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Vertical control and price cycles in gasoline retailing

by

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Abstract

We examine Norwegian gasoline pump prices using daily station-specific observations from 2003 to 2006. The big four gasoline companies use an industry-wide adopted vertical restraint (labeled price support) to move price control from the hands of independent retailers into the hands of the headquarters of the big four companies. Retail gasoline prices follow a fixed weekly pattern, where retail outlets all over Norway simultaneously (without knowing their rivals' prices) increase their prices to the same level every Monday around noon. The price level on Mondays corresponds to the recommended prices published by the gasoline companies' headquarters.

[Ψ] Irina Karamushko, Asgeir Thue, Irene Kvernenes, Åse Tiller Vangsnes and Elisabeth Flasnes partly undertook the data collection as part of their master theses, and we are grateful for their assistance. We are also grateful for access to the DinSide data collection. The authors also gratefully acknowledge the helpful comments and suggestions of Kjetil Andersson, Stephen Davies, Gorm Grønnevet, Joseph E. Harrington, Erling Hjelmeng, Hans Jarle Kind, Lars Sørgard, Otto Toivanen and seminar participants at the Directorate-General for Competition Chief Economists 2008, the Centre for Competition Policy at the University of East Anglia 2007, The NIE, Summer Conference, Loughborough 2008. The CRESSE conference Athens 2008, EARIE 2008, Toulouse, Universidad Carlos III de Madrid, 2008, Copenhagen Business School 2008, Kiel University 2009, the Norwegian School of Management 2007 and the Norwegian School of Economics and Business Administration 2008. The title of an early version of the present paper was "Gasoline prices jump on Mondays: An outcome of aggressive competition?".

1. Introduction

All over Norway we observe gasoline price cycles that last exactly one week. Every Monday around noon, almost all retail outlets throughout Norway increase their retail prices to the same level. For the majority of retail outlets prices then gradually decline over the week, and are at their lowest level during the weekend and Monday morning.

We show how the big four gasoline companies use a vertical restraint (labeled price support) to move price control from the hands of independent retailers into the hands of the headquarters of the big four companies. The way the price support system is used to ensure intrabrand synchronization of pump prices when the price cycles are restarted, resembles findings from Australia (Wang, 2009). We show that since 2004 the headquarters have managed to establish an industry-wide pattern where all retail outlets raise their pump prices according to the recommended prices set by the headquarters around noon every Monday. The price support system is thus a device that ensures intrabrand price coordination on Mondays. In contrast to the findings from Australia, we find that the headquarters simultaneously (without knowing rivals' pump prices) increase their prices on Mondays. In the rest of the week, gasoline pump prices are set sequentially, and we show that the degree of vertical price control imposed by the headquarters towards the retail outlets varies from a pure Resale Price Maintenance (RPM) to a price floor.

Price cycles, where sharp price increases are followed by a gradual reduction of retail prices, are found in markets in the United States (Castanias and Johnson, 1993, Doyle *et.al.* 2010, Lewis, 2011), Canada (Atkinson, 2009, Eckert, 2002, 2003, Eckert and West, 2004, and Noel, 2007a, 2007b) and Australia (ACCC, 2007 and Wang, 2008, 2009), among others. In contrast to our findings, the price cycles observed in other

markets are typically longer than a week, and do not have a fixed duration like the Norwegian price cycles. Weekly price cycles have recently been observed in Australia, where Thursday is the high-price day (ACCC, 2007). As mentioned above a price support system is also present in Australia, but to our knowledge, we do not observe an industry-wide jump in prices to the same level as described in the present paper.

The majority of these studies find empirical support for the notion that these price cycles are the outcome of competition à la Maskin and Tirole's (1988) Edgeworth cycle theory.[1] In Maskin and Tirole (1988) firms successively undercut each other in a price war phase, until further undercutting becomes too costly. We then have a war of attrition phase until one firm takes the burden and raises its prices. Other firms will then immediately follow suit and increase their prices, but not to the same level as the firm that initiated the price increase. The next cycle will then begin.[2] A critical assumption is that firms set prices sequentially in both the increasing phase and the decreasing phase.

When firms are in the war of attrition phase, Maskin and Tirole assume that firms play a mixed strategy game in order to decide whether they should be the first to increase the price or not. As emphasized by Wang (2009), firms have incentives to end the war of attrition game as soon as possible, and a firm may take the role as the price leader (see also Lewis, 2011). A main contribution of the present paper is to show how the headquarters of gasoline companies in Norway have managed to

[1] Labeled Edgeworth cycles owing to Edgeworth (1925).

[2] Eckert (2003) and Noel (2007b, 2008) show that Edgeworth cycles in equilibrium are not restricted to a symmetric duopoly with homogenous goods, as assumed by Maskin and Tirole (1988). These extensions (which e.g. allow for size asymmetries) still predict that firms move sequentially.

establish an arrangement whereby they simultaneously decide to increase pump prices to a given level (the recommended price).

The empirical studies closest in spirit to the current paper are Eckert and West (2004) and Noel (2007a), both of which use daily retail prices from the Canadian market. The main distinction between our observations and those of Eckert and West (2004) and Noel (2007a) relates to the process bywhich prices increase sharply.

Wang (2008) shows how phone activity by the market leader resets Edgeworth cycles in the Australian retail gasoline cartel. More recently, Clark and Houde (2011) analyze how retailers in Quebec used phone conversations to initiate price increases after periods of repeated price reductions. Other empirical studies have considered weekly retail gasoline prices. Wang (2009) analyzes gasoline pricing before and under a law that regulates both the timing and frequency of retail price changes in Australia. Eckert (2003) and Noel (2007b) analyze weekly prices in the Canadian retail gasoline market, and find cycles consistent with Edgeworth cycle theory. Importantly, the type of fluctuations on which we focus in the present analysis cannot be discovered using weekly data.[3] Noel (2009) analyzes how asymmetric cost pass-through in gasoline prices can be partly due to Edgeworth cycles using twice-daily price data from Canada. Analogous to Wang (2009) we draw attention to how the headquarters use vertical price control arrangements to restart the price cycles.

[3] Castanias and Johnson (1993) provide statistics for Los Angeles from 1968 to 1972 that appear as Edgeworth cycles. Moreover, several studies analyze different forms of asymmetric pricing, i.e., a faster reaction in retail prices to upward changes than to downward changes in wholesale prices (Bacon, 1991, Borenstein *et al*., 1997, Asplund *et al*., (2000), Bachmeier and Griffin, 2003, Eckert, 2002, Bettendorf *et al*., 2003 and Bettendorf *et al*., 2008). Slade (1987, 1992) analyzes separate price wars in the Vancouver area during the summer of 1983, finding that shifts in demand trigger price wars.

The rest of the paper is organized as follows. Section 2 describes the data sets used, and section 3 presents details of the price cycle pattern in Norway. In Section 4, we describe how retail prices are determined. In section 5 we discuss potential alternative explanations for the pattern observed. Finally, Section 6 concludes the paper.

2. Data description

We collected two data sets with daily station-specific observations of gasoline pump prices:

- The first is from a national website-based (NWB) panel data set. This is from a large number of nationwide Norwegian stations over the period March 2003 to April 2005, where consumers reported prices via text messages or emails. The original data set comprised approximately 40,000 observations. We reduced the sample to 26,823 observations by excluding gas stations with less than 100 observations, leaving us with 116 stations across Norway.
- The second data set comprises time series (LTS) of daily prices from local stations for two periods of four to five months during 2005 and 2006. This yielded 1,067 observations from seven stations, with consecutive daily time series of pump prices varying between 50 and 312 days.

