Is the German retail gas market competitive?

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Abstract

Does non-competitive price setting prevail in Germany's retail gasoline market? We explore this question by examining the influence of the international oil price on the retail gasoline price, focusing specifically on how this influence varies according to the brand and to the degree of competition in the vicinity of the station. Drawing on a geo-referenced dataset of daily gasoline prices from 13,701 German gas stations collected over a year, we estimate a quantile panel regression that reveals heterogeneity in the magnitude of the coefficient estimates over the conditional distribution of the dependent variable. This allows us to directly account for price dispersion in testing whether the price response varies according to the price level. Our analysis identifies several factors other than cost – including the absence of nearby competitors – that play a significant role in mediating the influence of the oil price on the retail gas price, suggesting price setting power among stations.

Keywords: panel data, quantile regression, competition, gas market

JEL Classification: C33, Q41, R41

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1 Introduction

Fluctuations in the gas price pose an ongoing source of consternation among motorists and politicians, one that typically centers around the suspicion that the price is not set competitively, but rather is subject to manipulation on the part of the major fuel brands. Such suspicion has long reigned in Germany, leading the German Cartel Office to undertake a study in 2011 on the setting of retail gasoline prices (Bundeskartellamt, 2011). The study, which descriptively analyzes data compiled from 407 gas stations located in four major cities between 2007 and 2010, concludes that five brands – BP, Jet (ConocoPhilipps), ExxonMobil, Shell, and Total – exercise market-dominating influence as oligopolists, leading to higher gas prices than would otherwise prevail under perfect competition. This assessment contrasts with that of the International Energy Agency, which in a recent report concludes that "Germany has a largely deregulated and competitive oil market" with "a large number of independents in the refining and retail sectors" (p. 8 IEA, 2012).

The justification for either of these judgments is difficult to establish empirically because it is premised on the relationship between price and marginal cost, which is itself unobservable. The literature on this topic has consequently employed alternative strategies for identifying whether the price-setting behavior of gasoline retailers departs significantly from the perfectly competitive ideal. Studies using time series data have investigated the influence of the oil price on the retail gas price, interpreting differential responses to oil price increases and decreases as evidence for market power or collusion among gas stations (e.g. Borenstein et al., 1997). Cross-sectional studies have examined the determinants of price-differentials among neighboring stations, focusing on the roles of spatial competition, branding, and other determinants that would be indicative of price setting that is not cost-based.

The present paper draws on elements from both of these streams to study retail gasoline price formation in the German market. Our empirical approach is motivated by the premise that a perfectly competitive market should not be characterized by heterogeneity in the ability of firms to pass on changes in input costs to consumers, holding fixed relevant station characteristics. Among the largest input costs faced by German gasoline retailers is that of Brent oil, comprising over a third of the price of gasoline at the pump. We consequently examine how the retail gas price responds to fluctuations in the Brent oil price and whether this response varies across stations.

To this end we analyze a panel of daily gasoline prices collected over 12 months beginning in 2012 from over 13,000 gas stations in Germany. We employ the quantile panel regression approach proposed by Canay (2011), which controls for unobserved fixed-effects while revealing how the impacts of the included covariates vary over the conditional distribution of the dependent variable. The model is used to test for five types of heterogeneity in the response to Brent oil price fluctuations according to (1) the level of the retail price, (2) the brand of gasoline, (3) the degree of competition as measured by the number of competing gas stations in the vicinity of the station, (4) the level of market concentration, and (5) the absence of competitors within 10 kilometers of the station. The coefficient estimates suggest statistically significant variation in the influence of the Brent oil price from all of these factors, suggesting deviation from perfectly competitive pricing.

Following a brief review in section 2 that anchors the present study in the related literature, the paper proceeds with a description of the data and the hypotheses to be tested. Section 4 describes the empirical methodology while section 5 discusses the results. The final section concludes the paper.

2 Related Literature

The literature analyzing the spatial determinants of gas prices and their dispersion goes back several decades, one of the first such studies being that of Livingston and Levitt (1959), who undertake a survey of stations from six metropolitan areas in the U.S. Midwest to test the assumption of uniform retail prices among the major brands. They conclude that there is more variation in retail gas prices than is frequently assumed, even among stations situated in the same neighborhood. Several subsequent studies have also found evidence for non-competitive pricing behavior. Shepard (1993), for example, finds substantial price differentials among stations in eastern Massachusetts, leading her to conclude that stations exercise sufficient local market power to price discriminate. Borenstein (1991), who studies differences in retail margins between leaded and unleaded gasoline, reaches a similar conclusion, noting that gasoline stations exercise some local market power and can price discriminate against consumers who are less likely to switch stations. Eckert and West (2004) study price uniformity using spatial data from Vancouver BC; their investigation of whether retailers match the mode price uncovers several statistically significant variables – including brand effects and local market structure – that are contrary to the competitive model.

The latter study is among a pool of more recent investigations that have drawn on the increased availability of station-level geo-referenced data to detect non-competitive price setting. These studies have yielded somewhat mixed results on the question of spatial competition, particularly as measured by the density of nearby competing stations. Ning and Haining (2003) and Van Meerbeeck (2003) study retail gasoline price formation using data from England and Belgium, respectively. Although the former study identifies statistically significant effects of several neighborhood characteristics, a variable measuring the number of stations included within a 2.5 km buffer of the station is not among these. Van Meerbeeck (2003) similarly finds that the number of local competitors has a negligible influence on the retail price.

By contrast, Barron et al. (2004) find that higher station density is associated with lower prices and a lower level of price dispersion in four metropolitan areas in the U.S. Clemenz and Gugler (2006) also find evidence for a negative association between station density and retail fuel prices with data from Austria. In another study from Austria of independent retailers, Pennerstorfer (2009) finds more ambiguous results: while the presence of independent retailers lowers prices, they simultaneously reduce price competition among major brands.

The present study contributes to the above line of inquiry with an analysis that investigates how spatial competition mediates the relationship between the price of Brent oil and that of gasoline. We infer deviations from perfect competition by empirically testing for differential effects of the Brent oil price according to the brand of gasoline and the degree of competition in the vicinity of the station. Our identification strategy is predicated on the idea that under perfect competition, gas stations with similar characteristics react uniformly to cost shocks. Identifying deviations from a uniform price response thus depends crucially on controlling for potential sources of cost variation.

