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# Price cycles in the German retail gasoline market - Competition or collusion?

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## Abstract

This paper analyses the cyclical price setting behavior of petrol stations in the German retail gasoline market. High-frequency price cycles can be observed, as gasoline stations undercut each other successively in price over the day followed by a sharp increase in price in the evening. These asymmetric price cycles are compared with theoretical Edgeworth cycles whereby some differences and contradictions are identified. The results of the empirical analysis suggest a strategy of intertemporal price discrimination between different types of consumers. Gasoline stations undercut each other successively over the day to attract consumers with price-elastic demand. However, this undercutting phase is stopped by simultaneous price increases to exploit the inflexible and price-inelastic consumers.

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## 1 Introduction

The German gasoline market is characterized by a very specific cyclical pricing pattern. Prices for fuel decrease over the day at all gasoline stations. In the evening, a larger price increase is adopted by all stations in the market and prices stay on a high level during nights until the price cycle starts again on the next day. This behavior raises the question of how competitive these markets are.

Price cycles can also be observed in gasoline markets in other regions. Several empirical studies investigate the cyclical pricing pattern of gasoline stations for a number of countries. Doyle, Muehlegger, and Samphantharak (2010) identify price cycles in a couple of US cities. Noel investigates the Canadian market in a number of studies (Noel 2007, and Noel 2015). But also the Australian gasoline market (Roos and Katayama 2013, and Wang 2009) and the Norwegian market (Foros and Steen 2013) feature price cycles.

However, these cycles differ from the ones observed in the German retail gasoline market, which have a much higher frequency. Most of the cycles investigated in the mentioned empirical work last over weeks or even months. The gasoline stations in Germany change prices several times during a day resulting in daily price cycles.

To evaluate the competitiveness of the cyclical pricing pattern in the German gasoline market I first describe the theory on Edgeworth cycles, which is the leading theory to explain price cycles in gasoline markets (Maskin and Tirole 1988). The subsequent empirical analysis tests the theoretical predictions on the data and reviews to what extent observed cycles in the German retail gasoline market conform to the theoretical model of Edgeworth cycles. First results already point to a price discrimination strategy implemented by the gasoline stations. The market participants compete for the price-elastic consumers that refuel during the day by successively undercut each other in price. However, this undercutting phase is interrupted by almost simultaneous price increases to enforce higher prices for price-inelastic consumers.

## 2 Theoretical Background

The theory of competitively driven price cycles dates back to Maskin and Tirole (1988). The authors consider two identical firms competing in prices and selling homogeneous products where demand is constant. Both firms have the same unit cost c and share the market equally when they charge the same price. The firms set their prices sequentially and are committed to their price for two periods ($p^i_{t+1} = p^i_t$).

Starting at a high price, firms undercut each other successively (undercutting phase) until the price reaches marginal cost. At this point, a price war begins as there is no gain in decreasing prices further and both firms are interested in raising prices again. A war of attrition (relenting phase) is starting, as each firm wants the other to relent first because relenting is a public good: the second-mover is able to undercut the price leader and realizes a higher profit. After one firm relents the price back to a high level, the other follows and the cycle begins anew.

Eckert (2003) extends the model by relaxing the assumption of identical firms and allowing the two firms to be asymmetrically sized and firms share the market unequally at equal prices. He shows that smaller firms lead the cycle downwards whereas large firms initiate price increases.

Noel (2008) shows that Edgeworth cycles exist with more than two firms. But in this scenario, the firms face coordination challenges at the bottom of the cycle resulting in delayed and false starts. If rivals do not follow a price increase, the price leader makes losses over a longer period of time, making it more challenging and costly to relent first.

These theoretical considerations yield to several predictions for the empirical analysis regarding the existence and shape of the cycles: *i*) price cycles are asymmetric, *ii*) price level induces price increases and *iii*) the size of the firm influences its behavior along the cycle.

