

Market Power in Retail Gasoline Markets

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Market Power in Retail Gasoline Markets

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Abstract

We estimate a structural model to uncover the degree of competition in retail gasoline markets using daily station-level data on quantity and price from the Swedish market. The structural model enables us to consider key features on both the demand and supply side that are important when evaluating retailers' ability to obtain market power. Endowed with station-level information on service level, contractual form and number of nearby stations, we take into account the main drivers of differentiation in the local market. Our findings suggest that retailers in general exercise significant intermediate levels of market power. Further, local station characteristics significantly affect to which extent stations are able to extract market power. Results are robust to different estimation methods.

Keywords: Gasoline markets, market power, markup estimation, local market competition

JEL Codes: D22, L13, L25, L81

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“...the stations’ gross margins naturally vary over time and depend on the local competition pressure.”

Swedish Competition Authority (2013, p.128)

1. Introduction

The same pattern is present in most countries: Gasoline markets are highly concentrated upstream, consisting of tight oligopolies, but often with a dispersed downstream retail market where the individual gasoline stations operate through various vertical contract arrangements. One important question raised is whether upstream market concentration restricts the level of competition downstream. The market structure has motivated much attention from both regulators and researchers, where pricing strategies and competition have been studied.¹

The aim of this paper is to examine the downstream competition level. Using detailed daily micro data on price and quantity, we estimate a structural model to uncover the degree of competition in retail gasoline markets. With information on each station’s local competition factors, station amenities and contractual arrangement, we address how local market conditions impact the competitive situation.² In an industry where markets are naturally geographically separated and local factors are the main drivers of differentiation, addressing station level characteristics is particularly important.

Endowed with a consecutive station level panel of daily quantity and price of gasoline for 180 stations for a whole year (2012), together with detailed information on the local competitive situation, we provide estimates of the degree of market power. The richness of the data allows us to introduce structure into the model.³ Due to both demography and local geography the gasoline market is divided into several local markets. Therefore, applying aggregate data will neglect the importance of variation in local conditions. Yet, because volume data have been

¹ For examples of government initiated studies, see for instance the Australian Competition and Consumer Commission (2007) for the Australian market, the Irish Competition Authority (2003) for the Irish market and the Norwegian Competition Authority (2014) for the Norwegian market.

² Examples on *local competition* studies include Alderighi and Baudino (2015), Firgo et al. (2015), Hosken et al. (2008), Barron et al. (2004), Barron et al. (2007), Cooper and Jones (2007) and Clemenz and Gugler (2006). Examples on *station amenities* studies include Haucap et al. (2017), Hosken (2008) and Eckert and West (2005). Examples on *brand identity and contractual forms* studies include Verlinda (2007), Cooper and Jones (2007), Hastings (2004), and Slade (1987).

³ Our data originate from an analysis performed by Foros and Steen (2013), initiated by the SCA. To obtain sufficient micro information at the station level 180 stations were picked for the calendar year 2012. The data were collected by the SCA, and stations were chosen to be representative for the whole Swedish market. For instance, the analysis covered all companies from different regional areas in Sweden in terms of urban and regional status as well as various city sizes. In our sample the highway market is also included as a separate group.

unavailable for the majority of the previous literature (as far as we are aware, exceptions are Slade, 1987 and Wang, 2009), this has restricted research to mainly study reduced form models using aggregate data (see e.g. Noel, 2016 for a survey). Others have employed proxies of quantity (e.g., Levin et al., 2017), which are exposed to measurement errors. In contrast, we get around both limitations with our data and are therefore in a favorable position to study the problem at hand. The structural model enables us to take into account key features in the gasoline retailing industry, both on the demand and on the supply side, that are important when evaluating retailers' ability to gain market power. By adding structure to the model, we are able to estimate the degree of market power. As such, we contribute to new insights to an unobserved economic measure of large interest for regulators.

We use data from the Swedish market. It shares features with most concentrated national gasoline markets. Specifically, at the upstream level, there are four major companies having 99% of the market during the sample period. Similar to several other countries, antitrust concerns have been raised on several occasions. In 2005, the Swedish Market Court found the major oil companies guilty of illegal cooperation. As a result, the companies paid 112 million SEK in fines. Between 2007 and 2010, the market went through four major mergers, thereby increasing concentration further. Later, in 2012, due to worries on the potential lack of competition, the Swedish government required the Swedish Competition Authority (hereafter referred to as SCA) to initiate studies of the market structure in the industry.⁴ The degree of competition in retail gasoline markets therefore remains a current and relevant question.

We proceed by estimating a structural system of demand and supply at the retail level using the model by Bresnahan (1982) and Lau (1982). This approach suggests the following identification of the degree of market power: By adding interaction terms between exogenous demand side variables and the retail price in the demand specification, changes in these variables both shift and pivot the demand curve. The degree of market power as modeled in the supply equation is then identifiable through these terms. We use instruments to correct for endogeneity in price and quantity.

From the demand estimates, we find a highly elastic gasoline demand at the station level (significant elasticity of -15.8). This suggests that price is a very important determinant of the demand a seller faces, and there are large substitution effects of the same product between local stations. A critical requirement for empirical identification in the Bresnahan-Lau approach is that exogenous demand variables that interact with price enter the demand equation in a well-

⁴ As a result, the SCA initiated two studies of the competitive structure of the Swedish retail market; see Foros and Steen (2013) and Ganslandt and Rönnholm (2014).

behaved fashion. We use local income and the distance to the nearest competitor in these interactions, and both measures come in significant. Using the information from the demand estimates we identify market power through the estimated supply relation. Our findings suggest that retailers exercise intermediate levels of market power in the Swedish market, where our baseline model provides a markup estimate of 0.277. When extending our model to allow for local station characteristics, the competitive level varies significantly. Specifically, we find that a station's market power decreases with the number of stations within its close vicinity, reducing the markup with 0.025 for each additional local station within 3 km distance. The station's service level increases market power: a full service station adds another 0.11 to its markup as compared to a self-service station. Finally, company-owned stations are able to extract higher markups, adding 0.098 to its markup. Hence, differentiation at the station level significantly affects retailers' ability to exercise market power.

To illustrate our results, we construct estimates for two stations with different local competitive characteristics. We show that differences in local station characteristics, even within the scope of the variation in our sample, have a large effect on local market power. The magnitude in these local differences implies that in some local markets, the station will be able to extract quite some market power (market power estimate of 0.411), while in other markets, local market conditions significantly reduce a station's possibility to extract market power (market power estimate of 0.163).

The rest of the paper proceeds as follows. In Section 2 we discuss the literature on measurement of market power and provide an overview of the most common sources of market power in gasoline retailing. Section 3 presents the structural Bresnahan-Lau model, while Section 4 describes the data and the industry. Section 5 presents the empirical specification of the Bresnahan-Lau model. The results are discussed in Section 6. Finally, Section 7 concludes.

2. Literature review

2.1 Measuring market power in gasoline retailing

Previous literature suggests several factors that might impact local price competition in retail gasoline markets. These are mainly demographics, station amenities, contractual forms, and station location and density. The majority of empirical studies look at the retail price as a function of independent determinants and derive the potential effects on competition from these results. Our approach is to estimate the market power parameter directly by applying the oligopoly model by Bresnahan (1982) and Lau (1982). To the best of our knowledge, no study

has yet used the Bresnahan-Lau method in examining gasoline retailing.⁵ Further, as already emphasized, our price and quantity data are of daily frequency, at the station level and consecutive for a whole year, allowing us to obtain precise estimation of structural demand and supply models. Even though high-frequency price data are available in most retail markets, quantity data at the station level have so far been rare in the literature of gasoline retailing. As far as we are aware, the only exceptions are Slade (1987) and Wang (2009).

