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Asymmetric pass-through and competition

Christos Genakos
Blair Yuan Lyu
Mario Pagliero

THE LONDON SCHOOL OF ECONOMICS AND POLITICAL SCIENCE

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Abstract
We study the retail price pass-through of four major tax changes in petroleum products using daily pricing data from gas stations on small Greek islands. We find that (i) the pass-through of the tax hikes is five times higher than for the tax decrease, (ii) the pass-through of the tax hikes increases with competition, while that of the tax decrease does not, (iii) there is significant asymmetry in the speed of price adjustments, and,(iv) the asymmetric price adjustment cannot be explained by tacit collusion, instead the evidence suggests that search is the most plausible explanation.

We dedicate this paper to the loving memory of Mario Pagliero, a brilliant economist and a dear friend, who passed away too soon.

Keywords: pass-through, rockets and feathers, tax incidence, gasoline market, market structure, competition
JEL: H22; L1

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Christos Genakos, University of Cambridge, Cambridge Judge Business School, CEPR and Centre for Economic Performance at London School of Economics. Blair Yuan Lyu, Cambridge Judge Business School. Mario Pagliero, University of Turin.

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1 Introduction

Over the past thirty years, a large body of literature showed that retail prices tend to respond faster to marginal cost increases than to decreases. This asymmetric pass-through, or asymmetric price adjustment, also known as the “rockets and feathers” phenomenon, was first studied by Bacon (1991) in relation to several enquires by the Monopoly and Merger Commission in the UK gasoline market. Empirical evidence has then accumulated not only on the gasoline market (Borenstein et al., 1997), but on a large set of different markets, including food markets and financial markets. For example, Peltzman (2000) documented that asymmetric pass-through is common across a variety of industries in the US economy. Recent surveys of the large and growing literature on the topic (Frey and Manera, 2007; Bakucs et al., 2014) confirm that, although not ubiquitous, asymmetric pass-through is a general phenomenon across industries, countries, and periods.

Empirical research on the asymmetric pass-through has been largely devoted to establishing whether pass-through is symmetric or not. However, a more recent literature is developing combining theoretical and empirical analysis in an attempt to understand the causes of asymmetric price adjustments. Although several competing explanations exists, including market power and collusion (Bacon, 1991, Borenstein et al., 1997), inventory management (Borenstein et al., 1997), menu costs (Meyer and von Cramon-Taubadel, 2004), and search costs (Yang and Ye, 2008; Tappata, 2009; Cabral and Gilbukh, 2020), there is no consensus on the relative merits of the different explanations.

Although market power was the first conjectured explanation for asymmetric response, surprisingly few empirical papers provide specific evidence on the relation between competition and asymmetric pass-through. The main reason is that it is hard to simultaneously identify the asymmetry of price responses and the relation between asymmetry and competition. In fact, most studies rely on industry-specific data on exogenous input cost shocks (positive and negative) to estimate the asymmetric response of prices. However, since market structure is fixed at the industry level, there is typically little to no variability that can be used to identify the interaction between competition and asymmetric pass-through. A second problem is that market structure is likely to be endogenous, hence the intensity of competition may well be determined in equilibrium together with firms' pricing strategies.

This paper directly tackles the issue of estimating the relation between competition and asymmetric pass-through. This is a critical piece of evidence to assess the relevance of standard models of competition and their ability to explain observed pricing patterns in the data. We fill this gap in the literature by using the approach of Genakos and Pagliero (2022), who exploit repeated, large, and unexpected changes in excise duties for petroleum products and exogenous variability in market size across Greek islands. Small islands precisely define oligopolistic retail markets for petroleum products, as some of these are so small to accommodate only one or few gas stations, providing variability in number of competitors that is driven by the specific geography of the region.

We find that, on average, the tax pass-through is 0.7 for tax increases and 0.14 for tax decreases (measured after 10 days). For monopoly markets, the pass-through is about 0.4 for tax increases and 0.2 for tax decreases. The pass-through of a tax increase then grows with competition and converges towards 1, but that of a tax decrease remains constant. The asymmetry in price response grows from 0.2 to 0.8 as the number of competitors increases from one to four/five, but it does not further grow in larger and more competitive markets.

We also find a significant asymmetry in the speed of price adjustments to positive and negative shocks. The average pass-through for tax increases grows significantly with the adjustment period considered, going from 23 percent after one day to 71 percent after ten days. On the contrary, the pass-through for the tax decrease grows very slowly, going from 1 percent after one day to only 14 percent after ten days.

In monopoly markets, where asymmetry is smallest, we cannot reject the null hypothesis of a symmetric response. Although the precision of our estimates is limited, the failure to reject symmetry in monopoly markets is consistent with standard monopoly pricing.

However, as competition increases, pass-through converges towards one, as predicted by oligopoly models, only for positive cost shocks. Although this asymmetry is not consistent with oligopoly models (Weyl and Fabinger, 2013; Miklós-Thal and Shaffer, 2021; Adachi and Fabinger, 2022), it is consistent with different models of asymmetric pass-through, for example with a dynamic equilibrium in which firms collude by not responding to negative cost shocks, as conjectured by the early literature on asymmetric pass-through, or with search cost models, where positive cost shocks trigger more active search by consumers than negative shocks and firms adjust their prices accordingly.

Our results on the relation between competition and asymmetric pass-through have also two additional implications for the growing empirical research on asymmetric pass-through. First, asymmetry is not necessarily apparent in very concentrated markets (monopolies in our case) and certain degree of competition might be necessary to observe a statistically significant asymmetry. Second, the relevant range for variability in competition is between one and four/five competitors. Beyond this point, the relation between competition and asymmetric pass-through flattens substantially. Hence, if one wants to test the impact of competition on asymmetric pass-through, it is critical to correctly identify oligopolistic markets with the appropriate number of competitors.

2 Market background and Data

We focus on the retail market for petroleum products on a sample of small Greek islands. For gas stations, the marginal cost of petroleum products depends on long-term contracts with trade companies and is reasonably constant. Petroleum products are subject to excise duties, which is a unit tax rate (€-cents per liter), and the Value Added Tax (VAT), which is a percentage tax. The retail price is determined as $P_{retail} = (P_{refinery} + exciseduty\&fees + margins) \times (1 + VAT)$. We focus on the impact of changes in excise duties on prices, which are reported net of VAT.

We augment the data of Genakos and Pagliero (2022) to cover the 2010-2013 period. Our sample covers three substantial increases in excise duties occurred in 2010 and a subsequent drop in 2012. Each of these tax changes was announced and implemented the day after the decision was made, as typically happens in order to reduce opportunities for arbitrage. Table 1 shows that the tax changes were significant (between -20% and +29%) and different across products. Remarkably, in each of these four events the excise duties of (at least) one of the products shown on the table remained unchanged. Hence, for the three increases we use heating oil, whereas for the decrease we use unleaded 95 as our control group.

Table 1: EXCISE DUTY CHANGES (€cents per litre and Δ%)

Type of energy product	(1) Unleaded 95	(2) Unleaded 100	(3) Diesel	(4) Super (leaded)	(5) Heating oil
before	41	41	30.2	42.1	2.1
10-Feb-10	53	53	35.2	54.1	2.1
	(29%)	(29%)	(17%)	(29%)	(0%)
04-Mar-10	61	61	38.2	62.1	2.1
	(15%)	(15%)	(9%)	(15%)	(0%)
03-May-10	67	67	41.2	68.1	2.1
	(10%)	(10%)	(8%)	(10%)	(0%)
15-Oct-12	67	67	33	68.1	33
	(0%)	(0%)	(-20%)	(0%)	(1471%)

Notes: The table reports the level and percentage changes in excise duties by product.
Source: Authors' calculations based on data from Eurostat (rates and structure of excise duties for energy products).

The data set includes daily station-level retail prices for five different gasoline products: unleaded 95, unleaded 100, super (or leaded gasoline), diesel, and heating oil. Our sample includes 37 islands with at most 131 gas stations and about 14,435 daily price observations.[1] Gas stations in our sample are independently operated and pricing decisions are taken locally. The data also includes socioeconomic (e.g., education, income, number of tourist arrivals) and geographic (size, distance from Piraeus[2], distance from mainland, number of ports and airports etc.) characteristics of each island from the Hellenic Statistical Authority (2010). We

[1]See Genakos and Pagliero (2022) for a discussion of the representativeness of the data and summary statistics.