The NWB and LTS data sets are complementary in the sense that, whereas the web-based data (NWB) allows us to examine a wider set of stations over a longer time-period, the local data (LTS) on specific gasoline stations allows for a more precise analysis of price patterns. In the LTS data we have consecutive observations for relatively long periods that we can compare with recommended prices. The data sets are described in more detail in Appendix A.

When we started to collect the LTS-prices, we were not aware of the role of the recommended prices. These prices were collected between 4 pm and 7 pm. In order to demonstrate more accurately the industry-wide raise in prices towards the recommended prices, we collected the following data set:

- Pump prices at 8 am and 2 pm for three consecutive Mondays in April 2008 for all gasoline stations in Oslo. We label this the OSLO data set.

As a complement to our analysis of the price data, we undertook the following survey:

- In 2008 and 2009 we interviewed 35 gasoline station managers in order to gain more information about the price support system and how price control shifts from the hands of the retailers to the headquarters, and how this system is used to ensure interbrand uniform pump prices on Mondays around noon.

3. Price cycles

3.1. Descriptive analysis

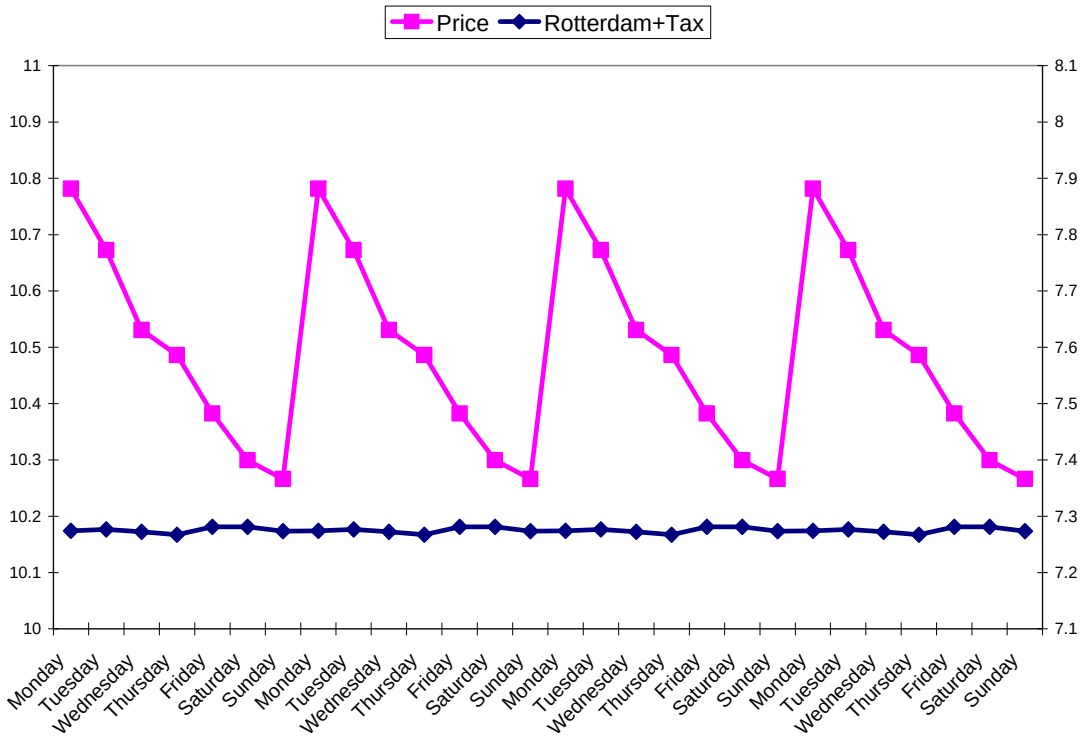
The Norwegian market is dominated by the big four gasoline companies; Statoil (the partially state owned oil company), Shell, Esso (Exxon), and Hydro-Texaco (now YX). In 2004 their market shares were 26.9%, 25.5%, 21.7%, 20.8%, respectively. The remaining 5.1% of the market consisted of independent automated stations.[4] The European Commission (2008) emphasizes that the Norwegian retail gasoline market is highly concentrated, and states that (page 36): *Fuel retail margins are very high in Norway, amongst the highest in Europe. Norwegian gross distribution margins were,*

[4] Source: The Norwegian Petroleum Industry Association.

expressed as a percentage of Community average, 128.9% for petrol and 155.8% for diesel in 2006.

The average daily prices over all seven local gasoline stations are illustrated in Figure 1. The price is clearly at its highest on Monday before gradually returning to its lowest level over the week. Looking only at averages might be misleading. To fully uncover the underlying dynamics in price changes across stations we have therefore tabulated all price changes for all stations and weeks for the LTS data in Table 1.

Figure 1 Weekly price and cost patterns based on the local time series (LTS) (n = 1,067 (price), n = 1,062 (Rotterdam price + gasoline tax), same pattern illustrated for four weeks)



There are potentially 149 Monday observations where the price can change, and as many as 117 (79%) are price increases, with the average price increase being quite high, NOK 0.68 (1 € ≈ NOK 8). If we consider the remaining days when prices could change (907 days), we only observe 67 days where prices increase (7%). Turning to

days with price reductions, we find that on only five occasions are price reductions observed on Mondays, while there are as many as 384 price reductions on other days of the week, (42% of the 907 observed days). Note also that the reductions are spread quite evenly over the rest of the week with between 65 and 86 reductions each day.

Table 1 Daily price changes across seven gasoline stations for the period January 4, 2005 to March 15, 2006 (n = 1,056)