A few papers estimate structural models of supply and demand in order to evaluate the degree of market power. Slade (1987) estimates station demand, cost and reaction functions using the same oligopoly supergame model as in Slade (1989), with data on daily price, volume and cost figures from stations in Vancouver, Canada. Houde (2012) considers stations close to the same commuter route as substitute stations as perceived by consumers, and estimates demand using bi-monthly station level data as well as data on road network structure for Quebec, Canada. Similarly, with monthly volume, price and station characteristics data from Hawaii, USA, Manuszak (2009) estimates demand and supply for both the upstream- and the downstream market. Both Houde (2012) and Manuszak (2009) use variants of the discrete-choice demand model for differentiated products developed by Berry et al. (1995). All these studies conclude that sellers in the downstream market exercise some market power.

In addition, many studies relate the degree of market power of retailers to how retail prices and margins respond to input price changes. For instance, Borenstein and Shepard (1996) examine price patterns that are consistent with models of tacit collusion and find that retail margins are higher when the wholesale price is anticipated to fall as predicted by these models. Further, Borenstein et al. (1997) and Deltas (2008) relate asymmetric responses of retail prices to market power of retailers by estimating lag adjustment models.

2.2 Sources of market power in gasoline retailing

When it comes to local competition, studies have found ambiguous relations between station density and price. On the one hand, Barron et al. (2004), Barron et al. (2008) and Clemenz and Gugler (2006) show that higher station density tends to lower average prices, suggesting that a higher number of sellers raises local competition. This is in line with our findings, which

⁵ See Bresnahan (1989) for a discussion of this model. Several studies have applied this methodology in various disguises on several industries. For some of these see, for *consumer credit*: Toolsema (2002), for *banking*: Gruben and McComb (2003), Shaffer (1993) Suominen (1994), for *petroleum*: Considine (2001), for *cement*: Rosenbaum and Sukharomana (2001), for *cigarettes*: Delipalla and O'Donnell (2001), for *beef processing*: Muth and Wohlgenant (1999); for *salmon*: Steen and Salvanes (1999); for *sugar*: Genesove and Mullin (1998); for *advertising*: Jung and Seldon (1995), for *lumber*: Bernstein (1994), for *coconut oil*: Buschena and Perloff (1991) and for *electricity*: Puller (2007) and Graf and Wozabal (2013).

propose that a seller's market power decreases in the number of neighbour stations. Similarly, Alderighi and Baudino (2015) suggest that stations' prices rely on neighbour stations' prices within around 1km. On the other hand, Hosken et al. (2008) find no relation. Cooper and Jones (2007) show that a station faces strongest competition from the nearest neighbor station, while Firgo et al. (2015) suggest that sellers who have a central location in a market relative to their competitors have a stronger influence on pricing decisions of competitors and on the equilibrium market price.

Regarding the impact of service level measured through station amenities on prices and competition, previous studies provide mixed results. Eckert and West (2005) find that local market structure and station characteristics affect sellers' (uniform) price setting and suggest the presence of imperfect competition. Haucap et al. (2017) document that prices are positively related to station service levels, while Shepard (1991) finds that stations charge a full-service markup. In contrast, Hosken et al. (2008) find no impact of station amenities. We find in our study that higher service level is positively related to market power.

Turning to the effect of contractual forms and brand identity, Eckert and West (2005) show that major brand stations with supplier control are more likely to set the market mode price, suggesting that the presence of vertically integrated major brand stations might increase incentives to tacitly collude. Cooper and Jones (2007) document that interbrand competition is more intensive than intrabrand competition. Hastings (2004) finds that the presence of independent retailers serves to decrease prices due to higher local price competition, while Verlinda (2007) finds that brand identity impacts how sellers respond to cost shocks, suggesting that asymmetric price responses may be explained by local market power.

3. The Bresnahan-Lau model

We make use of the Bresnahan-Lau model, after Bresnahan (1982) and Lau (1982). By estimation of market demand and a cost relation, a parameter referring to the level of competition in the market is identifiable.

Market demand is described by the function

$$Q = D(P, Z; \alpha) + \epsilon \quad (1)$$

where Q is aggregate quantity, P is price, Z is a vector of exogenous demand side variables, α a vector of parameters which are to be estimated and ϵ the error term.

Under the assumption that sellers are profit maximizing, the structure of the supply side depends on whether sellers are price-takers or not. Under perfect competition, the first-order

condition of the profit maximization problem gives price equal to marginal cost $c(\cdot)$, which can be written as

$$P = c(Q, W; \beta) + \eta \quad (2)$$

where W is a vector of exogenous supply side variables, β a vector of supply side parameters and η the error term. However, if sellers are not price takers, perceived marginal revenue is set equal to marginal cost. The price relation is then⁶

$$P = c(Q, W; \beta) - \lambda h(Q, Z; \alpha) + \eta. \quad (3)$$

$h(\cdot)$ is defined as

$$h(\cdot) = \frac{\partial D^{-1}(Q, Z; \alpha)}{\partial Q} Q. \quad (4)$$

Hence, $P + h(\cdot)$ is industry marginal revenue while $P + \lambda h(\cdot)$ is the seller's perceived marginal revenue. λ can be interpreted as the industry average conjectural variation elasticity, where firm i 's conjectural variation elasticity is (Dickson, 1981);

$$\lambda_i = \frac{\partial Q/Q}{\partial q_i/q_i} = \frac{\partial Q}{\partial q_i} \frac{q_i}{Q}. \quad (5)$$

That is, λ_i measures firm i 's anticipated change in the output of all remaining firms following a change in its own output. Likewise, λ measures the industry's average level of competition and lies in the range $[0,1]$ if it is to be given meaningful economic translation. $\lambda = 0$ thus implies perfect competition, $\lambda = 1$ implies a perfect cartel, while intermediate values refer to various sorts of oligopoly regimes.

Bresnahan (1982) and Lau (1982) show that by interacting exogenous demand side variables Z with P in the demand specification, changes in these variables both shift and pivot the demand curve such that λ can be econometrically identified. Formally, assuming that both the demand function and the marginal cost function are linear, the latter of which is given by $c(\cdot) = \beta_0 + \beta_1 Q + \beta_2 W$, the simultaneous equation system consisting of the demand and supply relation is⁷

⁶ Profit maximization at the industry level is (simplified by omitting vectors of explanatory variables and parameters) $Max_Q \Pi = QD^{-1}(Q) - C(Q)$, where $D^{-1}(Q)$ is the inverse demand function and $C(Q)$ the cost function. Solving for P from the first-order condition yields $P = (\partial C(Q)/\partial Q) - (\partial D^{-1}(Q)/\partial Q)Q$. The average fraction of a firm's industry profits is λ , hence $P = (\partial C(Q)/\partial Q) - \lambda(\partial D^{-1}(Q)/\partial Q)Q$, which is equivalent to Eq. (3) where $c(\cdot) = \partial C(Q)/\partial Q$ and $h(\cdot) = (\partial D^{-1}(Q)/\partial Q)Q$.

