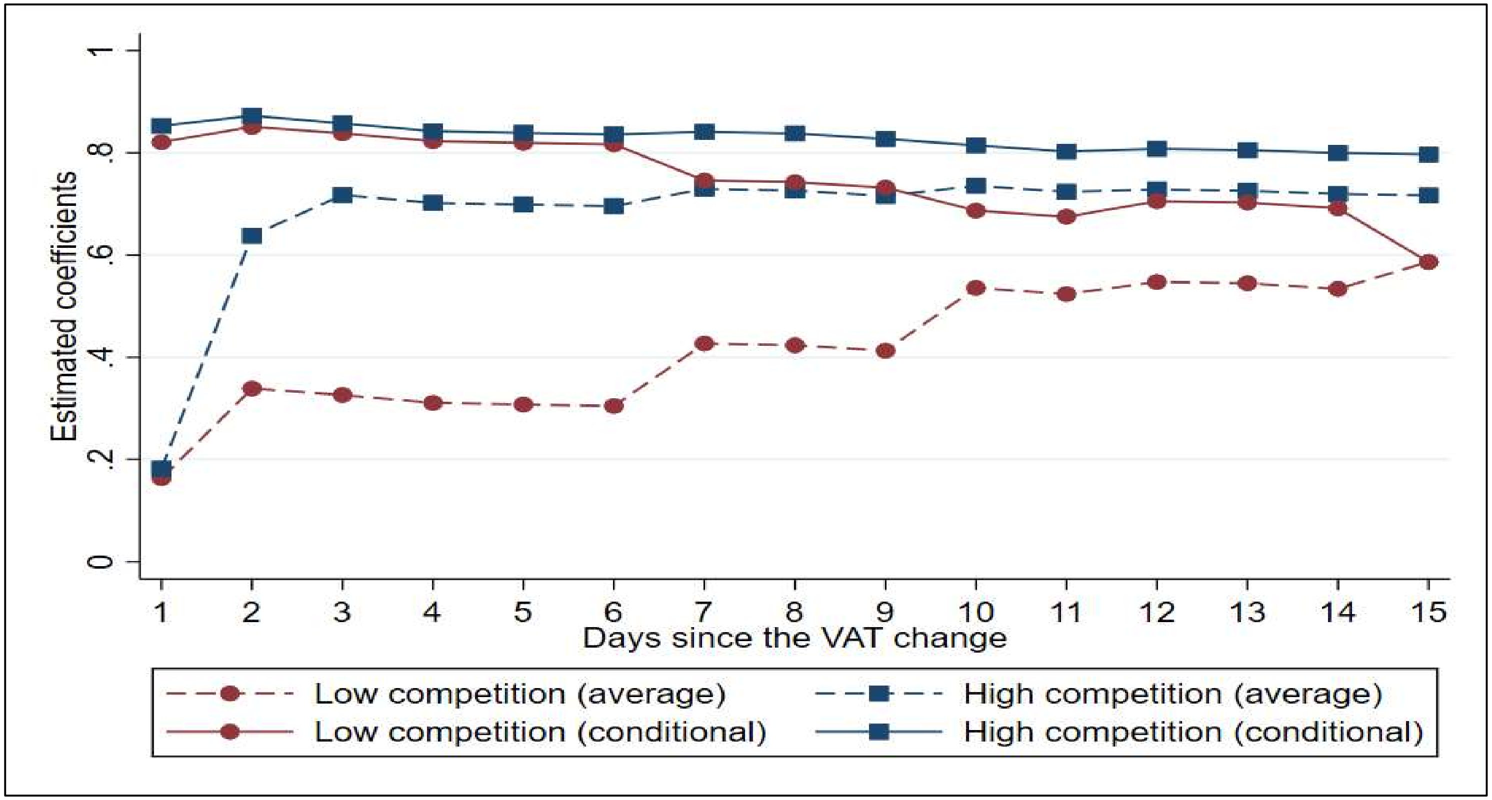
Notes: The figure plots the estimated coefficients from Table 5. The average pass-through is estimated using all the data. The conditional pass-through is estimated using observations for station-product combinations that have changed the price at least once between τ and τ+δ, where τ is the date of the VAT change and δ=1,...,15.
Source: Authors' calculations based on data from the Greek Ministry of Development.

