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Market definition of the German retail gasoline industry on highways and those in the immediate vicinity

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Abstract

The geographical definition of markets is a crucial challenge for economists. With the availability of multiple tools to compare prices, the idea of market definition is entering a new era as it infiltrates the digital sphere. Since December 1st, 2013 the market transparency unit of the Federal German Cartel Office is forwarding all prices, for every gasoline type, at every gasoline station in Germany at all times, through consumer information services to consumers by the means of websites or smartphone apps. Gasoline is a perfectly homogenous product as there is no alternative for its consumption by car, bus or truck drivers in the short or medium run. The availability of price data allows us to study what premiums drivers are willing to pay in order to avoid search costs or additional driving distances. The research question is how prices of highway gasoline stations are dependent upon prices offered by street gasoline stations in the vicinity, and what additional price customers are willing to pay to avoid searching for another gasoline station away from the highway. Results indicate that there is a premium of 10 to 11 cents per litre throughout the day and 15 cents per litre in the evening on gasoline sold by stations on the highway. When checked for robustness, results indicate that the pricing behavior of gasoline stations differ depending on the particular market environment. There is no uniform pricing behavior of highway gasoline stations. Some highway gasoline station are setting their prices independently from the gasoline stations in the vicinity, other are acting like regular gasoline stations and do not even charge an additional premium. Furthermore, a high frequency of traffic on highways leads to lower prices whereas a high population density leads to higher prices.

Keywords: market definition, applied economics, pricing patterns, gasoline market

JEL-Classification: D03, D40, L11

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1. Introduction

Defining the geographical market is an economic aspect that is little considered in academic research. With the availability of mobile internet and price comparison websites, there are many opportunities to compare prices of different suppliers. At the same time, some goods cannot be mailed easily and therefore have a limited geographical market. Some markets have a high level of price transparency. One example of this is the German retail gasoline market. Price data exists for all gasoline stations on the German gasoline market, roughly 14.700 gasoline stations, for all types of gasoline available over a duration of 18 months. This amount of 150 million price observations allows for different assessments. The geographical market definition is a concept, which has been comprehensively discussed in theory. These concepts have seldom been applied in practice for any good or service. The market transparency unit gasoline of the Federal German Cartel Office has primarily focused on price developments within particular zip code areas.

The analysis at hand describes a geographical market definition of a pivotal part of a market economy. In the case of highway gasoline stations there are two hypotheses

(i) Highway gasoline stations are holding a monopoly position and can charge the monopoly rent. If a company is holding the monopoly position, they are able to charge prices without considering the prices of any other gasoline retailer. Consequently, the price changes are primarily due to different crude oil prices and are rather independent of gasoline stations in the immediate vicinity.

(ii) Highway gasoline stations are competing with regular gasoline stations in their proximity. Consequently, there is a price markup and the prices are moving accordingly.

These theories are tested empirically.

The gasoline market is of pivotal importance in every market economy. The availability of gasoline is crucial for mobility of all market participants. Since every market participant, every commuter and every car driver is in need of gasoline, gasoline prices have become a matter of political debate. There is a growing debate about alternative ways of commuting, like public transportation, but the majority of commuters are still using their own vehicle that runs on either Diesel or gasoline.

Fehl and Schmidtchen examined the market of highway gasoline stations in 1986. They found it had been a separate geographical market than gasoline stations in the

proximity. Prices would be 2 Pfennig (1 Euro Cent) higher than at surrounding gasoline stations. Every price increase above 1 Euro Cent would constitute an abuse of market dominance, especially the existence of a “track monopoly would require a special justification for a higher price markup. In 1986 the average price for gasoline in Germany was 0.54 € per litre (1.08 German Marks) and the average price for Diesel was 0.50 € per litre (0.99 German Marks), a little bit less than half the price in the time of the examination. According to this adjustment, a price difference of more than 2 Cents per litre would constitute an abuse of market dominance of highway gasoline stations.

There is a large number of further studies on the functioning of the German fuel market, but these do not deal with market definition. Neukirch/Wein (2016) have investigated the German fuel market using medium-sized cities as geographical boundaries. They examined the pricing behaviour of the 5 most powerful petrol station operators, the alleged "oligopolists" (Aral, Shell, Total, Esso, Jet) and the other petrol station operators.

Haucap/Heimeshoff/Siekmann (2016) examined service stations, which were connected to another retailer and only sell fuel as a by-product. These have a price-reducing effect on the surrounding petrol stations. According to Dewenter/Heimeshoff/Lüth (2017), the higher price transparency has led to a higher price level. The Federal German Cartel Office also regularly examines the development of the fuel market after the introduction of the market transparency office for fuels, usually on an annual basis.

The theoretical background for price cycles has been developed by Maskin/Tirole (1988). According to their model, two companies are competing solely based on the price. They take turns in setting the price and only the price of the current period is relevant for their decision (Markov strategies). Competitors try to undercut each other with their prices in order to win over consumers; however, once the companies have reached their marginal costs, one company is forced to raise the price because it cannot lower it any further. All other companies follow this example and price-undercutting competition continues from the higher price level until marginal costs are reached again. This creates Edgeworth cycles. In the following analysis, we assume that Edgeworth cycles exist. Edgeworth cycles arise when there is strong competitive pressure in a market, but it is a matter of the scientific debate whether or not Edgeworth cycles are a sign of malfunctioning markets or competitive markets.

Eibelshäuser/Wilhelm (2017) have identified the existence of Edgeworth cycles on the German gasoline market, which in turn lead to lower consumer welfare. Noel (2007a, b, 2008) and Atkinson/Eckert/West (2014) found evidence for Edgeworth cycles in the

Canadian gasoline market, especially in Toronto. Byrne & de Roos (2019) and Doyle/Muehlegger/Samphantharak (2010) and Lewis (2012) found Edgeworth cycles in the US gasoline market. Wang (2009a, b) found evidence for Edgeworth cycles in Western Australia. Foros/Steen (2013) find the evidence of Edgeworth cycles in the gasoline market in Norway and Nguyen/Steen (2018) in Sweden.

Another branch of research on the gasoline market is the speed at which retail gasoline prices adjust to price changes on the crude oil or wholesale market. This is described as rocket and feather behaviour, meaning a quick reaction to price increases and a slow reaction to price decreases. Bacon (1991), Galeotti/Lanza/Manera (2003), Verlinda (2008), Bremmer & Kesselring (2016) and Tappata (2009) found evidence for this pricing behaviour on the retail gasoline markets of different countries.

The role of market power on the price level of different gasoline markets has been investigated by Borenstein/Shepard (1996), Deltas (2008) and Dewenter/Heimeshoff/Lüth (2017). Kihm/Ritter/Vance (2016) have identified factors other than crude oil prices that have an impact on fuel prices. Noel (2019) is testing the most efficient method in calendar synchronisation to allow consumers to predict lower gasoline prices. On the international level, there are many different studies on facets of the functioning of gasoline markets.

