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Price Dispersion and Station Heterogeneity on German Retail Gasoline Markets*

Justus Haucap† Ulrich Heimeshoff‡ Manuel Siekmann§

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Abstract

Price levels and movements on gasoline and diesel markets are heavily debated among consumers, policy-makers, and competition authorities alike. In this paper, we empirically investigate how and why price levels differ across gasoline stations in Germany, using eight months of data from a novel panel data set including price quotes from virtually all German stations. Our analysis specifically explores the role of station heterogeneity in explaining price differences across gasoline stations. Key determinants of price levels across fuel types are found to be ex-refinery prices as key input costs, a station's location on roads or highway service areas, and brand recognition. A lower number of station-specific services implies lower fuel price levels, so does a more heterogeneous local competitive environment.

JEL-Classification: L11, L71

Keywords: Gasoline Pricing, Price Dispersion, Fuel Prices, Gasoline Stations

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1 Introduction

Competition and pricing on retail gasoline and diesel markets have already long been highly debated topics among consumers, media as well as regulatory and antitrust authorities in many countries around the globe (see OECD 2013). Gasoline and diesel markets, and their retail segments in particular, have also been a field of intensive empirical research, around (asymmetric) pass-through of wholesale prices, evaluation of market power, or the effects of regulatory interventions, to name just a few examples (see Houde 2011; Noel 2007a,b, 2009). In particular, studies focusing on dynamic pricing behavior and characteristics of price cycles as well as studies analyzing (station-level) price dispersion and determinants of price levels have received substantial attention (see Eckert 2013; Noel 2011). In addition, numerous competition authorities have conducted in-depth inquiries into the sector (see ACCC 2007; Bundeskartellamt 2011a; OECD 2013).

Given specific characteristics such as a high degree of product homogeneity, relatively low search costs, a high degree of market transparency and low menu costs, as well as a market structure dominated by a few vertically-integrated players, gasoline and diesel markets constitute an interesting field to study. Comprehensive pricing data sets for empirical investigations, however, are difficult to obtain as gasoline and diesel are sold through numerous locally distributed, stationary sales outlets. Several existing empirical studies, primarily for areas in the U.S. and Canada, hence, have relied on city-level data or survey data from a small sample of stations (e.g., Borenstein and Shepard 1996; Lewis 2009; Noel 2007a; Shepard 1993), in part with self-collected price observations (e.g., Atkinson 2009; Noel 2007b; Slade 1987, 1992). Recently, however, regulatory requirements on price transparency in some regions have led to more comprehensive and centrally collected databases. As an example, Wang (2009a) uses a census of daily prices for the city of Perth in Western Australia, collected by a regulatory body, to document oligopoly pricing strategies in a time-controlled market environment.[1]

While gasoline markets around the world are a field of extensive empirical research, pricing studies of the German market are rare. Only recently, the Bundeskartellamt (2011a) has investigated pricing behavior in four large German cities as part of a sector inquiry on fuel retailing. Moreover, Kihm, Ritter, and Vance (2014) examine differentiated pass-through of crude oil prices on the basis of customer-submitted price data. To the best of our knowledge, we are the first to use a novel panel data set for the German market representing a census of price quotes from

[1] This represents a census of price data as Western Australian stations are restricted to a single price change per day.

virtually all gasoline stations, centrally collected by the German federal cartel office since December 2013. This data set allows us to analyze the extent of price dispersion in a market without pricing regulations.[2] By combining price data with various stations characteristics (e.g., amenities such as shop offerings or car wash facilities) and measures for spatial competition, we are able to identify key factors determining station-level prices in different segments (e.g., road and highway stations) and on different product markets (i.e., Super E5, Super E10, and diesel).[3]

Our empirical investigation, thus, specifically looks at how and why average daily and daytime price levels as well as the number of price changes differ across stations in Germany. We show that a significant part of price distribution can be associated to observable station characteristics and wholesale price shocks. Ex-refinery prices are a good predictor of input cost changes, while stations located at highway service areas or associated to premium brands charge significantly higher prices. In addition, certain brands seem to have distinctly different day- and nighttime pricing strategies as a reaction to different levels of local competition intensity. Moreover, additional service offerings positively affect price levels, while heterogeneity among local competitors appears to imply lower prices. Finally, stations offering gasoline as a by-product (e.g., supermarket-owned stations) have distinctly lower prices, albeit opening hours are structurally different.

The rest of this paper is structured as follows: We will start with an overview of related empirical literature in the following section. Section 3 then introduces the German gasoline and diesel market as well as data sets used for the empirical investigation. The latter includes (retail and wholesale) price data as well as station characteristics. Section 4 follows with the empirical investigation and results. Finally, section 5 summarizes main findings, highlights limitations and gives ideas for further research.

2 Related Literature

Empirical studies on gasoline pricing have largely focused on retail markets in the U.S. (e.g., Borenstein and Shepard 1996; Doyle, Muehlegger, and Samphantharak 2010; Lewis and Noel 2011; Shepard 1993; Zimmerman, Yun, and Taylor 2013), in

[2]Station operators in Germany are neither restricted in the frequency nor in the direction of price changes.

[3]Road and Autobahn (i.e., highway service area) stations are considered distinct business segments (with a distinct competitive environment) as the single player "Tank & Rast GmbH" is responsible for leasing out all Autobahn stations. Gasoline (i.e., Super E5 and Super E10) and diesel represent non-substitutable product markets in the short- to medium-term due to technical characteristics of engines. For more details, see section 3.1.

Canada (e.g., Atkinson 2009; Byrne, Leslie, and Ware 2015; Noel 2009; Slade 1987, 1992), and in Australia (e.g., Valadkhani 2013; Wang 2008, 2009a,b; Wills-Johnson and Bloch 2010b). On a European level, fewer empirical studies are available. For the Norwegian market, Foros and Steen (2013), for instance, use a (consumer-submitted or self-observed) unbalanced panel data set of gasoline prices at Norwegian stations to estimate a fixed-effect model. Controlling for regional, brand, and weekday effects, among others, the model supports their observation of implicit price control mechanisms at the headquarters of leading companies. The authors find evidence of a significant "day-of-the-week" effect, where prices seem to regularly "jump up" on Mondays. Applying difference-in-differences and fixed effects models to weekly nationwide price data, Dewenter and Heimeshoff (2012), as a second example, compare the impact of different pricing rules on price levels in Austria, finding a significant price-lowering effect of Austria's regulations.[4] While general attention to gasoline price levels and price changes in Germany is high, empirical analyses specifically for the German market are rarely available. So far, a comprehensive pricing investigation was conducted by the Bundeskartellamt (2011a,b) as part of a sector inquiry on fuels. Within this inquiry, a market-dominating oligopoly and certain behaviors suggesting implicit collusion have been observed. Moreover, an empirical analysis of four model regions revealed the existence of recurring Edgeworth-type cycles.[5] In a recent paper, Kihm, Ritter, and Vance (2014) examine how crude oil price increases are passed through by major brands vis-à-vis other brands. The authors use large-scale customer-submitted price data from January 2012 to February 2013 and find heterogeneity in the extent of cost pass-through as well as a statistically significant but economically small impact of competition metrics.[6]

Indeed, a large number of studies, mostly outside of Germany, focus on price dynamics, by either looking at how upstream costs are passed through to retail prices or by linking (elements of) what is known as Edgeworth cycles to empirically observed prices (see Eckert 2013 or Byrne 2012 for an overview). Studies of the latter group analyze patterns resembling asymmetric price cycles formalized by Maskin and Tirole (1988).[7] These recurring cycles are characterized by a phase of

[4]The authors also look at Western Australian price rules in a different regulatory setting, finding no significant effect of regulation on price levels but on price volatility.

[5]Model regions were Cologne, Hamburg, Munich, and Leipzig; in total, price movements at 407 gasoline stations were analyzed with data from 1 January 2007 to 30 June 2010.

[6]Empirical studies on asymmetric pass-through of wholesale costs to retail gasoline prices in other countries include, among others, Bachmeier and Griffin (2003), Bacon (1991), Borenstein, Cameron, and Gilbert (1997), Eckert (2002), Lewis (2009), Noel (2009), and Radchenko (2005).

[7]The basic model of Maskin and Tirole (1988) has been refined over the last years, for example, by Eckert (2003), Noel (2008), and Wills-Johnson and Bloch (2010a). See Noel (2011) for a non-technical introduction to Edgeworth cycle theory. Numerous empirical studies focus on elements

fast and large price increases, in theory to a level slightly above the monopoly price ("relenting phase"), and a longer sequence of small step-wise price cuts, down to the level of marginal cost ("undercutting phase"). Another stream of empirical research focuses instead on identifying key determinants of station- or market-level prices, for instance, as a result of mergers (e.g., Simpson and Taylor 2008) or regulatory interventions (e.g., Carranza, Clark, and Houde forthcoming; Dewenter and Heimeshoff 2012). Within this stream, there are also studies that focus on price dispersion and price differentials (e.g., Barron, Taylor, and Umbeck 2004; Lewis 2008).

In our empirical analysis, we will specifically look at how and why price levels differ across various stations in Germany. Therefore, among others, Hosken, McMillan, and Taylor (2008) provide valuable input. The authors use station-specific, weekly gasoline prices from a sample of 272 stations around Washington, D.C. from 1997 to 1999 to investigate the existence and dynamics of price dispersion as well as the impact of supplier and market characteristics on price levels. They find, for instance, frequently changing (relative) price positions (i.e., stations do not apply simple pricing rules) and differentiated impacts of brands. Moreover, in a recent paper, Pennerstorfer et al. (2014) look at quarterly diesel prices of Austrian stations to study the relationship between information (approximated by the fraction of commuters) and measures of price dispersion, and provide insight into routing-based measures for spatial competition and market area delineation.

In this paper, we will rely on a large-scale price data set and various station-specific characteristics to test for price dispersion as well as the influence of local competition, supply characteristics and demand-side effects on price levels. After a brief introduction to the German gasoline market and to data sets used in the following section, we will present empirical findings on station-specific price levels for German gasoline stations in section 4.