[2]The primary distribution center for gasoline products in Greece.

measured the number of gas stations operating in each island using independent information from Yellow Pages (2018) and company reports. We verified and updated information on the number of gas stations as in some islands the number of gas stations slightly changed between 2010 and 2013. The key feature of our data is that arbitrage across islands is impossible, since transportation of petroleum products is too costly (and dangerous) to be economically viable, on top of being illegal. Hence, substitution effects across islands are reasonably absent and each island can be considered as an independent market.

3 Identification and Empirical Methodology

We use the econometric approach of Genakos and Pagliero (2022), but we allow for a different pass-through for the tax increases and decreases. Hence, results exactly replicate those for the tax increases, but differ for the tax decrease, allowing to test the asymmetry in estimated pass-through. Our baseline estimation framework is as follows:

$$P_{kist} = \beta_0 + \rho_U(U_t \times Tax_{kt}) + \rho_D(D_t \times Tax_{kt}) + \beta_{1ks}U_t + \beta_{2ks}D_t + \beta_t + e_{kist} \quad (1)$$

where P_{kist} denotes the retail price of product k, on island i, in gas station s, on day $t \in \{\tau(n) - 1,\ \tau(n) + \delta\}$, where $\tau(n)$ is the date of each of the four excise duty changes ($n = 1, \ldots 4$) and $\delta = 1, \ldots, \delta_n$ is the length of the adjustment period considered. U_t is an indicator variable equal to one for the observations around the tax increases, and D_t is the corresponding indicator for periods around the tax decrease. Tax_{kt} is the excise duty, and the coefficients ρ_U and ρ_D capture the tax pass-through for positive and negative tax changes. Finally, the model includes product-gas station and calendar day fixed effects that capture any unobserved permanent differences across stations (geographical location, brand name, reputation etc) as well as macroeconomic common time shocks.

We then allow for a more flexible specification by making the parameters ρ_U and ρ_D

depend on island characteristics:

$$P_{kist} = \beta_0 + \rho_U(n_i, Z_i)(U_t \times Tax_{kt}) \; + \rho_D(n_i, Z_i)(D_t \times Tax_{kt})\beta_{1ks}U_t + \beta_{2ks}D_t + \beta_t + e_{kist} \quad (2)$$

where the pass-through $\rho_U(n_i, Z_i)$ may be a linear function $\rho_U(n_i, Z_i) = \vartheta_{U0} + \vartheta_{U1}n_i + \vartheta_{U2}Z_i$ of the number of competitors n_i and other island specific characteristics Z_i and, similarly, $\rho_D(n_i, Z_i) = \vartheta_{D0} + \vartheta_{D1}n_i + \vartheta_{D2}Z_i$. The number of competitors and island characteristics do not vary around each excise duty change as we consider a relatively small time window (10 days) in each case. For simplicity, we omit the subscript t for variables n_i and Z_i in equation Equation 2.

Alternatively, the relation between pass-through ρ_U and ρ_D and number of stations j can be non-parametrically estimated replacing $\rho_U(n_i) = \sum_j \rho_{Uj} I(n_i = j)$ and $\rho_D(n_i) = \sum_j \rho_{Dj} I(n_i = j)$, where I is an indicator variable for each observed number of gas stations on island i. The identifying assumption is $E(e_{kist}|X) = 0$, where X is the matrix of all covariates.

Although variables in Z_i capture the potential effect of other observed island characteristics on pass-through, in Section 5.2 we will also report IV estimates of Equation 2, where exogenous variability in market size is used to estimate the impact of the number of competitors on pass-through. The rationale for this approach is based on the observation that market size is a crucial determinant of entry and competition, while it is arguably uncorrelated with unobservable determinants of the pass-through (such as demand convexity). Hence, the IV approach assumes that market size can be excluded from Z_i, while being correlated with measures of competition.

3.1 Parallel Trends

Following Ashenfelter et al. (2013) and Genakos and Pagliero (2022), we conduct two tests of the parallel trend assumption. First, we estimate the following equation:

$$P_{kist} = \beta_0 + \gamma Trend_t + \gamma_T Trend_t \times Treat + \beta_k + \beta_s + e_{kist} \tag{3}$$

where P_{kist} denotes the retail price of product k, on island i, in gas station s, on day t and $Treat$ is an indicator variable for products in the treatment group. We separately estimate Equation 3 using data for the 10 days before each excise duty change. We then test and cannot reject the null hypothesis that the coefficient γ_T is equal to zero at the 5 percent confidence level (Table A1).

Second, we replace the trend variable in Equation 3 with more flexible period-specific dummies β_t. We also replace the interaction of trend and the treatment group indicator with $\beta_t \times Treat$ and then test the null hypothesis that the coefficients of the period-specific interactions are all equal to zero (individually and jointly). Even with this more flexible specification, we cannot reject the null hypothesis of parallel trends at the 5 percent confidence level (Table A2).

4 Empirical Results

4.1 Asymmetric Pass-through and Competition

We use Equation 1 and Equation 2 to estimate the "average" pass-through and the "conditional" pass-through ("conditional on starting to adjust"), using respectively all the data or only the data for firms that have changed their prices at least once by a given date. We separately report results on average and conditional pass-through as they measure the "extensive" and the "intensive" margins of adjustment.

Table 2, Columns 1 and 2 report the estimated average and conditional pass-through for a

10-day adjustment period. The 10-day adjustment period is chosen so that it is close enough to the change in excise duty, but is also long enough for almost all of the gas stations (94%) to have changed their prices for the tax increases.[3] The average pass-through is 0.7 for a tax increase and 0.14 for a tax decrease. The conditional pass-through is only slightly higher. The differences between the pass-through for tax increases and decreases are significant at 1 percent confidence level.

Table 2, Columns 3-8 report the results of Equation 2. Column 3 shows that average pass-through increases with competition for positive tax changes but does not depend on competition when it comes to a tax decrease. Column 4 adds additional interactions with variables Z_i. Finally, Column 5 reports IV estimates of the impact of competition on pass-through. The results are not substantially affected. One additional competitor implies an increase in the asymmetry of the average pass-through between 7 and 9 percent.

Figure 1a reports the average pass-through obtained using the semiparametric version of Equation 2, where pass-through is estimated using interactions with dummies for the number of competitors. Table A3 in the Appendix reports the corresponding regression coefficients and standard errors. For monopoly markets, the level of pass-through is about 0.427 for tax increases and 0.178 for tax decreases. In spite of the large difference in point estimates, we cannot reject the symmetry of pass-through for monopoly markets (p-value = 0.270).[4]

[3]For the tax decrease, we also estimated the specifications using longer time windows (40 days) after the policy change and the results remain unchanged (see Table A5).

[4]Refer to Table A4 for the results of the coefficient equality tests for Table A3.

Table 2: EXCISE DUTY PASS-THROUGH AND COMPETITION

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Estimation Method	FE	FE	FE	FE	IV	FE	FE	IV
Pass-through Definition	Average	Conditional	Average	Average	Average	Conditional	Conditional	Conditional
Dependent Variable	$Price_{kist}$	$Price_{kist}$	$Price_{kist}$	$Price_{kist}$	$Price_{kist}$	$Price_{kist}$	$Price_{kist}$	$Price_{kist}$
Sample	$\tau-1$, $\tau+10$	$\tau-1$, $\tau+10$	$\tau-1$, $\tau+10$	$\tau-1$, $\tau+10$	$\tau-1$, $\tau+10$	$\tau-1$, $\tau+10$	$\tau-1$, $\tau+10$	$\tau-1$, $\tau+10$
Tax_{kt} × Increase	0.713***	0.767***	0.409***	-0.465	0.403***	0.449***	-0.668	0.464***
	(0.101)	(0.097)	(0.106)	(0.858)	(0.129)	(0.101)	(0.851)	(0.109)
Tax_{kt} × Increase × Number of competitors			0.082***	0.066*	0.083***	0.086***	0.079**	0.082***
			(0.023)	(0.034)	(0.024)	(0.024)	(0.032)	(0.023)
Tax_{kt} × Decrease	0.142**	0.175***	0.217*	-0.694	0.316**	0.330**	-0.785	0.458***
	(0.053)	(0.059)	(0.127)	(0.757)	(0.135)	(0.156)	(0.763)	(0.165)
Tax_{kt} × Decrease × Number of competitors			-0.013	-0.014	-0.029*	-0.024	-0.024	-0.045**
			(0.018)	(0.019)	(0.017)	(0.022)	(0.020)	(0.020)
First stage F-test (Increase × Number of competitors)					26.87			30.64
First stage F-test (Decrease × Number of competitors)					21.31			21.95
Observations	1341	1253	1341	1341	1341	1253	1253	1253
Time FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Product × Station FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Excise change × Product type FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Excise change × Station FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Additional controls				Yes			Yes	
Test equality of coefficients (p-value)								
Tax_{kt} × Increase=Tax_{kt} × Decrease	0.000	0.000						
Tax_{kt} × Increase × Number of competitors= Tax_{kt} × Decrease × Number of competitors			0.002	0.018	0.000	0.001	0.004	0.000