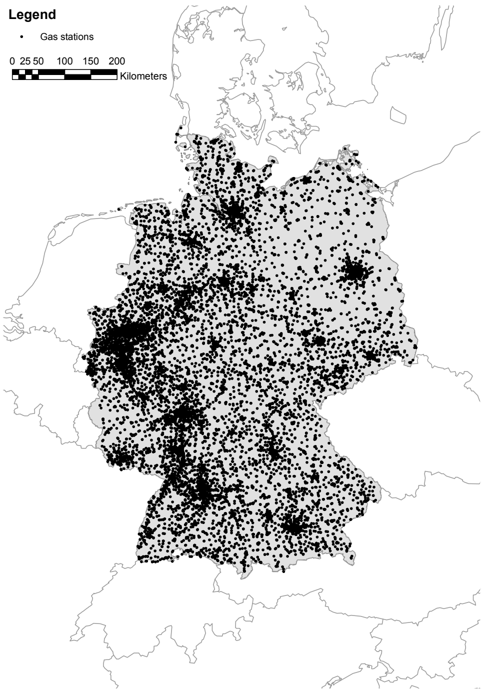
We avail a rich data set comprising an unbalanced panel of stations over 382 days that covers virtually the entire German retail market for gasoline. This data structure allows us to specify fixed effects at the level of the station, thereby holding constant unobservable cost elements and features of the market environment whose omission could otherwise bias the results. By employing a quantile panel estimator, we are additionally able to explore whether the influence of the explanatory variables varies across the conditional distribution of the response, thereby simultaneously accounting for both the price level and its dispersion.

3 Data and model specification

The data for this study was obtained from the site `www.clevertanken.de`. Upon entering a zip code, users of the site receive a listing of fuel prices at local gas stations. These prices, which are frequently if irregularly updated depending on the demand at the station, are entered to the site via mobile apps from motorists. For a period of about one year, from January 24, 2012 to February 8, 2013, we ran an automated program that continuously retrieved entries on the site and stored these on a server. To construct the dependent variable, we calculated an average gas price by station and day, which resulted in a collection of 2,245,067 observations from 13,701 German gas stations, representing approximately 95% of all stations.

The data posted by Clevertanken is not geo-referenced but does contain

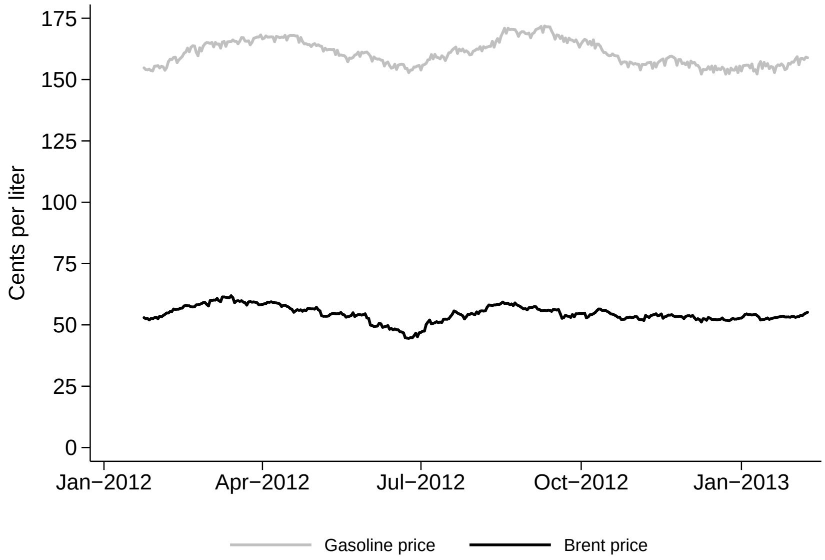
Figure 1: *Observed gas stations across Germany*



each station's brand name, street addresses and zip code. We uploaded the addresses in batches to Google Maps to obtain the geo-coordinates of each station, which were then digitized using a Geographic Information System (GIS) displayed in Figure 1. Note that the map, and the analysis that follows, excludes the roughly 300 filling stations located along the Autobahn (highway) as these operate within a distinctly different competitive environment.

As a main aim of the analysis is to study how gas prices react to changes in the international oil price, we include in the specification a variable measuring the previous day's closing spot price for Brent oil, a time series for which was obtained from the US EIA and merged with the data. A plot of the Brent price is presented in Figure 2 along with a plot of the average daily price for gasoline, calculated from the Clevertanken data. The fluctuations of the two series are tightly correlated, with the Brent price averaging about 54 Euro cents per liter over the observed time interval compared with 161 Euro cents per liter for gasoline. An Augmented Dickey Fuller test (not

Figure 2: *Daily average prices for gasoline, diesel, and brent*



shown) indicates that both series are integrated of order one and pairwise cointegrated.

Table 1 presents descriptive statistics for the variables used in the analysis. Aside from the Brent price, the main explanatory variables of interest include dummies for each of the five major brands (with non-major brands as the base case) as well as GIS-created variables that characterize the degree of competition in the vicinity of the station. Three such measures of competition are included. The first is a dummy that equals one if there is no other station within a 10-kilometer radius of the observation. Consistent with the model of spatial competition (Hotelling (1929)), we hypothesize that stations sufficiently buffeted by a lack of competitors would exercise greater ability to pass on increases in input costs. The remaining two spatial variables are each measured over a 5 kilometer radius from the station. The first is a count of the number of competitor stations within the buffer; stations of the same brand are excluded from the count. The second variable is the Herfindahl index of the share of filling stations of a particular brand within the buffer.

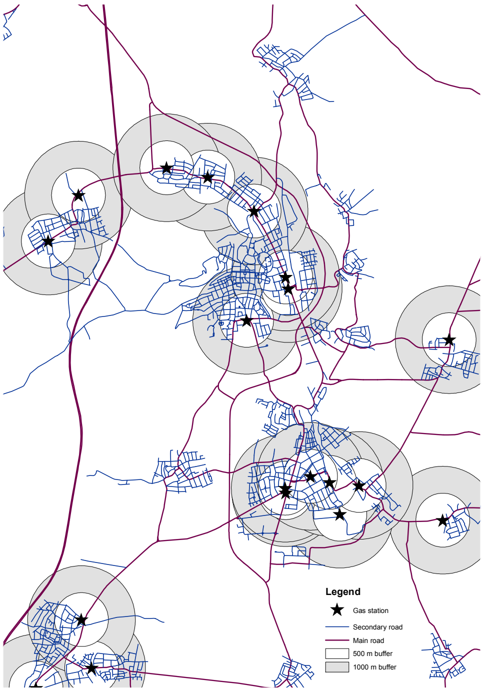
Table 1: *Descriptive statistics (N = 2,245,067)*