## 3 Empirical Analysis of Price Cycles

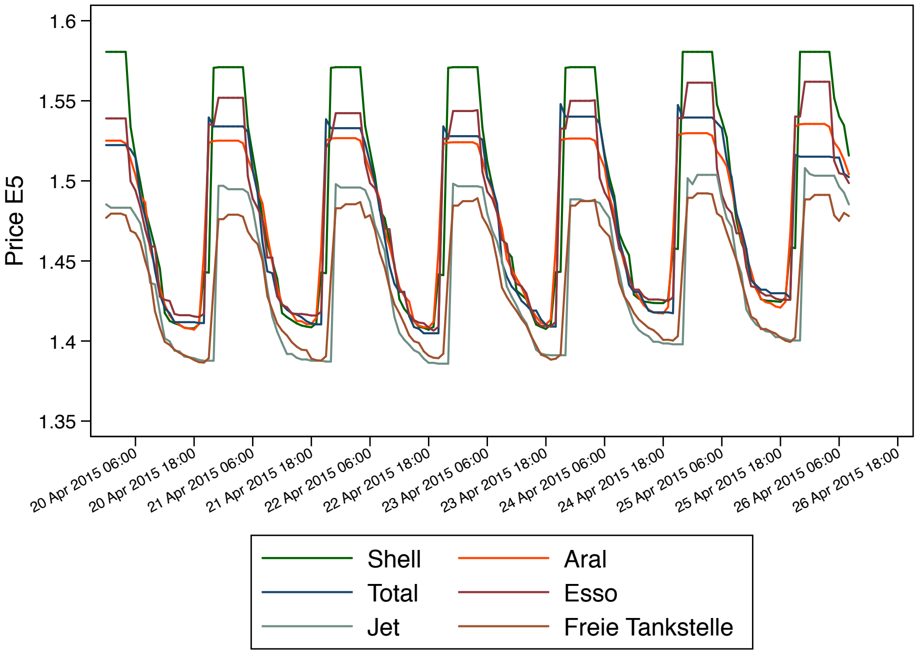
The dataset used encompasses prices of approximately 14,700 gasoline stations in Germany from October 2013 until June 2015. The dataset contains all price changes of reporting gasoline stations for fuel types Super E5, E10 and Diesel and additional information on the stations' brand, name, address and GPS-coordinates. This data is complemented with the crude oil price (Brent). The data originates from the German Market Transparency Unit for Fuels (MTU) and is provided by the price comparison site "Spritpreismonitor".

Figure 1 plots the price for fuel type E5 for the gasoline stations of Shell, Aral, Total, Esso, Jet and the so-called Freie Tankstellen (independent stations) in Hamburg for one week (from Monday to Sunday) in April 2015.[1] Shell, Aral, Total, Esso and Jet are the five big players on the German retail gasoline market which operate a nationwide network of petrol stations. The stations summarized under the term Freie Tankstelle are independently owned petrol stations which operate only regionally. The repeating daily price cycles can be observed for all brands. Prices are decreasing over the day until six or seven p.m. where all stations seem to increase their prices. This price setting behavior can be observed throughout the German retail gasoline market and is not limited to the example presented in this analysis.

These homogeneous price cycles will be examined with a Markov Switching

[1] This week is chosen only as an example. This type of cycles can be observed over the whole period under consideration and for other brands than the ones depicted in figure 1.

Figure 1: Price Cycles of Different Brands




Regression model (MS model) estimated with equation (1). This model is frequently used to investigate series with various phases as it allows the process to evolve differently in each state and the unobserved states can be identified by the different dynamics. As the model allows the parameters to vary over unobserved states, both, strength as well as duration of the two phases of the cycles can be investigated.

As prices are changed very often by the gasoline stations, a Markov switching dynamic Regression (MSDR) model is implemented. The dynamic model allows a quick adjustment after the process changes state and is therefore suitable to model high frequency data. The model implemented to investigate the price cycles takes the following form:

$$\Delta P_t = \mu_t^s + x_t\alpha + z_t\beta_t^s + \varepsilon^s \tag{1}$$

where $s = 1, 2$ for the two (unobserved) states of the price cycle and $t$ is the time ($t = 1, 2, ..., T$). The dependent variable $\Delta P_t$ is the price change which exhibits the two states. The constant term $\mu_t^s$ is a state dependent intercept and reflects the average price change of the relevant state. The parameter $x_t$ is a vector of exogenous variables that do not vary with the states. The model also allows for exogenous variables $z_t$ that vary with the phases of the process and have state-dependent coefficients $\beta_t^s$. The vector of independent and identically distributed (i.i.d.) normal errors with mean zero and state-dependent variance is represented by $\varepsilon^s$.

The states are identified endogenously by the model and no assumptions are needed about the beginning and the end of the states. This means that time of transition between states and their duration is random.

