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by

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Abstract

Do we have effective competition between the gasoline's big five oligopolists (Aral, Shell, Esso, Total and Jet) and fringe gasoline stations? Using 2014 Market Transparency price data from 66 cities with populations between 60,000 and 100,000, we analyze which brands lead price increases, the first average price mark-up in the evening, and the trend on price increases until midnight. Furthermore, we measure the response time it takes for competitors to react to these price increases, and how much prices change from the beginning to the end of a day. By watching local activities of the big brands, it is possible to measure how smaller businesses, such as Jet or independent retailers, react to Aral's and Shell's price changes. Multivariate estimations allows to control for gasoline type (regular or diesel), school holidays, weekends, weekdays, location -such as East or West Germany-, wholesale and starting prices. Descriptive results show the typical patterns. Aral (or Shell) will start a price increase round, and then Shell (or Aral) will more or less immediately follow. Total, Esso and Non-Oligopolists react within one or two hours. Jet behaves more as an “outsider” with later reaction times and lower price mark-ups. Multivariate estimation indicates that the single cause “price change by competitors” is less important and nearly irrelevant for Jet.

JEL-classification: L13, L41, L81

Keywords: Market power, collusive behavior, gasoline market

1 The Problem

The volatility of price changes in the German gasoline market is impressive. For example, Figure 1 shows Lueneburg average diesel prices of the two major brands Aral and Shell for two days in the spring of 2014. Lueneburg's four Aral and three Shell stations charged high prices in the evening and night times. Both brands mainly reduced prices during early morning and afternoon hours, and increased prices before 10 a.m. and again before 8 p.m. The volatility of prices cannot be explained by daily wholesale prices because wholesale prices were nearly constant in the short period studied. A closer look at the data shows that both brands behaved similarly during the evening price increase, and that local competitors followed the upward price movements, but in different time spans. Morning price increases were mostly unsuccessful because competitive forces consecutively extort price confessions for both market-leading brands. Hence, evening upward price developments are reason to explain price restorations.

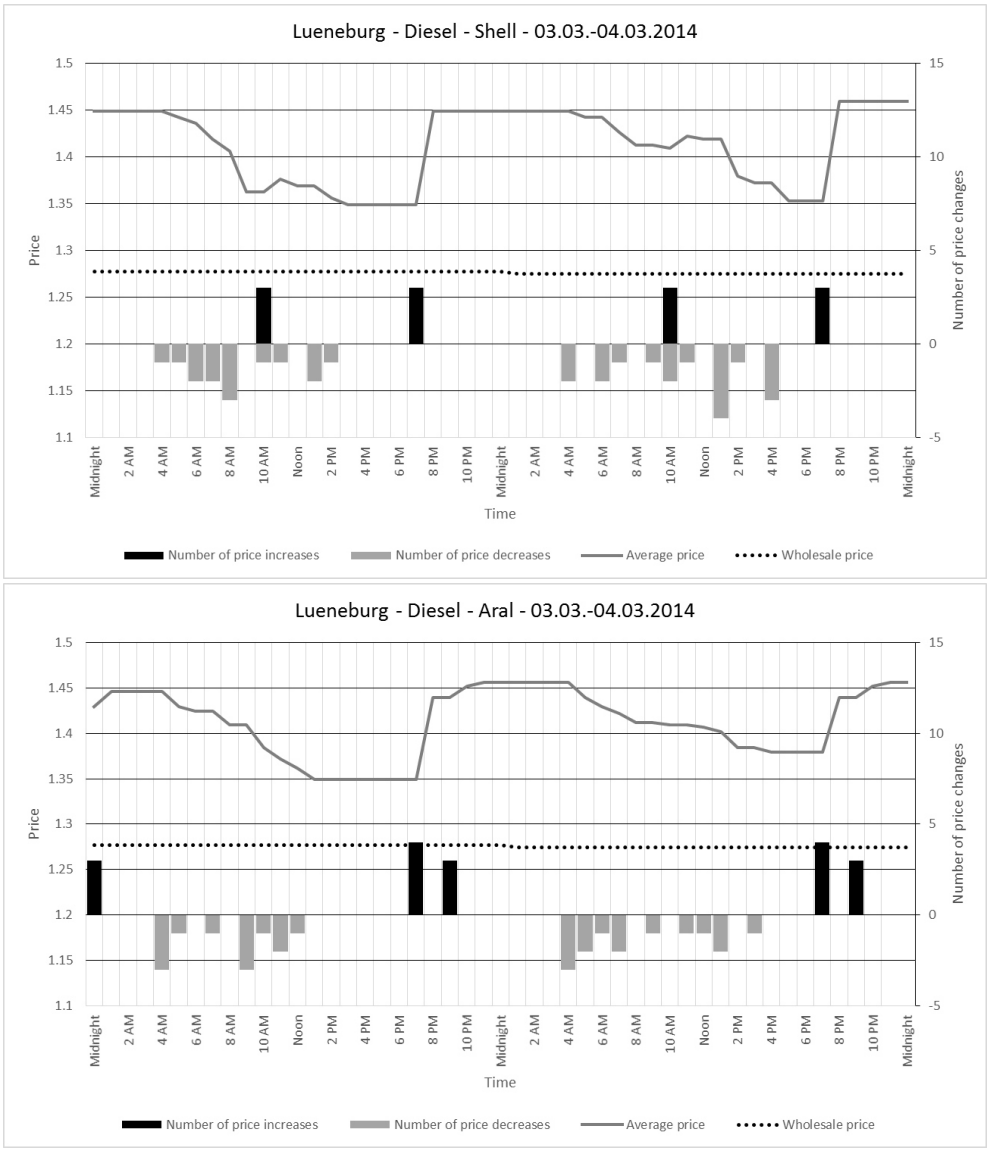

Figure 1: Price Developments of Lueneburg Aral and Shell Gasoline Stations

Own calculations

Because collusive behavior mainly occurred within daily movements, empirical investigations must rely on intraday prices. There is very few intraday price analysis when it comes to review studies outside of

Germany. Atkinson (2009) showed that both national major gasoline companies in Canada were executing price increases mainly in the mid-afternoon. Data included eight daily price checks at individual stations in summer and fall of 2005. Lewis (2012) found for stations in Midwestern United States that a highly vertical integrated brand very often caused price increases when price data was analyzed three times per day. Intraday price studies are relevant for Germany because the German Cartel Office collected prices from four metropole regions for three and half years (second half of last decade). Additionally, the Market Transparency Unit has collected German gasoline price changes within five minutes of change at the local level for all gasoline and diesel stations since the beginning of 2014.

The German Cartel Office began an official investigation of market conditions concerning gasoline stations (Bundeskartellamt, 2011). Gasoline stations, which supply the metropole regions Cologne, Hamburg, Leipzig, and Munich, were obliged to disclose detailed price information for diesel and petrol from January 2007 to June 2010. Furthermore, they had to provide information on how many gasoline stations they were monitoring in their neighborhood and the quantity of gasoline they sold. Besides special price patterns concerning weekdays, daily hour times, and holidays, the main results showed remarkable price increasing patterns. Using the definition of dominant price increases[1] 90 percent of all Aral stations immediately followed Shell's price increase, which mostly occurred in the early evening hours from 6 to 7 p.m. Shell reacted exactly the same way when Aral increased prices. 70 percent of all regional Esso stations followed suit, but had a regional time difference of between three and six hours later. Jet followed the price increase after five hours, or, at the latest, the following morning. Hence, price restorations mainly occurred as a collective act.

Kihn et al. (2014) used intraday price data for German gasoline stations found on the website *www.clever-tanken.de*. From January 2012 to February 2013, *clever-tanken.de* received price data from drivers who had reported their own price observations via email, mobile phone, social networks, etc. The econometric analysis tried to discover the relationship between wholesale and station prices by controlling for competitive relationships because wholesale prices were only provided on daily basis, and station prices were provided in a daily average. Haucap et al. (2015) based their panel analyses on eight months data set created by the Market Transparency Unit. To explain the price dispersion, they conducted a regression model with average prices per day, or restricted to a period in which stations were open. Hence, the intraday price movements were also ignored.

Using the Market Transparency Unit data, the German Cartel Office was able to conduct a follow-up analysis according to their own previous study (Bundeskartellamt, 2014). Further metropolitan regions as Berlin, Frankfort (Main), Stuttgart, and Dresden were added to the old four regions. The analysis was restricted to prices because the law obliges gasoline stations to deliver price changes within a five-minute time period. It is likely that manpower restrictions cause the concentration of prices from February to May 2014 for Super Gasoline E5. Price increasing mostly occurred between 8 p.m. and midnight. From 8 to 9 p.m., Aral and Shell led the price increases. Esso and Jet always responded with a price increase after 9 p.m. Jet was often as late as after 11 p.m. with their change. Collusive behavior was also relevant during this period.

Following the old regional differentiation of the Federal Cartel Office (2011) from March to May, and September 2014, Neukirch/Wein (2015) showed that nearly the half of all price increases in the evenings began with Shell or Aral. Both brands followed each other's price changes within five to thirty

[1] More than 50 percent of all brand specific gasoline stations within one region.

minutes. It took to react between one and one and a half hour for Esso and Total. Jet usually reacted even later, mostly after two and a half hours. Holding all other relevant factors constant, Shell increased their price by 1 to 1.2 ct., after Aral led in the price increase with 1 ct. Aral's reaction to Shell's price increase was weaker, by roughly 0.2 ct. in the case of a 1 ct. higher leading price. Jet always reacted with lower price changes, between 0.04 and 0.35 ct. For the "old" metropolitan regions, the same collusive patterns occurred in 2014 as they did in mid/end of last decade 2000.

In this paper, we use a market definition in opposite to Neukirch/Wein (2015). We assume that the used four metropolitan regions include so many gasoline stations and so wide areas that not all of them are competitively related. We use the new regional price data set (section 2), in order to analyze the connection between the leading upward price movements of major market-dominant companies and the reactions of their competitors. Because the relevant upward price movements occurred between 6 p.m. and midnight, we use a specific method to measure the start of price changes and the reactions (section 3). Within section 4, we show descriptive results concerning the average initial price increases from the dominant companies, their average upward movements until midnight, as well as the price reactions of competitors through the end of day. By differentiating between price changes initiated by Aral and Shell, we are able to run multivariate estimations about the strength of the price reactions of the other dominant majors or outsiders, holding factors constant such as price levels before upward price movements, petrol sorts, day characteristics, and wholesale prices. The final section includes a summary and conclusions of our results.