Notes: The dependent variable is the retail price of product k, on island i , in gas station s, and day $t \in \{\tau-1, \tau+10\}$, where τ is the date of each of the four excise duty changes. The pass-through is estimated using observations for station-product combinations that have changed the price at least once between τ and τ+10 (conditional pass-through), or all the available data (average pass-through). Standard errors clustered at the island level are reported in parentheses below coefficients. Additional controls include interactions with income, education, number of ports, and airports, distance from Piraeus and tourist arrivals. *** p<0.01, ** p<0.05, * p<0.1.

For duopoly markets the estimated pass-through is 0.54 for tax increases and 0.147 for the tax decrease and their difference is statistically significant (p-value = 0.036). Then the pass-through of a tax increase sharply grows with competition and converges to 1 in markets with 4 competitors, but that of a tax decrease does not show any systematic correlation with competition. The asymmetry in price response grows systematically as the number of competitors increases.[5] In markets with 6 or more firms, the estimated pass-through for tax increases is still not significantly different from one and that of tax decreases is still not significantly different from zero. The difference in pass-through is about 0.8.

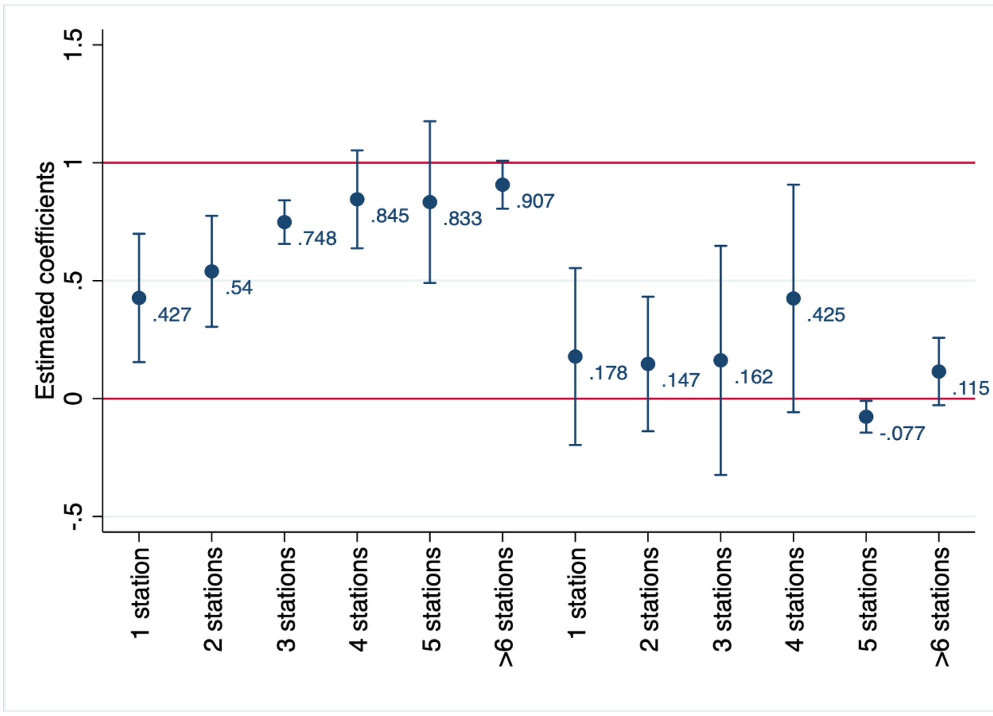
Figure 1b shows the same pattern for the conditional pass-through. Since this is computed using only data for firms that have adjusted their price at least once, the conditional pass-through is systematically higher than the average pass-through. However, differences are small and do not impact our general results on the asymmetric pass-through. Even conditional on adjusting their prices at least once, firms change their prices very little in response to a drop in taxes, no matter what the level of competition is. On the other hand, firms fully adjust their prices to tax hikes when competition is sufficiently intense.

4.2 Asymmetric Pass-through and Speed of Adjustment

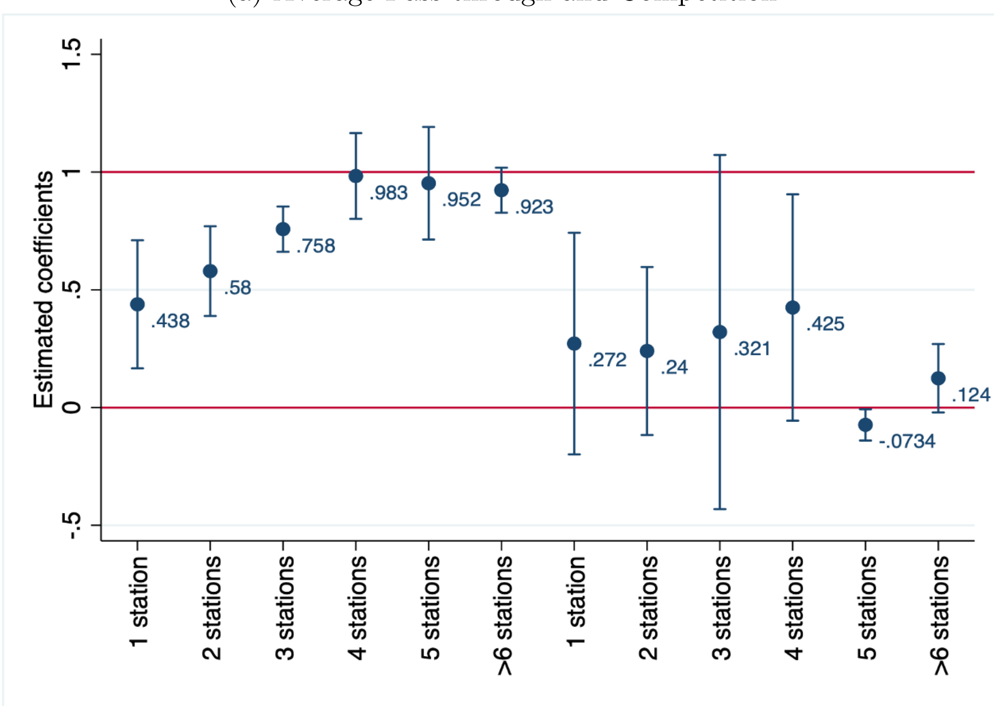
We re-estimate Equation 1 changing the adjustment window around each tax change from 1 to 10 days. The results are reported in Figure 2, in which each pair of points corresponds to the pass-through for positive and negative tax changes estimated for a different adjustment period. Each pair of points comes from a separate regression using Equation 1. Table A5 in the Appendix reports the corresponding regression results.

Figure 2a shows that the average pass-through for a tax increase grows sharply with the adjustment period, from about 0.23 one day after the policy change to 0.71 after 10 days. On the contrary, the pass-through for a tax decrease grows very slowly, from about 0.01

[5] The positive relationship between competition and pass-through for the tax increase case suggests an environment where marginal costs are constant. Ritz (2024) presents an analysis in which this result is reversed with convex costs.



