Time as a Strategic Variable: An Empirical Analysis of Opening Hours in the Austrian Gasoline Market

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1 Introduction

While business hours of firms still are strongly regulated in many markets, some countries took first steps towards deregulation at least for a few sectors of their economy in recent years. This deregulation provides firms with new opportunities in setting business hours strategically in competing with rivals.

The importance of strategic interactions between firms when choosing opening hours is nicely illustrated in (3): "An argument commonly advanced by traders opposing liberalization starts by observing that if a few shops were to choose to open on Sunday they would attract so much business from retailers trading only on weekdays that soon all shops would be forced to open on Sunday"...."A counter-argument denies that all shops would be forced to open on Sundays" ((3), p.379). Whether or not an extension of opening hours of one firm 'forces' competitors to act similarly - i.e. whether opening hours are strategic complements - can have important consequences for market performance ((15)). It is well-known that multiple equilibria are typical in the presence of strategic complementarities, which makes comparative statics and policy analysis difficult. How can the policymaker be sure that changing a parameter has the desired effect?

While some very elaborate theoretical models on firms' strategic choices of opening hours have been presented and discussed in industrial organization ((10), (9), (14), (16), (17)), no empirical evidence on firms' strategic choices of business hours is available so far. This lack of empirical evidence might be due to the fact that shop closing laws in many sectors of the economy still are too restrictive to allow economists observing strategic interactions in business hours to unfold in practice. One of the few exceptions of markets, where business hours are liberalized in Austria, is the retail gasoline market. According to the "Öffnungszeitengesetz" (2003), gasoline stations in Austria are free to choose their desired business hours. A further advantage of analyzing opening hours in the gasoline market is that gasoline is a rather homogenous product; the main source of product differentiation is the location of a gasoline station. With the availability of data on the location of gasoline stations in space, the specific neighborhood relations between individual gasoline stations and thus the degree of horizontal product differetiation can be identified[1].

The aim of the present analysis is to provide first empirical evidence on the strategic choice of opening hours. Specific attention will be given to the interaction between horizontal (spatial) differentiation and quality choices (opening

[1]An excellent discussion of the available empirical literature on this market is available in (4).

hours). The following section two provides an overview of different theoretical models on the strategic choice of opening hours in markets with imperfect competition. Section three describes the data and the empirical approach. Result are reported and discussed in section four.

2 Theoretical Background

Opening hours can be interpreted as a quality attribute of retailers which positively influences consumers' willingness to shop at their store. (7) investigates consumers' utility maximizing behaviour under a time constraint and shows that longer opening hours exert a positive effect on consumers' willingness to pay for products sold at these stores. Additional arguments for a positive effect of opening hours on willingness to pay emerge when explicitly considereing the effects of uncertainty. When consumers are uncertain about when they want to shop, for example, opening hours might incorporate a real option value by creating flexibility in the eyes of consumers' ((14), p.1194). Similarly, consumers may be uncertain about the precise timing of opening hours of a store. Thus, stores with long opening hours (or the reputation of it) might be preferred by consumers ((11)).

When interpreting opening hours as a quality attribute of the retailer, industrial organization models with endogenous quality choice are a natural starting point for understanding the strategic effects of choosing opening hours. This literature, however, provides conflicting predictions on the form of the strategic interaction in quality levels (opening hours): whether quality levels are strategic complements or strategic substitutes is conditional on the particular structure of the model. More specifically, the slope of firm's reaction function depends on whether firms' profit functions are sub- or supermodular.