2 Data

We use price information from the Market Transparency Unit, which we received from the internet and app provider *clever-tanken.de*. As mentioned before, our data includes March to May 2014 and September 2014 for diesel and premium petrol E10.[2] Retail prices higher than € 2 are probably entry errors and can be excluded from data set (six observations). Prices which were fixed for more than one week are presumably incorrect and have been deleted (445 observations). Motorway gasoline stations can be supposed to build their own market (Bundeskartellamt, 2011); hence, these price observations are ignored. Assuming a high relevance of brand competition we have allocated all stations either to the group of the so-called five oligopolists "Aral, Shell, Esso, Total, or Jet" or being part of the group of Non-Oligopolists (NO). Price observations are restricted to diesel and gasoline E10 because of non-availability of price data for other sorts. Using the station data set of *PetrolView* with opening hours we are able to restrict us on "market active" price data, excluding overnight prices of closed stations.[3]

In contrast to Neukirch/Wein (2015), we assume that the used four metropolitan regions include so many gasoline stations and so wide areas that not all of them are competitively related. Instead, we argue that in cities with populations between 60,000 and 100,000, gasoline stations are more likely part of the competitive pressure between each other. Table 1 shows the included 66 cities and the total number of observed brands. The number of diesel stations is higher because few stations supply only diesel. In mid-sized cities, there are usually between ten and twenty stations.

[2] Data are complete for March 2014, 1st. to 31th., April 2014, 2nd.-15th., 17th. -27th. April, 29th.-June 2014, 1st., and the full September 2014.

[3] The complete dataset can be requested by email from the authors.

Table 1: Number of Gasoline Stations/Brands/Diesel and Super E10

Cities/Brands	Aral	Shell	Esso	Total	Jet	NO	Sum
Aalen	2/2	1/1	1/1	0/0	0/0	12/11	16/15
Arnsberg	3/3	1/1	0/0	1/1	0/0	11/11	16/16
Aschaffenburg	4/3	2/2	2/2	1/1	0/0	8/8	17/16
Bamberg	4/4	1/1	1/1	0/0	2/2	10/9	18/17
Bayreuth	1/1	2/2	3/3	0/0	2/2	13/12	21/20
Bocholt	2/2	0/0	0/0	1/1	1/1	9/9	13/13
Brandenburg a. d. Havel	2/2	2/2	1/1	3/3	0/0	5/5	13/13
Castrop-Rauxel	1/1	1/1	0/0	1/1	2/2	7/5	12/10
Celle	4/4	3/3	1/1	0/0	2/2	8/8	18/18
Cottbus	2/2	2/2	1/1	2/2	1/1	3/3	11/11
Delmenhorst	2/2	2/2	0/0	2/2	2/2	8/7	16/15
Dessau	3/3	2/2	1/1	1/1	1/1	4/4	12/12
Detmold	1/1	2/2	0/0	0/0	1/1	12/11	16/15
Dinslaken	0/0	2/2	0/0	1/1	1/1	4/4	8/8
Dormagen	1/1	2/2	1/1	0/0	0/0	3/2	7/6
Dorsten	1/1	4/4	1/1	0/0	0/0	11/10	17/16
Dueren	1/1	2/2	1/1	3/3	2/2	12/12	21/21
Esslingen am Neckar	1/1	0/0	3/3	1/1	0/0	5/5	10/10
Flensburg	3/3	5/5	0/0	0/0	0/0	11/11	19/19
Fulda	2/2	1/1	1/1	0/0	2/2	3/3	9/9
Gera	3/3	2/2	0/0	1/1	0/0	6/6	12/12
Giessen	3/3	3/3	2/2	0/0	4/4	6/6	18/18
Gladbeck	2/2	1/1	1/1	1/1	0/0	5/4	10/9
Grevenbroich	0/0	2/2	1/1	1/1	0/0	6/4	10/8
Guetersloh	1/1	4/4	2/2	1/1	1/1	13/12	22/21
Hanau	2/2	3/3	1/1	2/2	1/1	9/8	18/17
Herford	3/3	1/1	3/3	1/1	1/1	8/8	17/17
Herten	1/1	0/0	1/1	1/1	0/0	4/4	7/7
Hildesheim	4/4	2/2	2/2	1/1	2/2	12/10	23/21
Iserlohn	3/3	3/3	0/0	1/1	0/0	6/6	13/13
Kaiserslautern	4/4	3/3	2/2	1/1	2/2	6/6	18/18
Kempten	2/2	1/1	1/1	0/0	1/1	8/8	13/13
Kerpen	3/3	0/0	2/2	0/0	0/0	8/8	13/13
Konstanz	1/1	0/0	0/0	0/0	0/0	5/4	6/5
Landshut	2/2	1/1	1/1	1/1	1/1	11/10	17/16
Lippstadt	1/1	0/0	0/0	0/0	2/2	10/10	13/13
Ludwigsburg	3/3	1/1	2/2	1/1	2/2	3/3	12/12
Luedenscheid	2/2	2/2	2/2	1/1	1/1	6/3	14/11
Lueneburg	4/4	3/3	1/1	0/0	0/0	7/7	15/15
Luenen	4/4	2/2	1/1	0/0	1/1	8/8	16/16
Marburg	4/4	1/1	2/2	0/0	2/2	4/4	13/13
Marl	2/2	1/1	2/2	0/0	0/0	7/7	12/12
Minden	1/1	3/3	0/0	0/0	1/1	14/14	19/19
Neubrandenburg	2/2	3/3	0/0	1/1	1/1	8/7	15/14
Neumuenster	2/2	2/2	0/0	3/3	2/2	11/10	20/19
Neuwied	1/1	2/2	0/0	1/1	0/0	5/5	9/9
Norderstedt	3/3	2/2	1/1	0/0	1/1	7/7	14/14
Plauen	2/2	1/1	0/0	1/1	0/0	5/4	9/8
Ratingen	2/2	2/2	2/2	1/1	0/0	5/5	12/12
Rheine	1/1	1/1	0/0	0/0	2/2	13/13	17/17
Rosenheim	1/1	2/2	1/1	0/0	1/1	4/4	9/9
Ruesselsheim	3/3	3/3	0/0	0/0	0/0	5/5	11/11
Salzgitter	2/2	4/4	1/1	0/0	0/0	11/10	18/17
Schwerin	5/5	2/2	1/1	3/3	0/0	11/9	22/20
Sindelfingen	1/1	3/3	3/3	0/0	0/0	4/4	11/11
Troisdorf	3/3	1/1	0/0	0/0	0/0	6/6	10/10
Tuebingen	2/2	0/0	3/3	1/1	2/2	3/3	11/11
Velbert	2/2	2/2	2/2	1/1	0/0	6/6	13/13
Viersen	3/3	1/1	0/0	0/0	1/1	6/6	11/11
Villingen-Schwenningen	3/3	4/4	2/2	0/0	0/0	7/6	16/15
Weimar	2/2	1/0	0/0	0/0	2/2	4/4	9/8
Wesel	2/2	2/2	0/0	1/1	1/1	5/5	11/11
Wilhelmshaven	3/3	3/3	0/0	0/0	1/1	7/7	14/14
Witten	4/4	1/1	2/2	0/0	1/1	7/7	15/15
Worms	5/5	2/2	2/2	0/0	2/2	4/4	15/15
Zwickau	5/5	2/2	0/0	2/2	1/1	6/5	16/15
Sum	154/153	122/121	67/67	46/46	59/59	481/452	929/898

The number of gasoline stations varies because not all of them supply Super E 10. Own calculations with Stata 13.1.

Aral and/or Shell are active in all 66 cities, each offering a maximum of five stations. One or two of either Esso, Total, or Jet are active in each city. The Non-Oligopolists (NO) play a crucial role in these markets because they make up one-half to three quarters of all existing stations. In sum, more than 900 stations are included in the data. Roughly one sixth belongs to Aral or Shell, and more than one half are others brands outside the oligopoly. The Appendix shows two maps with the locations of gasoline stations and included cities (see Figures A1 and A2). Analyzing the location of the included cities, most cities are probably not interconnected, but competitive relations between cities are possible in North Ruhr and Lower Rhine.

Table 2 gives a descriptive overview for all explanatory variables. We have roughly one-half of a million observations for both blends. The average diesel price is 15 ct. lower than E10. In the early evening (6 pm) diesel had been sold for 131 to 133 ct. on average, Non-Oligopolists have charged the lowest, Aral/Shell the highest prices. E10 prices are located on average between 146 to 148 ct. Wholesale prices are roughly 5-6 ct. below retail prices of N0. Weekday price data are given in roughly equal shares. 27/28 % of reported prices have been introduced during weekends/holidays; school holidays are relevant for a little bit more than ten percent of observations. 12 % of all prices have been charged by East German gasoline stations.

Table 2: Number of Observations within 66 Regions

	Diesel					E10				
	N	Mean	SD	Min	Max	N	Mean	SD	Min	Max
Price	550421	137.02	4.52	122.90	169.90	528104	152.06	4.56	128.90	167.90
Aral 6.00 pm	538675	133.82	2.27	126.90	148.90	517912	148.95	2.59	141.90	163.90
Shell 6.00 pm	508864	133.88	2.16	127.90	147.90	483859	148.68	2.56	141.90	161.90
Esso 6.00 pm	365818	132.28	2.47	126.90	148.90	352407	147.45	2.78	139.90	160.90
Total 6.00 pm	282211	132.31	2.36	127.40	144.90	269094	147.64	2.71	140.90	160.90
Jet 6.00 pm	336249	131.55	2.23	126.90	141.90	321294	146.81	2.55	139.90	156.90
NO 6.00 pm	550421	131.83	2.23	126.70	144.43	528104	147.01	2.55	140.15	160.18
Wholesale price	550421	126.14	1.10	123.52	129.29	528104	141.90	1.95	135.90	145.66
Rate of change of wholesale price	550421	0.00	0.04	-1.41	1.13	528104	0.00	0.04	-1.00	1.36
Monday	550421	0.14		0	1	528104	0.14		0	1
Tuesday	550421	0.16		0	1	528104	0.16		0	1
Wednesday	550421	0.15		0	1	528104	0.15		0	1
Thursday	550421	0.15		0	1	528104	0.15		0	1
Friday	550421	0.15		0	1	528104	0.15		0	1
Saturday	550421	0.13		0	1	528104	0.13		0	1
Sunday	550421	0.11		0	1	528104	0.11		0	1
Weekend/Holiday	550421	0.27		0	1	528104	0.28		0	1
School holidays	550421	0.11		0	1	528104	0.11		0	1
East Germany	550421	0.12		0	1	528104	0.12		0	1

Own calculations with Stata 13.1.

Table 3 represents the price increases in our data set. More than 100,000 upward price movements occurred in the evening hours prior to midnight, and include more than four fifths of all price increases. Seven, respectively eight percent of all upward price movements have been made from midnight until 6 am, and from 6 am until noon. Price increases in the afternoon are rare events (two percent for both blends). In all, upward price movements mostly appeared in the evening hours.

Table 3: Upward Price Movements - Number of Price Increases in 66 Regions

Time	Diesel	E10
Absolute		
00-06	9890	8251
06-12	9748	8737
12-18	2936	2693
18-24	105982	103119
Sum	128556	122800
Percentage		
00-06	8%	7%
06-12	8%	7%
12-18	2%	2%
18-24	82%	84%
Sum	100%	100%

Own calculations with Stata 13.1.