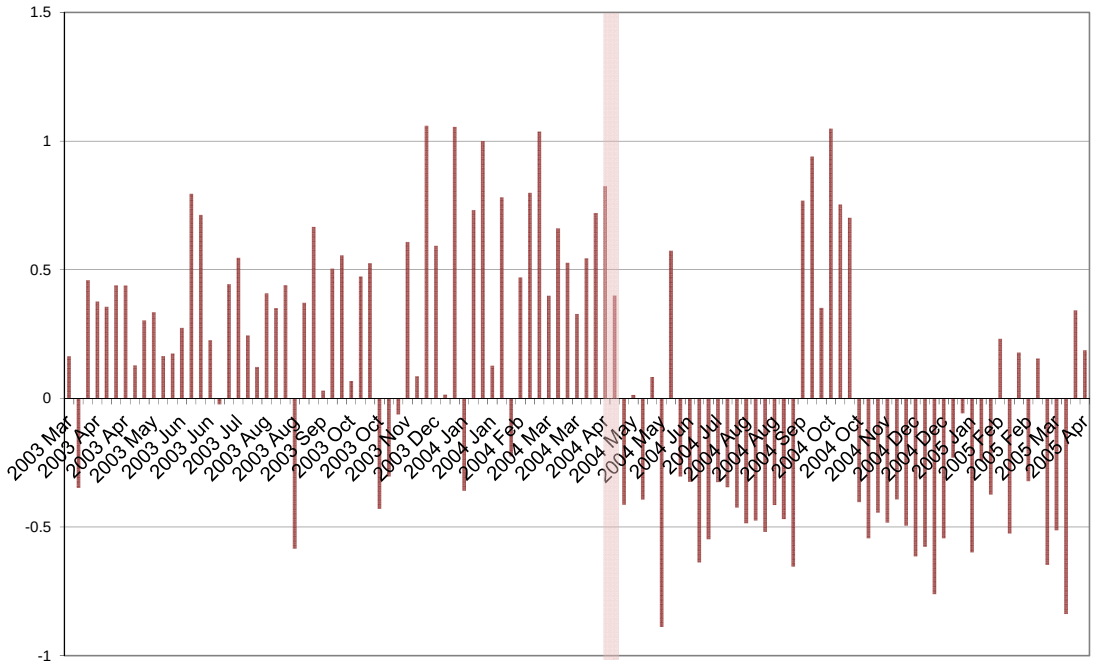
	Observations	*Price increases*		*Price reductions*		*No Price change*
		n	*mean*	*n*	*Mean*	*n*
Monday	149	**117** (78.5%)	0.677	5 (3.4%)	–0.108	27 (18.1%)
Tuesday	153	8 (5.2%)	0.575	**80** (52.3%)	–0.266	65 (42.5%)
Wednesday	152	7 (4.6%)	0.579	**86** (56.6%)	–0.314	59 (38.8%)
Thursday	149	31 (20.8%)	0.436	**65** (43.6%)	–0.274	53 (35.6%)
Friday	149	14 (9.4%)	0.594	**79** (53.0%)	–0.285	56 (37.6%)
Saturday	152	5 (3.3%)	0.224	**52** (34.2%)	–0.264	95 (62.5%)
Sunday	152	2 (1.3%)	0.690	**22** (14.5%)	–0.163	128 (84.2%)
Total	1056	184 (17.4%)		389 (36.8%)		483 (45.7%)

We now turn to the NWB data, where we find an identical pattern. In order to make the picture clearer, we construct alternative days in the sense that each day starts at noon, e.g., Monday starts at noon on Monday and lasts until noon on Tuesday but is still denoted '*Monday*' in figures and tables. However, in this dataset the price pattern changes after Easter 2004 (after 27.04.2004) from being highest on Thursdays to being highest on Mondays.

In fact, from April 27th 2004 Monday changed from being the low-price day to becoming the high-price day. To better observe this, we calculated price differences between Monday and Thursday for the NWB data over the period March 2003 to

April 2005, and present these in Figure 2. The figure shows a clear pattern whereby the Thursday price is predominantly higher than the Monday price up until Easter 2004. After Easter 2004, the price is higher on Mondays. Figure 2 also suggests a return to the previous Thursday pattern over six weeks during the fall of 2004 (06.09.04-17.10.04). We have not been able to find an explanation for this return to the previous pattern.

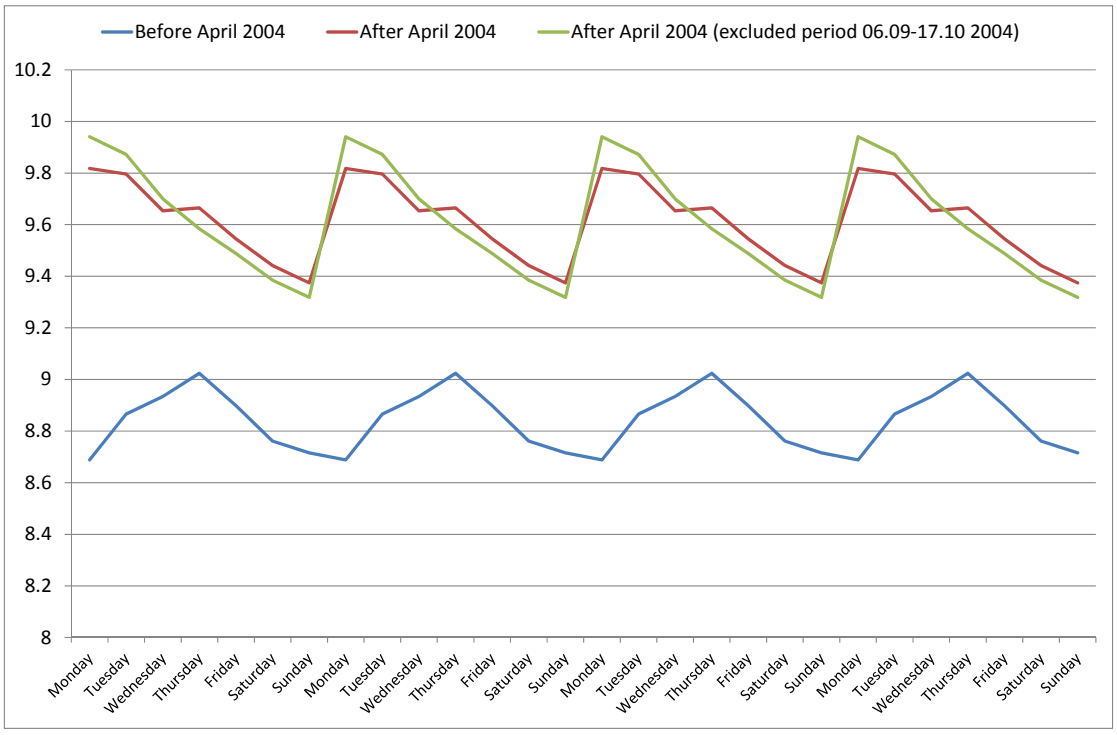
Figure 2 Price differences between Monday and Thursday (Thursday price minus Monday price) for the period March 2003 to April 2005 based on the web-based panel data (NWB) where days are defined as noon to noon, (n = 26,823, area marked is April 2004)



In Figure 3 we illustrate the weekly cycles for the period before and after April 2004. After Easter, we observe the same pattern as in the LTS data, whereas up until Easter 2004, Thursday was the high-price day. The 'After April 2004' pattern shows a small 'bump' also on Thursdays. This is primarily due to the return of the old pattern during the six weeks in the fall of 2004. When we disregard these six weeks, the small

Thursday 'bump' disappears, and the Monday effect is even more visible. We also know from the interviews with the station managers that prices are sometimes raised in the same way on Thursdays as on Mondays.