To disentangle the behavior of different brands, table I shows results for the five different gasoline station chains (column 1 to 6) which were already depicted in figure 1.[2] The first row of table I displays the non-switching exogenous variable *Brent* ($x_t$). The second row shows the coefficients for state 1 and the third row for state 2. The crude oil price (*Brent*) is included as a non-switching exogenous variable ($x_t$) since oil prices do not exhibit intraday fluctuations.

The exogenous switching variable *stickyprice* ($z_t$) is a dummy variable which equals one during periods of stable prices ($stickyprice = 1 \; if \; \Delta P_t = 0$)[3]. Since hourly prices are used for the analysis, there are longer periods where gasoline stations do not change their prices. To control for these stable periods, a dummy variable is implemented, which takes value one during these periods. The coefficients for the other variables do not change noticeable when *stickyprice* is added to the model, but the dummy improves the fit of the model.[4] *Stickyprice* can be considered as a second constant in this model. The constant term in the MS model itself works like a dummy variable, which equals one during the respective phase and zero otherwise.

The coefficients of greatest interest for analyzing the strength of the price cycles are the constant terms which indicate the average price changes of the respective state. As $\mu_t^s$ is positive in state 2, state 2 indicates a phase where the price is increasing, whereas state 1 indicates a decreasing phase. Moreover, the average price decrease is weaker than the price increase for all brands.

The strongest price increases can be identified for Shell and Total (column 1 and column 3 in table I), where prices increase by 11 eurocents per liter. Stations of these brands have very pronounced cycles with the highest maximum prices during the day.

Moreover, these two brands have a long price decreasing phase and a very short increasing phase which can be derived from the transition probabilities $p11$ and $p21$ at the bottom of table I.[5] $p11$ denotes the probability that the process stays in state 1 in the next period when it is already in state 1 in the current period. $p21$ is the probability that the process changes from state 2 to state 1. A value close to one indicates a persistent process which is expected to stay in a given state for a longer time.

For Shell $p22$ equals 0.01 and for Total 0.03. Hence, stations that belong to

[2]Results are presented for the price for fuel type E5. However, the results for the other types of fuel are similar.

[3]$\Delta P_t = 0 \; if \; p_t = p_{t-1}$.

[4]This model is favored over the constant-only model because the Bayesian information criterion (BIC) is lower than the BIC for the constant-only model.

[5]The transition probability is given by $Pr(s_t = j | s_{t-1} = i) = p_{ij}$.

Table I: Markov Switching Model - Brands

| | (1) Shell | (2) Aral | (3) Total | (4) Esso | (5) Jet | (6) Freie Tankstelle |
|---|---|---|---|---|---|---|
| Brent | -0.000822 | -0.00196* | -0.00211* | -0.00252 | -0.00173* | 0.00241** |
| | (-0.51) | (-2.07) | (-2.31) | (-1.78) | (-2.46) | (3.16) |
| State 1 | | | | | | |
| Stickyprice | 0.00643*** | 0.00633*** | 0.00835*** | 0.00533*** | 0.00596*** | 0.00425*** |
| | (21.03) | (33.68) | (54.80) | (22.00) | (46.99) | (23.15) |
| Constant | -0.00611*** | -0.00555*** | -0.00752*** | -0.00434*** | -0.00528*** | -0.00518*** |
| | (-9.46) | (-14.75) | (-20.55) | (-7.79) | (-18.83) | (-17.12) |
| State 2 | | | | | | |
| Stickyprice | -0.111*** | -0.0540*** | -0.110*** | -0.0873*** | -0.0863*** | -0.0409*** |
| | (-84.61) | (-87.07) | (-192.99) | (-90.06) | (-252.07) | (-81.90) |
| Constant | 0.111*** | 0.0548*** | 0.111*** | 0.0883*** | 0.0869*** | 0.0399*** |
| | (124.14) | (119.76) | (221.14) | (113.18) | (225.42) | (112.96) |
| p11 | 0.94 | 0.94 | 0.93 | 0.94 | 0.94 | 0.95 |
| p21 | 0.99 | 0.51 | 0.97 | 0.88 | 0.44 | 0.47 |
| $N$ | 9302 | 9302 | 9302 | 9302 | 9302 | 9302 |

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

Shell or Total raise their prices on average in one step. These two brands exhibit the strongest and very asymmetric price cycles. The other brands have a slightly lower though longer price increasing phase and seem to raise their prices not in one step but over several periods. However, the price increasing phase for these brands is still shorter than their price decreasing phase confirming the asymmetric shape of the price cycles, which is specific for the theoretical Edgeworth cycles. The gasoline stations undercut each other successively in prices over the day to attract customers and to gain market shares resulting in a longer price decreasing phase of the cycles.