(a) Average Pass-through and Competition



(b) Conditional Pass-through and Competition

Figure 1: ASYMMETRIC PASS-THROUGH AND COMPETITION

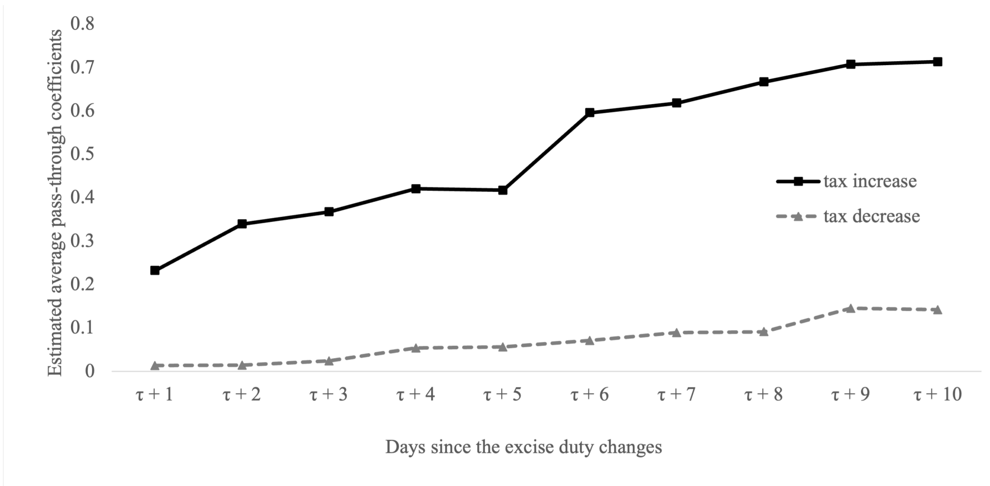
Notes: The figure plots the estimated coefficients from Table A3, together with the 95% confidence interval.

one day after the change to 0.14 after 10 days. The wedge between the two lines becomes statistically significant (at 5% confidence level) when the adjustment period is two days and grows thereafter.

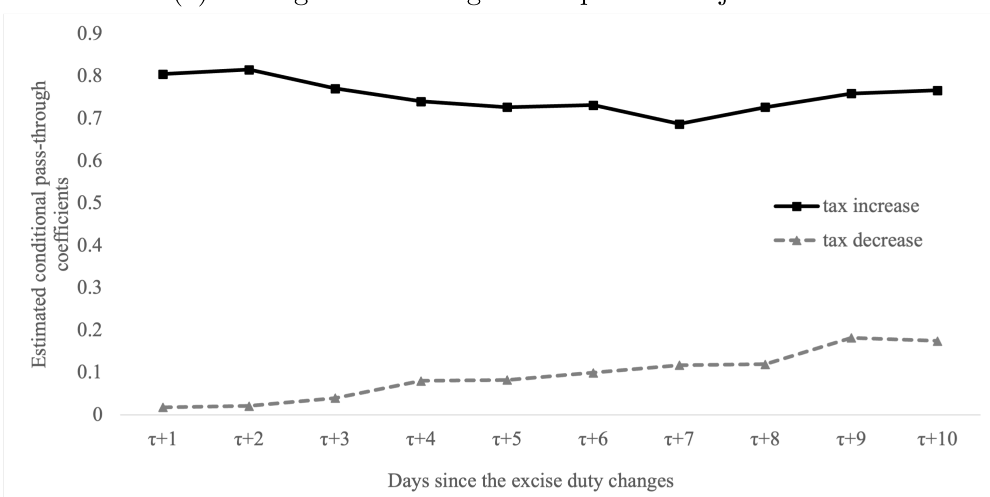
Figure 2b reports the corresponding values for the conditional pass-through. The conditional pass-through does not substantially change with the length of the adjustment period for tax increases. This reflects the fact that when firms adjust their prices, they tend to do that fully to the new level. However, there is a very slow increase of the conditional pass-through for the tax decrease, as firms partially adjust prices even after ten days after the tax change. The estimated pass-through (average and conditional) for longer adjustment periods are not significantly different. The results are reported in Table A5, columns 3 and 4 in the Appendix.

We also compute the results of Figure 2 and Table A5 splitting islands into two groups. The "low competition" group includes those with 1 to 3 competitors and the "high competition" group those with 4 or more competitors. Although the speed of adjustment is higher for more competitive markets when taxes increase, we do not detect any significant difference between more and less competitive markets when taxes decrease. The results are reported in Table A6 in the Appendix.

Finally, Figure 3 reports the cumulative frequency of station-product combinations that changed their prices between τ and $\tau + \delta$ for the tax decrease, on islands with 1-3 (low competition) and 4-7 (high competition) gas stations. The Kolmogorov-Smirnov test does not reject the equality of the CDFs for the two groups of islands at the 1 percent confidence level. This implies that competition does not significantly affect the speed of price adjustment when taxes decrease. This stands in contrast with the corresponding results for the tax increases (Figure 6 in Genakos and Pagliero (2022)), which show significant differences between the two CDFs for islands with low and high competition for the tax increases.



(a) Average Pass-through and Speed of Adjustment



(b) Conditional Pass-through and Speed of Adjustment

Figure 2: PASS-THROUGH AND SPEED OF ADJUSTMENT

Notes: The figure plots the estimated coefficients from Table A5. 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 excise duty change and δ=1,...,10. is the date of each of the four excise duty changes.

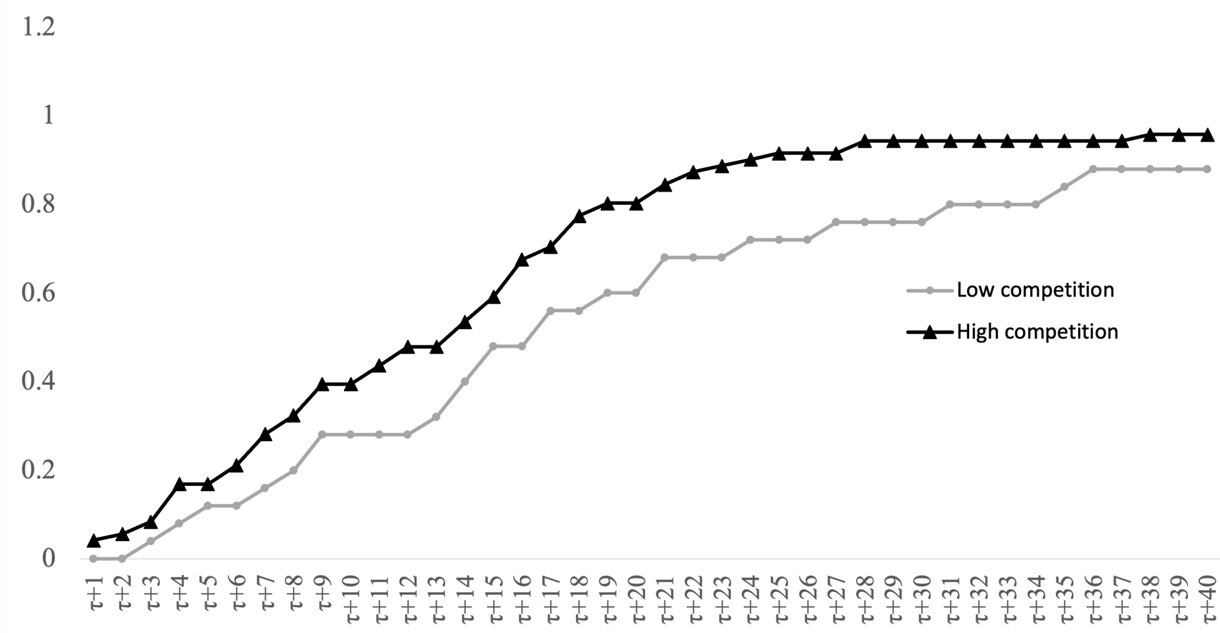


Figure 3: CUMULATIVE FREQUENCY OF PRICE CHANGES

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 tax decrease event and δ=1,...,40, on islands with one to three ("low competition") and four to seven ("high competition") gas stations.

4.3 Consistency of Empirical Results on Pass-through Asymmetry

Borenstein et al. (1997) find a pass-through of 0.55 of positive shocks after two weeks but no significant response to negative shocks (see, their Figure 3) using US data. Pass-through of negative shocks grows slowly over time generating asymmetry that becomes insignificant after six weeks. In more recent studies, Johnson (2002) finds a cumulative pass-through of 0.50 vs. 0.16 for gasoline after two weeks, and 0.70 vs. 0.40 for diesel (see Table V), while in Verlinda (2008) the pass-through after three weeks is 1.10 for wholesale cost increases, but only 0.83 for cost decreases. Finally, Montag et al. (2021) also confirm this asymmetry in Germany, estimating a pass-through of 0.34 to 0.79 for the VAT tax cut and 0.69 to 0.92 for the tax rise.