FIGURE 6: CUMULATIVE FREQUENCY OF PRICE CHANGES



Notes: The figure plots the cumulative frequency of station-product combinations that changed their prices between τ and $\tau+\delta$, where τ is the date of the VAT change and δ=1,...,15, on islands with 1-2 (low competition) and more than eight competitors (high competition) gas stations. The Kolmogorov-Smirnov test rejects the equality of the CDFs at the 1 percent confidence level.

FIGURE 7 - SPEED OF ADJUSTMENT AND COMPETITION



Notes: The figure plots the average and conditional pass-through on islands with 1-2 (low competition) and more than eight (high competition) gas stations. The average pass-through is estimated using all the data. The conditional pass-through is estimated using observations for station-product combinations that have changed the price at least once between τ and $\tau+\delta$, where τ is the date of the VAT change and δ=1,...,15. Estimated coefficients are reported in Table 6.

Source: Authors' calculations based on data from the Greek Ministry of Development.

TABLE 1 - SUMMARY STATISTICS

Variable	Mean	Standard Deviation	Median	10th percentile	90th percentile
PANEL A - PRICES					
Unleaded 95 (€ cents per litre)	172	9.5	174	159	182
Diesel (€ cents per litre)	143	7.6	145	132	152
PANEL B - ISLAND CHARACTERISTICS					
Size (Km^2)	274	157	288	45	476
Population (number of inhabitants)	17,900	10,985	16,992	1,973	33,388
Ports	2.2	1.5	1	1	4
Arrivals (number of tourists)	35,296	22,318	40,350	7,956	62,509
Distance from Piraeus (Km)	126	58	103	31	200
Income (€)	16,618	1,588	16,215	15,261	19,321

Notes: Island socioeconomic and geographic characteristics were obtained from the Hellenic Statistical Authority (Census 2010). Arrivals refer to tourist arrivals by air or sea in 2017. Income per capita based on a release from the Independent Authority of Public Revenue.
Source: Authors' calculations based on data from the Greek Ministry of Development and the Hellenic Statistical Authority.

TABLE 2 - AVERAGE AND CONDITIONAL PASS-THROUGH

	(1)	(2)	(3)	(4)
Pass-through definition	Conditional	Conditional	Average	Average
Dependent variable	$\ln(Price_{jigt})$	$\ln(Price_{jigt})$	$\ln(Price_{jigt})$	$\ln(Price_{jigt})$
Sample	Full sample	1-to-1 matching	Full sample	1-to-1 matching
VAT	0.762***	0.757***	0.697***	0.692***
	(0.054)	(0.072)	(0.093)	(0.098)
Observations	474	314	484	324
Within R^2	0.915	0.93	0.848	0.861
Station × Product Type FE	yes	yes	yes	yes
Day FE	yes	yes	yes	yes

Notes: The dependent variable is the logarithm of retail price of product j, on island i, in gas station g, and day $t \in \{\tau - 1, \tau + 15\}$, where τ is the date of VAT change. Standard errors are clustered at the island level and are reported in parentheses below coefficients. ***, **, * mark statistical significance at the 0.01, 0.05 and 0.10 level respectively.

Source: Authors' calculations based on data from the Greek Ministry of Development and Eurostat.