3 German Retail Gasoline Market and Data

3.1 Market Characteristics

Gasoline and diesel are fairly homogeneous products (in terms of their physical characteristics), which are sold exclusively via retail gasoline and diesel stations. Product differentiation results primarily from the spatial location of a specific station, its brand recognition, or by-products in form of shop offerings, while product innovation does not play a significant role (see, e.g., OECD 2013, pp. 9-30). Most

of Edgeworth cycles on gasoline markets, among them are Doyle, Muehlegger, and Samphantharak (2010), Isakower and Wang (2014), Noel (2007b), and Zimmerman, Yun, and Taylor (2013).

common fuel types sold at German stations are gasoline – specifically "Super E5", with a minimum research octane number (RON) of 95 and up to 5% of ethanol or "Super E10", with 95 RON and 10% ethanol – as well as diesel.[8] Gasoline and diesel constitute different product markets in the short- to medium-term as consumers cannot substitute between the two given different technical specifications of engines.[9] Notwithstanding the above, most consumers may freely choose between the two gasoline products Super E5 and Super E10, only very few (older) cars are not allowed or not recommended to use Super E10.

Only a few vertically integrated oil companies have both a large network of stations (and, thus, comparably high market shares), and direct access to refining capacities in Germany. These players have fairly similar interests and are well-connected (e.g., through joint ventures for refineries, tank farms, or pipelines; Bundeskartellamt 2011b, pp. 20-21). As these companies also supply other than their own retail stations, their influence is larger than reflected by the sheer number of branded retail sites. In general, brand affiliation and ownership of a station are not contingent on each other. It is, therefore, helpful to distinguish between oil company and dealer ownership of stations next to brand affiliation (see Shepard 1993, pp. 60-66 or Bundeskartellamt 2011b, pp. 166-171). Apart from "major" players, gasoline and diesel stations are operated either by other integrated oil companies without refinery capacities in Germany, or by a large number of small-to-medium sized retailers ("independents"), many of which cooperate via associations. Among the latter are also stations at, for instance, car wash or supermarket sites, where selling gasoline and diesel is considered a by-product. Competition of individual stations is restricted to a – from a consumer's perspective – practically meaningful local market area.[10] A special characteristic of the German market is, moreover, a different competitive environment for the small number of so-called Autobahn stations (i.e., stations integrated in highway service areas) as opposed to the majority of road stations. This is a result of assigning responsibility for construction, operation and leasing out of Autobahn stations (almost) exclusively to "Tank & Rast GmbH" after a privatization effort of formerly state-owned Autobahn gasoline

[8]Other fuel types offered at German stations include, most notably, different "premium" fuels, with higher octane ratings (for gasoline) or special additives (for gasoline and diesel). Furthermore, several stations sell liquefied petroleum gas (LPG, "Autogas") or compressed natural gas (CNG, "Erdgas") as alternative fuel types. Finally, numerous stations offer special truck diesel at high-speed pumps (see, e.g., `www.adac.de/infotestrat/tanken-kraftstoffe-und-antrieb`).

[9]In the long-run, gasoline and diesel may indeed be considered substitutes, as most cars are available with different engine types and most stations in Germany – as opposed to other countries – offer gasoline as well as diesel fuel types.

[10]While there is no single dominant approach for local market delineation in related literature, we propose simple measures of spatial competition in section 3.3.

station companies in 1998 (see Bundeskartellamt 2011b, pp. 213-218).

In contrast to other markets (e.g., in Austria or Western Australia), gasoline and diesel pricing in Germany is not subject to pricing regulations. German gasoline and diesel station operators are, thus, free to choose at which time, in which direction and by which amount they change prices for all fuel types offered.[11] While station operators' menu costs are low, so are consumers' switching costs (Noel 2007a, p. 7). With product homogeneity and the chance to easily compare prices (within a regional market area), market transparency is, at least in theory, fairly high. The recent emergence of several online information service providers on the German market helped to increase actual transparency for consumers (and suppliers) as prices can be retrieved from an up-to-date price database provided by the German Federal Cartel Office free of charge (e.g., via smartphones). Our empirical analysis will largely build on this novel database, which will be described in the next section.

3.2 Price Data

Empirical studies on gasoline and diesel retail pricing so far largely utilize daily, weekly or quarterly price data of larger cities, on an average city-level basis or on a station-by-station level (see Eckert 2013). Price observations are often collected at specific daytimes and cover a sample of stations. Only more recently, with the emergence of larger data sets, more comprehensive investigations are possible. Within this study, we make use of a rich panel data set comprising a census of gasoline (Super E5, Super E10) and diesel retail price quotes covering virtually all German gasoline stations. This novel data set is collected by the German market transparency unit for fuel ("Markttransparenzstelle für Kraftstoffe", MTS-K) starting on 1 December 2013. Since then, gasoline station owners are obliged to instantaneously report any price change (including a precise time stamp), resulting in a comprehensive price data set across the country.[12]

Given the novelty of the data source, accuracy of price data might be a concern. The technical infrastructure itself was tested by the MTS-K during a three-month testing phase before launching standard operation phase ("Regelbetrieb") on 1 December 2013. To ensure data quality within the operation phase, we analyze submitted price quotes along data validation rules defined in Bundeskartellamt (2011b, Appendix p. 3). We exclude the first month of data submission (i.e., December

[11] A possible exception is that station operators might need to make certain trade-offs in pricing to meet minimum sales targets for fuel type Super E10.

[12] For more information on the market transparency unit for fuel, please visit `www.bundeskartellamt.de/DE/Wirtschaftsbereiche/Mineral%C3%B6l/MTS-Kraftstoffe/mtskraftstoffe_node.html`.

2013), mainly as a number of active gasoline stations failed to submit prices in the first month. Looking at data from January 2014 onwards only, price quotes considered "invalid" (e.g., empty price quote or price change of 0.00 Euro/liter) are at an acceptable level of about 1% of total observations (see Appendix A for an overview of data preparation steps). In our analysis, we, therefore, rely on eight months of price data, from January to August 2014. All retail prices are nominal end-customer prices in Euro per liter and include all taxes and duties (i.e., value-added tax, energy tax, and a fee for the Petroleum Stockholding Assocation "EBV").

In the empirical analysis in section 4, we use station-level daily and daytime prices. Therefore, we aggregate precise price quotes to average prices per station and day with the help of two aggregation routines. First of all, we compute 24-hour average "daily prices" on a station-level by weighting all prices charged throughout the day with the length of their validity. Secondly, to compute "daytime prices", we follow the same logic but restrict the aggregation to prices charged from 8 am to 8 pm each day. We, thereby, focus on the part of the day, where most stations are indeed open and demand is presumably highest. Both price metrics incorporate the full variety of price levels (and times of validity) over the day or during daytime, and they are, arguably, more accurate and unbiased with regard to a specific time of observation than data used in several earlier studies.[13]

To account for main input cost variations, we, furthermore, use daily wholesale prices "ex-refinery" for Super E5, Super E10 and diesel products. These prices are generated by Oil Market Report (O.M.R.), a widely used, independent information service provider, with the help of daily interviews of active market participants. We make use of the fact that this price data is available at a regional level, reflecting eight major refinery regions in Germany.[14] Individual stations are assigned to one of the eight refinery regions based on minimum linear distance to the region's market place (see section 3.3 for details on calculation methodology). Ex-refinery wholesale prices are nominal and quoted in Euro per liter free on tank-lorry (fot) as of German refinery or storage including energy tax and fees for the Petroleum Stockholding Assocation "EBV". Wholesale prices might differ depending on whether they are sold "branded" or "unbranded", which, however, is not reflected in the data set. Price quotes are, moreover, not available on weekends and public holidays. We, therefore, assume prices to remain constant on previous-day levels in these cases.[15]

[13]Note, however, that we cannot observe varying intraday demand levels as well as restricted opening hours at certain stations.

[14]Refinery regions are North (with market place Hamburg), East (Berlin), Seefeld, South-East (Leuna), West (Duisburg, Gelsenkirchen, Essen), Rhine-Main (Frankfurt), South-West (Karlsruhe), and South (Neustadt, Vohburg, Ingolstadt).

[15]Some studies use crude oil prices instead of wholesale (rack) prices to control for input costs

3.3 Station Data

Apart from retail prices, the MTS-K data set includes station-specific data on virtually all gasoline stations across Germany, including geographical coordinates, detailed information on opening hours and brand affiliation. Similar to price data, we also check MTS-K station data for quality and exclude inactive entries and stations without submitted price quotes (per fuel type). Beyond this, we do not impose further threshold levels regarding, for instance, a minimum required number of price quotes per station and allow the data set to be unbalanced (see Appendix A).

In total, stations are allocated to around 70 single brands. On top of this, we add two characteristics for each station, reflecting "brand categories", in line with a proposal in Bundeskartellamt (2011b, pp. 13/21). In the first categorization, based on its brand, a station is classified into one of the three groups: oligopolistic player, other integrated player, or independent player. The first group includes all stations branded as Aral (BP), Shell, Total, Esso (ExxonMobil), and Jet (ConocoPhilipps). Apart from a nationwide network of gasoline stations, only these oil companies have direct access to refinery capacities. The second group consists of all brands of other integrated oil companies with a less dense network and without direct access to refinery capacities, mainly Star (Orlen), Agip (ENI), HEM (Tamoil), and OMV. In the third group, several small- to medium-sized retail brands ("independents") are subsumed, many of which reflect affiliation to associations, which operate under joint brands such as AVIA, bft, or Raiffeisen. The second additional classification on the basis of brand information, in turn, focuses specifically on brand value: Here, Bundeskartellamt (2011b) distinguishes "premium brands" (e.g., Aral, Esso, Shell, Total, Orlen, OMV, Agip, AVIA, Westfalen), "established brands" (e.g., Jet, Star, HEM, Q1, avanti24), and other brands or independent suppliers (e.g., bft). For both characteristics, ownership structure is not included in MTS-K data, but only the branding of stations. Oligopolistic players may potentially influence other retail sites through contractual partnerships, too. In addition to the brand affiliation of stations, MTS-K data includes weekday-specific opening hours. We mainly use this information to distinguish between stations, which are closed on Sundays from stations that are open every weekday as well as stations opening 24 hours per day and seven days per week from stations with more restrictive opening hours.