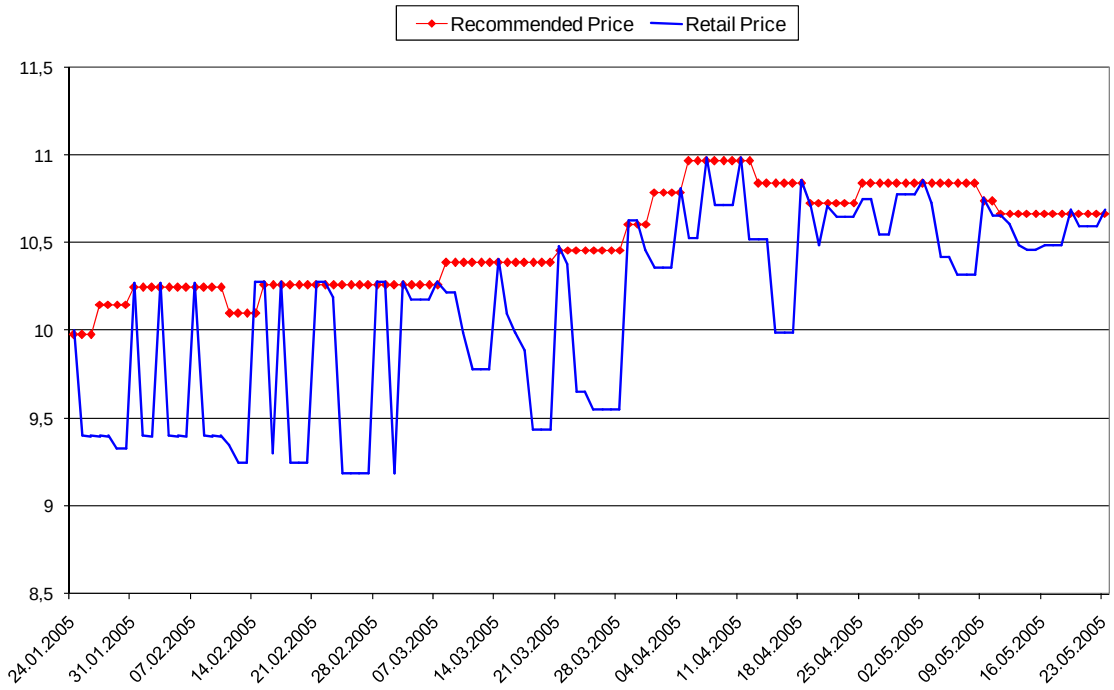
Figure 3 Weekly price pattern based on web-based panel data (NWB) where days are defined from noon to noon, showing the series of daily prices, and averages per day per year (n = 26,823, same pattern illustrated for four weeks)



Another distinctive feature of the observed price cycles is the fact that retail prices throughout Norway are raised to the recommended prices set by the headquarters of the gasoline companies (how retail prices are determined is discussed in the next section). In Figure 4, we show the development of actual retail and recommended prices for one of the Statoil stations in the LTS data set. Every Monday, the recommended price and the actual retail price coincide. Due to transportation costs, the individual rule for this station is to set the pump price NOK 0.02 above the

recommended price (≈0.25 €-cent).[5] From Figure 4 we see that the pump price is increased on 17 out of 18 Mondays. For 16 Mondays the pattern follows the individual rule – NOK 0.02 above the recommended price.[6] We also observe six price increases on Thursdays, five of which follow the individual rule.

Figure 4: Daily gasoline prices, Statoil gasoline station, NHH, Bergen, January 2005 to May 2005, (LTS data, n = 120)



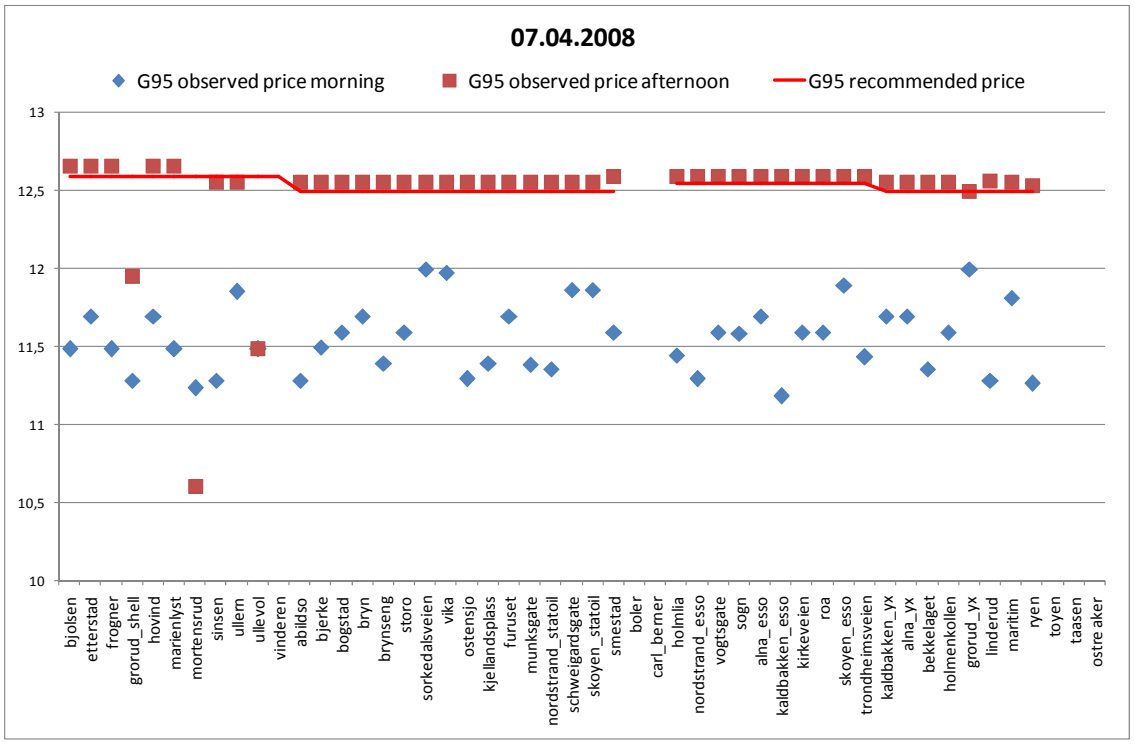
In order to better explain the industry-wide raise in prices on Mondays, and the relationship between pump prices and recommended prices, we now turn to the OSLO data set. We asked all gasoline stations in Oslo about their pump prices at 8 am and 2 pm for three consecutive Mondays in April 2008. Figure 5 shows the observed prices

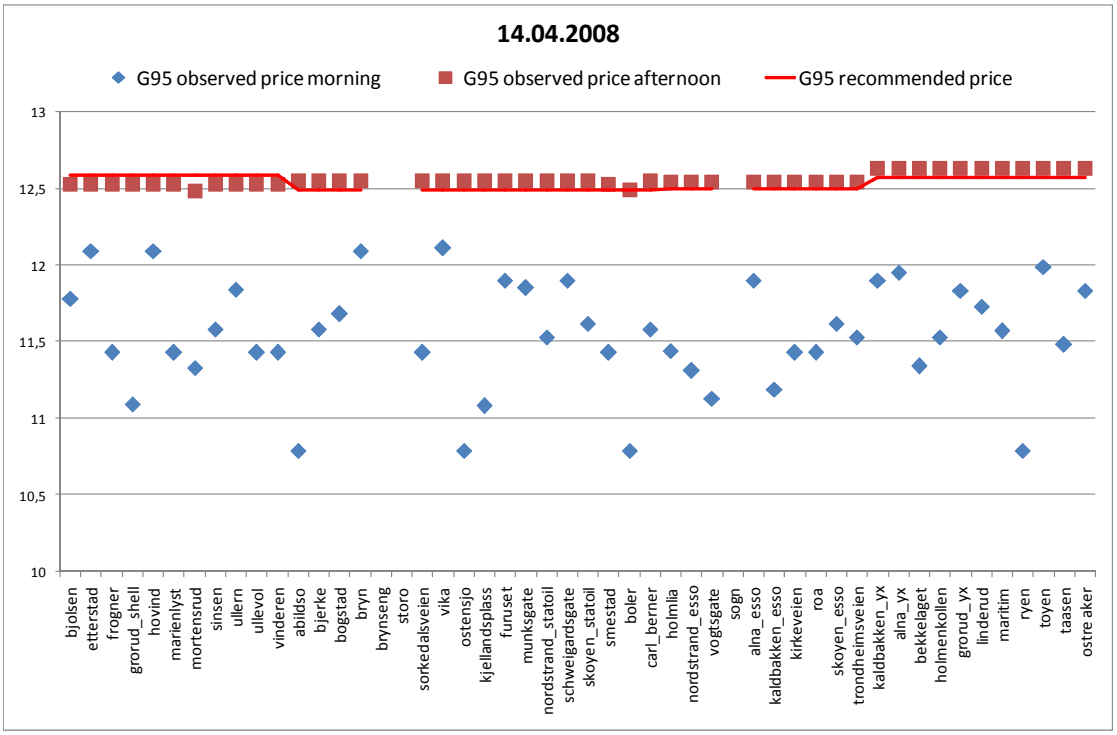
[5] The big four companies use a detailed system where each station is given a transportation cost that depends on location. This system is briefly described on www.statoil.no and is confirmed in our interviews with station managers and also by The Norwegian Competition Authority (2010).