Consider a duopoly market in which firms set quality levels (opening hours) in the first stage and then compete on prices. Let $\Pi_1 = \Pi_1 \left[h_1, h_2, p_1(h_1, h_2), p_2(h_1, h_2)\right]$ denote firm 1's profit as a function of opening hours (h_1, h_2) and prices, and let $p_1(h_1, h_2)$ and $p_2(h_1, h_2)$ denote the second-stage optimal prices conditional on opening hours. The first-order condition for choice of h_1 is $\partial\Pi_1/\partial h_1 = 0$. Totally differentiating this condition yields: $d\frac{\partial\Pi_1}{\partial h_1} = \frac{\partial^2\Pi_1}{\partial h_1^2}dh_1 + \frac{\partial\Pi_1}{\partial h_1 \partial h_2}dh_2$. From this, the slope of firm 1's reaction function is: $\frac{dh_1}{dh_2} = -\frac{\partial\Pi_1}{\partial h_1 \partial h_2}/\frac{\partial^2\Pi_1}{\partial h_1^2}$. Since the denominator of this equation must be negative for the second-order condition to be satisfied, the slope will take the sign of the cross-partial derivative in the numerator. This sign of $\frac{\partial\Pi_1}{\partial h_1 \partial h_2}$ will generally be ambiguous and dependent on the detailed structure of the model (i.e. whether a 'differentiation effect' or a 'demand stealing effect' is more important).

Textbook models of pure vertical differentiation with heterogeneous consumers in the tradition of (8) and (13) focus on the 'differentiation effect' of quality changes (opening hours): competitors differentiate qualities in order to relax price competition. In this framework, (12) shows that $\frac{\partial \Pi_1}{\partial h_1 \partial h_2} > 0$: the best response to an increase in a rival's product quality is to increase quality of your own product. As the high-quality seller raises quality and thus expands the disparity between qualities, price competition is alleviated and, as a result, the low-quality producer has a stronger incentive to raise quality. When the low-quality seller raises quality and thus becomes a closer substitute to the high quality seller, the incentive of the high-quality seller to differentiate himself from the low-quality seller becomes stronger. (2) further show that this conclusion is unaffected by the timing on the quality choices of duopolists (i.e. whether quality decisions are made simultaneously or sequentially). In the terminology of Bulow, Geanakopolis, and Klemperer (1985), qualities (opening hours) are locally strategic complements in this modelling framework.[2]

This contrasts with a second type of models, inspired by the seminal work of (5), where vertical differentiation is introduced alongside with the imperfect substitutability of goods stemming from horizontal differentiation. This approach suggests that quality levels (opening hours) are strategic substitutes. Economides investigates a three-stage game where two firms choose their location on the Hotelling line as well as the quality of their products before setting prices. In this model, an increase in opening hours of one firm is assumed to lead to a proportional increase in consumer demand for this firm. At the same time, consumer demand for the rival's product and the rival's marginal returns of quality decreases: the sign of $\frac{\partial \Pi_1}{\partial h_1 \partial h_2}$ is negative. Increasing opening hours has a 'demand stealing' effect on rivals. modifies this setting to consider the case of n firms competing on a circular market. In the same framework, (16) analysis firms' entry and exit decisions in a circular market to investigate the relationship between opening hours and the concentration in the retail sector. Again, business hours are strategic substitutes (although this is not explicitly highlighted by the authors). [3]

[2](1)) extends this analysis by comparing price and quantity competition in the second stage: "Product market competition matters because qualities are locally strategic complements with Bertrand competition but are locally strategic substitutes with Cournot competition in the relevant range"((1), p.654).

[3]Note that the specific way in which opening hours increase consumer demand is not particularly important. Following (3) and (7), for example, shopping hours can be related with transportation costs; if a consumer cannot shop at her most preferred point in time (because the shop is closed), her opportunity costs of time for shopping at a different point in time will be higher. Longer opening hours thus tend to decrease consumers' opportunity

An important advantage of this approach is that horizontal and vertical differentiation are investigated simultaneously ((6)). Previous empirical research in the gasoline market also finds that both, horizontal (i.e. spatial) as well as vertical differentiation (via opening hours) are key factors in explaining firm performance in the gasoline market ((Pennerstorfer and Weiss)). An important charakteristic of the retail gasoline market is that gasoline stations often are members of a network of multi-station firms (large chains of gasoline stations) and coordinate their strategic behaviour within the network. The implications of neighbourhood relations and coordinated behaviour within the network of multi-station firms for strategic decisions on opening hours has recently been investigated in (17).

