NORGES HANDELSHØYSKOLE

Bergen, June 2006

Price discrimination and competition in a retail gasoline market

A Case Study from Sandviken and Askøy

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Master Thesis

NORGES HANDELSHØYSKOLE

This thesis was written as a part of the Master of Science in Economics and Business Administration program - Major in International Business. Neither the institution, nor the advisor is responsible for the theories and methods used, or the results and conclusions drawn, through the approval of this thesis.

Acknowledgements

I would like to express the words of appreciation to my supervisor Professor Frode Steen, at the Department of Economics at Norwegian School of Economics and Business Administration, for his guidance and constructive criticism, which created considerable motivation to work.

I would like to thank all the people, and personally Olga Tikhonova, who helped me in a long exhausting process of data collection, voluntarily or otherwise.

I would also like to thank James Hosea, Jan Isaaksen and Jochen Well, who were also suffering their own way through writing process, and who gave me a sense of not being alone after having long and fun lunch pauses together.

And final "Thank you" goes to Steffen Sivertsen for showing patience and support and for giving me motivation for completing my thesis.

Contents

Abstract

Gasoline retail prices are generally easily observable on an everyday basis, and high price volatility raises public concern. There seems to be widespread opinion that higher gasoline prices are the result of firm collusion aimed at restricting local competition. The purpose of this paper is to test the nature of competition concerning price setting in the Norwegian retail gasoline market. By using data on daily retail gasoline prices collected during spring 2005 in two Bergen areas, Sandviken and Askøy, we attempt to define if the competition climate can be described as competitive, imperfectly competitive or tacitly collusive. An econometric method used is based on the distinction of the effects of local market competition, input prices and common strategies of oil companies on trends in daily retail prices. We can not reject the hypothesis that retail gasoline stations enter tacit agreements, and we find that the observed behavior is inconsistent with the competitive model or with the non-collusive imperfect competition model.

1. Introduction

Retail gasoline markets have characteristics that make them different from other commodity markets. Most petrol companies control the production process from the exploration of crude oil to the refining and distribution of the final product. On the Norwegian retail gasoline market these integrated players have a very dense retail network and meet each other in most local markets. Theoretically, a situation with few integrated companies operating on the market, which in addition have large market power concentration, makes tacit or explicit cooperation in setting higher prices easier.

There seems to be widespread public concern in many countries that high gasoline prices are the result of firms' collusion, which naturally restricts competition. The reasons why gasoline prices get so much attention when prices are raising are that fuel expenses constitute a large part of households' budget and that gasoline prices are easily observable in everyday life. It is plausible that volatility in retail gasoline prices due to other factors, such as for example, corresponding fluctuations in international crude oil prices, could be sometimes mistaken as evidence of collusion.

In this paper we attempt to contribute to the solution of the problem by using data on price dispersion across two geographical Bergen areas over the same 5-month long time period. We estimate the impact of local market competition, input prices and common strategies of oil companies on trends in daily retail prices charged for Euro 95 gasoline. We distinguish the effects, which all mentioned factors individually have on retail prices, separately for both areas, and further apply them to area characteristics by using relevant elaborated theory of tacit collusion. On the ground of this we make a conclusion about competition structure in the area.

In Norway several investigations of gasoline industry have been carried out by the Norwegian Competition Authority (Konkurransetilsynet), and no signs of collusion in the market were found so far. Although, several integrated players operating on the Norwegian gasoline market, were proven participating in tacit collusions on the gasoline retail markets in other countries, such as Sweden and Italy. Moreover, the structure of the Norwegian gasoline market theoretically makes existence of collusions possible. Therefore, we think that more thorough analysis of the situation is required.

Current paper, which is based on the analysis of comprehensive data, makes a contribution to the solution of the problem. The results might have practical relevance for policymakers, who currently base their decisions on assumption of competitive gasoline markets. Therefore, if tacit collusion is in fact takes place on the market, efforts aimed at ensuring lower retail gasoline prices through enhancing competition at both retail and wholesale levels should be made.

1.1 Hypothesis

Price discrimination is one of the monopoly power enhancing practices. It is based on the principle of differentiated pricing of the same product sold to different consumers, for reasons not associated with differences in costs (Moschandreas, 2000). This practice allows companies to reach higher total revenues. Due to peculiar characteristics of gasoline, geographical markets of which can be effectively segregated in most cases, the so called "third degree of price discrimination" can be applied.

In addition, Norwegian market for gasoline can be characterized as an oligopolistic, since gasoline is sold exclusively through very few vertically integrated chains, which belong to five major brands (figure 3.1). These firms have a very dense retail network and meet each other in many local markets. Moreover, the five major brands are not present in all local geographical markets, making oligopoly even more valid. Decision making for different gasoline stations in different local markets depends to a certain degree on conjectures about behavior of rivals, located in the same area. In order to avoid uncertainty and rivalry, which may result in price wars, and to increase market power, chains and consequently stations can enter into collusive agreements.

According to Norwegian Competition Authority (Konkurranseloven §10), any form of formal or informal competition restricting agreements, including those concerning retail price, are prohibited if it can be proved that parties have been in contact with each other. It is not illegal to unilaterally adjust retail prices to other firms' prices.

On the ground of all said above, we state that

Norwegian retail gasoline chains enter into tacit collusive agreements.

We base our hypothesis on the evidence on retail price variation collected during a 5-month period at five different gas stations belonging to three major gasoline brands and located in two separate geographical areas.

1.2 Materials and Methods

The data on prices of unleaded gasoline Euro 95 was collected from the display boards of five different gas stations located in two Bergen areas – Sandviken and Askøy, and from official primary data publications available on the internet. In addition secondary sources of information, both quantitative and qualitative, such as results of macroeconomic analysis of the industry and published opinions of experts in the field, were used.

In order to verify hypothesis one should apply data to the theory. In the first part of the paper we consider three relevant, in our opinion, theoretical models of competition. We first make an assessment in rather general terms and then apply them to retail gasoline industry, creating a base for relating our results to it later. We also give brief overview over which models authorities and experts think realistically describe state of affairs in different countries including Norway.

In the second part we describe current situation on the Norwegian retail gasoline market, giving brief assessment of market structure, main players, trends in retail and wholesale prices as well as presenting collected data.

Further in the paper we formulate an econometric model for primary data assessment, which is based on the multiple linear regression analysis of time-series data. By doing this we aim to predict how trends in prices at the considered gas stations are dependent on different factors, such as local competition, company's common strategy or changes in input prices, all expressed in quantitative terms. In this part we also define several qualitative parameters, which could be significant in a process of theory application.

1.1.1 Multiple regression model

In general terms the model with k predictors is like following:

$$y = \beta_0 + \beta_1 x_1 + \ldots + \beta_k x_k + u,$$

where y – dependent variable, x_1-x_k – predictor variable, β_0 - intercept, β_1 - β_k measure the change in y with respect to x_1- x_k, holding other factors fixed, u – error term (disturbance).

Based on zero conditional mean assumption, regression coefficients $\hat{\beta}_0, \hat{\beta}_1, \ldots, \hat{\beta}_k$, which are the estimates of $\beta_0, \beta_1, \ldots, \beta_k$, are obtained by applying so called "least-squares procedure", which minimises the sum of squared residuals (Wooldridge, 2006):

$$SSR = \sum_{t=1}^{n} \hat{u}_t^2 = \sum_{t=1}^{n} (y_t - \hat{y}_t^2)$$

Once intercept and slope estimates are determined, it is possible to form the OSL regression line:

$$\hat{y} = \hat{\beta}_0 + \hat{\beta}_1 x_1 + \ldots + \hat{\beta}_k x_k$$

A useful parameter of the regression is coefficient of determination R^2, which measures the overall quality of the regression:

$$R^2 = 1 - \frac{\sum_{t=1}^{n} (y_t - \hat{y}_t)}{\sum_{t=1}^{n} (y_t - \bar{y}_t)}$$

It is the percentage of total variation exhibited in the y data that is accounted for by the sample regression line. A high R^2 means that most of the variation we observe in the y data can be attributed to their corresponding x values.

In order to check the model for validity, considering the nature of the data, we find it useful to perform autocorrelation and multicollinearity tests. Autocorrelation test checks the assumption of independence of the error terms, since for time-series data the error terms can be correlated across time. Also considering retail price formation process, the problem of multicollinearity (when two of the x variables are strongly correlated) can arise, which can provide coefficient estimates with a wrong sign or magnitude.

In the next chapter we perform data analysis. It is primarily based on the statistical model discussed above, although some additional tests and simple estimations are made. For price comparison purposes we use paired t-tests. Simple statistical analysis of price adjustments is also performed. We use statistical software STATA as a tool for performing all the calculations.

In the final part we thoroughly discuss obtained results and apply them to the theory. Afterwards, conclusions about the nature of competition in the areas are made and hypothesis is substantiated.

2. Applicable competition models

Significant public belief in the incidence of collusive behavior in many western countries (USA, Canada, UK, etc.) has led to frequent public demands for government intervention to lower high gasoline prices due to price-fixing or other anti-competitive acts undertaken by large gasoline firms (Sen, 2003). Competition authorities in a number of European and North American countries have recently started investigating the competitiveness of retail markets for oil products.

In some countries like Italy and Sweden authorities were able to show that big integrated players, who own a dense network of service stations, entered various collusive agreements, for example, by converging their “recommended prices” (Meerbeeck, 2003) or by simultaneously lowering list prices and introducing unfavorable discount systems (KonkurranseNytt 5/2004). As a result these companies have been imposed heavy fines for restricting price competition in retail gasoline markets. Most of these integrated players, such as Esso, Shell, Conoco, Norsk Hydro, Statoil and Texaco, are also active on the Norwegian retail petrol market.

The authorities of a few other countries (Netherlands, Belgia) so far could not prove the existence of secret agreements between the oil companies, but concluded that price competition is in fact limited and pricing in the retail gasoline market needs to be monitored closely (Meerbeeck, 2003).

In Canada and USA, on the other hand, competition authorities agreed that regional price differences and swings in price over time are chiefly a result of corresponding trends in crude oil prices rather than collusion of local firms (Sen, 2003). Therefore, they described retail gasoline markets as competitive. However, they neither fully specified a single elaborated competitive market model of retail gasoline pricing, nor tested hypothesis to confirm the predictions the model might make (Eckert, et al., 2005).

In Norway no clear cut conclusions about structure of retail gasoline market has been made so far by Norwegian Competition Authority (Konkurransetilsynet), but several investigations of gasoline industry have been carried out. One of the key research areas was investigation into high retail price volatility in all of the Norwegian counties (Konkurransetilsynet, 2001).

High price volatility and dispersion was attributed to intense competition and did not serve as evidence of collusion for Konkurransetilsynet as it is sometimes interpreted in the literature. They also stated that although there were very few companies operating in vertically structured Norwegian petrol market, none of them had more than 30% share of the market and, therefore, it was generally competitive with no signs of collusion found so far (Konkurransetilsynet, 1998).

According to the Competition Authority, the local market power that the firms can possess in some areas is outbalanced by centralized competition, since all of the companies meet each other in most local markets. Taking into consideration that many gasoline stations in every big chain operate under franchise agreements, Konkurransetilsynet allows oil companies to set maximum retail prices the former can charge, by that restricting local market power of stations and facilitating local competition. Increased local competition in turn is supposed to weaken incentives to collude on national scale. Moreover, the presence of a number of automatic gasoline stations (UnoX, Smart and Jet) is seen as factor facilitating competition in the areas they are located. The growth in number of these stations as well as their turnover on the ground of lower retail prices point to the fact that consumers are mobile, price aware and price sensitive, which can be interpreted as a sign of an efficient market (Konkurransetilsynet, 2001).

One of other controversial issues we found in reports of the Norwegian Competition Authority was the existent wholesale practice of distribution of gasoline in existent vertically integrated market. The oil companies do not own gasoline depots in every area; instead in order to minimize transportation costs, their branded stations buy gasoline from the closest depot, which can belong to a competitive chain. On this ground major companies (Esso, Statoil, HydroTexaco and Shell) have bilateral agreements, which secure them steady and cheap supplies. In our opinion it creates high entrance barriers for other firms and independent stations. Although, in response to Jet's complaint to Konkurransetilsynet on discrimination by quoting higher wholesale prices to Jet than to other major market players and by that restricting competition, the Competition Authority did not find that the majors exercise market power and did not consider interruption to be necessary (Konkurransetilsynet, 1998).

In general we find several conclusions made by Konkurransetilsynet to be controversial and inconsistent with the theory. The reasons to consider current market structure to be favorable for tacit collusions existence can be summarized as follows:

- Observed high price volatility can sometimes serve as evidence of collusion, assuming firms are able to make sophisticated calculations to achieve the highest sustainable collusive price;
- Large retail networks of all players lead to the situation where firms meet each other on almost all local markets, and collusion is, therefore, more likely;
- Vertical integration and wholesale practice (bilateral agreements) of very few large players supports an oligopolistic market structure and create high entry barriers, which naturally restricts competition;
- The existence of published recommended prices and maximum price agreements between companies and their franchisees can facilitate coordination on a collusive price or a set of retail prices (Meerbeeck, 2003).

