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by

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Abstract

The German petrol station market is characterized by strong intraday price cycles, which probably correspond to the well-known Edgeworth cycles. The prices go up strongly in the late evening or in the middle of the night, fall relatively heavily in the early morning and then go up and down several times in the course of the day. Locally, the analysis is limited to the 26 petrol stations that plausibly form a common market in the Lueneburg region. This essay picks out the specific sequence in which, after generally rising prices during the day, a single supplier is the first to reverse the price trend and lower its price. For this purpose, current price reports are used to define the price reduction event down to the second, and to show only the valid prices of competitors prior to the event. All German petrol stations have to report price changes to the Bundeskartellamt's Market Transparency Department. Tankerkoenig then publishes the full reports. This results in one panel observation for each price reduction event. Out of nearly 300,000 price observations, just over 10,000 panel observations result. Fixed-effect logit estimates are used to test whether the theoretically and economically significant price differences of the Edgeworth cycles explain the behavior of the price cutters, or whether market structure factors, such as brand affiliation/independence of the petrol station, service offerings, or location characteristics predict price-cutting behavior. The novel recording of the price dynamics in the petrol station market by using the accurate petrol station price data to the second indicates promising research of extensive price data and avoids the enormous loss of information in the previously common calculation of average prices at certain times.

JEL-Classification: L13, L41, K21

Keywords: Edgeworth cycles, gasoline prices, dynamic pricing

1. Introduction

The price development at German filling stations is characterized by a high degree of price fluctuations. There are strong ups and downs of prices within one day. For example, the development of prices in Lueneburg can be traced using data from the Bundeskartellamt's Market Transparency Office. Figure 1 shows the price reports for diesel from all 15 petrol stations active in the Lueneburg town area as they were issued on 31 March 2019. A color was assigned to each of the Lueneburg petrol stations. The majority of the price reports took place between about six o'clock in the morning and in the evening. There was a price increase in the early morning, after six o'clock, and in the further course of the day, price reductions occurred again and again. A large number of petrol stations reacted with price concessions at each reduction. The red arrows in Figure 1 are intended to indicate price reductions. The question remains as to why suppliers who have worked their way up to a higher price level are prepared to leave the high level. In particular, if the development repeats itself within a day and over the days, why don't suppliers learn from it and stay at high prices? Why do they voluntarily give up the price paradise?

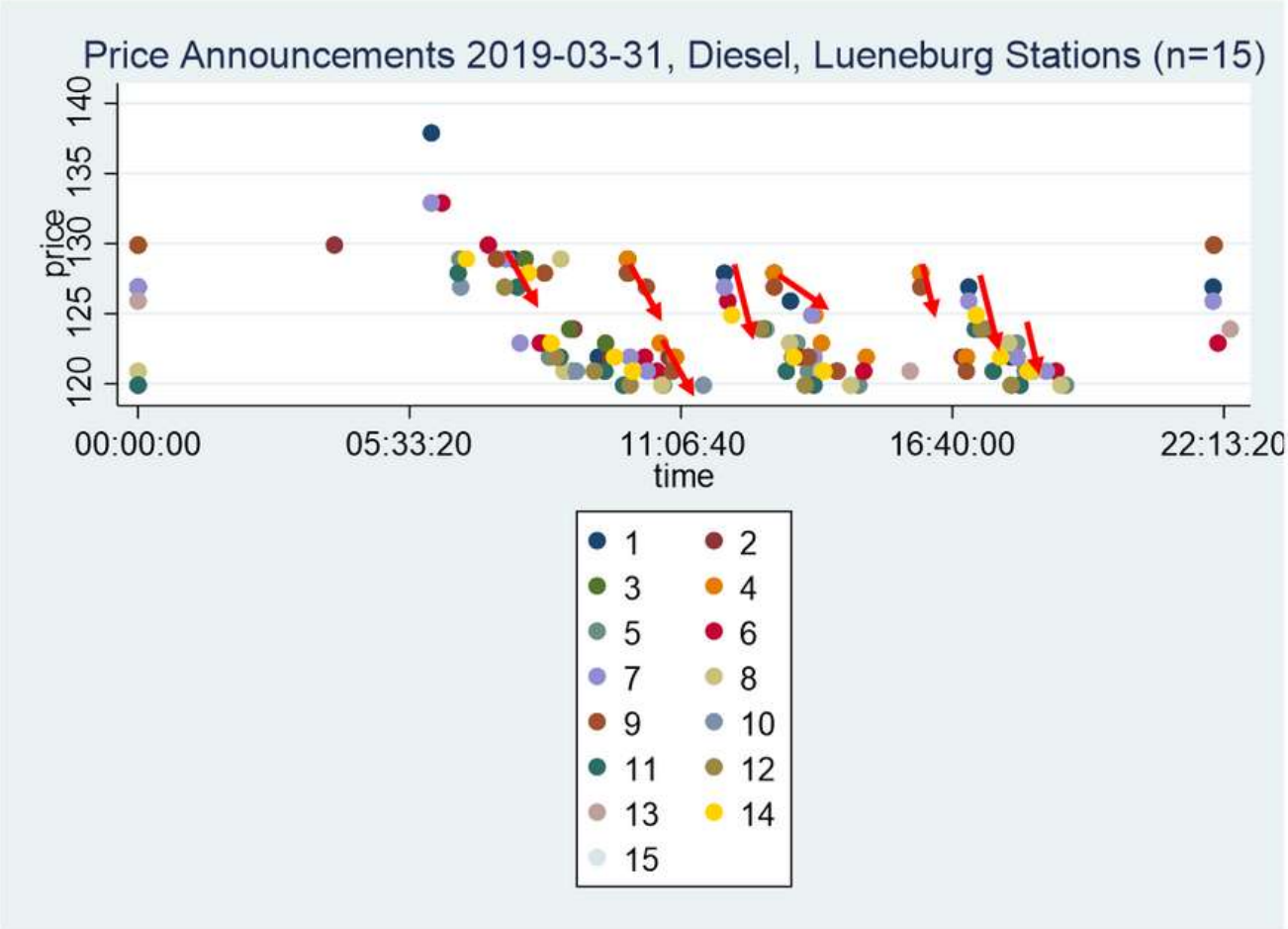

Figure 1: Price Announcements Diesel, 03/31/2019, Lueneburg, 15 stations

The theoretical background for price cycles is fundamentally based on the work of Maskin/Tirole (1998). Two suppliers competing exclusively on price set their prices alternately. Only the price of the current period is relevant (Markov-strategies). If prices are set for a certain period in line with marginal costs, a war of attrition develops. One company hopes that the other loses his nerve, relents, and is the first to raise prices again. After one company increases the price (jump), the other follows with his price increase, but remains slightly below the first company's price. All the demand goes to the cheaper supplier. The too expensive supplier reacts by slightly undercutting its competitors. The now too expensive supplier also responds with price undercutting. At the end of the mutual undercutting phase, both suppliers have returned to their marginal costs. Then a war of attrition, jump, and undercutting will start anew again. Noel (2008) extended this approach to three companies fighting price wars with each other. Once again, there are attrition wars, price jumps, and mutual undercutting. There are new possibilities that the subsequent price increases will be delayed (delayed starts) or even cancelled due to a lack of imitators (false starts). Stochastic price movements of input prices can influence the manifestations of cycles.

Edgeworth cycles have been empirically proven in many industrialized countries. Australia has recently demonstrated cycles; although, in one federal state the rule is that petrol station prices must be kept constant for 24 hours (Byrne/De Roos, 2019; De Roos/Katayama, 2013; Wang, 2009a,b; Wills-Johnson/Bloch; 2010). At Canadian petrol stations, there are many confirmatory indications found by evaluating long-term data at the local level (Atkinson, 2009; Atkinson/Eckert/West, 2014; Byrne/Leslie/Ware, 2015). In Germany, data from the Market Transparency Office have been used in recent years to find corresponding cycles based on daily average price data at defined hours (Eibelshäuser/Wilhelm, 2017; Haucap/Heimeshoff/Sieckmann, 2017; Siekmann, 2017). In two Scandinavian countries, Norway and Sweden, the results for local petrol markets also point to the existence of Edgeworth cycles (Foros/Steen, 2013; Nguyen/Steen, 2018). The United States of America has the longest tradition of empirical testing for the existence of Edgeworth cycles, with confirming results available from the past decade (Doyle/Muehlegger/Samphantharak, 2010; Lewis, 2012; Lewis/Noel, 2011; Zimmerman/Yun/Taylor, 2013). The well-confirmed Edgeworth cycles explain price reductions as reactions to price undercutting by one or two competitors, but they can't explain why petrol stations reduce prices when their competitors charge almost the same prices.

It has been known for some time that powerful petrol stations are raising prices more and are unwilling to lower prices later (Borenstein/Shepard, 1996; Deltas, 2008). Sharply rising petrol prices can especially be observed when crude oil prices or wholesale prices go up; however, declining purchase prices are only slowly passed on to end customers. Prices rise like a rocket but fall like a feather. This "rocket-feather-relationship," was first documented by Bacon (1991), and later confirmed by Galeotti, Lanza, and Manera (2003), and again by Verlinda (2008). Bremmer/Kesselring (2016) have recently

added to this by checking whether falling cost prices during the global economic crisis in the thirties of the last century led to a contrary trend (known as “balloons and rocks”). Price cuts are thus a delayed response to falling input prices. Since input price fluctuations play a very small role in the intraday cycles under consideration, this explanatory approach is unlikely to be relevant for this paper.

One would tend to expect that rising search costs among petrol consumers would make it more difficult to compare prices at petrol stations and that stations could charge excessive prices. The easier prices can be compared, the more stable the prices will remain. Thus, there will be fewer price reductions (Chandra/Tappata, 2011). Byrne and De Roos (2017) show that in times of increasing price differentials, information media with price information from petrol stations are used more frequently in corresponding websites. Haucap et al. (2017) interpret the developments in German petrol price cycles as an indication of easier search activities by German final customers through information apps that provide current price data on the basis of the Market Transparency Unit (MTU). In summary, simplified search activities would increase price volatility and thus make price reductions more likely. Since search activities will hardly change within one day, this approach cannot be tested in this paper.

Recently, Byrne/De Roos (2019) turned its attention to the question of how the uniform behavior of petrol station owners arise. It is therefore not the question of whether the petrol price development follows due to tacit collusion or Edgeworth cycles, but how novel price cycles are initiated. For this, they use price data from more than 600 petrol stations over a fourteen-year period. Due to the West Australian price rule that applies throughout this period, all petrol stations must announce the daily petrol prices on the previous day and are bound to this price for 24 hours. Due to the unusually long data set, more than 1.5 million price data are available. Supply shocks—such as natural disasters, or market entry in the petrol station market—also occurred during this time. As a result, the authors can describe relatively precisely how a change from one cycle form to another occurred. Neukirch and Wein (2019) also use local data from medium-sized cities and large German metropolises to classify brand-specific price markups in the German Edgeworth cycles, which are run several times a day using the Lerner index. The entirety of their cycles is not the object of investigation in either approach. Instead, the dynamics within the cycle (Neukirch and Wein, 2019) or between the cycles (Byrne and De Roos, 2019) are the focus.

Applying general microeconomic considerations, a petrol station is even more likely to reduce its price if the revenue gain from falling prices outweighs the revenue losses caused by the price reductions. Falling prices could therefore be associated with the hope of attracting additional demand. Since many petrol stations offer additional services such as shops, ATMs, toilets, car washes, bistros, baking stations, or vacuum cleaners, they have a great interest in encouraging as many customers as possible to refuel at their petrol station. Lowering the price could be a suitable measure. The longer a petrol

station is open, the more likely it will sell more products, and prices will lower. Petrol stations that are further away from motorway entrances, do not offer services on main roads (federal roads), or are located along typical commuter routes with price-sensitive end customers, are more likely to reduce prices than others.

Since many petrol stations sell fuel in the name and on the account of their major, they receive a fixed fee per liter of fuel. This means that there is no loss of turnover due to price reductions. These petrol stations are all the more interested in turnover from services, which is promoted by price reductions rather than by adhering to high prices. The trend to lure customers to petrol stations by lowering prices is intensifying. Since the large majors often have card customers whose bills are paid by third parties such as their employers, customers are less willing to look for lower prices than customers at independent petrol stations. Increasing volume through price lowering is likely to be less relevant for self-service stations or for petrol stations with associated car repair shops. The former because fixed personnel costs have to be distributed less, and the latter because the petrol station is perhaps only a source of additional profits. Petrol stations that are within sight of each other react immediately to price reductions of the other. Petrol station-specific factors such as location, service, or brand can also influence their willingness to reduce prices.

This paper examines why a service station is the first to lower prices after a period of rising prices, within the intraday German Edgeworth cycles. Edgeworth cycle theory would require price undercutting by a competitor. Petrol stations with market power would be less forced to lower prices than powerless ones. More interest in selling additional services, the location of the petrol station and existing brand loyalty may also be reasons to be the first to give up the high-price paradise. The third chapter shows how MTU's available data have to be converted for the question described. Descriptive statistics are provided within Section 4. Section 5 describes the estimated results of multivariate fixed effect logit estimates of why a single service station lowers their price and the others do not. Robustness tests are presented in Section 6. Summarized results and conclusions can be found in the seventh section.

2. Data

Since December 2013, the legal requirements for the activities of the Market Transparency Unit (MTU) of the Federal Cartel Office have been in place. Filling stations must notify MTU of their new prices within five minutes. The agreements with individual providers of information services via the Internet or Apps have been available for public download and kept up to date for many years on the Tankerkönig.de homepage. In this paper, I limit reports to the Lueneburg region with the fuel types diesel and petrol (unleaded E5 and E10), for the years 2018 and 2019. Unfortunately, there is no

quantity data available at the filling station level. Other station-specific characteristics are recorded for the individual filling stations, however. For example, other products offered by the filling station, opening times, spatial location, as well as the type of road traffic connection. We evaluated data from the app-based information services Clever Tanken and Tankerkönig. Information from individual stations' webpages are included as well as the author's local knowledge. All filling stations are assigned to the brands of the five majors (Aral, Shell, Esso, Total, Jet), to the superregional without upstream structure acting as non-oligopolists 1 (star, AVIA, HEM, OIL!, Agip, OMV, Westfalen, NO1), or to the independent, locally active filling stations (non-oligopolists 2, NO2).