	Mean	Std. Dev.
Fuel price (cents / liter)	161.110	5.589
Brent price (cents / liter)	54.445	3.211
1 if brand is Aral	0.266	0.442
1 if brand is Shell	0.231	0.421
1 if brand is Esso	0.015	0.121
1 if brand is Total	0.089	0.285
1 if brand is Jet	0.077	0.266
Herfindahl Index (5000 m)	0.285	0.216
1 if no competitors in 10 km radius	0.005	0.072
1 if obs on Monday	0.164	0.370
1 if obs on Tuesday	0.160	0.367
1 if obs on Wednesday	0.159	0.366
1 if obs on Thursday	0.166	0.372
1 if obs on Friday	0.160	0.366
1 if obs on Saturday	0.152	0.359
1 if obs on Sunday	0.039	0.193
1 if winter holiday	0.007	0.083
1 if spring holiday	0.036	0.185
1 if pentecost holiday	0.012	0.110
1 if summer holiday	0.114	0.318
1 if autumn holiday	0.030	0.171
1 if christmas holiday	0.036	0.188
1 if public holiday	0.030	0.170
1 if day before holiday	0.008	0.088
1 if day between holidays	0.007	0.086

Std. Dev. is for standard deviation.

The inclusion of these two variables follows closely the specification of Clemenz and Gugler (2006) in their study of the Austrian gas station market. As these authors note, the expected sign of the Herfindahl is positive owing to higher market concentration allowing for higher price setting power, while that of the count of competitor stations is ambiguous. One reason for this ambiguity is the possibility – discussed at length in the study of the German Cartel Office – that stations in close proximity coordinate rather than compete with one another in price setting. Given that coordination prevails, we would expect a higher density of stations to be associated with a higher pass-through of the Brent price to the retail price.

Figure 3: *Creating buffers around gas stations*



Of course, the feasibility of coordination will also depend on the size of the region under question. Whether a 5 kilometer buffer is appropriate for capturing such spatial effects – be these of coordination or competition – is ultimately an empirical question. Too large a buffer will tend to dilute effects, while too small a buffer may fail to adequately capture the spatial gradient. Indeed, differences in defining the extent of the neighborhood may be one source of the differing results with respect to the question of station density documented in the literature review.[1] We consequently undertake robustness checks using two alternative buffers with radii of 3 and 7 kilometers.

Completing the specification are dummy variables for all weekdays (with Sunday as the excluded category) and for major holidays over the course of the year to control for temporal fluctuations in fuel demand. A dummy is also included for the day preceding each holiday to capture the possibility

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[1] Scale, however, is not the only source of differing results. As Barron et al. (2004) discuss, there is a long history of models adopting the search-theoretic approach to price dispersion that counterintuitively demonstrate that prices may increase with increases in competition.

– commonly lodged in media reports – that gas stations price gouge in anticipation of high demand on these days.

4 Method

Our point of departure in estimating the determinants of daily retail gasoline prices is a fixed-effects model, with the fixed effects specified at the level of the gas station. One potentially restrictive feature of the fixed-effect estimator is its focus on the conditional expectation function, which precludes the ability to estimate differential effects of an explanatory variable at different points in the conditional distribution of the dependent variable. The quantile regression estimator, introduced by Koenker and Bassett (1978), avoids this restriction by allowing estimation of the impact of a regressor at any point in the conditional distribution of the response, not just the conditional mean. In the context of the retail gas market, this flexibility affords a way to explore the implications of price dispersion for the determinants of price setting. Specifically, the estimates reveal the extent to which the magnitude of the coefficients depends on the price level.

Following the introduction of Koenker and Hallock (2001), the starting point for quantile regression are the unconditional quantiles, obtained by minimizing the sum of asymmetrically weighted residuals with an accordingly chosen constant b:

$$Q_\tau(y) = \min_{b \in \mathbb{R}} \sum \rho_\tau \cdot (y_i - b) \ . \tag{1}$$

The weighing scheme $\rho_\tau(\cdot)$ is the absolute value function that takes on different slopes depending on the sign of the residuals and the quantile of interest.

Moving from the unconditional to the conditional quantiles is achieved by substituting the b by the parametric function $b(\boldsymbol{x}_{it}, \beta)$ and minimizing the following equation using linear optimization:

$$Q_\tau(y) = \min_{\beta} \in \mathbb{R} \sum \rho_\tau \cdot (y_{it} - b(\boldsymbol{x}_{it}, \beta) \ , \tag{2}$$

with the vector $\boldsymbol{x}$ containing the control variables while β is the corresponding parameter vector. The solution to this minimization problem yields estimates of the impact of the controls at any point in the conditional distribution of the response.

To additionally control for time-invariant unobserved heterogeneity, we apply a two-step technique suggested by Canay (2011). Assuming that the fixed effect is a pure location shifter, i.e. it only affects the location but not the shape of the conditional distribution of the response, the fixed effect is constant. Therefore, it is possible to apply the standard within estimator

$$y_{it} = \boldsymbol{x}_{it}^T \cdot \beta + \epsilon_{it} + u_i \ , \tag{3}$$

where ϵ_{it} indicates an error term, while u_i is the unobserved fixed effect and estimate

$$\hat{u}_i = y_{it} - \hat{y}_{it} \ . \tag{4}$$

Subtracting the estimated fixed effect from the response variable

$$\hat{y}_{it} = y_{it} - \hat{u}_i \ , \tag{5}$$

yields a dependent variable free of the influence of unobserved heterogeneity. The quantile regression estimator introduced by Koenker and Bassett (1978) can then be applied using the transformed dependent variable in the second step to obtain estimates free of the influence of unobserved, time-invariant heterogeneity. One prerequisite is that there are sufficient observations for each individual to estimate the fixed effect with meaningful precision. With an average of about 166 observations for each gas station, this prerequisite is fulfilled.

A final estimation issue arising from the inclusion of fixed-effects is the fact that our measures of spatial competition and the brand dummies exhibit no temporal variation. To identify these variables, we interact them with the time-varying measure of the Brent oil price. The corresponding coefficients are thus interpreted in terms of how the static variables and the Brent price mediate one another in their influence on the retail gas price.

4.1 Results

We begin our discussion of the results with the estimates from a standard fixed effects (FE) model, presented in the first column of Table 2. The results from this model are used to create the transformed dependent variable used in the quantile model, presented subsequently. The appendix additionally presents robustness tests and ancillary results referenced in the discussion below.