3 Methods

The methodological approach of our paper is explained by the hypothetical example show in Table 4. Our local market is constituted with three Aral stations, three Shell stations, and two independent stations. All stations began with the same starting price (1.28 €). We assume the market dominant price restorations were given if more than 50 percent of all Aral stations increased their prices simultaneous. Hence, the economic relevant price restoration starts at 6:10 p.m. with 5.3 ct. Until midnight, Aral charges 10.3 ct. higher prices than other stations. Shell reacts at 7 p.m. and increased prices until midnight by 13 ct. The first independent retailer reacted at 7:25 p.m. and moved up by 14 ct.

Each petrol station's incentive to follow the major company's price increases likely depends on the local competition playing field. In particular, the existence of other brands may determine price reactions. Table 5 shows how mid-sized German towns differ with price increases according their market structures. To exclude specific circumstances, we ignore combinations which occur less than five times. Hence, the number of analyzed cities reduces to 54 cities with diesel stations, and 53 cities with Premium E10. In the most frequent market structure (without Total), twelve local cities have stations from each oligopolists except for Total. This market structure contains 178 suppliers, with 37 Aral stations, 21 Shell and 21 Jet stations, 18 Esso stations and 81 Non-Oligopolists stations. The second most frequent market structure with all majors includes roughly 180 stations. Local markets without Jet and Total are found in eight cities. Vehicle drivers in six cities are “missing” Jet or Total. A restricted supply side without Esso and Jet is found in five cities. Exclusions of Esso and Total exist in six cities concerning diesel supply and five without Weimar for Premium E10. Nearly 130 stations are no longer included compared to the complete data set if the analysis is restricted to typical relevant market structures. (The complete list of included markets/cities can be found in the Appendix in Table A1).

Table 4: An Example of Price Increases by Aral and the Reaction of Competitors.

Time	18					19					23					24					
	00	05	10	15	…	00	05	…	25	…	00	…	30	35	55	00	Start ↑	First Price +	Total Price +	Response Time	Total price+
Action																					
Aral 1	1.28	1.35	1.36	1.36	1.40	1.40	1.38		1.38	1.37	1.37		1.37	1.37	1.37	1.37					
Aral 2	1.28	1.28	1.36	1.36	1.40	1.40	1.40		1.40	1.41	1.38		1.38	1.38	1.38	1.38					
Aral 3	1.28	1.28	1.28	1.35	1.35	1.40	1.40		1.40	1.40	1.40		1.40	1.40	1.40	1.40					
Average	1.28	1.303	1.333	1.353	1.383	1.400	1.393		1.393	1.393	1.383		1.383	1.383	1.383	1.383	18:10	0.053	0.103		
Reactions																					
Shell 1	1.28	1.28	1.28	1.28	1.28	1.40	1.38		1.39	1.41	1.41		1.41	1.41	1.41	1.41					
Shell 2	1.28	1.28	1.28	1.28	1.28	1.28	1.40		1.38	1.39	1.41		1.41	1.41	1.41	1.41					
Average	1.28	1.28	1.28	1.28	1.28	1.34	1.39		1.385	1.40	1.41		1.41	1.41	1.41	1.41				19:00	0.13
Others 1	1.28	1.28	1.28	1.28	1.28	1.28	1.28		1.38	1.39	1.41		1.41	1.41	1.41	1.40					
Others 2	1.28	1.28	1.28	1.28	1.28	1.28	1.28		1.28	1.39	1.41		1.41	1.42	1.43	1.44					
Average	1.28	1.28	1.28	1.28	1.28	1.28	1.28		1.28	1.39	1.41		1.41	1.415	1.42	1.42				19:25	0.14

Table 5: Market Structure - Diesel/E10 (54/53 Regions)

Market Structure	Aral	Shell	Esso	Total	Jet	NO	Number of Petrol Stations	Regions
All majors	27/27	23/23	18/18	15/15	15/15	85/85	183/183	11/11
Without Jet	17/17	10/10	9/9	10/10	-	40/40	86/86	6/6
Without Total	37/37	21/21	18/18	-	21/21	81/81	178/178	12/12
Without Esso	14/14	12/12	-	10/10	9/9	44/44	89/89	6/6
Aral, Shell, Esso	16/16	21/21	12/12	-	-	61/61	110/110	8/8
Aral, Shell, Total	12/12	9/9	-	5/5	-	33/33	59/59	5/5
Aral, Shell, Jet	11/9	11/10	-	-	8/6	55/51	85/76	6/5
Sum	134/134	107/107	57/57	40/40	53/53	399/399	790/790	54/53

Own calculations with Stata 13.1.

In the following chapter, we start by describing the occurrence of market relevant price restorations initiated by one of the five oligopolists, depending of our defined different market structures. Further on, we measure the average characteristics of price starts in the different market structures done by Aral or Shell, followed by a description of the average responses of the other oligopolists and NO. Multivariate OLS-estimations try to explain the magnitude of upward price movements of starters with market relevant price restorations by explaining variables like market structure, 6 pm price level of starters, diesel/E10, wholesale prices, weekend/holidays, weekday and East/Western Germany.

4 Descriptive Results

Upward price movements are shown in Tables 6 and 7, as market relevant price restorations. Starting with time spans after 6 p.m., Aral and Shell are overwhelmingly responsible toward upward price rounds.

Table 6: Number of Rounds of Absolute Price Increases - Diesel/E10 (54/53 Regions)

Market Structure	Aral	Shell	Esso	Total	Jet	Diesel/E10	Sum
All majors	567/571	539/534	24/25	49/49	-	1179/1179	2358
Without Jet	294/322	394/388	22/8	11/3	-	721/721	1442
Without Total	686/692	837/834	22/20	-	2/1	1547/1547	3094
Without Esso	368/366	390/389	-	5/8	1/1	764/764	1528
Aral, Shell, Esso	460/464	489/488	13/12	-	-	962/964	1926
Aral, Shell, Total	277/278	320/319	-	6/6	-	603/603	1206
Aral, Shell, Jet	257/200	332/269	-	-	3/2	592/471	1063
Sum	2909/2893	3301/3221	81/65	71/66	6/4	6368/6249	12617

Own calculations with Stata 13.1.

Concentrating on cities with all major brands the dominant majors, Aral and Shell, started price increases in roughly 570 and 540 cases, respectively. Nearly 25 and 50 price increase rounds began by Esso and Total, and Jet has never started a round of price increases. In all, half of all collective price increases start with one of the five majors. Regarding all other market structures, Jet almost never started a price round, and Esso and Total are very seldom responsible. Table 7 concentrates on price rounds started by majors in percent. Shell is the leading actor in more than 50 percent of cases. Aral leads in slightly less than half of all cases. The three others, Esso, Total, and Jet, almost never start

price increase rounds, and if they do, it is a rare event. Hence, upward price movements are mostly connected with Aral and Shell.

Table 7: Number of Rounds of Price Increases in Percentage - Diesel/E10 (54/53 Regions)

Market structure	Aral	Shell	Esso	Total	Jet	Sum
All majors	48%/48%	46%/45%	2%/2%	4%/4%	-	100%/100%
Without Jet	41%/45%	55%/54%	3%/1%	2%/0%	-	100%/100%
Without Total	44%/45%	54%/54%	1%/1%	-	0%/0%	100%/100%
Without Esso	48%/48%	51%/51%	-	1%/1%	0%/0%	100%/100%
Aral, Shell, Esso	48%/48%	51%/51%	1%/1%	-	-	100%/100%
Aral, Shell, Total	46%/46%	53%/53%	-	1%/1%	-	100%/100%
Aral, Shell, Jet	43%/42%	56%/57%	-	-	1%/0%	100%/100%

Own calculations with Stata 13.1.

Tables 8 and 9 describe price rounds started by Aral or Shell, and the reactions of other major companies, and of Non-Oligopolists, separated for the seven market structures. The data reports who starts a price increase, the average starting time of relevant price restorations, the average magnitude of the first price increase, and the average total price increase until midnight. Additionally, we calculated the average number of participating stations of respective brands. The reactions of the other major companies, and of Non-Oligopolists, can be described by the average price change until midnight, by the average time span for reaction, and by the average number of reacting stations inside respective brands.

For example, Aral started with the market relevant price restorations for diesel. Table 8 shows that Aral increase prices on average between 6:35 p.m. and 6:45 p.m. They began starting upward price movements in the range between 8.02 ct. (without Esso) and 10.57 ct. (without Jet). Aral is on average not able to hold constant prices until midnight. Their final upward price movements end between 6.42 ct. in the market structure, which includes all majors except Esso, and 8.67 ct. in market structure including Aral, Shell, and Esso. Until midnight, price changes are on average completed by Aral stations at the lowest 1.25 times, as seen in market structure “Aral, Shell, Jet”, and 1.53 times in cities without Jet. Shell stations respond on average within 24 minutes in cities with Aral, Shell, and Total. In cities with local markets excluding Jet, it takes 38 minutes to make price mark-ups between 10 and 11 ct. on average. Roughly, all Shell stations are changing prices once per evening. Cities in which diesel is also supplied by Esso see price reactions at roughly 8.7 ct. within five quarter hours and 110 minutes. On average, Esso stations change between 1.3 times (without Total) and 1.5 times (without Jet) per evening. Total's prices go up by about 10 ct. until midnight if Aral creates price upward movements. Total waits roughly one and a half hours to change prices, and averages one price change per evening. Jet typically reacts very late (between two and a half and three hours) with a 6.5 ct. price increase until midnight. All Non-Oligopolists go up between 6.6 and 10.1 ct., dependent on different market structures. Reaction times are between one hour and 25 minutes and two hours and 12 minutes. Table 8 shows that the number of observations differ between 257 price increase rounds in market structure with Aral, Shell, and Jet, and 686 price restorations in cities without Total.

Table 8: Upward Price Rounds/Starter Aral/Diesel

		Market Structure						
	Action	All majors	Without Jet	Without Total	Without Esso	Aral, Shell, Esso	Aral, Shell, Total	Aral, Shell, Jet
Aral	start ↑	18:44:19	18:37:47	18:39:15	18:35:15	18:39:54	18:39:50	18:35:06
	first +	9.43	10.57	8.96	8.02	10.01	10.38	8.96
	total +	7.91	7.52	7.73	6.42	8.67	8.38	7.42
	number +	1.29	1.53	1.28	1.37	1.25	1.37	1.30
	Response							
Shell	total +	10.06	11.85	10.36	10.05	10.47	10.12	11.16
	response time	00:25:33	00:38:25	00:33:34	00:28:07	00:32:34	00:24:40	00:25:55
	number +	1.01	0.93	1.00	0.95	1.01	1.02	0.96
Esso	total +	8.77	8.80	8.89		8.64		
	response time	01:26:28	01:14:27	01:50:37		01:25:48		
	number +	1.42	1.52	1.29		1.33		
Total	total +	10.02	10.31		10.21		9.87	
	response time	01:23:52	01:37:35		01:37:59		01:32:27	
	number +	1.03	1.00		1.00		1.01	
Jet	total +	6.61		6.62	6.58			6.48
	response time	02:38:29		02:52:32	03:00:51			02:56:17
	number +	0.97		0.98	1.01			1.00
NO	total +	8.18	10.13	7.55	8.01	8.50	6.62	8.31
	response time	02:12:57	01:59:28	01:42:10	01:41:21	01:26:30	02:03:43	01:25:48
	number +	0.81	0.73	0.84	0.77	0.78	0.97	0.97
	Observations	567	294	686	368	460	277	257

Own calculations with Stata 13.1.