A total of 26 petrol stations are included in the data set for the Lueneburg region, of which 15 are in the city area and eleven in neighboring municipalities (Figure 1). Two petrol stations (Aral Brietlingen, No. 21, and Raiffeisen Barendorf, No. 23) ceased operations in the course of 2019. With the aid of Google Maps, the shortest route between the individual filling stations was determined manually, whereby the mean value of both directions was taken as a basis (Table 1). Tables A2-A3 in the Annex provide information on the characteristics of each service station.

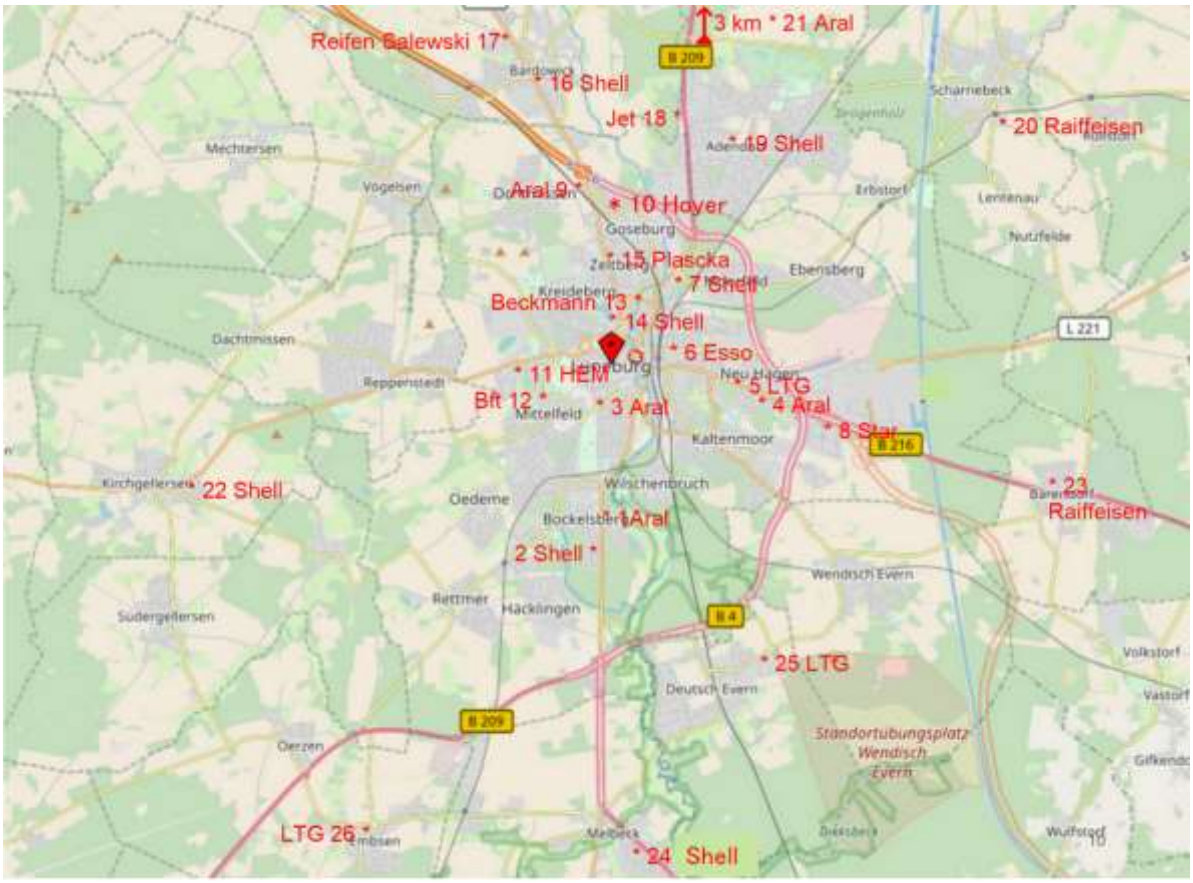

Figure 1: Filling stations in the region of Lueneburg

Table 1: Distances between filling stations[1]

			id	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
id	**Brand**	**Street**	**Place**																										
1	Shell	Universitaetsallee	Lueneburg	-	0.28	2.75	4.80	8.00	3.80	4.90	6.90	6.50	6.70	3.90	3.50	2.90	4.10	1.10	8.90	8.90	7.8	6.90	11.60	12.50	10.50	10.00	5.30	4.80	8.50
2	ARAL			-	-	2.10	4.60	3.90	3.70	3.90	6.35	5.70	6.40	3.90	3.20	4.20	4.70	4.95	8.10	8.60	7.60	6.70	11.40	12.30	10.00	9.80	5.50	4.80	9.00
3		Soltauer Strasse		-	-	-	3.70	3.05	2.85	3.90	5.45	4.85	6.45	1.80	1.00	3.25	3.20	4.05	7.30	7.60	6.80	5.90	10.60	11.40	7.80	9.00	7.90	7.30	8.40
4		Dahlenburger Landstraße		-	-	-	-	0.65	1.80	3.35	1.70	5.50	5.80	5.15	3.60	3.60	3.30	4.40	7.50	8.90	6.40	5.45	7.65	10.90	11.40	5.20	10.30	5.65	13.30
5	LTG			-	-	-	-	-	1.25	3.40	2.40	4.80	5.20	4.30	3.50	2.90	2.60	3.70	6.90	7.40	6.35	5.50	8.35	11.00	10.60	5.80	10.90	6.35	14.00
6	Esso	Bleckeder Landstr.		-	-	-	-	-	-	2.85	3.65	4.40	4.70	5.60	3.70	2.40	2.60	3.20	5.90	7.20	5.40	4.50	8.05	10.00	9.40	7.30	9.00	7.45	10.90
7	Shell	Erbstorfer Landstr.		-	-	-	-	-	-	-	4.75	3.50	3.90	4.00	4.05	1.35	2.00	2.40	5.10	6.10	3.15	2.30	6.70	7.85	10.00	8.20	12.90	8.25	12.10
8	STAR	Auf den Bloecken		-	-	-	-	-	-	-	-	7.35	8.05	6.45	6.35	5.80	5.50	5.70	9.10	16.90	7.50	6.60	9.10	12.20	13.20	4.50	10.20	5.65	13.30
9	ARAL	Hamburger Strasse		-	-	-	-	-	-	-	-	-	0.60	4.60	3.05	2.35	2.40	1.10	2.40	2.70	3.40	3.20	8.20	9.50	10.80	11.20	11.70	11.20	13.6
10	Hoyer	Bessemerstr.		-	-	-	-	-	-	-	-	-	-	5.00	3.90	2.60	2.60	1.50	2.60	3.10	3.20	3.20	10.40	9.60	11.00	11.50	11.90	11.30	13.80
11	HEM	Vor dem Neuen Tore		-	-	-	-	-	-	-	-	-	-	-	4.60	3.05	3.20	3.50	6.60	7.80	6.90	6.00	10.60	11.60	6.10	10.80	9.40	9.00	9.90
12	Bft	Am Grasweg		-	-	-	-	-	-	-	-	-	-	-	-	5.10	2.55	3.55	6.90	7.30	7.00	6.10	10.80	11.60	6.80	10.10	8.70	8.30	9.20
13	Beckmann/Lindemann	Auf der Hude		-	-	-	-	-	-	-	-	-	-	-	-	-	0.75	1.20	4.30	4.90	4.30	3.40	8.00	9.00	9.05	9.20	9.70	9.10	11.60
14	Shell	Vor dem Bardowicker Tore		-	-	-	-	-	-	-	-	-	-	-	-	-	-	2.40	4.60	4.80	4.90	4.05	8.70	9.55	8.40	8.80	9.40	8.90	11.30
15	Freie Tankstelle	Hamburger Str.		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3.20	3.70	5.30	4.50	9.10	10.00	9.50	9.80	10.40	9.80	12.30
16	Shell	Hamburger Landstr.	Bardowick	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.80	4.60	6.30	9.40	7.30	11.00	16.20	14.10	13.90	16.00
17	Freie Tankstelle Salewski			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4.80	6.50	9.60	7.50	11.40	16.40	14.10	13.70	16.90
18	JET	Artlenburger Landstr.	Adendorf	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.80	6.90	4.80	13.00	11.80	13.10	11.50	15.00
19	Shell	Bültenweg		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6.40	6.50	12.10	10.90	15.10	10.60	14.10
20	Raiffeisen	Raiffeisenstr.	Scharnebeck	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	7.60	16.70	8.50	16.90	12.90	18.80
21	ARAL	Bundesstraße	Brietlingen	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	18.10	16.20	17.70	16.10	19.60
22	Shell	Lueneburger Str.	Kirchgellersen	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	17.90	12.70	13.80	8.80
23	Raiffeisen		Barendorf	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	14.20	9.60	17.70
24	Shell	Uelzener Str.	Melbeck	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5.00	4.50
25	LTG	Timelostr.	Deutsch Evern	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	8.10
26		Bahnhofstr.	Embsen	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

[1] Mean value of both directions.

3 Data Modification

All diesel price data provided by Tankerkönig for petrol station 1 (Shell Universitaetsallee) on the third and fourth of January 2018 are shown in Table 2. If the variable “startprice” equals one, this means that the last price of the previous day was leaked. A start price variable with a value of zero shows a daily price message. For example, the first new price at 5.17 and five seconds in the morning with a value of 128.9 Eurocents (ct), i.e. a price reduction of 3 ct compared to the previous day. All further price messages on January 3, 2018, are then again new price messages. For January 4, 2018, the last price message of the previous day (January 3) is also fed before all new price changes of the current day are displayed. With the variables "open" and "close" the opening and closing times of the respective petrol station are displayed. Petrol station 1 is open all day. The variable "timemh" measures the time period between midnight and the announcement of the new price in machine hours. Hence, a calculable time distance is provided, in addition to the non-useable variable “time.” If a petrol station had not been open all day, machine hour time would be calculated from the opening time. On January 3, there are 14 new price messages, of which three are increases (by 5, 3, and 15 ct) and eleven occur as reductions (between -1 to -4 ct). One day later, it looks relatively similar. There are drastic price increases in the evening, two more moderate price increases (+3 and +5 ct), and again many small reduction rounds between -1 to -4 ct.

Table 2: Price announcements Shell, Universitaetsallee 1, Diesel, January 3. + 4., 2018

date	time	id	open	close	timemh	price	startprice	ddiff
03.01.2018	00:00:00	1	0	24	0.0	131.9	1	15
03.01.2018	05:17:05	1	0	24	5.3	128.9	0	-3
03.01.2018	06:32:06	1	0	24	6.5	124.9	0	-4
03.01.2018	07:02:06	1	0	24	7.0	123.9	0	-1
03.01.2018	10:02:06	1	0	24	10.0	119.9	0	-4
03.01.2018	12:30:07	1	0	24	12.5	124.9	0	5
03.01.2018	14:47:06	1	0	24	14.8	121.9	0	-3
03.01.2018	15:47:06	1	0	24	15.8	119.9	0	-2
03.01.2018	17:00:07	1	0	24	17.0	122.9	0	3
03.01.2018	18:18:06	1	0	24	18.3	121.9	0	-1
03.01.2018	19:44:12	1	0	24	19.7	120.9	0	-1
03.01.2018	20:08:06	1	0	24	20.1	118.9	0	-2
03.01.2018	20:45:07	1	0	24	20.8	117.9	0	-1
03.01.2018	21:05:06	1	0	24	21.1	116.9	0	-1
03.01.2018	22:00:06	1	0	24	22.0	131.9	0	15
04.01.2018	00:00:00	1	0	24	0.0	131.9	1	15
04.01.2018	05:18:06	1	0	24	5.3	128.9	0	-3
04.01.2018	06:32:06	1	0	24	6.5	124.9	0	-4
04.01.2018	06:51:06	1	0	24	6.9	123.9	0	-1
04.01.2018	09:47:07	1	0	24	9.8	119.9	0	-4
04.01.2018	12:30:07	1	0	24	12.5	124.9	0	5
04.01.2018	13:38:07	1	0	24	13.6	122.9	0	-2
04.01.2018	14:44:07	1	0	24	14.7	119.9	0	-3
04.01.2018	16:12:06	1	0	24	16.2	117.9	0	-2
04.01.2018	17:00:07	1	0	24	17.0	120.9	0	3
04.01.2018	18:18:06	1	0	24	18.3	119.9	0	-1
04.01.2018	18:47:06	1	0	24	18.8	118.9	0	-1
04.01.2018	18:56:06	1	0	24	18.9	117.9	0	-1
04.01.2018	20:02:06	1	0	24	20.0	116.9	0	-1
04.01.2018	22:00:07	1	0	24	22.0	131.9	0	15

Table 3 includes the data set that was extended to include all petrol stations in the Lueneburg region for the morning of January 3. Starting in the early hours of the morning, the petrol stations that are not continuously open only start operating. At that point, price observations should only be included in the data set of relevant price reductions when all petrol stations are open. On this day, the filling stations 25 and 26 did not open until seven o'clock in the morning and obviously only after the usual price increases of 10 ct on the previous day had been followed up. It comes now again to a price reduction of 21 (Aral in Brietlingen) at a value of 2 ct. This price reduction is referred to as a price reduction relevant to the investigation (event=1); however, it is perhaps atypical, since Aral Brietlingen rather participated in the early morning price reduction. Data was prepared in such a way that the most recent price message is displayed from every petrol station relevant in the market area. All other, older price reports, of course only from open petrol stations, were deleted for this price reduction round. On the same day (January 3) the next first price reduction by 21 (Aral-Brietlingen) occurs at 12:10:06 by 2 ct, after the petrol stations 2, 3, 21, 4, and 9 (all Aral) have increased their prices mostly up to 5 ct, and all at the same time shortly after 12 o'clock. The reduction of 21 is referred to as the next price reduction event. Again, for all local petrol stations, including those of the defined price decreaser, only the most recent price messages are stored in the data record. In this case, only price messages that occurred January 3 or later were kept. Since some petrol stations had not yet set new prices on New Year's Day 2018, only the comprehensive price data of January 2 can be used to place them into the data set for January 3. In this respect, my data set does not start until January 3, 2018.