The purpose of this paper is to examine the price space-time variation prediction of the tacit collusion model. The econometric model used for this will also generate results that describe the actual pricing pattern observed in the local market. If the tacit collusion model can be rejected, we can then determine whether the pricing pattern is more consistent with the type of pattern that could result from alternative types of pricing behavior. Two alternative types of pricing in the retail gasoline market are considered on the basis of conclusions drawn by competition authorities of other countries: competitive pricing (Canadian case, Eckert, et al., 2005; Sen, 2003) and imperfectly competitive, non-collusive pricing in a spatial market (Dutch and Belgian cases, Meerbeeck, 2003).

2.1 The competitive market model

As it has been mentioned earlier, Canadian authorities and a number of industry functionaries adopt a competitive market model (www.competition.ic.gc.ca). The adoption is based on the belief that local retail gasoline markets satisfy three of the four basic assumptions of the classical model (Eckert, et al., 2005; Pindyck, Rubinfeld, 1997):

1. Consumers are mobile and can easily get information about prices at different stations in a particular geographical market. Gasoline stations have information about prices at rival stations as everybody posts prices (*Perfect information principle*);
2. Gasoline stations act as they are undifferentiated firms competing in a spaceless world (*Product homogeneity principle*);
3. Individual stations set their own prices (implying *Price taking principle*).

Because these principles eliminate all spatial product differentiation and expensive consumer search, retail prices are predicted to be the same everywhere in the market, irrespective of location, proximity to competitors or the characteristics of the retailers (Eckert et al., 2005). In addition he states that the retail price of gasoline established in the market in this case is a competitively determined price.

At first sight it seems that it is easy to reject the competitive model right away, since the prices in the market are not the same. However, there are a few arguments in favor of still contemplating the model.

First, as Eckert (2005) states, rejection of the model on this basis would not be sufficient to persuade its proponents in some countries that alternative models better explain retail gasoline station pricing; therefore, we need to specify an econometric model, which would contain variables that the competitive model suggests should not affect the probability that a station charges the market price. Otherwise, in absence of a clear rejection, the authorities will continue to be guided by a belief that retail gasoline markets are competitive and think that anti-competitive conduct in these markets can not succeed.

Secondly, Sen (2003) emphasizes the impact of highly volatile international crude oil prices, which, as her research shows, contribute more to the high retail price level and dispersion than local market structure. Therefore, since both factors play an important role, it is hard to see whether price volatility in the retail market is due to corresponding fluctuations in international crude oil prices or an evidence of collusion. In order to avoid confusion, empirical studies requiring significant data need to be exercised.

2.2 Tacit collusion

Although vertically integrated firms may not necessarily be engaging in collusive activities, retail gasoline prices should be impacted by the degree of competition in retail and wholesale markets. An increase in **market concentration** makes collusion among firms easier (Sen, 2003).

On the other hand, unstable cost and/or demand conditions of the gasoline industry make it difficult to maintain such a collusion, creating conditions for the emergence of price wars. Borenstein and Shepard (1996) emphasize two factors - **changes in demand and marginal cost**, as contributable to sustainability of collusion. They claim that when current demand is higher and/or current costs are lower than expected future parameters, collusion is more difficult to sustain because the gain from cheating increases in the current period while the loss of punishment increases in future period with lower demand and/or higher costs. Therefore, collusion is more difficult to sustain when demand is declining or cost is increasing. Though as they mention, there is a reason to believe that non-collusive prices would also respond to expected future cost changes, change in costs would change collusive prices more than non-collusive ones due to the prediction that they will respond negatively.

The selection of a collusive price is complicated by **product and spatial differentiation**. A distinction can be made between vertical and horizontal product differentiation. Vertical product differentiation is linked to quality differences, when consumers have the same ranking of the product variants and will buy the same variant provided that prices are uniform. Horizontal product differentiation takes place when, even if prices are uniform, different consumers prefer different variants due to their different tastes (Meerbeeck, 2003). Therefore, differences in the intrinsic quality of gasoline, service level and product mix, offered by different retailers, all can be sources of price differences across stations.

Many authors (Slade, 1986) state that location effect plays the most important role in explaining price differences across stations. Since consumers usually prefer nearby stations, retail gasoline market is characterized by localized competition.

In her research Slade (1986) on the example of Vancouver gasoline retail market shows that in spite of the fact that gasoline sold by different firms is chemically indistinguishable, consumer preferences vary systematically with service-station characteristics. On this ground, demand at retail level is not perfectly elastic and she rejects the hypothesis that pricing is competitive.

On the ground of all of the above, it is logical that collusive pricing can involve different retailers setting different prices, which can also change over time. The lack of a unique collusive price though possesses coordination difficulties for firms that may be alleviated through price matching (Eckert, et al., 2005).

In general, economic theories are unable to predict the prices at which firms will tacitly collude. Outside of price-wars periods firms enter tacit collusions as a result of a repeated game. This yields higher pay-offs to all players in each period than the Nash (non-cooperative) equilibrium of the one-shot game (Pindyck, Rubinfeld, 1998). Basic game theory (the Folk theorem of repeated games) demonstrates that, over an infinite time horizon, a group of firms can sustain a wide range of payoffs in a collusive equilibrium (Fudenberg, Tirole, 1991). There is also a number of alternating move models to retail gasoline, such as, for example, staggered price setting models (Eckert, et al., 2005). According to them, a large number of tacitly collusive prices can be sustained, although only one at the time.

Tacit collusion models make different predictions regarding retail pricing behavior in a market, than the competitive market model or the imperfect non-collusive competition model.

- *Deviations from the tacitly collusive price*

  For stations not participating in collusion, the optimal price can be either above or below the tacitly collusive price (Eckert, et al., 2005). An isolated station can set a monopoly price for that area, which will be above the tacitly collusive price. Alternatively some non-colluding stations can set their prices below the latter in attempt to overcome disadvantages in location or product.

- *Major players vs. fringe firms*

  As we have already mentioned, large integrated players have bigger incentives to set the tacitly collusive price because the cost of not doing so is larger for them than that for smaller firms. Smaller firms may undercut the tacitly collusive price to increase market share, believing that the cost to the larger firms of abandoning the tacitly collusive price exceeds the potential gain from responding to the lower price of the smaller firms (Eckert, et al., 2005). Major players also have greater ability to coordinate behavior given the fact that they meet each other in most of the local markets.

- *Spatial and product differentiation*

According to this model, consumers don't view gasoline sold at different stations to be a homogenous product and price is not everything they care about. However, the model predicts that product characteristics should not affect the probability that tacitly collusive firms match prices (Eckert, et al., 2005). Eckert also states that allowing station characteristics to affect pricing would make achieving and maintaining the tacitly collusive price more difficult. However, we think that it is reasonable to allow for the constant differences in collusive prices between different colluding firms to be incorporated into the model, therefore, allowing a range of collusive prices instead of one single collusive price for all firms. This prediction is also in line with the earlier mentioned Folk theorem (general feasibility theorem).

A station's choice, whether to set collusive price, depends on local concentration of stations of the same brand and on the distance to the nearest competing station. Regions with higher market concentration and/or smaller number of stations are usually expected to be more likely to sustain tacit collusion.

- *Intertemporal fluctuations in the tacitly collusive price*

Unstable demand and costs conditions (highly volatile Rotterdam spot price) in retail gasoline industry make it difficult to sustain collusion and simultaneously respond to demand and wholesale price changes. In the long run, according to supergame models of tacit collusion, prices also change with respect to expected future collusive profits, i.e. increase when demand is expected to increase or marginal costs are expected to decline (Borenstein, Shepard, 1996).

In order to maintain price "stability" and prevent possible price wars a number of strategies exist. Price rigidity (or stickiness) and price signaling (leadership) can be worth mentioning in our case. Price rigidity appears when firms are reluctant to change price in response to the cost changes, because that can send the wrong message to their competitors, and either set off a round of price warfare or lead to the loss of a market share, depending on the direction of a change (Pindyck, Rubinfeld, 1998). The stickiness of prices and their symmetry with respect to spot market prices (prevailing of upward price flexibility) is a well-known phenomenon and can be interpreted as a sign of collusive behavior (Asplund, et. al., 2000).

Price signaling is yet another form of implicit collusion. One firm (a leader) can set the price, and the other firms, the "price followers", follow suit. Sometimes a large firm naturally acts as leader, and sometimes different firms can be the leader in different points in time. Price signaling can be a way of dealing with price rigidity problem.

One of the forms of intertemporal price discrimination is the practice of charging different retail prices in different days of the week ("day-of-the-week-effect") or holidays. Some studies show (Bettendorf et al., 2003) that the day of the week for which prices are observed matters for the results of statistical analysis on price response to costs changes.

- *Price regulations*

In competitive markets gasoline retailers are not restricted in their pricing behavior by the maximum price, introduced by major Norwegian oil companies on their franchisees. The latter should normally offer a discount vis-à-vis the maximum price. The size of such discounts depends on the degree of competition in a particular local market. According to the tacit collusion model, such maximum price agreements as well as recommended price publishing can facilitate coordination on a collusive price or set of retail prices, which will be close to or equal to the maximum/recommended price (Meerbeeck, 2003).

2.3 Imperfect non-collusive competition

A third possible model explaining price dispersion over space and time is imperfect non-collusive competition (INC).

In the case of uniform population density and diminished spatial differentiation with many independently owned homogenous outlets everywhere in the market, this model would lead to spaceless Bertrand competition and produce price uniformity in the market. In the absence of such high station density or unequal spacing between them (which is closer to the real world picture) prices would differ according to costs, station ownership, local demand, and the number, location and types of local competitors (Eckert, et al., 2005). Therefore, this model generally predicts price variation across space, with the possible exception of price uniformity within the member outlets of a retail chain. The latter can, for example, happen because price is advertised across the entire market or imposed on chain members directly, etc., but not as a result of tacit collusion. However, different chains would have different uniform prices (Eckert, et al., 2005).

2.4 Existing evidence on retail gasoline pricing

Many recent international studies focus on gasoline price movements and variate dependency through time (serial correlation) and space (spatial autocorrelation), and with problems associated with processes that generate such dependency (Haining, 1984). M. Slade (1987), Borenstein and Shepard (1996), Eckert and West (2005) and some other authors have addressed the question whether recent game theoretic models are compatible with observed price movements in gasoline markets. A few empirical studies concentrate specifically on spatial aspects of competition (Meerbeeck 2003, Haining 1984, Sen 2003, Clemenz and Gugler 2002), while others (Asplund, Eriksson and Friberg 2000) are concerned with price adjustments in response to cost changes. Several researches (Slade 1996, Meerbeeck 2003) have used data from gasoline markets to assess the impact of policy measures and certain contractual agreements on retail gasoline prices.

Although these studies investigate many other western markets for gasoline, so far very little attention has been paid to the Norwegian petrol market. The oil companies operating on this market are present in almost all other countries, but peculiarities of both local regulations and local market structure makes this a special case.

3. Market and data description

3.1 The market

Vertical integration is prevailing in the Norwegian gasoline market, and gasoline is sold exclusively by relatively few branded retail stations. Oil companies have a very dense retail network and meet each other in most local markets in Norway. Available data relating to sales of gasoline during the last years indicate that *Statoil* and *Shell* appear to be the market leaders in terms of volume, having 20-30% market share each (Case No Comp/M.3375). They are closely followed by *Esso* and *HydroTexaco*, whose market shares are exceeding 15-25% (figure 3.1). The share of *ConocoPhillips*, which is represented in Norway with its automatic station brand *Jet*, hardly exceeds 5% of the market and located mostly in the Oslo-area. Regarding the number of retail stations, Shell has the largest number of gas stations (25-35%). All other parties' share of the total number of retail stations (except minor share of *ConocoPhillips*) exceeds 15-25% (Case No Comp/M.3375).