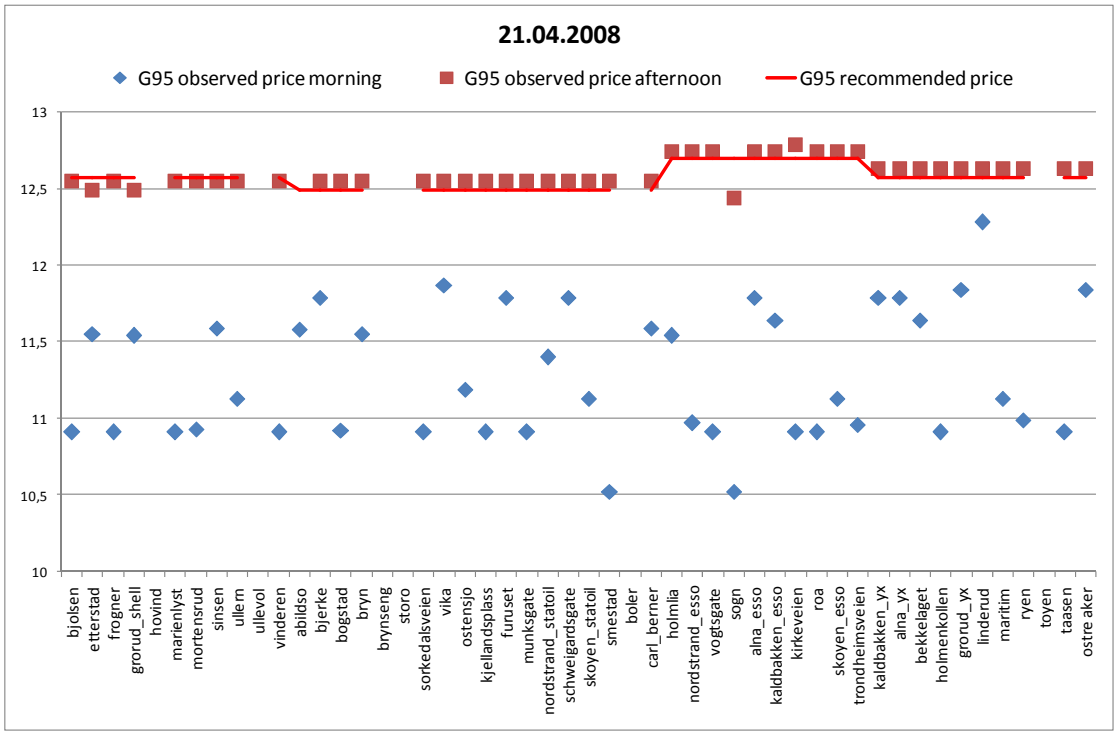
[6] The only Monday where we do not observe a price increase is 28 March, which was a holiday. In this case, the price instead increased according to the rule on the following Tuesday. Monday 16th May we observe an increase, though not strictly according to the rule - this may be due to the fact that the next day was a holiday.

on (i) Monday April 7, (ii) Monday April 15, and (iii) Monday April 21, 2008. We observe that at 8 am there exists a significant degree of price dispersion, but at 2 pm almost all stations have raised their price according to the recommended prices. If we concentrate on Statoil, we have in total 49 observed prices at 8 am and 47 observed prices at 2 pm. At 2 pm, for 42 of the 47 observations, the pump prices were set exactly NOK 0.06 above the recommended price.

Figure 5 Retail and recommended prices at 8 am and 2 pm for all gasoline stations in Oslo (i) Monday April 7, (ii) Monday April 15, and (iii) Monday April 21, 2008.

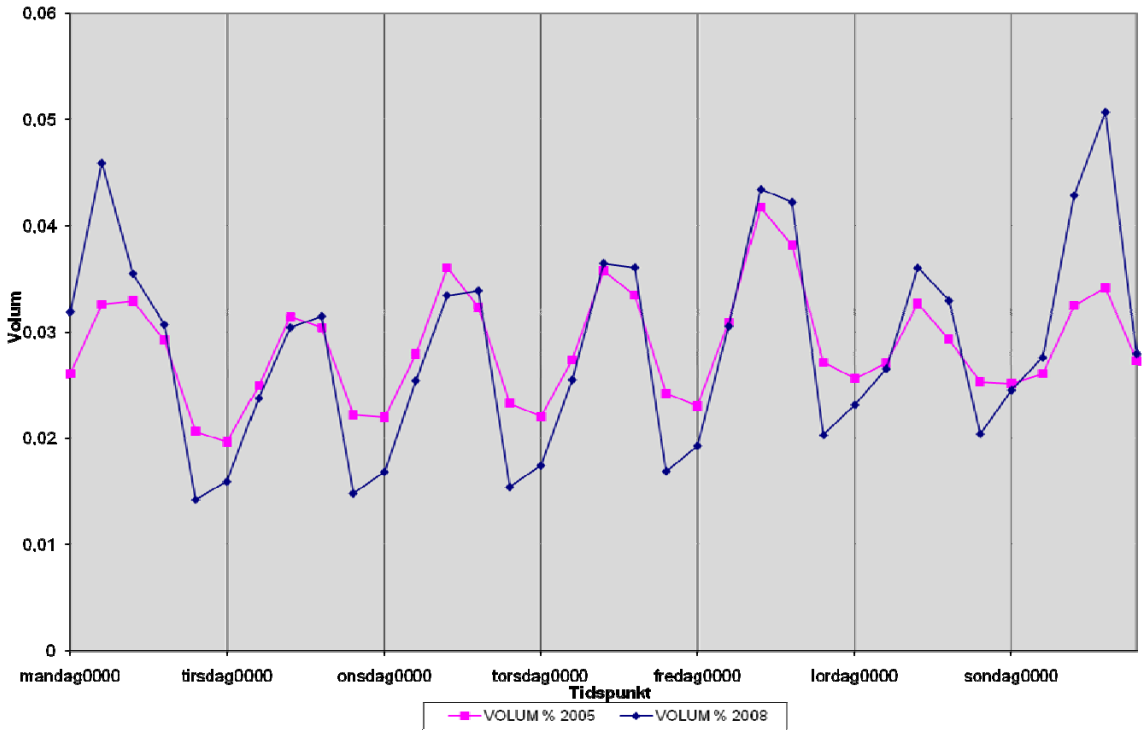



14.04.2008
G95 observed price morning
G95 observed price afternoon
G95 recommended price
13
12,5
12
11,5
11
10,5
10
bjolsen
etterstad
frogner
grorud_shell
hovind
marienlyst
mortensrud
sinsen
ullern
ullevol
vinderen
abildso
bjerke
bogstad
bryn
brynseng
storo
sorkedalsveien
vika
ostensjo
kjellandsplass
furuset
munksgate
nordstrand_statoil
schweigardsgate
skoyen_statoil
smestad
boler
carl_berner
holmlia
nordstrand_esso
vogtsgate
sogn
alna_esso
kaldbakken_esso
kirkeveien
roa
skoyen_esso
trondheimsveien
kaldbakken_yx
alna_yx
bekkelaget
holmenkollen
grorud_yx
linderud
maritim
ryen
toyen
taasen
ostre aker