Consumers that decide to fill up their gas on a highway gasoline station are paying a higher price that can be perceived as a premium to avoid search costs. Additionally, considering the high fluctuations in the German retail gasoline market, these drivers reduce uncertainty about possible price increases that might have just taken place at gasoline stations at the exits.

To begin, the theories on geographical market definitions are outlined (2.). As a next step, the econometric model and the underlying data are presented (3.). The descriptive results are presented (4.) as well as the multivariate result (5.). A number of robustness checks are conducted to check the viability of the results (6.). Finally, a conclusion is drawn (7.).

2. Geographical market definition

There is exhaustive theoretical literature on the geographical market definition. The concepts mentioned in the following part are only the most renowned and most relevant ideas for geographical market definition. In the economic market definition, substitution plays

the decisive role in defining the geographic market (as well as the product market). In turn, there are different methodological approaches to determining substitution.

The Federal German Cartel Office is basing its estimation on the accessibility model, which was developed by the Federal German Institute for Research on Building, Urban Affairs and Spatial Development. By assessing all means of transportation, streets, railroads, waterways and aviation, it is estimating which areas belong to each other, because they can be reached within a certain time (BBSR (2020)). Through the accessibility of individual gasoline stations, consumers could decide to refuel at another place.

Massey (2000) developed and further elaborated the idea of price elasticity and cross-price elasticity. By increasing the price for product, I there might be a quantity effect for product J as consumers desire to substitute it. As engines operate with either diesel or gasoline, product substitution does not need to be considered. According to the theory of the substitution gap, all goods compete with each other. However, there are substitution gaps that arise because the nearest substitution product is too far away. As a result, spatially delimitable markets emerge.

The demand market concept says that all products and services that consumers consider have the same characteristics and the same purpose of use as well as being in the same price category. In order to quantify this, the SSNIP test method is used. In the SSNIP test, an abbreviation for "Small but significant and non-transitory increase in prices", the prices of a good in a market are increased by 5-10%. If there is a price increase or increased demand for other goods in other regions, it is the same market and the goods are substitution goods or complementary goods. Nevertheless, according to the demand market concept, price increases from highway service stations at nearby road service stations would have to be reflected if the geographic market is common. Juselis and Stenbacka (2011) apply this concept to the wholesale electricity market in the Nordic countries.

Critics of the SSNIP test complain that it cannot be used if a powerful company has already set an excessive price for a certain product or service. However, this test is not appropriate if there is already a higher price level. This is described as a "cellophane paradox". On the fuel market, however, prices change so frequently that this is not relevant. If highway filling stations increase their fuel prices and nearby filling stations belong to the same geographic market, they would have to react within a (relatively) short amount of time. In the later section of this paper, this question is investigated. Since consumers also have the opportunity to compare prices in the immediate vicinity of their location before refuelling their car, they would respond immediately to lower prices at other gasoline stations. Because of

this assumed behaviour, price changes are eliminated in the medium-term, according to economic theory.

Additional concepts on the geographical market definition have been developed, but are not applicable in this case (Strand 2006). The concept of cross-price elasticity cannot be applied here, because cars need to be fuelled with either Diesel or regular gasoline. The price increase or decrease of one does not affect the demand of the other.

3. Model and Data

In light of the previous section, I present a model on the demand of the price developments on the highway gasoline market. In the first estimation, the price at the gasoline station is determined by the basis price and a possible premium at the highway gasoline station as well as an error term.

The share of drivers can be higher on particular days, because people with corporate cars might be commuting from their workday homes to their family homes. For traditional work relationships, these times would be Monday or Saturday morning and Friday or Sunday evening. Taking into account flexible working, like working from home etc., means different days might have a different effect. Besides that, prices on Sunday or holidays might be higher, because of a higher uncertainty whether or not gasoline stations close to the highway are open.

Furthermore, in order to compare prices of gasoline stations that are open, only prices at 8:00 hours, 12:00 hours, 16:00 hours and 20:00 hours are examined. Additionally, it is investigated whether or not there is a special premium at night, 24:00 hours, and early in the morning, 4:00 hours. At these times, the likelihood that a gasoline station in the proximity is closed is very high. This would come along with a high uncertainty when leaving the highway.

Besides that, there might be different pricing behaviours during different working days. This would come along with a different pricing behaviour during different days of the week. Finally, several control variables is introduced that controls for several other effects. These control variables are a high traffic frequency, the number of gasoline stations in the proximity of the highway gasoline station, the distance to the three closest gasoline stations, the population density and if the gasoline station was located in former East or West Germany.

Every gasoline station in Germany is legally obliged to report the prices for all types of gasoline at sale every 5 minutes to the Market Transparency Unit (MTU) of the Federal German Cartel Authority. The MTU is then forwards all information to privately organised companies that make the data accessible for final consumers through websites or smartphone applications. However, data on the volume of gasoline sales is not made accessible. All price data has been provided by Tankerkönig. The original data set covered Diesel, E5 and E10 gasoline prices of all gasoline stations in Germany. The data consists of all price observations from May 1st, 2016 to March 8th, 2018. There are 360 highway gasoline stations in Germany and a random sample of 5% has been drawn, overall it considers the prices of 18 highway gasoline stations.

Graph 1: Sample of Highway Gasoline Stations

All price data has been modified in a way that outlines the price at every full hours. The following example illustrates the data processing: If a gasoline station increase their price at 15:23:39 hours from 1.21 € to 1.28 €, the given price is 1.21 at 15:00 hours and 1.28 at 16:00 hours. Additional control variables have been created manually. The distance from the sample of highway gasoline stations to the closest, the second closest and the third-closest gasoline stations have been identified by using GoogleMaps. Variables for each day of the week and Federal holidays in Germany have been created. The Federal holidays are New Year's Day, Good Friday, Easter Sunday, Easter Monday, Ascension Day, Labour Day (May 1st), Pentecost Monday, German Reunion Day (October 3rd) and the first and second day of Christmas.

4. Descriptive Results

For the spatial allocation of highway filling stations and road filling stations, the highway exit before and after the highway filling station would be shown on a road map with a diameter of 5 kilometres with all road filling stations located in this area. This map was presented to three independent people who would decide which service stations they would approach from the highway. If all the information was correct, the road filling stations would be assigned to the respective highway filling station. If the data did not match completely, the concrete cases were discussed together and the corresponding road filling stations were assigned to the highway filling station. In 30-40% of the cases, the identified gasoline stations were not identical and consequently discussed. A measure of five kilometres was chosen, because driving this distance would take the driver 5 to 10 minutes. Additionally, considering fuel consumption during the search for an alternative street gasoline station etc. this would be perceived by the author as a reasonable detour in search of cheap gasoline.