Furthermore, we connect three other data sources to MTS-K station data in order to present a comprehensive picture of station characteristics beyond brand affiliation and differences in opening hours. First, as a relevant control variable, we

(e.g., Chouinard and Perloff 2007). We argue, however, that regional ex-refinery prices more precisely reflect input costs of stations.

distinguish the two segments, road and Autobahn stations (almost all of the latter operated by Tank & Rast GmbH). To separate the two groups, we link information on highway service stations available on the Tank & Rast website[16] with MTS-K station data. All stations listed on the Tank & Rast website are identified within the MTS-K station data set; additionally, a small number of other Autobahn stations not operated by Tank & Rast are identified on the basis of a keyword search (e.g., "A*" or "BAB*") of the MTS-K address field. Secondly, we apply a rich data set of station characteristics collected by "Petrolview", a data provider for gasoline and diesel stations across Europe. By connecting Petrolview's individual station characteristics to MTS-K's station and price data, we are able to account for several observable variables influencing station heterogeneity.[17] Station-specific variables used in this study include the type of station ownership, the presence and type of a shop, the presence of a car wash facility, the intensity of traffic around the station, and the number of gasoline and diesel pumps (also the presence of truck diesel, CNG, or LPG pumps). While some station characteristics are represented by discrete or binary variables (e.g., number of pumps), others are clustered into meaningful groups (e.g., traffic intensity from very high to low).[18] Thirdly, to test for price differences during public and school holidays, we use information on the respective federal state of each gasoline station on the basis of ZIP code data. Here, we make use of a comprehensive list of ZIP code and federal state combinations available via the "OpenGeoDB" website.[19] This is a prerequisite to include time series data on regionally different public and school holidays. An overview of public holidays by federal state is available on the website of the German Ministry of Internal Affairs.[20] In Germany, there are no further local holidays.[21] School holidays, which also differ by federal state, are published by the standing conference of the ministers of education.[22]

[16] See `www.tank.rast.de`.

[17] We are able to connect 14,135 or 98% of MTS-K stations with Petrolview station characteristics (see Appendix A for details).

[18] The number of (gasoline, diesel) pumps is an integer variable, representing full pump installations with one or more slots and plugs for different fuel types. The presence of pumps for truck diesel, CNG, or LPG, and the presence of a car wash are binary variables. Regarding ownership, company-owned (i.e., brand and ownership are in line), dealer-owned, or other (e.g., supermarket-owned) can be distinguished. Categories for traffic intensity include very high (traffic levels $>$25,000 vehicles per day), high (15,000 to 25,000), medium (5,000 to 15,000), or low ($<$5,000). Categories for shop type include none, kiosk (i.e., small shop), standard store (offering, e.g., oil, cigarettes, confectionery products, some food and drinks), or convenience store (with a wide range of items).

[19] See `www.opengeodb.org`.

[20] See `www.bmi.bund.de/SharedDocs/Downloads/DE/Lexikon/feiertage_de.html`.

[21] The only exception is "Friedenfest" on 8 August, which is a public holiday in the city of Augsburg only.

[22] See `www.kmk.org/ferienkalender.html`.

Finally, to complete our station characteristics, we include measures reflecting a station's exposure to local competition. Several empirical studies implicitly assume (larger) cities to represent distinct market areas. While using cities as a measure for market delineation allows to incorporate other available city-level data (such as population density), it remains an arbitrary view on competitive dynamics. Similar to Pennerstorfer et al. (2014), we, hence, propose a different logic of local market delineation, enabled by geographical coordinates (latitude, longitude) of all registered stations included in the MTS-K data set. Based on this information, we calculate simple distance measures of the level of spatial competition by comparing a station's spatial relationship to each other station in three ways: (1) linear distance ("as the crow flies"), (2) minimum driving distance, and (3) shortest driving time. Linear distance, on the one hand, is computed as the shortest distance between two geo-coded locations ("orthodromic distance").[23] Retrieving minimum driving distance and time, on the other hand, requires extensive road network data and corresponding routing algorithms. Therefore, these two measures are calculated with professional geocoding software. We report each station's distance to its single closest competitor as well as the number of competitors within a surrounding area defined by different critical values (e.g., 1, 2, or 5 km linear/ driving distance or 2, 5, or 10 min driving time, respectively). Moreover, we look at the specific type of competitors by calculating shares of different brand categories (e.g., oligopoly or independent players) within the surrounding area.

In the following sections, we will present empirical findings based on combining all sources described above. A summary of variables used in the analysis and corresponding data sources can be found in Table 9 in Appendix B.

4 Empirical Analysis

4.1 Descriptive Findings

In this section, we will briefly present relevant descriptive statistics on price levels, station characteristics, and measures of spatial competition. Underlying, granular data sets will afterwards be used to identify price dispersion (in section 4.2) and to estimate the impact of station heterogeneity on price levels and price volatility (in section 4.3).

[23] Using $dist = arccos(sin(lat1) * sin(lat2) + cos(lat1) * cos(lat2) * cos(lon2 - lon1)) * earthradius$ to compute "arc length" distances in kilometers, with $(lat1, lon1)$ and $(lat2, lon2)$ as coordinates of start and end point given in radians (converted from degrees by multiplying with $2\pi/360$), and $earthradius = 6378km$.

Table 1: Summary Statistics: Retail & Wholesale Prices

Variable	Super E5	Super E10	Diesel
Daily average price (24-hour, in Euro/liter)	1.569	1.530	1.385
Daytime average price (8 am to 8 pm, in Euro/liter)	1.548	1.508	1.362
Average intraday price spread (in Euro/liter)	0.088	0.090	0.093
Price changes per day (in number)	4.6	4.6	4.6
Wholesale price "ex-refinery" (in Euro/liter)	1.228	1.194	1.067

Note: 3,340,814, 3,199,708, 3,379,622 observations for Super E5, Super E10, and diesel.
Source: MTS-K data (Jan-Aug 2014), O.M.R. data, own calculation.

Across the period of observation, 24-hour average daily price levels of fuel type Super E5 are highest with an average of 1.569 Euro/liter, followed by Super E10 with 1.530 Euro/liter, and diesel with 1.385 Euro/liter. Daytime prices (i.e., prices between 8 am and 8 pm), in turn, show lower average values across fuel types with 1.548 Euro/liter Super E5, 1.508 Euro/liter Super E10, and 1.362 Euro/liter diesel, respectively. The lower average daytime prices are a result of the fact that many stations increase prices in the evening hours, which typically remain valid during the night. Due to this difference of day- and nighttime prices, we will use both 24-hour daily and daytime prices in our analysis. Stations, on average, change prices between four and five times a day (with a corresponding average validity of each price of around five hours). While some stations do not change their prices over several days, there are several stations with 15 or more price changes on certain days. Daily ex-refinery wholesale prices across the whole period and across regions are at an average level of 1.228 Euro/liter Super E5, 1.194 Euro/liter Super E10, and 1.067 Euro/liter diesel, respectively. Across refinery regions, total average prices vary by up to 2 Eurocents/liter, with South-West (gasoline) or North (diesel) regions offering lowest and South-East region offering highest average price quotes. Based on shortest linear distance to a refinery region's market place, we assign between 910 (East) to 3,147 (West) stations to any single refinery region. While differences between ex-refinery prices and retail prices ("at the pump") are predominantly driven by the value-added tax of 19%, transport costs (from refinery to retail site), sales costs of the station operator, and, eventually, the retail margin are further elements to be considered. Table 1 shows summary statistics of price data by fuel type across all stations included in the data set. Figure 1, moreover, presents a time series of daily retail and (average) wholesale prices.[24]

In the MTS-K data set slightly less than 15,000 stations are registered. Exclud-

[24] An Augmented Dickey Fuller test on average prices suggests that Diesel retail and wholesale price series are stationary, while Super E5 and Super E10 retail and wholesale price series are individually integrated of order one and pairwise cointegrated.

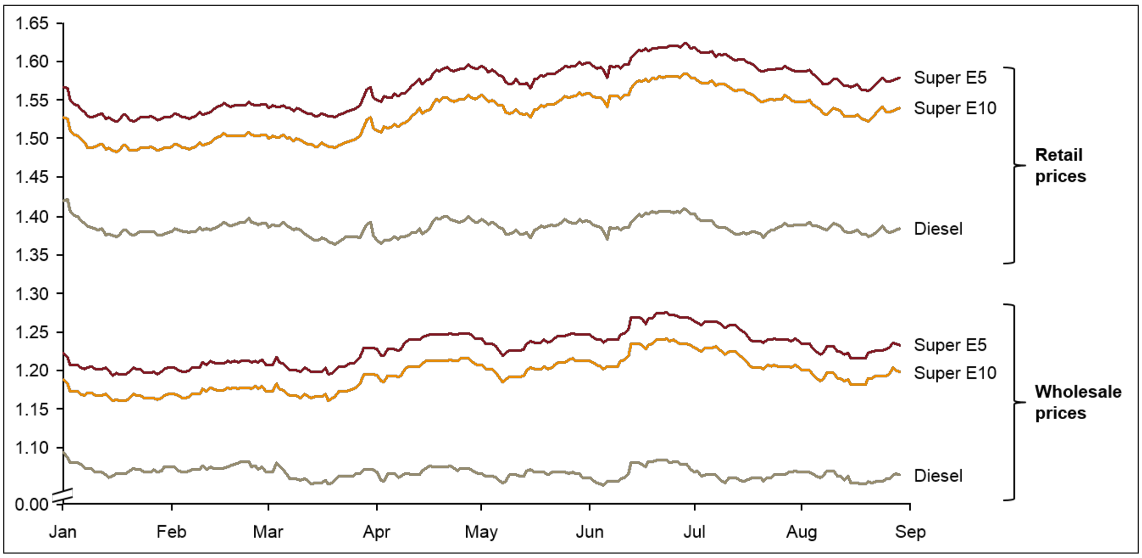


Figure 1: Average Daily Retail & Wholesale Price Series (in Euro/liter)

ing inactive stations as well as stations with a new brand or ownership and, moreover, focusing on stations with a complete set of station characteristics provided by Petrolview leaves us with 14,135 stations to be used for the empirical analysis. Except for just below 400 stations located on the Autobahn, all other retail sites are classified as road stations. Interestingly, almost all stations offer diesel as a fuel type, reflecting the fact that diesel-fueled engines are widespread among passenger cars in Germany (compared, for instance, to the U.S. market).[25] Only a very few stations do not offer Super E5, while around 5% of all stations do not sell Super E10, a recent fuel type introduced in 2011. In the data set, about 70 single brands can be identified. With 2,346 stations and 1,858 stations, respectively, Aral and Shell are the two largest single brands, together accounting for more than a quarter of all stations. Within the small segment of Autobahn stations, most of them leased out by Tank & Rast, Aral and Shell even operate more than half of all stations. Next to Aral and Shell, six other brands (Esso, Total, Avia, bft, Jet, and Star) can be found with more than 500 stations each. Classifying brands into categories introduced in section 3.3 shows that both oligopoly-player brands and independent brands comprise even more or slightly less than 6,000 stations. In total, 40% of stations are open “24/7”, among those are 54% oligopoly-branded stations, compared to a smaller overall share of 47% oligopoly-branded stations in the market. While this classification based on MTS-K data merely reflects branding of stations and

[25] According to the Kraftfahrtbundesamt (German Federal Motor Transport Authority), about 30% of all passenger cars in Germany are diesel-powered vehicles (see `www.kba.de/DE/Statistik/Fahrzeuge/Bestand/Umwelt/2014_b_umwelt_dusl_absolut.html`).

not ownership structure, a look at Petrolview's station characteristics shows that almost two thirds of stations are owned by dealers, the remaining part is largely owned by the company also owning the brand.[26] Nowadays, most stations have a shop offering, while size and variety differ. With data at hand, we can differentiate stations with a convenience store (41%), a standard store (46%) and a smaller kiosk-type store (4%). Moreover, more than 90% of stations have between one and four gasoline and diesel pumps, individual station data shows a maximum of 16 pumps. Beyond gasoline and diesel pumps, almost half of all stations have at least one additional truck pump and a corresponding bay, while a third offers LPG and no more than 5% offer CPG pumps. Regarding traffic at the (primary) street of a station's location, stations with very high (9%), high (36%), medium (43%), and low (12%) intensity can be differentiated. Furthermore, 4,619 stations also benefit from traffic of a secondary road (e.g., at a crossing). Table 2 shows summary statistics on the number of stations across various characteristics.