Beyond gasoline, Peltzman (2000) reports a pass-through of 0.235 for a one percent input price increase vs. 0.127 for an equivalent decrease in input cost for a large and diverse sample of consumer and producer goods. Similarly, Benzarti et al. (2020) report a pass-through of 35% to prices of VAT increases in Europe for a wide variety of goods, while VAT decreases are pass-through only 6% one month after the reforms. Therefore, although the pass-through magnitudes differ across products, time and countries, the ratio between cost or tax increases and decreases varies between two and five times, similar to what we observe in the Greek islands environment.

4.4 Consistency of Results with Alternative Theoretical Models

In this subsection, we discuss the most relevant possible explanations that the literature has provided to explain the asymmetric price response.

Menu costs: Menu costs may generate asymmetric responses if drops in marginal costs are short lived, leading to temporary adjustments only, which do not allow to recover the fixed costs involved in changing prices (Blinder, 1982; Ball and Mankiw, 1994; Kovenock and Widdows, 1998). This type of explanation is unlikely to explain our results for two reasons. First, menu costs are negligible for gas stations, which typically adjust prices at a very high frequency and do not face any physical cost or information cost involved in adjusting prices. Second, tax changes are typically long lived, and the tax drop of January 2013 was no exception. Differently from most of the literature, in our analysis we do not use high frequency changes in crude oil prices as a source of identifying variation, but long lasting changes in taxes.

Inventory management: The quantity adjustment caused by a drop in price is constrained by existing inventories. Hence, in principle, this may limit the ability to decrease prices. However, this explanation is unlikely to hold for retail markets (Borenstein and Shepard, 2002; Borenstein et al., 1997), as gas stations generally hold sufficient inventories in underground tanks to accommodate the increased demand and may receive new deliveries at short notice.

Market power and collusion: The oldest explanation for asymmetric pass-through posits that firms collude on prices when costs fall using dynamic strategies based on the threat of a punishment phase (e.g. a price war) in case of deviations. Among the infinite number of strategies that can support collusion in repeated games, those using the old retail price as focal point for collusion after a cost drop seem natural candidates for collusion (Bacon, 1991; Borenstein et al., 1997).

On monopoly islands there is no competition and no role for collusion, hence we should see no asymmetry. This is consistent with our results. In all other market configurations, we cannot reject that the pass-through for negative tax changes is equal to that of a monopolist. Taken together, our results show no relation between competition and pass-through for negative tax changes.

In principle, these two results are consistent with gas stations competing when costs increase but colluding and pricing “like a monopolist” when costs fall. However, the collusion explanation requires firms not only being able to monitor (at least imperfectly) each other and having a focal point (“keep price constant when cost falls”), but also having a sufficiently high discount factor. In most collusive equilibria in repeated games, there is a threshold value of the discount factor that guarantees the stability of collusion. This threshold generally increases with the number of firms, making collusion more difficult as competition increases. Hence, in more competitive markets, deviations from the "constant price strategy when costs fall" should be more likely, and, on average, we should observe an increasing pass-through of negative cost shocks as the number of competitors increases.

We do not find evidence of this general comparative static result. First, we do not observe higher pass-through in markets with more firms when tax decreases. This is surprising, since we do see a large increase in pass-through for positive cost changes, which is consistent with a significant increase in competition. (Hence, it seems that the range in which the number of firms is varying in our sample is the relevant range for measuring competition). Second, we do not find any direct evidence of price wars in which collusion breaks down in any period in our sample. We do not observe sudden drops in prices on any island in any period, not even on islands with six or more firms.[6] Instead we observe a very slow and gradual adjustment of prices even after forty days since the tax decrease (Figure 2, Table A5). Although observing price wars is not theoretically a necessary condition for the collusion explanation (in equilibrium we might not observe any price war; Green and Porter, 1984), the empirical literature has emphasized the empirical relevance of price wars in collusive markets (Byrne and De Roos, 2019). Hence, it seems unlikely that collusion is prevalent in practice, but we do not find any direct evidence of sudden island-specific price drops that are specific to a given island.

Deltas (2008) uses monthly state level data and shows that markets with high average retail-wholesale margins (high market power) experience a slower adjustment and a more asymmetric response. Verlinda (2008) studies how local market power affects asymmetric pass-through. Exploiting variation local supply and demand conditions to proxy for market

[6] The evidence on this point is obtained by plotting the difference between the price for each station-product and the average price for each island-product. Sudden increases of this difference for some stations and decreases for others should signal a price war (results not reported here, available on request).

power, he finds that increasing the number of rivals within one mile and decreasing the distance to the nearest rival decreases asymmetry. Assuming these variables are negatively correlated with market power, these results are consistent with more market power increasing the likelihood of collusion and asymmetric pass-through.[7] However, both papers, as well as the literature that follows, typically defined markets based on the distance between gas stations (Shepard, 1991; Barron et al., 2004; Eckert and West, 2005; Hosken et al., 2008). While realistic, this approach cannot guarantee the absence of substitution effects with firms outside the geographical area considered. In contrast, Greek islands clearly define local markets and allows us to measure market power in a clean way.

Consumers' search: Our results are consistent with asymmetric pass-through being caused by consumers' search behavior rather than collusion. On monopoly islands, there is no reason for consumers to search for the lowest price. Hence, if asymmetric pass-through is caused by search, we should see no asymmetry on monopoly islands also in this case. This simple prediction is consistent with our results.

In search models, more price dispersion generally leads to more search, hence higher pass-through. Asymmetric pass-through occurs because incentives to search are higher when costs increase than decrease. Although the specific mechanism that leads to consumers' search depends on the modelling assumptions, the intuition is that, faced with more consumers searching, firms compete more intensely.

Although we do not directly observe search, we use the daily price data to construct different measures of price dispersion for each gasoline product on each island. First, we construct 'clean' or 'residual' prices. These are the price level net of any persistent seller heterogeneity and are obtained from a regression of raw prices on station fixed effects. Then, we construct three measures of price dispersion using these 'clean' prices. The first measure is the sample range SR_{kit}, calculated as the difference between the maximum and the minimum price in the market, that is, $SR_{kit} = RP_{ikt}^{\max} - RP_{ikt}^{\min}$. This measure captures, on average, the most

[7]However, they are also consistent with search theories, since the number of rivals in close proximity and the distance from rivals should decrease search costs and therefore reduce asymmetry.

a consumer can save by searching every gas station in the market. However, this measure might be strongly influenced by outliers, so we construct the second measure using the sample standard deviation at each island SD_{kit}, calculated as $SD_{kit} = \sqrt{\sum_{s \in i} \frac{(RP_{\text{kist}} - \overline{RP_{\text{kit}}})^2}{N_i}}$. This measure does not rely on extreme values and is commonly used as a measure of price dispersion in the literature (see for instance, Noel 2018). For our last measure, we construct gains from search (GS_{kit}) for consumers $\text{GS}_{kit} = E_i(RP_{kist} - RP^{\text{min}}_{ikst})$, which is the difference between the expected price and the expected minimum price in each market i (Chandra and Tappata 2011). We calculate the expected price for each gasoline product in the market using the average market price for that product.

We then estimate a diff-in-diff model similar to Equation 1,

$$PD(P_{\text{kit}}) = \beta_0 + \rho_U(U_t \times \text{Tax}_{kt}) + \rho_D(D_t \times \text{Tax}_{kt}) + \beta_{1k}U_t + \beta_{2k}D_t + \beta_t + e_{kit} \quad (4)$$

where $PD(P_{kit})$ is any of the three measures of price dispersion we introduced above for product k on island i in period t. This regression provides evidence on whether tax increases and decreases affect differentially price variability across firms. We then allow parameters ρ_U and ρ_D to depend on island characteristics, $\rho_U(n_i, Z_i)$ and $\rho_D(n_i, Z_i)$.

Table 3 summarizes the results. As we can see in the first three columns, increases in taxes led to increases in the variability of prices, no matter which measure of variability we use. On the contrary, decreases in taxes had no effect on price variability. The last three columns confirm that competition has a positive effect on price variability, but only when taxes increase. Overall, our results are consistent with consumers searching more when costs increase than decrease and searching more in more competitive markets.