The gasoline stations within 5 kilometres of the exit prior to the highway gasoline station and at the exit after the gasoline stations have also been identified. A total of 89 street gasoline stations were matched with the highway gasoline stations. This means an average of nearly 5 street gasoline stations for every highway gasoline station. A list of the gasoline stations in the data set can be found in appendix A. All gasoline stations have been assigned to either one of the five major brands, Aral, Shell, Total, Esso or Jet, to smaller, but countrywide or regionally operating companies (labelled as divers), or to independent gasoline stations that set their prices as a result of an economic decision of the one gasoline station.

A number of control variables have been introduced into the data set. Those are the market share of Aral and Shell that have been determined in previous research as the price leaders on the German gasoline market. Another control variable is the market share of the 5 most powerful brands of gasoline station operators and the only companies in Germany that also have refinery capacity and are therefore vertically integrated. Those companies are assumed to hold an oligopoly on the German gasoline market by the Federal German Cartel Authority (2011: p. 11). Furthermore, there are control variables for the population density, the number of gasoline stations in the proximity and the traffic density at the highway section in question.

Besides that, dummy variables have been created for every highway gasoline station and every assumed market around the highway gasoline stations to capture effects of unidentified characteristics of a particular highway gasoline station or a particular market. Moreover, there are control variables for the distance from the highway gasoline station to the closest, second-closest and third-closest street gasoline station in the vicinity. These distances have also been squared for another control variable.

The average highway gasoline station has 4.41 gasoline stations in its proximity. The average market share of the oligopolists (Aral, Shell, Total, Esso and Jet combined) is 43% and the average market share of only Aral and Shell is 26%. The average distance to the closest, second closest and third closest gasoline station in the proximity is 7.19, 8.19 and 8.27 kilometres. The mean price for gasoline at highway gasoline stations is 1.386 € per litre. The mean price for gasoline at gasoline stations in the vicinity is 1.278 € per litre.

Table 1 Descriptives I – Data Set

	mean	Standard deviation	Min	Max
Price	129.27	11.95	109.99	151.90
Number gas stations in the proximity	4.41	1.96	1	10
Share oligopolists	0.43	0.22	0	1
Share Aral/Shell	0.26	0.21	0	0.6

Distance first	7.19	5.99	2.1	23.2
Distance second	8.19	5.92	2.5	23.3
Distance third	8.27	7.11	3.5	26.2

Table 2 Descriptives II – Data Set

	Mean	Min	Max
Highway	0.15	0	1
East	0.25	0	1
Frequency	0.61	0	1
Population density	0,42	0	1

5. Multivariate Results

Table 1 is conducting the first estimation of gasoline prices of highway gasoline stations compared to ordinary gasoline stations in their proximity. The calculation is an OLS estimation. It intends to determine the marginal effects. If an independent factor changes by one unit, this has a certain, quantifiable effect on the dependent variable, the gasoline station's retail price. The general price increase for consumers refueling at the highway gasoline station compared to gasoline stations in the proximity is 10.79 cents per litre. The values produced in table 1 are highly significant and indicate a clear premium for gasoline stations at a highway in Germany. 10.79 Cents per litre is the price increase compared to a gasoline station in the vicinity, if a gasoline station is located right at the highway. The t-value of 404.32 indicates that the likelihood of rejecting the hypothesis that there is no positive price effect for highway gasoline stations because of an unrepresentative sample is below 0.1 %. Consequently, it can be said with more than 99.9 % certainty that highway gasoline stations are charging a higher price than gasoline stations in their vicinity.

When it comes to significance levels, one needs to distinguish between economic and statistical significance. In the case at hand, the statistical significance is very high, as it is above 99.9 %. The economic significance is given in the case at hand, since a price increase of 10.79 Cents per litre represents a price increase of 8.44 %, considering the basis price of 127.84 Cents per litre gasoline. If the value was lower, as can be seen in following tables, there might be statistical significance, but economic significance is missing.

Based on the assessment there are the following results:

Table 3: Basic Estimation

	(1)
	Price
Highway	10.79***
	(404.32)
Basis	127.84***
	(13141.66)
N	1577320

t statistics in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Own calculation on the basis of Stata 15.0; OLS estimation

As the market is possibly behaving differently at different times, table 4 is estimating the premiums for gasoline at a gasoline station on a highway compared to those in the proximity. It becomes obvious that highway gasoline stations are charging 10 to 15 cents more per litre than gasoline stations in the proximity. Additionally, there is a clear indication that consumers are willing to pay a higher premium for highway gasoline in the morning with 11.13 Cents per litre. Especially in the evening, there is a higher premium of 15.47 Cents per litre when refueling at 20:00 hours. When considering different times, there are the following results:

Table 4: Basic estimation according to different times

	(1)	(2)	(3)	(4)
	08:00 hours	12:00 hours	16:00 hours	20:00 hours
Highway	11.13***	9.771***	10.60***	15.47***
	(439.36)	(393.61)	(427.57)	(602.18)
Basis	129.66***	125.25***	124.46***	123.29***
	(14040.02)	(13840.47)	(13772.27)	(13160.45)

N	1577291	1577306	1577306	1577306

t statistics in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

As a next step, several control variables are introduced into the estimation of effects on highway gasoline prices. The vast majority of variables are highly significant when being compared to refueling on a Monday. In most cases, the difference is not higher than 1 Cent per litre. Only Sunday at 8:00 hours and on public holidays is there is an additional premium on highway gasoline stations of more than 1 Cent per litre. Most other variables are highly significant which is, considering the high number of observations, an expected effect.

Considering different days of the week:

Table 5: Estimation considering different days

	(1)	(2)	(3)	(4)
	8:00 hours	12:00 hours	16:00 hours	20:00 hours
Highway	11.12***	9.766***	10.60***	15.47***
	(439.80)	(393.69)	(427.57)	(602.29)
Tuesday	-0.1301***	-0.1267***	-0.1236***	-0.0472
	(-4.07)	(-4.04)	(-3.95)	(-1.45)
Wednesday	-0.0276	-0.1464***	-0.1010**	0.0128
	(-0.86)	(-4.66)	(-3.22)	(0.39)
Thursday	-0.1914***	-0.2957***	-0.2564***	-0.1222***
	(-6.01)	(-9.47)	(-8.22)	(-3.78)
Friday	-0.0664*	-0.0601	-0.1095***	0.00469
	(-2.07)	(-1.91)	(-3.49)	(0.14)
Saturday	0.7723***	0.2878***	0.0259	0.2624***
	(23.73)	(9.02)	(0.81)	(7.94)
Sunday	1.371***	0.7176***	0.2769***	0.4429***
	(41.93)	(22.38)	(8.64)	(13.34)
Holiday	1.976***	1.435***	1.419***	1.780***
	(35.44)	(26.24)	(25.98)	(31.44)
Basis	129.39***	125.17***	124.47***	123.17***
	(5594.08)	(5517.57)	(5492.52)	(5243.71)
N	1577291	1577306	1577306	1577306

t statistics in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

6. Robustness Check

There are a number of other different factors that could play a role in the pricing behaviour. They include the question of whether or not a certain highway section is occupied densely or sparsely. The average number of cars on a German highway is 51.200 in 2016 (Fitschen/Nordmann (2019)). If the highway gasoline station is above that level, it is considered a highly frequented highway. If it is below that number, it is considered a less frequented highway. Another variable could be the question of East and West. An additional control variable is the question of whether or not the area is located in an urban agglomeration. An urban agglomeration is defined as an area with a population density of more than 1.000 residents per square kilometer and a total of more than 500.000 residents (Lexikon der Geowissenschaften (2000)).