In Germany, the density of gasoline stations varies significantly across regions, with a high density, for instance, in the Rhine-Main area and a considerably lower density, for instance, in the Eastern part of the country. As an example, the distance to the closest competitor – irrespective of segment, product offering, or brand – ranges from virtually zero to around 25 km. On average, across the country, there is a station every 1.6 km (linear distance), 2.2 km (driving distance), or six minutes (driving time). Within a circular surrounding area of 1 km linear distance around a given station, there are typically 0.9 competitors. Within 2 km and 5 km, this number increases to 2.6 and 10.5 other stations, respectively. In line with intuition, driving distance measures show higher values, as the road network virtually never represents the shortest possible connection between a pair of stations. For driving distance, there are 0.5, 1.5, and 6.9 competitors within a (non-circular) area of 1, 2, and 5 km.[27] In terms of driving time, averagely 3.8 stations are not more than ten minutes away (without traffic congestion). Finally, the type of competition within the limits of a different surrounding areas varies in all categories between 0 and 100%, but, on average, reflects overall shares of brand categories with 47% oligopoly-branded players and 42% independent players.

[26] Other ownership types include supermarket-owned stations. Ownership type data might not be fully up-to-date and, thus, needs to be treated with caution.

[27] Routing-based algorithms do not find a direct competitor for a few stations (e.g., from island Sylt to mainland Germany).

Table 2: Summary Statistics: Gasoline and Diesel Stations

By type			By brand			By characteristics			By local competition	
Segment			*Brands (>500 stations)*			*Amenities*			*Linear distance*	
Road station	13,769	97%	Aral	2,346	17%	Convenience store	5,761	41%	Closest comp.	1.58
Autobahn station	366	3%	Shell	1,858	13%	Standard store	6,455	46%	Comp. in 1 km	0.92
Ownership type			Esso	1,048	7%	Kiosk	563	4%	Comp. in 2 km	2.64
Company-owned	5,455	39%	Total	834	6%	Car wash	10,432	74%	Comp. in 5 km	10.45
Dealer-owned	8,269	59%	Avia	738	5%	*Traffic intensity*			*Driving distance*	
Other	411	3%	bft	601	4%	Very high	1,266	9%	Closest comp.	2.21
Product offering			Jet	583	4%	High	5,054	36%	Comp. in 1 km	0.52
Super E5	14,006	99%	Star	536	4%	Medium	6,118	43%	Comp. in 2 km	1.54
Super E10	13,436	95%	*Brand category 1*			Low	1,697	12%	Comp. in 5 km	6.85
Diesel	14,131	100%	Oligopoly	6,669	47%	Secondary road	4,619	33%	*Driving time*	
Business hours by day			Other integrated	1,565	11%	*Number of pumps*			Closest comp.	6.07
Monday-Saturday	14,116	100%	Independent	5,901	42%	1 to 2 pumps	4,345	31%	Comp. in 2 min	0.40
All week	13,481	95%	*Brand category 2*			3 to 4 pumps	8,482	60%	Comp. in 5 min	1.19
Business hours by time			Premium	7,705	55%	5 to 6 pumps	1,196	8%	Comp. in 10 min	3.77
8 am to 6 pm	12,038	85%	Established	1,518	11%	>6 pumps	112	1%		
8 am to 8 pm	11,729	83%	Other	4,912	35%	Truck pumps	6,627	47%		
24 hours, 7 days	5,623	40%				LPG pumps	4,617	33%		
						CNG pumps	759	5%		

Note: Included are 14,135 active stations with price quotes (MTS-K) and all station characteristics (Petrolview); closest comp(etitor) stated in kilometers or minutes, all other variables in number of stations.
Source: MTS-K data, Petrolview data, own calculations.

4.2 Identification of Price Dispersion

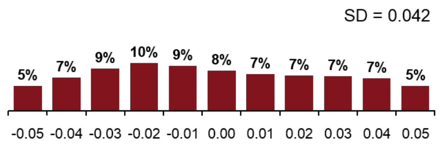
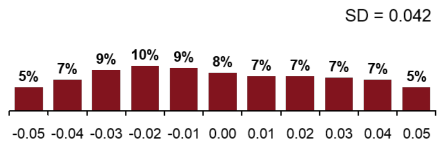
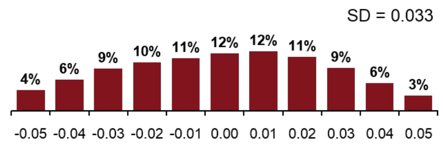
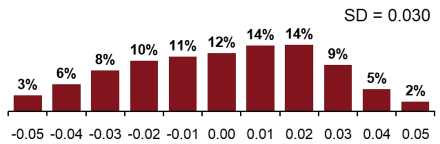
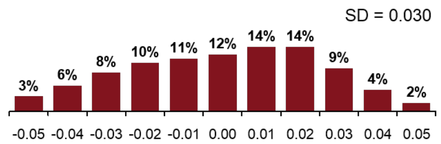
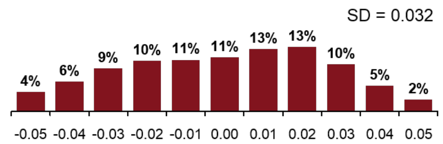
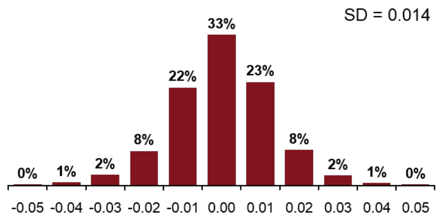
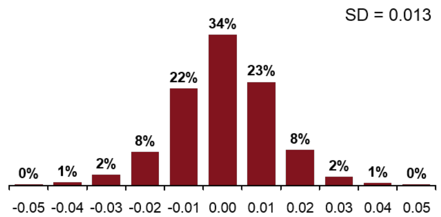
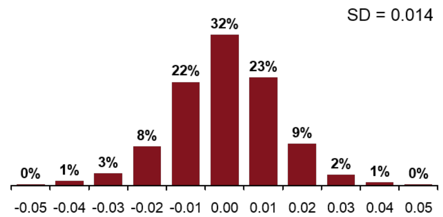
In this section of the empirical analysis, we will focus on the extent of price dispersion across stations in Germany. Price dispersion means that firms charge different prices for selling the same good at the same time (Lewis 2008, p. 654). Previously, we have introduced gasoline and diesel as fairly homogeneous products. However, as stations are not homogeneous, price differentiation can be considered a result of a station's characteristics rather than the physical characteristics of the fuel offered. Heterogeneity of stations might, thus, be able to explain observed price dispersion. Following, among others, Lewis (2008) and Hosken, McMillan, and Taylor (2008), we propose a simple model using (time-invariant) station-fixed effects to control for this heterogeneity of stations (irrespective of whether characteristics are observed or unobserved) as well as time-fixed effects (i.e., in form of time dummies for all days considered) to account for price changes over time, which are common to all stations. Equation 1 below describes such a two-way fixed effects regression model (see Cameron and Trivedi 2005, p. 738)

$$p_{it} = \alpha + \theta_i + \gamma_t + u_{it} \quad (1)$$

with p_{it} as station i's average (daily) retail price (i.e., for Super E5, Super E10, or diesel respectively) at day t, θ_i representing station-fixed effects and γ_t representing time-fixed effects. Residuals u_{it} are considered deviations from the "clean" or "residual" price after controlling for station heterogeneity and (input) price variations equally affecting stations (Pennerstorfer et al. 2014).

In the following, we will illustrate the retail price distribution for Super E5, Super E10, and diesel using three distinct price series, namely (i) retail prices as listed at the pump, (ii) prices corrected solely for time-fixed effects, and (iii) clean prices as introduced above, estimated by the two-way fixed effects model in equation 1. Table 3 shows frequency distributions of residuals around the estimated price in the respective model, rounded to the nearest Eurocent per liter of fuel. The estimated price in the center of the distribution thereby represents either (i) a simple average price across all stations and days for daily retail price series, (ii) a daily average price across all stations for prices corrected by time-fixed effects, and (iii) the daily average price determined by a specific station's characteristics for clean prices. Albeit intraday spreads might be considerably larger, the distribution around (i) represents the average daily volatility a consumer – unaware of crude oil or refinery price changes – is exposed to. In contrast, distributions around (ii) and (iii) correct for time- or station-specific factors largely unobservable for the consumer.

Table 3: Price Dispersion (in Euro per liter, rounded to nearest cent)

Price series	Super E5	Super E10	Diesel
(i) Distribution of prices around mean: $u_{it} = \overline{p} - p_{it}$			
(ii) Distribution of prices with time-fixed effects: $u_{it} = \hat{p}_t - p_{it}$			
(iii) Distribution of "clean" or residual prices: $u_{it} = \hat{p_{it}} - p_{it}$			

Note: SD = standard deviation; price distributions only illustrated for range of -0.05 and +0.05 Euro/liter.
Observations: 3,340,814 for Super E5, 3,199,708 for Super E10, 3,379,622 for diesel.
Source: MTS-K data, own calculation.