Regarding the duration of the price decreasing phase, an interesting and striking feature of the price cycles provides guidance to the price setting behavior of the gasoline stations. The estimate for $p11$ is very similar for the different brands indicating a homogeneous length of the price decreasing phase over different gasoline stations. This contradicts the theory where the duration of the undercutting phase is random, since reaching marginal cost initiates price increases. The very homogeneous length of the price decreasing phase suggests that price increases are not depending on marginal cost, but are rather initiated by a specific time of day when almost simultaneous price increases of the petrol stations terminate the undercutting phase. Only the independent stations (column 6 in table I) have a slightly longer undercutting phase which could be an indication for a follower role. Smaller stations tend to decrease their prices longer to benefit from a larger market share during periods of low prices. Companies that have a larger station network raise their prices first to increase the price level. This difference in behavior of small and large firms is predicted by the theoretical model (see Eckert 2003).

This conduct can be identified for gasoline stations throughout Germany.[6] Sta-

[6]Besides Hamburg, the MS model was estimated for several cities and rural areas across Germany to confirm the cyclical pricing pattern which reveals a homogeneous pattern of

tions of the same brand behave very similar across different regional markets in Germany: price cycles of Shell and Total are always characterized by very strong price increases whereas the other brands show slightly lower price increases and also the timing of these increases is extremely homogeneous across different regional markets. Moreover, the cyclical pattern cannot only be observed for stations in urban areas, but is also followed by stations in rural areas with a rather low station density. Hence, the cyclical price setting is followed by gasoline stations throughout Germany, irrespective of the local degree of competition. Even stations in rural areas, which certainly have some monopoly power due to the low station density, exhibit this pattern. Furthermore, the observed cyclical price setting can be identified for the whole observation period and no coordination problem seems to be present, like predicted by Noel (2008) in his theoretical model.

The fixed timing for the daily price increases may be used to overcome the coordination problem at the bottom of the cycle and may be part of a common strategy of dynamic price discrimination. The simultaneous price increases are used to interrupt the undercutting phase, whereby competition is weakened during periods where demand is high or when demand elasticity is low.[7] For the price-inelastic demand, gasoline stations want to enforce higher prices as these customers seem to be inflexible in their behavior. This particularly concerns commuter traffic, when many car drivers refuel out of habit or because it is the only rational option. Accordingly, prices increase around six or seven p.m. These consumers are rather price-inelastic and do not compare prices in contrast to motorists that refuel by day. Price discrimination would also explain the high prices at night: motorists who refuel at night will not compare prices as they usually urgently need fuel. Therefore, gasoline stations hold prices stable on a high level to exploit the high willingness to pay. The subsequent chapter gives further insights into a possible strategy of dynamic price discrimination in the German retail gasoline market.

## 4 A Strategy of Dynamic Price Discrimination

A strategy of dynamic price discrimination that distinguishes between price-elastic (informed customers) and price-inelastic (uninformed customers) demand results in a cyclical pricing behavior over the day as identified within the scope of the empirical analysis. With this dynamic pricing strategy, the petrol stations are able to take advantage of the presence of heterogeneous consumers. Gasoline stations compete fiercely for the price-elastic consumers over the course of the day resulting in a longer undercutting phase of the price cycles. With the introduction of the MTU numerous comparison apps and websites emerged that

the different brands.

[7] Unfortunately, data on demand is not available.

facilitate price comparison for drivers which could actually have some competitive enhancing effect on the gasoline stations. However, the oil companies interrupt the competitive undercutting phase by simultaneous price increases to weaken competition and to exploit the price-inelastic consumers.

Theoretical models that consider dynamic price discrimination in conjunction with cyclical pricing are scarce. Conlisk, Gerstner, and Sobel (1984) consider a durable goods monopolist implementing periodic sales to price discriminate between different types of customers with high or low willingness to pay. The authors also show that this equilibrium as well holds if the product is of limited durability. Sobel (1984) considers asymmetric sellers and emphasizes that each seller needs monopoly power over some (loyal) customers with a high willingness to pay in order to have an incentive to increase prices again after a sale. However, these models do not properly depict the German gasoline market.

