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VAT Pass-Through and Competition: Evidence from the Greek Islands[1]

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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 study how changes in VAT rates are passed through to consumers in islands with different number of retailers. We show that pass-through increases with competition, going from 50% in monopoly to around 80% in more competitive markets but remains incomplete. In addition, we find that there is a positive correlation between competition and the speed of price adjustment. Finally, we find higher pass-through for products with more inelastic demand.

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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 (Anderson, De Palma and Kreider, 2001; Weyl and Fabinger, 2013). 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.

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In addition, since VAT typically applies countrywide, it is hard for researchers to find a good comparison group. Two approaches have been used in the literature to study VAT pass-through. The first one looks at the same product and compares countries that experience a change in VAT with countries that did not.[10] A potential limitation of this approach is that it is hard to assume random treatment. There may be various reasons why the tax changed in one country and not in others and these factors may also affect differentially consumer behavior across countries. The second approach compares products whose tax change with other products that did not, within the same country.[11] However, this comparison may also be problematic, particularly if there are significant substitution effects between the two groups of products. In such a case, the estimates instead of reporting the true pass-through, will indicate the differential impact between the treatment and the control group. This will lead to an underestimation of pass through, if goods are substitutes, and to an overestimation, if they are complements.

In this paper we measure how VAT pass-through varies for the same products, within the same country, across isolated oligopolistic markets of different sizes. We exploit a decision in January 2018 by the Greek government to equalize VAT rates across islands. We focus on the retail market for petroleum products, and we measure VAT pass-through by comparing prices for unleaded gasoline and diesel on the islands affected by the change to similar islands for which the rates remained the same. In addition, the naturally occurring variability in land mass across those islands generates exogenous variation in the retail gas station market structure allowing us to study the impact of competition on pass-through. Islands clearly define local markets and there is no substitutability among them.[12] The logic

[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.

of this approach follows Bresnahan and Reiss (1991), who were the first to study entry in geographically isolated oligopolistic markets.

Using daily gas station data, we study how the VAT pass-through for unleaded gasoline and diesel varied across markets with different 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 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 also find that more competitive markets adjust more quickly, leading to a faster pass-through. Fourth, we find higher pass-through for products with more inelastic demand.

Our results contribute to several strands of the literature. First, our results 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 also find undershifting in an environment where we can credibly control for market power.

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). Our findings of incomplete VAT pass-through together with the results from

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Genakos and Pagliero (2022) of complete excise duty pass-through confirms 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.

Lastly, our findings on the quick response to VAT changes contribute 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 some general results on how competition and other variables interact in determining the level of pass-through (Stern, 1987; Delipalla and Keen, 1992; Anderson, De Palma and Kreider, 2001). To summarize the key ideas, we follow Weyl and Fabinger (2013) who express the impact of an increase in marginal cost (i.e., the pass-through) on the equilibrium price in an oligopolistic market with n symmetrically differentiated firms as

$$\rho = \frac{1}{1+\frac{\theta}{\epsilon_\theta}+\frac{\epsilon_D-\theta}{\epsilon_S}+\frac{\theta}{\epsilon_{ms}}}. \quad (1)$$

The pass-through parameter ρ depends on the conduct parameter θ, which captures the intensity of the competition among firms (θ varies from zero in perfect competition to one

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in a monopoly market), how it varies as the quantity produced changes ($\epsilon_\theta = \frac{\theta}{q\frac{d\theta}{dq}}$), but also on the determinants of the elasticity of demand ϵ_D, the elasticity of the inverse marginal cost curve ϵ_S (the elasticity of supply), and the curvature of the demand function ϵ_{ms}.[13] In general, the sign and magnitude of the pass-through is ambiguous.

The expression for ρ greatly simplifies under a set of assumptions that seem realistic in our environment. If the marginal cost were constant, θ were constant, and demand were linear, then $\rho = \frac{1}{1+\theta}$ 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. The conduct parameter is assumed to be a constant in most empirical applications. Given that we investigate a small time window around the policy change, it also makes sense to assume that the intensity of competition is constant. Finally, an important determinant of the pass-through is the demand curvature. Many empirical studies are based on linear demand specifications, but it is not uncommon to assume different demand specifications that imply different curvature, although there is little guidance in the literature on the sign and magnitude of ϵ_{ms}. Hence, in general, the impact of an increase in competition on pass-through remains largely an empirical issue.

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

[13]ms measures the curvature of the log of demand. If demand is linear then ms=1, if concave ms<1, if convex ms>1.

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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 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

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

[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.

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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 Value Added Tax (VAT), which is a percentage tax.

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.

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

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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 "similar" islands from the rest of Greece for which the VAT did not change. More specifically, as you can see in Table 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, education, income) and the same (statistically speaking) number of competitors on average (Table A2, Panel D). Finally, as a robustness exercise, we also 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

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(through an entry game). 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 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.

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

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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.[17] The identifying assumption of our difference in 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

[17] 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).

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individually and jointly (Table A4), which indicates that the parallel trends assumption is satisfied.[18]

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-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 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,

[18] 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).

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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.

5. Results

5.1. 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.[19] 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 our 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).

[19] 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.

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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 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,[20] indicating incomplete VAT pass-through. Several recent empirical studies also find incomplete VAT pass-through.[21] 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

[20] The P-values are 0.003 and 0.0002 respectively.

[21] 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).

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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.

5.2. 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 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 pass-through prediction from a monopoly model with linear demand. The pass-through increases for duopoly and the more competitive islands,[22] but remains statistically less than 1, i.e., less

[22] Although estimated coefficients increase, most of the differences are not statistically significant (the monopolist seem to be different than the competitive subgroup at 10%), which is most likely due to the small sample size.

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 with more competitors, 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 taxes (Stern, 1987; Delipalla and Keen, 1992; Anderson, De Palma and Kreider, 2001). 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. 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.

5.3. 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

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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). We believe that the difference in the speed of adjustment has to do with the fact that 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.[23]

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.[24] The differences are stark. By the third day since the policy change 84% of 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.

[23] 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.
[24] The Kolmogorov-Smirnov test rejects the equality of the CDFs at the 1 percent confidence level.

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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 τ+15 (significant at 10%). The average pass-through is higher in more competitive islands, although not very strong statistically.[25] 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 amount of the tax to consumers and Genakos and Pagliero (2022), who find similar results for excise duty taxes. Therefore, although the overall level of pass-through seems to be different for ad valorem versus specific taxes, their speed adjustment behavior with respect to competition looks similar across the two types of taxes.

5.4. 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

[25] 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.

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. From 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).

6. 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. Moreover, we find faster adjustment in more competitive markets and higher pass-through for 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

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products across different markets within the same country. We believe that the results contribute to our understanding on VAT pass-through by showing new evidence on relationships that may be present in other settings and in larger markets.

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