TABLE 3 - PASS-THROUGH AND COMPETITION

	(1)	(2)	(3)	(4)
Estimation method	FE	FE	FE	IV
Dependent variable	$\ln(Price_{jigt})$	$\ln(Price_{jigt})$	$\ln(Price_{jigt})$	$\ln(Price_{jigt})$
	PANEL A: CONDITIONAL PASS-THROUGH			
Tax_{it}	0.569***	1.010	0.538***	0.584***
	(0.088)	(0.863)	(0.143)	(0.101)
Tax_{it} × Number of $competitors_s$	0.016***	0.019***	0.026	0.015**
	(0.005)	(0.005)	(0.028)	(0.007)
Tax_{it} × Number of $competitors_s^2$			-0.001	
			(0.001)	
First stage F-test (Number of competitors)				*61.334*
Within R^2	0.925	0.935	0.926	0.925
Observations	474	474	474	474
	PANEL B: AVERAGE PASS-THROUGH			
Tax_{it}	0.445***	1.083	0.621***	0.418***
	(0.114)	(0.863)	(0.149)	(0.134)
Tax_{it} × Number of $competitors_s$	0.021***	0.019***	-0.033	0.024***
	(0.007)	(0.005)	(0.031)	(0.008)
Tax_{it} × Number of $competitors_s^2$			0.003*	
			(0.001)	
First stage F-test (Number of competitors)				*55.317*
Within R^2	0.867	0.886	0.874	0.867
Observations	484	484	484	484
Day FE	yes	yes	yes	yes
Station × Product Type FE	yes	yes	yes	yes
Additional controls (interactions with income, education, number of ports and tourist arrivals).		yes		

Notes: The dependent variable is the logarithm of retail price of product j, on island i, in gas station g, and day $t \in \{\tau\text{-}1, \tau\text{+}15\}$, where τ is the date of VAT change. The full results of column 2 are presented in Table 5 of the Appendix. For column 4, the instrument is the island population. Standard errors are clustered at the island level and are reported in parentheses below coefficients. ***, **, * mark statistical significance at the 0.01, 0.05 and 0.10 level respectively.
Source: Authors' calculations based on data from the Greek Ministry of Development and the Hellenic Statistical Authority.

TABLE 4 - PASS-THROUGH AND COMPETITION

	(1)	(2)	(3)	(4)
Pass-through definition	Conditional	Average	Conditional	Average
Dependent variable	ln($Price_{jigt}$)	ln($Price_{jigt}$)	ln($Price_{jigt}$)	ln($Price_{jigt}$)
Sample	Full sample	Full sample	1-to-1 matching	1-to-1 matching
VAT × Monopoly	0.498***	0.498***	0.494**	0.494**
	(0.148)	(0.148)	(0.158)	(0.158)
VAT × Duopoly	0.719***	0.719***	0.714***	0.714***
	(0.098)	(0.098)	(0.108)	(0.108)
VAT × 8+ Competitors	0.797***	0.717***	0.792***	0.712***
	(0.040)	(0.101)	(0.063)	(0.105)
Observations	474	484	314	324
Station × Product Type FE	yes	yes	yes	yes
Day FE	yes	yes	yes	yes
F-test (*p-value*)				
Monopoly = Duopoly	*0.221*	*0.221*	*0.271*	*0.271*
Duopoly = 8+ Competitors	*0.450*	*0.989*	*0.488*	*0.990*
Monopoly = 8+ Competitors	*0.060*	*0.230*	*0.102*	*0.280*
Monopoly = 0.5	*0.992*	*0.992*	*0.969*	*0.969*
Duopoly = 1	*0.008*	*0.008*	*0.033*	*0.033*
8+ Competitors = 1	*0.000*	*0.010*	*0.014*	*0.029*

Notes: The dependent variable is the logarithm of retail price of product j, on island i, in gas station g, and day $t \in \{\tau\text{-}1, \tau+15\}$, where τ is the date of VAT change. Standard errors are clustered at the island level and are reported in parentheses below coefficients. ***, **, * mark statistical significance at the 0.01, 0.05 and 0.10 level respectively.
Source: Authors' calculations based on data from the Greek Ministry of Development and the Hellenic Statistical Authority.