Table A2 refers to dominant price upward movements completed by Aral for premium E10. Aral roughly starts with 8 to 9 ct., but mark-ups must be reduced between one and two cents until midnight. Shell responds with a greater increase of between 9-10 ct. and waits approximately 30 minutes before making the change. Esso's typical reaction is an increase of 9 ct. after one and a half hours; the same can be said for Total. Jet goes up by a little bit more than 6 ct. within two and a half to three hours. The Non-Oligopolists mostly charge 1 or 2 ct. more than Jet within shorter time spans.

Tables 9 and A3 clearly show that Shell starts very early if it plays the starting role in the price rounds, independent of whether diesel or E10 is regarded. Shell mostly charges initial price mark-ups by 10 ct. or 11 ct., and does not substantially reduce prices until midnight. Aral reacts very quickly (at a maximum of one-quarter hour) and has price mark-ups of roughly 7.5 ct. Esso, Total and the Non-Oligopolists react and increase prices by 8 to 9 ct. within one to two hours. Jet increases prices later (after three hours) and weaker (by 6 ct.).

Table 9: Upward Price Rounds/Starter Shell/Diesel

		Market Structure						
	Action	All majors	Without Jet	Without Total	Without Esso	Aral, Shell, Esso	Aral, Shell, Total	Aral, Shell, Jet
Shell	start ↑	18:06:26	18:10:12	18:11:37	18:07:18	18:05:47	18:08:09	18:07:23
	first +	10.63	11.41	9.94	10.50	9.93	10.52	10.89
	total +	10.35	10.87	9.55	10.30	9.36	9.63	10.61
	number +	1.06	1.10	1.08	1.06	1.09	1.12	1.07
	Response							
Aral	total +	7.46	7.38	6.97	6.87	7.93	8.50	7.24
	response time	00:08:48	00:07:47	00:10:16	00:10:34	00:12:16	00:08:00	00:14:43
	number +	1.27	1.39	1.19	1.39	1.25	1.25	1.40
Esso	total +	9.01	8.96	9.05		8.68		
	response time	01:46:46	00:58:47	01:56:00		01:30:59		
	number +	1.37	1.48	1.25		1.24		
Total	total +	9.78	10.28		9.96		9.81	
	response time	01:32:34	01:29:56		01:31:49		01:30:18	
	number +	1.00	1.01		1.00		1.01	
Jet	total +	6.19		5.98	6.10			6.10
	response time	02:56:08		02:53:35	02:58:43			02:59:18
	number +	1.11		1.09	1.11			1.13
NO	total +	8.77	11.09	7.72	8.22	7.93	6.43	8.09
	response time	02:01:59	01:43:50	01:32:59	01:44:20	01:17:41	01:56:27	01:24:03
	number +	0.79	0.73	0.85	0.78	0.78	0.87	1.12
	Observations	539	394	837	390	489	320	332

Own calculations with Stata 13.1.

5 Multivariate Results

Along with bivariate descriptive analysis, OLS regressions show the correlation between higher prices starting in the evenings with Aral until midnight, and the reactions of Shell, Jet, and independent stations during the same time span. Tables 10 to 13 and A7/A8 present multivariate estimations on how Shell, Jet, and the Non-Oligopolists react on Aral price increases. Respectively, the tables show how Aral, Jet, or the Non-Oligopolists follow price increase rounds created by Shell. Tables A4 and A5 show descriptive statistics for the data set used for multivariate estimations.

If Aral started with a dominant price restoration, we are able to analyze how the other dominant major, Shell, as main "inside competitor" reacts (see Table 10), when we control for other possible influencing factors. Model 1 shows that Shell will respond to Aral's price mark up of one cent by an increase of 0.26 ct., which is significant and has a low error probability of less than 1/1000.

Table 10: Shell's Reactions to Aral's Price Increases[1]

	Shell (1)	Shell (2)	Shell (3)	Shell (4)	Shell (5)
Aral's total price ↑	0.256***	0.137***	0.0700***	0.0711***	0.0644**
	(0.0200)	(0.0194)	(0.0198)	(0.0199)	(0.0204)
Without Jet[2]	1.658***	1.363***	1.357***	1.382***	1.447***
	(0.189)	(0.177)	(0.174)	(0.172)	(0.175)
Without Total[2]	0.429**	0.638***	0.813***	0.821***	0.774***
	(0.160)	(0.152)	(0.153)	(0.152)	(0.154)
Without Esso[2]	0.242	0.501**	0.692***	0.627***	0.632***
	(0.171)	(0.158)	(0.156)	(0.154)	(0.153)
Aral, Shell, Esso[2]	0.290	0.673***	1.169***	1.129***	1.088***
	(0.165)	(0.160)	(0.164)	(0.163)	(0.164)
Aral, Shell, Total[2]	-0.208	0.0797	0.0459	-0.00584	0.0281
	(0.206)	(0.200)	(0.196)	(0.194)	(0.193)
Aral, Shell, Jet[2]	1.051***	1.244***	1.520***	1.492***	1.473***
	(0.211)	(0.195)	(0.188)	(0.185)	(0.185)
Price Shell 6.00 pm		-0.473***	-0.701***	-0.666***	-0.662***
		(0.0202)	(0.0258)	(0.0259)	(0.0265)
E10		6.143***	1.564***	0.796*	0.638
		(0.280)	(0.387)	(0.401)	(0.413)
Wholesale price			0.519***	0.536***	0.542***
			(0.0374)	(0.0380)	(0.0394)
Rate of change of wholesale price			0.293*	0.243	0.359*
			(0.134)	(0.135)	(0.144)
School holidays				-1.808***	-1.749***
				(0.247)	(0.263)
Weekend/Holiday				-0.446***	
				(0.103)	
Tuesday					0.00964
					(0.166)
Wednesday					-0.322
					(0.176)
Thursday					-0.592***
					(0.175)
Friday					-0.431*
					(0.190)
Saturday					-0.252
					(0.176)
Sunday					-0.985***
					(0.186)
East Germany					-0.239
					(0.136)
Constant	7.821***	71.96***	37.47***	30.71***	29.78***
	(0.185)	(2.710)	(3.520)	(3.633)	(3.734)
Observations	5425	5425	5425	5425	5425
Adjusted R^2	0.052	0.150	0.183	0.193	0.197
F	43.29	102.0	118.0	105.4	75.12

[1]Dependent variable: Shell's total price increasing from 6 pm to midnight. [2]Compared to all majors. Standard errors in parentheses. * p < 0.05, ** p < 0.01, *** p < 0.001; Own calculations with Stata 13.1.

Compared to market structures with all major companies, Shell charges 1.7 ct. higher prices if Jet is not active in these cities. Local markets without Total seem to have 0.4 ct. higher price increase by

Shell compared to “full” markets. If Esso and Jet are not part of the local markets, Shell's upward movements are higher by one cent compared to a “complete” market. All market structure effects are highly or most highly significant. Including the evening start prices of Shell and controlling for different petrol blends (Model 2), Shell reacts by 0.14 ct. on a 1 ct. price mark up by Aral. Additionally, market structures without Esso or Jet/Total are correlated with significant price increasing's of 0.5 or 0.7 ct. by Shell compared to a “full” market. If Shell charges a 1 ct. higher evening price (after 6 p.m.) compared to another day, Shell's price mark is 0.48 ct. lower. Customers who are buying premium E10 are typically confronted with 6 ct. price increases, holding all other factors constant. Controlling for wholesale prices (Model 3), Shell reaction is highly significant with an increase of 0.07 ct. if Aral increased prices by 1 ct. Shell significantly charges higher prices (+0.5 to +1.4 ct.) in “non-complete” compared to “complete” market structures. But Shell does not have clear price changes in cities in which Aral, Shell, and Total are alone as majors. 1 ct. higher starting 6 p.m. prices create 0.7 ct. lower upward price movements by Shell. Shell's price mark-ups are only 1.6 ct. higher if premium E10 sells compared to diesel. If the wholesale price is higher by 1 ct., Shell will increase prices by 0.5 ct. Shell will respond to one percent higher wholesale prices compared to the day by increasing by 0.3 ct. Including dummy variables for school holidays and weekend/holidays (model 4) significantly diminishes Shell's price mark-up by -1.8 ct., and 0.4 ct. respectively. Comparing Mondays Thursdays, Fridays, and Sundays, Shell moves up slower, in detail between -0.4 ct. and -1 ct., but the significances are different as seen in model 5. All highly significant models are based on 5,425 observations, and total explanatory power increases from 5% to 19.7%.

Jet's reactions to dominant price restorations started by Aral are found in Table 11. Model 1 shows that Jet reacts with +0.2 ct. until midnight if the starter Aral has changed by 1 ct. during the evening until midnight. Market structure variables are not significant. Adding Jet's starting price and petrol blend to the estimation, as seen in model 2, Jet's reaction becomes significantly smaller (0.1 ct.), higher in markets without Total (+0.3 ct.), and without Esso (+ 0.3 ct.). It lowers prices by 0.4 ct. per 1 ct. higher than the Jet 6 p.m. prices, and is stronger with 6.1 ct. for premium E10. 1 ct. Higher wholesale prices can explain +0.5 ct. of Jet's reaction, but contra-intuitively, a 1 percent increase of wholesale prices compared to the day before diminishes Jet's reaction by 0.4 ct. (see model 3). Model 4 shows that weekend/holidays have a price-cutting effect of -0.14 ct. Controlling for weekdays instead of weekend/holidays shows that on Thursdays, Saturdays and Sundays, Jet's price mark-ups lowered by 0.2 to 0.3 ct. (as seen in model 5). Additionally, Jet increases prices less than 1.3 ct. in East Germany compared to West Germany. All five estimated models are highly significant, but only 3,469 observations are included. The first model can only explain 10 percent of the variance, but explanation power increases to more than 50 percent in the last specification. Including more and more explanatory variables, models 2 and 4 show that the magnitude of Jet's price mark-ups decrease from 0.09 to 0.03 ct. if Aral starts the price increase by 1 ct. Hence, Jet's upward movements seem not to be a result of Aral's increase if other price factors are controlled for.