Wenzel investigates competition between an independent retailer operating a single station and a retail chain operating two stations. The author shows that the independent retailer can gain more from extending opening hours than its competitor. By extending opening hours, the independent retailer attracts customers from both neighbouring stations (both owned by the retail chain). Conversely, the retail chain can only gain customers from one station, but has to pay the costs twice (once for each affiliated station). This model suggests (a) that the strategic choice of opening hours differs between independent retailers and members of a retail chain, and (b) that the location of firms in space matters for their choices of opening hours.[4] Note that in following previous research ((9), (14)) the choice of opening hours in (17) is a discrete one: a store can either choose part-time shopping hours or full-time shopping hours (authors distinguish between opening during day-time and/or night-time). Each consumer is assumed having an ideal shopping time and they only care whether a store is open at that time or not. Thus, consumers do not care about the length of shopping hours per se and the optimal length of opening hours (which is the main focus of the present analysis) is not derived explicitly. Further note, this set-up does not allow deriving best-response functions for competitors' opening hours: rather a (perfect) coordination in choosing opening hours is assumed for members of the retail chain.

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costs of time (and thus reduce transportation costs). In contrast to (5), this decrease in transportation costs not only raises consumers' utility but at the same time increases the degree of substitution between products. The main focus of (3) and (7), however, is on the welfare consequences of a de-regulation of shopping hours and the strategic interactions between individual firms in choosing opening hours is not explicitly analyzed. In appendix A, we show that opening hours are strategic substitutes in this framework too.

[4](17) shows that this result depends significantly on efficiency differences between the retail chain and the independent retailer. If the efficiency difference is small, the independent retailer may choose longer shopping hours than the retail chain. The opposite result emerges when the efficiency difference is large.

In the next step we study the strategic interdependence between competitors in setting business hours in the Austrian gasoline market empirically. Specific attention will be devoted to the impact of spatial differentiation (location) of stations as well as the differentiation between independent suppliers and members of large retail chains.

3 Data and Estimation Strategy

The present empirical analysis uses data on opening hours, location, and a number of specific characteristics (whether the station has service bays, a convenience store, the number of pumps, ...) of all 2,814 gasoline stations in Austria in 2003. Figure 1 suggests that gasoline stations are open for 17 hours on average; figure 1 also reveals some variation in opening hours between gasoline stations. A noticeable feature of this figure further is the large number of gasoline stations that are open for 24 hours, most of these stations (x per cent) are located on highways.

To characterize the spatial distribution of suppliers and to measure distances and neighbourhood relations between gasoline stations we collect information about the structure of the road network. Using data from ArcData Austria and the ArcGIS extension WIGeoNetwork, the geographical location of the individual gasoline stations are linked to information on the Austrian road system to generate accurate measures of distance. We further supplement the individual data with demographic data (population density, commuting behavior and importance of tourism) of the municipality, where the gasoline station is located. This information is collected by the Austrian statistical office ('Statistik Austria'). Finally, information on land prices on a district level is obtained from the Chamber of Commerce ('Wirtschaftskammer'). The definition of all variables as well as some descriptive statistics is provided in table **??** in Appendix A.

A strategic interdependence in opening hours implies that firm i's decisions on opening hours (h) are not only influenced by i's own characteristics (captured by the matrix X) but also by rival's decisions on opening hours. The specification of the empirical model that accounts for both effects is given by the following spatial autocorrelation (SAC) model[5]:

$$h = \rho W h + X\beta + u$$
$$u = \lambda W u + \epsilon$$
$$\epsilon \sim N(0, \sigma_\epsilon^2),$$