6.1 Various Control Variables

With numerous control variables introduced, the results of many are highly significant, but do not represent an explanation for the price variation. When running the regression, the variable for highway gasoline stations is omitted because of perfect collinearity.

After running the more detailed regression less results in table, 6 are statistically significant. Regarding different working days, only Thursday and Saturday remain statistically significant at 8:00 hours, 12:00 hours and 16:00 hours. Still the price increase during those days and times does not hit one Cent per litre. Additionally, there is a price increase above 1 Cent per litre on public holidays and Sunday at 12:00 hours.

The other control variables are also producing interesting results. Gasoline stations on the highway in areas that have a very high population density have a lower price by 2.3 to 6.3 Cents per litre apart from the morning times. Gasoline stations at highways with a high frequency of vehicles are on average between 2.5 and 3.1 Cents per litre cheaper at 8:00, 12:00 and 16:00 hours, but are 2.1 Cents more expensive at 20:00 hours. Furthermore, gasoline stations in East Germany are 4.9 to 7.5 Cents per litre less expensive than those in West Germany.

Other counter-intuitive results are the increase of gasoline prices with the number of gasoline stations between 0.6 and 0.7 Cents per litre for every additional gasoline station in

the market. There also appears to be a negative correlation between the price of gasoline at a highway gasoline station and the distance to the first and second closest regular gasoline station.

Table 6: Estimation with first set of control variables

	(1)	(2)	(3)	(4)
	8:00 hours	12:00 hours	16:00 hours	20:00 hours
Tuesday	-0.1369 (-1.48)	-0.1277 (-1.39)	-0.1267 (-1.37)	-0.0513 (-0.52)
Wednesday	-0.0173 (-0.02)	-0.0976 (-1.06)	-0.0778 (-0.84)	0.1492 (1.50)
Thursday	-0.2479** (-2.68)	-0.2145* (-2.34)	-0.2537** (-2.74)	-0.1031 (-1.04)
Friday	0.0317 (0.34)	-0.0122 (-0.13)	-0.1405 (-1.51)	0.0576 (0.58)
Saturday	0.2366* (2.51)	0.6602*** (7.04)	0.1502 (1.59)	0.0764 (0.75)
Sunday	0.7538*** (7.99)	1.192*** (12.73)	0.4851*** (5.14)	0.0792 (0.78)
Holiday	1.661*** (10.52)	1.795*** (11.45)	1.471*** (8.98)	1.671*** (9.87)
Population density	0.3521*** (4.48)	-2.276*** (-29.14)	-3.564*** (-45.32)	-6.250*** (-74.05)
East	-4.876*** (-71.04)	-7.249*** (-106.29)	-6.919*** (-100.77)	-7.508*** (-101.89)
Frequency	-3.122*** (-33.67)	-2.529*** (-27.46)	-2.712*** (-29.24)	2.163*** (21.74)
Share Aral	-11.13*** (-57.74)	-5.310*** (-27.73)	-7.460*** (-38.70)	-19.04*** (-92.05)
Share Oligopoly	1.773*** (6.85)	4.158*** (16.16)	3.408*** (13.16)	2.646*** (9.52)
Number of	0.6135***	0.7338***	0.7330***	-0.1175***

gasoline stations	(35.43)	(42.94)	(42.32)	(-6.32)
Distance first	-0.3317*** (-11.44)	-0.7771*** (-26.97)	-0.0181 (-0.89)	-0.3584*** (-11.51)
Distance second	-0.7099*** (-34.87)	0.0307 (1.52)	-0.0181 (-0.89)	-1.359*** (-62.21)
Distance third	0.5183*** (45.94)	0.5941*** (53.00)	0.7244*** (64.19)	1.170*** (96.57)
Basis	147.11*** (967.47)	136.00*** (900.11)	137.59*** (904.61)	150.46*** (921.75)
N	209610	209610	209610	209610

t statistics in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Finally, there is a comprehensive analysis that is controlling for unknown individual market effects around every highway gasoline station, unknown characteristics of the highway gasoline station itself, the distance to the closest, second closest and thirst closest street gasoline station, the number of gasoline stations in the proximity, the market share of assumed oligopolists (Aral, Shell, Total, Esso, Jet), the market share of Aral & Shell, whether a gasoline station is located in East or West Germany, the population density, the number of vehicles that pass by the gasoline station, and the day of the week, including Federal holidays.

In the comprehensive regression analysis, the following variables are omitted because of perfect collinearity:

- highway gasoline station
- market share of Aral & Shell
- highway gasoline markets 5, 6, 7, 8, 9, 11, 13, 17, 18
- characteristics of highway gasoline stations itself 2, 3, 4, 5, 6, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18

This indicates that individual characteristics of highway gasoline stations that have not yet been controlled for like the degree of service provided for drivers, families, accommodation etc. does not lead to higher premiums of gasoline stations at a highway. Still, there are some characteristics of gasoline stations that lead to higher premiums.

By dropping the variable highway gasoline station because of perfect collinearity, it may be indicated that some highway gasoline stations are just setting their prices in a way gasoline stations in their proximity do whereas other highway gasoline stations act differently.

The results of table 7 when considering a set of control variables indicate that the effect of the day, apart from holidays and Sundays is statistically less significant. On those days, there is a premium of 0.9 to 1.8 Cents per litre. Population density leads to higher premiums of 1.4 to 8.7 Cents per litre, depending on the exact time. A high frequency of vehicles on the highway leads to a lower price of 5.7 to 9.7 Cents per litre. Some markets and highway gasoline stations have higher or lower prices. In the case of market 16, there are higher premiums in at 8:00 and 20:00 hours and lower premiums at 12:00 and 16:00 hours.

Interestingly and counter-intuitively, the premiums increase with the number of gasoline stations on the market and increase, if the closest and second-closest competitor are closer to the highway gasoline station.