⁷ Note that the inverse demand function is $D^{-1}(Q) = (Q - \alpha_0 - \alpha_2 Z)/(\alpha_1 + \alpha_3 Z)$. Hence, $h(\cdot) = Q(\partial D^{-1}(Q, Z; \alpha)/\partial Q) = Q(1/(\alpha_1 + \alpha_3 Z))$. Marginal revenues are $MR = (\partial(Q \times P)/\partial Q) = P + h(\cdot) = P + Q/(\alpha_1 + \alpha_3 Z)$. If there is monopoly pricing, the equilibrium condition is $c(\cdot) = MR$, and solving for P we obtain

$$Q = \alpha_0 + \alpha_1 P + \alpha_2 Z + \alpha_3 PZ + \epsilon \quad (6)$$

$$P = \beta_0 - \lambda \left[\frac{Q}{\alpha_1 + \alpha_3 Z} \right] + \beta_1 Q + \beta_2 W + \eta. \quad (7)$$

By first estimating Eq. (6) of the system, α_1 and α_3 can be treated as known parameters. In Eq. (7), there are two included endogenous variables, Q and $Q^* = Q/(\alpha_1 + \alpha_3 Z)$, and two excluded exogenous variables, Z and PZ . The term $\alpha_3 Z$ allows separation between Q and $Q^* = Q/(\alpha_1 + \alpha_3 Z)$ and hence identification of λ . If PZ is omitted in Eq. (6), $Q^* = Q/\alpha_1$. Then, we would have two structural parameters λ and β_1 , but only one estimate based on the coefficient of Q . The supply relation is still identified, but we would not know whether we have to do with the case of $P = c(\cdot)$ or $MR = c(\cdot)$. Hence, inclusion of the interaction term PZ is crucial for identification of the level of competition in the market.

Note that we apply the model on station level data, and further use information that identifies differences in competition across local markets. The Bresnahan-Lau model will therefore provide us with an (average) markup reflecting the degree of competition at the station level.

The Bresnahan-Lau model along with other conjectural variation (CV) models received critique in the late nineties for being atheoretical, in particular from Corts (1999). His argument is that inference regarding the extent of market power cannot be made without specifying underlying behavior. More specifically, he argues that the mapping between equilibrium variation and the equilibrium value of the elasticity-adjusted price cost margin is not valid, unless average and marginal responses of margins to demand shifters are the same. However, at the same time Genesove and Mullin (1998) assessed actual, as opposed to potential, bias in CV models as predicted by Corts, using data on observed costs and margins in the sugar refining industry. The sugar refining industry's very simple fixed coefficient technology serves as an objective benchmark to the estimated models. They find that estimated and actual cost margins are quite close, and the potential bias as suggested by Corts very small, if even existing, which they argue favors the atheoretical CV model. They directly address Corts' argument (p.369): *"The proper test of a methodology is not the correctness of its assumptions, however, but its success or failure in doing what it is meant to do. So while acknowledging the failure of an assumption to hold, we examine how well the methodology does in reproducing the full-information estimates of conduct and cost"*. In a recent study discussing among other things the CV models, Aguirregabiria and Slade (2017) also conclude accordingly. The Bresnahan-Lau

$P = \beta_0 - (Q/(\alpha_1 + \alpha_3 Z)) + \beta_1 Q + \beta_2 W$. It follows that the econometric specification for supply is $P = \beta_0 - \lambda(Q/(\alpha_1 + \alpha_3 Z)) + \beta_1 Q + \beta_2 W + \eta$ (or equivalently, $P = \beta_0 + \lambda(-Q/(\alpha_1 + \alpha_3 Z)) + \beta_1 Q + \beta_2 W + \eta$).

and Genesove-Mullin conduct approach is thus still valid as an empirical way of measuring market power. It was recently applied in an empirical study of pass-through, where Weyl and Fabinger (2013) postulate a model where the elasticity-adjusted Lerner index is set equal to a conduct parameter in the fashion of Bresnahan (1982, 1989) and Genesove and Mullin (1998).

4. Overview of industry and data

4.1 Industry characteristics

During the sample period, there are four major companies in the Swedish market; Statoil Fuel & Retail AB (operating the brands Statoil and Jet), St1 Energy AB (operating the brands St1 and Shell), OK-Q8 AB and Preem AB.⁸ These four companies run 2 416 of 2 716 retail stations (Ganslandt and Rönholm, 2014). Statoil Fuel & Retail AB has a market share in volume of gasoline of 34.9%, St1 Energy AB of 22.6%, OK-Q8 of 27.9% and Preem AB of 14.2% (SPBI, 2013). In total, the four majors have a market share of over 99%, and the Herfindahl index of the industry is 2 173, suggesting that the market is concentrated.⁹ The majority of retail stations are vertically integrated in the sense that the upstream company owns the stations and is responsible for running them. The rest of the stations are either commissioned agent stations, franchise stations or dealer owned stations.¹⁰

Market power is a highly relevant issue in this industry, hence assessing the degree of competition in the market is important. This is underlined both by the vast existing general literature on the topic, and, more specifically, by a high focus on the part of the regulators on competition challenges in the Swedish gasoline market. In 2005 the Swedish Market Court found the major oil companies guilty of illegal cooperation during the year 1999. They were penalized for, among other things, coordinated rebate reductions in order to sort customers into different groups, internal agreements not to compete for customers among themselves, and agreements on increasing the retail price (Swedish Market Court, 2005). Common for these actions were their potential to soften competition. In total, the companies paid 112 million SEK in fines.¹¹ At that time, there were six major companies operating; OK-Q8 (market share 26.20%), Statoil (24.0%), Shell (16.70%), Hydro (11.9%), Preem (10.90%) and Jet (8.3%)

⁸ Of these brands, Jet and St1 only operate self-serviced retail stations.

⁹ Typically, the other stations are small. As opposed to the 99.6% market share in volumes, the four firms have more than ten percentage points fewer stations (89%).

¹⁰ In gasoline retailing, the most common contract types are (i) company-owned contracts, which correspond to full vertical integration, (ii) franchising contracts which assign some control to the upstream firm, and (iii) open-dealer contracts at the other end, corresponding to full vertical separation (Shepard, 1993).

¹¹ In 2005, one US dollar was worth between 6.8 and 7.6 SEK.

(Foros and Steen, 2013). This corresponds to a Herfindahl index of 1 874, which is lower than the 2012 level. The growth in concentration is mainly due to four major mergers taking place between 2007 and 2010.¹² This also led to steadily increasing gross margins over the period by around 30%.¹³ Later, in 2012, and partly due to this development and worries about the potential lack of competition, the SCA was required by the government to initiate studies of the market structure in this market.¹⁴

4.2 Data

The data period is 1 January 2012 to 31 December 2012 and the sample consists of 180 stations. Sample stations are from four different geographical regions. These are «larger cities» (Stockholm, Gothenburg and Malmo, the respective first, second, and third largest cities in Sweden), «smaller cities» (cities with a population between 33 000 and 80 000), «E6 highway»¹⁵ and «rural areas» (population below 10 000). Regions can be subdivided into counties and municipalities.¹⁶ An overview of station and municipality distribution for the sample is provided in Table 1.

Table 1: Station and municipality distribution across geographical regions.

Region	Number of stations	Number of municipalities
Larger cities	81	8
Smaller cities	32	6
E6 highway	26	9
Rural areas	41	28
Total	180	51

Information on station characteristics and facilities includes the distance to the nearest, second nearest and third nearest competitor, as well as brand and contractual form with the upstream company (company-owned, commissioned agent, franchise or independent). These data are collected by the SCA. To obtain a measure of the prices charged by nearby stations, we compute for each station a rival price equal to the daily average retail price per liter of the

¹² In 2007, Statoil acquired Norsk Hydro, in 2008 Statoil acquired Jet from Conoco Phillips, in 2009 St1 acquired 158 self-serviced stations from Statoil, and in 2010 St1 bought Shell (Ganslandt and Rönnholm, 2014).

¹³ See report by the SCA (2013), in particular Figure 3.11, p 123.

¹⁴ See Foros and Steen (2013) and Ganslandt and Rönnholm (2014).