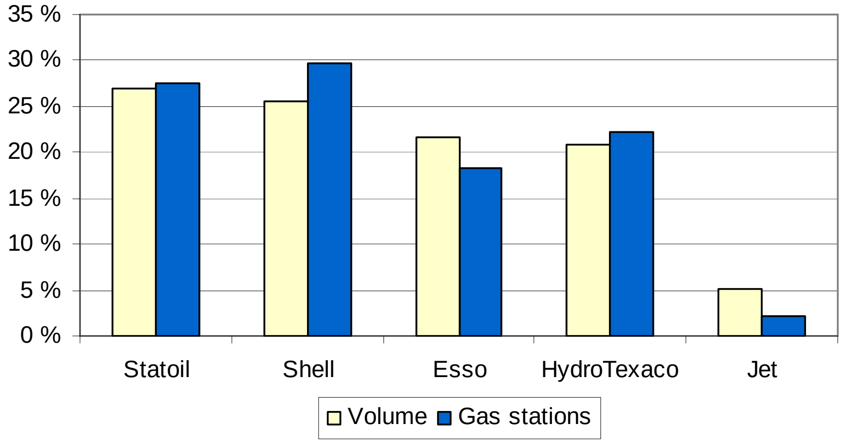

Figure 3.1. Market shares in 2004 (*Source: Norsk Petroleumsinstitutt).*

Three out of five companies (*Shell*, *Hydro-Texaco* and *ConocoPhillips*) active on the Norwegian retail gasoline market also operate chains of fully automated gas stations (*Smart*, *UnoX* and *Jet* respectively). Lower expenses due to smaller start-up and operating costs and shorter supply chains lead to a situation where automatic stations can offer a lower range of prices for the same type of gasoline as full service stations do, even despite the fact that they sell less variety of goods, to which they can allocate these costs. After having made thorough research, the Norwegian competition authority (Konkurransetilsynet) decided that these stations constitute the same market for sale of gasoline as full service stations operating under the company's names do, in spite of lower prices and different service level at automatic stations. Research also shows (Konkurransetilsynet, 1998) that in geographical areas where both types of stations are operating, price level for gasoline falls, but full service stations can still survive due to the fact that gasoline is not fully homogenous good.

Most of the stations belonging to the four dominating retail chains for sale of gasoline operate under franchise agreements, where station owners decide on retail prices. Although all these oil companies have a minor share of stations, which is still driven directly by the head offices. For *Shell*, for example, this share accounts for about 25% of outlets, while for *Esso* it does not exceed 5% (Konkurransetilsynet, 2001).

In order to encourage local competition, all major oil companies set maximum retail prices station owners can charge (Konkurransetilsynet, 2001). They also recommend particular retail prices to their filling stations, and *Statoil*, *Shell* and *HydroTexaco* publish changes to the recommended prices on their websites.

We concentrated our attention on the retail list prices of Statoil. Statoil is a vertically integrated firm and its geographic market for gasoline at retail level is national in scope. In the year 2004 Statoil Detaljhandel Skandinavia AS (SDS), which operates the chain of retail service stations, was fully acquired by Statoil ASA. The latter is active in exploration and production of oil and natural gas, petroleum refining and delivering gasoline to the retail markets. At the wholesale level SDS sources gasoline solely from Statoil ASA (Case No Comp/M.3375). Although at retail level all four major companies have bilateral agreements for wholesale supply of gasoline to their retail stations. Since these oil companies do not own gasoline depots in every area, their branded stations in order to minimize transportation costs buy gasoline from the closest depot, even if it belongs to a competitive chain (Konkurransetilsynet, 1998).

Important parameters of competition such as the price and the quality are typically decided and implemented by Statoil at the national level (Case No Comp/M.3375). Prices at national level, which Statoil recommends as a consumer price to all of its stations in Norway (*www.statoil.no*), are adjusted in response to cost and demand changes. Cost changes are normally also reflected in the input (wholesale) price, even though usually with a 1-2 weeks time lag. Therefore, Daily Rotterdam Spot price for gasoline can be the relevant input price for our analysis; even firms who have their own refineries and do not buy gasoline on the spot market, use this price as a transfer price within a firm.

Retail petrol prices are also influenced by costs of transportation of gasoline to a station from a depot (0-zone). It is interesting to see that the abolishment of the practice of "transportation costs equating" ("fraktutjevningsordningen") introduced earlier by the authorities in order to keep retail gasoline prices at the same level all over the country by providing support to remote stations, did not lead to increased price differences between different zones.

Due to such a short sample period (about 5 months), the Norwegian gasoline market remained stable with unchanged market concentration and relatively stable monthly sales of gasoline with insignificant seasonal fluctuations (figure 3.2). Therefore we did not consider such factors as change in market concentration and overall demand to be influential for a short-run pricing behavior. Taxes on gasoline also remained unchanged during this period, and according to the *Norwegian Ministry of Finance* constituted on average 4.74 NOK per liter of unleaded gasoline with low concentration of sulphur (varying slightly in different municipalities). Value-added tax also remained stable during the period and constituted 25%, calculated on the consumer price.

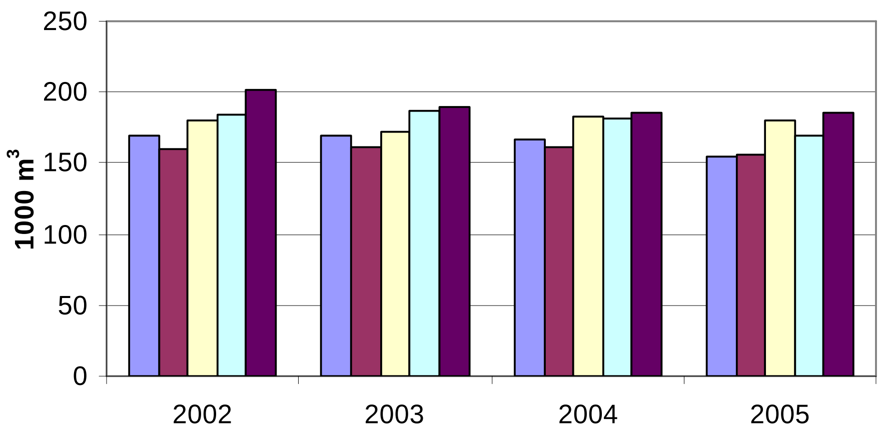

Figure 3.2. Monthly Norwegian sales of gasoline in the period January-May in 2002-2005 (*Source: Statistisk sentralbyrå*).

3.2 The data

We study the retail price of unleaded gasoline (Euro 95) in Bergen, Norway, in the period from 23 January 2005 to 22 May 2005.

In our research we consider five different retail gas stations, located in Bergen area. They belong to three major brands: *Statoil*, *Hydro-Texaco* (with its *"UnoX"* automatic stations) and *Shell* (with its *"Smart"* automatic stations). Since markets for gasoline for Norwegian oil companies are both local and national, in order to verify the hypothesis about the competition structure we chose two relatively isolated in terms of closest competitors geographical areas of Bergen: Sandviken and Askøy, both of which contained a *Statoil* station. Stations located in Sandviken lay on the major route (E39) with a lot of traffic during the week days, while Askøy is a residential area.

The data set includes list prices collected twice a day (in the morning and in the evening) at three gas stations in Sandviken (*Statoil*, *UnoX* and *Smart*) and daily (mostly morning) list prices for two gas stations on Askøy (*Statoil* and *Hydro-Texaco*).

Since *Statoil* has different competitors in these two areas, it gives us a perfect opportunity to follow and compare its pricing patterns at different gas stations and later make conclusions about the influence of different parameters. The fact that list prices were highly volatile and different for both *Statoil*'s stations is valuable for our analysis. It might expose the influence of strategic factors along with the response to cost changes on the pricing decisions of the retail stations.

Further data is complemented by recommended *Statoil* retail prices and daily Rotterdam spot price, which as we already mentioned, is the most important input for the price of Euro 95. Every day (except weekends and holidays) the latter is assessed by Platt's London in US dollars. To convert this price in Norwegian Krones, we use the daily dollar/NOK exchange rate given by *Norges Bank*.

Summary statistics of collected data is given in Table 5.7.

Beneath in the figure 3.3, time-series data for *Statoil* over the considered period is plotted.

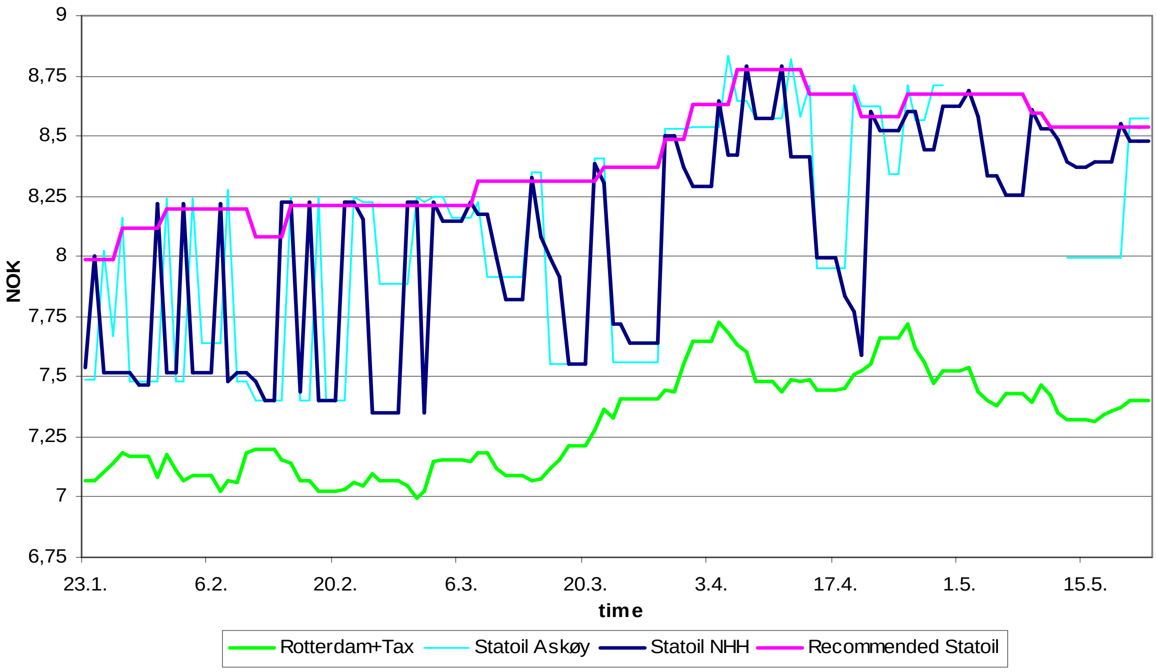

Figure 3.3. Development of *Statoil*'s retail and recommended price for Euro 95 (excluding VAT) and marginal cost + tax (January – May 2005) (*Sources: www.statoil.no, display boards of individual gas stations, Official Energy Statistics from the U.S. Government (EIA)*).

Despite daily fluctuations in the Rotterdam spot price and the exchange rate (green line), the recommended price (pink line) was held constant in the short run. While in the longer run the price seemed to follow the cost movements, adjusting in the direction motivated by the underlying cost. This phenomenon is called price stickiness. According to Asplund (2000), a recurring theme in literature is whether price adjustments are symmetric with respect to underlying variable.

Retail prices at the given *Statoil* stations showed much higher volatility over time (on average local list prices at *Statoil* as well as at the other stations under consideration were adjusted once per day). Following the logic, under tacit collusion condition, retail prices would probably be close to the recommended price exceeding it on a value equal to the area transportation cost (4-5 øre excluding VAT for Bergen, *www.shell.no*), or be higher than recommended price, converging to maximum price under agreement between the company and a gas station. In our case they were generally lower than the recommended price, more or less following movements of the latter in their maximum states (during particular days of almost each week) (figure 3.3).

Except for a response to the corresponding fluctuations in international crude oil prices, retail gasoline price volatility can be explained by the degree of competition in retail and wholesale markets, which mainly depends on firm's market concentration and the number and nature of competitors.

Slade (1986), for example, distinguishes between two types of players in the market: price cutters (usually independent firms in US and Canada or automatic stations as in our case) and majors, who lead price restorations. Competition between these two types of players can cause high price volatility within a week. In some other cases the situation can be explained by an unleashed price war.

Such high volatility of prices on a daily basis can also sometimes be explained by the "day-of-the-week" effect – different price setting strategies of the companies during the week (mostly being different for weekends) (Bettendorf et al., 2003). Therefore, we want to account for this factor in our econometric model by introducing dummy variables for different days of the week.

From figures 3.4 and 3.5 it is evident that price movements at different stations located in the same area often follow each other.

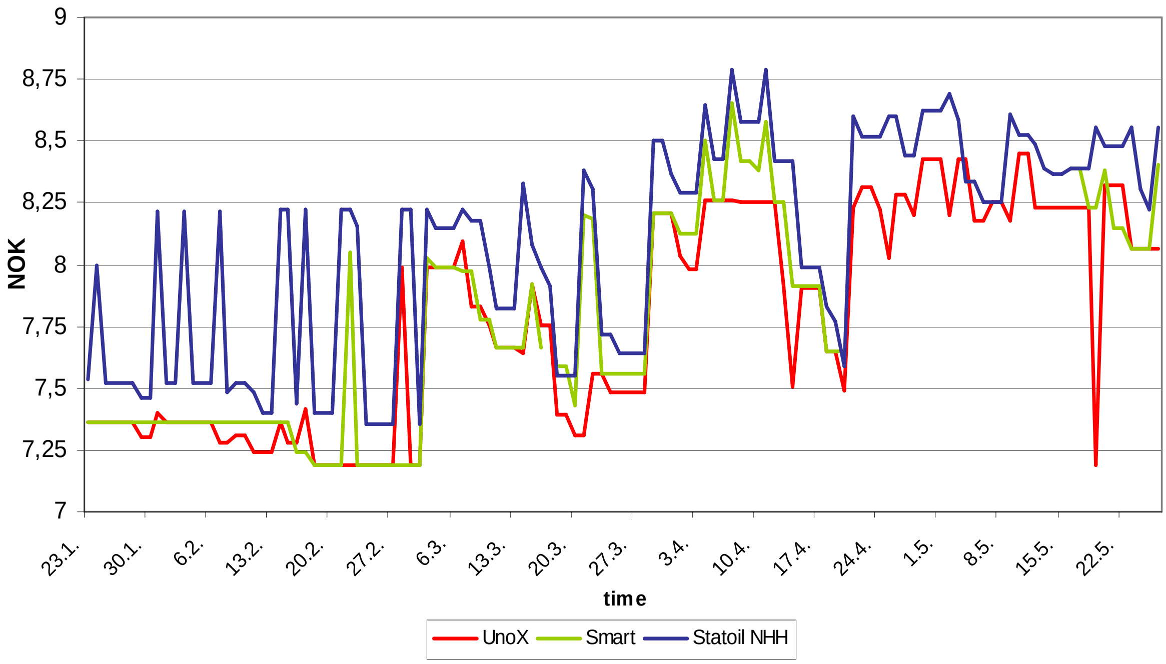

Figure 3.4. Development of retail price (excluding VAT) at Statoil, UnoX and Smart gas stations in **NHH area**, Sandviken (January – May 2005).