21.04.2008
G95 observed price morning
G95 observed price afternoon
G95 recommended price
13
12,5
12
11,5
11
10,5
10
bjolsen
etterstad
frogner
grorud_shell
hovind
marienlyst
mortensrud
sinsen
ullern
ullevol
vinderen
abildso
bjerke
bogstad
bryn
brynseng
storo
sorkedalsveien
vika
ostensjo
kjellandsplass
furuset
munksgate
nordstrand_statoil
schweigardsgate
skoyen_statoil
smestad
boler
carl_berner
holmlia
nordstrand_esso
vogtsgate
sogn
alna_esso
kaldbakken_esso
kirkeveien
roa
skoyen_esso
trondheimsveien
kaldbakken_yx
alna_yx
bekkelaget
holmenkollen
grorud_yx
linderud
maritim
ryen
toyen
taasen
ostre aker

We do not have volume data, but the Norwegian Competition Authority (NCA, 2010) has recently presented data on how demand varies over the week.[7] In Figure 6 we show a facsimile from the Norwegian Competition Authority (2010).

Figure 6 Volume in % of weekly consumption over the week in 2005 and 2008, respectively. Source: The Norwegian Competition Authority (2010).



Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
00:00	00:00	00:00	00:00	00:00	00:00	00:00

Two important observations can be made: First, as the new pattern with low prices Sunday and Monday morning has become known to more and more customers, volumes in the periods 09:36-19:12 on Sundays and 04:48-09:36 on Mondays have increased by around 50% from approximately 3% to 4-5% of weekly consumption from 2005 to 2008. Second, while volume is reduced in off-peak periods during the

[7] The NCA has collected all prices, price changes and corresponding volumes for the total Norwegian market from the oil companies. The data allows them to aggregate the prices and price changes into different time intervals. They have chosen to divide the 24 hour period into five intervals, each of 4 hours and 48 minutes; 00:00-04:48, 04:48-09:36, 09:36-14:24, 14:24-19:12 and 19:12-24:00, providing 35 intervals per week. The NCA (2010) report confirms the price pattern we find in our data.

weekdays, volume is not reduced in peak-periods during weekdays. This suggests that it is not as easy for the utility drivers to change their consumption pattern during weekdays as it is for the more price sensitive ordinary customers that can indeed adapt to the changes in the weekly cycle by filling gasoline during the weekend (see discussion on price discrimination below).

3.2. Econometric analysis

In this section, we introduce some simple econometric models. We use the NWB data set. Since we have an unbalanced panel with a significant number of consecutive observations for only some stations, we choose not to impose an autoregressive process. To account for potential local market effects and heterogeneity across stations we estimate a fixed effect model where we include a full set of station dummies (α_i). In addition, we include seven brand dummies (*Brand*).[8] We estimate the following model:

$$(1) \quad \begin{aligned} P_{i,t} &= \beta_{TAX} TAX_t + \beta_{Rotterdam} Rotterdam_t + \beta_{Trend} Trend_t \\ &+ \sum_{d=1}^{6} \phi_d AltDay_{d,t} + \sum_{b=1}^{7} \delta_b Brand_{i,b} + \alpha_i + \varepsilon_{i,t} \end{aligned}$$

Tax enters through a continuous variable as total tax in NOK (*TAX*), and we also allow for a linear trend (*Trend*). Furthermore, we control for changes in the wholesale price of gasoline (*Rotterdam*). We estimate the model for the period 'prior to Easter 2004' (07.03.2003–26.04.2004), and for the period 'after Easter 2004' (27.04.2004–08.04.2005). The 'after Easter' model is also estimated where we exclude the six

[8] We have eight brands (number of observations in parentheses): four majors; Esso (8,382), Hydro-Texaco (3,167), Shell (3,791) and Statoil (6,831), and four automat companies; JET (1,973), UnoX (830), SMART (1,584) and REMA (265). We assign dummies to the first seven.

weeks where the pattern changed back (06.09.04-17.10.04), see the discussion around Figure 2 and Figure 3 above. The weekly retail price cycle is controlled for using six weekdays dummies (indicating noon to noon periods), with Monday and Thursday as the reference days.

The results are presented in Table 2.[9] Both the tax and the wholesale variables are significant and positive for both periods.[10] The results suggest a weak negative trend, though it turns positive when we exclude the six weeks of fall in 2004.[11] The brand dummies are significant in five to six out of seven cases. The lower-priced automated stations, as expected, have negative parameters, which are significant in five out of six cases across models. The explanatory power is reasonably high, even though we were unable to incorporate an autoregressive process into the model.[12] Note that we increase the explanation power from 0.37 to 0.49 and to the same same level as for the model for the period prior to April 2004 (0.50) when we exclude the noise from the six fall weeks of 2004.

Turning to the weekly cycles, we find results that are in accordance with the average prices reported in Figure 3. Prior to April 2004, Thursday is the high-price day. The price on Thursday is significantly higher than on all other days. When looking at the weekly pattern after April 2004, the reference day (Monday) is the high-price day,

[9] Fixed effect dummies (116) are not reported here, but are available on request to the authors.

[10] There are some differences in magnitude on these parameters across models. We have re-estimated the models, imposing the 'Prior' parameter estimates for Tax and Rotterdam price in the 'After' models, and the 'After' parameter estimates in the 'Prior' models. The results remains the same, in particular the price pattern parameters are very similar to those in Table 2.

[11] All three models have been estimated removing the trend, and the results are much the same.

[12] We have estimated the models also applying the generalized least squares method of Prais-Winsten, allowing an AR(1) process in the error term. The results are robust to this estimation technique. The price pattern we find using OLS is confirmed also in these models.

with all weekday dummies being significant and negative, and generally increasing in magnitude (negative) until Sunday. As we saw in Figure 3, when we exclude the six weeks when the pattern returned in the fall of 2004 (column 3), the Thursday jump disappears and the weekly price difference increases. The predicted difference between Sunday and Monday varies between NOK 0.43 and 0.60.[13] [14]

A potential worry might be that the results are driven by the aggregation across more than a hundred gasoline stations with varying degrees of observations over time and days of the week (highly unbalanced panel). For instance one might think that price reporting systematically differed according to day of the week and rural and central areas, thereby imposing patterns due to the reporting routines. Atkinson (2008) compares a panel of systematically collected station prices and internet based prices. He finds that a station's price is not more likely to be reported if it is higher or lower than the daily citywide mean or mode price. To elaborate on this issue in our NWB dataset, we have looked at the distribution of observations across ten regions, where regions differ between remote rural areas, intermediate rural areas and different cities. There are, however, no systematic differences across regions regarding on which days prices are reported. To check for the importance of potential systematic effects from missing observations over time across stations we have estimated all three models in Table 2 where we include only the 10 (20) stations where we have the longest time series ('top 10' and 'top 20').