¹⁵ E6 is a part of the international E-road network. We consider it a separate geographical region as customers who frequently purchase from stations along the highway mostly are highway commuters. Further, it is likely that demand around highways is more variable in relation to weekends and holidays.

¹⁶ Sweden is divided into 21 counties and 290 municipalities. Some counties are represented in several of the geographical regions because the E6 highway is located near several larger and smaller cities. Our sample consists of observations from 14 distinct counties.

other stations in the same municipality as the station.¹⁷ Further, from the information on distance to the nearest competitors, we compute the number of stations within three km from each seller, which we use as a measure of station density. A carwash indicator, a self-service indicator and the total number of stations in a county are obtained from the petroleum companies' websites.¹⁸

Table 2: Overview of data definition and sources.

Data definition	Variable name	Level	Frequency	Source
95 octane gasoline retail price per liter	P	Station	Daily	SCA
Volume in liters sold of 95 octane gasoline	Q	Station	Daily	SCA
Rotterdam wholesale price per liter (Platts)	Wholesale price	Industry	Daily	SCA
Rival retail price per liter	Rival price	Station	Daily	SCA
Diesel retail price per liter	Diesel price	Station	Daily	SCA
Brand	Brand	Station	Yearly	SCA
Distance to nearest competitor in kilometers	Distance to competitor	Station	Yearly	SCA
Number of stations within 3 km radius	Station density	Station	Yearly	SCA
Average disposable income in 1000 SEK	Y	Municipality	Yearly	Statistics Sweden
Population number in 1000	Population	Municipality	Quarterly	Regional Facts
Supply of public transportation in 1000 kilometers per capita	Public transportation	County	Yearly	STA
Total number of stations	Number of stations	County	Yearly	Company websites

We assemble data on demographics from 'Regional Facts', data on average disposable income¹⁹ from Statistics Sweden, and data on public transportation²⁰ from the Swedish Transport Analysis (STA) based on the stations' location, using their addresses. These data are

¹⁷ Of the 180 stations, 159 have at least one other station located in the same municipality in the sample. The remaining stations are the only station in their municipalities. Of these, 18 stations have at least one other station located in the same county. For these, we instead compute the daily average price of the other stations in the same county. For the remaining 3 stations, we use the average daily price of other stations in the same region.

¹⁸ Some facility information is accessed in 2017. Hence, we implicitly assume that these facilities are the same in 2017 as in 2012.

¹⁹ Disposable income is measured as the sum of all tax deductible and non-tax deductible income subtracted taxes and other negative transfers.

²⁰ The supply of public transportation measured in kilometers is the sum of kilometers driven by buses, trains, trams and lightrails.

either at the municipality or the county level and are either quarterly or yearly data. A complete overview of data and sources is presented in Table 2.

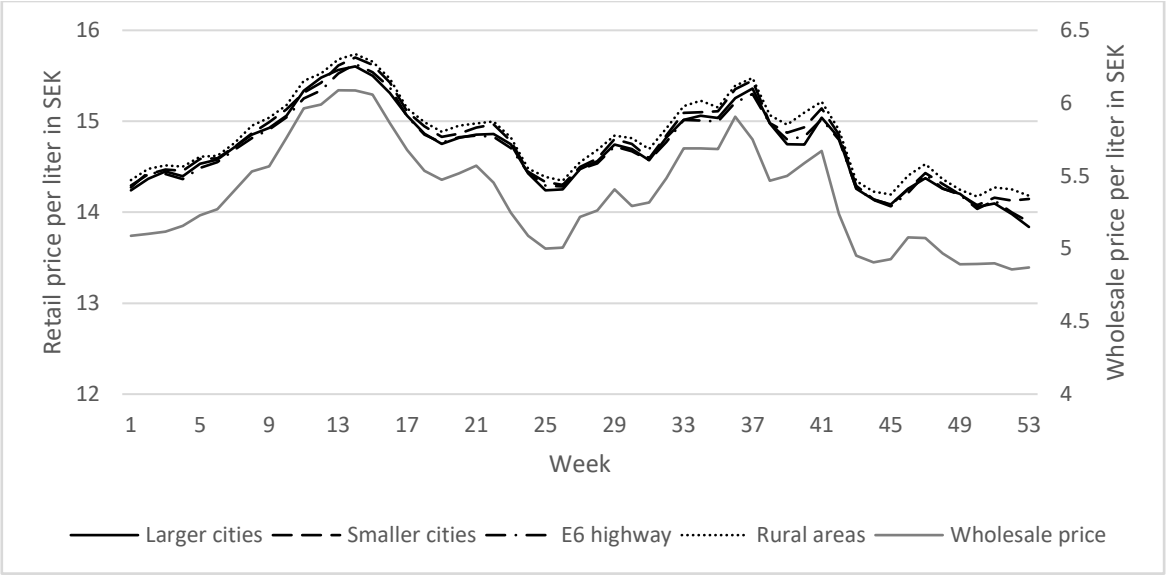


Figure 1: Average weekly retail price for each geographical region (left axis) and wholesale price (right axis). Sample period is 1 January 2012 to 31 December 2012.

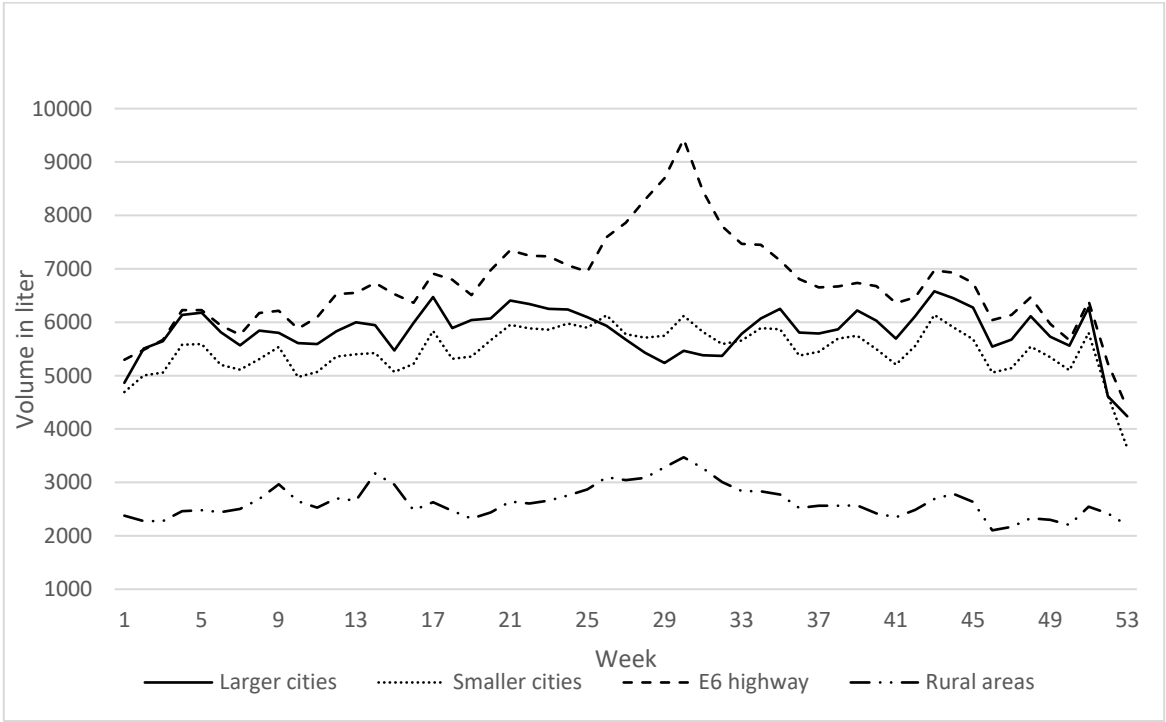


Figure 2: Average weekly quantity sold at the station level in different geographical regions. Sample period is 1 January 2012 to 31 December 2012.