Tappata (2009) explains asymmetric pass-through in a model of all-or-nothing simultaneous endogenous search with cost persistence (modeled as a Markov process). The intuition is that when marginal costs are expected to remain relatively high, consumers expect prices to remain high and have little dispersion. Hence, consumers have little incentive to search. In this case, if costs unexpectedly fall, sellers will not adjust prices downwards, as consumers will tend not to react to the lower prices. On the other hand, when marginal costs are expected to remain relatively low, consumers expect prices to remain low and have large dispersion. Hence, incentives to search are high. In this case, if costs unexpectedly increase, sellers will adjust prices upwards as consumers will tend to react to the higher prices. In practice, firms face more inelastic demands when the cost drops than when it goes up and this generates the asymmetric pass-through.

Yang and Ye (2008) also propose a model of search. The model shares a number of features with Tappata (2009), such as non-sequential search and Markov dynamics with persistent cost shocks. However, consumers never observe past cost realizations and gradually learn the true state. In equilibrium, consumers quickly learn about cost increases and slowly learn about cost decreases, leading to faster upward adjustment of prices. As the cost shocks become more persistent, the downward price adjustment on average spreads over longer periods of time. These characteristics of the equilibrium are in line with the differences in the speed of price adjustments that we estimate for tax increases and decreases, which are relatively infrequent and persistent policy changes.

Lewis (2011) develops a search model in which consumers' expectations of prices are based on mean prices observed during previous periods, so that expectations (or reference prices) are adaptive. The model generates asymmetric pass-through and predicts that consumers search less when prices are falling, which results in higher profit margins and a slower price response to cost changes. The model has only two firms and there are no comparative statics with respect to competition. Implications regarding margins cannot be tested as we do not have margins. Also, Remer (2015) shows that prices for premium gasoline fall more slowly than regular gasoline, which is reasonably purchased by consumers with lower search costs. We cannot test this as our treatment group includes only one type of fuel. Finally, our conclusion that consumer search is the most likely explanation also corroborate the results in Heim (2021), who makes a similar case for the rockets and feathers phenomenon in the German residential electricity market.

Table 3: ASYMMETRIC PASS-THROUGH AND PRICE DISPERSION

	(1)	(2)	(3)	(4)	(5)	(6)
Estimation Method	FE	FE	FE	FE	FE	FE
Dependent variable	PD1	PD2	PD3	PD1	PD2	PD3
Sample	τ-1, τ+10	τ-1, τ+10	τ-1, τ+10	τ-1, τ+10	τ-1, τ+10	τ-1, τ+10
Tax_{kt} × Increase	0.330***	0.191***	0.166***	0.113	0.072	0.057
	(0.101)	(0.063)	(0.052)	(0.185)	(0.121)	(0.086)
Tax_{kt} × Increase × Number of competitors				0.017***	0.007***	0.008***
				(0.003)	(0.002)	(0.001)
Tax_{kt} × Decrease	-0.004	0.025	0.002	-0.026	0.067	-0.008
	(0.080)	(0.039)	(0.062)	(0.322)	(0.187)	(0.165)
Tax_{kt} × Decrease × Number of competitors				-0.001	-0.003	-0.0001
				(0.007)	(0.004)	(0.004)
Observations	399	399	399	399	399	399
Time FE	Yes	Yes	Yes	Yes	Yes	Yes
Excise change × Product type FE	Yes	Yes	Yes	Yes	Yes	Yes
Additional controls				Yes	Yes	Yes

Notes: The dependent variable is the different measure of price dispersion of product k, on island i and day $t \in \{\tau - 1, \tau + 10\}$, where τ is the date of each of the four excise duty changes. PD1 is the the sample range. PD2 is sample standard deviation, and PD3 is the gains from search. Additional controls include interactions with income, education, number of ports, and airports, distance from Piraeus and tourist arrivals. Standard errors clustered at the island level are reported in parentheses below coefficients. *** p<0.01, ** p<0.05, * p<0.1.

4.5 Implications for Research on Asymmetric Pass-through

Our results on the relation between competition and asymmetric pass-through have also two additional implications for the growing empirical research on asymmetric pass-through. First, asymmetry is not necessarily apparent in very concentrated markets (monopolies, for example) and certain degree of competition might be necessary to observe a statistically significant asymmetry. Second, the relevant range for variability in competition is between one and four/five competitors. Beyond this point, the relation between competition and asymmetric pass-through flattens substantially. Hence, if one wants to test the impact of competition on asymmetric pass-through, it is critical to correctly identify oligopolistic markets with the appropriate number of competitors.

5 Conclusion

This paper contributes to the empirical literature by providing new evidence on the relation between competition and asymmetric pass-through that could be useful in the search for the causes of the "rockets and feathers" phenomenon. We document a strong asymmetry in retail prices with the average tax pass-through for tax increases to be five times larger than that of tax decreases (0.7 vs. 0.14). Most importantly, we show that the pass-through of a tax increase grows with competition and converges to 1 after four/five competitors, whereas that of the tax decrease does not vary with competition (asymmetric competition effect). We also find a significant asymmetry in the speed of price adjustments, with tax increases been transmitted much faster than tax decreases. These finding have important policy implications as often times governments around the world have been modifying tax rates trying to raise more revenue or provide a fiscal stimulus (for example, during the recent Covid19 pandemic).

We provide evidence that potential explanations, such as menu costs, inventory management and, particularly, market power and collusion are unlikely to be the sources for the "rockets and feathers" phenomenon. Our results are consistent with consumers searching more when there is a positive than a negative shock and searching more in more competitive markets. More research is needed in this direction to more precisely understand the exact mechanism that search is affecting price dispersion and pass-through.

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 different tax shocks across different markets within the same country. We believe that the results contribute to our understanding of asymmetric price adjustment, by showing new evidence on relationships that may be present in other settings and in larger markets.

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Appendix

NOT FOR PUBLICATION, ONLINE APPENDIX ONLY

Table A1: Parallel Trend Tests

	(1)	(2)	(3)	(4)
Dependent variable	$Price_{kist}$	$Price_{kist}$	$Price_{kist}$	$Price_{kist}$
Sample	Tax Increase 1	Tax Increase 2	Tax Increase 3	Tax Decrease
$Trend_t$	-0.017	0.052	0.041	-0.038
	(0.029)	(0.074)	(0.039)	(0.023)
$Trend_t$ × Treat	0.039	0.166	0.023	0.025
	(0.037)	(0.097)	(0.051)	(0.023)
Window before the event	$[\tau - 10, \tau - 1]$	$[\tau - 10, \tau - 1]$	$[\tau - 10, \tau - 1]$	$[\tau - 10, \tau - 1]$
Observations	1,196	1,552	1,750	2,011
Product type FE	Yes	Yes	Yes	Yes
Station FE	Yes	Yes	Yes	Yes

Notes: The table reports results for the parallel trend assumption test based on Equation 3 in the main text. Standard errors clustered at the island are reported in parentheses below coefficients.

Table A2: Parallel Trend Tests (Non-parametric)

	(1)	(2)	(3)	(4)
Dependent Variable	$Price_{kist}$	$Price_{kist}$	$Price_{kist}$	$Price_{kist}$
Sample	Tax Increase 1	Tax Increase 2	Tax Increase 3	Tax Decrease
Day (T-10) × Treat	-0.395	-1.666	-0.329	-0.170
	(0.305)	(0.733)	(0.464)	(0.164)
Day (T-9) × Treat	-0.473	-1.078	-0.175	-0.166
	(0.373)	(0.756)	(0.372)	(0.164)
Day (T-8) × Treat	-0.341	-0.849	-0.017	-0.178
	(0.321)	(0.725)	(0.360)	(0.168)
Day (T-7) × Treat	-0.337	-0.909	0.107	-0.061
	(0.320)	(0.718)	(0.261)	(0.140)
Day (T-6) × Treat	-0.283	-0.909	0.073	0.021
	(0.314)	(0.717)	(0.237)	(0.116)
Day (T-5) × Treat	-0.263	-0.257	0.121	0.098
	(0.177)	(0.570)	(0.237)	(0.088)
Day (T-4) × Treat	-0.274	-0.553	-0.020	0.050
	(0.163)	(0.540)	(0.086)	(0.070)
Day (T-3) × Treat	-0.274	-0.282	-0.038	0.010
	(0.163)	(0.223)	(0.070)	(0.060)
Day (T-2) × Treat	-0.146	0.000	-0.022	0.007
	(0.130)	(0.000)	(0.017)	(0.011)
Joint test of significance (F-test)	1.579	2.106	0.0298	0.216
(p-value)	(0.231)	(0.167)	(0.864)	(0.645)
Window before the event	$[\tau-10,\tau-1]$	$[\tau-10,\tau-1]$	$[\tau-10,\tau-1]$	$[\tau-10,\tau-1]$
Observations	1,196	1,552	1,750	2,011
Time FE	Yes	Yes	Yes	Yes
Product type FE	Yes	Yes	Yes	Yes
Station FE	Yes	Yes	Yes	Yes

Notes: The table reports results for the parallel trend assumption test based on Equation 3 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.