Across all frequency distributions, Super E5 and Super E10 only marginally differ. In fact, in 1-Eurocent groups shown in Table 3, (almost) no difference is visible. While distributions in rows (i) and (ii) are very smooth in general, a shift of highest relative frequency bands from the area slightly below the average (i.e., 0.00 Euro/liter) to the area slightly above the average can be observed for both gasoline products. In other words, there is a negative difference between median and mean daily price in (i) and a positive difference in (ii). Reasons for this are twofold: First, a period of generally higher price levels for gasoline products in early summer (see Figure 1). Secondly, a cross-sectional (i.e., station-specific) observation that a large number of stations offer prices just above the average on a particular day, while stations pricing below the average are more dispersed. Residual distributions of diesel in Table 3 support the first argument as both rows (i) and (ii) show a similar pattern in light of more constant retail price levels across the period of observation. Controlling for both time- and station-fixed effects does not only reduce price dispersion but also leads to a concentration around the average value. Next to time-specific factors such as refinery price changes, station specifics, thus, clearly influence variations in retail prices. The following section will explain which factors are most relevant in determining price levels. Still, there is also evidence of unexplained or "true" price dispersion. In the case of Super E5, for instance, roughly 95% of this dispersion is in a 5 Eurocents/liter range around the stations' relative average prices.

4.3 Impact of Station Heterogeneity

In this section, we will focus on the impact of refinery price variation over time, various time-invariant variables reflecting station characteristics, as well as demand-side controls on retail price levels. While not visible for retail customers, (region-specific) refinery prices for gasoline and diesel products are an obvious determinant of retail price variation as they represent a major source of input costs (Hosken, McMillan, and Taylor 2008). Regarding station characteristics, we will use a wide range of variables with a potential impact on price levels on the basis of existing studies (Eckert 2013). Thereby, we also reduce the risk of misspecification. Specifically, we control for variables representing brand and ownership structure, station location and amenities, and spatial competition metrics[28] in a random effects model setup. On top, we include demand-side controls in form of weekday, state, and (school, public) holiday dummies. We are aware of the potential omitted variable bias of

[28] Similar to Eckert and West (2005), we focus on count and type of local competitors within a 2 km surrounding area. Furthermore, the local competition metric used for all estimations is linear distance.

such a model (e.g., due to unobserved station characteristics). However, we assume a robust specification in light of the variety of control variables included, similar to other empirical studies on gasoline markets estimating random effects models (e.g., Pennerstorfer et al. 2014). The specified model is described below in equation 2

$$p_{it} = \alpha + \beta c_{it} + \boldsymbol{x}_i \boldsymbol{\gamma} + \boldsymbol{d}_{it} \boldsymbol{\delta} + u_{it} \tag{2}$$

with p_{it} as station i's average daily (i.e., 24-hour) or daytime (i.e., 8 am to 8 pm) retail price at day t, $\boldsymbol{x}_i$ representing a vector of all time-invariant, station-specific control variables, c_{it} as region-specific refinery prices, and $\boldsymbol{d}_{it}$ as a vector of dummy variables to control for weekdays, federal states, as well as public and school holidays (varying by the federal state of a station's location). Table 4 presents results for a number of specifications of the generic model introduced in equation 2. Specifically, we estimate the model for all three fuel types (specifications (1) & (2) for Super E5, (3) & (4) for Super E10, and (5) & (6) for diesel) and use either daily average prices (in specifications (1), (3), and (5)) or daytime average prices (in specifications (2), (4), and (6)) as the dependent variable (see section 3.2 for details on calculation routine).[29] All coefficients are denoted in Eurocents/liter of fuel. Similar to empirical findings in Kihm, Ritter, and Vance (2014) using a large-scale gasoline price panel data set, we find most regressors to be statistically highly significant, influenced by the sheer number of observations. Most coefficients affect prices in the expected way (i.e., coefficients' signs are in line with expectations, cf. Eckert 2013, pp. 152-156). Moreover, the direction of price impact of all (significant) covariates is robust with regard to using daily or daytime prices. In turn, the economic impact of individual variables is, ceteris paribus, significant for some variables, while being negligible for others. Furthermore, some coefficients vary in magnitude between daily and daytime price specifications. We see at least two reasons for this finding: First of all, varying coefficient values can, to a limited extent, be associated to diverse opening hours across stations. While we account for such differences with two dummy variables (i.e., 24/7 opening and Sunday opening) in all specifications, this might not filter out the entire station- and weekday-specific granular opening hour variety. Secondly, however, pricing behavior of stations is, to a large extent, simply different during day- and nighttime, possibly as a result of a different demand levels and varying competition intensity. While daytime price specifications are, thus, arguably more

[29]The number of observations slightly differs between specifications given that some "partial" days are not considered for daily (24-hour) prices, while they are considered for daytime prices. As a robustness check, we also estimate equivalent models with time-fixed effects instead of region-specific ex-refinery prices (and all covariates, except for weekdays), showing largely similar results.

robust, daily price specifications offer additionally insights, which we will comment where reasonable.

First of all, ex-refinery prices appear to be a good predictor of (daily) input price changes. Notably, in specification (5) and (6) for diesel, as opposed to gasoline products, we find a considerably lower coefficient on refinery prices (and a correspondingly higher constant), which might be influenced by rather stable diesel (refinery and retail) prices across the observation period (compare Figure 1). Driven by a restricted competitive environment and, potentially, a lower price elasticity of consumers, the Autobahn station dummy variable has the largest coefficient. Everything else being equal, Autobahn stations charge a surcharge of around 6 Eurocents/liter, which is even higher during daytime. Moreover, all brands subsumed by Bundeskartellamt (2011a) in the oligopoly-type player group charge significantly more than other stations. This effect, however, is only about half as large during daytime hours. Regarding station amenities, results are largely in line with the expectation that a wider range of services for the customer, and, therefore, a "one-stop shopping" offering, is associated with higher price levels. Between no shop offering and a convenience store is a range of about 0.4 to 1.2 Eurocents/liter, while having a car wash facility, ceteris paribus, is associated with a price increase of close to another 0.2 to 0.4 Eurocents/liter. For spatial competition-related variables, we find the distance to the nearest competitor to be significant but negligible in magnitude. Furthermore, as expected, an additional station within a local area, on average, slightly decreases price levels. Interestingly, both variables reflecting the share of a brand category in the local market have a positive sign. We infer from this finding that in local market areas that comprise a homogenous group of stations, price competition is less intense, while a larger heterogeneity of local competition appears to induce lower prices. Using variables reflecting shares of individual oligopoly-player brands (instead of a single group variable) shows that the effect more than doubles in all specifications for Aral and Shell, suggesting higher price levels in local environments with particularly a higher share of these two brands. School and public holidays, as relevant demand-side controls, have the expected positive impact on price levels. The extent of price effects from school holidays is ambiguous, as coefficient values diminish in specifications with daytime prices (especially for diesel). As the magnitude of both public and school holidays in general is limited, drastic price increases as observed by many customers are, if present, either limited to a subset of stations or limited to specific holiday periods.[30]

[30] Regressing single, nationwide public holidays and a set of covariates on Super E5 price levels shows, ceteris paribus, higher price levels on Whitmonday (+1.4 Eurocent/liter for daily prices, +1.5 Eurocent/liter for daytime prices), Labor Day (+1.2, +1.6), and Ascension Day (+0.9, +0.9).

Table 4: Regression of Average Retail Prices

Dependent variable:	Super E5		Super E10		Diesel	
Retail price	(1)	(2)	(3)	(4)	(5)	(6)
Station type						
Autobahn station	5.715	6.610	5.673	6.594	5.917	6.834
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
24/7 business hours	0.250	0.227	0.302	0.266	0.262	0.223
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Brand categories						
Oligopoly player brand	2.656	1.248	2.643	1.271	2.776	1.257
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Integr. player brand	0.919	0.666	0.890	0.676	0.911	0.618
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Station characteristics						
Convenience store	0.325	0.187	0.320	0.186	0.331	0.184
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Kiosk-type store	-0.353	*-0.090*	-0.282	*-0.043*	-0.418	*-0.133*
	(0.00)	*(0.26)*	(0.01)	*(0.62)*	(0.00)	*(0.10)*
No store	-0.980	-0.346	-0.858	-0.231	-0.879	-0.250
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Car wash	0.442	0.177	0.438	0.184	0.425	0.158
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Traffic intensity	*0.042*	*-0.001*	*0.041*	*0.006*	*0.034*	*-0.012*
	(0.10)	*(0.97)*	*(0.11)*	*(0.77)*	*(0.19)*	*(0.60)*
Secondary road	0.196	0.103	0.200	0.109	0.211	0.102
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Number of pumps	-0.121	-0.105	-0.130	-0.108	-0.128	-0.107
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Truck pumps	0.195	0.148	0.191	0.140	0.225	0.154
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Local competition						
Distance to nearest comp.	0.037	0.023	0.038	0.022	0.037	0.023
	(0.00)	(0.01)	(0.00)	(0.02)	(0.00)	(0.02)
# of competitors in 2 km	-0.108	-0.098	-0.110	-0.099	-0.121	-0.107
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Share of oligopoly brands	0.706	0.556	0.682	0.549	0.792	0.590
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Share of independents	0.560	0.698	0.528	0.677	0.643	0.753
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Demand-side controls						
School holiday	0.520	0.275	0.524	0.274	0.321	-0.051
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Public holiday	0.538	0.972	0.554	1.003	1.032	1.336
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Input costs						
Ex-refinery price	1.257	1.168	1.260	1.169	0.731	0.834
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Constant	-0.834	9.979	-0.980	9.650	58.088	46.705
	(0.01)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Number of observations	3,286,373	3,298,068	3,150,305	3,161,785	3,314,436	3,326,152
Number of groups	14,006		13,436		14,131	
R^2	0.657	0.601	0.660	0.605	0.418	0.326

Note: Robust p-values in parentheses; non-significance at 10% level denoted in italics.

Specifications: (1), (3), (5) with daily prices; (2), (4), (6) with daytime prices.

Included but not shown: Weekday, state, LPG/CNG pump, ownership, and open on Sundays dummies.

Omitted variables: Road station, independent brand, standard store.

As a next step, we specifically investigate the impact of approximately 70 single brand dummies (instead of using brand categories) in a model also including all covariates discussed so far. While other coefficients not explicitly shown remain comparable in magnitude, Table 5 shows brand-specific estimates for daily prices (in specifications (7), (9), and (11)) as well as for daytime prices (in specifications (8), (10), and (12)). On a high-level, significant differences in magnitude across specifications for several brands are obvious, with prices being less dispersed during daytime for most brands. We interpret this as primarily a distinct day- versus nighttime pricing strategy of certain brands (e.g., Aral, Shell, OMV) in light of a higher competition intensity, which is, however, not common to all brands (cf. Agip). Moreover, findings across all specifications support the Bundeskartellamt's (2011a) classification of "premium brands" (such as Aral, Shell, Esso, Total, OMV, Agip, or Avia), which are able to charge highest prices. Coefficients on "established brands" (e.g., Star or HEM) are ambiguous in direction. Thus, these brands do not seem to constantly price above the omitted variable of all stations without explicit brand information. Among the independents, remaining associations (e.g., bft or Raiffeisen) show slightly but significantly higher price levels than other independents.