Figure 1 depicts the retail price averaged over stations within each geographical region. Prices across regions are quite similar, however, rural areas have slightly higher prices than other regions in most parts of the sample period. Prices are highest during the spring and autumn months, and fluctuations seem to follow those observed in the wholesale price. On the other hand, as shown in Figure 2, the average quantity sold for stations varies more across regions as compared to prices. Average quantity sold per station is highest in the cities and the E6 highway, while lowest in rural areas. Volumes resemble the population in these areas, as more inhabitants naturally lead to higher consumption of fuel. The E6 highway is one of the main commuting highways in Sweden, which explains the high average volume sold in this region. Further, the summer holiday season stands out for the E6 highway with an upward peak in the volume sold in the summer months (July and August) due to increased traffic. Descriptive statistics of the main variables are presented in Table 3.

Table 3: Statistical properties of main variables (number of stations $n=180$).

Variable name	Mean	St.dev.	Min	Max
P	14.756	0.472	13.300	15.950
Q	5197.569	3776.033	11.000	29833.630
Wholesale price	5.394	0.358	4.800	6.151
Y	384.508	58.996	295.700	616.700
Rival price	14.761	0.457	13.399	15.950
Diesel price	14.583	0.330	13.340	15.680
Public transportation	81.391	18.272	31.707	114.630
Population	243.533	277.779	3.196	881.235
Number of stations	49.997	33.338	4	122
Distance to competitor	1.822	3.734	0.020	30
Station density	2.396	1.417	0	4
Carwash	0.322	0.467	0	1
Self-service	0.353	0.478	0	1
Company-owned	0.761	0.427	0	1
Commissioned agent	0.205	0.404	0	1
Franchise	0.011	0.106	0	1
Independent	0.023	0.149	0	1

5. Empirical specification of the Bresnahan-Lau model

The first equation in our simultaneous equation system is the demand function

$$Q_{it} = \alpha_0 + \alpha_1 P_{it} + \mathbf{z}' \alpha_z + P_{it} \mathbf{z}' \alpha_{Pz} + \mathbf{x}' \alpha_x + \epsilon_{it}, \quad (8)$$

where i indexes station and t indexes day. Q_{it} is the daily volume sold in liters and P_{it} is the price per liter at station i at time t . In Section 3 we showed that the inclusion of interactions

between variables in \mathbf{z} and P_{it} is crucial for the identification of the supply side equation, and that the choice of \mathbf{z} -variables hence identifies the markup in the Bresnahan-Lau framework. In the literature, variables that from theory are believed to both be exogenous to quantity demanded and very likely shift demand have been used as \mathbf{z} -variables. Typically, these are variables that affect demand through income or market size, or variables related to substitute products.²¹ The \mathbf{z} -variables' validity are empirically evaluated in these models based on two factors; whether they enter significantly in the estimated demand equation and whether the demand elasticities where these \mathbf{z} -variables enter predict reasonable values according to theory and market characteristics. We choose \mathbf{z} as a 2×1 column vector consisting of average disposable income and the distance to the closest competitor. We can interpret the distance to the closest competitor as the degree of substitute possibilities between a station's gasoline and another station's gasoline. Hence, the \mathbf{z} -vector includes one income measure and one substitute measure.

We also include additional exogenous variables which do not interact with P_{it} in the $K \times 1$ column vector \mathbf{x} , consisting of the rival price, the population in the municipality, the number of 1000 kilometers driven by the public transportation per capita and the total number of stations in the county. In addition, \mathbf{x} includes a full set of day-of-the-week dummy variables using Monday as baseline, a full set of month dummy variables using January as baseline, and a full set of region dummy variables using larger cities as reference category. A complete overview of variable definitions, data source, granularity and frequency is presented in Section 4. Finally, ϵ_{it} is the idiosyncratic error term representing unobserved factors which have an impact on the quantity demanded on each station.

The supply specification is

$$P_{it} = \beta_0 + \lambda Q_{it}^* + \beta_1 Q_{it} + \mathbf{w}' \boldsymbol{\beta}_w + \eta_{it}, \quad (9)$$

²¹ Prices of substitute goods and income are commonly applied as \mathbf{z} -variables in studies of commodity markets (e.g., Steen and Salvanes, 1999; Buschena and Perloff, 1991; Rosenbaum and Sukharomana, 2001). Time trends and seasonal factors have also been applied (e.g., Buschena and Perloff, 1991; Considine, 2001). In the banking literature, market interest rates, which serve as substitute prices, and GDP, a measure of macroeconomic activity, are used (e.g., Toolsema, 2002; Shaffer, 1993; Shaffer and DiSalvo, 1994; Suominen, 1994). Graf and Wozabal (2013) use a temperature index as an exogenous demand rotator in their study of electricity markets. Jung and Seldon (1995) include the number of new products introduced to the advertising market when studying the advertisement market.

where $Q_{it}^* = -Q_{it}/(\alpha_1 + \mathbf{z}'\alpha_{Pz})$. \mathbf{w} is a $K \times 1$ column vector of exogenous supply side variables consisting of the daily wholesale price, a dummy for whether station i offers carwash or not, a dummy for whether station i is self-serviced or not, a full set of month dummy variables, a full set of region dummy variables, contractual form dummies and a full set of brand dummy variables.²² η_{it} is the idiosyncratic error term which represents unobserved differences in sellers' marginal costs while Q_{it} is the actual quantity sold at station i on day t .²³

A fundamental endogeneity problem arises as quantity demanded affects the price sellers set, while price setting also affects the quantity demanded by consumers. Hence, the two variables of interest are simultaneously determined within the model, causing P_{it} to be correlated with ϵ_{it} in Eq. (8) and, likewise, Q_{it} to be correlated with η_{it} in Eq. (9). To correct for the biases, we apply two stage least squares (2SLS). We use the wholesale price and the diesel price as instrumental variables for P_{it} in the demand equation. In the supply relation, the variables included in \mathbf{z} are used as instrumental variables for Q_{it} .

We use the wholesale price as an instrument for P_{it} because the wholesale price is the main input cost for gasoline.²⁴ Further, there is no obvious direct relationship between the cost of input factors and the quantity demanded in the retail market, implying that the wholesale price is uncorrelated with ϵ_{it} . However, since it only exhibits variation over time, we also include the station-specific diesel price as an instrument. It correlates with P_{it} through time-varying factors that might affect both prices, such as oil and refinery conditions. In addition, it correlates with P_{it} through the local conditions at the station level such as local competition intensity, and thus captures some of the cross-sectional variation in P_{it} . Further, diesel and gasoline are not substitute goods at the transaction time. To the extent that the relative price ratio might influence long-run decisions regarding which car type (diesel or gasoline fueled) to buy, our dataset only spans one calendar year. This suggests that the diesel price reflects local competition on a daily basis in the same fashion as local competition affects the gasoline price, however, has no direct impact on the gasoline price as such. The diesel price is thus unlikely systematically correlated with shocks to gasoline demand within a calendar year. Hence, we believe the diesel price serves as both a valid and exogenous instrument. This choice of instrument is also motivated

²² The variables included in \mathbf{w} have an impact on a seller's marginal costs. Consequently, by using P_{it} as the left hand side variable we can estimate the supply relation without knowing marginal costs.

²³ In order to estimate the equations and impose market clearing, we assume that prices clear the market, allowing us to treat Q_{it} as the equilibrium quantity. We believe this is a reasonable assumption to make since the Swedish retail market is not under governmental regulation neither at the demand nor at the supply side during the sample period.