Table 11: Jet's Reactions to Aral's Price Increases[1]

	Jet (1)	Jet (2)	Jet (3)	Jet (4)	Jet (5)
Aral's total price ↑	0.216***	0.0972***	0.0304**	0.0311***	-0.00174
	(0.0122)	(0.00966)	(0.00926)	(0.00927)	(0.0100)
Without Total[2]	0.0812	0.250***	0.410***	0.410***	0.156**
	(0.0811)	(0.0692)	(0.0637)	(0.0636)	(0.0505)
Without Esso[2]	0.192*	0.342***	0.484***	0.481***	0.528***
	(0.0876)	(0.0731)	(0.0645)	(0.0649)	(0.0633)
Aral, Shell, Jet[2]	-0.175	0.137	0.454***	0.453***	0.361***
	(0.103)	(0.0858)	(0.0777)	(0.0777)	(0.0725)
Price Jet 6.00 pm		-0.414***	-0.623***	-0.619***	-0.636***
		(0.0116)	(0.0131)	(0.0134)	(0.0132)
E10		6.142***	1.483***	1.396***	0.531**
		(0.172)	(0.200)	(0.210)	(0.202)
Wholesale price			0.515***	0.518***	0.589***
			(0.0178)	(0.0181)	(0.0181)
Rate of change of			-0.437***	-0.433***	-0.433***
wholesale price			(0.0721)	(0.0728)	(0.0702)
School holidays				-0.102	-0.244*
				(0.0902)	(0.0962)
Weekend/Holiday				-0.143**	
				(0.0526)	
Tuesday					-0.0651
					(0.0860)
Wednesday					-0.0417
					(0.0888)
Thursday					-0.370***
					(0.0895)
Friday					-0.104
					(0.0899)
Saturday					-0.244**
					(0.0923)
Sunday					-0.232**
					(0.0868)
East Germany					-1.267***
					(0.108)
Constant	5.026***	60.13***	23.03***	22.31***	16.18***
	(0.114)	(1.538)	(1.764)	(1.853)	(1.760)
Observations	3469	3469	3469	3469	3469
Adjusted R^2	0.090	0.370	0.498	0.499	0.542
F	88.36	288.0	361.9	301.7	217.4

[1]Dependent variable: Jet's total price increasing from 6 pm to midnight Standard errors in parentheses. [2]Compared to all majors. * p < 0.05, ** p < 0.01, *** p < 0.001. Own calculations with Stata 13.1.

The Non-Oligopolists' reactions to Aral-initiated price rounds are mostly comparable to Jet's reactions (see Table 12). The simplest estimation (Model 1) indicates that Non-Oligopolists go up by 0.2 ct. if Aral charges 1 ct. higher prices until midnight. The Non-Oligopolists charge 1.8 ct. more until midnight in local markets without Jet compared to "full" markets. Cities without Total and without Jet and Esso are characterized by lower mark-ups of 0.5 ct., and 1.7 ct. respectively, compared to "full" markets. Model 2 shows that the Non-Oligopolists increase prices only by 0.09 ct. if Aral has increased their price by 1 ct.

Table 12: Reactions of Non-Oligopolists (NO) to Aral's Price Increases[1]

	NO (1)	NO (2)	NO (3)	NO (4)	NO (5)
Aral's total price ↑	0.201***	0.0893***	0.0168	0.0163	0.00231
	(0.0124)	(0.0117)	(0.0117)	(0.0117)	(0.0120)
Without Jet[2]	1.843***	1.433***	1.322***	1.337***	1.426***
	(0.112)	(0.106)	(0.102)	(0.101)	(0.0976)
Without Total[2]	-0.454***	-0.274**	-0.0948	-0.0873	-0.183
	(0.106)	(0.0992)	(0.0985)	(0.0980)	(0.102)
Without Esso[2]	0.109	0.135	0.217*	0.195*	0.211*
	(0.114)	(0.104)	(0.0998)	(0.0991)	(0.0966)
Aral, Shell, Esso[2]	0.156	0.511***	1.016***	1.006***	0.935***
	(0.124)	(0.113)	(0.110)	(0.109)	(0.112)
Aral, Shell, Total[2]	-1.706***	-1.407***	-1.400***	-1.425***	-1.360***
	(0.125)	(0.121)	(0.116)	(0.115)	(0.115)
Aral, Shell, Jet[2]	0.274	0.477***	0.772***	0.764***	0.728***
	(0.152)	(0.139)	(0.134)	(0.133)	(0.133)
Price NO 6.00 pm		-0.356***	-0.566***	-0.556***	-0.565***
		(0.0117)	(0.0137)	(0.0138)	(0.0139)
E10		4.735***	0.244	-0.144	-0.431
		(0.173)	(0.240)	(0.243)	(0.253)
Wholesale price			0.501***	0.517***	0.544***
			(0.0201)	(0.0202)	(0.0209)
Rate of change of wholesale price			-0.190*	-0.216*	-0.248**
			(0.0870)	(0.0878)	(0.0887)
School holidays				-0.859***	-0.922***
				(0.144)	(0.150)
Weekend/Holiday				-0.235***	
				(0.0582)	
Tuesday					-0.0213
					(0.111)
Wednesday					-0.0176
					(0.112)
Thursday					-0.0860
					(0.118)
Friday					0.0882
					(0.111)
Saturday					-0.241*
					(0.111)
Sunday					-0.205
					(0.109)
East Germany					-0.483***
					(0.0672)
Constant	6.436***	54.27***	19.30***	16.05***	14.07***
	(0.128)	(1.572)	(2.063)	(2.079)	(2.138)
Observations	5425	5425	5425	5425	5425
Adjusted R^2	0.156	0.276	0.346	0.351	0.354
F	218.1	323.4	395.6	341.9	239.0

[1]Dependent variable: NO's total price increasing from 6 pm to midnight. [2]Compared to all majors. Standard errors in parentheses. * p < 0.05, ** p < 0.01, *** p < 0.001. Own calculations with Stata 13.1.

In three market structures (without Jet, Aral/Shell/Esso, and Aral/Shell/Jet) price increases of Non-Oligopolists are significantly higher than in full markets, in two markets (without Total, and

Aral/Shell/Total) price changes are lower. Non-Oligopolists (NO) charge lower prices (-0.4 ct.) if the Non-Oligopolists have 1 ct. higher prices at 6 p.m. compared to another day. In the evening, the Non-Oligopolists go up with the E10-prices by 4.7 ct. compared to diesel. Models 3 through 5 can be ignored for our question because the reactions of the Non-Oligopolists are not significant. The highly significant models 1 and 2 are based on 5,425 observations and explain between 15 and 28 percent of variances.

Tables 13, A6 and A7 try to describe the reactions on price rounds that Shell starts. Following the first model in Table 13, Shell significantly reacts with 0.23 ct. if Aral charges 1 ct. more until midnight. If cities are “free” from Jet, Total, or Esso; Non-Oligopolists' upward price movements are lower (-0.2/-0.2/-0.5 ct.). If Aral, Shell and Jet are alone, they are taking an additional price surcharge of 1.1 ct. Model 2 additionally controls for the evening price of Aral and petrol blends. Aral prices that are 1 ct. higher at 6 p.m. diminish Aral's race to the top (-0.4 ct.) at the highest significant level. Customers who fill up with E10 must expect an additional price mark-up by 7 ct. Higher wholesale prices “create” an additional surcharge (0.5 ct.) and a positive change rate of wholesale prices diminish the retail price mark ups counterintuitively (model 3). Adding school holidays/weekend or holiday and weekdays make for the same correlations as in previous Tables (models 4 and 5). It is not surprising that including additional covariates diminishes the explaining power of Shell's price-upward movements from 0.23 to 0.17 ct. Models 1-5 are highly significant and explain between 12.2 to 29.9 percent of variances based on 6,442 observations.

Table A6 shows that Jet's price-increasing behavior cannot be explained by Shell's price mark-ups. Only 4,071 observations are included. The Non-Oligopolists react more or less in the same manner to Shell's price rounds compared to price rounds initiated by Aral (see Table A7).

By summarizing the best multivariate estimation results, we are able to see different aspects as shown in Table 14. The other dominant major companies react positively to price rounds initiated by other dominate players. If Shell goes up by 1 ct., Aral increases prices by 0.17 ct. If Aral goes up by 1 ct., Shell's response will be weaker with +0.06 ct. Jet does not follow the price increases of either of the dominant major companies, Aral or Shell (0.03 ct.). The Non-Oligopolists react more to Shell's price rounds compared to Aral's (0.25 ct. > 0.09 ct.). Jet's and the Non-Oligopolists' reactions are more certain when compared to the reaction of other dominant companies. There are mostly no clear indications of influence on price adjustments in market structures other than in complete markets. If Aral, Shell, and Esso are the single oligopolists, we see price increase reactions between 0.5 and 1 ct. in three of four possible estimations. In other words, the non-relevance of Jet and Total as inside-competitors is correlated with slightly higher price rounds, independent of whether Aral or Shell has initiated upward price movements.

Table 13: Aral's Reactions to Shell's Price Increases[1]

	Aral (1)	Aral (2)	Aral (3)	Aral (4)	Aral (5)
Shell	0.230***	0.186***	0.169***	0.170***	0.168***
	(0.00890)	(0.00760)	(0.00744)	(0.00759)	(0.00755)
Without Jet[2]	-0.214*	-0.582***	-0.497***	-0.517***	-0.466***
	(0.0982)	(0.0902)	(0.0930)	(0.0917)	(0.0938)
Without Total[2]	-0.244*	-0.200*	-0.157	-0.144	-0.247**
	(0.0966)	(0.0913)	(0.0907)	(0.0897)	(0.0923)
Without Esso[2]	-0.507***	-0.532***	-0.348***	-0.344***	-0.269**
	(0.105)	(0.0961)	(0.0959)	(0.0949)	(0.0979)
Aral, Shell, Esso[2]	0.703***	0.924***	1.212***	1.221***	1.122***
	(0.112)	(0.100)	(0.0990)	(0.0983)	(0.1000)
Aral, Shell, Total[2]	1.130***	1.076***	0.866***	0.887***	0.977***
	(0.128)	(0.117)	(0.117)	(0.116)	(0.116)
Aral, Shell, Jet[2]	-0.196	-0.149	0.0182	0.0251	-0.0216
	(0.116)	(0.112)	(0.113)	(0.112)	(0.112)
Price Aral 6 p.m.		-0.445***	-0.575***	-0.594***	-0.575***
		(0.0134)	(0.0152)	(0.0153)	(0.0153)
E10		6.981***	0.724	1.389**	0.644
		(0.216)	(0.433)	(0.474)	(0.485)
Wholesale price			0.508***	0.485***	0.512***
			(0.0308)	(0.0324)	(0.0329)
Rate of change of wholesale price			-0.177	-0.122	-0.129
			(0.0904)	(0.0902)	(0.0925)
School holidays				-0.0865	-0.103
				(0.0613)	(0.0636)
Weekend/Holiday				0.623***	
				(0.0605)	
Tuesday					0.205*
					(0.0976)
Wednesday					-0.0295
					(0.100)
Thursday					-0.162
					(0.109)
Friday					0.164
					(0.0971)
Saturday					0.485***
					(0.0988)
Sunday					0.597***
					(0.105)
East Germany					-0.460***
					(0.0754)
Constant	5.037***	65.30***	18.60***	23.79***	18.00***
	(0.108)	(1.822)	(3.331)	(3.647)	(3.716)
Observations	6442	6442	6442	6442	6442
Adjusted R^2	0.122	0.254	0.288	0.299	0.299
F	119.4	225.3	224.8	200.8	141.5

[1]Dependent variable: Aral's total price increasing from 6 pm to midnight. [2]Compared to all majors. Standard errors in parentheses. * p < 0.05, ** p < 0.01, *** p < 0.001. Own calculations with Stata 13.1.