Table 3: Relevant Data, January 3, 2018, Lueneburg Region

date	time	id	price	startprice	pdif	Event	date	time	id	price	startprice	pdif	Event
2018-01-03	00:00:00	14	122.9	1	-9		2018-01-03	08:35:07	23	119.9	0	-2	
2018-01-03	00:00:00	18	125.9	1	11		2018-01-03	08:36:06	20	119.9	0	-2	
2018-01-03	00:00:00	15	122.9	1	5		2018-01-03	08:53:06	24	119.9	0	-4	
2018-01-03	00:00:00	20	121.9	1	6		2018-01-03	10:02:06	1	119.9	0	-4	
2018-01-03	00:00:00	5	121.9	1	7		2018-01-03	10:13:06	17	120.9	0	-1	
2018-01-03	00:00:00	23	121.9	1	6		2018-01-03	10:15:08	22	118.9	0	-3	
2018-01-03	00:00:00	13	123.9	1	7		2018-01-03	10:32:06	12	117.9	0	-3	
2018-01-03	03:53:05	11	121.9	1	8		2018-01-03	10:38:07	11	117.9	0	-3	
2018-01-03	04:05:06	22	122.9	1	8		2018-01-03	10:49:10	14	118.9	0	-2	
2018-01-03	05:17:05	7	122.9	0	-9		2018-01-03	10:54:06	10	117.9	0	-1	
2018-01-03	05:21:06	12	121.9	1	7		2018-01-03	11:11:06	15	117.9	0	-4	
2018-01-03	05:25:06	19	122.9	1	7		2018-01-03	11:23:06	13	118.9	0	-1	
2018-01-03	05:33:06	8	121.9	0	-4		2018-01-03	11:26:06	7	118.9	0	-2	
2018-01-03	05:33:06	9	124.9	0	-13		2018-01-03	11:47:06	8	117.9	0	-1	
2018-01-03	06:01:06	21	124.9	1	7		2018-01-03	11:55:06	6	118.9	0	-2	
2018-01-03	06:10:06	4	123.9	0	-4		2018-01-03	11:56:06	18	115.9	0	-2	
2018-01-03	06:26:06	17	121.9	0	6		2018-01-03	11:57:06	5	117.9	0	-1	
2018-01-03	06:26:06	6	122.9	0	-6		2018-01-03	11:59:06	26	117.9	0	-1	
2018-01-03	06:31:06	3	123.9	0	-5		2018-01-03	11:59:06	16	118.9	0	-1	
2018-01-03	06:31:06	2	123.9	0	-5		2018-01-03	11:59:06	25	117.9	0	-1	
2018-01-03	06:33:06	10	121.9	0	-2		2018-01-03	12:05:06	19	116.9	0	-2	
2018-01-03	06:43:06	24	123.9	0	-1		2018-01-03	12:06:06	2	124.9	0	5	
2018-01-03	06:44:06	16	124.9	0	-2		2018-01-03	12:06:06	3	124.9	0	5	
2018-01-03	07:02:06	1	123.9	0	-1		2018-01-03	12:06:06	21	125.9	0	5	
2018-01-03	07:03:06	26	124.9	0	10		2018-01-03	12:06:06	4	123.9	0	3	
2018-01-03	07:05:06	25	124.9	0	10		2018-01-03	12:07:06	9	125.9	0	5	
2018-01-03	**07:30:07**	**21**	**122.9**	**0**	**-2**	**1**	**2018-01-03**	**12:10:06**	**21**	**123.9**	**0**	**-2**	**1**

Table 4 shows the first price reduction events of the first two days of the modified data set for diesel in the Lueneburg region. At about half past seven in the morning, petrol station 21 (Aral, Brietlingen) lowered prices after two other petrol stations (25, 26 LTG in Deutsch Evern and Embsen) had once again sharply increased their prices. As for the first day, both price increases are more likely to be the same as the previous day's price increases. Further in the course of this paper, whether these price reductions represent a separate case category should be examined. If more than one petrol station reacts to the same price situation with a price reduction at the same second, it is recorded as a further price reduction event and thus as another price reduction round.

Table 4: First price reductions on the first two days of the data set

date	time	id	price	startprice	pdif	Event	round	date	time	id	price	startprice	pdif	Event	round
2018-01-03	00:00:00	23	121.9	1	6		0	2018-01-04	00:00:00	20	121.9	1	4		0
2018-01-03	00:00:00	13	123.9	1	7		0	2018-01-04	00:00:00	15	117.9	1	-4		0
2018-01-03	00:00:00	15	122.9	1	5		0	2018-01-04	00:00:00	13	123.9	1	5		0
2018-01-03	00:00:00	5	121.9	1	7		0	2018-01-04	00:00:00	5	121.9	1	7		0
2018-01-03	00:00:00	14	122.9	1	-9		0	2018-01-04	00:00:00	23	121.9	1	4		0
2018-01-03	00:00:00	18	125.9	1	11		0	2018-01-04	00:00:00	14	122.9	1	-9		0
2018-01-03	00:00:00	20	121.9	1	6		0	2018-01-04	03:55:06	11	121.9	1	7		0
2018-01-03	03:53:05	11	121.9	1	8		0	2018-01-04	04:05:07	22	122.9	1	8		0
2018-01-03	04:05:06	22	122.9	1	8		0	2018-01-04	05:18:06	7	122.9	0	-9		0
2018-01-03	05:17:05	7	122.9	0	-9		0	2018-01-04	05:21:06	12	121.9	1	7		0
2018-01-03	05:21:06	12	121.9	1	7		0	2018-01-04	05:29:05	19	122.9	1	7		0
2018-01-03	05:25:06	19	122.9	1	7		0	2018-01-04	05:33:05	8	121.9	0	-4		0
2018-01-03	05:33:06	8	121.9	0	-4		0	2018-01-04	05:33:05	9	124.9	0	-14		0
2018-01-03	05:33:06	9	124.9	0	-13		0	2018-01-04	05:42:06	18	121.9	0	-4		0
2018-01-03	06:01:06	21	124.9	1	7		0	2018-01-04	06:00:06	21	124.9	1	7		0
2018-01-03	06:10:06	4	123.9	0	-4		0	2018-01-04	06:10:06	4	123.9	0	-4		0
2018-01-03	06:26:06	6	122.9	0	-6		0	2018-01-04	06:16:06	16	122.9	0	-4		0
2018-01-03	06:26:06	17	121.9	0	6		0	2018-01-04	06:30:07	17	121.9	0	6		0
2018-01-03	06:31:06	3	123.9	0	-5		0	2018-01-04	06:31:06	3	123.9	0	-5		0
2018-01-03	06:31:06	2	123.9	0	-5		0	2018-01-04	06:31:06	2	123.9	0	-5		0
2018-01-03	06:33:06	10	121.9	0	-2		0	2018-01-04	06:39:06	24	123.9	0	-1		0
2018-01-03	06:43:06	24	123.9	0	-1		0	2018-01-04	06:43:06	6	122.9	0	-6		0
2018-01-03	06:44:06	16	124.9	0	-2		0	2018-01-04	06:45:07	10	121.9	0	-2		0
2018-01-03	07:02:06	1	123.9	0	-1		0	2018-01-04	06:51:06	1	123.9	0	-1		0
2018-01-03	07:03:06	26	124.9	0	10		0	2018-01-04	07:03:06	26	124.9	0	10		0
2018-01-03	07:05:06	25	124.9	0	10		0	2018-01-04	07:05:06	25	124.9	0	10		0
2018-01-03	**07:30:07**	**21**	**122.9**	**0**	**-2**	**1**	**0**	**2018-01-04**	**07:29:06**	**21**	**122.9**	**0**	**-2**	**1**	**0**

Table 5 shows the chronological sequence of January 3, 2018 for three price reduction events (rounds 0-2), the two already introduced at 7:30:07 and 12:10:06 at petrol station 21 and the new petrol station 4 (Aral Lueneburg, Dahlenburger Landstraße). Petrol station 4 lowered the price by 1 ct to 122.9 at 12:32:04, after it had increased the price by 4 ct at 12:06:06. Their price reduction was defined as a new price reduction event, as the four petrol stations (#7, 16, 12, 1) had increased their prices by 3 and 5 ct respectively. All the current price reports for the petrol stations that were submitted before are still valid, of course. The crossed-out price changes (pdif) in Table 5 are irrelevant for the definition of the price reduction event, since it is only the next price reduction event after 12:10:06 that is at issue. In order to enable later estimates at the price reduction round level, a three-digit number is assigned to each day (1/3/2018=300, 1/4/2018=400,..., 2/1/2018=3200, …). If the respective lap

counter is also combined with this order number, a unique designation of the respective intraday lap results. Looking back from the time of the price reduction event, the variable “duration” indicates how long the respective “pre-price” has already been set in the market area (in machine hours).

Table 5: Relevant price announcements of the first three price reduction rounds on January 3, 2018

date	time	id	price	pdiff	event	round	duration	day_round	date	time	id	price	pdiff	event	round	duration	day_round	date	time	id	price	pdiff	event	round	duration	day_round
2018-01-03	00:00:00	5	121.9	7	0	0	7.501945	300	2018-01-03	08:35:07	23	119.9	-2	0	1	3.583055	301	2018-01-03	08:35:07	23	119.9	-2	0	2	3.949722	302
2018-01-03	00:00:00	14	122.9	-9	0	0	7.501945	300	2018-01-03	08:36:06	20	119.9	-2	0	1	3.566666	301	2018-01-03	08:36:06	20	119.9	-2	0	2	3.933333	302
2018-01-03	00:00:00	23	121.9	6	0	0	1.501945	300	2018-01-03	08:53:06	24	119.9	-4	0	1	3.283333	301	2018-01-03	08:53:06	24	119.9	-4	0	2	3.65	302
2018-01-03	00:00:00	18	125.9	11	0	0	1.501945	300	2018-01-03	10:02:06	1	119.9	-4	0	1	2.133333	301	2018-01-03	10:15:08	22	118.9	-3	0	2	2.282778	302
2018-01-03	00:00:00	15	122.9	5	0	0	2.501945	300	2018-01-03	10:13:06	17	120.9	-1	0	1	1.95	301	2018-01-03	10:38:07	11	117.9	-3	0	2	1.899722	302
2018-01-03	00:00:00	13	123.9	7	0	0	7.501945	300	2018-01-03	10:15:08	22	118.9	-3	0	1	1.916111	301	2018-01-03	10:49:10	14	118.9	-2	0	2	1.715555	302
2018-01-03	00:00:00	20	121.9	6	0	0	7.501945	300	2018-01-03	10:32:06	12	117.9	-3	0	1	1.633333	301	2018-01-03	10:54:06	10	117.9	-1	0	2	1.633333	302
2018-01-03	03:53:05	11	121.9	8	0	0	1.501945	300	2018-01-03	10:38:07	11	117.9	-3	0	1	1.533055	301	2018-01-03	11:11:06	15	117.9	-4	0	2	1.35	302
2018-01-03	04:05:06	22	122.9	8	0	0	1.501945	300	2018-01-03	10:49:10	14	118.9	-2	0	1	1.348889	301	2018-01-03	11:23:06	13	118.9	-1	0	2	1.15	302
2018-01-03	05:17:05	7	122.9	-9	0	0	2.217222	300	2018-01-03	10:54:06	10	117.9	-1	0	1	1.266666	301	2018-01-03	11:47:06	8	117.9	-1	0	2	.7499998	302
2018-01-03	05:21:06	12	121.9	7	0	0	1.501945	300	2018-01-03	11:11:06	15	117.9	-4	0	1	.9833331	301	2018-01-03	11:56:06	18	115.9	-2	0	2	.5999998	302
2018-01-03	05:25:06	19	122.9	7	0	0	1.501945	300	2018-01-03	11:23:06	13	118.9	-1	0	1	.7833331	301	2018-01-03	11:57:06	5	117.9	-1	0	2	.5833332	302
2018-01-03	05:33:06	9	124.9	-13	0	0	1.950278	300	2018-01-03	11:26:06	7	118.9	-2	0	1	.7333331	301	2018-01-03	11:59:06	25	117.9	-1	0	2	5.535	302
2018-01-03	05:33:06	8	121.9	-4	0	0	1.950278	300	2018-01-03	11:47:06	8	117.9	-1	0	1	.3833331	301	2018-01-03	11:59:06	26	117.9	-1	0	2	.5499998	302
2018-01-03	06:01:06	21	124.9	7	0	0	.5019445	300	2018-01-03	11:55:06	6	118.9	-2	0	1	.2499997	301	2018-01-03	12:05:06	19	116.9	-2	0	2	.4499998	302
2018-01-03	06:10:06	4	123.9	-4	0	0	1.333611	300	2018-01-03	11:56:06	18	115.9	-2	0	1	.2333331	301	2018-01-03	12:06:06	2	124.9	-5	0	2	.4333332	302
2018-01-03	06:26:06	17	121.9	6	0	0	1.066945	300	2018-01-03	11:57:06	5	117.9	-1	0	1	.2166664	301	2018-01-03	12:06:06	4	123.9	-4	0	2	.4333332	302
2018-01-03	06:26:06	6	122.9	-6	0	0	1.066945	300	2018-01-03	11:59:06	26	117.9	-1	0	1	.1833331	301	2018-01-03	12:06:06	3	124.9	-5	0	2	.4333332	302
2018-01-03	06:31:06	2	123.9	-5	0	0	.9836112	300	2018-01-03	11:59:06	25	117.9	-1	0	1	5.168333	301	2018-01-03	12:07:06	9	125.9	-5	0	2	.4166665	302
2018-01-03	06:31:06	3	123.9	-5	0	0	.9836112	300	2018-01-03	11:59:06	16	118.9	-1	0	1	.1833331	301	2018-01-03	12:10:06	21	123.9	-2	0	2	5.535	302
2018-01-03	06:33:06	10	121.9	-2	0	0	.9502779	300	2018-01-03	12:05:06	19	116.9	-2	0	1	.0833331	301	2018-01-03	12:11:06	17	117.9	-3	0	2	.3499998	302
2018-01-03	06:43:06	24	123.9	-1	0	0	.7836112	300	2018-01-03	12:06:06	21	125.9	5	0	1	.0666664	301	2018-01-03	12:20:06	6	116.9	-2	0	2	.1999999	302
2018-01-03	06:44:06	16	124.9	-2	0	0	.7669445	300	2018-01-03	12:06:06	4	123.9	3	0	1	5.168333	301	2018-01-03	12:30:07	7	123.9	5	0	2	.0330554	302
2018-01-03	07:02:06	1	123.9	-1	0	0	.4669445	300	2018-01-03	12:06:06	3	124.9	5	0	1	.0666664	301	2018-01-03	12:30:07	16	123.9	5	0	2	.0330554	302
2018-01-03	07:03:06	26	124.9	10	0	0	.5019445	300	2018-01-03	12:06:06	2	124.9	5	0	1	.0666664	301	2018-01-03	12:30:07	12	120.9	3	0	2	.0330554	302
2018-01-03	07:05:06	25	124.9	10	0	0	.4169445	300	2018-01-03	12:07:06	9	125.9	5	0	1	.0499997	301	2018-01-03	12:30:07	1	124.9	5	0	2	.0330554	302
2018-01-03	**07:30:07**	**21**	**122.9**	**-2**	**1**	**0**	**0**	**300**	**2018-01-03**	**12:10:06**	**21**	**123.9**	**-2**	**1**	**1**	**0**	**301**	**2018-01-03**	**12:32:06**	**4**	**122.9**	**-1**	**1**	**2**	**0**	**302**

Table 6 summarizes the modified data set as it is used for further analysis, here concerning the price reduction event rounds #300 to #302. The variable "pricediff" indicates how the competitors of the price decreaser deviate from the new price of the price decreaser (- -> cheaper; + -> more expensive). For example, looking on dayround #300, station 23 is still cheaper by -1 ct (€ 1.21) than station 21 with 1.22 at the time of price its price reduction to € 122.9. Due to the fact that the former price of the price decreaser are also included in every price round, “pricediff” measures the price decreasing amount here. For example, station 21 had been 2 ct more expensive at 6.01:06 compared to a new price at 7:30:07. While the price differences in day round 300 are relatively small, they are relatively large in day round 301.