Table 7: Estimation with comprehensive set of control variables

	(1)	(2)	(3)	(4)
	8:00 hours	12:00 hours	16:00 hours	20:00 hours
Tuesday	-0.1218	-0.1153	-1.190	-0.0657
	(-1.36)	(-1.29)	(-1.32)	(-0.72)
Wednesday	-0.00938	-0.953	-0.0783	0.1449
	(-0.10)	(-1.06)	(-0.87)	(1.58)
Thursday	-0.2375**	-0.2206*	-0.2652**	0.0596
	(-2.65)	(-2.47)	(-2.95)	(0.65)
Friday	0.0378	0.00931	-0.128	0.0391
	(0.42)	(0.10)	(-1.42)	(0.42)
Saturday	0.3432***	0.7459***	0.229*	0.2458**
	(3.75)	(8.17)	(2.43)	(2.63)
Sunday	0.8648***	1.289***	1.421***	1.705***
	(9.45)	(11.84)	(9.24)	(10.91)

Holiday	1.666*** (10.90)	1.808*** (11.84)	1.421*** (9.24)	1.705*** (10.91)
Population density	8.658*** (79.30)	1.510*** (13.85)	1.445*** (13.17)	6.169*** (55.27)
East	-3.852*** (-45.53)	-5.867*** (-69.43)	-5.390*** (-63.40)	-2.751*** (-31.81)
Frequency	-9.659*** (-73.26)	-5.727*** (-43.49)	-6.061*** (-45.74)	-9.507*** (-70.54)
Number gasoline stations	0.1525*** (8.99)	0.4905*** (28.95)	0.4588*** (26.91)	0.0314 (1.81)
Market 2	4.425*** (31.32)	4.154*** (29.43)	51.76*** (36.45)	19.32*** (133.77)
Market 4	-3.645*** (-24.24)	0.4802** (3.20)	-0.9263*** (-6.13)	-7.765*** (-50.51)
Market 10	-4.14*** (-38.44)	.0.665*** (-6.19)	0.1443 (1.33)	10.65*** (96.71)
Market 12	5.199*** (40.10)	-3.997*** (30.97)	5.842*** (44.84)	10.65*** (96.71)
Market 14	14.97*** (86.60)	11.83*** (68.52)	12.93*** (74.47)	23.58*** (133.47)
Market 15	14.68*** (80.93)	7.936*** (43.81)	9.129*** (50.09)	23.92*** (129.03)
Market 16	0.9646*** (7.68)	-2.385*** (-19.02)	-1.387*** (-10.99)	13.42*** (104.54)
Distance first	-0.1639*** (-7.86)	-0.6739*** (-32.36)	-0.5611*** (-26.78)	0.4947*** (23.21)
Distance second	-0.9640*** (-77.70)	-0.3857*** (-31.13)	-0.5611*** (-26.78)	0.4947*** (23.21)
Distance third	0.2022***	0.5681***	0.502***	-0.0839***

	(16.49)	(46.40)	(40.75)	(-6.70)
Highway 3	4.743***	2.396***	3.991***	6.052 ***
	(33.19)	(16.78)	(27.79)	(41.43)
Highway 7	9.251***	-2.159***	1.736***	16.54***
	(53.18)	(-12.42)	(9.93)	(93.02)
Basis	148.8	139.3	139.0	144.4
	(968.87)	(907.54)	(900.07)	(919.49)

t statistics in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

6.2 Logarithmised prices

The correlation between the gasoline prices of highway gasoline stations and gasoline stations in the proximity might not be a linear one. It is possible that there is a logarithmized correlation. Because of this consideration, all prices are logarithmised when the regression is run. The results presented in table 8 are statistically highly significant, but economically insignificant. A price increase by a gasoline station in the vicinity by 1 Cent lead to a 0.085% increase on a highway gasoline station at 8:00 hours.†

Table 8: Estimation with logarithmised prices

	(1)	(2)	(3)	(4)
	08:00 hours	12:00 hours	16:00 hours	20:00 hours
Highway	0.0819***	0.0745***	0.0811***	0.116***
	(414.31)	(371.54)	(402.16)	(559.24)
Basis	7.164***	7.129***	7.123***	7.114***
	(99401.68)	(97516.64)	(96943.78)	(93815.07)
N	1577234	1577219	1577239	1577143

t statistics in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

	(5)	(6)
	04:00 hours	24:00 hours

† When handling logarithmised data, in order to interpret them, the value from the regression analysis is inserted into an e-function and 1 is subtracted, since $e^0=1$. In the case at hand this means $e^{0.0819}-1=0.085$. As a result of this, a price increase of 1 Cent by a gasoline station in the vicinity lead the a 0.085% increase on a highway gasoline station.

Highway	0.0833***	0.0835***
	(412.73)	(413.32)
Basis	7.190***	7.190***
	(97778.15)	(97638.00)
N	1577229	1577156

t statistics in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

6.3 squared distance to the gasoline station in the proximity

The distance to the next three gasoline stations in the vicinity does not necessarily need to have a purely linear effect. It may also be subject to increasing or (in this case likely) decreasing marginal effects. Having another gasoline station within 3 kilometers instead of 4 is more likely to effect the prices to a higher degree then having it within 15 instead of 16 kilometers.

When the distance to the next gasoline station in kilometers is squared and the squared and linear effects are estimated, there are the following results that can be seen in table 9. The results for the effect of the distance to the closest street gasoline station is as assumed. For every kilometer the closest street gasoline station is further away, the price of the highway gasoline station increases by 1.1 to 2.8 Cents per liter. At the same time, this linear effect is reduced. For example the price effect for the closest street gasoline station at 8:00 hours becomes negative regarding the proximity to the highway gasoline station, if the distance exceeds 10.6 kilometers (10.6 x (-0.263)=2.7878 > 2.779).

Table 9: Estimation with squared distances to gasoline stations in the proximity

	(1)	(2)	(3)	(4)
	8:00 hours	12:00 hours	16:00 hours	20:00 hours
Highway	10.19***	5.285***	5.628***	15.50***
	(150.09)	(79.56)	(84.93)	(228.17)
Distance first	2.779***	1.100***	1.153***	1.733***
	(65.78)	(26.61)	(27.96)	(40.98)
Distance second	-1.923***	-0.448***	-0.923***	-3.061***
	(-34.29)	(-8.16)	(-16.86)	(-54.52)
Distance third	-0.241***	0.779***	1.263***	2.012***
	(-7.61)	(25.18)	(40.89)	(63.55)

Distance first2	-0.263***	-0.0877***	-0.0833***	-0.119***
	(-60.97)	(-20.79)	(-19.79)	(-27.62)
Distance second2	0.111***	0.0255***	0.0647***	0.165***
	(22.23)	(5.23)	(13.32)	(33.07)
Distance third2	0.0898***	-0.00837**	-0.0455***	-0.0868***
	(32.76)	(-3.12)	(-17.02)	(-31.64)
Basis	129.7***	125.2***	124.5***	123.3***
	(14137.61)	(13951.13)	(13896.65)	(13428.52)
N	1577291	1577306	1577306	1577306

When also considering the other control variables in the estimation, the results can be seen in table 10. The previous findings hold in the estimation. The distance between the highway gasoline stations seems to have a higher effect on highway gasoline prices in the morning (8:00 hours) and evening (20:00 hours).