²⁴ Swedish oil companies are price takers in the European gasoline market.

and used in Coyle et al. (2012). As instruments for Q_{it} we use the \mathbf{z} variables; namely the average disposable income and the distance to the closest competitor. These variables are good candidates as they directly influence gasoline consumption through an income and substitution effect. However, they have no clear partial effect on the retail price or factors determining sellers' marginal costs, implying no correlation with η_{it} .

Data differ in various dimensions. The main variables Q and P exhibit both time and cross-sectional variation, as do *rival price* and *diesel price*. *Wholesale price* varies from day to day. Station characteristics are fixed over time, but have significant variation across stations. The remaining independent variables vary across either municipality or county, but are fixed over time.²⁵ In order to use all within and between variation across different dimensions, we use pooled OLS as an estimation method (Baltagi and Griffin, 1983). First, we estimate Eq. (8) using two-stage least squares. Next, we use the estimated parameters from Eq. (8) to calculate Q^* . Finally, we estimate Eq. (9), again using two-stage least squares.

6. Empirical results

6.1 Market power in the Swedish retail gasoline market

Demand

Results for the demand equation (8) together with elasticities are presented in Table 4.²⁶ All \mathbf{z} -variables come in significant, both alone and through the interaction terms, confirming statistically that they can be used for identifying markup in the supply relation. Due to the interaction terms, parameter values and corresponding signs give little direct intuition. Elasticities are therefore a better measure in order to gain intuition, and to validate the chosen demand variables to interact with price.

Before turning to the estimation results, we examine the performance of the instruments for P . First, we consider instrument strength. The correlation between *wholesale price* and P is 0.881, while the correlation between *diesel price* and P is 0.765. Hence, both instruments are quite strongly related to the endogenous variable. Further, the correlation between the two instruments is 0.586, indicating that each of them correlates with some parts of P the other instrument does not account for. This supports our point above that *wholesale price* relates only to the variation over time in P , while *diesel price* also relates to the cross-sectional variation

²⁵ One exception is *population*, which is quarterly numbers.

²⁶ Consider the simplified demand equation $Q = \alpha_0 + \alpha_1 P + \alpha_Z Z + \alpha_{PZ} PZ$. Then, the elasticity of Z is given by $\epsilon_Z = (\alpha_Z + \alpha_{PZ} P)(Z/Q)$, where we use sample means of P , Z and Q .

that P exhibits. To formally test the validity requirement, Bound et al. (1995) and Staiger and Stock (1997) suggest that the first-stage F -test of joint significance of instruments and the partial R-squared are useful measures in this manner. These tests are reported in Table 4. Since P enters also in the interaction terms, these are also instrumented, which gives us in total three first stage regressions and hence three values of each test. The F -test shows that the instruments are jointly significant at the 1% level in all first stage regressions. All F -statistics are large, suggesting that the instruments are strong.²⁷ Moreover, the partial R-squared coefficients range between 0.518 and 0.592, which we believe are sufficiently high. Both instrument strength indicators therefore suggest that *wholesale price* and *diesel price* explain much of the exogenous variation in P . We also report the regression-based endogeneity test of regressors (Cameron and Trivedi, 2005, p. 276) in the last column of Table 4. We reject the null that P can be treated as exogenous, which suggests that we indeed need to use instruments.

The average price elasticity is estimated to be -15.79 and is significant, suggesting that gasoline demand is downward sloping and highly elastic to responses in fuel prices at the station level. This is comparable to the station-level elasticities found in Manuszak (2010) of around -20. On the other hand, the rival price elasticity is 13.56. These values imply large substitution effects of the same product between stations. The income elasticity is positive, significant and slightly larger than one (1.005), meaning that gasoline is a normal good. Results are within the range of elasticities found in other demand studies.²⁸

The elasticity of public transportation proposes that better access to public transportation lowers the gasoline demand with a negative significant elasticity of -0.480. Hence, public transportation is a substitute for car travel, although not a very strong one. The population elasticity is 0.052 and significant, suggesting that the number of licensed drivers rises with population, which in turn increases the gasoline consumption. Contrary to expectations, although elasticities are small, the effect of the *number of stations* is positive, while the effect of the *distance to competitor* is negative. Larger markets typically have more stations, which suggests higher market demand. Likewise, in a dense market, the distance to the closest competitor is lower than in less dense markets, where the distance between outlets is larger. This we attribute to our control for market size, which is defined at the regional level, and thus

²⁷ In comparison, Staiger and Stock (1997) recommend an F -statistic above 10 to have sufficiently strong instruments.

²⁸ See e.g. the survey by Basso and Oum (2007) as well as Johansson and Schipper (1997) and Baltagi and Griffin (1983) for OECD-countries, and Yatchew and No (2001) for Canada.

very likely too wide to fully account for all cross-market differences. The local market effects instead turn out through our elasticities for distance to competitors and number of stations.

Focusing on the interaction terms, we see that coefficients are strongly significant, which is important in order to identify the coefficient of Q^* in the supply equations. In total, the demand function behaves well and proposes plausible predictions.

Table 4: 2SLS estimation results of Eq. (8) and corresponding elasticities.

Variable	Coefficient	Std. err.	F-statistic ^a	Partial R-sq. ^a
P	-7,169.204***	241.381	497.655***	0.518
Y	-48.289***	8.100		
Distance to competitor	-1,079.811***	105.487		
P × Y	4.177***	0.546	572.148***	0.528
P×Distance to competitor	66.067***	7.070	454.884***	0.592
Rival price	4,676.645***	177.236		
Population	1.115***	0.033		
Public transportation	-30.033***	0.443		
Number of stations	6.761***	0.275		
Constant	38,393.332***	2,889.575		
Day of the week dummies	YES			
Month dummies	YES			
Region dummies	YES			
ϵ_P	-15.793***	0.558		
ϵ_Y	1.005***	0.014		
$\epsilon_{\text{Rival price}}$	13.555***	0.514		
$\epsilon_{\text{Public transportation}}$	-0.480***	0.007		
$\epsilon_{\text{Population}}$	0.052***	0.002		
$\epsilon_{\text{Number of stations}}$	0.065***	0.003		
$\epsilon_{\text{Distance}}$	-0.038***	0.0007		
Observations	64,366			
R-squared	0.239			
Endogeneity test ^a	26.635***			

*** p<0.01, ** p<0.05, * p<0.1. Standard errors clustered at the day level are reported for coefficients. Standard errors of elasticities are calculated using the delta method. Exponent of “a” marks results of the corresponding first stage regression. The regression-based endogeneity test statistic of regressors is $F(3, 365)$ distributed, with H_0 : variables assumed to be endogenous are exogenous. Sample period is 1 January 2012 to 31 December 2012.

Supply

Turning to the supply relation, baseline estimation results of Eq. (9) are presented in Table 5. All variables come in significantly and with anticipated signs. The marginal effects are difficult to interpret directly and we have therefore provided elasticities in the table as well.

The correlation between Y and Q is 0.325, between *distance to competitor* and Q -0.185, and between Y and *distance to competitor* -0.047. Both F -statistics from the F -test of joint significance of instruments are highly significant, as reported in Table 5. The partial R-squared

is 0.041 for Q and 0.097 for Q^* , which compared to those reported in Bound et al. (1995) are relatively large. Further, the regression-based endogeneity test of regressors reject the null that Q can be treated as exogenous.

Table 5: 2SLS estimation results of Eq. (9) and corresponding elasticities.