The estimate of the Brent price in the FE model suggests that non-major brands, the base case, increase the gas price by 1.006 cents for every cent increase in the Brent price. As a t-test (not presented) indicates that the estimate is statistically different than one, we conclude that there is a greater than one-for-one pass through of this input cost. Aral and Esso follow a similar response to the Brent price, indicated by the statistical insignificance of the interaction terms. The remaining three majors, Jet, Shell, and Total, all pass on significantly more of the Brent price increase than non-majors. In the case of the Total-Brent interaction, which has the largest coefficient of 0.057, the pass through is about 6% higher than that of the non-majors. Interestingly, this estimate is in the same ballpark as the direct mark-up for branding calculated by Shepard (1991) in her study of the gas market in Massachusetts.

With respect to the three variables measuring spatial competition, all are positive and statistically significant. The estimate on the interaction with the count of competitors within the five kilometer buffer is 0.001. Evaluated at the mean Brent price of 54.45 cents, this indicates that each additional competitor increases the pass through by 0.05 cents. One explanation for this result is that a high density of stations may facilitate collusion in passing through more of the Brent price increase to consumers.

Table 2: *Quantile panel results (N = 2,245,067)*

Variable	**FE**	**Percentile**				
		10th	30th	50th	70th	90th
Brent price	1.006**	1.018**	1.000**	0.925**	0.947**	1.156**
	(0.003)	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)
Aral * Brent price	−0.003	0.000	−0.001**	−0.004**	−0.005**	−0.004**
	(0.002)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Shell * Brent price	0.052**	0.055**	0.054**	0.051**	0.050**	0.051**
	(0.002)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Esso * Brent price	0.000	−0.005**	0.002**	0.003**	0.002**	0.004**
	(0.007)	(0.001)	(0.001)	(0.000)	(0.001)	(0.001)
Total * Brent price	0.057**	0.060**	0.057**	0.055**	0.056**	0.057**
	(0.003)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Jet * Brent price	0.030**	0.034**	0.031**	0.030**	0.030**	0.029**
	(0.003)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Competitors * Brent	0.001**	0.001**	0.001**	0.001**	0.001**	0.001**
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Herfindahl * Brent	0.022**	0.024**	0.023**	0.022**	0.023**	0.021**
	(0.005)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
No competitors * Brent	0.078**	0.080**	0.077**	0.076**	0.076**	0.076**
	(0.012)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Monday	0.343**	0.712**	0.248**	0.168**	0.429**	0.172**
	(0.015)	(0.027)	(0.020)	(0.016)	(0.018)	(0.022)
Tuesday	0.344**	0.860**	0.166**	0.137**	0.367**	0.087**
	(0.015)	(0.025)	(0.021)	(0.016)	(0.018)	(0.020)
Wednesday	0.225**	0.841**	−0.012	−0.012	0.243**	0.220**
	(0.015)	(0.023)	(0.021)	(0.016)	(0.018)	(0.022)
Thrusday	0.257**	0.536**	−0.011	−0.029	0.120**	0.808**
	(0.015)	(0.028)	(0.020)	(0.016)	(0.020)	(0.023)
Friday	0.293**	0.601**	−0.002	0.121**	0.291**	0.503**
	(0.015)	(0.028)	(0.021)	(0.015)	(0.018)	(0.024)
Saturday	0.549**	1.068**	0.409**	0.374**	0.568**	0.269**
	(0.015)	(0.026)	(0.021)	(0.017)	(0.020)	(0.022)
Winter holiday	−3.041**	−1.836**	−2.237**	−2.400**	−3.244**	−5.313**
	(0.031)	(0.040)	(0.033)	(0.036)	(0.029)	(0.030)
Spring holiday	1.749**	3.749**	3.388**	2.722**	1.122**	−2.367**
	(0.015)	(0.019)	(0.011)	(0.009)	(0.011)	(0.011)
Pentecost holiday	1.404**	3.462**	2.798**	1.755**	0.470**	−0.978**
	(0.024)	(0.027)	(0.016)	(0.017)	(0.011)	(0.020)
Summer holiday	2.235**	3.168**	3.038**	2.462**	1.703**	0.467**
	(0.008)	(0.013)	(0.008)	(0.007)	(0.011)	(0.010)
Autumn holiday	−0.691**	0.459**	−0.328**	−1.033**	−1.453**	−1.328**
	(0.015)	(0.015)	(0.012)	(0.018)	(0.028)	(0.029)
Christmas holiday	−4.492**	−2.207**	−2.788**	−4.000**	−5.491**	−7.627**
	(0.014)	(0.015)	(0.007)	(0.007)	(0.008)	(0.012)
Public holiday	0.047**	0.635**	0.422**	0.036**	−0.388**	−0.577**
	(0.015)	(0.021)	(0.012)	(0.011)	(0.010)	(0.015)
Day before holidays	−0.309**	0.019	0.048	0.394**	−0.079*	−1.492**
	(0.029)	(0.040)	(0.058)	(0.038)	(0.032)	(0.037)
Day between holidays	−0.065*	1.942**	1.347**	0.489**	−0.675**	−3.289**
	(0.030)	(0.034)	(0.023)	(0.032)	(0.020)	(0.025)
Intercept	103.877**	97.949**	102.008**	108.137**	109.078**	101.476**
	(0.047)	(0.109)	(0.048)	(0.036)	(0.038)	(0.050)

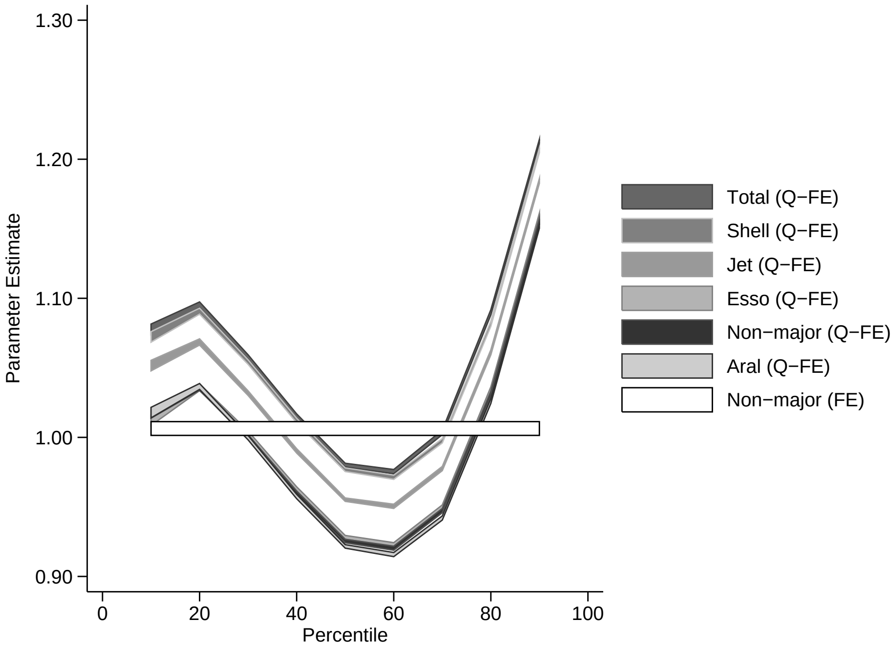
**, and * denotes significance at the 1% and 5% level. FE is for fixed-effects estimator.