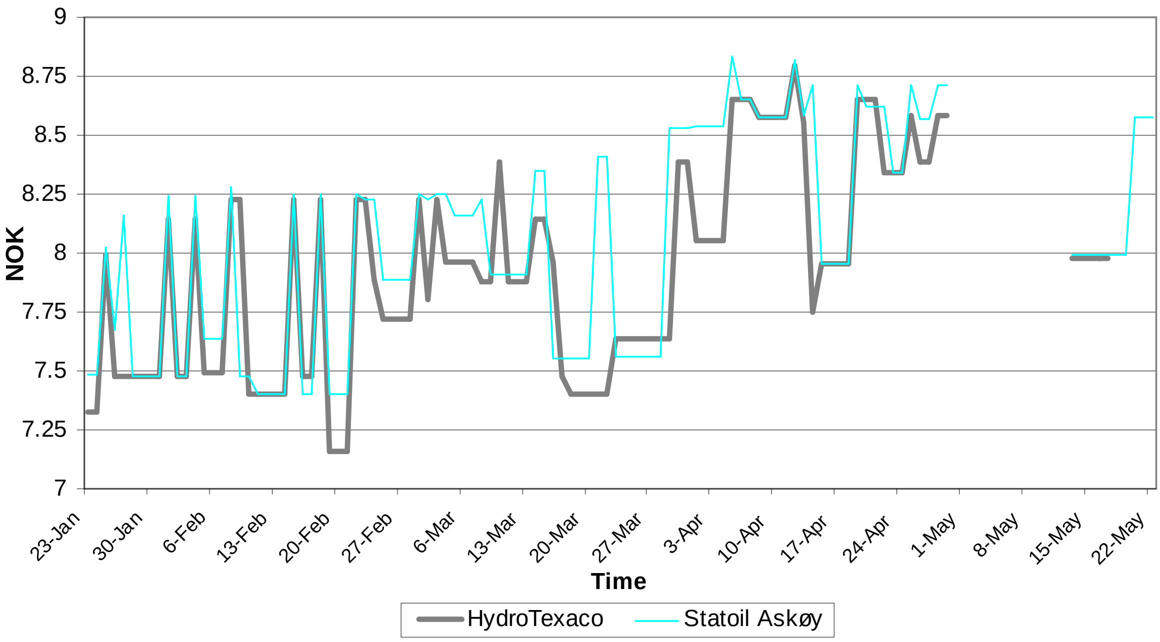

Figure 3.5. Development of retail price (excluding VAT) at Statoil and HydroTexaco gas stations in **Askøy** area (January – May 2005).

From these figures we can presuppose that variation in prices in the same area refers more to constant differences in price levels than to differences in the pattern of price adjustments.

We shall check for all these assumptions in our empirical analysis in the following chapter.

In general we can say that the market offered us a clean case for testing hypothesis of stations' tacit collusive behavior, as both prices and costs were observable on a daily basis at different individual gas stations as well as at the company level. Although some researches (Borenstein and Shepard, 1996) point out that diagnosing collusive pricing from only contemporaneous price, cost and demand data is quite difficult, and special restrictive assumptions are needed to be introduced in the model.

4. Econometric model

This section sets up an empirical specification, which will be used to describe the effects of wholesale prices, recommended prices and competition on *Statoil* retail prices, and to test certain predictions about these effects made by the tacitly collusive hypothesis. Because of the localized nature of competition (station's principal competitors are its closest neighbors, Slade 1986) and small number of stations, at which prices were observed, in order to assess these effects we specified one regression equation for each of two *Statoil* stations (one for each area).

The price of gasoline at each *Statoil* station at particular day is a function of rival price, the firm's recommended price, input price (Rotterdam spot price for gasoline) and price at other Statoil stations in the city at the corresponding day t:

1. *Sandviken* (*NHH*) *area:*

$$\mathbf{P(Statoil_{NHH})_t = \beta_0 + \beta_1 P(Smart)_t + \beta_2 P(UnoX)_t + \beta_3 P(Statoil_{recommended})_t + }$$

$$\mathbf{+ \beta_4 P(Rotterdam)_t + \beta_5 P(Statoil_{Askøy})_t + \varepsilon_{1t} \quad \ldots \quad (1)}$$

2. *Askøy area:*

$$\mathbf{P(Statoil_{Askøy})_t = \gamma_0 + \gamma_1 P(HydroTexaco)_t + \gamma_2 P(Statoil_{recommended})_t +}$$

$$\mathbf{+ \gamma_3 P(Rotterdam)_t + \gamma_4 P(Statoil_{NHH})_t + \varepsilon_{2t} \quad \ldots \quad (2),}$$

where ε_t is an error term;

β_0 and γ_0 are zero intercepts;

and β_1-β_5 and γ_1-γ_4 – coefficients, which measure the effect of corresponding

independent variable on the dependent variable, holding other factors fixed.

By including $P(Smart)_t$, $P(UnoX)_t$ and $P(HydroTexaco)_t$ into the model, we test the impact of retail spatial competition with respect to retail gasoline prices. By analyzing coefficient estimates for these variables, we can make a judgment about how much prices at local competing stations contribute to retail price changes.

We use $P(Rotterdam)_t$ in order to capture supply side fluctuations in retail prices. To account for fact that retail prices do not adjust to changes in input prices instantly, we also use lagged variables for Rotterdam Spot price by 1 and 2 weeks. Coefficient estimates of $P(Rotterdam)_t$ and its lagged values should reveal how much of retail price changes are due to Rotterdam Spot price fluctuations.

By including $P(Statoil_{recommended})_t$ and daily prices at another Statoil station - $P(Statoil_{NHH})_t$ or $P(Statoil_{Askøy})_t$, into the model, we test the impact of company's common policy regarding retail price level. Intuitively, these parameters should share a positive relationship with retail prices at Statoil stations.

In order to check for the "day-of-the-week effect", which can cause high retail price volatility, we further introduce dummy variables for the each weekday into the equations.

Due to data limitations we omit demand side determinants in the model. We should note that ignoring this factor may bias the expected causal relationship between retail gasoline prices and corresponding measures of local competition (Sen, 2003). For example, retail prices may be higher simply because of increased demand and not due to collusion between retailers.

Since we have only two areas with a small number of stations, it is meaningless to incorporate all multiple environmental factors into our regression model. Therefore, we shall also introduce rather descriptive comparison of the areas, based on parameters discussed below, and try to make logical conclusions about the influence of these parameters, based on paired t-tests for all stations and intertemporal statistical analysis of their price adjustments. From this we can also get some idea on the correlation between average retail prices and the number and nature of competitors.

4.1 Brands

Even though all stations under consideration belong to three major brands, we would distinguish automatic stations *Smart* and *UnoX* from the Major ones, since they operate under different names than their parent brands and have different marketing and pricing concepts, which help them to be perceived differently by customers. They are also sometimes referred to, by Norwegian Competition Authority, as a different niche of the market.

Majors (*Statoil* and *HydroTexaco*) would have a greater incentive to set the tacitly collusive price, so one would expect them to have a higher probability of matching the price than automatic stations. INC does not predict brand specific differences in the pricing behavior (Eckert, et al., 2005).

4.2 Contracts

Whether it is a station dealer (operator) or station supplier, who set the station's price, is dependent upon a contractual arrangement: a station can be operated under a franchising agreement or by the oil company (a supplier) directly. Although even when lessee has nominal control over price setting, a major company has some degree of control as well in form of pricing power at the wholesale level (which can especially be valuable during price wars), maximum price agreements and so on.

We do not have data about the contract type used by each of our stations, but we know that all of them are major brand stations that are predicted to have pricing power at the supplier level (Eckert, et al., 2005).

In comparison to the competitive model, tacit collusion and INC models suggest that in case when all stations belong to major brands and different brands are clustered in the same location (our case), it can create price matching inside and across local areas. For us it is difficult to check the influence of this parameter in full degree, since all stations fall in the same group.

4.3 Traffic flows

The competitive model would predict that stations that are not on big roads would charge the same price as stations on the major routes. In turn tacit collusion model predicts that collusive pricing is more important for stations located along the major roads, since their prices are easily observable and for whom undercutting would attract the largest market share from rivals (Eckert, et al., 2005). INC states that station location on major roads results in more intensive competition and, therefore, leads to higher variability and dispersion of prices.

4.4 Degree of local market concentration and competition

As we have already mentioned, according to the competitive market model, neither the number of closely situated competing outlets, nor the proportion of stations belonging to major brands among local competitors, should have any impact on price matching. Tacit collusion model states that collusive pricing is more probable in areas with fewer local competitors and in areas dominated by majors (Eckert, et al., 2005). According to the INC model, the more stations are located in the area, the less price matching signs can be observed; but with the increase of a majors' share among competing stations, probability of matching rises.

4.5 Day-of-the-week effect

Seven week day dummy variables are added to our regression in order to control for the day-of-the-week effect (D1-D7). A day-of-the-week effect should not be significant in the competitive market model. Under the tacit collusion hypothesis and INC model, different week days and especially weekends can have distinctive implication for retail prices. First, since consumers are not commuting on weekends, they can be less price aware. Second, demand could be higher on weekends (especially in residential areas), which could encourage stations either to undercut rivals to gain bigger market share, or increase the incentive to charge higher prices (Eckert, et al., 2005). Both arguments would lead to higher price dispersion in weekends in comparison to other weekdays. The weekend effect could also affect Mondays and Fridays, since these are the days when stations change to/from the weekend mode, something that can also lead to high price dispersion and volatility. Monday is also considered to be a day with high demand, which can enhance the mentioned consequences even more.

4.6 Margins

Margin estimates the distance between before-tax retail price and wholesale price. Eckert (2005) argues that the greater the distance between a tacitly collusive price and marginal cost, the greater the temptation to deviate. Since we do not have data for the wholesale prices in the Bergen area, we can't estimate the periods when margins were higher. However, considering that stations are purchasing gasoline from the same depot, under condition of bilateral agreements marginal costs should be similar for all stations. Therefore, we can estimate relative size of margins for different gas stations by comparing prices.

INC does not give clear predictions concerning this parameter, while the competitive model suggests that this factor has no effect on pricing behavior.

4.7 Past behavior

Time series variation is controlled in our analysis in several ways. We introduce two lagged variables for Rotterdam Spot price (7 days and 14 days) into our regression equation, as according to Borenstein and Shepard (1996) estimate, about two-thirds of the eventual pass-through of Rotterdam Spot prices occurs in the first two weeks following the change.

4.8 Station characteristics

As opposed to the competitive market model, which suggests that price is the only factor consumers take into consideration when purchasing gasoline, and station and product characteristics do not affect whether station exhibits price matching behavior, the tacitly collusive and INC pricing may depend on station characteristics.

Since we have only five stations, we distinguish only on one scale - type of station: full-service versus automatic. This division coincides with one we made according to the station brand; therefore it will be hard to make conclusions whether automatic stations choose a pricing model on the ground of their service level or due to the fact that they have completely different brand perception in customers' eyes based on a wide spectrum of factors.

In a tacit collusion model deviations from tacitly collusive price due to station's characteristics could lead to a breakdown of tacit collusion. Therefore, the latter should not affect the price (Eckert, et al., 2005). For INC station characteristics could affect pricing behavior, although it is hard to predict in what way since it would depend on the nature of the competition.

There is also a number of variables (such as station capacity, population income, distances between stations, etc.), effects of which are found to be significant in the literature, but which can't be incorporated in our model due to the data limitations.

5. Estimation results

5.1 Estimating linear regressions for Statoil stations

5.1.1 Statoil_{NHH}

Table 5.1 contains empirical estimates of the impact of competition, the company and input prices on **average daily retail prices** at Statoil_{NHH} station, based on Equation (1).