Table 6: Example for final data record

Date	Time	id	Price	pdif	Event	round	price-diff	Day_-round	Date	Time	id	price	pdif	event	round	price-diff	Day_round
03/01/2018	00:00:00	23	121.9		0	0	-1	300	03/01/2018	08:53:07	23	119.9		0	1	-4	301
		15	122.9				0			08:36:06	20	119.9				-4	
		13	123.9				1			08:53:06	24	119.9				-4	
		14	122.9				0			10:02:06	1	119.9				-4	
		20	121.9				-1			10:13:06	17	120.9				-3	
		18	125.9				3			10:15:08	22	118.9				-5	
		5	121.9				-1			10:32:06	12	117.9				-6	
	03:53:09	11	121.9				-1			10.38:07	11	117.9				-6	
	04:05:06	22	122.9				0			10:49:10	14	118.9				-6	
	05:17:05	7	122.9				0			10:54:06	10	117.9				-6	
	05:21:06	12	121.9				-1			11:11:06	15	117.9				-5	
	05:25:06	19	122.9				0			11:23:06	13	118.9				-5	
	05:33:06	9	124.9				2			11:26:06	7	118.9				-6	
	05:33:06	8	122.9				-1			11:47:06	8	117.9				-5	
	06:01:06	21	124.9				2			11:55:06	6	118.9				-8	
	06:10:06	4	123.9				1			11:56:06	18	115.9				-6	
	06:26:06	17	121.9				-1			11:57:06	5	117.9				-6	
	06:26:06	6	122.9				0			11:59:06	25	117.9				-6	
	06:31:06	3	123.9				1			11:59:06	26	117.9				-5	
	06:31:06	2	123.9				1			11:59:06	16	118.9				-7	
	06:33:06	10	121.9				-1			12:05:06	19	116.9				1	
	06:43:06	24	123.9				1			12:06:06	2	124.9				2	
	06:44:06	16	124.9				2			12:06:06	21	125.9				1	
	07:02:06	1	123.9				1			12:06:06	3	124.9				1	
	07:03:06	26	124.9				2			12:06:06	4	123.9				0	
	07:05:06	25	124.9				2			12:07:06	9	125.9				2	
	07:30:07	21	122.9	-2	1		0			12:10:06	21	123.9	-2	1		0	

The variable “pricediff” might not exactly measure the basic idea of the paper—that each of the petrol stations surveyed could have reacted to this "market equilibrium," since there is complete market transparency through the data of MTU. Hence, an alternative price difference can be calculated: “pricedifft.” For the very first observed price round on January 3, 2018, as already mentioned above, petrol station 21 reduced its price by 2 ct at 7:30:07 (pdif in Table 7). The variable "pricedifft" takes the former price of the price decreaser reference point (here 124.9 ct at 6:01:06, station 21) and calculates the price differences to the competitors. Inspecting Table 7, filling station 13 was thus 1 ct cheaper than the price reducer before the price reduction, filling station 23 even 3 ct. In contrast, petrol station 18 was 1 ct more expensive. Hence, negative values indicate that competitors had been cheaper, and positive means competitors had been more expensive. “Pricedifft” measures the price pressure which had been observable before the price decrease and might be the cause for price reduction. Expensive (positive values) and cheaper (negative values) stations can cancel each other out, and petrol stations with the same price can enter with zero. (Pricedifft are artificially imputed as 0 in case of the price decreser’s observation, meaning that the new price can have no influence on the perceived price pressure.) In order to map only the price pressure of the cheaper petrol stations, expensive petrol stations were set to zero for the variable “pricediffb,” for example petrol station 18.

Table 7: Alternative Concepts for Price Pressure

date	time	id	price	pdif	Ereignis	pricediff	pricedifft	pricediffb
03.01.2018	00:00:00	13	123.9		0	1	-1	-1
03.01.2018	00:00:00	5	121.9		0	-1	-3	-3
03.01.2018	00:00:00	23	121.9		0	-1	-3	-3
03.01.2018	00:00:00	14	122.9		0	0	-2	-2
03.01.2018	00:00:00	20	121.9		0	-1	-3	-3
03.01.2018	00:00:00	18	125.9		0	3	1	0
03.01.2018	00:00:00	15	122.9		0	0	-2	-2
03.01.2018	03:53:05	11	121.9		0	-1	-3	-3
03.01.2018	04:05:06	22	122.9		0	0	-2	-2
03.01.2018	05:17:05	7	122.9		0	0	-2	-2
03.01.2018	05:21:06	12	121.9		0	-1	-3	-3
03.01.2018	05:25:06	19	122.9		0	0	-2	-2
03.01.2018	05:33:06	9	124.9		0	2	0	0
03.01.2018	05:33:06	8	121.9		0	-1	-3	-3
03.01.2018	06:01:06	21	124.9		0	2	0	0
03.01.2018	06:10:06	4	123.9		0	1	-1	-1
03.01.2018	06:26:06	6	122.9		0	0	-2	-2
03.01.2018	06:26:06	17	121.9		0	-1	-3	-3
03.01.2018	06:31:06	2	123.9		0	1	-1	-1
03.01.2018	06:31:06	3	123.9		0	1	-1	-1
03.01.2018	06:33:06	10	121.9		0	-1	-3	-3
03.01.2018	06:43:06	24	123.9		0	1	-1	-1
03.01.2018	06:44:06	16	124.9		0	2	0	0
03.01.2018	07:02:06	1	123.9		0	1	-1	-1
03.01.2018	07:03:06	26	124.9		0	2	0	0
03.01.2018	07:05:06	25	124.9		0	2	0	0
03.01.2018	07:30:07	21	122.9	-2	1	0	0	0

4 Descriptive Results

In the final modified data set, 10,918 diesel price reduction events were defined (Table 8). Three-quarters of all events refer to relatively small reductions of 1 or 2 ct. A little bit less than half are only price reductions of 1 ct. Larger price reductions are therefore relatively rare, and the "probability" decreases as the amount increases.

Table 8: Frequency and extent of price reduction events

Price decreases	Frequencies	Percent
-19	2	0.02
-18	1	0.01
-17	2	0.02
-15	2	0.02
-14	2	0.02
-13	4	0.04
-12	3	0.03
-11	4	0.04
-10	25	0.23
-9	52	0.48
-8	119	1.09
-7	191	1.75
-6	336	3.08
-5	382	3.50
-3.9 and 4	860	7.88
-3	979	8.97
-2	2,991	27.40
-1	4,963	45.46
	10,918	100.00

Own calculations

Table 9 gives an overview of how often the respective petrol station is the first to reduce prices in the daily rounds (in detail Tables A4a + A4b). In the first round (round #0) of the respective days, petrol station 16 (Shell in Barowick) initiated the downward price movement with roughly 17 percent of all 728 first price round events. Esso in Lueneburg (petrol station 6) contributed about 13 percent, and Shell in Melbeck (station #24) had a share of one tenth. Inspecting the following price reduction events up to round 9, it is remarkable that all stations are responsible for being the first to leave the paradise on various days. The highest shares (between five to ten percent) can be observed for Aral (# 2, 4, 9) and Shell (# 14, 16). The number of price round events are decreasing in the course of the day. The detailed tables in the Annex also show this decreasing trend, with the number of rounds approaching zero for the last few rounds, as was to be expected. In the last, the 36th round, there is only one price reduction event. If the individual gas stations are summarized at brand level, i.e., not taking individual suppliers into account, and weighted with the number of gas stations occurring in the Lueneburg

region, Aral and Shell each contribute about five percent to the effect of being the first to lower prices in the first eleven price reduction rounds after previous price increases. The small brands "LTG" and "Raiffeisen," on the other hand, play almost no role in this form of price dynamics. The average values are calculated as an arithmetic mean of the existing petrol stations so that they do not add up to 100.

Table 9: Percentages of Price Decreasers/First 10 Rounds

				Round									
Id	Brand	Street	Place	0	1	2	3	4	5	6	7	8	9
				%									
1	Shell	Universitätsallee	Lueneburg	2.5	5.8	4.3	3.2	4.6	3.8	3.4	3.3	3.8	2.9
2	ARAL			3.9	8.5	8.4	8.0	6.1	5.6	5.4	4.0	4.4	5.6
3		Soltauer Str.		3.4	5.0	6.3	6.5	5.3	4.6	5.9	6.6	4.1	5.1
4		Dahlenburger Landstr.		5.0	6.7	9.9	7.7	7.6	8.4	8.0	7.2	8.2	8.1
5	LTG			1.3	3.4	2.4	3.7	2.9	2.1	1.3	2.1	1.1	1.4
6	ESS0	Bleckeder Landstr.		13.1	2.6	3.0	3.2	3.9	5.0	4.3	6.0	4.7	4.7
7	Shell	Erbstorfer Landstr.		6.6	3.9	4.5	4.8	5.0	3.9	3.7	3.3	3.6	5.2
8	STAR	Auf den Bloecken		1.1	2.6	1.1	1.7	0.7	0.4	0.9	1.5	0.6	0.8
9	ARAL	Hamburger Str.		5.4	6.6	6.3	5.2	6.5	7.1	4.6	5.3	5.7	4.6
10	Hoyer	Bessemer Str		3.2	5.2	4.4	4.4	3.0	2.7	3.4	1.1	2.5	2.0
11	HEM	Vor dem Neuen Tore		1.5	3.0	2.1	2.2	1.7	2.1	2.3	2.7	3.5	2.9
12	Bft	Am Grasweg		2.8	2.6	2.8	2.8	3.9	3.5	3.0	4.5	4.7	3.5
13	Beck-mann/Lin.	Auf der Hude		2.5	2.1	3.3	1.8	1.2	1.8	1.0	0.6	2.1	1.0
14	Shell	Vor dem Bardowicker Tore		1.1	4.0	4.5	4.1	7.3	8.7	8.3	10.2	10.4	10.3
15	Freie Tankstelle	Hamburger Str.		0.3	0.4	1.1	1.2	1.4	0.6	0.6	0.2	0.5	0.8
16	Shell	Hamburger Landstr.	Bardowick	17.2	6.2	5.5	4.3	5.1	6.1	6.6	5.1	5.2	7.1
17	Freie Tankstelle Salewski			2.8	2.6	2.3	1.8	1.4	1.1	1.3	0.8	2.7	1.9
18	JET	Artlenburger Landstr.	Adendorf	2.6	4.0	2.2	2.5	1.9	1.8	0.4	1.1	0.6	1.7
19	Shell	Bueltenweg		1.4	1.9	2.5	5.4	2.8	6.6	5.4	3.6	6.2	4.4
20	Raiffeisen	Raiffeisenstr.	Scharne-beck	1.2	1.7	1.8	2.1	1.5	1.5	1.4	2.0	1.3	1.7
21	ARAL	Bundesstr.	Brietlingen	4.3	5.0	4.4	4.8	6.9	4.6	5.4	6.3	4.0	4.9
22	Shell	Lueneburger Str.	Kirch-gellersen	3.2	7.3	6.2	8.1	8.7	8.0	10.4	11.3	9.9	10.9
23	Raiffeisen	Lueneburger Str.	Barendorf	2.6	3.2	4.3	4.4	2.6	1.7	2.4	3.5	2.5	1.4
24	Shell	Uelzener Str.	Melbeck	10.2	3.7	3.6	2.9	4.8	4.3	6.0	5.4	4.7	5.9
25	LTG	Timelostr.	Deutsch Evern	1.1	0.7	1.7	1.7	1.9	2.4	2.4	1.4	1.4	1.0
26		Bahnhofstr.	Embsen	0.3	1.5	1.4	1.8	1.2	1.5	2.0	0.6	1.7	0.5
Sum of price decreasers				728	728	728	727	723	717	699	667	635	594
Weighted shares for brands with at least two service stations:													
Shell (6 Stations)				6.5	5.5	5.2	5.5	6.2	6.9	7.3	7.1	5.7	6.8
ARAL (5 Stations)				4.4	6.4	7.1	6.4	6.5	6.1	5.9	5.9	5.3	5.7
LTG (3 Stations)				0.9	1.9	1.8	2.4	2.1	2.0	1.9	1.4	1.4	1.0
Raiffeisen (2 Stations)				0.8	1.1	1.6	2.0	1.4	1.6	1.7	1.3	1.5	1.1

Diesel. Own calculations with Stata 16.0.

The generated dataset is described by using Tables 10 and 11. According to Table 10, the average price messages correspond to a value of 126 ct for diesel, with a standard deviation of 5.9 ct. The lowest price in the observation period was 108.9 and the highest 151.9 ct. A total of slightly less than 300,000 observations were included in the data set. The average price differences can be calculated differently, as already explained above.