where h is a $m \times 1$ vector of stations' opening hours and m is the total number of observations (2,442 gasoline stations). The spatial weights matrix W is of dimension $m \times m$ defining neighborhood relations between gasoline stations. Let w_{ij} be the element in the ith row and the jth column of W. Then w_{ij} is set equal to zero if the j th station is not among the 15 nearest neighbors of i and is set equal to the inverse of the driving time from station i to station j otherwise. X is an $m \times k$ matrix of k explanatory variables including a constant and ϵ is the $m \times 1$ vector of i.i.d. residuals. β is a $k \times 1$ vector of coefficients of the exogenous variables in X. The parameter estimate of ρ measures the (spatially weighted) strategic interaction of opening hours between neighboring stations. A positive (negative) parameter estimate of ρ implies that opening hours are strategic complements (strategic substitutes). Note that the SAC model also controls for unobserved spatial correlation (correlation of residuals between neighboring stations). In the absence of any strategic interaction between neighboring gasoline stations, a non-zero correlation of their opening hours might emerge as a result of similar (unobservable) local characteristics of these gasoline stations. The parameter λ measures the spatial correlation of residuals.

4 Empirical Results and Extensions

Results from two different specifications of the spatial autocorrelation model are reported in table **??**. The first specification does not differentiate between independent stations and those that are members of a network of a multi-station firm, i.e. the spatial weights matrix W captures distances between all gasoline stations (irrespective of their group membership). The second model includes two spatial weights matrices and allows differentiating between the strategic interaction in opening hours between gasoline stations that are members of the same network as well as those that are independent or are members

[5]Unfortunately, data on consumer demand (the quantity of gasoline purchased at individual stations) is not available. Estimation of a structural model of opening hours and pricing thus is impossible. Instead, we aim at inferring the strategic interdependence between firms from a reduced form spatial model on opening hours.

of competing networks. While the parameter estimate for ρ in the first specification is not significantly different from zero, the second models suggests a significant (but imperfect) coordination in the setting of opening hours among members of the same network: a positive parameter estimate for ρ, which is significantly different from zero at the 1%-level, implies that opening hours are strategic complements. An increase of opening hours by one gasoline station is associated with an increase in opening hours of neighboring group members. The parameter estimate of ρ, which captures the strategic interdependence between independent stations or members of competing networks, is also positive but is not significantly different from zero. This might be the result of the two countervailing effects described in section 2 (the 'differentiation effect' and the 'demand stealing effect').

The specification of the spatial weights matrices W implies that the strength of this strategic effect between firms depends on the degree of horizontal differentiation (distance between competitors in space) and decreases with the inverse of the driving time from station i to station j. This highlights the importance of considering the relationship between vertical and horizontal product differentiation. Note that the observed strategic interaction between neighboring gasoline stations is not the result of similar (unobservable) local characteristics of these gasoline stations. This spatial correlation of residuals is captured by the parameter λ, which is positive and significantly different from zero in both specifications.

Table **??** further includes a variable that aims at measuring the intensity of spatial competition between rivals. The parameter estimate for a variable measuring the distance to the nearest neighbor (DISTNB) is negative and significantly different from zero at the 1%-level. Gasoline stations thus tend to open longer hours in areas where competition is more intense, ceteris paribus.

Most other control variables are significant, carry the expected sign and are robust to modifications of the empirical specification. A larger share of commuters (COMMUTERS) in a specific region tends to increase opening hours significantly. Since commuters tend to be better informed about all relevant features of gasoline stations (including opening hours), this variable not only can be interpreted as a proxy for demand but also for competition. A second proxy for regional variations in consumer demand, population density (POPDENS), also carries a positive sign in both specifications. We find that stations located at highly frequented roads (TRAFFIC) have longer opening hours; on average their business hours exceed those located at less frequented roads by 1.4 to 2.3 hours per day. Company owned stations (COMPANY) tend to have longer opening hours than dealer owned stations (the reference category); on average, the difference amounts to one hour per day. Many locations offer additional amenities, like service bays (GARAGE), convenience stores (SHOP) or car wash facilities (CAR WASH). These variables can be associated with higher costs but at the same time should affect consumer demand positively. While we do not find a significant correlation between opening hours and the CARWASH variable, Table 2 suggests that locations offering service bays (GARAGE) and convenience strores (SHOP) tend to have shorter opening hours. We further find that larger gasoline stations tend to have longer opening hours. The parameter estimate for the AREA variable, measuring the size of the station in square meters, is positive and significantly different from zero in both specifications. The number of pumps (PUMPS), however, does not exert a significant impact on business hours. The three major brands operating in Austria (BP, OMV and SHELL) tend to have significantly longer opening hours than minor brands (AGIP, ARAL, ESSO, JET, AVANTI and Stroh) as well as unbranded stations (the reference category).