Explanatory variables	(1)	(2)	(3)	(4)	(5)
$P(\text{UnoX})_t$	0.3140 (0.1857)**		0.0098 (0.1951)		
$P(\text{Smart})_t$	0.7213(0.1858)***		0.5726 (0.1782)***	0.4540 (0.1248)***	0.6010 (0.1250)***
$P(\text{Statoil}_{\text{Askøy}})_t$			0.2281 (0.0959)***	0.2888 (0.1032)***	0.2015 (0.0925)***
$P(\text{Statoil}_{\text{recommended}})_t$		0.8736(0.4139)***	-0.0278 (0.2256)	0.3205 (0.3673)	0.0252 (0.1807)
$P(\text{Rotterdam})_t$		0.4185 (0.4149)	0.2620 (0.2779)		
$P(\text{Rotterdam})_{t-7}$		-1.0591 (0.4421)***		-0.6511 (0.3507)**	
$P(\text{Rotterdam})_{t-14}$		0.7482 (0.2780)***		0.5831 (0.2315)***	
Monday dummy					1.7228 (0.9174)*
Tuesday dummy					1.5560 (0.9514)*
Wednesday dummy					1.4578 (0.9502)***
Thursday dummy					1.5990 (0.9629)
Friday dummy					1.4885 (0.9438)***
Saturday dummy					1.4218 (0.9429)***
Sunday dummy					1.3942 (0.9423)***
Adjusted R^2	0.9990	0.9988	0.9991	0.9992	0.7200
constant included	no	no	no	no	yes

Table 5.1. Impact of competition, the company and input prices (Spot Rotterdam price + tax) on average daily retail prices (excluding VAT) at Statoil_{NHH} station.

Standard errors of coefficient estimates, showed in parentheses, were Newey-West corrected for seventh order autocorrelation. *** denotes significance at the 1% level ** denotes significance at the 5% level * denotes significance at the 10% level

Column 1 of the table evaluates the impact of local market competition (UnoX and Smart) on average daily retail prices at Statoil_{NHH} station in isolation from other potential factors. Similarly, column 2 examines the effects of Statoil recommended prices and Rotterdam input prices (including tax) and their one and two weeks lagged values on average daily retail prices. Column 3 combines local market competition, the company's recommended prices, prices at other gas stations, belonging to the same brand, and input prices. In column 4 we refit the model, dropping two predictors - $P(UnoX)_t$ and $P(Rotterdam)_t$. Coefficient for $P(UnoX)_t$ has the highest t-probability and statistically indistinguishable from zero. Coefficients for $P(Rotterdam)_t$ and $P(Statoil_{recommended})_t$ are both statistically insignificant and have almost perfect correlation (0.953) (Table 5.2):

	P(UnoX)	P(Smart)	$P(Statoil_{Askøy})$	$P(Statoil_{Recom.})$	P(Rotterdam)
P(UnoX)	1.0000				
P(Smart)	-0.7445	1.0000			
P(StatoilAskøy)	-0.1252	-0.1468	1.0000		
$P(Statoil_{recom.})$	-0.1066	-0.0980	-0.2088	1.0000	
P(Rotterdam)	-0.0002	0.0571	0.0999	**-0.9533**	1.0000

Table 5.2. Matrix of Pearson product-moment correlations between predictors for equation (1), column 3 in Table 5.1.

Such high correlation indicates a possible multicollinearity problem among these variables. By estimating variance inflation factor (VIF) in STATA before and after excluding $P(Rotterdam)_t$ from the equation, it becomes evident that the existing problem of multicollinearity can be avoided by dropping this predictor. In this case the largest VIF drops from 10.15 down to acceptable level of 6.68 (we consider tolerance criterion to be 10).

Finally, the day-of-the-week effect is accounted for in column 5 by including seven dummy variables for each week day.

Column 1 demonstrates that average retail daily prices at competing gas stations Smart and UnoX are significantly and positively associated with average retail daily prices at $Statoil_{NHH}$. Specifically, a 1 NOK increase in each of the retail prices is significantly associated with 1.0353 NOK increase in daily retail prices at Statoil gas station. Further, the adjusted R^2 implies that prices at Smart and UnoX explain 99.90% of total variation in $Statoil_{NHH}$ prices. However, high R-values are typical for the equations without a constant (adjusted R^2 value for the same regression with a constant reached only 0.6364). Norusis (2003) also stresses that in general high R-values are typical for the time-series data and especially in periods of instability.

The empirical results contained in column 2 suggest that Statoil recommended price and Rotterdam input prices explain somewhat smaller amount of the total variation in average daily $Statoil_{NHH}$ prices. The coefficient estimates of Statoil recommended prices as well as current and 2 weeks lagged input prices have the expected positive signs. However, the coefficient estimate of current Rotterdam input prices is statistically insignificant, which can be explained by lags in the response of retail prices to Rotterdam Spot price and presumably by discussed above high correlation between two used predictors - current Rotterdam input prices and Statoil recommended prices. The coefficient estimate of 1 week lagged input prices possesses a statistically significant but counter-intuitive negative sign. This could be the result of several factors. First, some authors (Sen, 2003) explain it by shifts in demand in response to changing retail prices. We think that 1 week is too short time period for such long term trends. Another possible explanation comes from Borenstein and Shepard (1996) estimate, which shows that about two-thirds of the eventual pass-through of Rotterdam Spot prices occurs in the first two weeks following the change. Therefore, next week marginal costs (wholesale prices) can be influenced by the Spot price from the last week. According to Borenstein and Shepard (1996), unexpected negative relationship between 1 week lagged input prices and today's retail prices can be explained by the presence of collusion mechanism - the station shows an intention to enter tacit cooperation over prices by maintaining or even increasing the price when expected next week costs are lower (as tomorrow's punishment will exceed today's gain of defecting) and defects by lowering the price when future costs are higher (as in this case the current gain from defecting is greater than the anticipated future loss from the punishment triggered by the defection). They also mention that there is a reason to believe that non-collusive margins would also respond to expected future costs changes, but change in costs would change collusive margins more than non-collusive ones due to the prediction that margin will respond negatively. In our case the coefficient for 1 week lagged input price has the largest value in column 2 and is significant at the 1% level.

Although in our opinion, the most probable explanation to the described situation could be the presence of the day-of-the-week effect, which will be more thoroughly discussed in next subchapter under analysis of daily retail price adjustments during a week.

Column 3 combines local market competition factors, company's factors – daily retail prices at another Statoil station on Askøy and current input prices. Not surprisingly, the precision and magnitude of coefficient estimates of most of these variables are reduced. At the same time the explanatory power of the regression grows. This suggests that coefficient estimates from studies, which do not control the effects of local market competition and input prices as well as the company's influence may be biased because of omitted variables. The most abrupt change occurs with the coefficient estimates of $P(Statoil_{recommended})_t$, which decreases by about 103% (from 0.8736 to -0.0278) and becomes insignificant, and $P(UnoX)_t$, which decreases by around 97% and also becomes insignificant at the 10% level.

The estimation power of the regression in column 4 grows after we have dropped $P(UnoX)_t$ (due to its highest t-probability) and $P(Rotterdam)_t$ (due to its almost perfect correlation with $P(Statoil_{recommended})_t$ and low t-statistics), and included two lagged variables for $P(Rotterdam)_t$, magnitude and precision of which were significant in previous equations. Out of all variables in column 4, only $P(Statoil_{recommended})_t$ remains insignificant. This means that daily retail prices at competing gas stations (Smart), daily retail prices at gas stations belonging to the same chain ($P(Statoil_{Askøy})_t$) and one and two weeks lagged input prices are statistically significant determinants of trends in average retail prices at $Statoil_{NHH}$. All these variables are consistently significant and all of them except 1 week lagged input price, possess theoretically plausible coefficient signs. Coefficient estimates indicate that at $Statoil_{NHH}$ an increase in retail price at competing gas station Smart by 1 NOK/l is significantly associated with 0.45 NOK/l increase in daily average retail prices, and increase in retail price at another Statoil gas station by 1 NOK/l is significantly associated with 0.29 NOK/l increase in daily average retail prices. Coefficient estimates of 2 weeks lagged input Rotterdam prices suggest that within 2 weeks only about half of 1 NOK/l increase in input prices is passed onto daily average retail prices at $Statoil_{NHH}$.

Finally, column 5 accounts for day of the week effect. Average daily retail prices at $Statoil_{NHH}$ after controlling for the prices at neighboring gas station Smart, another Statoil gas station on Askøy and Statoil recommended price, are significantly higher on Mondays and lower (descending down to Sunday) during all other days of the week except Thursdays, coefficient for which is insignificant. Test if day-of-the-week, taken as a whole, significantly contributes toward the explanatory power of the regression, shows that even at 1% level we can reject the hypothesis that, taken together, day-of-the-week has no effect on the gasoline price at $Statoil_{NHH}$ gas station (F-statistics for the test is 5.95).

Estimating regressions for two Statoil_{NHH}'s different data sets – one with only morning and another with only evening retail prices, reveals some interesting results (Table 5.3 and 5.4).

Explanatory variables	(1)	(2)	(3)	(4)	(5)
$P(UnoX)_t$	0.4636 (0.1420)***		0.2830 (0.1409)**	0.1949 (0.1384)	0.2598 (0.0648)**
$P(Smart)_t$	0.5743 (0.1389)***		0.2997 (0.1732)**	0.2857 (0.1886)**	0.3582 (0.1257)***
$P(\text{Statoil}_{Askøy})_t$			0.2686 (0.0955)***	0.2915 (0.1077)***	0.2635 (0.0971)***
$P(\text{Statoil}_{recommended})_t$		0.7537 (0.3855)**	-0.1796 (0.2654)	0.2209 (0.3448)	-0.1093 (0.1594)
$P(Rotterdam)_t$		0.4915 (0.3789)	0.3957 (0.3130)		
$P(Rotterdam)_{t-7}$		-0.9453 (0.4297)***		-0.5097 (0.3683)	
$P(Rotterdam)_{t-14}$		0.7006 (0.2747)***		0.5284 (0.2747)**	
Monday dummy					2.2000 (0.8616)**
Tuesday dummy					1.9959 (0.8648)**
Wednesday dummy					1.9509 (0.8730)*
Thursday dummy					2.1028 (0.8852)**
Friday dummy					2.0245 (0.8647)**
Saturday dummy					1.8888 (0.8588)*
Sunday dummy					1.8892 (0.8569)*
Adjusted R^2	0.9988	0.9988	0.9990	0.9991	0.9992
constant included	no	no	no	no	no

Table 5.3. Impact of competition, the company and input prices (Spot Rotterdam price + tax) on daily **morning** retail prices (excluding VAT) at Statoil_{NHH} station.

Standard errors of coefficient estimates, showed in parentheses, were Newey-West corrected for seventh order autocorrelation. *** denotes significance at the 1% level ** denotes significance at the 5% level * denotes significance at the 10% level

Analysis reveals that Statoil_{NHH}'s morning prices show more correlation with morning prices of UnoX and prices of $\text{Statoil}_{Askøy}$, and less correlation with morning Smart prices than we can see for the evening prices. The precision and magnitude of coefficient estimates of P(UnoX) and $P(\text{Statoil}_{Askøy})$ grow essentially for all regression runs for the morning dataset, and due to this fact the magnitude of coefficient estimates of P(Smart) decreases. Since data for $\text{Statoil}_{Askøy}$ was collected once a day and mostly in the mornings, it is consistent that there is more correlation between daily retail prices at $\text{Statoil}_{Askøy}$ and Statoil_{NHH}'s morning retail prices than between prices at $\text{Statoil}_{Askøy}$ and Statoil_{NHH}'s evening prices.

Explanatory variables	(1)	(2)	(3)	(4)	(5)
$P(UnoX)_t$	0.3465 (0.1542)***		0.2157 (0.1555)*	0.1334 (0.1727)	0.2547 (0.0909)**
$P(Smart)_t$	0.6887 (0.1511)***		0.5469 (0.1734)***	0.4788 (0.1838)***	0.5198 (0.1212)***
$P(Statoil_{Askøy})_t$			0.0978 (0.0991)	0.1882 (0.0926)**	0.0912 (0.0839)
$P(Statoil_{recommended})_t$		0.9640 (0.4476)***	0.0333 (0.1885)	0.3619 (0.3712)	-0.0061 (0.2056)
$P(Rotterdam)_t$		0.3953 (0.4558)	0.1436 (0.2112)		
$P(Rotterdam)_{t-7}$		-1.1559 (0.4609)***		-0.6360 (0.4107)**	
$P(Rotterdam)_{t-14}$		0.7619 (0.2868)***		0.4610 (0.2454)**	
Monday dummy					1.5920 (0.9853)*
Tuesday dummy					1.3522 (1.0139)***
Wednesday dummy					1.2998 (1.0090)***
Thursday dummy					1.4298 (1.0211)**
Friday dummy					1.2200 (1.0034)***
Saturday dummy					1.2133 (1.0045)***
Sunday dummy					1.2213 (1.0011)***
Adjusted R^2	0.9990	0.9987	0.9990	0.9991	0.7476
constant included	no	no	no	no	yes

Table 5.4. Impact of competition, the company and input prices (Spot Rotterdam price + tax) on daily **evening** retail prices (excluding VAT) at $Statoil_{NHH}$ station.