Two further findings are noteworthy: First, Jet's pricing, neither seems to resemble other established brands nor other oligopoly-type player brands. Removing Jet from the group of oligopoly players changes the coefficient for the remaining four-player group considerably, for instance, for daily Super E5 prices from 2.656 to 3.857. Secondly, among the brands with most negative coefficients (based on daily Super E5 values) and 15 or more active stations are, next to the two regional Bavarian players Deutscher Brennstoff Vertrieb (DBV) and Benzin-Kontor (BK) as well as independent player ED Mineralölhandels KG (ED), three chains, whose primary service offering is different from selling gasoline (namely, Mr. Wash, a car wash chain, and Globus and V-Markt, two supermarket chains). For these players, selling gasoline can be considered a by-product of car wash or supermarket operations. Common for these stations, however, are in many cases structurally different business hours, matching those of the primary service activity (e.g., "24/7" or Sunday opening is rare). Therefore, next to examining the robustness with regard to daytime price specifications, which are less prone to a potential opening hour bias, we perform an additional robustness check by estimating a set of specifications including a subset of stations with 24/7 opening hours only (see Table 10 in Appendix B). Results are

Contrary to public opinion, coefficients are smaller and even ambiguous, at least in 2014 and including all stations across the country, on dummy variables for Good Friday (-0.5, +0.3) and Easter Monday (-0.3, +0.6). Only a few existing studies specifically investigate this question, among them, Hall, Lawson, and Raymer (2007), who find no holiday effect.

Table 5: Regression of Average Retail Prices (Single Brands)

Dependent variable:	Super E5		Super E10		Diesel	
Retail price	(7)	(8)	(9)	(10)	(11)	(12)
Oligopoly player brand						
Aral	4.313	2.044	4.245	2.039	4.411	2.040
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Shell	4.380	1.601	4.292	1.588	4.646	1.625
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Esso	2.982	1.042	2.941	1.044	3.138	1.003
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Total	2.743	0.911	2.672	0.907	2.732	0.794
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Jet	*-0.049*	-0.371	*-0.125*	-0.378	-0.313	-0.551
	(0.54)	(0.00)	*(0.14)*	(0.00)	(0.00)	(0.00)
Other integrated player						
Star	0.805	-0.142	0.735	-0.149	0.791	-0.206
	(0.00)	(0.09)	(0.00)	(0.09)	(0.00)	(0.02)
Agip	2.097	2.195	2.000	2.167	2.017	2.109
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
HEM	0.256	-0.211	0.195	-0.203	0.194	-0.287
	(0.00)	(0.02)	(0.03)	(0.03)	(0.03)	(0.00)
OMV	4.318	1.423	4.190	1.364	4.324	1.220
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Independent brands (associations)						
AVIA	2.303	1.053	2.179	0.990	2.192	0.869
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
bft	0.569	0.228	0.554	0.239	0.634	0.242
	(0.00)	(0.01)	(0.00)	(0.01)	(0.00)	(0.00)
Raiffeisen	0.404	*0.141*	0.483	0.196	0.301	*0.108*
	(0.00)	*(0.14)*	(0.00)	(0.07)	(0.01)	*(0.26)*
Other selected independent brands						
Mr. Wash	-3.842	-2.941	-4.013	-3.050	-4.009	-3.055
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
DBV	-1.819	-0.894	-2.017	-1.009	-1.377	-0.521
	(0.00)	(0.02)	(0.00)	(0.01)	(0.00)	(0.06)
V-Markt	-1.674	*-0.390*	-1.854	-0.520	-1.019	*0.206*
	(0.00)	*(0.16)*	(0.00)	(0.07)	(0.00)	*(0.43)*
Globus	-1.635	-0.592	-1.701	-0.634	-1.617	-0.558
	(0.00)	(0.01)	(0.00)	(0.01)	(0.00)	(0.01)
BK	-1.617	-1.249	-1.737	-1.302	-1.254	-0.898
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
ED	-1.587	-1.436	-1.605	-1.361	-1.722	-1.551
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Input costs						
Ex-refinery price	1.257	1.168	1.260	1.169	0.731	0.834
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Constant	-1.053	10.079	-1.070	9.840	57.917	46.849
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Number of observations	3,286,373	3,298,068	3,150,305	3,161,785	3,314,436	3,326,152
Number of groups	14,006		13,436		14,131	
R^2	0.736	0.634	0.738	0.637	0.561	0.383

Note: Robust p-values in parentheses; non-significance at 10% level denoted in italics.
Specifications: (7), (9), (11) with daily prices; (8), (10), (12) with daytime prices.
Included but not shown: Other single brands; all station characteristics and demand-side controls.
Omitted: “Unbranded” stations and other omitted variables as in previous specifications.

Table 6: Regression of Daily Price Changes

Dependent variable:	Super E5		Super E10		Diesel	
# of daily price changes	(13)	(14)	(15)	(16)	(17)	(18)
Station type						
Autobahn station	-2.077	-0.557	-2.068	-0.556	-2.130	-0.560
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
24/7 business hours	-0.089	-0.030	-0.089	-0.028	-0.088	-0.030
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Brand categories						
Oligopoly player brand	0.141	0.036	0.097	0.027	0.179	0.044
	(0.00)	(0.01)	(0.01)	(0.04)	(0.00)	(0.00)
Integr. player brand	-0.240	-0.053	-0.287	-0.062	-0.169	-0.037
	(0.00)	(0.01)	(0.00)	(0.00)	(0.00)	(0.07)
Station characteristics						
Convenience store	0.077	0.020	0.059	*0.016*	0.079	0.020
	(0.01)	(0.05)	(0.03)	*(0.10)*	(0.01)	(0.06)
Kiosk-type store	-0.414	-0.105	-0.379	-0.092	-0.426	-0.107
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
No store	-0.899	-0.255	-0.866	-0.238	-0.946	-0.265
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Car wash	0.075	*0.008*	*0.047*	*0.001*	*0.048*	*0.000*
	(0.03)	*(0.50)*	*(0.17)*	*(0.94)*	*(0.17)*	*(0.99)*
Traffic intensity	0.103	0.025	0.089	0.021	0.104	0.025
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Secondary road	*0.006*	*0.000*	*0.003*	*-0.001*	*0.018*	*0.003*
	(0.83)	*(0.98)*	*(0.91)*	*(0.90)*	*(0.48)*	*(0.74)*
Local competition						
Distance to nearest comp.	-0.055	-0.013	-0.047	-0.011	-0.056	-0.013
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
# of competitors in 2 km	0.024	0.006	0.024	0.006	0.024	0.006
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.01)
Share of oligopoly brands	-0.280	-0.057	-0.257	-0.051	-0.268	-0.054
	(0.00)	(0.04)	(0.00)	(0.05)	(0.00)	(0.06)
Share of independents	-0.688	-0.159	-0.612	-0.137	-0.689	-0.158
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Demand-side controls						
Monday	1.305	0.313	1.308	0.309	1.346	0.318
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Saturday	0.624	0.162	0.626	0.160	0.642	0.164
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
School holiday	0.121	0.026	0.120	0.026	0.027	0.006
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Public holiday	-1.158	-0.277	-1.158	-0.273	-1.252	-0.295
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Constant	9.653	2.604	9.855	2.644	7.409	2.101
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Number of observations	3,286,373	3,286,373	3,150,305	3,150,305	3,314,436	3,314,436
Number of groups	14,006		13,436		14,131	
R^2	0.156		0.148		0.165	

Note: Robust p-values in parentheses; non-significance at 10% level denoted in italics.

Specifications: (13), (15), (17) with OLS; (14), (16), (18) with Poisson estimation.

Included but not shown: Weekday, state, pumps, ownership, and open on Sundays dummies.

Omitted variables: Road station, independent brand, standard store, Sunday.

largely comparable, suggesting not to have a structural difference of results induced by varying opening hours. Thus, while daytime prices reduce coefficients' negative magnitude, specifically also for the group of other selected independents, significant negative values remain in all specifications.[31]

Finally, we investigate drivers of price volatility to analyze how and why gasoline prices differ in the German market. To approximate volatility, we choose the number of price changes per day as the dependent variable and regress again on a full set of control variables (see Table 6 for estimation results). Given that our dependent variable in this case comprises count data, in addition to generalized least square estimations (in specifications (13), (15), and (17)), we also estimate a Poisson random-effects model (see Wooldridge 2010, p. 760) for each fuel type (in specifications (14), (16), and (18)). Both models indicate a consistent direction of effects (coefficients of Poisson model estimations can, however, not be linearly interpreted). First of all, daily price changes are influenced by the segment, that is, Autobahn stations change prices about two times less often during the day. Secondly, among station-specific characteristics, the type of shop, particularly the absence of a shop, is of relevance. This suggests less volatility in light of less sophisticated operations (e.g., with few employees or automated stations, fewer price changes can be assumed). Third, volatility is, specifically, also driven by two demand-side factors, namely weekends (specifically Sundays) and public holidays, both inducing one or more price changes less over a typical day.

5 Conclusion

In this paper, we have presented a large-scale analysis of price dispersion and price determinants on German retail gasoline and diesel markets, using a census of price quotes of virtually all stations in Germany. Specifically, we have been able to compare pricing of three different fuel types (i.e., Super E5, Super E10 and diesel), on different market segments (i.e., Autobahn and road stations), and to assess the impact of a rich set of station characteristics and measures of spatial competition on price levels. For this purpose, we have computed average daily and daytime retail prices (based on precise intraday price quotes), which we tested for price dispersion

[31]When interpreting results in Table 10 in Appendix B, please note, however, that for the group of other selected independent brands, a focus on stations with 24/7 opening hours quite dramatically reduces the number of observations, for reasons stated above. Specifically, Mr. Wash has no station (out of 19 in total), which is always open, while DBV, V-Markt, Globus, BK, and ED operate 10 (of 16), 5 (of 28), 38 (of 41), 8 (of 28), and 4 (of 106) stations on a 24/7 opening hours basis, respectively. Mr. Wash's highly negative coefficients, thus, cannot be tested within a 24/7 opening hour setup.

in a fixed effects setup and regress on various supply- and demand-side controls in (station-) random effects models.