In order to confirm that the results are not driven by the specific definition of market boundaries and neighborhood relations, regressions were run using perturbations of these definitions as well as including additional measures of local market concentration, and the results were robust to these changes. The signs and significance of explanatory variables remained the same, although the point estimates varied slightly by a statistically insignificant amount. Results from these estimation experiments, which are available from the authors upon request, show that our results described above are robust with respect to these modifications.

Note that the present analysis has exclusively focused on the total number of opening hours of retailers. We find some first empirical evidence for a strategic interdependence in decisions on opening hours for neighboring gasoline stations. Opening hours tend to be strategic complements; the positive strategic interaction is particularly strong for gasoline stations that are members of the same network of a multi-station firm. Further, we find that the intensity of spatial competition tends to increases opening hours.

However, we need to keep in mind that the present empirical analysis exclusively focuses on the total number of business hours and thereby ignores one important dimension of choosing opening hours: the degree of 'overlap' of opening hours between neighboring stations. Two neighbouring gasoline stations, that are open for 12 hours each, could either compete intensively for the same customer if both open during day-time. However, the same number of opening hours would not lead the two stations to compete for the same group of customers if one station opens during day-time while the other opens during night-time. By differentiating between the total number of opening hours and the 'overlap' of hours in future empirical research, we hope to be able to better isolate the 'differentiation effect' and the 'demand stealing effect' and thereby improve our understanding of the determinants and consequences of opening hours.

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A Appendix

Figure 1: Histogram of open hours (incl. all Austrian petrol stations in 2010)