An alternative explanation, and one consistent with the theory of spatial competition, is that stations surrounded by many competitors set the price closer to their marginal cost and thus have less leeway in absorbing increases in their input costs. To further explore this latter possibility, we estimated a random effects (RE) model, which allows identification of the direct effect of the time invariant variables subject to the assumption that they are not correlated with the fixed effects. As presented in Table 7 in the Appendix, the RE model indicates that the relationship between competition density and the price is negative, corroborating similar findings from Clemenz and Gugler (2006) and Barron et al. (2004). Moreover, the positive coefficient on the interaction term in this model indicates that the magnitude of the negative effect diminishes with increases in the Brent price. Overall, this pattern does not appear to be consistent with a story of collusion. Rather, a more coherent interpretation is rooted in spatial competition: an increased density of competitors has a direct impact in lowering the price, which in turn compels retailers to pass on more of the increase in the Brent price.

The positive and statistically significant effects of the interaction with the Herfindahl index and the dummy indicating the absence of competitors within a 10 kilometer buffer confirm the intuition that market concentration and spatial isolation both increase the ability of stations to pass on increases in input costs. Evaluated at the mean of the Brent price, a one-standard deviation in the Herfindahl index increases the retail price by 0.259 cents. The effect of the spatial isolation dummy is more pronounced; stations buffeted by a 10 kilometer radius free of competition pass on nearly 4.247 cents more evaluated at the mean of the Brent price.

The remaining control variables for weekdays and holidays are likewise statistically significant but have varying signs. Notwithstanding media allegations that stations price gouge on holidays, the pattern of estimates in the table paints a more complicated picture. For starters, the dummy indicating the day before a holiday has a negative coefficient, indicating a price drop of almost a third of a cent on a day when gas demand is thought to be high. The pattern on the holidays themselves is generally more consistent with a demand side interpretation, with higher gasoline prices in warm weather months and lower prices in the colder months. On Christmas, for example, when the roads are relatively empty in Germany, the gas price is roughly

Figure 4: *Brand dummies interacted with Brent*

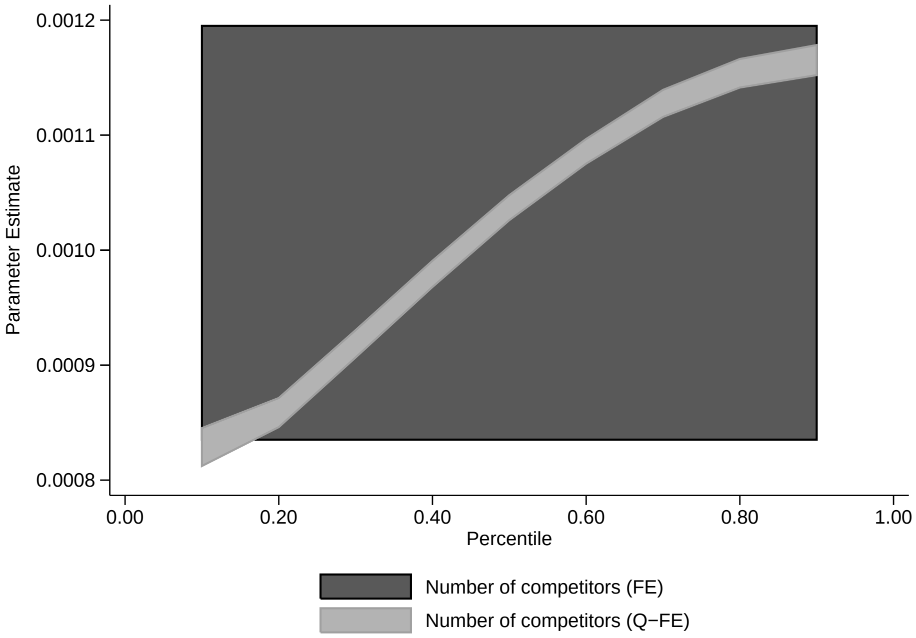


4.5 cents lower than on non-holidays.

Columns 2-6 of Table 2 present the results from the quantile fixed-effects regression (Q-FE) corresponding to the estimates from the 10th, 30th, 50th, 70th and 90th quantiles. Overall, the differences in the estimates across the quantiles is for many of the variables substantial, especially for the holiday dummies, which in some cases change signs. The Appendix presents test results on the equality of coefficients across the conditional distribution of the response. In the majority of cases, the estimates are statistically different from one another. This heterogeneity is shown graphically in Figures 4 to 7, which present the 95% confidence intervals (CI) of select estimates over each quantile, as well as the CI of the FE estimate.

Figure 4 presents this pattern for the brand-Brent interactions. The plots of Aral, Esso and the non-majors, the bottom three curves, are statistically indistinguishable from one another, as indicated by the high degree of overlap of the confidence intervals. The highest coefficients, also statistically indistinguishable, are seen for Shell and Total, while Jet falls in the