TABLE 5 - PASS-THROUGH AND SPEED OF ADJUSTMENT

	(1)	(2)
Pass-through definition	Average	Conditional
Dependent variable	ln($Price_{jigt}$)	ln($Price_{jigt}$)
Sample	Full sample	Full sample
VAT	0.179***	0.848***
(τ-1, τ+1)	(0.034)	(0.012)
VAT	0.593***	0.871***
(τ-1, τ+2)	(0.177)	(0.014)
VAT	0.658***	0.856***
(τ-1, τ+3)	(0.127)	(0.017)
VAT	0.643***	0.841***
(τ-1, τ+4)	(0.127)	(0.018)
VAT	0.639***	0.837***
(τ-1, τ+5)	(0.127)	(0.019)
VAT	0.637***	0.835***
(τ-1, τ+6)	(0.127)	(0.019)
VAT	0.684***	0.831***
(τ-1, τ+7)	(0.111)	(0.030)
VAT	0.680***	0.827***
(τ-1, τ+8)	(0.111)	(0.030)
VAT	0.670***	0.817***
(τ-1, τ+9)	(0.111)	(0.033)
VAT	0.705***	0.797***
(τ-1, τ+10)	(0.094)	(0.042)
VAT	0.693***	0.785***
(τ-1, τ+11)	(0.094)	(0.042)
VAT	0.701***	0.794***
(τ-1, τ+12)	(0.096)	(0.042)
VAT	0.698***	0.791***
(τ-1, τ+13)	(0.096)	(0.042)
VAT	0.691***	0.785***
(τ-1, τ+14)	(0.098)	(0.043)
VAT	0.697***	0.762***
(τ-1, τ+15)	(0.0933)	(0.054)

Notes: The dependent variable is the logarithm of retail price of product j, on island i, in gas station g, and day $t \in \{\tau\text{-}1, \tau+\varphi\}$, where τ is the date of VAT change and φ= 1, …, 15 is the adjustment period. Each coefficient comes from a separate regression. Standard errors are clustered at the island level and are reported in parentheses below coefficients. ***, **, * mark statistical significance at the 0.01, 0.05 and 0.10 level respectively. The regressions include day and product × station fixed effects.
Source: Authors' calculations based on data from the Greek Ministry of Development.

TABLE 6 - COMPETITION AND SPEED OF ADJUSTMENT

PANEL A. AVERAGE PASS-THROUGH

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
Dependent variable	$\ln(Price_{jigt})$	$\ln(Price_{jigt})$	$\ln(Price_{jigt})$	$\ln(Price_{jigt})$	$\ln(Price_{jigt})$	$\ln(Price_{jigt})$	$\ln(Price_{jigt})$	$\ln(Price_{jigt})$	$\ln(Price_{jigt})$	$\ln(Price_{jigt})$	$\ln(Price_{jigt})$	$\ln(Price_{jigt})$	$\ln(Price_{jigt})$	$\ln(Price_{jigt})$	$\ln(Price_{jigt})$
Sample	$(\tau-1, \tau+1)$	$(\tau-1, \tau+2)$	$(\tau-1, \tau+3)$	$(\tau-1, \tau+4)$	$(\tau-1, \tau+5)$	$(\tau-1, \tau+6)$	$(\tau-1, \tau+7)$	$(\tau-1, \tau+8)$	$(\tau-1, \tau+9)$	$(\tau-1, \tau+10)$	$(\tau-1, \tau+11)$	$(\tau-1, \tau+12)$	$(\tau-1, \tau+13)$	$(\tau-1, \tau+14)$	$(\tau-1, \tau+15)$
Tax_{it} × Low competition	0.163	0.339*	0.326	0.311	0.308	0.305	0.427**	0.423**	0.413**	0.536***	0.524***	0.547***	0.545***	0.534***	0.586***
(1-2 competitors)	(0.150)	(0.192)	(0.192)	(0.192)	(0.192)	(0.192)	(0.182)	(0.182)	(0.182)	(0.146)	(0.146)	(0.156)	(0.156)	(0.156)	(0.110)
Tax_{it} × High competition	0.182***	0.638***	0.717***	0.702***	0.699***	0.696***	0.729***	0.726***	0.716***	0.736***	0.724***	0.728***	0.726***	0.720***	0.717***
(8+ competitors)	(0.029)	(0.188)	(0.118)	(0.118)	(0.118)	(0.119)	(0.107)	(0.107)	(0.107)	(0.0964)	(0.0964)	(0.0993)	(0.0994)	(0.101)	(0.101)
Test equality of coefficients (*p-value*)	*0.905*	*0.275*	*0.094*	*0.094*	*0.094*	*0.094*	*0.161*	*0.161*	*0.161*	*0.256*	*0.256*	*0.330*	*0.330*	*0.321*	*0.383*