First, if one compares the previous average prices of the competitors and the price reducer, with the new price of the price reducer at the reduction event (pricediff), there is almost no average deviation (0.06 ct) at a standard deviation of 4.13 ct. The latter points to special events; however, if one takes the average price pressure of the decreaser, which was exposed up to one second before the price reduction (pricedifft), the prices were on average slightly more than 2 ct lower; standard deviation and extreme values hardly change. If one considers the average price pressure before the price reduction as the price difference, and assumes that more expensive petrol stations do not exert any price pressure (pricediffb), the average price difference increases to 2.7 ct. Combined with a significantly higher standard deviation of over 10 ct, the lower extreme value remains the same and the maximum is, by definition, zero. The average duration of all competitors' prices within the price reduction rounds is 1.29 machine hours. The price differences to the next, second, or third closest competitors (see table A1 in the appendix), weighted by the distance between the petrol stations, can also exert price pressure and thus motivate price reductions. If one takes the price of the price reducer after the price reduction as a benchmark, the next closest suppliers are on average exactly 1 ct cheaper. The second closest is 0.67 ct cheaper, and the third closest 0.79 ct cheaper. If, however, one takes the prices of the price reducer before the reduction as a benchmark, the next (second-next/third-next) petrol stations were on average 6.3 (9.2/10.4) ct cheaper. Assuming that only cheaper petrol stations exert pressure before the price reduction event, the nearest petrol stations charge 5.4 ct less. By contrast, the second or third closest competitors are on average about 10 ct cheaper. In summary, if the benchmark is set at the price of the price reducer before reduction, there was considerable price pressure from competitors. That pressure was preceded by a price reduction, irrespective of whether the absolute price differences, the time-weighted differences, or the differences to the next three petrol stations were taken as a basis. On average, the petrol stations offer 3.3 services, slightly less than nine price reduction rounds per day were defined, and the average customer satisfaction was 4.1, albeit with little variance. The petrol stations have an average of 20.7 hours open during the week, slightly less on Saturdays and slightly less on Sundays and public holidays with just under 20 hours if one refers to the price reduction rounds recorded in the data set.

Table 10: Descriptives I – Data Set

	mean	Sd	Min	max
Announced prices	126.0	5.9	108.9	151.9
Price differences				
-Average prices before price decreasing versus decreased price (pricediff)	0.06	4.13	-25	25
-Average prices before price price decreasing versus price of decreasers before its price decreasing (pricedifft)	-2.09	4.04	-27	21
-Average prices before price price decreasing versus price of decreasers before its price decreasing; more expensive excluded (pricediffb)	-2.70	10.51	-27	0
Duration of prices	1.29	2.09	0.5	17.50
Local competition				
Prices of non-decreasers versus decreased price				
-To nearest competitor	-1.00	11.14	-140.8	109.8
-To second nearest competitor	-0.67	15.10	-193.2	123.5
-To third nearest competitor	-0.79	16.52	-183.3	142.5
Prices of non-decreasers versus before price of non-decreasers				
-To nearest competitor	-6.31	11.29	-153.6	0
-To second nearest competitor	-9.23	14.24	-218.4	0
-To third nearest competitor	-10.40	15.28	-210.6	0
Prices of non-decreasers versus before price of non-decreasers; more expensive excluded				
-To nearest competitor	-5.41	12.30	-153.6	103.70
-To second nearest competitor	-9.23	14.24	-218.4	115.6
-To third nearest competitor	-10.40	15.28	-210.6	132.6
Additional variables				
Number of services	3.30	1.64	0	6
Number of accepted credit cards	3.62	1.92	0	5
Rounds per day	8.69	6.61	0	36
Customer satisfaction	4.07	0.35	3.4	4.8
Opening hours				
Mondays to Fridays	20.72	4.05	12	24
Saturdays	20.35	4.83	6	24
Sundays & Public holidays	19.9	5.87	0	24

293,902 observations for all variables without consumer satisfaction (277,316); Diesel only. Calculated with Stata 16.

Descriptive evaluations of dummy variables of the data set can be found in Table 11. The petrol stations located on the main road account for almost a quarter of all prices recorded, whereas the only petrol station located directly on the motorway access road only accounts for less than a twentieth of the data set. Less than 1/10 concern price reports from Aral and Shell in Universitätsallee, which are within sight of each other. Of the approximately 300,000 price announcements, 15 percent are located on the commuter route (see Table A3) toward Dahlenburg; 12 percent can be allocated to the routes towards Gellersen and Uelzen, and 15 and 8 percent, respectively, are on the way to the motorway

entrance "Lueneburg-North" and to the entrance "Lueneburg-Middle." About two-fifths of all price reports concern petrol stations outside the Lüneburg city area. In regard to market-structural factors, it should be noted that almost one fifth of prices are due to Aral petrol stations. Shell is represented with almost 30 percent and the non-oligopolists1 with one quarter. The independent local Non-Oligopolists2 occurs in roughly 15 percent of all cases. If the service variables are taken up:

- the four petrol stations with ATMs contribute 16 percent of the price reports,
- petrol stations with bistros 42 percent,
- petrol stations with car repair shops 32 percent,
- with car washes almost half,
- with backshop one fifth,
- with kiosk 5 percent,
- with Rewe to Go 8 percent,
- as self-service stations 22 percent,
- with shop three quarters,
- with toilets 56 percent, and
- with vacuum cleaners 32 percent

of the data set. The days of the week are distributed more or less equally, and holidays concern one third of all price announcements.

Table 11: Descriptives II – Data Set

	Mean	Min	max
Location			
Near national roads?	0.24	0	1
Near motorways?	0.04	0	1
Shell/Aral Universitaetsallee?	0.08	0	1
Commuter route Lueneburg North?	0.15	0	1
Commuter route Lueneburg Middle?	0.08	0	1
Commuter route Gellersen?	0.12	0	1
Commuter route Uelzen?	0.12	0	1
Commuter route Dahlenburg?	0.16	0	1
Rural?	0.41	0	1
Market structure			
Aral?	0.18	0	1
Shell?	0.28	0	1
Non-Oligopolists1?	0.27	0	1
Non-Oligopolists2?	0.14	0	1
Services			
ATM?	0.16	0	1
Bistro?	0.42	0	1
Car repair?	0.32	0	1
Car wash?	0.44	0	1
In-store-bakery?	0.20	0	1

Kiosk?	0.05	0	1
Rewe to Go?	0.08	0	1
Self service station?	0.22	0	1
Shop?	0.77	0	1
Toilet?	0.56	0	1
Vacuum Cleaner?	0.32	0	1
Days			
Mondays?	0.16	0	1
Tuesdays?	0.15	0	1
Wednesdays?	0.15	0	1
Thursdays?	0.15	0	1
Fridays?	0.14	0	1
Saturdays?	0.13	0	1
Sundays and Public Holidays	0.11	0	1
Holidays	0.32	0	1

293,503 observations; Diesel only, calculated with Stata 16.0.

5 Multivariat Results

Multivariat estimations will now be applied to examine which possible influencing factors explain the willingness of a petrol station to be the first to lower the price. As shown above, most price reductions are made in the 1-2 ct range. Consequently, it is obvious to specify the dependent variable as a dummy variable, whereby price reduction at the respective petrol station is defined as one, and non-price reduction takes on the value zero. Consequently, simple logit models are possible. Each price reduction round must be regarded as a separate unit, since the prevailing market constellation could be the reason why a gas station reduces the price even though prices have risen before. The data of the individual price reduction rounds have already been assigned to an unambiguous classification number, which unites the date and number of the round on the respective day. A maximum of 26 petrol stations are included as observation characteristics, 363 days count for 2018 and 365 days for 2019, in sum 728 days. In total, a maximum of 37 laps per day were recorded. The panel could therefore contain 37 * 728 = 26, 936 observations, but in fact 37 laps did not occur on all days. The panel therefore comprises only 10,918 observations. Hence, a fixed-effect logit model with “time variable” round is applicable. Prices and price differences, also time-weighted and related to local competitors, market structural variables, location variables, station characteristics, service variables, day variables can be theoretically included in different estimation models. In each model, the point estimators of the respective coefficients are given exactly, and in brackets the t-values of the coefficients for estimating the statistical quality. In addition, the marginal average effects are shown in dashes in order to estimate the economically relevant size effects. Tables 12-15 and Table A5 show the results of the estimation if individual independent variables are gradually included in the estimation equation or—to avoid problems such as multicollinearity—replaced by others. For all

independent variables relating to price differences, the prices of the non-lowering petrol stations are compared with the price of the price-reducing petrol station before the latter decides to deviate downward (pricedifft), as this difference is probably the most plausible economic expression of the price pressure for the price reducer.

Table 12 looks separately at the influence of price differences, brand affiliation and the location of the petrol stations in order to determine the probability of a petrol station initiating a price reduction round. According to estimation model 1, the absolute price difference between the average prices of all non-lowering petrol stations, and the price of the lowering supplier, causes an increased probability of price reduction at the highest significance level. The marginal average effect that competitors would offer was on average 1 ct cheaper than the sinking supplier was at five percentage points. Since price differences are mostly very small, this independent variable has a relatively small economic impact. Even smaller is the time-weighted influence of the price difference on the likelihood of a reduction, according to which the again highly significant positive coefficient increases the probability of leaving the price paradise. If competitors become one cent cheaper and this price difference applies for one hour, the probability of a price reduction increases by only 0.4 percentage points (pp). To this extent, the two independent variables that are solely based on the price differences may provide a significant statistical explanation, but in economic terms these effects are relatively small. It is precisely the theory of the Edgeworth cycles with price differences as an "undercutting" explanatory factor that would see a major influence here. Later, it should be examined whether the results change when the proximity of petrol stations to each other is combined with the price differences. Estimation model 2 deals with the market structure effects. In the fixed-effect model, the change of a petrol station to the Aral brand would increase the probability of becoming a price reducer by 19 pp (highly significant coefficient). Switching to the Shell brand would also significantly increase the probability of becoming a price reducer, by 14 pp to be precise. On the other hand, switching a petrol station to non-oligopolistic brands, being nationally operating brands or local, independent suppliers, would drastically reduce the probability of a reduction. In the case of switching to non-oligopolistic nationwide brands, the probability of reduction would decrease by 89 pp, and by 78 pp for local independent brands, both underlying negative coefficients are secured at the 1/1000 significance level. According to the second estimation model, it is the big brands that are the first to lower prices. Even more importantly, the non-oligopolists have no interest in acting as price breakers. A methodological limitation, however, is to admit that no brand changes occurred in the two-year data set. If, according to estimation model 3, we only look at the location of price-reducing petrol stations, the following explanatory factors have a negative influence on the probability of a reduction. Changing a petrol station from Lueneburg to the Lueneburg area reduces the probability of leaving the paradise by 7 pp, and being near Aral and Shell in Lueneburger Universitaetsallee by 8.6 pp, to settle on the commuter route to Lueneburg-Mitte at

10.4 pp, to open a petrol station on the commuter route to Dahlenburg at 8 pp, to change to a federal road at 2.2 pp, or to operate a new petrol station near the Lueneburg-North motorway access road at 11.7 pp (except for the influence of the federal road, secured with the least possible probability of errors). A change to the commuter route to Gellersen (3.3 pp), to settle on the route to Uelzen by 11.4 pp, has a positive effect on the probability of decreasing prices. A change to the commuter route Lueneburg-North is not significant. With regard to the location of the petrol stations, the picture is mixed. It is not surprising that a change to the surrounding area or a settlement in the immediate vicinity of adjacent petrol stations reduces the probability, the same applies to the location on the federal road or motorway. Being located on commuter routes increases sometimes the probability of lowering prices. The significant marginal average effects are economically quite remarkable. A cautionary note for the economic interpretation is that here again in the data set there were no corresponding changes of location.

Table 12: Fixed-Effect-Logit – Price Differences, Market Structure, and Location Effects[1]

	(1)	(2)	(3)
Price difference to price sinker, compared to price before	0.219*** |0.05| (0.004)		
Price difference * duration; measured in machine h	0.0173*** |0.004| (0.0004)		
Aral?		0.760*** |0.19| (0.036)	
Shell?		0.576*** |0.14| (0.035)	
Non-oligopolist, nationwide?		-0.357*** |-0.89| (0.04)	
Non-oligopolist, local?		-0.306*** |-0.78| (0.045)	
Stations in rural area?			-0.284*** |-0.070| (0.0277)
In sight?			-0.350*** |-0.086| (0.058)
Commuter route to			
motorway exit Lueneburg-North?			-0.0132 |-0.003| (0.033)
motorway exit Lueneburg-Middle?			-0.421*** |-0.104| (0.042)
direction West (Gellersen)?			0.132*** |0.033|

			(0.031)
direction South (Uelzen)?			0.459*** |0.114| (0.051)
direction East (Dahlenburg)?			-0.324*** |-0.080| (0.034)
Station located			
at Federal Road?			-0.0898* |-0.022| (0.0371)
near Motorway?			-0.472*** |-0.117| (0.060)
Observations	293798	293798	293798

[1]Dependant variable: Within one round: 1 = decreasing price observ., 0= non-decreasing price observ. Standard errors in parentheses; * p < 0.05, ** p < 0.01, *** p < 0.001. Values in || marginal average effects. Own calculations by using Stata 16.0.

If the evaluation concentrates on services offered by the petrol stations, Table 13 shows the probability of a price reduction event. The longer a petrol station is open, the more service offers could play a role, and for petrol stations located outside the city area, the less services should be important. For opening hours and rural areas, additional checks are therefore made in the estimate. Factors that significantly increase the probability of price reductions are petrol stations that have a shop by 3.2 pp, with a REWE-to-Go-Shop 2.2 pp, with toilets 0.9 pp, that accepts all credit cards 1.6 pp, with a car wash 3.3 pp, with a bistro 1.6 pp, with the offer of vacuum cleaners 3.1 pp. Significant negative influence to become an initiator for a price reduction event occurs when the property of a petrol station operates as a self-service station (2.6 pp). Automatic filling stations and filling stations with an in-house bakery have a highly significant 2.6 pp and 5.4 pp lower sink probabilities. Without significant impact are petrol stations with a car repair shop, ATMs, and higher consumer satisfaction. One hour longer opening hours on Saturdays, Sundays, and holidays significantly increase the probability of reduction by 1.5 and 0.8 pp, respectively. Whereas, on working days they decrease the probability by 3.4 pp. Filling stations located in rural areas have a small 0.5 percentage point reduction probability. Overall, the majority of service offerings have an increasing, but moderately positive influence on the willingness of a petrol station to leave paradise. Obviously, petrol stations with longer opening hours on working days often use the instrument of being the first to lower the price, perhaps to lure customers to their multi-offer business premises. The same could apply to petrol stations with longer opening hours on Saturdays and Sundays. Surprisingly, the opposite applies to longer opening hours on working days. However, it has to be said that there is no variation in the range of services or opening hours in the two-year data set, as these cannot be reliably measured and may not have been relevant at all; this places limits on the interpretation of the fixed-effect logistic approach used.