Table 14: Important Results

Reactions		Dominant Major Companies		Jet		Non-Oligopolist	
		Aral	Shell				
Actions							
Dominant Major Companies							
Aral	estimated coefficients[1]	-	0.06**	0.03***	-	0.09***	-
Shell		0.17**	-	-	0.03***	-	0.25***
Market Structures:							
Aral, Shell, Esso, Total		-0.47***	1.45***	-	-	1.43***	1.45***
Aral, Shell, Esso, Jet		-0.25**	0.77***	0.41***	n.s.	-0.27**	-0.63**
Aral, Shell, Total, Jet		-0.27**	0.63***	0.48***	n.s.	n.s.	-0.33**
Aral, Shell, Esso		1.12***	1.09***	-	-	0.51***	n.s.
Aral, Shell, Total		0.98***	n.s.	-	-	-1.41***	-1.96***
Aral, Shell, Jet		n.s.	1.47***	0.45	n.s.	0.48***	-0.33***
Model/Table		5/13	5/10	4/11	5/A6	2/12	5/A7

n.s.: Not Significant; - Not Possible. [1] * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

6 Conclusions

German gasoline prices show high price volatilities. More than 80 percent of upward price movements occur between 6 p.m. and midnight, which create market-wide upward price movements during that time span. Previous studies have shown that the two dominant majors, Aral and Shell, start price increases shortly after 6 p.m. If one dominant player increased prices, the others follow within a maximum of 30 minutes. Esso, Total and the Non-Oligopolists need no more than two hours to react. Jet roughly waits three hours. Jet also follows with lower price increases compared to the other competitors. These empirical facts are mainly derived from price data for big cities in Germany, and have been stable for several years.

It seems that little attention is given to the fact that all petrol stations in big cities do not belong to the same type of market. In particular, if the distance between stations is high then we expect no real competitive relationship. To analyze real competitive relations we focused on mid-sized cities between 60,000 and 100,000 inhabitants, which have no more than 20 gas stations. These 66 cities are characterized by different market structures because not all brands are active in all local markets. By building comparative markets, we excluded brand combinations which occur in less than five cities. Depending on whether diesel or E10 filing stations are active, the number of analyzed cities must be diminished to 53/54 cities. We completed a descriptive and multivariate analysis of dominant price rounds (price restorations), which means that at least 50 percent of all stations of one brand increase prices at the same time in one city.

As for the descriptive analysis for Hamburg, Cologne, Leipzig, and Munich, Shell's price restorations start roughly ten minutes after 6 p.m. with a 10 ct. price mark-up, which is not reduced until midnight. Aral, Esso, and Total respond with roughly 3 ct. lower prices until midnight. Aral reacts very quickly (within 10 minutes), and Esso, Total, and the Non-Oligopolists wait for about two hours to respond. Jet's reaction is smaller by roughly 6 ct. and certainly lasts longer — roughly three hours. If Aral is responsible for price starts, Aral starts later (30 minutes after 6 p.m.), weaker (+9 ct.) and must give up 1-2 ct. until midnight. The reactions of the other brands are comparable to the way they respond to

Shell's price increases. Hence, it seems that Jet behaves less parallel compared to other oligopolists, and more aggressive compared to Non-Oligopolists.

Multivariate OLS-estimations shows that the strength of reaction is low. Aral goes only up 0.17 ct. if Shell charges 1 ct. more, if we control for other influential factors. Shell's reactions to Aral's changes are smaller (0.06 ct.). Jet does not economically react, independent of the starter (0.03 ct.). Non-Oligopolists significantly react with 0.25 ct. if Shell starts price increase and with 0.09 ct. when Aral starts the price increases. Hence, Jet's picture of price aggressive behavior is not different to the others.

Because our data set allows us to analyze different market structures, we are also able to check whether the presence of different brands can explain upward price movements. Most market structures give no clear indication of this aspect. But, if Total and Jet are not active, price rounds are 0.5 to 1 ct. higher compared to “complete” market structures. This result may be additional evidence that Jet's price decreasing function becomes clear if Jet is not a player in the local market.

Comparing our results with the metropolitan regions Cologne, Hamburg, Munich, and Leipzig it is evident that reaction time spans are comparable. But, price reactions are certainly lower and it is unclear why. A correct definition of markets seems to create the necessity of creating a tighter market definition. Our empirical results indicate that metropolitan regions are less competitive because of higher upward movements. Perhaps the existence of more stations in my neighborhood, which is certainly more relevant in metropolises, allows us to see more upward price movements. Hence, the collusive speed of price rounds will accelerate. To split up the time span from 6 p.m. to midnight perhaps can help for a better explanation of collusive upward gasoline price movements.