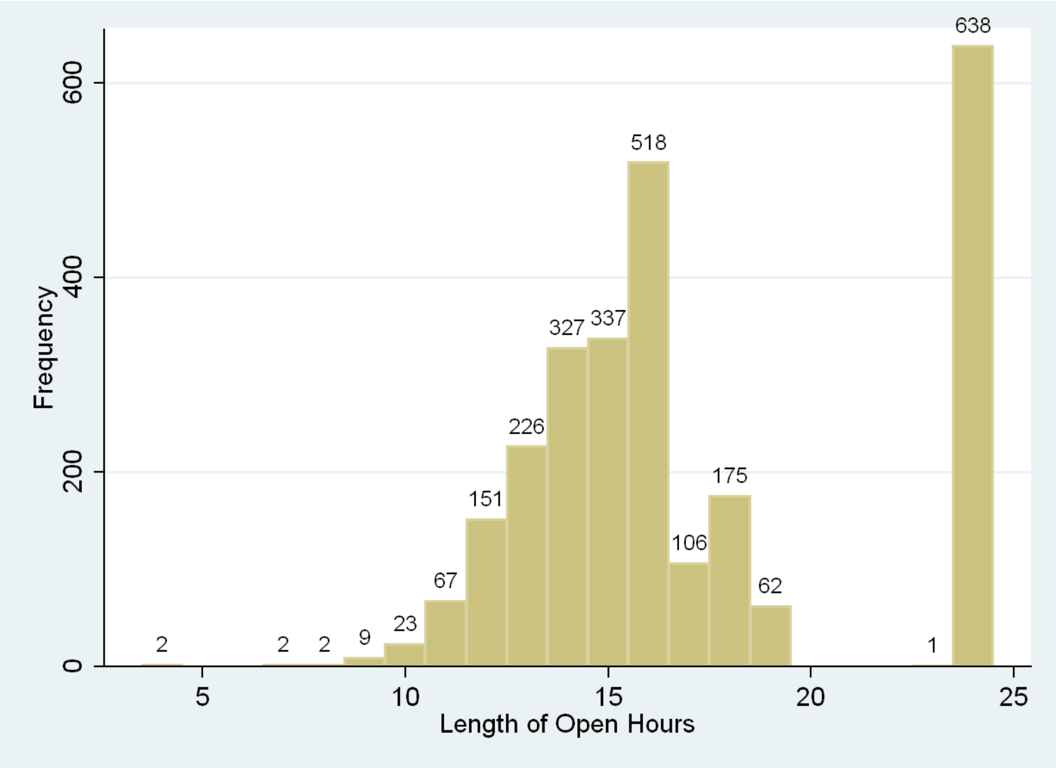

Figure 2: Brands of the Austrian petrol stations in 2010

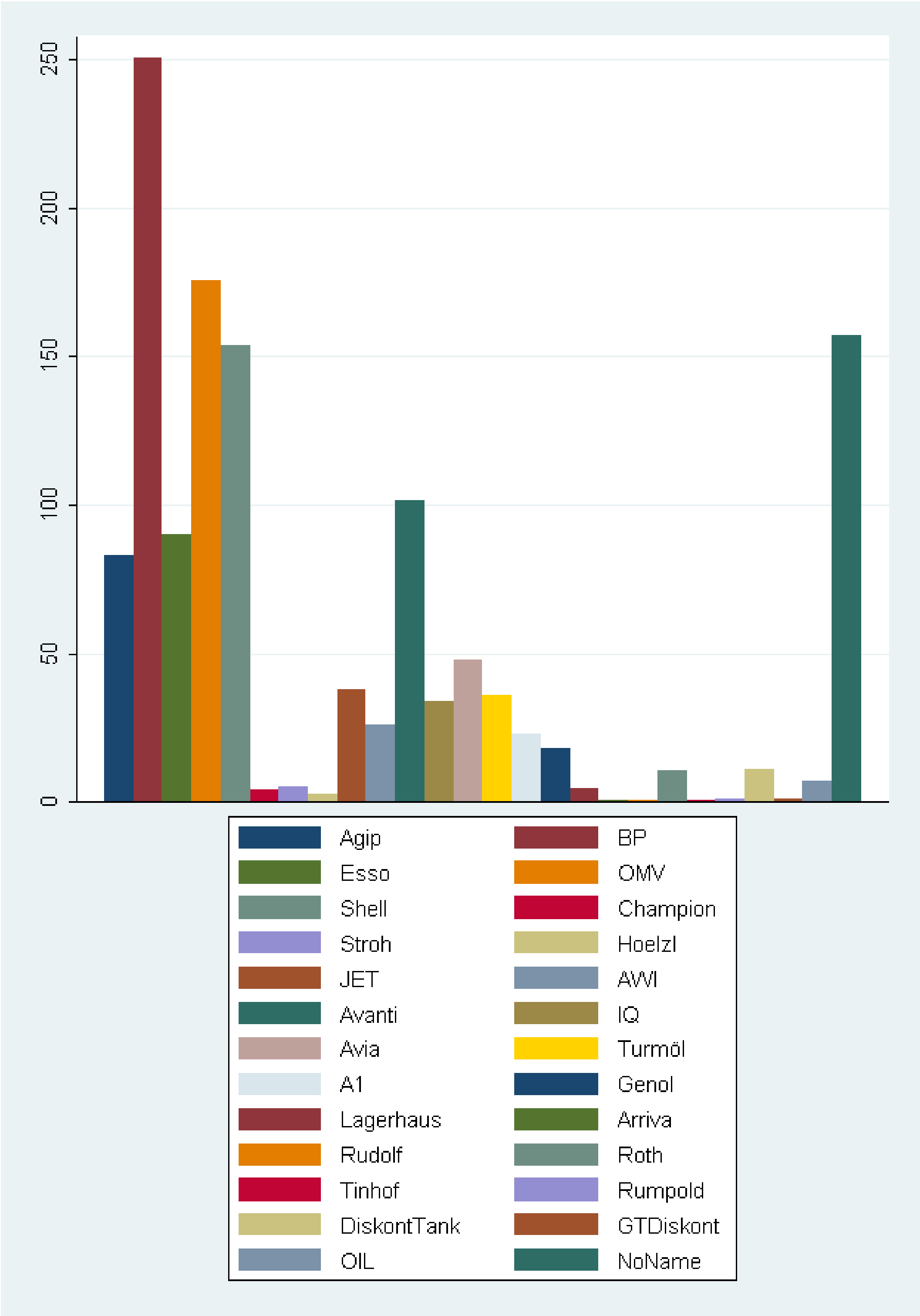

Table 1: Variable Details

Variable	Mean	Std. Dev.	Min.	Max.	N	Description
Dependent variable						
HOURS	17.04384	4.3279	4	24	2660	Total amount of open hours per day
Measures of competition						
DISTNB	2.3353	2.6610	1.0000e-003	22.6490	2646	Distance to the next neighboring station in kilometers
Measure of demand						
COMMUTERS	0.5372	0.2181	0.0726	0.9260	2701	Ratio of incoming plus outgoing commuters to population
POPDENS	29934.97	58506.22	3	265318	2700	Population density of the municipality in thousands inhabitants per squared kilometer
TRAFFIC	0.1325		0	1	2701	Dummy variable equal to one if road traffic at the location is heavy
Site characteristics						
PUMPS	2.8116	1.1546	1	9	2648	Number of pumps per station
AREAE	1763.694	2167.812	15	40000	2664	Size of a station's area in
COMPANY	0.6061	0.4887	0	1	2701	Dummy variable equal to one if the station is owned by the oil company
GARAGE	0.4343	0.4958	0	1	2701	Dummy variable equal to one if the station also has its own garage