Table A3: Pass-through and Competition (Non-linear)

	(1)	(2)
Estimation Method	FE	FE
Pass-through Definition	Average	Conditional
Dependent Variable	$Price_{kist}$	$Price_{kist}$
Sample	τ-1, τ+10	τ-1, τ+10
Tax_{it} × One competitor × U	0.427***	0.438***
	(0.133)	(0.134)
Tax_{it} × Two competitors x U	0.540***	0.580***
	(0.115)	(0.094)
Tax_{it} × Three competitors x U	0.748***	0.758***
	(0.045)	(0.047)
Tax_{it} × Four competitors x U	0.845***	0.983***
	(0.102)	(0.090)
Tax_{it} × Five competitors x U	0.833***	0.952***
	(0.168)	(0.118)
Tax_{it} × Six+ competitors x U	0.907***	0.923***
	(0.050)	(0.047)
Tax_{it} × One competitor × D	0.178	0.272
	(0.184)	(0.231)
Tax_{it} × Two competitors × D	0.147	0.240
	(0.140)	(0.176)
Tax_{it} × Three competitors × D	0.162	0.321
	(0.238)	(0.370)
Tax_{it} × Four competitors × D	0.425*	0.425*
	(0.236)	(0.237)
Tax_{it} × Five competitors × D	-0.077**	-0.073**
	(0.033)	(0.033)
Tax_{it} × Six+ competitors × D	0.115	0.124*
	(0.070)	(0.071)
Observations	1,341	1,286
Time FE	Yes	Yes
Product × Station FE	Yes	Yes
Excise incident × Product type FE	Yes	Yes
Excise incident × Station FE	Yes	Yes

Notes: The dependent variable is the retail price of product k, on island i, in gas station s, and day $t \in \{\tau - 1, \tau + 10\}$, where τ is the date of each of the three excise duty changes. In Column (1) we use all available data (average pass-through), whereas in Column (2) the pass-through is estimated using observations for station-product combinations that have changed the price at least once between τ and τ +10 (conditional pass-through). Standard errors clustered at the island level are reported in parentheses below coefficients.

Table A4: Test Equality of Coefficients for Pass-through and Competition (Non-linear)

	Tax_{it} × 1 comp × D	Tax_{it} × 2 comp × D	Tax_{it} × 3 comp × D	Tax_{it} × 4 comp × D	Tax_{it} × 5 comp × D	Tax_{it} × 6 comp × D
Tax_{it} × 1 comp × U	0.270	0.153	0.341	0.994	0.001	0.043
Tax_{it} × 2 comp x U	0.111	0.036	0.164	0.670	0.000	0.003
Tax_{it} × 3 comp x U	0.007	0.000	0.025	0.181	0.000	0.000
Tax_{it} × 4 comp x U	0.003	0.000	0.005	0.103	0.000	0.000
Tax_{it} × 5 comp x U	0.015	0.004	0.030	0.177	0.000	0.001
Tax_{it} × 6 comp x U	0.001	0.000	0.004	0.060	0.000	0.000

Notes: This table reports the p-values from the test of equality of coefficients presented in Table A3 Column (1).

Table A5: Speed of Adjustment

	(1)	(2)	(3)	(4)
Dependent Variable	$Price_{kist}$	$Price_{kist}$	$Price_{kist}$	$Price_{kist}$
Pass-through definition	Average	Conditional	Average	Conditional
Sample	Symmetric (10 days)	Symmetric (10 days)	Asymmetric (10 days increase, 40 days decrease)	Asymmetric (10 days increase, 40 days decrease)
Tax_{it} x U	0.232**	0.805***	0.232**	0.805***
(τ-1, τ+1)	(0.109)	(0.128)	(0.109)	(0.128)
Tax_{it} x U	0.339***	0.816***	0.339***	0.816***
τ-1, τ+2	(0.099)	(0.125)	(0.099)	(0.125)
Tax_{it} x U	0.368***	0.771***	0.368***	0.771***
τ-1, τ+3	(0.097)	(0.116)	(0.097)	(0.116)
Tax_{it} x U	0.421***	0.741***	0.421***	0.741***
τ-1, τ+4	(0.089)	(0.107)	(0.089)	(0.107)
Tax_{it} x U	0.417***	0.727***	0.417***	0.727***
τ-1, τ+5	(0.089)	(0.106)	(0.089)	(0.106)
Tax_{it} x U	0.596***	0.732***	0.596***	0.732***
τ-1, τ+6	(0.111)	(0.109)	(0.111)	(0.109)
Tax_{it} x U	0.618***	0.687***	0.618***	0.687***
τ-1, τ+7	(0.116)	(0.108)	(0.116)	(0.108)
Tax_{it} x U	0.667***	0.727***	0.667***	0.727***
τ-1, τ+8	(0.115)	(0.111)	(0.115)	(0.111)
Tax_{it} x U	0.707***	0.759***	0.707***	0.759***
τ-1, τ+9	(0.103)	(0.100)	(0.103)	(0.100)
Tax_{it} x U	0.713***	0.767***	0.713***	0.767***
τ-1, τ+10	(0.101)	(0.096)	(0.101)	(0.096)
Tax_{it} x D	0.013	0.018	0.013	0.018
τ-1, τ+1	(0.018)	(0.031)	(0.018)	(0.031)
Tax_{it} x D	0.014	0.021	0.014	0.021
τ-1, τ+2	(0.018)	(0.030)	(0.018)	(0.030)
Tax_{it} x D	0.024	0.040	0.024	0.040
τ-1, τ+3	(0.020)	(0.031)	(0.020)	(0.031)
Tax_{it} x D	0.054**	0.081**	0.054**	0.081**
τ-1, τ+4	(0.023)	(0.034)	(0.023)	(0.034)
Tax_{it} x D	0.056**	0.083**	0.056**	0.083**
τ-1, τ+5	(0.023)	(0.033)	(0.023)	(0.033)
Tax_{it} x D	0.071**	0.100**	0.071**	0.100**
τ-1, τ+6	(0.027)	(0.038)	(0.027)	(0.038)
Tax_{it} x D	0.089**	0.118**	0.089**	0.118**
τ-1, τ+7	(0.036)	(0.047)	(0.036)	(0.047)
Tax_{it} x D	0.091**	0.120**	0.091**	0.120**

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τ-1, τ+8	(0.038)	(0.048)	(0.038)	(0.048)
Tax_{it} x D	0.145***	0.182***	0.145***	0.182***
τ-1, τ+9	(0.052)	(0.058)	(0.052)	(0.058)
Tax_{it} x D	0.142**	0.175***	0.142**	0.175***
τ-1, τ+10	(0.052)	(0.058)	(0.052)	(0.058)
Tax_{it} x D			0.165**	0.197***
τ-1, τ+11			(0.062)	(0.068)
Tax_{it} x D			0.165**	0.199***
τ-1, τ+12			(0.063)	(0.070)
Tax_{it} x D			0.174**	0.207***
τ-1, τ+13			(0.065)	(0.071)
Tax_{it} x D			0.191***	0.230***
τ-1, τ+14			(0.068)	(0.075)
Tax_{it} x D			0.205***	0.231***
τ-1, τ+15			(0.067)	(0.071)
Tax_{it} x D			0.216***	0.245***
τ-1, τ+16			(0.067)	(0.070)
Tax_{it} x D			0.222***	0.246***
τ-1, τ+17			(0.068)	(0.070)
Tax_{it} x D			0.230***	0.256***
τ-1, τ+18			(0.068)	(0.070)
Tax_{it} x D			0.232***	0.253***
τ-1, τ+19			(0.071)	(0.072)
Tax_{it} x D			0.221***	0.242***
τ-1, τ+20			(0.072)	(0.073)
Tax_{it} x D			0.249***	0.265***
τ-1, τ+21			(0.065)	(0.066)
Tax_{it} x D			0.225***	0.242***
τ-1, τ+22			(0.071)	(0.072)
Tax_{it} x D			0.237***	0.255***
τ-1, τ+23			(0.073)	(0.074)
Tax_{it} x D			0.231***	0.231***
τ-1, τ+24			(0.070)	(0.070)
Tax_{it} x D			0.253***	0.253***
τ-1, τ+25			(0.063)	(0.064)
Tax_{it} x D			0.263***	0.263***
τ-1, τ+26			(0.068)	(0.068)
Tax_{it} x D			0.259***	0.259***
τ-1, τ+27			(0.068)	(0.068)
Tax_{it} x D			0.241***	0.241***
τ-1, τ+28			(0.076)	(0.076)
Tax_{it} x D			0.246***	0.246***
τ-1, τ+29			(0.074)	(0.074)
Tax_{it} x D			0.225***	0.225***