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Appendix

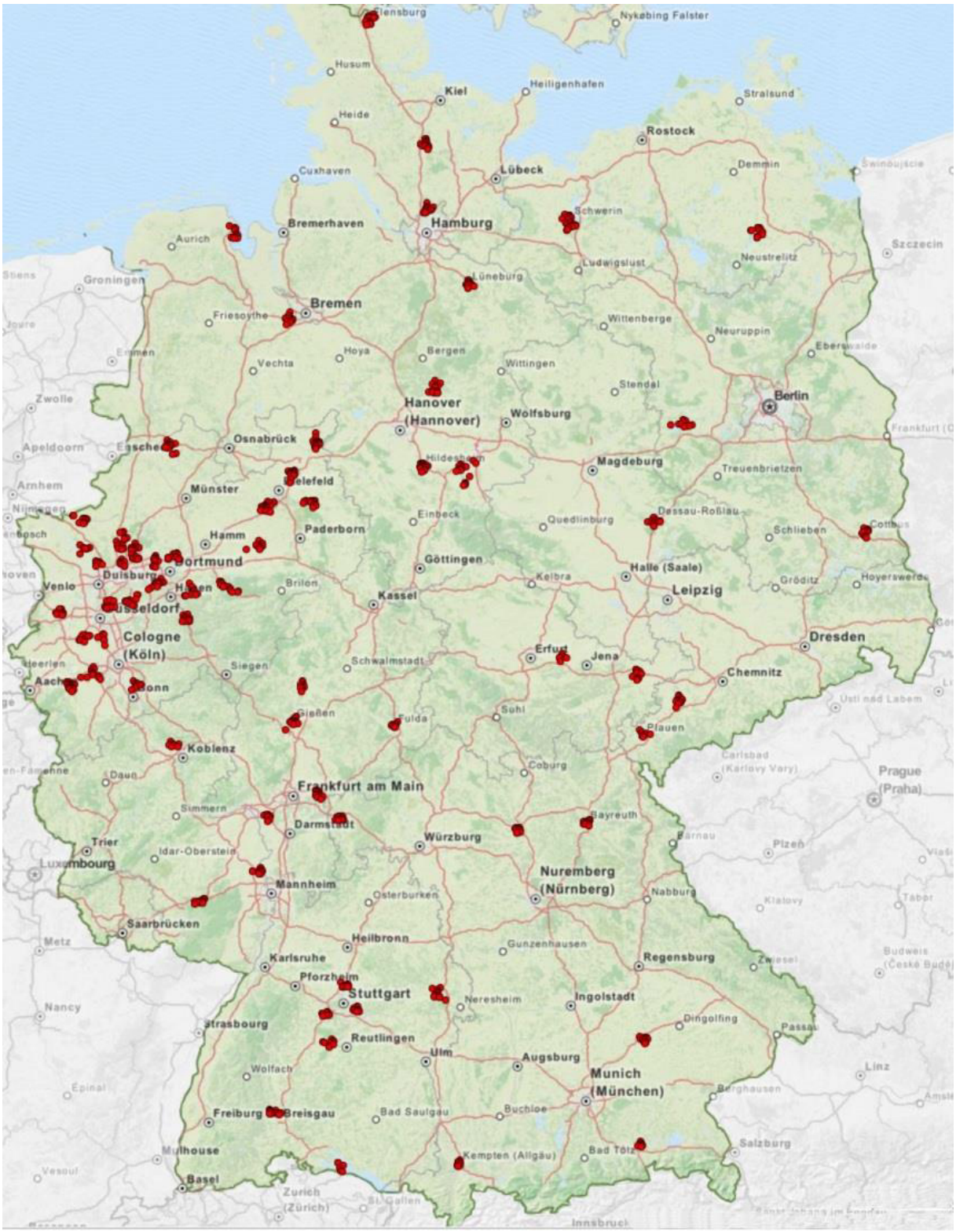

Figure A1: Map of Germany Showing Petrol Stations

Source: Map created at GPSVisualizer.com, OpenStreeMap data from MapQuest

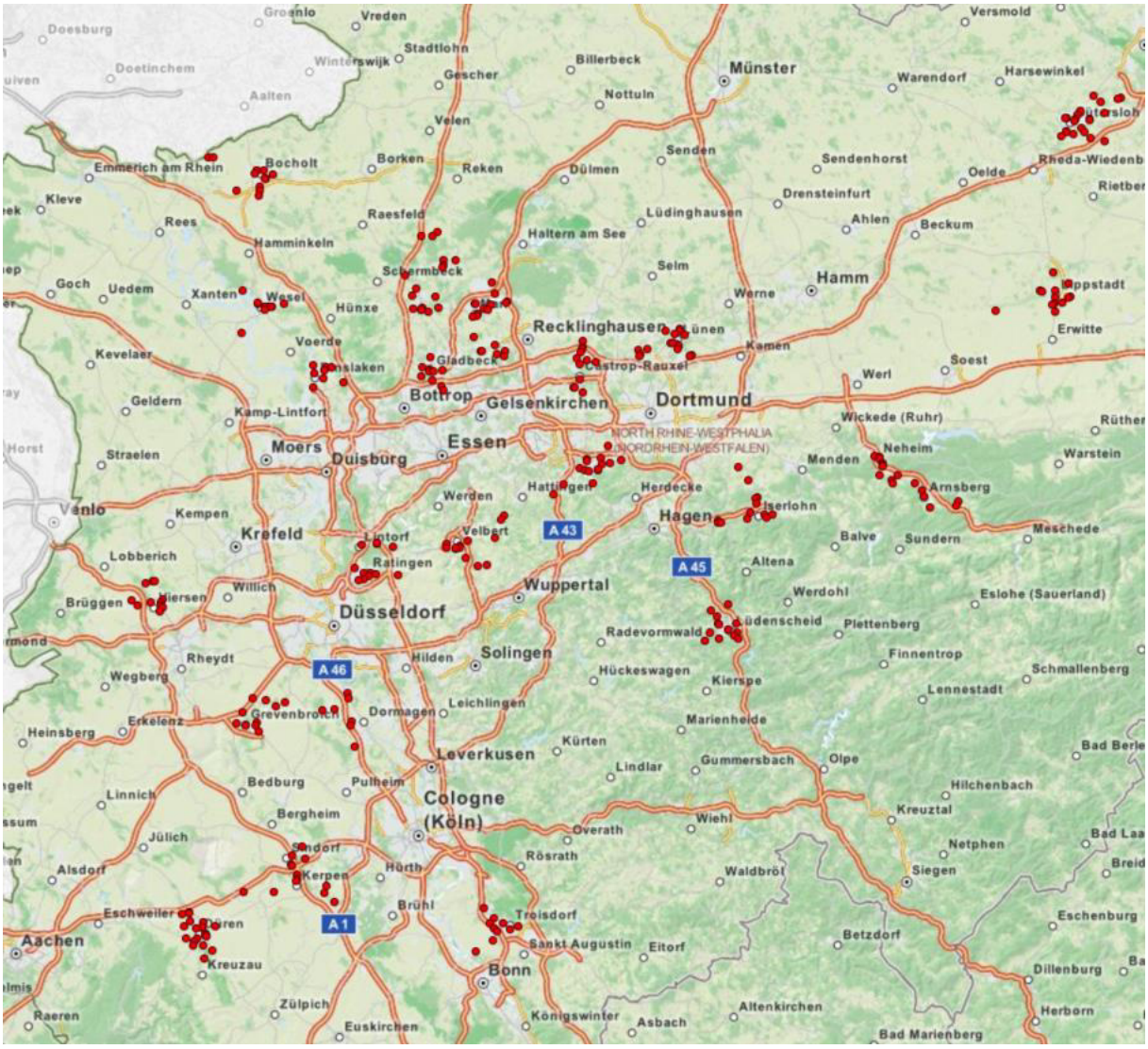

Figure A2: Map of the Ruhr Region Showing Petrol Stations

Source: Map created at GPSVisualizer.com, OpenStreeMap data from MapQuest

Table A1: Number of Petrol Stations - Diesel/E10 (54/53 Regions)

Cities/Brands	Market	Aral	Shell	Esso	Total	Jet	NO	Sum
Aalen	5/5	2/2	1/1	1/1	0/0	0/0	12/11	16/15
Arnsberg	6/6	3/3	1/1	0/0	1/1	0/0	11/11	16/16
Aschaffenburg	2/2	4/3	2/2	2/2	1/1	0/0	8/8	17/16
Bamberg	3/3	4/4	1/1	1/1	0/0	2/2	10/9	18/17
Bayreuth	3/3	1/1	2/2	3/3	0/0	2/2	13/12	21/20
Brandenburg a. d. H.	2/2	2/2	2/2	1/1	3/3	0/0	5/5	13/13
Castrop-Rauxel	4/4	1/1	1/1	0/0	1/1	2/2	7/5	12/10
Celle	3/3	4/4	3/3	1/1	0/0	2/2	7/7	17/17
Cottbus	1/1	2/2	2/2	1/1	2/2	1/1	3/3	11/11
Delmenhorst	4/4	2/2	2/2	0/0	2/2	2/2	8/7	16/15
Dessau	1/1	3/3	2/2	1/1	1/1	1/1	4/4	12/12
Detmold	7/7	1/1	2/2	0/0	0/0	1/1	12/11	16/15
Dormagen	5/5	1/1	2/2	1/1	0/0	0/0	3/2	7/6
Dorsten	5/5	1/1	3/3	1/1	0/0	0/0	11/10	16/15
Dueren	1/1	1/1	2/2	1/1	3/3	2/2	12/12	21/21
Fulda	3/3	2/2	1/1	1/1	0/0	2/2	3/3	9/9
Gera	6/6	3/3	2/2	0/0	1/1	0/0	6/6	12/12
Giessen	3/3	3/3	3/3	2/2	0/0	4/4	6/6	18/18
Gladbeck	2/2	2/2	1/1	1/1	1/1	0/0	5/4	10/9
Guetersloh	1/1	1/1	4/4	2/2	1/1	1/1	13/12	22/21
Hanau	1/1	2/2	3/3	1/1	2/2	1/1	9/8	18/17
Herford	1/1	3/3	1/1	3/3	1/1	1/1	8/8	17/17
Hildesheim*	1/1	4/4	2/2	2/2	1/1	2/2	10/8	21/19
Iserlohn	6/6	3/3	3/3	0/0	1/1	0/0	6/6	13/13
Kaiserslautern	1/1	4/4	3/3	2/2	1/1	2/2	6/6	18/18
Kempten	3/3	2/2	1/1	1/1	0/0	1/1	8/8	13/13
Landshut*	1/1	2/2	1/1	1/1	1/1	1/1	11/10	17/16
Ludwigsburg	1/1	3/3	1/1	2/2	1/1	2/2	3/3	12/12
Luedenscheid	1/1	2/2	2/2	2/2	1/1	1/1	6/3	14/11
Lueneburg	5/5	4/4	3/3	1/1	0/0	0/0	7/7	15/15
Luenen	3/3	4/4	2/2	1/1	0/0	1/1	8/8	16/16
Marburg	3/3	4/4	1/1	2/2	0/0	2/2	4/4	13/13
Marl	5/5	2/2	1/1	2/2	0/0	0/0	7/7	12/12
Minden*	7/7	1/1	3/3	0/0	0/0	1/1	14/14	19/19
Neubrandenburg	4/4	2/2	3/3	0/0	1/1	1/1	7/6	14/13
Neumuenster	4/4	2/2	2/2	0/0	3/3	2/2	11/10	20/19
Neuwied	6/6	1/1	2/2	0/0	1/1	0/0	5/5	9/9
Norderstedt	3/3	3/3	2/2	1/1	0/0	1/1	7/7	14/14
Plauen	6/6	2/2	1/1	0/0	1/1	0/0	5/4	9/8
Ratingen	2/2	2/2	2/2	2/2	1/1	0/0	5/5	12/12
Rheine*	7/7	1/1	1/1	0/0	0/0	2/2	12/12	16/16
Rosenheim*	3/3	1/1	2/2	1/1	0/0	1/1	4/4	9/9
Salzgitter	5/5	2/2	4/4	1/1	0/0	0/0	10/10	17/17
Schwerin	2/2	5/5	1/1	1/1	3/3	0/0	11/9	21/19
Sindelfingen	5/5	1/1	3/3	3/3	0/0	0/0	4/4	11/11
Velbert	2/2	2/2	2/2	2/2	1/1	0/0	6/6	13/13
Viersen	7/7	3/3	1/1	0/0	0/0	1/1	6/6	11/11
Villingen-Schwenningen	5/5	3/3	4/4	2/2	0/0	0/0	7/6	16/15
Weimar	7/0	2/2	1/0	0/0	0/0	2/2	4/4	9/8
Wesel	4/4	2/2	2/2	0/0	1/1	1/1	5/5	11/11
Wilhelmshaven	7/7	3/3	3/3	0/0	0/0	1/1	7/7	14/14
Witten	3/3	4/4	1/1	2/2	0/0	1/1	7/7	15/15
Worms	3/3	5/5	2/2	2/2	0/0	2/2	4/4	15/15
Zwickau	4/4	5/5	2/2	0/0	2/2	1/1	6/5	16/15
Sum		134/133	107/106	57/57	40/40	53/53	399/374	790/763

Because of brand changes, openings and closures the number of stations can vary during the period.

*Change of the market structure due to openings and closures. Own calculations with Stata 13.1.

Table A2: Upward Price Rounds/Starter Aral/Premium E 10

Market Structure[1]		1	2	3	4	5	6	7
	Action							
Aral	start ↑	18:44:21	18:34:56	18:39:23	18:35:25	18:39:39	18:39:16	18:36:22
	first +	8.81	9.28	8.48	7.31	9.24	8.91	8.23
	total +	7.37	6.80	7.28	5.90	8.06	7.33	6.91
	number +	1.30	1.47	1.28	1.38	1.24	1.37	1.28
	Response							
Shell	total +	9.54	10.85	9.99	9.30	10.03	9.09	10.02
	response time	00:25:44	00:43:38	00:33:19	00:28:08	00:32:22	00:24:24	00:25:44
	number +	1.00	0.95	0.98	0.95	1.00	1.01	0.95
Esso	total +	9.05	9.13	8.94		8.49		
	response time	01:26:01	01:13:13	01:50:48		01:25:32		
	number +	1.23	1.33	1.19		1.27		
Total	total +	9.34	9.08		9.14		8.64	
	response time	01:23:51	01:37:54		01:38:03		01:32:07	
	number +	1.02	1.07		1.00		1.02	
Jet	total +	6.78		6.81	6.52			6.34
	response time	02:38:27		02:53:45	02:59:26			02:54:26
	number +	0.98		0.99	1.01			1.00
NO	total +	7.83	9.28	7.37	7.54	7.95	6.01	7.88
	response time	02:13:17	02:02:45	01:44:14	01:42:08	01:27:23	02:04:15	01:08:41
	number +	0.96	0.76	0.84	0.88	0.80	0.98	0.95
	Observations	571	322	692	366	464	278	200

[1]Market Structure 1: All Majors; Structure 2: without Jet; Structure 3: without Total; Structure 4: without Esso; Structure 5: Aral, Shell, and Esso; Structure 6: Aral, Shell, and Total; Structure 7: Aral, Shell, and Jet. Own calculations with Stata 13.1.