While (true) price dispersion exists across fuel types, we find that a large part of the daily average distribution of prices observed "at the pump" can be associated with observable station characteristics as well as price shocks affecting all stations. Among the observable variables, differentiating between the two segments Autobahn and road stations, specific for the German market, is critical. Furthermore, brand recognition has a crucial impact on price levels in line with existing classifications of premium brands, but also with varying strategies regarding day- and nighttime pricing. Interestingly, Jet's position within the group of established brands and oligopoly-type players is rather ambiguous. Moreover, stations that sell gasoline and diesel as a by-product, are among the cheapest gasoline stations, even though structural differences in opening hours need to be accounted for. The type of local competition is found to be more relevant than the sheer number of players. Lower price levels can be expected the more heterogeneous the group of brands within a local area is. Finally, service offerings tend to increase prices, but in some instances also volatility. As an example, the absence of a shop and, thus, likely more automated operations, implies fewer price changes. The results are comparable across fuel types and largely support expectations on price determinants (Eckert 2013), while specific impacts naturally vary.

The findings presented in this paper are subject to certain assumptions and limitations. Among others, areas close to the border are subject to cross-border competition, which is not considered in the analysis (see, e.g., Banfi, Filippini, and Hunt 2005). Moreover, the method of calculating average daily and daytime prices might be biased in light of (not fully reflected) varying opening hours and different demand levels across day and night. Further research in the area of gasoline retail pricing in Germany may investigate specific aspects such as intraday pricing patterns, the impact of opening hours, or competition-related variables in a structural model.

References

ACCC (2007). *Petrol Prices and Australian Consumers: Report of the ACCC inquiry into the Price of Unleaded Petrol*. Canberra: ACCC.

Atkinson, Benjamin (2009). "Retail Gasoline Price Cycles: Evidence from Guelph, Ontario Using Bi-Hourly, Station-Specific Retail Price Data". In: *The Energy Journal* 30.1, pp. 85–110.

Bachmeier, Lance J. and James M. Griffin (2003). "New Evidence on Asymmetric Gasoline Price Responses". In: *Review of Economics and Statistics* 85.3, pp. 772–776.

Bacon, Robert W. (1991). "Rockets and Feathers: The Asymmetric Speed of Adjustment of UK Retail Gasoline Prices to Cost Changes". In: *Energy Economics* 13.3, pp. 211–218.

Banfi, Silvia, Massimo Filippini, and Lester C. Hunt (2005). "Fuel Tourism in Border Regions: The Case of Switzerland". In: *Energy Economics* 27.5, pp. 689–707.

Barron, John M., Beck A. Taylor, and John R. Umbeck (2004). "Number of Sellers, Average Prices, and Price Dispersion". In: *International Journal of Industrial Organization* 22.8-9, pp. 1041–1066.

Borenstein, Severin, A. Colin Cameron, and Richard Gilbert (1997). "Do Gasoline Prices Respond Asymmetrically To Crude Oil Price Changes?" In: *Quarterly Journal of Economics* 112.1, pp. 305–339.

Borenstein, Severin and Andrea Shepard (1996). "Dynamic Pricing in Retail Gasoline Markets". In: *RAND Journal of Economics* 27.3, pp. 429–451.

Bundeskartellamt (2011a). *Fuel Sector Inquiry: Final Report May 2011 - Summary*. Bonn: Bundeskartellamt.

— (2011b). *Sektoruntersuchung Kraftstoffe: Abschlussbericht Mai 2011*. Bonn: Bundeskartellamt.

Byrne, David P. (2012). "Petrol Price Cycles". In: *Australian Economic Review* 45.4, pp. 497–506.

Byrne, David P., Gordon W. Leslie, and Roger Ware (2015). "How do Consumers Respond to Gasoline Price Cycles?" In: *The Energy Journal* 36.1, pp. 115–147.

Cameron, A. Colin and Pravin K. Trivedi (2005). *Microeconometrics: Methods and Applications*. Cambridge: Cambridge University Press.

Carranza, Juan Esteban, Robert Clark, and Jean-François Houde (forthcoming). "Price Controls and Market Structure: Evidence from Gasoline Retail Markets". In: *Journal of Industrial Economics*.

Chouinard, Hayley H. and Jeffrey M. Perloff (2007). “Gasoline Price Differences: Taxes, Pollution Regulations, Mergers, Market Power, and Market Conditions”. In: *The B.E. Journal of Economic Analysis & Policy* 7.8, pp. 1–26.

Dewenter, Ralf and Ulrich Heimeshoff (2012). *Less Pain at the Pump? The Effects of Regulatory Interventions in Retail Gasoline Markets.* DICE Discussion Paper, No. 51.

Doyle, Joseph, Erich Muehlegger, and Krislert Samphantharak (2010). “Edgeworth Cycles Revisited”. In: *Energy Economics* 32.3, pp. 651–660.

Eckert, Andrew (2002). “Retail Price Cycles and Response Asymmetry”. In: *Canadian Journal of Economics* 35.1, pp. 52–77.

— (2003). “Retail Price Cycles and The Presence of Small Firms”. In: *International Journal of Industrial Organization* 21.2, pp. 151–170.

— (2013). “Empirical Studies of Gasoline Retailing: A Guide to the Literature”. In: *Journal of Economic Surveys* 27.1, pp. 140–166.

Eckert, Andrew and Douglas S. West (2005). “Price Uniformity and Competition in a Retail Gasoline Market”. In: *Journal of Economic Behavior & Organization* 56.2, pp. 219–237.

Foros, Øystein and Frode Steen (2013). “Vertical Control and Price Cycles in Gasoline Retailing”. In: *Scandinavian Journal of Economics* 115.3, pp. 640–661.

Hall, Joshua, Robert Lawson, and Lauren Raymer (2007). “Do Gas Stations Raise Prices on the Weekend or Holidays?” In: *Atlantic Economic Journal* 35.1, pp. 119–120.

Hosken, Daniel S., Robert S. McMillan, and Christopher T. Taylor (2008). “Retail Gasoline Pricing: What Do We Know?” In: *International Journal of Industrial Organization* 26.6, pp. 1425–1436.

Houde, Jean-François (2011). “Gasoline Markets”. In: *The New Palgrave Dictionary of Economics (Online Edition).* Ed. by Steven N. Durlauf and Lawrence E. Blume. Basingstoke: Nature Publishing Group.

Isakower, Sean and Zhongmin Wang (2014). “A Comparison of Regular Price Cycles in Gasoline and Liquefied Petroleum Gas”. In: *Energy Economics* 45, pp. 445–454.

Kihm, Alex, Nolan Ritter, and Colin Vance (2014). *Is the German Retail Gas Market Competitive? A Spatial-temporal Analysis Using Quantile Regression.* Ruhr Economic Papers #522.

Lewis, Matthew S. (2008). “Price Dispersion and Competition with Differentiated Sellers”. In: *Journal of Industrial Economics* 56.3, pp. 654–678.

Lewis, Matthew S. (2009). “Temporary Wholesale Gasoline Price Spikes Have Long-Lasting Retail Effects”. In: *Journal of Law & Economics* 52.3, pp. 581–605.

Lewis, Matthew S. and Michael D. Noel (2011). “The Speed of Gasoline Price Response in Markets with and without Edgeworth Cycles”. In: *Review of Economics and Statistics* 93.2, pp. 672–682.

Maskin, Eric and Jean Tirole (1988). “A Theory of Dynamic Oligopoly, II: Price Competition, Kinked Demand Curves, and Edgeworth Cycles”. In: *Econometrica* 56.3, pp. 571–99.

Noel, Michael D. (2007a). “Edgeworth Price Cycles, Cost-based Pricing and Sticky Pricing in Retail Gasoline Markts”. In: *Review of Economics and Statistics* 89.2, pp. 324–334.

— (2007b). “Edgeworth Price Cycles: Evidence from the Toronto Retail Gasoline Market”. In: *Journal of Industrial Economics* 55.1, pp. 69–92.

— (2008). “Edgeworth Price Cycles and Focal Prices: Computational Dynamic Markov Equilibria”. In: *Journal of Economics & Management Strategy* 17.2, pp. 345–377.

— (2009). “Do Gasoline Prices Respond Asymmetrically to Cost Shocks? The Effect of Edgeworth Cycles”. In: *RAND Journal of Economics* 40.3, pp. 582–595.

— (2011). “Edgeworth Price Cycles”. In: *The New Palgrave Dictionary of Economics (Online Edition)*. Ed. by Steven N. Durlauf and Lawrence E. Blume. Basingstoke: Nature Publishing Group.

OECD (2013). *Policy Roundtables: Competition in Road Fuel 2013*. Paris: OECD.

Pennerstorfer, Dieter et al. (2014). *Information and Price Dispersion: Evidence from Retail Gasoline*. Working Paper.

Radchenko, Stanislav (2005). “Oil Price Volatility and the Asymmetric Response of Gasoline Prices to Oil Price Increases and Decreases”. In: *Energy Economics* 27.5, pp. 708–730.

Shepard, Andrea (1993). “Contractual Form, Retail Price, and Asset Characteristics in Gasoline Retailing”. In: *RAND Journal of Economics* 24.1, pp. 58–77.

Simpson, John and Christopher T. Taylor (2008). “Do Gasoline Mergers Affect Consumer Prices? The Marathon Ashland Petroleum and Ultramar Diamond Shamrock Transaction”. In: *Journal of Law and Economics* 51.1, pp. 135–152.

Slade, Margaret E. (1987). “Interfirm Rivalry in a Repeated Game: An Empirical Test of Tacit Collusion”. In: *Journal of Industrial Economics* 35.4, pp. 499–516.

— (1992). “Vancouver’s Gasoline-Price Wars: An Empirical Exercise in Uncovering Supergame Strategies”. In: *Review of Economic Studies* 59.2, pp. 257–276.

Valadkhani, Abbas (2013). “Do Petrol Prices Rise Faster Than They Fall When the Market Shows Significant Disequilibria?” In: *Energy Economics* 39, pp. 66–80.

Wang, Zhongmin (2008). “Collusive Communication and Pricing Coordination in a Retail Gasoline Market”. In: *Review of Industrial Organization* 32.1, pp. 35–52.

— (2009a). “(Mixed) Strategy in Oligopoly Pricing: Evidence from Gasoline Price Cycles Before and Under a Timing Regulation”. In: *Journal of Political Economy* 117.6, pp. 987–1030.

— (2009b). “Station Level Gasoline Demand in an Australian Market with Regular Price Cycles”. In: *Australian Journal of Agricultural and Resource Economics* 53.4, pp. 467–483.