Standard errors of coefficient estimates, showed in parentheses, were Newey-West corrected for seventh order autocorrelation. *** denotes significance at the 1% level ** denotes significance at the 5% level * denotes significance at the 10% level

5.1.2 $\text{Statoil}_{\text{Askøy}}$

Table 5.5 contains empirical estimates of the impact of competition, the company and input prices on daily retail prices at $\text{Statoil}_{\text{Askøy}}$ station, based on Equation (2).

Explanatory variables	(1)	(2)	(3)	(4)	(5)
$P(\text{HydroTexaco})_t$	0.6960 (0.1245)***		0.6775 (0.0970)***	0.6104 (0.1207)***	0.5815 (0.1104)***
$P(\text{Statoil}_{\text{NHHaverage}})_t$	0.3148 (0.1241)***		0.2728 (0.1475)***	0.3415 (0.2015)***	0.2402 (0.1481)***
$P(\text{Statoil}_{\text{recommended}})_t$		1.4149 (0.6695)***	0.5915 (0.2850)**	0.2696 (0.3003)	0.3061 (0.1250)*
$P(\text{Rotterdam})_t$		-0.0655 (0.6360)	-0.6167 (0.3177)**		
$P(\text{Rotterdam})_{t-7}$		-0.6240 (0.4631)*		0.0340 (0.3856)	
$P(\text{Rotterdam})_{t-14}$		0.1681 (0.3792)		-0.2836 (0.2388)	
Monday dummy					-1.0972 (0.8791)
Tuesday dummy					-0.8946 (0.8596)**
Wednesday dummy					-1.1176 (0.9037)
Thursday dummy					-1.0518 (0.9054)
Friday dummy					-1.0549 (0.8633)
Saturday dummy					-1.0964 (0.8604)
Sunday dummy					-1.0912 (0.8606)
Adjusted R^2	0.9992	0.9983	0.9992	0.9992	0.7583
constant included	no	no	no	no	yes

Table 5.5. Impact of competition, the company and input prices (Spot Rotterdam price + tax) on daily retail prices (excluding VAT) at $\text{Statoil}_{\text{Askøy}}$ station.

Standard errors of coefficient estimates, showed in parentheses, were Newey-West corrected for seventh order autocorrelation. *** denotes significance at the 1% level ** denotes significance at the 5% level * denotes significance at the 10% level

Column 1 of the table evaluates the impact of local market competition (HydroTexaco) and the company - prices at another gas station, belonging to the same brand ($\text{Statoil}_{\text{NHH}}$), on average daily retail prices at $\text{Statoil}_{\text{NHH}}$ station in isolation from other potential factors. The high adjusted R^2 value suggests that these two predictors are significant determinants of daily retail prices at $\text{Statoil}_{\text{Askøy}}$ station. Both coefficient estimates have the expected positive sign and are statistically significant at the 1% level. Coefficient estimate for P(HydroTexaco) (0.696), describing the effect of local market competition, is almost twice as high as coefficient estimate for $\text{Statoil}_{\text{NHH}}$ (0.3148).

Column 2 examines the effects of Statoil recommended prices and Rotterdam input prices (including tax) and their one and two weeks lagged values on average daily retail prices at $\text{Statoil}_{\text{Askøy}}$ station. The empirical results (adjusted R^2 value) suggest that these factors explain much smaller amount of the total variation in daily retail prices than factors in previous column. Adjusted R^2 value in column 2 for $\text{Statoil}_{\text{Askøy}}$ (0.9983) is also much lower than that for corresponding equation for $\text{Statoil}_{\text{NHH}}$ station (0.9988). Moreover, the magnitude and significance of the coefficients differ. The coefficient estimate of Statoil recommended prices is positive and high (1.4149), while the coefficient estimates of current and 1 week lagged input prices have negative signs (from which only the coefficient for 1 week lagged input prices is significant at the 10% level), and the coefficient estimate of 2 weeks lagged input prices is positive but statistically insignificant. When analyzing the influence of Rotterdam input prices on retail prices at $\text{Statoil}_{\text{NHH}}$, we have already discussed possible causes for such situation, which are also valid for this case.

Column 3 combines local market competition factors (P(HydroTexaco), company's factors – daily retail prices at another Statoil station at NHH as well as Statoil recommended prices, and current input prices. The precision and magnitude of coefficient estimates of the first two predictors as well as the explanatory power of the regression stay almost at the same level as in the column 1. This is surprising considering that we included two more factors into the model, coefficients for which, in addition, are shown to be comparatively large and statistically significant at the 5% level. This situation can be caused by collinearity between the two last predictors, discussed earlier (table 5.6).

Therefore, in column 4 we refit the model, dropping one predictor - P(Rotterdam)_t, and also including both lagged variables for Rotterdam input price. The explanatory power of the regression stays the same, but coefficient estimates for Statoil recommended price and both lagged variables for Rotterdam input price become statistically insignificant. Moreover, coefficient for $\text{P(Statoil}_{\text{recommended}})$ reduces by about 54% (from 0.5915 to 0.2696), 1 week lag for the input price becomes positive (changes from -0.624 in column2 0.034) and 2 weeks lag for the input price becomes negative (changing from 0.1681 in column 2 to -0.2836). All said above means that daily retail prices at competing gas station HydroTexaco as well as daily retail prices at gas stations belonging to the same chain - $\text{Statoil}_{\text{NHH}}$, are statistically significant determinants of trends in average retail prices at $\text{Statoil}_{\text{NHH}}$. Both variables are consistently significant possessing theoretically plausible coefficient signs.

Coefficient estimates indicate that an increase in retail price at competing gas station HydroTexaco by 1 NOK/l is significantly associated with 0.61 NOK/l increase in daily average retail prices, and increase in retail price at another Statoil gas station ($\text{Statoil}_{\text{NHH}}$) by 1 NOK/l is significantly associated with 0.34 NOK/l increase in daily average retail prices.

	P(HydroTexaco)	P($\text{Statoil}_{\text{NHH}}$)	P($\text{Statoil}_{\text{Recom.}}$)	P(Rotterdam)
P(HydroTexaco)	1.0000			
P($\text{Statoil}_{\text{NHH}}$)	-0.2641	1.0000		
P($\text{Statoil}_{\text{recom.}}$)	-0.0716	-0.2016	1.0000	
P(Rotterdam)	-0.1213	0.0166	**-0.9512**	1.0000

Table 5.6. Matrix of Pearson product-moment correlations between predictors for equation (2), column 3 in Table 5.5.

Day of the week effect is accounted for in column 5 of the table. Average daily retail prices at $\text{Statoil}_{\text{Askøy}}$ after controlling for the prices at neighboring gas station HydroTexaco, another Statoil gas station at NHH and Statoil recommended price, are significantly higher on Tuesdays than during all other days of the week. Coefficient estimates for dummy variables for all other days are statistically insignificant. Test if day-of-the-week, taken as a whole, significantly contributes toward the explanatory power of the regression, shows that even at 10% level we can not reject the hypothesis that, taken together, day-of-the-week has no effect on the gasoline price at $\text{Statoil}_{\text{Askøy}}$ gas station (F-statistics for the test is 1.58). These results differ from ones for NHH area, where day-of-the-week effect plays significant role. In column 5, the precision and magnitude of coefficient estimates of P(HydroTexaco) and P($\text{Statoil}_{\text{NHH}}$) variables are reduced, since coefficient estimate of Statoil recommended price grows up to 0.31 and becomes significant (even though only at the 10% level).

5.2 Relative prices

Comparing summary statistics for retail prices at two considered Statoil gas stations (table 5.7) we can see that prices fluctuated basically in the same range.

Variable	N	Mean	Std. Dev.	Min	Max
NHH area					
Retail price at $\text{Statoil}_{\text{NHH}}$	245	8.091	0.423	7.352	8.792
Retail price at UnoX	247	7.795	0.431	7.192	8.448
Retail price at Smart	196	7.742	0.429	7.192	8.656
Askøy area					
Retail price at $\text{Statoil}_{\text{Askøy}}$	111	8.074	0.450	7.40	8.832
Retail price at HydroTexaco	102	7.926	0.429	7.16	8.792
Recommended Statoil retail price	124	8.412	0.224	7.984	8.776
Daily Spot Rotterdam price of gasoline	124	7.283	0.210	6.9757	7.7256

Table 5.7. Summary statistics for collected data.

According to performed paired t-test and Levene's test, there is no statistically significant difference between these two variables: we **can not** reject neither null hypothesis that means are equal when executing paired t-test, nor null hypothesis that variances are equal in Levene's test. More information can be obtained from the analysis of price adjustments, performed in next subchapter.

Results of consequent paired t-tests for each of Statoil gas stations and recommended Statoil price show that at the 1% level daily average retail prices at the gas stations are statistically different from recommended price and are smaller than the latter. The former also have higher variances than the latter, which can be explained by more frequent and large price adjustments (figure 3.3).

At the same time consequent t-tests for gas stations in both areas show that at 1% confidence level average everyday prices at Statoil gas stations are higher than at all other gas stations in same area. Comparing UnoX and Smart stations we found that average Smart prices are higher. We can summarize findings as follows (the mean for each parameter, which stands in brackets beneath the parameter, can differ from one stated in summary statistics due to restrictions of t-tests – only days, in which both variables have data, are taken into consideration):

NHH area: $\mathbf{P_t}$ **(Statoil$_{\mathbf{recommended}}$) >** $\mathbf{P_t}$ **(Statoil$_{\mathbf{NHH}}$) >** $\mathbf{P_t}$ **(Smart) >** $\mathbf{P_t}$ **(UnoX)**
(8.41) (8.09) (7.73) (7.66)

Askøy: $\mathbf{P_t}$ **(Statoil$_{\mathbf{recommended}}$) >** $\mathbf{P_t}$ **(Statoil$_{\mathbf{Askøy}}$) >** $\mathbf{P_t}$ **(HydroTexaco)**
(8.41) (8.07) (7.93)

Between areas, according to paired t-tests:

$\mathbf{P_t}$ **(HydroTexaco) >** $\mathbf{P_t}$ **(Smart) >** $\mathbf{P_t}$ **(UnoX)**.

Therefore, we can state that there is no constant difference in price levels between individual Statoil gas stations due to different local competition conditions in considered areas. We can also conclude that prices at automatic gas stations UnoX and Smart are on average lower than the prices at all full-service stations under consideration (two Statoil stations and HydroTexaco station).

By executing paired t-tests, we found one interesting detail. When comparing UnoX and Smart average prices, STATA only took days, for which data for both stations was available. Since there were a lot of missing days for Smart stations due to the fact that their display board did not function, STATA excluded data for UnoX for those days also. As a result, the mean of prices at UnoX was lower. Although, if general analysis of data separately for each station is performed ("summarize" command in STATA), we can see that the mean of UnoX price is higher. It shows us that in days when display board of Smart did not work, and customers could not make comparisons (unless they came directly to the Smart's pump) average prices at UnoX were higher than in other days. Although another possible explanation could be the level of Spot Rotterdam prices, which grew right before the period with missing data for Smart gas station.

5.3 Price adjustments

In order to add to the evidence on the behaviour of prices, we perform a third step of analysis of local price variation, where we give a detailed description of the pattern of price adjustments. Summary statistics of price adjustments is given in table 5.8.

Variable	No	mean	st.dev.	min	max	adj>0	adj<0
NHH area							
Retail price at $\text{Statoil}_{\text{NHH}}$	74	0.0141	0.4420	-0.872	1.008	27	47
Retail price at UnoX	59	0.0119	0.3843	-1.040	1.192	22	37
Retail price at Smart	31	0.0119	0.3979	-0.856	0.856	10	21
Askøy area							
Retail price at $\text{Statoil}_{\text{Askøy}}$	44	0.0411	0.5576	-0.848	0.968	22	22
Retail price at HydroTexaco	40	0.0314	0.5528	-1.064	1.064	19	21
Recom. Statoil retail price	14	0.0394	0.1036	-0.120	0.144	9	5
Daily Spot Rotterdam price	87	0.0042	0.0544	-0.127	0.124	46	41

Table 5.8. Summary statistics of price adjustments.

5.3.1 NHH area

All gasoline stations in NHH area were checked for prices twice a day. Due to the fact that data for Askøy area as well as Rotterdam Spot price of gasoline could be obtained only on a daily basis, and connected to this comparability problem, we used daily average prices for $\text{Statoil}_{\text{NHH}}$ in our previous calculations. All days when prices at $\text{Statoil}_{\text{NHH}}$ were changed in the afternoon (28 cases) are therefore different from the original dataset. Moreover, we also created missing values, when periods with missing data did not exceed 1 day, by taking an average of prices in previous and subsequent day, but they were not included in the analysis of adjustments.