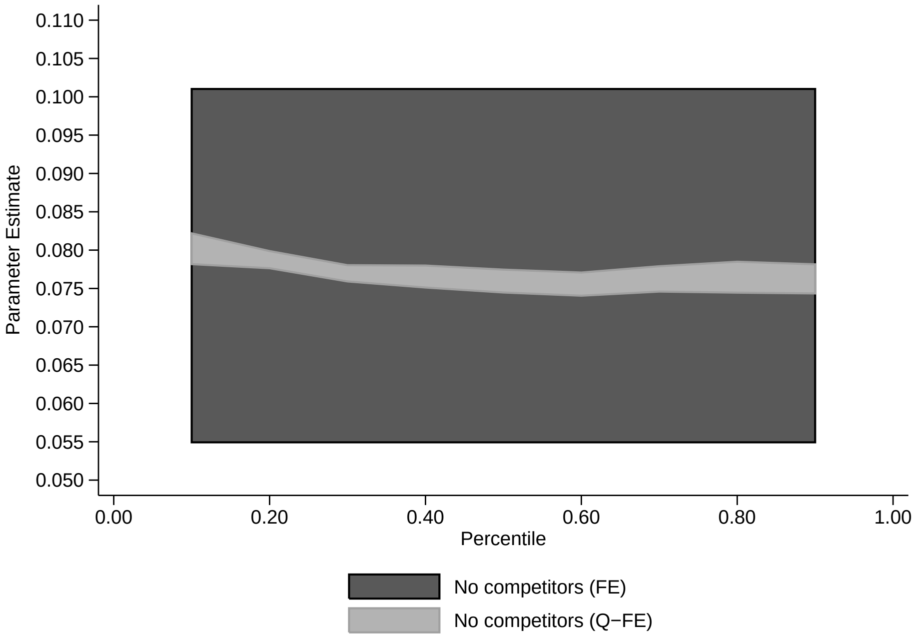
Figure 5: *Number of competitors within 5 kilometers interacted with Brent*



middle. The plot of all the brands follows a similar pattern characterized by substantial heterogeneity in the effect of the Brent price according to the level of the gas price. The strength of this effect declines by about 9% from the 20th to the 60th quantile, followed by an increase of about 25% from the 60th to the 90th quantile. Overall, the figure reveals that relatively low and high priced gas stations pass on more of the increase in Brent prices than those in the mid-range.

The estimates for the spatial competition variables also exhibit heterogeneity over the quantiles of the dependent variable, albeit subject to different patterns. Figure 5 illustrates that the positive influence of the count of competitors on the price pass through increases by about 25% from the 10th to the 90th quantile. Conversely, Figures 6 and 7 illustrate that the positive influence of the Herfindahl index and the dummy indicating spatial isolation become weaker in higher quantiles, decreasing by about 12.5 and 5%, respectively. All three figures demonstrate a considerably higher degree of precision of the quantile estimates relative to those of the standard FE

Figure 6: *No competitors within 10 kilometers interacted with Brent*



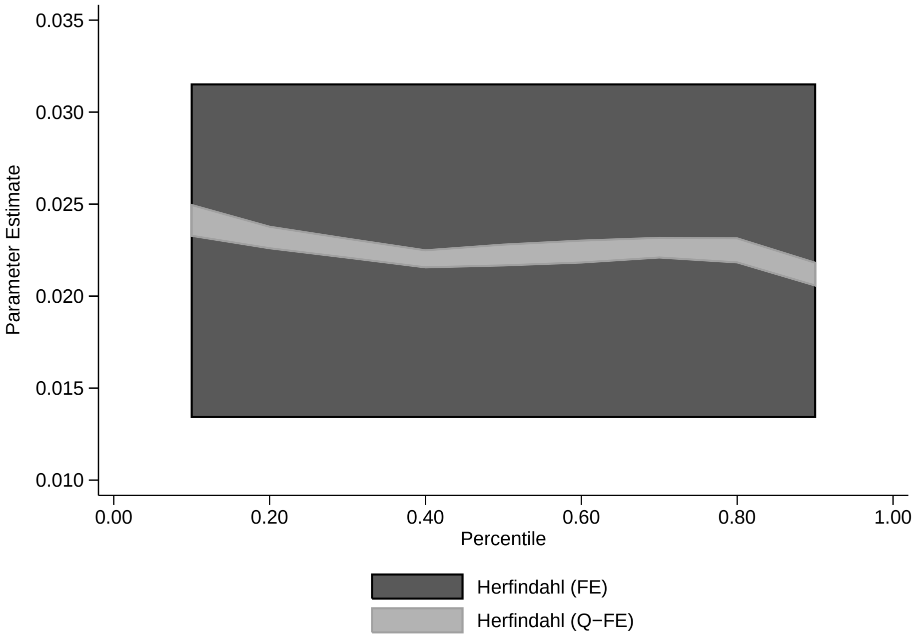
model, a likely reflection of the heterogeneity in the coefficients across the conditional distribution of the response.

As to the question of whether the results are sensitive to the size of the buffer used to construct the spatial variables, Tables 8 and 9 in the Appendix present models with variables calculated from 3 and 7 kilometer buffers. The differences in the estimates across these two scales are negligible.

5 Conclusion

Using a panel of daily price data collected over a year from 2012 to 2013, this paper has investigated the influence of the Brent oil price on the gasoline price in the German retail market. We were particularly interested in detecting deviations from cost-based pricing, identified by differential effects of the Brent oil price across stations. Our results show that the effect of this price varies by the brand, with Total and Shell having the highest pass through of Brent price increases and Aral and the non-majors having the

Figure 7: *Herfindahl-Index interacted with Brent*



lowest. Moreover, the influence of the Brent price on the gas price is stronger as the degree of local competition increases, measured by variation in market concentration, the density of competing stations, and spatial isolation from competing stations.

Another key finding of our analysis is that there is significant heterogeneity in the coefficients across the conditional distribution of the gasoline price - a fact that is otherwise obscured when relying on mean regression. For example, the mean regression fixed effects model estimated that the average cost pass-through from variations in the oil price is close to one, while results from quantile panel regression indicate that, depending on the percentile of interest, this pass-through may be substantially higher or lower, varying by upwards of 25%. Across all brands, the pattern of heterogeneity suggests that stations with relatively high and relatively low gas prices pass on more the the Brent price than those at the median.

Do these findings undermine the proposition that the German retail gas market is competitive? Our verdict falls somewhere between the optimistic outlook of the IEA report and the pessimistic tenor of the report from the German Cartel Office along with the public discussion that followed its release. Reacting to the report, the German economics minister at the time, Philipp Roesler, broached the idea of limiting stations to a single price increase per day, following rules introduced in Austria. Although our results clearly indicate that price setting at gas stations deviates from what would be expected under perfect competition, the magnitude of this deviation does not appear to warrant such a drastic restriction on price setting flexibility. Nevertheless, competition authorities would be well advised to vigilantly scrutinize merger applications given our finding that the market landscape is already subject to some degree of local dominance.

References

Barron, J. M., B. A. Taylor, and J. R. Umbeck (2004). Number of sellers, average prices, and price dispersion. *International Journal of Industrial Organization 22*(8), 1041–1066.