Wills-Johnson, Nick and Harry Bloch (2010a). “A Simple Spatial Model for Edgeworth Cycles”. In: *Economics Letters* 108.3, pp. 334–336.

— (2010b). *Gasoline Price Cycle Drivers: An Australian Case Study*. Curtin University of Technology Working Paper.

Wooldridge, Jeffrey M. (2010). *Econometric Analysis of Cross Section and Panel Data*. 2nd ed. Cambridge: MIT Press.

Zimmerman, Paul R., John M. Yun, and Christopher T. Taylor (2013). “Edgeworth Price Cycles in Gasoline: Evidence from the United States”. In: *Review of Industrial Organization* 42.3, pp. 297–320.

A Preparation of Raw Data

In this appendix, we will describe the process of data validation including any corrections made to MTS-K raw data with respect to both price and station data.

First, closely following validation rules suggested in Bundeskartellamt (2011b, Appendix p. 3), retail price raw data as submitted to the market transparency unit for fuel is corrected for obvious errors. Broadly speaking, Bundeskartellamt (2011b) proposes to delete inaccurate data entries for one of three reasons: missing entries (i.e., empty price cells), most likely incorrect price levels (i.e., prices below a threshold level of 0.50 Euro per liter or above a threshold level of 2.00 Euro per liter), or most likely incorrect price changes (i.e., zero price change or price change below or above a threshold level of |0.20| Euro per liter). Given that we focus on the standard operation phase ("Regelbetrieb") starting 1 December 2013 and leave out the first month (i.e., December 2013) as several stations are not (yet) submitting prices to MTS-K in this period, necessary adjustments to raw data for the period January to August 2014 are, in total, on an acceptable level. Table 7 presents an overview of validation rules and affected data records. Please note that deleting a data entry due to an incorrect price change might create a new instance of an incorrect price change. Therefore, we conduct corrections in as many iterations as required to eliminate all errors. Table 7 shows the sum of corrected price changes after all iterations. The empirical analysis presented in this paper relies on "total valid observations".

Table 7: Raw Price Data Preparation

Variable	Super E5	Super E10	Diesel
Total observations	15,650,930	15,242,059	16,046,924
Empty price cell	5,865	35,406	3,148
Price $<$ 0.50 Euro/liter	0	0	0
Price $>$ 2.00 Euro/liter	0	0	0
Change = 0.00 Euro/liter	164,335	168,197	155,641
Change $>$ |0.20| Euro/liter	3,891	2,654	3,845
Total invalid observations	174,091	206,257	162,634
Total valid observations	15,476,839	15,035,802	15,884,290

Source: MTS-K data (Jan-Aug 2014), own calculation.

In a second step, we check MTS-K station data for activity status and submission of price quotes for each fuel type. In total, the MTS-K data set (as of end of August 2014) includes 14,838 entries. A number of entries are, however, flagged as no longer active as, for instance, some stations were closed, simple re-entered into the database, or changed their ownership structure and/ or brand name, leading to double entries. These inactive entries are, therefore, disregarded from the analysis. Some further stations do not submit price quotes at all or not for all three fuel types (e.g., a station does not offer all products). After excluding stations without price quotes, in total, 14,454 stations are considered valid and are used for pricing analysis. For fuel-type specific analysis, (different) subsets of active stations with (valid) price quotes are used. While we explicitly exclude stations without any (fuel-type specific) price quotes, we do not impose further (subjective) threshold levels regarding, for instance, a minimum required number of price quotes per station to be considered. As a consequence, we allow the data set to be unbalanced. Finally, we link various station characteristics from Petrolview to MTS-K station data on the basis of geographic coordinates as well as address information (i.e., street, ZIP code, city). In total, we are able to connect 14,135 or 98% of all valid MTS-K stations with Petrolview data and consequently use this data set to determine price level determinants. Table 8 presents the number of stations along the categories described above. The empirical analysis in this paper relies on "active stations with price quotes" or, more precisely, fuel-type specific sub-groups, as well as "stations with all characteristics" or fuel-type specific sub-groups, respectively.

Table 8: Raw Station Data Preparation

Variable	Count
Total entries (MTS-K)	14,838
Active stations (MTS-K)	14,530
Active stations with price quotes (MTS-K)	14,454
Thereof: Offering Super E5	14,270
Thereof: Offering Super E10	13,673
Thereof: Offering Diesel	14,450
Stations with all characteristics (MTS-K, Petrolview)	14,135
Thereof: Offering Super E5	14,006
Thereof: Offering Super E10	13,436
Thereof: Offering Diesel	14,131

Source: MTS-K data, Petrolview data, own calculation.

B Tables

Table 9: Overview of Variables

Variable	Type	Source
Station location:		
Station ID	Integer, constant	MTS-K
Latitude	Decimal, constant	MTS-K
Longitude	Decimal, constant	MTS-K
ZIP code	Integer, constant	MTS-K
Federal state	Cluster, constant	OpenGeoDB/ own calc.
Type:		
Brand name	String, constant	MTS-K
Brand category 1	Cluster, constant	Bundeskartellamt/ own calc.
Brand category 2	Cluster, constant	Bundeskartellamt/ own calc.
Ownership type	Cluster, constant	Petrolview
Autobahn station	Binary, constant	Tank & Rast/ own research
Station offering & amenities:		
Offering Super E5	Binary, constant	MTS-K/ own calc.
Offering Super E10	Binary, constant	MTS-K/ own calc.
Offering diesel	Binary, constant	MTS-K/ own calc.
Shop type	Cluster, constant	Petrolview
Car wash facility	Binary, constant	Petrolview
Gasoline/ diesel pumps	Integer, constant	Petrolview
Truck pumps	Binary, constant	Petrolview
LPG pumps	Binary, constant	Petrolview
CNG pumps	Binay, constant	Petrolview
Traffic intensity	Cluster, constant	Petrolview
Secondary road	Binary, constant	Petrolview
Spatial competition:		
Nearest competitor	Decimal, constant	Own calculation
Competitors in 1 km	Integer, constant	Own calculation
Competitors in 2 km	Integer, constant	Own calculation
Competitors in 5 km	Integer, constant	Own calculation
Share of oligopoly players	Decimal, constant	Own calculation
Share of independents	Decimal, constant	Own calculation
Business hours:		
Open on Sundays	Binary, constant	MTS-K/ own calc.
Open “24/7”	Binary, constant	MTS-K/ own calc.
Retail prices:		
Fuel type	Integer, constant	MTS-K
Avg. daily retail price	Decimal, variant	MTS-K/ own calc.
Avg. daytime retail price	Decimal, variant	MTS-K/ own calc.
Wholesale prices:		
Refinery region	String, constant	O.M.R./ own calc.
Refinery price	Decimal, variant	O.M.R.
Weekday & holidays:		
Weekday	Integer, variant	Own calculation
Public holiday	Binary, variant	BMI
School holiday	Binary, variant	KMK

Note: BMI = Bundesministerium des Inneren, KMK = Kultusministerkonferenz
MTS-K = Markttransparenzstelle für Kraftstoffe, O.M.R. = Oil Market Report

Table 10: Regression of Average Retail Prices (Single Brands, Open 24/7)

Dependent variable: Retail price	Super E5 (19)	Super E5 (20)	Super E10 (21)	Super E10 (22)	Diesel (23)	Diesel (24)
Oligopoly player brand						
Aral	4.494	1.958	4.441	1.900	4.510	1.870
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Shell	4.471	1.436	4.393	1.372	4.679	1.406
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Esso	3.064	0.851	3.042	0.805	3.209	0.802
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Total	2.692	0.514	2.636	0.455	2.617	0.336
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.03)
Jet	*-0.148*	-0.896	*-0.222*	-0.975	-0.555	-1.197
	(0.39)	(0.00)	*(0.21)*	(0.00)	(0.00)	(0.00)
Other integrated player						
Star	0.745	-0.471	0.689	-0.529	0.625	-0.616
	(0.00)	(0.01)	(0.00)	(0.00)	(0.00)	(0.00)
Agip	2.639	2.269	2.545	2.166	2.544	2.165
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
HEM	0.598	*-0.243*	0.546	*-0.294*	0.405	-0.436
	(0.00)	*(0.17)*	(0.00)	*(0.10)*	(0.02)	(0.02)
OMV	4.458	1.278	4.324	1.137	4.455	1.070
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Independent brands (associations)						
AVIA	2.164	0.769	1.994	0.629	2.076	0.624
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
bft	*0.246*	*0.076*	*0.280*	*0.080*	*0.283*	*0.117*
	(0.22)	*(0.63)*	*(0.20)*	*(0.64)*	*(0.14)*	*(0.43)*
Raiffeisen	0.438	*0.023*	0.498	*0.036*	0.311	*-0.016*
	(0.00)	*(0.85)*	(0.00)	*(0.79)*	(0.03)	*(0.89)*
Other selected independent brands						
Mr. Wash	no obs.	no obs.	no obs.	no obs.	no obs.	no obs.
DBV	-1.899	-1.180	-2.151	-1.400	-1.231	-0.574
	(0.00)	(0.01)	(0.00)	(0.00)	(0.00)	(0.09)
ED	-2.203	-1.835	-2.290	-1.873	-2.410	-2.039
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
BK	-1.224	-1.334	-1.557	-1.646	-0.810	-0.910
	(0.00)	(0.00)	(0.00)	(0.00)	(0.01)	(0.01)
Globus	-1.816	*-0.525*	-1.801	*-0.533*	-1.972	-0.661
	(0.00)	*(0.10)*	(0.00)	*(0.15)*	(0.00)	(0.04)
V-Markt	-1.543	*-0.063*	-1.789	*-0.357*	-1.195	*0.307*
	(0.03)	*(0.93)*	(0.01)	*(0.61)*	(0.09)	*(0.65)*
Input costs						
Ex-refinery price	1.281	1.184	1.287	1.187	0.703	0.803
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Constant	-3.903	8.519	-4.152	8.281	61.237	50.751
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Number of observations	1,283,967	1,288,333	1,224,281	1,228,569	1,310,178	1,314,574
Number of groups	5,504		5,249		5,622	
R^2	0.750	0.660	0.751	0.663	0.601	0.458

Note: Robust p-values in parentheses; non-significance at 10% level denoted in italics.
Specifications: (19), (21), (23) with daily prices; (20), (22), (24) with daytime prices.
Included but not shown: Other single brands; all station characteristics and demand-side controls.
Omitted: "Unbranded" stations and other omitted variables as in previous specifications.

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