There were totally 74 price adjustments in the sample period at $\text{Statoil}_{\text{NHH}}$, implying that on average price was adjusted every 1.7 day. As it can be seen from figure 5.1, the size distribution of adjustments is not symmetrical: the center of symmetry is skewed to the left (small negative adjustments are more frequent) with the peak of around -0.05; while positive adjustments do not have peaks of frequencies and more smoothly distributed along the scale. Due to these facts, the mean of positive adjustments is almost twice as high (0.458/-0.241), while the amount of them is almost twice as low. We think it might reflect discussed earlier day-of-the-week effect – large positive adjustments on Mondays and many smaller negative adjustments during the week as a result of competition influence.

Bin	*Frequency*
-1	0
-0.95	0
-0.9	0
-0.85	1
-0.8	2
-0.75	1
-0.7	0
-0.65	3
-0.6	0
-0.55	1
-0.5	0
-0.45	1
-0.4	1
-0.35	1
-0.3	0
-0.25	1
-0.2	4
-0.15	5
-0.1	3
-0.05	16
0	6
0.05	3
0.1	3
0.15	0
0.2	2
0.25	1
0.3	0
0.35	0
0.4	3
0.45	0
0.5	1
0.55	1
0.6	0
0.65	0
0.7	2
0.75	0
0.8	2
0.85	3
0.9	3
0.95	0
1	0
1.05	1
1.1	0
More	0

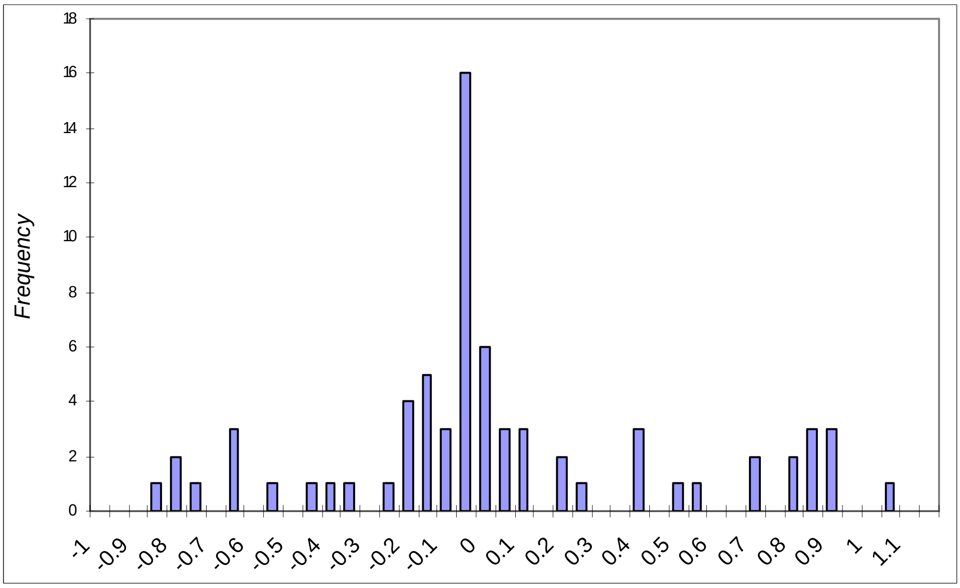

Figure 5.1. Frequency distribution of Statoil$_{NHH}$ price adjustments.

One more feature of the distribution is the minimum absolute size of adjustments, which is equal to about 0.008. In consumer price terms (including VAT) it is equal to 0.01 NOK (1 øre). It is the minimum, which can be reflected on the display boards of the stations. It can serve as a proof to our earlier guess that there are no fixed costs associated with price changes or that they are very insignificant.

At other gas stations from the same area (UnoX and Smart) the pattern of adjustments is similar (table 5.8). There are fewer price adjustments at these gas stations than at Statoil$_{NHH}$ (59 at UnoX and 31 adjustments at Smart). For Smart it can be partly explained by a huge gap in data due to technical reasons (Smart encountered some problems with their display board – our source of data). Similarly to Statoil$_{NHH}$, negative adjustments were almost twice as frequent at both stations, and the mean of positive adjustments is nearly twice as high. It is worth mentioning that negative adjustments fluctuated in nearly same range (around 1

NOK) as positive adjustments for all three stations. It could be explained by several reasons. First, time period under consideration was too short for macro events such as inflation, tax changes, etc., to influence the positive (or otherwise, negative) range in a great degree. Second, no big disturbances of oil market happened during this period. Third, indirectly it can also prove the absence of price wars between the stations, which we will discuss later.

5.3.2 Askøy area

The picture for the second area, namely Askøy, differs from the one described above. The amount of positive adjustments at both stations was similar as the amount of negative adjustments; the mean of negative adjustments (-0.416 for $\text{Statoil}_{\text{Askøy}}$ and -0.425 for HydroTexaco) was just insignificantly lower than that of positive ones (0.499 for $\text{Statoil}_{\text{Askøy}}$ and 0.536 for HydroTexaco) - prices grew a little though the time.

As it can be seen from figure 5.2, no particular pattern for the size distribution of adjustments can be seen. Although very small and very big adjustments are prevailing from both sides, there is no distinguished center of symmetry.

It is hard to compare two different areas in terms of the amount of price adjustments, since prices were collected with different frequency. We can only say that due to the fact that there were almost twice as many price adjustments, which are on average about 3 times smaller, at $\text{Statoil}_{\text{NHH}}$, the variance of their retail prices was statistically undistinguishable from variance of $\text{Statoil}_{\text{Askøy}}$'s retail prices in previously performed Levene's test.

Bin	*Frequency*
-1	0
-0.95	0
-0.9	0
-0.85	0
-0.8	4
-0.75	3
-0.7	0
-0.65	1
-0.6	0
-0.55	1
-0.5	0
-0.45	0
-0.4	0
-0.35	1
-0.3	2
-0.25	1
-0.2	1
-0.15	1
-0.1	1
-0.05	4
0	2
0.05	2
0.1	1
0.15	2
0.2	0
0.25	1
0.3	1
0.35	0
0.4	2
0.45	1
0.5	1
0.55	1
0.6	1
0.65	1
0.7	0
0.75	0
0.8	3
0.85	3
0.9	1
0.95	0
1	1
More	0

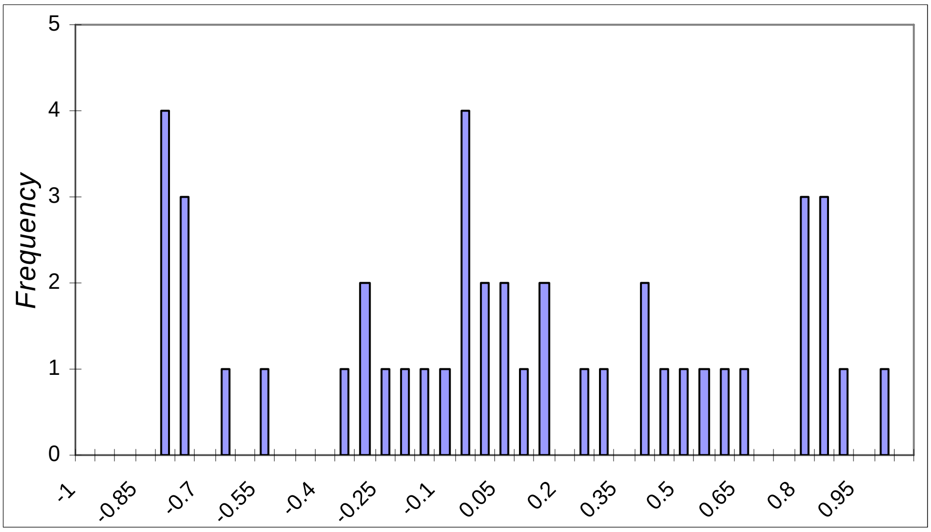

Figure 5.2. Frequency distribution of Statoil$_{Askøy}$ price adjustments.

5.4 Distribution of price adjustments in time

It is also useful to look into a distribution of adjustments in time (on different days of the week and monthly changes):

Statoil NHH

	obs	mean	st.dev.	min	max	obs>0	obs<0
Mon	17	0.403	0.346	-0.16	0.872	**16**	1
Tue	15	-0.194	0.394	-0.736	0.864	1	**14**
Wed	11	-0.302	0.323	-0.872	0.04	2	**9**
Thu	12	0.248	0.531	-0.8	1.008	7	5
Fri	16	-0.207	0.265	-0.824	0.184	1	**15**
Sat	3	-0.053	0.028	-0.08	-0.024	0	3
Sun	0					0	0

UnoX

	obs	mean	st.dev.	min	max	obs>0	obs<0
Mon	14	0.02	0.434	-0.856	0.856	6	8
Tue	11	0.075	0.385	-0.8	0.728	6	5
Wed	4	-0.16	0.154	-0.344	0.032	1	3
Thu	10	-0.047	0.534	-1.04	0.8	3	7
Fri	13	0.009	0.495	-0.96	1.192	4	**9**
Sat	5	-0.012	0.063	-0.056	0.08	2	3
Sun	**2**	-0.084	0.006	-0.088	-0.08	0	2

Smart

	obs	mean	st.dev.	min	max	obs>0	obs<0
Mon	5	0.211	0.392	-0.264	0.768	3	2
Tue	6	0.197	0.478	-0.32	0.856	3	3
Wed	6	-0.369	0.3	-0.856	-0.12	0	**6**
Thu	4	0.304	0.486	-0.344	0.832	3	1
Fri	7	-0.062	0.117	-0.24	0.152	1	**6**
Sat	1	-0.24		-0.24	-0.24	0	1
Sun	**2**	-0.096	0.091	-0.16	-0.032	0	2

Statoil Ask

	obs	mean	st.dev.	min	max	obs>0	obs<0
Mon	3	0.555	0.263	0.368	0.856	3	0
Tue	12	0.515	0.35	-0.144	0.968	**11**	1
Wed	12	-0.439	0.343	-0.848	-0.024	0	**12**
Thu	4	0.196	0.202	0.024	0.488	4	0
Fri	9	0.03	0.591	-0.76	0.848	4	5
Sat	4	-0.454	0.337	-0.848	-0.088	0	4
Sun	0					0	0

HydroTex

	obs	mean	st.dev.	min	max	obs>0	obs<0
Mon	2	0.252	0.017	0.24	0.264	2	0
Tue	11	0.516	0.385	-0.2	1.064	**9**	2
Wed	8	-0.223	0.499	-0.744	0.744	2	**6**
Thu	7	-0.187	0.561	-0.824	0.504	3	4
Fri	10	-0.011	0.421	-0.504	0.744	3	**7**
Sat	2	-0.856	0.294	-1.064	-0.648	0	2
Sun	0					0	0

Table 5.9. Distribution of adjustments in different days of the week.

5.4.1 NHH area

As it can be seen from the table 5.9, a striking feature of distribution for $Statoil_{NHH}$ in comparison to other stations in the same area, is clear tendency of price increase on Mondays (16 increases in total 18 weeks in the period) and price decreases on Tuesdays, Wednesdays and Fridays (14, 9 and 15 respectively). Similar patterns could be inferred from the day-of-the-week effect analysis, performed earlier.

For UnoX and Smart no such clear tendencies can be seen. Only on Wednesdays and Fridays the amount of negative adjustments are clearly prevailing at Smart and in a smaller degree at UnoX. The striking feature for both automatic gas stations (Smart and UnoX) as well as for all full-service stations, is few (or none) price changes on Saturdays and Sundays. The simplest explanation can be that financial markets and the Rotterdam spot market are closed during weekend and thus no new information arrives on these days (Asplund et al., 2000).

In NHH area lower prices on weekends can also be explained by different demand characteristics in comparison to Askøy area. Since the amount of adjustments on Saturdays and Sundays at all stations in the NHH area is very low or equals to zero, we can assume that the stations compete for low weekend prices (or presumably enter tacit collusion) on Fridays, which can be reflected in such a large number of one-way adjustments.

Logically on Mondays firms can try to restore prices for the coming working week, which obviously has different demand characteristics. As it can be seen from the table, in NHH area only $Statoil_{NHH}$ has clear pattern of making positive and large price adjustments on Mondays. On Tuesdays, Wednesdays and Fridays, on the contrary, the station made mainly negative adjustments.

It can serve as a sign that Statoil leads price restorations in the area. According to M. Slade (1986), major players in the area often lead the price restorations, and these restorations are only sometimes successful, since others do not follow every time. In order to verify this statistically, we ran three regression equations for each station in the area using just seven dummy variables for each of different days of the week as predictors of price adjustments:

$$\Delta P(Statoil_{NHH})_t = \sum_{i=1}^{7} \beta_i * D_i$$

Results show that coefficient estimate for Monday dummy is higher for $Statoil_{NHH}$ (0.36) than for other two stations (0.09 for Smart and 0.001 for UnoX), which means that $Statoil_{NHH}$ increased prices mostly on Mondays and other stations did not always follow the increases and/or increases were not that large. The fact that other stations did not always follow or did not follow in the same degree, could be partly a reason of such profound weekly pattern for Statoil price adjustments, since the station needed to compete the price down during next days. Thursday was another day with positive adjustments prevailing over negative ones. Possible explanation could be that Statoil tried to signal price increase, hoping that other station will follow it just one day before the final reduction on Friday.