Table 10: Estimation with squared distances to gasoline stations in the proximity and control variables

	(1)	(2)	(3)	(4)
	8:00 hours	12:00 hours	16:00 hours	20:00 hours
Tuesday	-0.122	-0.115	-0.119	-0.0657
	(-1.36)	(-1.29)	(-1.32)	(-0.72)
Wednesday	-0.00938	-0.0953	-0.0783	0.145
	(-0.10)	(-1.06)	(-0.87)	(1.58)
Thursday	-0.238**	-0.221*	-0.265**	0.0596
	(-2.65)	(-2.47)	(-2.95)	(0.65)
Friday	0.0378	0.00931	-0.128	0.0391
	(0.42)	(0.10)	(-1.42)	(0.42)
Saturday	0.343***	0.746***	0.223*	0.246**
	(3.75)	(8.17)	(2.43)	(2.63)
Sunday	0.864***	1.289***	0.583***	0.278**
	(9.45)	(14.12)	(6.35)	(2.98)
Holiday	1.666***	1.808***	1.421***	1.705***
	(10.90)	(11.84)	(9.24)	(10.91)
Pop_density	-0.763***	2.923***	0.574***	1.873***
	(-5.59)	(21.42)	(4.18)	(13.41)

East	-8.579*** (-75.50)	-4.122*** (-36.32)	-5.686*** (-49.79)	-10.98*** (-94.49)
Frequency	-8.342*** (-69.72)	-7.039*** (-58.90)	-7.214*** (-59.99)	-9.734*** (-79.59)
number_gas~n	1.153*** (53.84)	0.612*** (28.62)	0.553*** (25.70)	-1.318*** (-60.20)
BAB2	6.150*** (41.20)	3.535*** (23.71)	4.609*** (30.72)	17.65*** (115.66)
BAB6	-9.674*** (-42.37)	0.128 (0.56)	-5.414*** (-23.60)	-28.05*** (-120.20)
BAB12	1.226*** (7.73)	3.726*** (23.54)	2.819*** (17.70)	-2.211*** (-13.65)
BAB14	0.496* (2.32)	12.34*** (57.78)	8.757*** (40.76)	6.967*** (31.88)
BAB15	8.320*** (45.33)	8.933*** (48.73)	7.802*** (42.30)	15.62*** (83.28)
BAB16	-4.265*** (-29.19)	0.0169 (0.12)	-1.808*** (-12.32)	0.0483 (0.32)
Distance_first	3.165*** (45.72)	0.0299 (0.43)	0.161* (2.31)	-2.768*** (-39.12)
Distance_second	-5.421*** (-64.99)	-0.380*** (-4.56)	-2.011*** (-23.99)	-8.699*** (-102.02)
Distance_third	0.829*** (12.53)	0.308*** (4.67)	1.661*** (25.00)	9.716*** (143.73)
Distance_first2	-0.439*** (-64.07)	-0.0536*** (-7.83)	-0.0912*** (-13.26)	0.194*** (27.77)
Distance_second2	0.443*** (57.95)	0.00422 (0.55)	0.166*** (21.61)	0.720*** (92.28)
Distance_third2	0.0255*** (4.51)	0.0229*** (4.06)	-0.0717*** (-12.65)	-0.733*** (-127.01)
Basis	148.6*** (774.85)	136.9*** (714.85)	138.8*** (720.24)	159.4*** (813.09)
N	209610	209610	209610	209610

t statistics in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

6.4 Only considering highway gasoline stations

Another robustness check is the consideration of only highway gasoline stations. Again, the significance concerning different days of the week and different times is very limited, especially when considering the economic significance. Only on public holidays and Sunday at 12:00 hours is there a significant premium of more than 1 Cent.

With an increasing population density, there is also a price increase at gasoline stations between 1.4 and 8.7 Cents per litre. In East Germany, there are lower gasoline prices of 2.8 to 5.9 Cents per litre. Highways that are used by a high number of customers have gasoline stations that charge 5.7 to 9.7 Cents less per litre.

Interestingly, the number of gasoline stations does not lower prices at highway gasoline stations, but increases them. Furthermore, there are price differences between different highway gasoline stations of -7.8 to +23.92 Cents per litre.

Table 11: Estimation when only considering highway gasoline stations

	(1)	(2)	(3)	(4)
	8:00 hours	12:00 hours	16:00 hours	20:00 hours
Tuesday	-0.1218	-0.1153	-0.1190	-0.0657
	(-1.36)	(-1.29)	(-1.32)	(-0.72)
Wednesday	-0.00938	-0.0953	-0.783	0.1449
	(-0.10)	(-1.06)	(-0.87)	(1.58)
Thursday	-0.2375**	-0.2206*	-0.2652**	0.0596
	(-2.65)	(-2.47)	(-2.95)	(0.65)
Friday	0.0378	0.00931	-0.1280	0.0391
	(0.42)	(0.10)	(-1.42)	(0.42)
Saturday	0.3432***	0.7459***	0.2229*	0.2458**
	(3.75)	(8.17)	(2.43)	(2.63)
Sunday	0.8638***	1.289***	0.5834***	0.2780***
	(9.45)	(14.12)	(6.35)	(2.98)
Holiday	1.666*	1.808***	1.421***	1.705***
	(10.90)	(11.84)	(9.24)	(10.91)
Population	8.658***	1.510***	1.445***	6.169***

density	(79.30)	(13.85)	(13.17)	(55.27)
East	-3.852*** (-45.53)	-5.867*** (-69.43)	-5.390*** (-63.40)	-2.751*** (-31.81)
Frequency	-9.659*** (-73.26)	-5.727*** (-43.49)	-6.061*** (-45.74)	-9.507*** (-70.54)
Number gasoline stations	0.1525*** (8.99)	0.4905*** (28.95)	0.4588*** (26.91)	0.0314 (1.81)
Highway 2	4.425*** (31.32)	4.154*** (29.43)	5.176*** (36.45)	19.32*** (133.77)
Highway 3	4.743*** (33.19)	2.396*** (16.78)	3.991*** (27.79)	6.052*** (41.43)
Highway 4	-3.645*** (-24.24)	0.4802*** (3.20)	-0.9263*** (-6.13)	-7.765*** (-50.51)
Highway 7	9.251*** (53.18)	-2.159*** (-12.42)	1.736*** (9.93)	16.54*** (93.02)
Highway 10	-4.140*** (-38.44)	-0.6665*** (-6.19)	1.442 (1.33)	10.65*** (96.71)
Highway 12	5.199*** (40.10)	3.997*** (30.87)	5.842*** (44.84)	11.65*** (87.89)
Highway 14	14.97*** (86.60)	11.83*** (68.52)	12.93*** (74.47)	23.58*** (133.47)
Highway 15	14.68*** (80.93)	7.936*** (43.81)	9.129*** (50.09)	23.92*** (129.03)
Highway 16	0.9646*** (7.68)	-2.385*** (-19.02)	-1.387*** (-10.99)	13.42*** (104.54)
Distance first	-0.1639*** (-7.86)	-0.6739*** (-32.36)	-0.5611*** (-26.78)	0.4947*** (23.21)
Distance second	-0.9640*** (-77.70)	-0.3857*** (-31.13)	-0.3902*** (-31.29)	-1.316*** (-103.78)
Distance	0.2022***	0.5681***	0.5020***	-0.0839***