PANEL B. CONDITIONAL PASS-THROUGH

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
Dependent variable	$\ln(Price_{jigt})$	$\ln(Price_{jigt})$	$\ln(Price_{jigt})$	$\ln(Price_{jigt})$	$\ln(Price_{jigt})$	$\ln(Price_{jigt})$	$\ln(Price_{jigt})$	$\ln(Price_{jigt})$	$\ln(Price_{jigt})$	$\ln(Price_{jigt})$	$\ln(Price_{jigt})$	$\ln(Price_{jigt})$	$\ln(Price_{jigt})$	$\ln(Price_{jigt})$	$\ln(Price_{jigt})$
Sample	$(\tau-1, \tau+1)$	$(\tau-1, \tau+2)$	$(\tau-1, \tau+3)$	$(\tau-1, \tau+4)$	$(\tau-1, \tau+5)$	$(\tau-1, \tau+6)$	$(\tau-1, \tau+7)$	$(\tau-1, \tau+8)$	$(\tau-1, \tau+9)$	$(\tau-1, \tau+10)$	$(\tau-1, \tau+11)$	$(\tau-1, \tau+12)$	$(\tau-1, \tau+13)$	$(\tau-1, \tau+14)$	$(\tau-1, \tau+15)$
Tax_{it} × Low competition	0.821***	0.851***	0.838***	0.823***	0.820***	0.817***	0.746***	0.743***	0.732***	0.687***	0.675***	0.705***	0.703***	0.692***	0.586***
(1-2 competitors)	(0.001)	(0.023)	(0.024)	(0.025)	(0.026)	(0.026)	(0.051)	(0.052)	(0.053)	(0.057)	(0.057)	(0.071)	(0.071)	(0.071)	(0.110)
Tax_{it} × High competition	0.853***	0.872***	0.858***	0.842***	0.839***	0.836***	0.841***	0.838***	0.827***	0.815***	0.803***	0.808***	0.805***	0.800***	0.797***
(8+ competitors)	(0.011)	(0.014)	(0.017)	(0.018)	(0.019)	(0.020)	(0.027)	(0.028)	(0.030)	(0.038)	(0.038)	(0.040)	(0.040)	(0.041)	(0.040)
Test equality of coefficients (*p-value*)	*0.008*	*0.416*	*0.473*	*0.473*	*0.473*	*0.473*	*0.087*	*0.087*	*0.087*	*0.043*	*0.043*	*0.184*	*0.184*	*0.168*	*0.076*

Notes: The dependent variable is the retail price of product *j*, on island *i*, in gas station *g*, and day $t \in \{-1, \tau + \varphi\}$, where τ is the date of VAT change and φ= 1, …, 15 is the adjustment period. Each coefficient comes from a separate regression. Standard errors are clustered at the island level and are reported in parentheses below coefficients. ***, **, * mark statistical significance at the 0.01, 0.05 and 0.10 level respectively. The regressions include day and product × station fixed effects.