[13] A corresponding econometric analysis of the LTS data has been undertaken. This shows a clear pattern of Monday as the high-price day, mirroring the results found for the NWB dataset after April 2004 (Foros and Steen, 2008).

[14] In Table 2 we use ordinary least squares standard errors. One could argue that it would be more appropriate to use clustered standard errors. To check for robustness we have estimated the models both using clustering (station*day-of-week), and only station. The standard errors do increase somewhat, but all main conclusions are robust.

Table 2 Empirical results for gasoline price models using web-based panel data where days are defined from noon to noon (n = 26,823)

	Prior to 04:2004	After 04:2004	After 04:2004 (excluded 06:09:04-17:10:04
tax	1.640***	0.993***	0.478***
	(0.168)	(0.111)	(0.103)
rotterdam	1.389***	0.887***	0.982***
	(0.025)	(0.019)	(0.019)
alttrend	-0.0009***	-0.0001*	0.0001*
	(4.86E-05)	(0.00007)	(0.00006)
Monday	-0.340***		
	(0.012)		
Tuesday	-0.163***	-0.055***	-0.105***
	(0.012)	(0.014)	(0.013)
Wednesday	-0.098***	-0.194***	-0.268***
	(0.012)	(0.013)	(0.013)
Thursday		-0.149***	-0.346***
		(0.014)	(0.013)
Friday	-0.222***	-0.283***	-0.460***
	(0.016)	(0.017)	(0.017)
Saturday	-0.326***	-0.367***	-0.552***
	(0.022)	(0.022)	(0.022)
Sunday	-0.288***	-0.423***	-0.598***
	(0.012)	(0.014)	(0.014)
Esso	-0.047	0.346*	0.229
	(0.079)	(0.202)	(0.183)
Hydro-Texaco	-0.195**	-0.107	-0.335***
	(0.093)	(0.090)	(0.107)
JET	-0.002	-0.377***	-0.553***
	(0.059)	(0.080)	(0.086)
Shell	0.305***	0.340***	0.191*
	(0.072)	(0.105)	(0.102)
Smart	-0.379***	-0.216**	-0.269***
	(0.072)	(0.094)	(0.095)
Statoil	-0.132*	0.209**	0.053
	(0.080)	(0.104)	(0.230)
UnoX	-0.426***	-0.304***	-0.253**
	(0.062)	(0.110)	(0.120)
R^2	0.502	0.372	0.495
N	14746	12077	10026

*** significant at the 1% level, ** significant at the 5% level, * significant at the 10% level

The price pattern and main findings are confirmed also within these models.[15]

3.3 Margin development

An interesting question is whether the shift in price pattern has affected the gross margin. In Table 3, we present summary statistics on some of the key variables.

Table 3 Summary statistics: gross margin, tax, wholesale price and retail gasoline price from web-based panel data (n = 26,823)

	n	*Mean*	*Stnd.Dev.*	*Min.*	*Max.*
The 100 days before Easter 2004*					
Retail price	3897	9.145	0.554	7.550	10.220
Wholesale price	3897	1.795	0.132	1.587	2.129
Tax	3897	4.720	0.000	4.720	4.720
VAT	3897	1.829	0.111	1.510	2.044
Gross margin	3897	0.801	0.422	–0.525	1.608
The 100 days after Easter 2004**					
Retail price	2920	9.732	0.501	7.210	13.230
Wholesale price	2920	2.156	0.162	1.861	2.441
Tax	2920	4.720	0.000	4.720	4.720
VAT	2920	1.946	0.100	1.442	2.646
Gross margin	2920	0.909	0.410	–0.968	3.554

* Period: 07:03:2003–27:04:2004. ** Period: 28:04:2004–08:04:2005.

Over a period of six months within the same year, it is unlikely that the cost components covered by the gross margin should change significantly. The retail price increases from NOK 9.14 to 9.73 over these two periods (6.4%). However, whereas the tax did not change during these two hundred days, the wholesale price did, increasing from NOK 1.80 to NOK 2.16. If we account for the VAT, this amounts to most of the price increase. Still, when we look at the gross margin it has increased over these two periods by as much as NOK 0.11, or 13.5%, on average. Considering only averages does not allow us to control for changes in costs and the weekly price pattern. In Foros and Steen (2008), we use the web-based panel data set (NWB) to

[15] For the 'top 10' stations, we have between 385 and 750 price observations per station, representing 5532 observations in total (27.6% of total sample). The 'top 20' stations constitute between 342 and 750 station specific price observations, and represents a total of 9161 observations (34.2% of the total sample). The results are available on request to the authors.

specify a simple econometric gross margin model. We find a significant and higher increase in the average margin when econometrically controlling for week pattern, costs and trend. The results suggest that the average gross margin went up by more than 20% after April 2004.[16]

4. Price determination[17]

At the retail level the big four companies have a combination of fully vertically integrated retail outlets and vertically separated retail outlets. This dual distribution system corresponds to what is observed in several other countries, and Shepard (1993) and Slade (1998), among others, analyze the rationales behind the choice of market structure from the upstream headquarters' perspective.

Under vertical separation retailers have exclusive long-term contracts (usually for five years or more) with one of the major oil companies, and the pump price is (formally) set by the retailer. We thus have a market structure with multiple upstream-downstream pairs, and within an upstream-downstream pair the downstream firm uses the upstream firm's brand. We now scrutinize on the vertical restraints imposed on vertically separated retail outlets to show how the (upstream) headquarters transfer the control over pump prices from the retailers at least for part of the week.

[16] Clearly, the average margin understates the true change in retail margins since customers will take time to adapt to the new price cycle. Furthermore, one might think that the imposed price support system reduces price dispersion across nearby stations. If this is the case, there is less room for customers to shop around for lower prices and thereby retail margins might have been improved.

[17] This section is based on interviews with 35 retail outlet managers and on press articles. In particular, we also have copies of faxes and communication information between headquarters and retailers provided anonymously by some of the retailer managers. 31 of these interviews were undertaken by Irene Kvernenes and Åse Tiller Vangsnes as a part of their master thesis.

Let c be the channel's input price per liter of gasoline (the major components of c in Europe are the Rotterdam price and tax). The margin for the total channel is thus p-c, where p is the pump price. The upstream firm uses a sophisticated profit-sharing scheme towards the downstream firm.

The first part of the scheme specifies a maximum RPM, which is *de facto* the recommended price (p^{rp}) exclusive of transportation costs. As long as the pump price equals the recommended price (the price ceiling), the retailer is charged a wholesale price w^{rp}, where w^{rp} is significantly higher than c. If we abstract from the transportation cost element, the retailer then achieves the margin $M^{rp}=p^{rp} - w^{rp}$ as long as the pump price equals the maximum RPM. This part of the profit sharing scheme is permanently available throughout the week.