Variable	Coefficient	Std. err.	F -statistic ^a	Partial R-sq. ^a
Q	-0.000008	0.000005	1444.810	0.041
Q^*	0.277***	0.018	2234.800	0.097
Wholesale price	1.069***	0.050		
Carwash	0.026***	0.006		
Self-service	-0.131***	0.020		
Constant	8.808***	0.258		
Month dummies	YES			
Region dummies	YES			
Brand dummies	YES			
Contract form dummies	YES			
ε_Q	-0.003	0.002		
$\varepsilon_{\text{Wholesale price}}$	0.390***	0.018		
$\varepsilon_{\text{Carwash}}$	0.0005***	0.0001		
$\varepsilon_{\text{Self-service}}$	-0.003***	0.0005		
Observations	58,345			
R-squared	0.800			
Endogeneity test ^a	134.340***			

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. Standard errors clustered at the day level are reported for coefficients. Standard errors of elasticities are calculated using the delta method. Exponent of “a” marks results of the corresponding first stage regression. The regression-based endogeneity test statistic of regressors is $F(2, 365)$ distributed, with H_0 : variables assumed to be endogenous are exogenous. Sample period is 1 January 2012 to 31 December 2012.

Marginal costs do not vary with Q as the elasticity is insignificant. Increases in the wholesale price raises costs (elasticity=0.39). From the coefficient estimate, we note that the absolute pass-through in the wholesale price is 1.069, which corresponds to full pass-through. The station amenity variables both influence costs; self-service reduces costs (elasticity=-0.003), while carwash facilities marginally increase costs (elasticity=0.0005).

Turning to the markup parameter, the model predicts λ to be 0.277 and significant. The estimate suggests that Swedish gasoline retailing exhibits an average intermediate level of market power. Considering the small standard error the confidence interval is quite narrow, suggesting that with 95% confidence the markup is between 0.242 and 0.312. This suggests that retailers exercise some market power, but they do also experience some competition: We can clearly reject a full monopoly-markup $\lambda=1$. This is in line with several other studies such as Houde (2012), Manuszak (2009) and Slade (1987), though they use less frequent data and other approaches.

In the baseline model, we do not identify to which extent potential effects on the firms' markup level depend on station characteristics. The literature points in particular to three groups of station characteristics that might influence the level of market power locally; (i) local competition level, (ii) station service level and (iii) contract form. We first look at these groups in turn, before we introduce all three jointly into the same model. The results are shown in Table 6, while additional results of instrument strength are reported in Table 7. All four models perform well in terms of explanation power, instrument strength and endogeneity tests.

6.2 Sources of local market power

Local competition

To analyze the effects of local competition, we let Q^* interact with *station density* in the supply relation (Eq. (9)). *Station density* is an alternative measure of a station's closeness to rival stations. Results are reported in column (1) of Table 6.²⁹

The model performs in the same manner as the baseline model. The baseline estimate of λ is now 0.387 and somewhat higher compared to the benchmark. However, the interaction-term coefficient is negative, implying that if seller i faces an additional outlet within its neighbourhood (3 km radius), its market power decreases by 0.026. Hence, the interaction term suggests that the more competitors a station has within its close vicinity, the less market power is attainable for the station.

One possible interpretation of this result is that the higher the station density in a seller's close vicinity is, the more stations are within each consumer's reach, hence the seller's product has more substitutes from a consumer's point of view. Other things equal, increasing spatial competition thus reduces each seller's market power. In total, this result suggests that differentiation in terms of location has significant impact on a station's level of market power; raising the density of stations has a detrimental effect on each seller's markup and hence a positive effect on local competition. These findings are in line with those of Barron et al. (2004), Barron et al. (2008) and Clemenz and Gugler (2006).

²⁹ There are fewer observations used in the estimation of the models in Table 6 because information about distance to the nearest sellers is missing for some stations. We do not replace missing values in order to avoid smoothing effects. However, results are qualitatively the same when replacing missing values with the mean value for each distance variable in each county.

Station service levels

We move on to examine whether differences in service level affect market power by interacting Q^* with *self-service* in the supply equation, using serviced stations as reference category. One could think that a seller providing service to customers is able to charge a markup that covers more than the actual cost of offering this service. For instance, Eckert and West (2005) find that station's service levels affect sellers' price setting. On the other hand, other studies show no impact of service level or station amenities on retail markups, such as Hosken et al. (2008).

From the results presented in Table 6 column (2), the coefficient of the interaction term is negative, however, insignificant. When we only focus on this measure the results suggests that there are no significant differences in markup between serviced stations and self-serviced stations. Not surprisingly, the overall markup in this model (0.274) is very similar to the one estimated in our baseline model (0.277).

Contract forms

Now, we examine whether market power varies with the degree of vertical integration. Specifically, we separate between the market power by company-owned stations and other contract forms by interacting Q^* with a dummy variable which is equal to one if the station is company-owned. In our sample, 76% of the stations are company-owned, as reported in Table 3. The results presented in Table 6 column (3) show that parameters, significance and elasticities are similar to those of our baseline model.

A company-owned station has 0.075 higher market power parameter than stations on contract forms with less vertical integration. Company-owned stations have market power in the same magnitude ($0.212+0.075=0.287$) as suggested by λ in the baseline model of 0.277. Hence, company-owned stations from this model have an average market power in line with our baseline case, whereas less integrated stations have substantially less market power. This suggests that stations with a higher degree of vertical integration are able to extract higher markups. Similar findings are obtained in Hosken et al. (2008). One explanation is that these stations may benefit from efficiency gains and lower costs, which in turn enable them to portion out higher markups for a given price compared to stations on other contract forms.

Table 6: Estimation of Eq. (9) with inclusion of interaction between Q^* and local competition, station service level and contract form.

Variable	(1)	(2)	(3)	(4)
Q	-0.00003*** (0.000003)	-0.000006 (0.000004)	0.000006 (0.000005)	-0.00003*** (0.000003)
Q*	0.387*** (0.019)	0.274*** (0.016)	0.212*** (0.017)	0.373*** (0.018)
Q*×Station density	-0.026*** (0.001)			-0.025*** (0.001)
Q*×Self-service		-0.002 (0.006)		-0.110*** (0.005)
Q*×Company-owned			0.075*** (0.005)	0.098*** (0.004)
Wholesale price	1.067*** (0.050)	1.069*** (0.050)	1.069*** (0.050)	1.065*** (0.050)
Carwash	0.059*** (0.002)	0.024*** (0.004)	0.024*** (0.006)	0.036*** (0.002)
Self-service	-0.073*** (0.020)	-0.131*** (0.020)	-0.124*** (0.020)	-0.036* (0.020)
Constant	8.781*** (0.257)	8.805*** (0.259)	8.841*** (0.258)	8.860*** (0.257)
Month dummies	YES	YES	YES	YES
Region dummies	YES	YES	YES	YES
Brand dummies	YES	YES	YES	YES
Contract form dummies	YES	YES	YES	YES
ϵ_Q	-0.009*** (0.001)	-0.002 (0.001)	-0.002 (-0.002)	-0.010*** (0.001)
$\epsilon_{\text{Wholesale price}}$	0.390*** (0.018)	0.390*** (0.018)	0.391*** (0.018)	0.389*** (0.018)
$\epsilon_{\text{Carwash}}$	0.001*** (0.00005)	0.0005*** (0.00009)	0.0005*** (0.0001)	0.0007*** (0.00005)
$\epsilon_{\text{Self-service}}$	-0.002*** (0.0005)	-0.003*** (0.0005)	-0.003*** (0.0005)	-0.004*** (0.0005)
Observations	58,345	58,345	58,345	58,345
R-squared	0.824	0.798	0.794	0.826
Endogeneity test ^a	323.056***	125.986***	164.425***	248.872***
F-statistic ^a of Q	1791.320***	1526.000***	1190.980***	1405.620***
F-statistic ^a of Q*	2248.890***	2093.730***	1664.690***	1644.230***
Partial R-sq. ^a of Q	0.072	0.047	0.041	0.078
Partial R-sq. ^a of Q*	0.128	0.101	0.098	0.133

*** p<0.01, ** p<0.05, * p<0.1. Standard errors clustered at the day level are reported for coefficients. Standard errors of elasticities are calculated using the delta method. Exponent of “a” marks results of the corresponding first stage regression. The regression-based endogeneity test statistic of regressors is $F(L, 365)$ distributed, with H_0 : variables assumed to be endogenous are exogenous. L is the number of endogenous regressors. Sample period is 1 January 2012 to 31 December 2012.