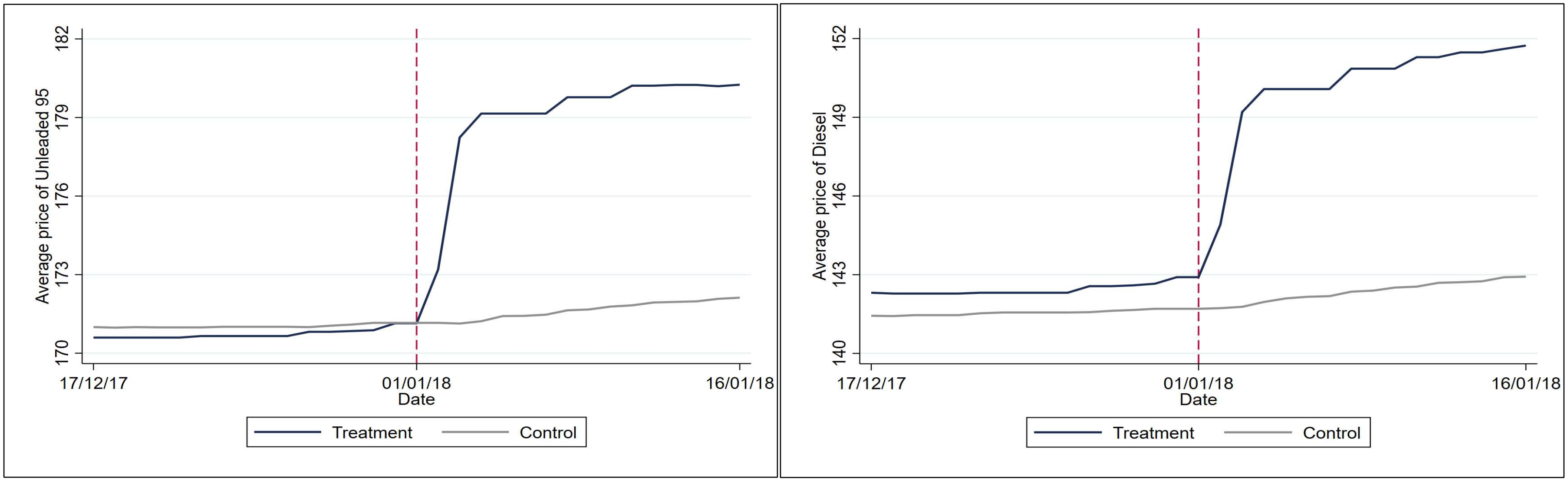
TABLE 7 - PASS-THROUGH AND PRODUCT HETEROGENEITY

	(1)	(2)	(3)	(4)
Pass-through definition	Average	Average	Conditional	Conditional
Dependent variable	ln($Price_{jigt}$)	ln($Price_{jigt}$)	ln($Price_{jigt}$)	ln($Price_{jigt}$)
Sample	Full sample	Full sample	Full sample	Full sample
VAT × Unleaded95	0.641***		0.712***	
	(0.096)		(0.051)	
VAT × Diesel	0.757***		0.814***	
	(0.090)		(0.056)	
VAT_t × Unleaded95 × Low competition		0.514***		0.514***
		(0.111)		(0.111)
VAT_t × Diesel × Low competition		0.659***		0.659***
		(0.113)		(0.113)
VAT_t × Unleaded95 × High competition		0.662***		0.751***
		(0.104)		(0.034)
VAT_t × Diesel × High competition		0.775***		0.845***
		(0.097)		(0.046)
Observations	484	484	474	474
Within R^2	0.852	0.855	0.918	0.925
Station × Product Type FE	yes	yes	yes	yes
Day FE	yes	yes	yes	yes
F-test (*p-value*)				
U95 = Diesel	0.000		0.000	
U95 = 1	0.001		0.000	
Diesel = 1	0.012		0.003	
Low comp (U95) = Low comp (Diesel)		0.040		0.040
High comp (U95) = High comp (Diesel)		0.000		0.000

Notes: The dependent variable is the logarithm of retail price of product *j*, on island *i*, in gas station *g*, and day $t \in \{-1, \tau + 15\}$, where τ is the date of VAT change. Standard errors are clustered at the island level and are reported in parentheses below coefficients. ***, **, * mark statistical significance at the 0.01, 0.05 and 0.10 level respectively.

Source: Authors' calculations based on data from the Greek Ministry of Development and the Hellenic Statistical Authority.

FIGURE A1: AVERGE PRICES OF PETROLEUM PRODUCTS BEFORE AND AFTER THE VAT CHANGE.



Notes: The two figures plot average retail prices (€ cents per litre) of Unleaded 95 and Diesel for 15 days before and after the VAT change.
Source: Authors' calculations based on data from the Greek Ministry of Development.