5.4.2 Askøy area

If we turn our attention to Askøy, it is evident that Statoil has pronounced pattern of price adjustments through the week in this area also, but rather different from the one in NHH area. Majority of price increases and decreases happens on Tuesdays and Wednesdays respectively. This pattern corresponds more to the behavior of HydroTexaco station situated in the same area, but the latter shows less clear cut character. There is also no such low price arrangement in weekends at Askøy as in NHH area. Such differences can be attributed to area characteristics, such as demographic and environmental variables, which according to Ingene and Brown (1987), influence the retail patterns in a great degree.

In order to test if Statoil leads the price restorations in this area as well, we ran two similar regression equations for each station in the area using again seven dummy variables for each of different days of the week as predictors:

$$\Delta P(Statoil_{Askøy})_t = \sum_{i=1}^{7} \beta_i * D_i$$

Results showed that coefficient estimates for Tuesday dummy (since Tuesday seems to be the day of main price increases on Askøy according to the results from the regression equation run reported in table 5.5 and from weekly adjustments distribution) were almost the same (around 0.38) for both stations. Therefore, we can't say that Statoil displays signs of price restoration behavior in Askøy area.

Statoil NHH

	obs	mean	st.dev.	min	max	obs>0	obs<0
Jan	5	0.136	0.478	-0.472	0.752	2	3
Feb	17	0.000	0.666	-0.824	0.872	7	10
Mar	19	0.008	0.460	-0.872	0.872	5	14
Apr	16	0.016	0.354	-0.424	1.008	6	10
May	17	-0.003	0.171	-0.272	0.352	7	10

UnoX

	obs	mean	st.dev.	min	max	obs>0	obs<0
Jan	2	0.020	0.107	-0.056	0.096	1	1
Feb	11	0.054	0.467	-0.856	0.856	5	6
Mar	16	0.014	0.376	-0.800	0.800	5	11
Apr	17	-0.038	0.375	-0.960	0.744	6	11
May	13	-0.028	0.488	-1.040	1.192	5	8

Smart

	obs	mean	st.dev.	min	max	obs>0	obs<0
Jan	0					0	0
Feb	4	-0.042	0.701	-0.856	0.856	1	3
Mar	13	0.078	0.431	-0.624	0.832	4	9
Apr	10	-0.056	0.282	-0.344	0.392	3	7
May	4	0.022	0.269	-0.240	0.336	2	2

Statoil Ask

	obs	mean	st.dev.	min	max	obs>0	obs<0
Jan	4	-0.002	0.609	-0.680	0.536	2	2
Feb	14	0.029	0.726	-0.848	0.848	6	8
Mar	11	0.058	0.585	-0.848	0.968	6	5
Apr	14	0.013	0.358	-0.760	0.760	7	7
May	1	0.584	.	0.584	0.584	1	0

HydroTex

	obs	mean	st.dev.	min	max	obs>0	obs<0
Jan	2	0.076	0.832	-0.512	0.664	1	1
Feb	13	0.018	0.771	-1.064	1.064	6	7
Mar	13	0.051	0.420	-0.504	0.744	6	7
Apr	12	0.017	0.422	-0.800	0.696	6	6
May	0					0	0

Rotterdam+Tax

	obs	mean	st.dev.	min	max	obs>0	obs<0
Jan	6	0.01	0.04	-0.025	0.085	3	3
Feb	20	-0.002	0.056	-0.083	0.124	10	10
Mar	23	0.016	0.048	-0.069	0.119	14	9
Apr	19	0.014	0.062	-0.127	0.116	11	8
May	19	-0.015	0.055	-0.102	0.072	8	11

Table 5.10. Monthly distribution of adjustments.

Analysis of a pattern of price adjustments in time on a monthly basis (table 5.10) does not show any clear trends. Though we should take into consideration that data was not continuous in several cases (some periods are missing for Smart (part of April), for Askøy area (part of May and the first two-thirds of January for all). It explains low quantity of adjustments for both $\text{Statoil}_{\text{Askøy}}$ and HydroTexaco stations in May. Another reason for small number of adjustments on Askøy in May can be a fact that Hydro Texaco closed for repairs in the second half of the month. Therefore, $\text{Statoil}_{\text{Askøy}}$ lost its only competitor and could maintain high prices without changing them at all. Prices were kept on the level, which exceeded even Statoil recommended price.

Another conclusion we can make from looking at the monthly data is that there were no severe price wars during the sampling period. Price adjustments were more or less evenly distributed in time given the restrictions, though in NHH area negative adjustments were more frequent in March for all stations. It can be partly explained by larger amount of adjustments for Rotterdam Spot price compared to other months, although the latter were mainly positive.

6. Discussion

Five months of daily input and output prices for three major gasoline retail chains provide an opportunity to confront price-setting theories with data. The three main theories for how prices are set are tacit collusion model (the one we base our hypothesis on), imperfectly competitive non-collusive pricing model and competitive market model. Below we summarize the contribution of these theories to our understanding of the results obtained from the econometric analysis, which describes observed pricing pattern. If the tacit collusion model can be rejected, we can then determine whether the pricing pattern is more consistent with the type of pattern that could result from two alternative types of pricing behaviour.

The main predictions of the tacit collusion model examined in this paper are that firms operating in tight oligopoly setting engage in price matching behaviour, and that retail gasoline prices in this case are above competitive level. The probability that a gas station engages in collusive pricing is affected by spatial differentiation, measures of local competition and the characteristics of the retailer. The way the firm's retail prices respond to changes in input prices can also be used to substantiate the model.

Our statistical analysis is based on a comparison of two relatively isolated geographical areas of Bergen. Previous empirical research (Pinkse et al., 2002) demonstrates that gasoline price competition is highly localized, and only measure of being nearest neighbors is a strong determinant of the strength of interterminal rivalry. Therefore, a decision to set a tacitly collusive price should be taken independently in every considered area.

Our results show that the local variation for one retail chain across the areas (Statoil) refers to constant differences in the pattern of retail price adjustments and not to differences in prices levels. Paired t-tests showed that prices at two Statoil gas stations located in different areas are on average similar and higher than at all other gas stations belonging to different retail chains, but at the same time lower than the Statoil recommended price. Analysis of price adjustments exhibited different price setting patterns during the week in the areas; while regression equations run separately for both Statoil stations showed that retail prices at Statoil gas stations respond differently to changes in costs (Rotterdam input price) and Statoil recommended price.

Such different dynamic patterns can theoretically be produced by tacit collusion if we assume that stations are able to make sophisticated calculations to achieve the highest sustainable collusive price. On the other hand, both considered areas have very different characteristics, which most likely should result in different collusive prices. Moreover, in our theoretical part we allowed for constant differences between collusive prices for stations located in the same area.

Majors (Statoil and HydroTexaco) on Askøy would have greater incentive to set tacitly collusive price than automatic stations UnoX and Smart, who can be more interested in undercutting. At the same time $\text{Statoil}_{\text{NHH}}$ faces fiercer competition since the amount of competitors is twice as high; therefore the collusion is again less likely in the NHH area. On the other hand, collusive pricing is more important for stations located along the major roads as in the NHH area, since their prices are easily observable.

The results of the regression analysis in fact demonstrate that the three major factors, taken into consideration in the regression equations – competition (area specific factor), costs (common factor) and the company (common factor), explain retail price variation in the considered areas in different ways. We find that lagged input prices in a greater degree, and retail prices at the local competing gas stations UnoX and Smart in smaller degree, are significantly associated with trends in retail prices at $\text{Statoil}_{\text{NHH}}$; whereas retail prices at the competing HydroTexaco station in greater degree, and retail prices at another Statoil station, located in different area ($\text{Statoil}_{\text{NHH}}$), in smaller degree, are more important determinants of retail prices at $\text{Statoil}_{\text{Askøy}}$. Therefore, competition is an important parameter for pricing at both stations in the sense that stations of the same area match their price adjustments, although for the Askøy area this parameter is more significant. These results are consistent with most predictions of tacit collusion model described above. They are consistent with predictions of imperfect competition model (INC) as well (more competitors – less matching), but inconsistent with the competitive model.

If we look at the location for the stations, which according to INC should lead to more intensive competition along major roads and therefore higher variability and dispersion of retail prices, then results for the analysis of price adjustments can serve as a support to this model.

However, results show that high price volatility at $\text{Statoil}_{\text{NHH}}$ can be attributed mainly to two factors.

First, the day-of-the-week effect is statistically significant in this area. Retail prices are generally lower in weekends and higher on Mondays, reflecting changing demand conditions during a week. These results are also consistent with both tacit collusion and INC, and inconsistent with the competitive model. Another factor, which could add to significance of the day-of-the-week effect, is price restoration efforts. Additional regression equations show that $\text{Statoil}_{\text{NHH}}$ acted like a price leader, performing price restoration efforts on Mondays by making large positive adjustments. This behavior is partly consistent with tacit collusion model, since according to our findings, other firms did not always follow the suit. In Askøy area no station acted like a price leader.

Second, highly volatile lagged input prices are significantly associated with trends in retail prices at $\text{Statoil}_{\text{NHH}}$, but are not significant determinants of prices at $\text{Statoil}_{\text{Askøy}}$. Borenstein and Shepard (1996) describe the observed pattern of response to input prices by $\text{Statoil}_{\text{NHH}}$ as a sign of collusive behaviour. Although they state that other models (such as the inventory model or the consumer loyalty model) also can be possible explanations for this effect.

A fluctuation in input prices is not a significant determinant of retail prices at $\text{Statoil}_{\text{Askøy}}$. According to the tacit collusion model, this can be a sign of price rigidity, where the station is reluctant to change the prices as a response to cost changes, fearing to send the wrong message to competitors.

We should also note that we did not find any significant correlation between retail prices at any of the Statoil stations and prices recommended by the supplier. Although according to tacit collusion model, recommended price can be used as a tool to facilitate coordination on a collusive price. In most periods retail prices were significantly lower than recommended price, with the exception of one period in Askøy, when HydroTexaco closed for repairs and the Statoil station became a monopolist. In this period the monopoly price was higher than the recommended price.

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We can conclude that in a short run stations of the same company located in different areas choose their pricing strategies based on the local competition conditions. For example, we found signs of price restoration efforts in the NHH area and price rigidity on Askøy. Nevertheless, strong influence of the supplier (which is manifested in significant coefficient estimates of retail prices at Statoil gas station located in another area) leads to a situation where the competition climate in the areas is usually reflected not in different price level for gas stations of the same brand (price discrimination), but rather in different dynamics of price adjustments. The pattern of price adjustments reflects a particular strategical price-setting behaviour chosen by the station as a result of conjectures about rival prices. However, data limitations (for example, lack of demand data or spatial assessment of the stations) make these conclusions more conjectural than affirmatory.

Some findings are consistent with predictions from both the non-collusive imperfect competition model and the tacit collusion model. These include the effects of matching of price adjustments in the areas and day-of-the-week. Most of the results are inconsistent with the competitive model – prices vary inside and across geographical space, and the proximity to and the concentration of competitors influence the price adjustment pattern.

However, some findings, such as gas stations response to costs, are consistent only with predictions of the tacit collusion model. Therefore, based on the evidence on retail price variation in the two Bergen areas, **we are not able to reject the hypothesis** that Norwegian retail gasoline chains enter into tacit collusive agreements in favour of either the imperfect competition model or the competitive model.

7. Conclusion

It is a raising concern in many countries that limited competition between firms leads to higher retail gasoline prices, and yet little has so far been written on the effect of competition on the retail gasoline prices in Norway. This study contains empirical estimates of the impact of local market competition, input prices and common strategies of Norwegian oil companies on trends in daily retail gasoline prices. We found that the way prices respond to mentioned factors conforms more to the tacit collusion model than to the more widely used competition model. This result is not very surprising because the structure of the Norwegian retail gasoline industry is a tight oligopoly setting, which is the main prerequisite for the formal models of collusion. The results show that evidence supporting tacitly collusive pricing is reflected in the dynamic pattern observed in retail pricing by the firms, rather than in the situation where prices are close to or equal to a monopoly level or to prices of other firms.

The results of this paper should be of interest to Norwegian policymakers. They suggest that when taking decisions and initiating projects under wrong assumptions about competition climate in the region, authorities should expect that these decisions can have limited or reverse impact on local retail or wholesale competition and lead to undesired price movements. On the other hand, authorities initiatives aimed at enhancing retail and wholesale competition could have some positive effects on retail prices.

The main limitation of this study has been the failure to incorporate the influence of a local demand parameter into the model. We also think that a more rich data set, covering bigger amounts of gas stations and geographical areas, would have contributed to more precision in our conclusions. Therefore, we would recommend further extended research in this area. The results have, however, provided certain indication of the way competition climate in the country influences daily retail gasoline prices.

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