Table 13: Fixed-Effect-Logit – Services, Opening Hours and Non-Lueneburg Stations[1]

Services	
Car repair?	0.040 |0.005| (0.55)
Self service station?	-0.216*** |-0.026| (0.054)
Station with Shop?	0.265*** |0.032| (0.065)
Station with Rewe-to-Go-Shop?	0.183* |0.022| (0.079)
ATM?	-0.061 |-0.007| (0.043)
Restrooms available?	0.077* |0.009| (0.035)
Number of accepted credit cards?	0.136*** |0.016| (0.016)
Car Wash?	0.277*** |0.033| (0.058)
Consumer satisfaction?	-0.170 |-0.020| (0.105)
Bistro?	0.135*** |0.016| (0.036)
Vacuum cleaner?	0.229*** |0.027| (0.031)
In-Store-Backery?	-0.452*** |-0.054| (0.045)
Opening hours	
Monday to Friday?	-0.284*** |-0.034| (-11.22)
Saturday?	0.129*** |0.015| (0.025)
Sunday/Public Holiday?	0.065*** |0.008| (0.008)
Stations in rural area?	-0.108*** |-0.005| (-0.013)
Observations	260,141

[1]Dependant variable: Within one round: 1 = decreasing price observ., 0= non-decreasing price observ. Standard errors in parentheses; * p < 0.05, ** p < 0.01, *** p < 0.001. Variable "Kiosk" is omitted. Values in || marginal average effects. Own calculations by using Stata 16.0.

In extension to Table 12, Model 1, the estimates in Table 14 concentrate on the price differences to competitors, i.e. the extent to which price pressure could explain directly, time-weighted or distance-dependent why a petrol station starts to reduce prices after previously rising prices. According to the first model, the average marginal effects for price differences to nearby petrol stations show hardly

any economically relevant effects. In one case, it even showed an insignificant coefficient. One ct lower average price of the nearest petrol station lowers the probability of a price reduction event by 0.5 pp. The third nearest one increases it by the same pp value. If the estimate is extended by the average price difference and by time-weighted price differences, the price difference of the nearest station becomes highly significantly positive. The difference to the third nearest station, although still positive, is only hedged at the 5 percent level. In both cases, the marginal effects are economically very small (0.5 pp each). In the price differences to the second closest provider, there is a significantly negative, but even smaller economic effect (0.3 pp). Even the extended inclusion of price differences does not seem to have a major impact on the incentive to be the first to lower the price. In other words, price pressure as an explanatory variable has so far been ruled out. At least, rather, according to the estimation methods used.

Table 14: Fixed-Effect-Logit – Price differences[1]

	(1)	(2)
Distance weighted price differences to nearest station, before	-0.026***	0.039***
	|-0.005|	|0.005|
	(0.06)	(0.009)
Distance weighted price differences to second nearest station, before	0.008	-0.021***
	|0.156|	|-0.003|
	(0.005)	(0.005)
Distance weighted price differences to third nearest station, before	0.070***	0.010*
	|0.005|	|0.002|
	(0.016)	(0.005)
Price difference to price sinker, compared to price before		0.184***
		|0.042|
		(0.008)
Price difference * duration; measured in machine h		0.013***
		|0.003|
		(0.002)
Observations	293,798	293,798

[1]Dependant variable: Within one round: 1 = decreasing price observ., 0= non-decreasing price observ. Standard errors in parentheses; * p < 0.05, ** p < 0.01, *** p < 0.001. Values in || marginal average effects. Own calculations by using Stata 16.0.

Combining the various "structural" explanatory approaches, such as the importance of the two major petrol brands or the non-oligopolists, location factors, or service offerings with price pressure variables, results in Table A-5 in the Annex. Model 1 combines the market structural variables with those of the location of the petrol stations included. Essentially, the same results are obtained for the location in terms of significance and marginal average effects. However, the marginal effects are reversed for the petrol station located directly next to the Lüneburg-Nord motorway access road. That location now has a 4 pp higher probability of decreasing price, secured at the 1/1000 level. Also, longer opening hours on Saturday reduce its probability of being the first to lower the price, although this effect is economically very small (0.9 pp). Probably far more significant is that the market structural variables (Aral, Shell, national and local non-oligopolists) "keep" their signs but become considerably

smaller. They reach just under 10 pp or lower. Service offerings and the location of petrol stations seem to determine the probability of a reduction far more than under which brand/non-brand one offers one's services. The joint estimation of service variables with price differences (model 2) results in hardly any change in values compared to the above separate estimates. In particular, although price pressure as the theoretically most significant influence is still highly significant. From an economic perspective the marginal average effects remain minimal. Model 3 combines price pressure variables with market structural factors. Now, only the market structural variables are subject to major changes. In three out of four cases, the marginal effects are now opposite. According to this model, Aral and Shell have lower probabilities of reductions and nationwide non-oligopolists have higher probabilities; however, all three variables remain below or just above the order of 5 pp for the probabilities. Model 3 therefore feeds further doubts as to whether market structural factors actually play a major role in price reductions.

Finally, it can be examined whether price pressure variables explain the probabilities of reduction. If, in addition to the round-specific fixed effects, as assumed so far, station-specific effects also play a role. For this purpose, a dummy variable was created for each filling station and each filling station, with the exception of the Lueneburg Shell filling station in Universitaetsallee (# 1), was included in the estimate. Table 15 shows the results, the petrol station results are always to be interpreted in comparison to the above petrol station (# 1). The actual price pressure variables remain largely the same, both in their statistical validation and in their economic explanation. From the average price differences of the competitors to the price of the sinker before its price reduction, are time-weighted as well as distance-weighted. Prices of the nearest and the third nearest petrol stations increase the probability of a very significant reduction, but are only economically significant in the direct price difference (approx. 7 pp). All three others remain below one percentage point in difference. The second closest petrol station has a statistically lower probability of a reduction but is only limited to 0.6 pp. A look at the individual petrol stations reveals a differentiated picture. The stations bft, Lüneburg (#12, 37.5 pp), Hoyer, Lueneburg (#10, 36.4 pp), Shell, Kirchgellersen (#22, 32.7 pp), Shell Lueneburg, Vor dem Bardowicker Tore (#14, 32.9 pp) and HEM, Lüneburg (#11, 32.3 pp) have particularly high, and of course highly significant, probabilities of decreasing prices. The Aral petrol station (Soltauer Allee, # 3, varied range of services) located near the center of Lueneburg, as well as the independent petrol station Autohaus Plaschka, are automatic petrol stations without any noteworthy service offerings (# 15) and have a significantly lower probability of contributing to the price reduction, at 0.3 or considerable 10.7 percentage points. At the lower end of the increased reduction, probabilities are the stations Shell, Lueneburg, Erbstorfer Landstraße (#7, 1.3 pp), Freie Tankstelle, Bardowick (#17, 4.7 pp), Shell, Bardowick, Hamburger Landstraße (#16, 6.3 pp), Aral,

Lueneburg Dahlenburger Landstr. (#4, 7pp) and Star, Lueneburg, Auf den Bloecken (#8, 9 pp). In total, the station-specific effects do not show a recognizable pattern. Neither is Shell always a price reducer, nor are the small independent suppliers to be regarded as "relative" non-sinkers. The same ambiguity exists in regard to the differentiation between city and rural petrol stations and the differences in service offerings. Only one thing becomes clear: station differences are far more influential than price pressure variables.

Table 15: Fixed-Effect-Logit: Price Differences and „Station fixed-Effects[1]

	(1)
Price difference to price sinker, compared to price before	0.268***
	|0.067|
	(0.010)
Price difference * duration; measured in machine h	0.0109***
	|0.003|
	(0.002)
Distance weighted price differences to nearest station, before	0.0315***
	|0.008|
	(0.005)
Distance weighted price differences to second nearest station, before	-0.021***
	|-0.005|
	(0.006)
Distance weighted price differences to third nearest station, before	0.009
	|0.002|
	(0.005)
Stations, compared to Station 1	
Station 2	0.501***
	|0.125|
	(0.063)
Station 3	0.269***
	|0.067|
	(0.065)
Station 4	0.282***
	|0.070|
	(0.063)
Station 5	0.785***
	|0.196|
	(0.089)
Station 6	1.081***
	|0.270|
	(0.065)
Station 7	0.512***
	|0.0128|
	(0.067)
Station 8	0.362***
	|0.090|
	(0.103)
Station 9	0.514***
	|0.128|
	(0.064)
Station 10	1.455***
	|0.364|
	(0.083)
Station 11	1.293***
	|0.323|
	(0.079)

Station 12	1.501*** |0.375| (0.074)
Station 13	0.572*** |0.143| (0.095)
Station 14	1.316*** |0.329| (0.063)
Station 15	-0.428*** |-0.107| (0.117)
Station 16	0.736*** |0.184| (0.063)
Station 17	0.189* |0.047| (0.093)
Station 18	0.633*** |0.158| (0.091)
Station 19	0.452*** |0.113| (0.073)
Station 20	0.596*** |0.149| (0.099)
Station 21	0.920*** |0.230| (0.072)
Station 22	1.467*** |0.367| (0.063)
Station 23	1.110*** |0.277| (0.082)
Station 24	0.583*** |0.146| (0.067)
Station 25	0.832*** |0.208| (0.094)
Station 26	0.469*** |0.117| (0.113)
Observations	293,798

[1]Dependant variable: Within one round: 1 = decreasing price observ., 0= non-decreasing price observ. Standard errors in parentheses; * p < 0.05, ** p < 0.01, *** p < 0.001. Values in || marginal average effects. Own calculations by using Stata 16.0.

In summary, although the explanatory variables included usually produce highly significant coefficients, the results are not always as good as expected from an economic point of view. However, the economic explanatory contribution often produces only minor or even negligible marginal effects. This applies in particular to the variables that measure the price pressure for the price reducer, even though it is precisely from a theoretical point of view that price pressure should be the central explanatory factor. Market structural factors alone have a very high economic significance. When

service variables, location parameters, and price differences are included, however, market structures dramatically lose in economic relevance. Service variables and location parameters are not methodologically well established, since in the data set service stations have neither changed their service offerings nor changed their location. Therefore, if one chooses to add "station-specific" effects to the estimation model, the price pressure variables continue to stand out with extremely little economic relevance. The individual stations participate to a very different extent in being the first price reducer when they offer other services. Neither petrol stations that are highly likely to be the first to lower their prices, nor stations that are less likely to lower their prices, have a recognizable pattern when it comes to their features. They do not belong to major brands, do not have the characteristic of being a petrol station in the city of Lueneburg, do not have a large range of services, and do not possess certain location characteristics. The present data set only allows for the conclusion that it is not the price differences that are important, but rather the features of the stations that determine whether one leaves the price paradise.

6 Robustness checks

It is possible that the derived results are distorted by the data selection. Gas station Aral Brietlingen (#21), as already mentioned, seems to follow an "unconventional" pricing policy in the morning. More generally, the first price reduction rounds on respective days could be distorted, as the operators orientate themselves more on the price level of the previous evening than on the prices of their competitors, who are already open that morning. As the later price reduction rounds occur much less frequently than the first ones, there may be different motives for price reductions. It is also conceivable that the assumed rationality of gas stations is exaggerated. Although the prices of competitors are relevant for the price reduction decision of a gas station, which can be easily determined by MTU, the speed of reaction is overestimated. Instead of allowing gas stations to react even to competitors' prices that changed a second ago, as has been the case up to now, it is possible to rule out very timely changes. As a result, it is possible to make alternative estimates by excluding price changes less than six or twelve minutes ago. These exclusions also take into account the fact that, formally, gas stations only have to notify MTU of price changes within five minutes. Although the obligation to report seems to be predominantly electronic and thus without time delay, reliable information on the "how" is not available. Furthermore, the generated definition of the price reduction event "suffers" from the fact that in most cases only one or two ct price reductions are observed. Consequently, alternative price reduction measures can be used to redo the estimates.

Table 16 shows the results of the robustness checks developed from the above considerations. In all alternative estimates, only the respective price pressure variables were used as explanatory variables,

since the price difference is at the center of the economic explanatory approach. Column 1 shows the results reported in the last chapter if only price difference variables are used. Thus, if we compare the results of the estimates without the first round on the respective day (round 0, column 2), we find almost exactly the same marginal average effects. If we examine only the influence of price pressure at petrol stations in the city area, we can include only those price reduction events that are attributable to petrol stations in Lueneburg in the given data set. Thus, we must exclude non-Lueneburg petrol stations (column 3a), or limit the data set from the outset only to city petrol stations and calculate new price reduction events from this, and an alternative data set results (column 3b). With the exception of the absolute price difference variable, the marginal average effects are the same in regard to the significance of the coefficients. With the absolute price difference, however, a fundamentally different result is obtained. With an increasing price difference of 1 ct, the probability of being the first to lower the price decreases by 4.9 or 4 pp. Although this approach reduces the number of cases to almost a third, the significant levels do not deteriorate at all. In this respect, it can only be stated that the result for petrol stations in the Lueneburg city area is counterintuitive if the absolute price difference is taken as a basis. However, all other price pressure variables do not change. If we estimate for the first ten price rounds only, there are almost no differences to the reference estimation (column 4). The omission of station #21 (Aral, Brietlingen), which can be done by omitting the price reduction events of station 21 (column 5a) or by excluding the gas station at the beginning of the data set creation/formation of a new data set (column 5b), only leads to about 1 pp less effect on the absolute price difference compared to the reference situation, without a change in sign. If very short-term price reductions are excluded (6 minutes for column 6, and 12 minutes for column 7), almost everything also remains the same. Only the direct price difference leads to a 1 ct higher average price, which in turn leads to a 1 pp higher probability of a reduction compared to column 1. If only the 1 or 2 ct reductions are taken into account, the marginal average effect for the direct price difference decreases slightly. Across all the robustness checks carried out, the results hardly differ, only the direct price difference when restricted to city petrol stations comes to a completely different, theoretically unexplainable result.