SHOP	0.8108	0.3917	0	1	2701	Dummy variable equal to one if the station also has a shop included
CARWASH	0.6335	0.4819	0	1	2701	Dummy variable equal to one if the station has a car wash
MINORS	0.3239	0.4680	0	1	2646	Dummy variable equal to one if the station is affiliated with a minor
MAJORS	0.5121	0.4999	0	1	2646	Dummy variable equal to one if the station is affiliated with a major

Table 2: Results of SAC estimations

Variable	Coef	t-stat		Coef	t-stat	
Const	16.3296	9.6629	***	16.4286	22.8341	***
DISTNB	-0.1934	-2.7137	***	-0.1983	-2.8067	***
$DISTNB^2$	0.0081	1.3488		0.0084	1.4146	
COMMUTERS	1.4856	2.1757	**	1.332	1.9674	**
POPDENS	0.0000	2.2081	**	0.0000	2.1182	**
TRAFFIC	1.5779	5.9801	***	1.5806	6.0649	***
COMPANY	0.7932	4.2882	***	0.5099	2.47	**
GARAGE	-1.3745	-8.3586	***	-1.3525	-8.2555	***
SHOP	-2.3627	-9.6689	***	-2.251	-9.1956	***
CARWASH	0.2779	1.4864		0.2583	1.3867	
AREA	0.0005	11.9297	***	0.0005	12.0211	***
PUMPS	0.0389	0.5247		0.0513	0.6919	
MINORS	0.4389	1.7183	*	0.4147	1.6242	
MAJORS	0.8051	3.1137	***	0.6651	2.5447	**
ρ	0.0650	0.6794				
ρ-Group				0.0327	2.7638	***
ρ-NoGroup				0.0535	1.6417	
λ	-0.0040	-0.0384		0.0867	2.3734	**
Province-Dummy	Yes			Yes		
N	2646			2646		