The price setting pattern of the German gasoline stations can be interpreted as a mixed strategy implemented by the market participants: the undercutting phase during the day reflects effective competition as petrol stations undercut each other to attract price-sensitive and informed customers. However, this undercutting phase is interrupted at a specific time of the day by a sharp increase in price. This price increase is initiated when demand is more inelastic. These drivers are hardly flexible in their purchase and usually do not have the ability to wait.

It has to be questioned whether such a strategy could be implemented in a competitive market without any coordination between the market participants as price increases occur according to the time dependent presence of price-inelastic consumers. It seems more likely, that some form of tacit collusion is present. However, more theoretical models on the coexistence of price cycles and dynamic price discrimination would be necessary to determine the role of tacit collusion.

Prices for stations of a brand are usually decided by the pricing department in the headquarter. For the majority of gasoline stations in Germany the price sovereignty is not handled by the service station operator (Bundeskartellamt 2011). The oil companies that operate a large station network centrally coordinate price increases and decreases for their stations and have established pricing mechanisms to set prices automatically. Such pricing algorithms are commonly used in industries where prices are changed frequently to dynamically adjust prices. Pricing decisions coordinated by headquarters can easily be spread throughout the retail market resulting in almost simultaneous price increases of the stations, which as well explains the homogeneous behavior throughout the German retail gasoline market identified in the course of the empirical analysis in chapter 3. That also explains why stations in rural and urban areas have implemented the same pricing strategy. Moreover, the centrally controlled pricing radically reduces the number of competitors leaving some large companies that operate filing stations throughout Germany, which makes it easier to coordinate on a common pricing strategy.

A descriptive consideration of the prices and price changes of the gasoline stations further reveals that stations of the same brand do not only increase their prices at the same time of the day. The price level after the daily increase is also very similar across different regions for stations of the same brand (for stations in cities and rural areas). This homogeneous behavior across different regions reinforces the assumption of a coordinated pricing strategy by headquarters which decide about the timing of the daily price increase and the price level after this increase. However, while the time of the price increase also seems to be almost simultaneously across different brands, the stations of different brands do not increase their prices to a specific or recommended price level. Across brands the price level varies even if a local market is considered.

Recommended prices are often used to establish a coordinated strategy between market participants. Foros and Steen (2013), for example, identify a fixed weekly pattern of the retail gasoline prices in the Norwegian market with simultaneous price increases to the same level on Mondays by all gasoline stations. These price increases are coordinated by means of a recommended price which is published by the headquarters on the companies' websites.

The German gasoline stations, however, do not coordinate on a recommended price after the simultaneous price increases. However, the filing stations appear to have established a fixed order after the concurrent price increases: stations belonging to Shell have on average the highest prices, followed by Aral, Esso and Total. Jet and the independent stations have the lowest prices. This pattern can be observed nationwide for rural and urban areas.

Dewenter, Linder, and Schwalbe (2018) discuss the possibility of dynamic price discrimination and tacit collusion in the German gasoline market in more detail. The authors elaborate how such a pricing strategy could be implemented by the market participants. An explicit agreement between the market participants is not necessary to establish such a behavior as the transparency in this market is very high. Gasoline stations can easily observe and monitor price changes of their competitors and are able to learn the price setting behavior of their rivals and could coordinate on a profitable pricing strategy.

## 5 Conclusion

First results show that the price cycles in the German gasoline market only partly resemble the theoretical Edgeworth cycles. Especially the almost simultaneous price increases at a specific time of day contradict the theory.

The gasoline stations seem to have implemented a mixed pricing strategy: the undercutting phase during the day reflects effective competition as petrol stations undercut each other to attract customers. Thus, price-sensitive drivers that compare prices might indeed exert some competitive pressure on the gasoline stations. However, the undercutting phase is interrupted at a specific time of day by a sharp increase in price. Moreover, this behavior can be observed for all gasoline stations and the pattern is very similar across different regional markets whereby stations belonging to the network of large oil companies have the strongest price increases and seem to initiate the daily price increases.

Due to the high market transparency and the technological developments, though, no explicit communication between the market participants is needed to coordinate on a strategy of dynamic price discrimination that differentiates between price-elastic and price-inelastic consumers. The centralized price setting of the large oil companies and the use of pricing algorithms for price changes enable firms to react very fast to the behavior of their competitors. A specific timing for price increases can easily be implemented to coordinate on this common pricing strategy.

However, theoretical literature on the coexistence of price cycles and dynamic price discrimination should be developed further, especially with regard to the role of tacit collusion.

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