Table 16: Robustness Checks 1: Fixed-Effect-Logit[1]

	(1)	(2)	(3a)	(3b)	(4)	(5a)	(5b)	(6)	(7)	(8)	(9)
	All announ-cements (reference Estimation)	Without round 0	Lueneburg only Given price rounds	Lueneburg only New price rounds	First ten rounds only	Without station 21 Given price rounds	Without station 21 New price rounds	Without latest 6 minutes	Without latest 12 minutes	One cent price decreases only	Two cent price decreases only
Price difference to price sinker, compared to price before	0.184***	0.184***	-0.222***	-0.189***	0.192***	0.135***	0.141***	0.247***	0.281***	0.177***	0.160***
	|0.043|	|0.042|	|-0.49|	|-0.040|	|0.044|	|0.031|	|0.032|	|0.054|	|0.059|	|0.041|	|0.038|
	(0.008)	(0.008)	(0.019)	(0.018)	(0.009)	(0.008)	(0.008)	(0.008)	(0.008)	(0.016)	(0.010)
Price difference * duration; measured in machine h	0.0134***	0.014***	0.022***	0.026***	0.013***	0.022***	0.022***	0.005***	-0.003	0.0160***	0.014***
	|0.003|	|0.003|	|0.005|	|0.005|	|0.003|	|0.005|	|0.005|	|0.001|	|-0.0005|	|0.004|	|0.003|
	(0.002)	(0.002)	(0.003)	(0.001)	(0.002)	(0.002)	(0.002)	(0.001)	(0.001)	(0.004)	(0.002)
Distance weighted price differences to nearest station, before	0.039***	0.036***	0.314***	0.269***	0.042***	0.031***	0.031***	0.043***	0.040***	0.0465***	0.036***
	|0.008|	|0.008|	|0.070|	|0.057|	|0.010|	|0.007|	|0.007|	|0.009|	|0.008|	|0.011|	|0.009|
	(0.004)	(0.004)	(0.013)	(0.013)	(0.005)	(0.004)	(0.004)	(0.004)	(0.005)	(0.009)	(0.006)
Distance weighted price differences to second nearest station, before	-0.021***	-0.020***	-0.133***	-0.107***	-0.015*	-0.023***	-0.021***	-0.019***	-0.014**	-0.033**	-0.016*
	|-0.005|	|-0.005|	|-0.030|	|-0.029|	|-0.004|	|-0.005|	|-0.005|	|-0.004|	|-0.003|	|-0.008|	|-0.004|
	(0.005)	(0.005)	(0.007)	(0.007)	(0.006)	(0.005)	(0.005)	(0.005)	(0.005)	(0.011)	(0.007)
Distance weighted price differences to third nearest station, before	0.010*	0.011*	0.173***	0.148***	-0.001	0.028***	0.026***	0.010*	0.008	0.024*	0.002
	|0.002|	|0.003|	|0.047|	|0.031|	|-0.001|	|0.047|	|0.048|	|0.002|	|0.002|	|0.005|	|0.001|
	(0.005)	(0.005)	(0.039)	(0.008)	(0.005)	(0.006)	(0.006)	(0.005)	(0.005)	(0.011)	(0.007)
Observations	293,798	275,048	112,320	122,442	179,312	277,512	284,000	263,225	237,854	80,729	132,469

[1]Dependant variable: Within one round: 1 = decreasing price observ., 0= non-decreasing price observ. Standard errors in parentheses; * p < 0.05, ** p < 0.01, *** p < 0.001.
Values in || marginal average effects. Own calculations by using Stata 6.0.

In further robustness checks, the price pressure variables for different fuel types (diesel, Super E5 and E10) were used. Since the data set is not reduced in scope (no price observations or petrol stations were excluded), it is possible to check for effects specific to petrol stations. Table 17, with the exclusively printed price pressure effects, shows that there are identical marginal average effects compared to the estimate in Table 15, shown in column 1. In this respect, the incentives to be the first to lower the price do not seem to differ with respect to the fuels offered.

Table 17: Robustness check 2[1]

	(1) Diesel	(2) E5	(3) E10
Price difference to price sinker, compared to price before	0.268*** |0.067| (0.010)	0.258*** |0.065| (0.010)	0.247*** |0.062| (0.010)
Price difference * duration; measured in machine h	0.0109*** |0.003| (0.002)	0.013*** |0.003| (0.002)	0.009*** |0.002| (0.002)
Distance weighted price differences to nearest station, before	0.0315*** |0.008| (0.005)	0.023*** |0.006| (0.006)	0.038*** |0.010| (0.005)
Distance weighted price differences to second nearest station, before	-0.021*** |-0.005| (0.006)	-0.005 |-0.001| (0.006)	-0.007 |-0.002| (0.005)
Distance weighted price differences to third nearest station, before	0.009 |0.002| (0.005)	0.002 |0.001| (0.005)	-0.008 |-0.002| (0.005)
Observations	293,798	298,414	295,552

[1]Dependant variable: Within one round: 1 = decreasing price observ., 0= non-decreasing price observ. Controlled for station dummies. Standard errors in parentheses; * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. Values in || marginal average effects. Own calculations by using Stata 16.0.

The fact that the later observable willingness to be the first to lower the price, after which prices have previously gone up, would have feedback effects on the previously set prices can hardly be justified in theory (no problem of reverse causality). Whether the price differences determined are actually causal in the sense that the price cutters "respond" to them is first tested by a) ruling out very short-term price cuts (less than six or twelve minutes), b) excluding the first round and c) only the first ten rounds. Secondly, checks were carried out for observable market structural factors (thus also for uniform group strategies at Aral and Shell), location factors, service offerings, as well as for unobservable round-specific, and, if applicable, petrol station-specific fixed effects. The latter would, for example, also take into account the fact that individual petrol stations pursue a fixed price reduction policy, such as always reducing prices at the same time or always orienting themselves to a reference petrol station (if this is one of the three nearest petrol stations, this was explicitly controlled). Random price reduction behavior would be neglected by the approaches used. Of course, it is conceivable that other explanatory factors are relevant (omitted variables), but what should they be and how should they be

measured? The alleged price pressure variables in particular explain only relatively little why price reductions occur.

7 Summary and Conclusions

German gas stations must report their current price reports to MTU of the Federal Cartel Office. Internet and app providers such as Clever Tanken use this information to generate information services that motorists can use to help them choose the cheapest filling stations. Of course, this information is not only useful to those who demand it, but it is also much easier for providers to overlook the prices set by their local competitors than was the case before MTU was introduced at the end of 2013. In this respect, from an economic point of view, one would expect gas stations to react very quickly to price changes.

Gasoline prices in Germany fluctuate very strongly within a day. With a more or less fixed ritual, they go up in the late evening or in the middle of the night, drop relatively sharply in the early morning and then go up and down again in the course of the day. In this paper, the price reduction of the supplier was identified for the Lueneburg area, who, after rising prices, is the first supplier to go down again. In economic terms, he is thus leaving the high price level for all petrol stations and lowering his price, although he should know from experience that his competitors will follow him. So, he is the first to give up the price paradise. According to the theory of Edgeworth cycles, such price undercutting occurs when the price-reducing petrol station (price reducer) is too expensive without a price reduction. Simply micro-economically speaking, one would lower one's price if the sales gains from the price reduction exceeded the sales losses that would not occur without the price reduction. Thus, especially petrol stations that compete on price due to worse locations tend to lower their price. In the same way, they would tend to lower prices if they wanted to attract customers by offering services. The existence of shops, for example, falls into this category. This quantity incentive is strengthened if, like the petrol stations tied to the big brands, they only receive a fixed revenue per quantity sold anyway. Suppliers with market power should have less need to act as the first price reducer.

In order to explain who is the first to lower the price, the generally accessible data set has been massively revised. The data set I used, which covers the years 2018 and 2019 almost completely, was limited locally to the maximum of 26 petrol stations that are active in Lüneburg and the surrounding area. The limitation to one region allows the assumption that the companies located there are in competition with each other. On the basis of the definable first price reduction after price increases, the price that applied immediately before the price reduction event was determined for all petrol stations. The basic assumption of the essay was that one second before the price reduction event all petrol stations were facing the same price situation, but only one petrol station decided to reduce its

price. The currently valid price observations of the non-lowerers, and those of the lowerers before their price reduction (26), plus the price observation of the lowerers with the reduced price form a panel unit. Up to 37 price reduction events on one day and thus panel observations could be identified. The reworking of the data in the manner described above thus allows the price dynamics to be mapped, which is extremely easy to identify due to the high time precision of MTU data. A fixed-effect logit approach was then used to test what distinguishes the price cutters from the non-price cutters.

For the estimated logit approaches, it is true that the explanatory variables included usually produce highly significant coefficients, but some of them produce only minor or quite limited significant effects from an economic point of view. According to the theory of Edgeworth cycles, the price pressure exerted by competitors should be particularly relevant for the price reducer, although it actually plays a relatively minor role. Market structural factors have a very high economic significance, which, however, is significantly reduced if service variables, location parameters and price differences are included. Since service variables and location parameters do not change in the data set, an estimation model with "station-specific" effects is most plausible. There, the highly significant price pressure variables have only very little economic relevance. The factor alone, that on average 1 ct cheaper competitors increase the probability of reduction by 6 pp, is economically significant. When looking at the station-specific effects, individual brands, service offerings, and certain location characteristics do not seem to be decisive. However, the stations themselves are more important than the price differences when it comes to willingness to leave the price paradise.

Sometimes it is Adam, and sometimes Eve, to leave the price paradise. One does not know why they do so. Is it not the external so-called seductive snake that pressures them to lower prices? These results are also robust for alternative model specifications. Only if the data set is reduced to petrol stations in urban areas do lower prices of competitors lead to a lower probability of lowering prices, a counterintuitive result.

The above results should be treated with caution to a certain extent. First, only the Lueneburg region was analyzed. In other regions, especially those with a different composition of the petrol station stock, the results could change. For the decisive question of market definition, however, local knowledge is extremely important in order to clearly define commuter routes, or to decide which fringe petrol stations still belong to them. It would also be nice to have variations over time in the market structure, services offered, and location variables. However, the effort required to record the service variables on a day-to-day basis is very high, and changes in brand image, or relocation are very rare in the German petrol station market. It should also be problematic that only price information is received before the price reduction event, but no one looks at what happens at least shortly afterwards. It is possible that other petrol stations react to the market situation with price reductions in the same way

as the supplier reacts with the identified price reduction, perhaps only shortly afterwards. Considering how long the path is from the common evaluation of MTU data based on average prices at specific times, to the mapping of price dynamics as in this paper, should be left to further research. Overall, however, I fully agree with the thesis of Byrne/De Roos (2019) that the future of empirical research on gasoline prices will lie in the analysis of dynamic price processes.

Annex

Table A1

Id	Nearest station	Second nearest station	Third nearest station
	id		
1	2	3	13
2	1	3	12
3	12	11	2
4	5	8	6
5	4	6	8
6	4	2	13
7	13	4	19
8	4	5	6
9	10	15	13
10	9	15	13
11	3	13	14
12	3	14	19
13	14	15	7
14	13	7	15
15	1	9	13
16	17	9	10
17	16	9	10
18	18	9	10
19	18	7	9
20	19	18	21
21	18	19	17
22	11	12	3
23	4	5	26
24	26	25	1
25	1	2	24
26	24	3	25

	Nearest	Second nearest	Third nearest
id	id		
1	2	3	13
2	1	3	12
3	12	11	2
4	5	8	6
5	4	6	8
6	4	2	13
7	13	4	19
8	4	5	6
9	10	15	13
10	9	15	13
11	3	13	14
12	3	14	19
13	14	15	7
14	13	7	15
15	1	9	13
16	17	9	10
17	16	9	10
18	19	7	10
19	18	7	9
20	19	18	21
21	18	19	17
22	11	12	3
23	4	5	26
24	26	25	1
25	1	2	24
26	24	3	25

Table A2: Station characteristics I

Id	In sight	National road	Car repair	Self Service	Shop	Rewe to go	ATM	Toilet	Car wash	Bistro	Vacuum cleaner	In Bakery-store	Kiosk
1	X	X	X		X		X	X	X				
2	X	X			X				X				
3					X	X		X	X	X			
4					X	X			X				
5					X			X		X	X	X	
6					X				X		X		
7					X		X	X	X				
8					X					x		X	
9					X			X	X	x			
10				X	X			X	X	x			
11					X		X			x	X		
12					X								
13				X							X		
14			X		X			X		X	X	X	
15				X									
16		X			X		X	X	X	X			
17		X	X										
18		X		X					X				
19			X		X			X		X	X	X	
20					X				X				
21										X			X
22			X		X			X			X		
23				X				X					X
24		X	X	X	X			X		x		x	
25			X		X			X			X		

26		X				X			

Table A3: Station characteristics II

	Dahlenburg	Gellersen	Uelezen	Lüneburg-Nord	Lüneburg-Mitte	Mo-Friday	Staturday	Sunday/Public-Holidays
	Commuter routes					Opening hours		
1			X	X		24	24	24
2			X			17	16	15
3						24	24	24
4	X					24	24	24
5	X					16	15	14
6						18	16	16
7					X	24	24	24
8	X					17	17	14
9				X		24	24	24
10						24	24	24
11		X				24	24	24
12		X				16	15	14
13				X	X	24	24	24
14						18	17	16
15				X		24	24	24
16						24	24	24
17						14.5	14	13
18						24	24	24
19						24	24	24
20						24	24	24
21						13	24	14
22		X				16	16	14
23	X					24	24	24
24			X			17	16	24