third				
	(16.49)	(46.40)	(40.75)	(-6.70)
Basis	148.84***	139.27***	138.96***	144.40***
	(968.87)	(907.54)	(900.07)	(919.49)
N	209610	209610	209610	209610

t statistics in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

7. Conclusion

Since 2013, all gasoline stations have to report their prices and price changes to the market transparency unit of the Federal German Cartel Office. They are made public to the consumers through different private companies that publish them on the internet or in an app on smartphones. Not only consumers can compare prices and put gasoline stations under pressure to provide the lowest price in the proximity. Gasoline stations themselves are able to monitor the behaviour and pricing of their competitors. Therefore, it is irrelevant whether or not gasoline stations have an explicit or implicit agreement whether to set certain prices and adjust them accordingly or if it is just a result of economically rational pricing behaviour. With price data being available for all gasoline stations, for every gasoline type at any time over a course of nearly two years, a comprehensive assessment was possible. Gasoline prices in German are highly volatile and change several times during the day. With the availability of price data, it is possible to check whether or not and to which degree highway gasoline stations belong to the same geographical market.

The aim is to explain the pricing behaviour of highway gasoline stations. That is why the data set has been modified to a strong degree. A number of control variables such as individual market characteristics, the share of Aral and Shell on the market, shares of assumed oligopolists, distances to the next regular gasoline station, the frequency of cars on that particular highway section and the population density as well as the density of gasoline stations, have been introduced.

In order to explain the pricing behaviour of gasoline stations located on a highway, a sample of 18 highway gasoline stations has been drawn from a total of 360 highway gasoline stations in Germany. The gasoline stations near those 18 highway gasoline stations have been identified and put into individual markets.

The results indicate that a sufficiently large group of gasoline consumers are paying a premium at highway gasoline stations of 10 to 11 cents per litre from 8:00 to 16:00 hours and 15 cents per litre at 20:00 hours. This initial result does not hold when being further investigated and checked for robustness. The results and the robustness check indicate that some highway gasoline stations are holding a monopoly position and are using their pricing techniques accordingly. Other highway gasoline stations are competing with gasoline stations in the vicinity and are unable to charge higher premiums.

Surprisingly, there is a geographical difference between the prices of gasoline stations in East Germany and West Germany as well as in densely populated areas. It indicates that in densely populated areas there is a higher number of price-insensitive customers that are willing to pay an extra premium to refuel their vehicle at the highway gasoline station. This customer group that will likely have corporate cards for their vehicle could be located to a higher degree in West Germany than in East Germany. An explanation could be the fact that Berlin, as the German capital and seat of many public administrative entities, also has a number of vehicles that belong to the ministries, public agencies etc. These vehicles usually get refuelled at special gasoline stations that have a framework contract. Consequently, there is no incentive for other gasoline stations to attract them by decreasing the price. Therefore, it would be interesting to learn more about the characteristics of the customers of highway gasoline stations. On top of that, another interesting field of research is the question of which impact the prices of the second and third-closest competitors have on the prices of highway gasoline stations.

It would be of further interest to add data of the volume of sales to the price developments. Currently, this data is not available, but the current draft of the 10th amendment of the Federal German Law Against Restraint of Competition is proposing an obligation to not only provide price data, but also data on the volume of sales.

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Appendix A

List of the gasoline stations

Gasoline Station	Make	Distance	Frequency
Allertal	Aral		
Jantzon Tankstelle	HEM	7.5	
Raiffeisen	Raiffeisen	15.5	
Aral an der Autobahn	Aral	2.4	
Classic	Classic	3.0	
Buddikate West	Aral		
Raiffeisen - Hamburger Str.	Raiffeisen	8.6	
Star Delingsdorf	Star	11	
Aral Bargteheide	Aral	7.8	
Walsleben West	Total		
team-Neuruppin	team	10.3	
Shell-Neurippin	Shell	11.8	
Shell-Neurippin 2	Shell	12.6	
Esso - Neuruppin	Esso	11.1	
Shell-Wittstock	Shell	18.4	
Raiffeisen-Kyritz	Raiffeisen	37.2	
Neustädter Bucht West	AVIA		
Weidemann-Tank	independent	9.3	
Shell-Ponitz	Shell	8.2	
Altenburger Land Süd	Total		
Star - Schmölln	Star	15.1	
freie Tankstelle	Independent	15.4	
Aral - Ronneburg	Aral	7.3	
Esso-Löbichau	Esso	7.4	
AVIA - Ronneburg	AVIA	11.3	
Eifel Ost	Total		
bft - Wittlich	Bft	14.5	
Aral - Wittlich	Aral	15.0	
Total - Wittlich	Total	15.4	
Raiffeisen - Wittlich	Raiffeisen	13.8	
Allertal West	Aral		
Raiffeisen - Mönkeberg	Raiffeisen	8.0	
Jantzon Tankstelle	Independent	7,5	
SB - Wietze	Independent	12.0	

Classic	Independent	15.0
bft	Bft	17.0
Aral - Hodenhagen	Aral	17.0
Rhynern Süd	Esso	
Jet - Werl	Jet	10.0
star - Werl	Star	10.7
Shell - Werl	Shell	12.3
Total - Werl	Total	10
star - Hamm	Star	7.0
Aral - Hamm	Aral	7.7
Westfalen - Hamm	Westfalen	6.6
Total - Hamm	Total	4.7
SB - Hamm	Independent	3.0
Shell - Hamm	Shell	4.7
Wolfslake Ost	Esso	
Total - Dallgow	Total	23.2
Kaufland - Dallgow	Independent	26.2
Eni-Agip - Fehrbellin	Agip	23.3
Siegburg Ost	Shell	
Mundorf Tank	Independent	5.2
Jet - Rösrath	Jet	13.0
bft - Rösrath	Bft	6.7
Aral - Rösrath	Aral	3.1
Spessart Süd	Aral	
Esso - Weibersbrunn	Esso	7.8
Uttrichshausen Ost	Shell	
bft - Gersfeld	Bft	20.0
bft - Hattenhof	Bft	16.0
Total - Eichenzell	Total	11.0
AVIA - Eichenzell	AVIA	11.0
Raiffeisen - Eichenzell	Raiffeisen	12.0
Börde Nord	Total	
Hem - Irxleben	Hem	3.8
Shell - Hohenwarsleben	Shell	3.8
Aral - Hohenwarsleben	Shell 2	4.0
Shell - Uhrsleben	Aral	13.4
star - Erxleben	Star	18.0
Tecklenburger Land West	Aral	
Raiffeisen - Brochterbeck	Raiffeisen	11.0
Classic - Lengerich	Classic	13.3