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τ-1, τ+30			(0.058)	(0.058)
Tax_{it} x D			0.221***	0.221***
τ-1, τ+31			(0.049)	(0.049)
Tax_{it} x D			0.231***	0.231***
τ-1, τ+32			(0.044)	(0.044)
Tax_{it} x D			0.237***	0.237***
τ-1, τ+33			(0.043)	(0.043)
Tax_{it} x D			0.239***	0.239***
τ-1, τ+34			(0.043)	(0.043)
Tax_{it} x D			0.244***	0.244***
τ-1, τ+35			(0.042)	(0.042)
Tax_{it} x D			0.252***	0.252***
τ-1, τ+36			(0.042)	(0.042)
Tax_{it} x D			0.271***	0.271***
τ-1, τ+37			(0.039)	(0.039)
Tax_{it} x D			0.267***	0.267***
τ-1, τ+38			(0.043)	(0.043)
Tax_{it} x D			0.258***	0.258***
τ-1, τ+39			(0.045)	(0.045)
Tax_{it} x D			0.264***	0.264***
τ-1, τ+40			(0.046)	(0.046)
Day FE	Yes	Yes	Yes	Yes
Product × Station FE	Yes	Yes	Yes	Yes
Excise change × Product type FE	Yes	Yes	Yes	Yes
Excise change × Station FE	Yes	Yes	Yes	Yes

Notes: Each coefficient comes from a separate regression. The dependent variable is the retail price of product k, on island i, in gas station s, and day $t \in \{\tau - 1, \tau + \delta\}$, where τ is the date of each of the three excise duty changes and δ=1,...,40 is the adjustment period. 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 $\tau + \delta$. Standard errors clustered at the island level are reported in parentheses below coefficients.

Table A6: Speed of Adjustment and Competition

Panel A: Average Pass-through

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Estimation Method	FE	FE	FE	FE	FE	FE	FE	FE	FE	FE
Dependent Variable	$Price_{ist}$	$Price_{ist}$	$Price_{ist}$	$Price_{ist}$	$Price_{ist}$	$Price_{ist}$	$Price_{ist}$	$Price_{ist}$	$Price_{ist}$	$Price_{ist}$
Sample	All changes	All changes	All changes	All changes	All changes	All changes	All changes	All changes	All changes	All changes
	(τ-1, τ+1)	(τ-1, τ+2)	(τ-1, τ+3)	(τ-1, τ+4)	(τ-1, τ+5)	(τ-1, τ+6)	(τ-1, τ+7)	(τ-1, τ+8)	(τ-1, τ+9)	(τ-1, τ+10)
Tax_{it} × Low competition × U	0.136*	0.200**	0.198**	0.273***	0.268***	0.410***	0.443***	0.456***	0.519***	0.531***
(1-3 competitors)	(0.072)	(0.080)	(0.076)	(0.063)	(0.063)	(0.103)	(0.102)	(0.101)	(0.092)	(0.090)
Tax_{it} × High competition × U	0.301*	0.433***	0.500***	0.534***	0.534***	0.747***	0.766***	0.831***	0.855***	0.856***
(4-7 competitors)	(0.149)	(0.126)	(0.116)	(0.109)	(0.109)	(0.123)	(0.132)	(0.115)	(0.105)	(0.105)
Test equality of coefficients (p-value)	0.216	0.051	0.007	0.008	0.007	0.010	0.017	0.004	0.006	0.008
Tax_{it} × Low competition × D	0.056	0.055	0.092	0.090	0.088	0.085	0.067	0.064	0.052	0.052
(1-3 competitors)	(0.053)	(0.053)	(0.061)	(0.061)	(0.061)	(0.061)	(0.062)	(0.062)	(0.062)	(0.062)
Tax_{it} × High competition × D	-0.005	-0.002	0.003	0.039	0.033	0.060	0.036	0.046	0.115	0.111
(4-7 competitors)	(0.010)	(0.011)	(0.015)	(0.024)	(0.025)	(0.037)	(0.052)	(0.056)	(0.076)	(0.076)
Test equality of coefficients (p-value)	0.263	0.298	0.172	0.453	0.420	0.740	0.708	0.829	0.507	0.541
Day FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Product × Station FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Excise change × Product type FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Excise change × Station FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1,320	1,316	1,351	1,352	1,355	1,363	1,372	1,390	1,396	1,395

Panel B: Conditional Pass-through

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Estimation Method	FE	FE	FE	FE	FE	FE	FE	FE	FE	FE
Dependent Variable	$Price_{ist}$	$Price_{ist}$	$Price_{ist}$	$Price_{ist}$	$Price_{ist}$	$Price_{ist}$	$Price_{ist}$	$Price_{ist}$	$Price_{ist}$	$Price_{ist}$
Sample	All changes	All changes	All changes	All changes	All changes	All changes	All changes	All changes	All changes	All changes
	(τ-1, τ+1)	(τ-1, τ+2)	(τ-1, τ+3)	(τ-1, τ+4)	(τ-1, τ+5)	(τ-1, τ+6)	(τ-1, τ+7)	(τ-1, τ+8)	(τ-1, τ+9)	(τ-1, τ+10)
Tax_{it}× Low competition × U	0.639***	0.614***	0.528***	0.528***	0.523***	0.509***	0.486***	0.502***	0.552***	0.565***
(1-3 competitors)	(0.106)	(0.089)	(0.076)	(0.070)	(0.070)	(0.103)	(0.094)	(0.091)	(0.083)	(0.080)
Tax_{it}× High competition × U	0.888***	0.952***	0.966***	0.953***	0.932***	0.939***	0.886***	0.926***	0.948***	0.951***
(4-7 competitors)	(0.116)	(0.079)	(0.056)	(0.059)	(0.065)	(0.088)	(0.093)	(0.087)	(0.074)	(0.074)
Test equality of coefficients (p-value)	0.048	0.000	0.000	0.000	0.000	0.001	0.001	0.000	0.000	0.000
Tax_{it}× Low competition × D	0.146	0.145	0.148	0.146	0.119	0.115	0.096	0.093	0.080	0.081
(1-3 competitors)	(0.125)	(0.124)	(0.088)	(0.088)	(0.077)	(0.077)	(0.078)	(0.077)	(0.078)	(0.078)
Tax_{it}× High competition × D	-0.012	-0.005	0.005	0.052	0.045	0.076*	0.044	0.052	0.120	0.116
(4-7 competitors)	(0.017)	(0.017)	(0.021)	(0.031)	(0.032)	(0.045)	(0.058)	(0.061)	(0.078)	(0.078)
Test equality of coefficients (p-value)	0.220	0.242	0.132	0.330	0.394	0.669	0.590	0.677	0.717	0.746
Day FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Product × Station FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Excise change × Product type FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Excise change × Station FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	811	904	1,002	1,079	1,100	1,188	1,248	1,287	1,306	1,307

Notes: The dependent variable is the retail price of product k, on island i, in gas station s, and day $t \in \{\tau-1, \tau+\delta\}$, where τ is the date of each of the three excise duty changes and δ=1,...,10. Standard errors clustered at the island level are reported in parentheses below coefficients. *significant at 10%; **significant at 5%; ***significant at 1%.

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The Centre for Economic Performance Publications Unit
Tel: +44 (0)20 7955 7673 Email info@cep.lse.ac.uk
Website: http://cep.lse.ac.uk Twitter: @CEP_LSE