Table 7: *F*-statistic of the *F*-test of joint significance of instruments and partial *R*-squared from the corresponding first stage regressions of model (1) to (4) in Table 6.

	(1)	(2)	(3)	(4)
<i>F</i> -statistic				
Q	1791.320***	1526.000***	1190.980***	1405.620***
Q*	2248.890***	2093.730***	1664.690***	1644.230***
Q*×Station density	4724.180***			3173.360***
Q*×Self-service		2532.670***		1905.640***
Q*×Company-owned			3784.640***	3150.830***
Partial <i>R</i> -squared				
Q	0.072	0.047	0.041	0.078
Q*	0.128	0.101	0.098	0.133
Q*×Station density	0.379			0.386
Q*×Self-service		0.112		0.128
Q*×Company-owned			0.123	0.151

*** p<0.01, ** p<0.05, * p<0.1. Sample period is 1 January 2012 to 31 December 2012.

Combining local competition, station service level and contract form

Finally, in column (4) we let Q^* vary with local competition, service level and contract form in the same model. The results are similar to the baseline results when it comes to magnitudes of cost parameters and elasticities, while the estimate of λ is larger than in the baseline model reported in Table 5. All interactions with Q^* are significant and the explanatory power of the model is higher, suggesting that we can estimate the markup more precisely when we also account for the different sources of market power.

Compared to column (1) to (3), the interaction between Q^* and *number of competitors* and *company-owned*, respectively, have coefficients of the same sign and similar magnitude. On the other hand, the interaction with *self-service* is now significant. The coefficient is negative and increases in absolute value. This suggests that self-serviced stations exercise less market power than serviced ones. Our model finds a clear result: local station characteristics significantly affect the degree of market power for the local gasoline station when we also account for spatial competition and contractual form.

To illustrate our results, we construct estimates for two stations with different characteristics. Compare a full-service, company-owned station with an average density of stations (2.4) within a vicinity of three kilometers (station 1), with an independent self-serviced station with four rival stations in its vicinity (station 2). Station 1 has an estimated markup of 0.411 (with a 95% confidence interval from 0.373 to 0.448), while station 2 has an estimated

markup of 0.163 (with a 95% confidence interval from 0.130 to 0.193).³⁰ Both confidence intervals are quite narrow, and the difference between the two stations' markups is significant. In sum, local station characteristics influence market power to such an extent that in some local markets, a station will be able to extract quite some market power, whereas in others the local market characteristics significantly reduce this possibility.

6.3 Robustness

Table 8: Sensitivity to estimation methods. Results of Eq. (9) and corresponding elasticities.

Variable	LIML	GMM
Q	0.000004 (0.000006)	-0.00002*** (0.000002)
Q*	0.240*** (0.019)	0.298*** (0.012)
ϵ_Q	0.001 (0.002)	-0.005*** (0.0008)
$\epsilon_{\text{Wholesale price}}$	0.391*** (0.018)	0.378*** (0.018)
$\epsilon_{\text{Carwash}}$	0.0004*** (0.0001)	0.0007*** (0.00008)
$\epsilon_{\text{Self-service}}$	-0.003*** (0.0005)	-0.005*** (0.0005)
Observations	58,345	58,345
R-squared	0.788	0.804
F-statistic ^a of Q	1444.760***	1445.700***
F-statistic ^a of Q*	2236.230***	2257.690***
Partial R-sq. ^a of Q	0.041	0.041
Partial R-sq. ^a of Q*	0.097	0.099

*** p<0.01, ** p<0.05, * p<0.1. Standard errors clustered at the day level are reported for coefficients. Standard errors of elasticities are calculated using the delta method. Exponent of "a" marks results of the corresponding first stage regression. Sample period is 1 January 2012 to 31 December 2012.

Our instruments in the supply relation are not as strong as the instruments used in the demand relation. In the presence of weak instruments, the limited information maximum likelihood (LIML) estimator is documented to perform better than the 2SLS estimator (Greene, 2012, p.368). Therefore, we re-estimate Eq. (9) using the LIML method. Estimation results (shown in Table 8) are qualitatively similar, with a slightly lower λ of 0.240. We also estimate the baseline

³⁰ Estimated λ for the station 1: Baseline (0.373) + Station density (-0.025 \times 2.4) + Self-service (-0.110 \times 0) + Company-owned (0.098 \times 1)= 0.411. Estimated λ for the station 2: Baseline (0.373) + Station density (-0.025 \times 4) + Self-service (-0.110 \times 1) + Company-owned (0.098 \times 0)= 0.163.

model using GMM. We find similar results, with a markup of 0.298 and hence in the same ballpark, however, somewhat higher. In both cases, the point estimate is within or very close to the 95% confidence interval of our baseline result (0.242-0.312). In sum, this suggests that our baseline model is robust also if we use LIML or GMM estimation methods.

7. Concluding remarks

We have estimated a structural model to uncover the degree of competition in the retail gasoline market applying the Bresnahan-Lau (1982) model. We have used detailed data from the Swedish market on each station's contractual arrangements, service level and local competition to analyze how these factors impact on the competition level.

The paper addresses a relatively large but still non-conclusive empirical literature on how competition in gasoline retailing relates to local station characteristics. Micro data at the station level on both quantity and price are hard to obtain, restricting previous research to mainly study aggregate data and reduced form models. Our approach is thus different from the majority of previous literature, both due to the richness of our data, and because we combine several local station characteristics within the same model.

Our findings suggest that retailers exercise significant and intermediate levels of market power in the Swedish market. The competitive level varies significantly with local station characteristics. Specifically, we find that a station's market power decreases with the number of stations within its close vicinity, while it increases in a station's service level. Further, company-owned stations are able to extract higher markups, possibly due to efficiency gains but also due to more scope for vertical and horizontal coordination. Hence, differentiation at the station level affects retailers' ability to exercise market power.

The Swedish Competition Authority stated in 2013 (p.128) “...*the stations' gross margins naturally vary over time and depend on the local competition pressure.*”. We find a clear result reflecting this observation: local station characteristics significantly affect the degree of market power for the local gasoline stations. We show that differences in local station characteristics, even within the scope of the variation in our sample, have a large effect on local market power. The magnitude in these local differences implies that in some local markets, the station will be able to extract quite some market power, while in other markets, local market conditions significantly limit this possibility.

From a policy point of view, the findings imply that there is room for more competition in the downstream retail market; the extent varies with local market conditions. Paying attention to downstream characteristics might be just as important as the upstream characteristics in order to protect consumer welfare.

More entry into remote areas increase the competitive pressure on the already established stations, suggesting that regulations could be more lenient when evaluating suggested new entry in these areas. Considering contract form, vertical integration is well-known for enhancing efficiency gains. Yet, our results suggest that upstream direct control of outlets can also increase the potential for extracting market power. Therefore, policy makers should evaluate the consequences of more vertical integration despite potential efficiency gains.

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