BSB-Benzinkontor - Lengerich	Independent	11.8
bft - Lengerich	Bft	10.7
Aral - Lengerich	Aral	10.6
Esso - Lengerich	Esso	8.8
Reinhardshain Nord	Aral	
Roth-Station - Grünberg	Independent	6.9
TankPunkt - Grünberg	Independent	8.1
Jet - Grünberg	Jet	8.0
Autogas Tankstelle	Esso	6.8
Shell - Reiskirchen	Shell	16
Total - Reiskirchen	Total	16.3
Ostetal Nord	Shell	
Shell - Sittensen	Shell	2.1
star - Hollenstedt	Star	3.5
Raiffeisen - Hollenstedt	Raiffeisen	4.4
Raiffeisen - Heidenau	Raiffeisen	9.1
Aral - Hollenstedt	Aral	2.5
Holmmoor Ost	Esso	
star - Kollaustr.	Star	10.3
Hem - Kollaustr.	Hem	3.8
Aral - Kollaustr.	Aral	10.7
Shell - Kollaustr.	Shell	4.5
Hohe Mark West	Total	
SB-Tankstelle	Independent	2.7
HEM - Haltern am See	Hem	10.2

Appendix B – Overview of all variables

ID	Of the gasoline station
Price	Of gasoline (E10, E5 and Diesel)
Time	Of the price notification
BAB	Highway gasoline station
Umgebung	Gasoline station in the proximity
Date	Of the price notification
M1a	Price at 01:00 hours
M2a	Price at 02:00 hours
M3a	Price at 03:00 hours
M4a	Price at 04:00 hours
M5a	Price at 05:00 hours
M6a	Price at 06:00 hours
M7a	Price at 07:00 hours
M8a	Price at 08:00 hours
M9a	Price at 09:00 hours
M10a	Price at 10:00 hours
M11a	Price at 11:00 hours
M12a	Price at 12:00 hours
M13a	Price at 13:00 hours
M14a	Price at 14:00 hours
M15a	Price at 15:00 hours
M16a	Price at 16:00 hours

M17a	Price at 17:00 hours
M18a	Price at 18:00 hours
M19a	Price at 19:00 hours
M20a	Price at 20:00 hours
M21a	Price at 21:00 hours
M22a	Price at 22:00 hours
M23a	Price at 23:00 hours
M24a	Price at 24:00 hours
Observation	Day of the observation
Monday	Observation on Monday
Tuesday	Observation on Tuesday
Wednesday	Observation on Wednesday
Thursday	Observation on Thursday
Friday	Observation on Friday
Saturday	Observation on Saturday
Sunday	Observation on Sunday
Holiday	Observation on Federal holiday
BAB1	Special characteristics of highway gasoline station 1
BAB2	Special characteristics of highway gasoline station 2
BAB3	Special characteristics of highway gasoline station 3
BAB4	Special characteristics of highway gasoline

	station 4
BAB5	Special characteristics of highway gasoline station 5
BAB6	Special characteristics of highway gasoline station 6
BAB7	Special characteristics of highway gasoline station 7
BAB8	Special characteristics of highway gasoline station 8
BAB9	Special characteristics of highway gasoline station 9
BAB10	Special characteristics of highway gasoline station 10
BAB11	Special characteristics of highway gasoline station 11
BAB12	Special characteristics of highway gasoline station 12
BAB13	Special characteristics of highway gasoline station 13
BAB14	Special characteristics of highway gasoline station 14
BAB15	Special characteristics of highway gasoline station 15
BAB16	Special characteristics of highway gasoline station 16
BAB17	Special characteristics of highway gasoline station 17

BAB18	Special characteristics of highway gasoline station 18
Aral	Gasoline station belonging to brand Aral
Shell	Gasoline station belonging to brand Shell
Total	Gasoline station belonging to brand Total
Esso	Gasoline station belonging to brand Esso
Jet	Gasoline station belonging to brand Jet
Independent	Independent gasoline station
Divers	Branded gasoline company apart from big 5
Ost	Location of the gasoline station in East or West Germany
Frequency	High or low frequency of vehicles on the section of the highway
Market1	Special characteristics of market 1
Market2	Special characteristics of market 2
Market3	Special characteristics of market 3
Market4	Special characteristics of market 4
Market5	Special characteristics of market 5
Market6	Special characteristics of market 6
Market7	Special characteristics of market 7
Market8	Special characteristics of market 8
Market9	Special characteristics of market 9
Market10	Special characteristics of market 10
Market11	Special characteristics of market 11

Market12	Special characteristics of market 12
Market13	Special characteristics of market 13
Market14	Special characteristics of market 14
Market15	Special characteristics of market 15
Market16	Special characteristics of market 16
Market17	Special characteristics of market 17
Market18	Special characteristics of market 18
Number_gasoline_stations	Number of street gasoline stations in the vicinity
Number_gasoline_stations2	Squared number of street gasoline stations in the vicinity
Share_oligopolists	Market share of Aral, Shell, Total, Esso, Jet combined
Share_Aral	Market share of Aral
Share_Shell	Market share of Shell
Distance_first	Distance to the closest street gasoline station
Distance_second	Distance to the second-closest street gasoline station
Distance_third	Distance to the third-closest street gasoline station
Distance_first2	Squared distance to the closest street gasoline station
Distance_second2	Squared distance to the second-closest street gasoline station
Distance_third2	Squared distance to the third-closest street

	gasoline station
Logm8a	Logarithmised price at 8:00 hours
Logm12a	Logarithmised price at 12:00 hours
Logm16a	Logarithmised price at 16:00 hours
Logm20a	Logarithmised price at 20:00 hours
Logm24a	Logarithmised price at 24:00 hours
Logm4a	Logarithmised price at 4:00 hours
M1a2	Price at 01:00 hours squared
M2a2	Price at 02:00 hours squared
M3a2	Price at 03:00 hours squared
M4a2	Price at 04:00 hours squared
M5a2	Price at 05:00 hours squared
M6a2	Price at 06:00 hours squared
M7a2	Price at 07:00 hours squared
M8a2	Price at 08:00 hours squared
M9a2	Price at 09:00 hours squared
M10a2	Price at 10:00 hours squared
M11a2	Price at 11:00 hours squared
M12a2	Price at 12:00 hours squared
M13a2	Price at 13:00 hours squared
M14a2	Price at 14:00 hours squared
M15a2	Price at 15:00 hours squared
M16a2	Price at 16:00 hours squared

M17a2	Price at 17:00 hours squared
M18a2	Price at 18:00 hours squared
M19a2	Price at 19:00 hours squared
M20a2	Price at 20:00 hours squared
M21a2	Price at 21:00 hours squared
M22a2	Price at 22:00 hours squared
M23a2	Price at 23:00 hours squared
M24a2	Price at 24:00 hours squared

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