25	24	24	24
26	12	6	0

Table A4a: Percentages of Price Decreasers per Rounds

				Round																
id	Brand	Street	Place	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
				%																		
1	Shell	Universitätsallee 13	Lueneburg	2.5	5.8	4.3	3.2	4.6	3.8	3.4	3.3	3.8	2.9	2.7	3.6	4.0	2.2	2.8	5.0	2.5	2.4	3.7
2	ARAL	Universitätsallee		3.9	8.5	8.4	8.0	6.1	5.6	5.4	4.0	4.4	5.6	7.1	5.2	3.7	5.8	5.3	6.6	7.7	5.2	8.2
3		Soltauer Str.		3.4	5.0	6.3	6.5	5.3	4.6	5.9	6.6	4.1	5.1	5.8	5.2	6.8	6.0	4.4	4.1	10.5	9.2	6.9
4		Dahlenburger Landstr.		5.0	6.7	9.9	7.7	7.6	8.4	8.0	7.2	8.2	8.1	8.6	8.0	9.2	8.2	6.6	5.9	4.9	6.4	5.0
5	LTG	Dahleburger Landstr.		1.3	3.4	2.4	3.7	2.9	2.1	1.3	2.1	1.1	1.4	1.1	1.6	1.1	1.4	1.9	1.9	0.7	1.2	2.7
6	ESS0	Bleckeder Landstr. 35		13.1	2.6	3.0	3.2	3.9	5.0	4.3	6.0	4.7	4.7	6.0	4.4	5.1	8.4	6.9	7.5	9.8	7.6	8.2
7	Shell	Erbstorfer Landstr. 2b		6.6	3.9	4.5	4.8	5.0	3.9	3.7	3.3	3.6	5.2	5.3	4.2	5.1	4.6	6.1	4.7	3.9	4.4	6.4
8	STAR	Auf den Bloecken		1.1	2.6	1.1	1.7	0.7	0.4	0.9	1.5	0.6	0.8	0.9	1.2	1.1	0.7	0.8	0.3	0.7	1.2	0.5
9	ARAL	Hamburger Str.		5.4	6.6	6.3	5.2	6.5	7.1	4.6	5.3	5.7	4.6	5.5	7.0	6.2	6.2	6.4	8.8	7.4	6.0	6.4
10	Hoyer	Bessemer Str		3.2	5.2	4.4	4.4	3.0	2.7	3.4	1.1	2.5	2.0	2.7	2.6	2.4	1.4	3.3	2.5	1.1	2.0	3.7
11	HEM	Vor dem Neuen Tore		1.5	3.0	2.1	2.2	1.7	2.1	2.3	2.7	3.5	2.9	3.1	5.0	3.3	2.4	4.4	2.2	7.4	3.6	5.0
12	Bft	Am Grasweg 32		2.8	2.6	2.8	2.8	3.9	3.5	3.0	4.5	4.7	3.5	5.1	4.4	6.8	6.5	6.1	7.5	7.4	7.2	6.85
13	Beckmann/-Lindemann	Auf der Hude		2.5	2.1	3.3	1.8	1.2	1.8	1.0	0.6	2.1	1.0	1.1	1.4	1.3	1.0	1.1	1.9	1.4	1.2	0.5
14	Shell	Vor dem Bardowicker Tore		1.1	4.0	4.5	4.1	7.3	8.7	8.3	10.2	10.4	10.3	8.6	11.2	6.8	9.4	9.9	10.0	4.6	10.8	6.4
15	Freie Tankstelle	Hamburger Str.		0.3	0.4	1.1	1.2	1.4	0.6	0.6	0.2	0.5	0.8	1.1	1.4	1.1	0.7	1.4	1.9	0.7	2.0	1.4
16	Shell	Hamburger Landstr. 20	Bardowick	17.2	6.2	5.5	4.3	5.1	6.1	6.6	5.1	5.2	7.1	5.8	7.6	6.4	7.0	4.1	2.8	6.3	6.0	4.1
17	Freie Tankstelle Salewski	Hamburger Landstr.		2.8	2.6	2.3	1.8	1.4	1.1	1.3	0.8	2.7	1.9	1.5	0.8	0.9	2.0	0.6	0.6	1.1	1.2	1.8
18	JET	Artlenburger Landstr. 62	Adendorf	2.6	4.0	2.2	2.5	1.9	1.8	0.4	1.1	0.6	1.7	1.3	1.4	1.5	1.7	0.8	0.6	1.4	1.2	0.9
19	Shell	Bueltenweg		1.4	1.9	2.5	5.4	2.8	6.6	5.4	3.6	6.2	4.4	4.2	4.2	3.7	1.7	1.9	1.6	1.4	1.2	0.9
20	Raiffeisen	Raiffeisenstr.	Scharne-beck	1.2	1.7	1.8	2.1	1.5	1.5	1.4	2.0	1.3	1.7	1.3	0.6	0.7	1.9	1.9	1.3	2.1	0.0	0.5
21	ARAL	Bundesstr.	Brietlingen	4.3	5.0	4.4	4.8	6.9	4.6	5.4	6.3	4.0	4.9	5.5	3.8	5.1	3.8	3.0	2.2	2.1	2.8	1.4
22	Shell	Lueneburger Str.	Kirch-gellersen	3.2	7.3	6.2	8.1	8.7	8.0	10.4	11.3	9.9	10.9	7.9	4.8	9.5	7.9	8.8	9.7	6.0	6.4	9.1
23	Raiffeisen	Lueneburger Str.	Barendorf	2.6	3.2	4.3	4.4	2.6	1.7	2.4	3.5	2.5	1.4	0.7	1.8	1.5	1.9	2.2	2.2	1.8	2.0	0.9
24	Shell	Uelzener Str.	Melbeck	10.2	3.7	3.6	2.9	4.8	4.3	6.0	5.4	4.7	5.9	4.4	5.8	5.3	6.2	6.9	5.3	4.9	4.8	7.3
25	LTG	Timelostr.	Deutsch Evern	1.1	0.7	1.7	1.7	1.9	2.4	2.4	1.4	1.4	1.0	1.5	2.0	1.1	1.2	1.4	2.2	2.1	0.8	0.5
26		Bahnhofstr.	Embsen	0.3	1.5	1.4	1.8	1.2	1.5	2.0	0.6	1.7	0.5	1.3	0.6	0.4	0.0	0.8	0.9	0.4	3.2	0.9
Sum of price decreasers				728	728	728	727	723	717	699	667	635	594	548	499	455	417	362	320	285	250	219

Table A4b: Percentages of Price Decreasers per Rounds

				Round															
id	Brand	Street	Place	19	20	21	23	24	25	26	27	28	29	30	31	32	33	34	35	36
				%																
1	Shell	Universitätsallee 13	Lueneburg	5.7	2.4	3.4	2.9	5.1	3.2	6.1	2.6	10.0	4.6	0.0	6.3	25.0	0.0	0.0	0.0	0.0
2	ARAL	Universitätsallee		7.3	6.7	4.2	7.8	5.1	3.2	8.2	15.4	6.7	4.6	10.5	6.3	0.0	16.7	0.0	0.0	0.0
3		Soltauer Str.		5.7	12.2	6.3	7.8	3.8	6.5	4.1	2.6	6.7	18.2	10.5	0.0	0.0	0.0	0.0	33.3	0.0
4		Dahlenburger Landstr.		3.6	4.9	5.6	7.8	10.1	3.2	12.2	0.0	6.7	13.6	0.0	12.5	0.0	0.0	0.0	0.0	0.0
5	LTG	Dahleburger Landstr.		1.6	1.8	1.4	0.0	0.0	4.8	0.0	5.1	3.3	0.0	10.5	6.3	0.0	16.7	0.0	0.0	0.0
6	ESS0	Bleckeder Landstr. 35		11.4	11.6	11.3	14.6	16.5	4.8	12.2	12.8	6.7	4.6	10.5	6.3	25.0	33.3	20.0	0.0	0.0
7	Shell	Erbstorfer Landstr. 2b		3.1	5.5	5.6	1.0	2.5	3.2	2.0	5.1	3.3	4.6	0.0	18.8	25.0	0.0	0.0	0.0	0.0
8	STAR	Auf den Bloecken		3.1	3.1	1.4	1.0	0.0	3.2	0.0	7.7	3.3	9.1	5.3	6.3	0.0	0.0	20.0	0.0	0.0
9	ARAL	Hamburger Str.		6.7	5.5	5.6	4.9	5.0	4.8	6.1	10.3	13.3	9.1	5.3	12.5	0.0	16.7	0.0	0.0	100.0
10	Hoyer	Bessemer Str		2.1	0.6	4.2	3.9	1.3	1.6	2.0	2.6	3.3	13.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0
11	HEM	Vor dem Neuen Tore		4.7	6.1	6.3	1.9	10.1	3.2	4.1	10.3	3.3	4.6	5.3	0.0	0.0	0.0	0.0	33.3	0.0
12	Bft	Am Grasweg 32		6.2	5.5	7.8	3.9	7.6	8.1	8.2	2.6	6.7	0.0	0.0	6.3	0.0	0.0	0.0	0.0	0.0
13	Beckmann/Lindemann	Auf der Hude		1.6	0.6	2.8	0.0	0.0	0.0	2.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
14	Shell	Vor dem Bardowicker Tore		7.3	7.3	8.5	10.7	8.9	6.5	4.1	10.3	3.3	0.0	0.0	0.0	25.0	0.0	0.0	0.0	0.0
15	Freie Tankstelle	Hamburger Str.		0.5	1.8	0.0	0.0	0.0	1.6	0.0	0.0	0.0	4.6	0.0	0.0	0.0	0.0	0.0	33.3	0.0
16	Shell	Hamburger Landstr. 20	Bardowick	6.8	4.3	7.0	1.0	5.1	9.7	8.2	2.6	6.7	0.0	21.1	0.0	0.0	0.0	40.0	0.0	0.0
17	Freie Tankstelle Salewski	Hamburger Landstr.		0.5	3.1	0.0	1.9	0.0	1.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
18	JET	Artlenburger Landstr. 62	Adendorf	1.0	1.2	1.4	3.9	5.1	4.8	4.1	0.0	3.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
19	Shell	Bueltenweg		1.6	0.0	0.0	2.9	1.3	3.2	2.0	2.6	0.0	0.0	5.3	0.0	0.0	0.0	0.0	0.0	0.0
20	Raiffeisen	Raiffeisenstr.	Scharnebeck	3.6	0.0	0.0	0.0	0.0	1.6	2.0	0.0	3.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
21	ARAL	Bundesstr.	Brietlingen	0.5	1.2	0.0	0.0	0.0	0.0	0.0	-	-	-	-	-	-	-	-	-	-
22	Shell	Lueneburger Str.	Kirch-gellersen	3.6	4.9	5.6	8.7	3.8	4.8	6.1	0.0	0.0	4.6	0.0	6.3	0.0	0.0	0.0	0.0	0.0
23	Raiffeisen	Lueneburger Str.	Barendorf	2.1	1.2	0.7	1.9	2.5	1.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
24	Shell	Uelzener Str.	Melbeck	7.8	6.1	8.5	6.8	3.8	12.9	4.1	2.6	0.0	0.0	10.5	0.0	0.0	0.0	0.0	0.0	0.0
25	LTG	Timelostr.	Deutsch Evern	2.1	1.2	1.4	3.9	1.3	1.6	0.0	5.1	6.7	4.6	5.3	6.3	0.0	0.0	0.0	0.0	0.0
26		Bahnhofstr.	Embsen	0.0	1.2	0.7	1.0	1.3	0.0	2.0	0	0.0	0.0	0.0	6.3	0.0	0.0	0.0	0.0	0.0
Sum of price decreasers				193	164	142	103	79	62	49	39	30	22	19	16	8	6	5	3	1

Table A-5: Fixed-Effect-Logit 4[1]

	(1)	(2)	(3)
Aral	0.829***		-0.238***
	|0.102|		|-0.053|
	(0.049)		(0.008)
Shell	0.935***		-0.024
	|0.115|		|-0.005|
	(0.058)		(0.037)
Non-oligopolist, nationwide?	-0.262***		0.107**
	|-0.32|		|0.024|
	(0.047)		(0.041)
Non-oligopolist, local?	-0.381***		-0.237***
	|-0.047|		|-0.053|
	(0.054)		(0.046)
In sight?	1.087***		
	|0.133|		
	(0.175)		
Commuter to motorway exit Lueneburg-North?	0.041		
	|0.005|		
	(0.036)		
Commuter to motorway exit Lueneburg-Middle?	-0.399***		
	|-0.049|		
	(0.057)		
Commuter to direction West (Gellersen)?	0.230***		
	|0.028|		
	(0.040)		
Commuter to direction South (Uelzen)?	-1.216***		
	|-0.149|		
	(0.183)		
Commuter to direction East (Dahlenburg)?	-0.190***		
	|-0.023|		
	(0.036)		
Located at Federal Road?	-0.225***		
	|-0.028|		
	(0.046)		
Located near Motorway?	0.329***		
	|0.040|		
	(0.081)		
Car repair	-0.469***	0.397***	
	|-0.574|	|0.003|	
	(0.040)	(0.074)	
Self service station?	-0.013	0.940***	
	|-0.001|	|0.003|	
	(0.054)	(0.062)	
Opening hours Monday to Friday?	-0.160***	0.054*	
	|-0.003|	|0.003|	
	(-0.020)	(0.027)	
Opening hours Saturday?	-0.060***	-0.010	
	|-0.007|	|-0.003|	
	(0.009)	(0.027)	
Opening hours Sunday/Public Holiday?	0.137***	-0.098***	
	|0.017|	|-0.003|	
	(0.016)	(0.010)	
Price difference to price sinker, compared to price before		0.229***	0.202***
		|0.021|	|0.045|
		(0.010)	(0.008)
Price difference * duration; measured in machine h		0.017***	0.014***
		|0.002|	|0.003|
		(0.002)	(0.002)
Distance weighted price differences to nearest station, before		0.029***	0.039***
		|0.003|	|0.009|

		(0.005)	(0.004)
Distance weighted price differences to second nearest station, before		-0.032***	-0.025***
		|-0.003|	|-0.006|
		(0.006)	(0.005)
Distance weighted price differences to third nearest station, before		0.030***	0.014**
		|0.003|	|0.003|
		(0.005)	(0.005)
Station with Shop?		1.463***	
		|0.133|	
		(0.072)	
Station with Rewe-to-Go-Shop?		0.400***	
		|0.036|	
		(0.079)	
ATM?		0.288***	
		|0.026|	
		(0.044)	
Restrooms available?		-0.148***	
		|-0.013|	
		(0.037)	
Number of accepted credit cards?		-0.073***	
		|-0.007|	
		(0.013)	
Car Wash?		0.149*	
		|0.014|	
		(0.062)	
Consumer satisfaction?		0.575***	
		|0.052|	
		(0.106)	
Bistro?		0.371***	
		|0.034|	
		(0.039)	
Vacuum cleaner?		0.488***	
		|0.044|	
		(0.034)	
In-Store-Backery?		-0.556***	
		|-0.051|	
		(0.048)	
Stations in rural area?		0.111***	0.021
		|0.010|	|0.005|
		(0.028)	(0.022)
Observations	293,798	260,141	293,798

[1]Dependant variable: Within one round: 1 = decreasing price observ., 0= non-decreasing price observ. Standard errors in parentheses; * p < 0.05, ** p < 0.01, *** p < 0.001. Variable "round" has been omitted. Values in || marginal average effects. Own calculations by using Stata 16.0.

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