TABLE A1 - VAT CHANGES AND GREEK ISLANDS

	Monopolies		Duopolies		8+ competitor markets	
PANEL A: FULL SAMPLE						
	Treatment	Control	Treatment	Control	Treatment	Control
	Fourni	Anafi	Astypalaia	Antiparos	Ikaria	Andros
	Psara	Agistri	Patmos	Amorgos	Kalymnos	Kos
	Samothraki	Kimolos		Folegandros	Limnos	Naxos
		Meganisi		Poros		Paros
		Schoinousa		Spetses		Salamina
		Serifos				Syros
		Sikinos				Thasos
PANEL B: ONE-TO-ONE MATCHING						
	Treatment	Control	Treatment	Control	Treatment	Control
	Fourni	Schoinousa	Astypalaia	Amorgos	Ikaria	Naxos
	Psara	Sikinos	Patmos	Antiparos	Kalymnos	Kos
	Samothraki	Agistri			Limnos	Thasos

Notes: Treatment islands were those selected for the VAT equalization. Control islands were selected as explained in Section 3.
Source: Authors' calculations based on data from the Greek Ministry of Development.

TABLE A2 - DIFFERENCES IN ISLAND CHARACTERISTICS

	(1) Treatment Islands	(2) Control Islands	(3) p-value
PANEL A: TOTAL			
Number of competitors on the same island	5.125	5.176	0.511
Population	6342.375	6708	0.890
Size (Km^2)	154.494	119.263	0.429
Port arrivals (2018)	10408.06	20013.32	0.109
Distance from Peiraeus	160.375	105.882	0.001
Income	15950.25	17200.06	0.006
Population with university degree	0.10	0.10	0.540
Number of ports	1.5	1.588	0.813
PANEL B: MONOPOLIES			
Number of competitors on the same island	1	1	
Population	1588	759.571	0.026
Size (Km^2)	87.733	33.2689	0.016
Port arrivals (2018)	8259.333	3622.571	0.179
Distance from Peiraeus	146.333	103.429	0.055
Income	16250.54	17664.12	0.0351
Population with university degree	0.087	0.094	0.435
Number of ports	1	1	
PANEL C: DUOPOLIES			
Number of competitors on the same island	2	2	
Population	2190.5	2393.8	0.803
Size (Km^2)	65.281	46.765	0.436
Port arrivals (2018)	4228.75	15889.2	0.161
Distance from Peiraeus	166	83.6	0.001
Income	16113.82	16975.76	0.281
Population with university degree	0.17	0.11	0.311
Number of ports	1	1.2	0.436
PANEL D: MORE THAN 8 COMPETITORS			
Number of competitors on the same island	11.333	14.2	0.329
Population	13864.67	19350	0.172
Size (Km^2)	280.729	312.154	0.677
Port arrivals (2018)	16,676	47,085	0.002
Distance from Peiraeus	170.666	131.6	0.107
Income	15540.92	16774.68	0.190
Population with university degree	0.12	0.11	0.614
Number of ports	2.333	2.8	0.614

Note: Socioeconomic and geographic characteristics for each island obtained from the Hellenic Statistical Authority.
Source: Authors' calculations based on data from the Greek Ministry of Development and the Hellenic Statistical Authority.

TABLE A3 - PARALLEL TREND TESTS

	(1)	(2)	(3)
VARIABLES	log($Price_{ijtg}$)	log($Price_{ijtg}$)	log($Price_{ijtg}$)
Product	ALL products	Unleaded 95	Diesel
$Trend_t$	0.103***	0.067*	0.142***
	(0.026)	(0.036)	(0.03)
$Trend_t$ × Treat	0.104	0.104	0.103
	(0.120)	(0.123)	(0.126)
Window before the event	[τ-15, τ-1]	[τ-15, τ-1]	[τ-15, τ-1]
Adjusted R^2	0.996	0.998	0.997
Observations	3,630	1,875	1,755
Product type FE	yes		
Station FE	yes	yes	yes

Notes: The table illustrates the outcome for the parallel trend assumption test based on equation (2). The coefficients and the standard errors are multiplied by 1000.
Source: Authors' calculations based on data from the Greek Ministry of Development and the Hellenic Statistical Authority.