Table A3: Upward Price Rounds/Starter Shell/Premium E 10

Market Structure[1]		1	2	3	4	5	6	7
	Action							
Shell	start ↑	18:06:12	18:08:59	18:11:27	18:07:07	18:05:31	18:08:10	18:07:55
	first +	10.36	11.04	9.77	10.22	9.57	10.00	10.31
	total +	10.11	10.59	9.44	10.00	9.09	9.16	10.08
	number +	1.05	1.09	1.07	1.06	1.09	1.12	1.05
	Response							
Aral	total +	7.35	7.24	7.02	6.78	7.82	8.17	7.24
	response time	00:08:46	00:07:45	00:09:04	00:10:32	00:12:04	00:08:01	00:16:27
	number +	1.27	1.41	1.18	1.37	1.25	1.25	1.38
Esso	total +	9.02	9.00	9.30		8.74		
	response time	01:46:38	00:58:50	01:55:42		01:30:48		
	number +	1.29	1.40	1.17		1.20		
Total	total +	9.43	9.84		9.50		9.09	
	response time	01:32:35	01:30:42		01:32:05		01:30:50	
	number +	1.00	1.00		1.00		1.01	
Jet	total +	6.24		6.10	6.01			6.19
	response time	02:56:11		02:54:10	02:59:20			02:59:46
	number +	1.11		1.09	1.11			1.12
NO	total +	8.52	10.33	7.53	7.92	7.65	6.04	8.06
	response time	02:02:51	02:01:52	01:33:41	01:45:09	01:18:46	01:56:54	01:07:58
	number +	0.81	0.73	0.86	0.90	0.79	0.91	0.98
	Observations	534	388	834	389	488	319	269

[1]Market Structure 1: All Majors; Structure 2: without Jet; Structure 3: without Total; Structure 4: without Esso; Structure 5: Aral, Shell, and Esso; Structure 6: Aral, Shell, and Total; Structure 7: Aral, Shell, and Jet. Own calculations with Stata 13.1.

Table A4: Descriptive Statistics for Aral's Price Increases

Variable	N	Mean	SD	Min	Max
Aral's initial price increase	5425	9.06	2.66	1	19
Aral's price increase until midnight	5425	7.48	2.76	0.50	19
Shell's price increase until midnight	5425	10.15	3.68	-4	18
Jet's price increase until midnight	3469	6.64	1.91	0	13
NO's price increase until midnight	5425	7.92	2.47	-0.20	16.82
All majors	5425	0.20		0	1
Without Jet	5425	0.11		0	1
Without Total	5425	0.24		0	1
Without Esso	5425	0.13		0	1
Aral, Shell, Esso	5425	0.16		0	1
Aral, Shell, Total	5425	0.10		0	1
Aral, Shell, Jet	5425	0.08		0	1
Aral 6.00 pm Diesel	2719	133.60	2.33	126.9	143.9
Shell 6.00 pm Diesel	2719	133.40	2.24	127.9	147.9
Jet 6.00 pm Diesel	1757	131.52	2.44	126.9	140.9
NO 6.00 pm Diesel	2719	131.77	2.43	126.76	143.4
Aral 6.00 pm E10	2706	147.97	2.63	141.9	159.9
Shell 6.00 pm E10	2706	147.51	2.72	141.9	161.9
Jet 6.00 pm E10	1712	145.99	2.70	139.9	156.9
NO 6.00 pm E10	2706	146.17	2.66	140.15	159.4
E10	5425	0.50		0	1
East Germany	5425	0.16		0	1
Weekend/Holiday	5425	0.32		0	1
School holidays	5425	0.04		0	1
Monday	5425	0.10		0	1
Tuesday	5425	0.15		0	1
Wednesday	5425	0.16		0	1
Thursday	5425	0.12		0	1
Friday	5425	0.16		0	1
Saturday	5425	0.14		0	1
Sunday	5425	0.17		0	1
Wholesale price Diesel	2719	125.92	1.11	123.52	129.00
Rate of change wholesale price Diesel	2719	-0.04	0.34	-1.22	1.09
Wholesale price E10	2706	140.87	2.07	135.90	145.30
Rate of change wholesale price E10	2706	-0.00	0.34	-1.00	1.36

Own calculations with Stata 13.1.

Table A5: Descriptive Statistics for Shell's Price Increases

Variable	N	Mean	SD	Min	Max
Shell's initial price increase	6442	10.27	3.12	1	18
Shell's price increase until midnight	6442	9.85	3.64	-1.5	18.33
Aral's price increase until midnight	6442	7.35	2.68	0	18
Jet's price increase until midnight	4071	6.10	1.90	0	12
NO's price increase until midnight	6442	8.14	2.54	0	15.5
All majors	6442	0.16		0	1
Without Jet	6442	0.12		0	1
Without Total	6442	0.26		0	1
Without Esso	6442	0.12		0	1
Aral, Shell, Esso	6442	0.15		0	1
Aral, Shell, Total	6442	0.10		0	1
Aral, Shell, Jet	6442	0.09		0	1
Aral 6.00 pm Diesel	3260	134.38	2.23	127.9	144.9
Shell 6.00 pm Diesel	3260	134.80	2.08	128.9	142.9
Jet 6.00 pm Diesel	2071	132.10	2.32	126.9	141.9
NO 6.00 pm Diesel	3260	132.39	2.35	127.23	142.02
Aral 6.00 pm E10	3182	150.12	2.27	142.9	159.9
Shell 6.00 pm E10	3182	150.12	1.93	141.9	158.4
Jet 6.00 pm E10	2000	147.90	2.29	140.9	156.9
NO 6.00 pm E10	3182	148.17	2.35	141.15	157.4
E10	6442	0.49		0	1
East Germany	6442	0.16		0	1
Weekend/Holiday	6442	0.34		0	1
School holidays	6442	0.19		0	1
Monday	6442	0.15		0	1
Tuesday	6442	0.15		0	1
Wednesday	6442	0.12		0	1
Thursday	6442	0.16		0	1
Friday	6442	0.14		0	1
Saturday	6442	0.15		0	1
Sunday	6442	0.13		0	1
Wholesale price Diesel	3260	126.60	1.00	123.52	129.09
Rate of change wholesale price Diesel	3260	-0.00	0.34	-1.41	1.13
Wholesale price E10	3182	142.96	1.30	137.09	145.66
Rate of change wholesale price E10	3182	0.03	0.29	-1.01	1.19

Own calculations with Stata 13.1.

Table A6: Jet's Reactions to Shell's Price Increases[1]

	Jet (1)	Jet (2)	Jet (3)	Jet (4)	Jet (5)
Shell	0.0703***	0.0313***	0.0242***	0.0303***	0.0299***
	(0.00824)	(0.00590)	(0.00604)	(0.00592)	(0.00584)
Without Total[2]	-0.149	0.0634	0.0921	0.0922	0.0447
	(0.0824)	(0.0691)	(0.0681)	(0.0682)	(0.0659)
Without Esso[2]	-0.186*	-0.0379	0.0338	0.0168	0.0629
	(0.0934)	(0.0789)	(0.0786)	(0.0787)	(0.0810)
Aral, Shell, Jet[2]	-0.107	0.102	0.166*	0.155	0.134
	(0.0950)	(0.0834)	(0.0832)	(0.0831)	(0.0802)
Jet 6.00 pm		-0.430***	-0.471***	-0.474***	-0.473***
		(0.0112)	(0.0130)	(0.0131)	(0.0127)
E10		6.856***	5.068***	5.668***	5.737***
		(0.186)	(0.338)	(0.358)	(0.368)
Wholesale price			0.152***	0.118***	0.112***
			(0.0248)	(0.0255)	(0.0261)
Rate of change of			-0.832***	-0.836***	-0.904***
wholesale price			(0.0972)	(0.0964)	(0.101)
School holidays				0.273***	0.158*
				(0.0638)	(0.0632)
Weekend/Holiday				0.0302	
				(0.0494)	
Tuesday					0.0969
					(0.0776)
Wednesday					-0.906***
					(0.122)
Thursday					0.0490
					(0.0813)
Friday					-0.150
					(0.0876)
Saturday					0.0701
					(0.0686)
Sunday					0.323***
					(0.0621)
East Germany					-0.246**
					(0.0890)
Constant	5.510***	62.49***	48.80***	53.36***	54.07***
	(0.102)	(1.475)	(2.585)	(2.742)	(2.817)
Observations	4071	4071	4071	4071	4071
Adjusted R^2	0.018	0.282	0.303	0.306	0.338
F	18.93	252.6	236.8	192.0	131.7

[1]Dependent variable: Jet's total price increasing from 6 pm to midnight. [2]Compared to all majors. Standard errors in parentheses. * p < 0.05, ** p < 0.01, *** p < 0.001. Own calculations with Stata 13.1.

Table A7: Reactions of Non-Oligopolists (NO) on Shell's Price Increases[1]

	NO (1)	NO (2)	NO (3)	NO (4)	NO (5)
Shell	0.302***	0.265***	0.254***	0.252***	0.249***
	(0.00728)	(0.00610)	(0.00603)	(0.00620)	(0.00616)
Without Jet[2]	1.908***	1.372***	1.402***	1.405***	1.447***
	(0.0938)	(0.0808)	(0.0788)	(0.0788)	(0.0775)
Without Total[2]	-0.809***	-0.585***	-0.517***	-0.517***	-0.616***
	(0.0855)	(0.0737)	(0.0730)	(0.0730)	(0.0732)
Without Esso[2]	-0.553***	-0.550***	-0.413***	-0.406***	-0.329***
	(0.0868)	(0.0694)	(0.0670)	(0.0669)	(0.0678)
Aral, Shell, Esso[2]	-0.557***	-0.172*	0.0660	0.0711	-0.0229
	(0.0957)	(0.0789)	(0.0771)	(0.0771)	(0.0772)
Aral, Shell, Total[2]	-2.170***	-1.950***	-2.045***	-2.052***	-1.959***
	(0.0980)	(0.0899)	(0.0878)	(0.0881)	(0.0889)
Aral, Shell, Jet[2]	-0.602***	-0.432***	-0.286**	-0.282**	-0.325***
	(0.114)	(0.0988)	(0.0964)	(0.0965)	(0.0951)
Price NO 6.00 pm		-0.433***	-0.521***	-0.521***	-0.517***
		(0.00949)	(0.0106)	(0.0106)	(0.0105)
E10		6.606***	2.036***	1.845***	1.497***
		(0.156)	(0.307)	(0.338)	(0.340)
Wholesale price			0.365***	0.376***	0.393***
			(0.0217)	(0.0231)	(0.0232)
Rate of change of wholesale price			-0.252***	-0.249***	-0.270***
			(0.0690)	(0.0692)	(0.0707)
School holidays				-0.0921	-0.156**
				(0.0521)	(0.0538)
Weekend/Holiday				0.00483	
				(0.0455)	
Tuesday					0.181*
					(0.0784)
Wednesday					-0.0126
					(0.0873)
Thursday					0.106
					(0.0783)
Friday					0.168*
					(0.0793)
Saturday					0.0936
					(0.0784)
Sunday					0.0329
					(0.0821)
East Germany					-0.465***
					(0.0589)
Constant	5.562***	63.27***	28.80***	27.35***	24.75***
	(0.101)	(1.267)	(2.358)	(2.581)	(2.592)
Observations	6442	6442	6442	6442	6442
Adjusted R^2	0.381	0.528	0.548	0.548	0.552
F	619.9	881.4	799.6	682.8	487.2

[1]Dependent variable: NO's total price increasing from 6 pm to midnight. [2]Compared to all majors. Standard errors in parentheses. * p < 0.05, ** p < 0.01, *** p < 0.001. Own calculations with Stata 13.1.

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