Borenstein, S. (1991). Selling costs and switching costs: Explaining retail gasoline margins. *The RAND Journal of Economics*, 354–369.

Borenstein, S., A. C. Cameron, and R. Gilbert (1997). Do gasoline prices respond asymmetrically to crude oil price changes? *Quarterly Journal of Economics 112*(1), 305–339.

Bundeskartellamt (2011). *Sektoruntersuchung Kraftstoffe.* Berlin.

Canay, I. A. (2011). A simple approach to quantile regression for panel data. *The Econometrics Journal 14*(3), 368–386.

Clemenz, G. and K. Gugler (2006). Locational choice and price competition: some empirical results for the Austrian retail gasoline market. *Empirical Economics 31*(2), 291–312.

Eckert, A. and D. S. West (2004). A tale of two cities: Price uniformity and price volatility in gasoline retailing. *The Annals of Regional Science 38*(1), 25–46.

Hotelling, H. (1929). Stability in competition. *The Economic Journal 39*(153), pp. 41–57.

IEA (2012). Emergency response of IEA countries: Germany. *International Energy Agency*.

Koenker, R. and K. Hallock (2001). Quantile regression: An introduction. *Journal of Economic Perspectives 15*(4), 43–56.

Koenker, R. W. and G. W. Bassett (1978). Regression quantiles. *Econometrica 46*(1), 33–50.

Livingston, S. M. and T. Levitt (1959). Competition and retail gasoline prices. *The Review of Economics and Statistics*, 119–132.

Ning, X. and R. Haining (2003). Spatial pricing in interdependent markets: a case study of petrol retailing in sheffield. *Environment and Planning A 35*(12), 2131–2160.

Pennerstorfer, D. (2009). Spatial price competition in retail gasoline markets: Evidence from Austria. *The Annals of Regional Science 43*(1), 133–158.

Shepard, A. (1993). Contractual form, retail price, and asset characteristics in gasoline retailing. *The RAND Journal of Economics*, 58–77.

Van Meerbeeck, W. (2003). Competition and local market conditions on the belgian retail gasoline market. *De Economist 151*(4), 369–388.

6 Appendix

Table 3: *F-Test for equality of coefficients: The Brent price*

Variable			Percentile		
	10th	30th	50th	70th	90th
10	–	118.2**	2428.4**	1019.8**	4061.8**
30		–	9465.4**	2350.0**	17523.7**
50			–	600.9**	54069.4**
70				–	49782.1**
90					–

**, and * denotes significance at the 1% and 5% level.

Table 4: *F-Test for equality of coefficients: Number of competitors*

Variable			Percentile		
	10th	30th	50th	70th	90th
10	–	147.8**	631.7**	874.2**	1237.4**
30		–	576.5**	928.1**	965.5**
50			–	212.2**	275.3**
70				–	27.3**
90					–

**, and * denotes significance at the 1% and 5% level.

Table 5: *F-Test for equality of coefficients: Market concentration*

Variable			Percentile		
	10th	30th	50th	70th	90th
10	–	16.8**	19.3**	9.7**	36.8**
30		–	2.1	0.0	15.4**
50			–	2.5	8.3**
70				–	24.9**
90					–

**, and * denotes significance at the 1% and 5% level.

Table 6: *F-Test for equality of coefficients: No competitors*

Variable	**Percentile**				
	10th	30th	50th	70th	90th
10	–	9.3 ∗∗	9.9 ∗∗	9.6 ∗∗	8.5 ∗∗
30		–	3.0	0.7	0.5
50			–	0.1	0.1
70				–	0.0
90					–

**, and * denotes significance at the 1% and 5% level.

Table 7: *Results from random effects estimation (N = 2,245,067)*

Variable	**Coefficient estimate**	**Standard error**
Brent price	1.006∗∗	0.003
Aral	2.585∗∗	0.121
Aral * Brent	−0.003	0.002
Shell	−0.331∗∗	0.129
Shell * Brent	0.052∗∗	0.002
Esso	0.351	0.390
Esso * Brent	0.003	0.007
Total	−0.822∗∗	0.179
Total * Brent	0.057∗∗	0.003
Jet	−0.733∗∗	0.189
Jet * Brent	0.031∗∗	0.003
Competitors	−0.076∗∗	0.005
Competitors * Brent	0.001∗∗	0.000
Herfindahl	−0.788∗∗	0.266
Herfindahl * Brent	0.023∗∗	0.005
No competitors	−3.938∗∗	0.681
No competitors * brent	0.078∗∗	0.012
Monday	0.355∗∗	0.015
Tuesday	0.357∗∗	0.015
Wednesday	0.238∗∗	0.015
Thursday	0.271∗∗	0.015
Friday	0.307∗∗	0.015
Saturday	0.561∗∗	0.015
Winter holiday	−3.042∗∗	0.031
Spring holiday	1.752∗∗	0.014
Pentecost holiday	1.408∗∗	0.024
Summer holiday	2.238∗∗	0.008
Autumn holiday	−0.691∗∗	0.015
Christmas holiday	−4.496∗∗	0.014
Public holiday	0.047∗∗	0.015
Day before holiday	−0.306∗∗	0.029
Day between holidays	−0.064∗	0.030
Intercept	104.320∗∗	0.146

**, and * denotes significance at the 1% and 5% level.

While a Hausman test rejects the null hypothesis that the fixed effects are uncorrelated with the regressors, the coefficients on the interaction terms of the RE model presented above are nevertheless of a similar magnitude as the FE coefficients presented in Table 2. The RE model additionally shows the estimates for the time-invariant spatial variables, whose interpretation is contingent on the interaction effects. For example, evaluated at the mean of the Brent price, a one unit increase in the Herfindahl index increases the gas price by 0.46 cents.