TABLE A4 - PARALLEL TREND TESTS (NON-PARAMETRIC)

	(1)
Dependent variable	log($Price_{ijtg}$)
Sample	ALL products
Day(τ-15) × Treat	-0.214
	(0.260)
Day(τ-14) × Treat	-0.214
	(0.254)
Day(τ-13) × Treat	-0.233
	(0.253)
Day(τ-12) × Treat	-0.229
	(0.253)
Day(τ-11) × Treat	-0.229
	(0.253)
Day(τ-10) × Treat	-0.225
	(0.227)
Day(τ-9) × Treat	-0.244
	(0.226)
Day(τ-8) × Treat	-0.244
	(0.226)
Day(τ-7) × Treat	-0.244
	(0.226)
Day(τ-6) × Treat	-0.244
	(0.226)
Day(τ-5) × Treat	-0.110
	(0.176)
Day(τ-4) × Treat	-0.145
	(0.176)
Day(τ-3) × Treat	-0.149
	(0.184)
Day(τ-2) × Treat	-0.157
	(0.153)
Joint F-test (p-value)	0.88
	(0.356)
Window before the event	[τ-15, τ-1]
Observations	3,630
Within R^2	0.996
Day FE	yes
Product type FE	yes
Station FE	yes

Notes: The table reports results for the parallel trend assumption test based on equation (2) in the main text, where the trend is replaced by day binary indicators. Only the interaction effects of day fixed effects with the treat variable are reported here. Standard errors clustered at the island level are reported in parentheses below coefficients. The coefficients and the standard errors are multiplied by 1000.
Source: Authors' calculations based on data from the Greek Ministry of Development.

TABLE A5 - PASS-THROUGH AND COMPETITION - ROBUSTNESS

	(1)	(2)	(3)	(4)	(5)	(6)
Dependent variable	$Price_{kist}$	$Price_{kist}$	$Price_{kist}$	$Price_{kist}$	$Price_{kist}$	$Price_{kist}$
Sample	Full sample	Full sample	Full sample	Full sample	Full sample	Full sample
	PANEL A: CONDITIONAL PASS-THROUGH					
Tax_{it}	0.569***	1.299	0.370	0.662***	0.527***	1.010
	(0.088)	(0.849)	(0.534)	(0.061)	(0.110)	(0.863)
Tax_{it} × Number of $competitors_s$	0.016***	0.017***	0.010	0.015***	0.017***	0.019***
	(0.005)	(0.006)	(0.011)	(0.004)	(0.006)	(0.005)
Tax_{it} × $Income_s$ (×10000)		-0.000				-0.000
		(0.000)				(0.000)
Tax_{it} × $Education_s$			2.268			-1.103
			(5.499)			(2.993)
Tax_{it} × $Tourists_s$ (×10000)				-0.000***		-0.000***
				(0.000)		(0.000)
Tax_{it} × Number of $ports_s$					0.018	0.011
					(0.011)	(0.012)
Observations	474	474	474	474	474	474
Within R^2	0.925	0.926	0.926	0.935	0.926	0.935
	PANEL B: AVERAGE PASS-THROUGH					
Tax_{it}	0.445***	0.379	0.242	0.526***	0.599***	1.083
	(0.114)	(1.012)	(0.515)	(0.113)	(0.110)	(0.863)
Tax_{it} × Number of $competitors_s$	0.0213***	0.0211***	0.0154	0.021***	0.017***	0.019***
	(0.007)	(0.007)	(0.012)	(0.006)	(0.006)	(0.005)
Tax_{it} × $Income_s$ (×10000)		0.040				-0.179
		(0.633)				(0.443)
Tax_{it} × $Education_s$			2.323			-1.103
			(5.216)			(2.993)
Tax_{it} × $Tourists_s$ (×10000)				-0.021***		-0.024***
				(0.007)		(0.008)
Tax_{it} × Number of $ports_s$					-0.055***	-0.061***
					(0.011)	(0.012)
Observations	484	484	484	484	484	484
Within R^2	0.867	0.867	0.868	0.875	0.877	0.886

Notes: The dependent variable is the logarithm of retail price of product j, on island i, in gas station g, and day $t \in \{\tau\text{-}1, \tau\text{+}15\}$, where τ is the date of VAT change. Standard errors are clustered at the island level and are reported in parentheses below coefficients. ***, **, * mark statistical significance at the 0.01, 0.05 and 0.10 level respectively. All regressions include day and product × station fixed effects.
Source: Authors' calculations based on data from the Greek Ministry of Development.

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