Table 8: *Quantile panel results for 3 kilometer buffers (N = 2,245,067)*

Variable	**Percentile**				
	10th	30th	50th	70th	90th
Brent price	1.026**	1.009**	0.934**	0.957**	1.165**
	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)
Aral * Brent price	0.000	−0.001**	−0.004**	−0.006**	−0.004**
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Shell * Brent price	0.054**	0.054**	0.051**	0.050**	0.050**
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Esso * Brent price	−0.005**	0.003**	0.003**	0.003**	0.004**
	(0.001)	(0.000)	(0.000)	(0.001)	(0.001)
Total * Brent price	0.060**	0.057**	0.055**	0.056**	0.057**
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Jet * Brent price	0.034**	0.032**	0.030**	0.030**	0.029**
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Competitors * Brent	0.001**	0.001**	0.001**	0.002**	0.002**
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Herfindahl * Brent	0.006**	0.006**	0.005**	0.005**	0.004**
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
No competitors * Brent	0.089**	0.085**	0.084**	0.084**	0.084**
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Monday	0.716**	0.254**	0.168**	0.429**	0.163**
	(0.031)	(0.019)	(0.017)	(0.023)	(0.021)
Tuesday	0.868**	0.170**	0.137**	0.367**	0.080**
	(0.029)	(0.019)	(0.017)	(0.021)	(0.020)
Wednesday	0.846**	−0.007	−0.013	0.243**	0.214**
	(0.028)	(0.018)	(0.015)	(0.019)	(0.023)
Thrusday	0.542**	−0.008	−0.029	0.119**	0.801**
	(0.032)	(0.020)	(0.017)	(0.020)	(0.023)
Friday	0.605**	0.002	0.121**	0.289**	0.495**
	(0.026)	(0.018)	(0.017)	(0.021)	(0.024)
Saturday	1.074**	0.415**	0.373**	0.568**	0.262**
	(0.029)	(0.018)	(0.016)	(0.021)	(0.022)
Winter holiday	−1.841**	−2.237**	−2.402**	−3.246**	−5.319**
	(0.035)	(0.029)	(0.029)	(0.023)	(0.024)
Spring holiday	3.755**	3.387**	2.720**	1.120**	−2.364**
	(0.023)	(0.013)	(0.010)	(0.010)	(0.012)
Pentecost holiday	3.468**	2.804**	1.757**	0.470**	−0.976**
	(0.029)	(0.018)	(0.016)	(0.011)	(0.023)
Summer holiday	3.163**	3.035**	2.460**	1.700**	0.461**
	(0.014)	(0.009)	(0.008)	(0.012)	(0.010)
Autumn holiday	0.462**	−0.329**	−1.032**	−1.448**	−1.321**
	(0.019)	(0.014)	(0.015)	(0.023)	(0.028)
Christmas holiday	−2.206**	−2.787**	−4.001**	−5.492**	−7.628**
	(0.016)	(0.009)	(0.009)	(0.008)	(0.009)
Public holiday	0.637**	0.423**	0.036**	−0.387**	−0.582**
	(0.021)	(0.016)	(0.011)	(0.011)	(0.014)
Day before holidays	0.023	0.055	0.393**	−0.078**	−1.484**
	(0.036)	(0.051)	(0.038)	(0.029)	(0.043)
Day between holidays	1.945**	1.342**	0.488**	−0.676**	−3.286**
	(0.030)	(0.021)	(0.029)	(0.017)	(0.021)
Intercept	97.968**	102.002**	108.139**	109.078**	101.490**
	(0.125)	(0.060)	(0.054)	(0.056)	(0.056)

**, and * denotes significance at the 1% and 5% level. FE is for fixed-effects estimator.

Table 9: *Quantile panel results for 7 kilometer buffers (N = 2,245,067)*

Variable	**Percentile**				
	10th	30th	50th	70th	90th
Brent price	1.015**	0.998**	0.923**	0.945**	1.153**
	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)
Aral * Brent price	0.000	−0.001**	−0.004**	−0.005**	−0.004**
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Shell * Brent price	0.055**	0.054**	0.051**	0.050**	0.051**
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Esso * Brent price	−0.005**	0.002**	0.002**	0.002**	0.003**
	(0.001)	(0.000)	(0.000)	(0.001)	(0.001)
Total * Brent price	0.060**	0.057**	0.054**	0.056**	0.056**
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Jet * Brent price	0.034**	0.032**	0.030**	0.031**	0.029**
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Competitors * Brent	0.001**	0.001**	0.001**	0.001**	0.001**
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Herfindahl * Brent	0.026**	0.025**	0.024**	0.025**	0.023**
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
No competitors * Brent	0.080**	0.077**	0.076**	0.077**	0.077**
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Monday	0.713**	0.246**	0.169**	0.430**	0.173**
	(0.027)	(0.020)	(0.016)	(0.025)	(0.025)
Tuesday	0.864**	0.164**	0.138**	0.369**	0.089**
	(0.028)	(0.020)	(0.017)	(0.023)	(0.025)
Wednesday	0.844**	−0.013	−0.011	0.246**	0.222**
	(0.028)	(0.020)	(0.018)	(0.022)	(0.026)
Thrusday	0.537**	−0.013	−0.029	0.123**	0.809**
	(0.028)	(0.020)	(0.016)	(0.023)	(0.027)
Friday	0.603**	−0.005	0.122**	0.294**	0.505**
	(0.027)	(0.020)	(0.018)	(0.023)	(0.027)
Saturday	1.068**	0.409**	0.374**	0.569**	0.272**
	(0.024)	(0.019)	(0.017)	(0.022)	(0.024)
Winter holiday	−1.831**	−2.235**	−2.397**	−3.238**	−5.298**
	(0.035)	(0.038)	(0.030)	(0.027)	(0.029)
Spring holiday	3.748**	3.388**	2.723**	1.123**	−2.371**
	(0.019)	(0.010)	(0.010)	(0.010)	(0.010)
Pentecost holiday	3.456**	2.799**	1.753**	0.469**	−0.976**
	(0.026)	(0.018)	(0.018)	(0.015)	(0.025)
Summer holiday	3.170**	3.041**	2.463**	1.705**	0.472**
	(0.011)	(0.009)	(0.009)	(0.010)	(0.010)
Autumn holiday	0.452**	−0.331**	−1.035**	−1.456**	−1.336**
	(0.018)	(0.013)	(0.015)	(0.025)	(0.033)
Christmas holiday	−2.207**	−2.789**	−4.001**	−5.491**	−7.631**
	(0.018)	(0.010)	(0.009)	(0.008)	(0.010)
Public holiday	0.640**	0.422**	0.035**	−0.389**	−0.574**
	(0.023)	(0.011)	(0.012)	(0.012)	(0.015)
Day before holidays	0.023	0.047	0.394**	−0.078*	−1.489**
	(0.038)	(0.046)	(0.038)	(0.031)	(0.034)
Day between holidays	1.948**	1.348**	0.490**	−0.674**	−3.292**
	(0.029)	(0.021)	(0.034)	(0.020)	(0.024)
Intercept	97.943**	102.007**	108.136**	109.072**	101.465**
	(0.114)	(0.063)	(0.056)	(0.051)	(0.044)

**, and * denotes significance at the 1% and 5% level. FE is for fixed-effects estimator.