Three out of the four major firms (Statoil, Shell and YX) make the recommended price publicly available on their website.[18] Until 2005 Shell's recommended price was published on the Norwegian Petroleum Industry Association's website.[19] This information was removed after pressure from the competition authorities, but the companies are still permitted to post the information on their individual websites.[20]

The second part of the profit–sharing scheme is labeled *price support*. This scheme specifies a margin M^{ps} which is given to the retailer if the retailer reduces the pump

[18] Thanks to information provided by anonymous retailers we know that Esso operates a price support scheme system that resembles the system used by Statoil, Shell and YX.

[19] Between 1975 and 2005 the Norwegian Petroleum Industry Association made Shell's recommended price publicly available for the other major oil companies. Changes in Shell's recommended price were always made at 12 noon, and the Norwegian Petroleum Industry Association announced the new price the following morning. Source: the Norwegian Petroleum Industry Association.

[20] Recommended prices are observed used in several countries; e.g. Australia, (ACCC, 2007), Ireland (The Irish Competition Authority, 2003), The Netherlands, Germany and Italy (Faber and Janssen, 2008).

price below the maximum RPM (p^{rp}), where $M^{ps} < M^{rp}$. A crucial feature of this price support component is that it is not permanently available. The upstream firm may choose to withdraw the price support scheme for a period of time. When the price support is withdrawn, the retailer will have the margin $p\text{-}w^{rp}$. All the four major companies have seemingly set w^{rp} such that they induce the retailer to set $p = p^{rp}$ in periods where the price support is not available (the maximum RPM is binding).

The conditional price support system described above corresponds to the one used by one firm in Australia, as described by Wang (2009). Wang shows that when price support is withdrawn, the system forces the retailer to set the pump price in the interval $p^{rp-}\ w^{rp}$. Analogous to our findings, Wang accentuates that the interval $p^{rp-}\ w^{rp}$ is set such that the retailers are induced to set the pump price at the level suggested by the headquarters, and consequently leading to the synchronization of the retail prices from the company's retailers.

The main ingredients in the profit-sharing scheme described here correspond to what is found in other gasoline markets by The Irish Competition Authority (2003) in Ireland and by ACCC (2007) and Wang (2009) in Australia.[21] However, the profit-sharing arrangements used in Norway have some distinctive features. These features may explain why the Norwegian price cycles appear distinctive. Compared to Australia and Ireland there seems to be an industry-wide adoption of a very similar system for all the four major companies in Norway.

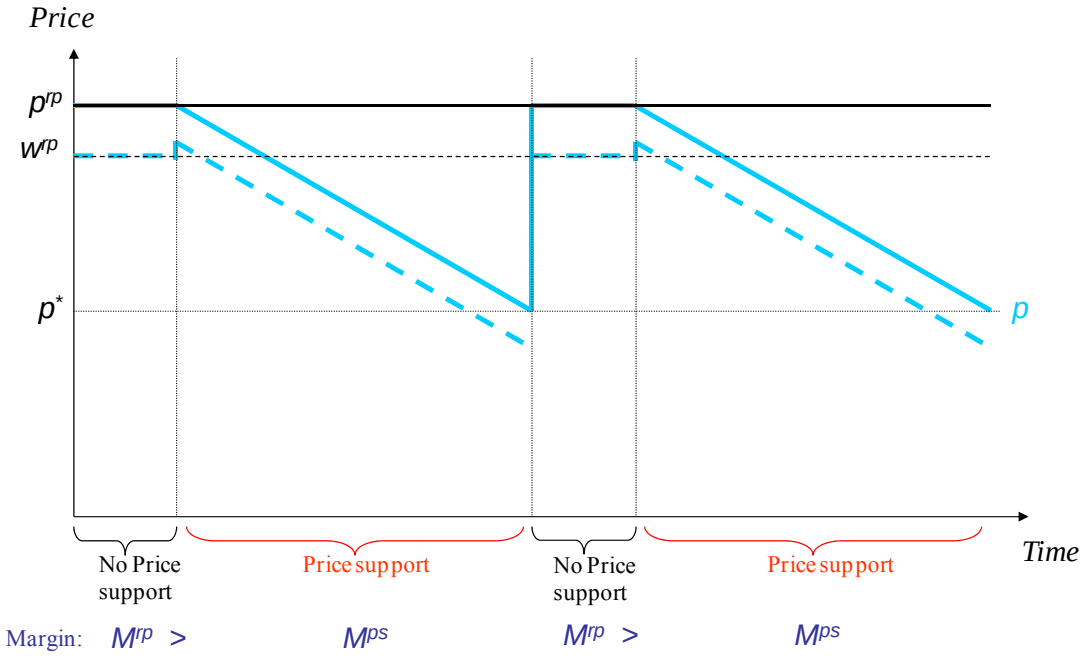
[21] On some aspects The Irish Competition Authority (2003) and ACCC (2007) provide more detailed information about the price support schemes. ACCC (2007) finds that the margin offered under the price support scheme is increasing in the retail price. In this case, the profit sharing scheme may be described as price-dependent, where M(p) and M'(p)>0. This may obviously reduce retailers' undercutting incentives.

Price support schemes (also labeled temporary allowances) are used in several countries during price war periods (see Slade, 1998, for descriptions of the schemes used in the Canadian market). The retailer then receives price support when the retail price is below a certain level. In contrast, the Norwegian arrangements appear distinctive in the way that price support is granted and withdrawn on a regular basis on given days of the week. Monday has emerged as a focal point for when the upstream firms (the big four) withdraw the price support. On Monday morning all the big four upstream firms inform their retailers through a fax that the price support scheme will be removed from around noon until five pm (the interval varies slightly between the companies).

This will *de facto* force the retailers to increase their prices to the recommended price (p^{rp}), and the retailers will in any case not reduce the price below this level before the price support system comes into effect again on Monday evening. This is illustrated in Figure 7. Suppose that a retailer's pump price on Monday morning is $p^{*}=p< w^{rp}$. As long as the price support scheme is in force, the retailer's margin is M^{ps}. When the upstream firm withdraws the price support, the retailer will have a negative margin $p-w^{rp}$ if (s)he does not raise the price.[22] As argued above, the level of w^{rp} is set so as to induce all the retailers to raise the price to p^{rp} (plus transportation costs). We thus have an industry-wide vertical restraint, which instructs a given price at around noon on Mondays, and the restraint may be regarded as an RPM (at least in the periods where the price support scheme is withdrawn).

[22] The cycle amplitude differs according to differences in local competition, but it is always significantly larger than the individual retailer's margin, where M^{rp} is typically 10-20% higher than M^{ps}.

Figure 7 An illustration of the price support arrangements



The industry-wide adoption of noon on Mondays as a focal point for when to withdraw the price support scheme has led to the outcome that all the retail outlets increase pump prices to the recommended prices. Pump prices on Mondays are thus set by the four headquarters rather than by a large number of independent retailers. Upstream firms have managed to establish a predictable pattern, but we should accentuate the fact that this pattern could have been established by explicit communication, by implicit collusion or by one of the firms taking the lead.

Usually gasoline pump prices are assumed to be set sequentially both in the increasing phase and in the decreasing phase (see discussion by e.g. Wang, 2009). We have revealed several features that indicate that the big four companies increase prices simultaneously (*without knowing the rivals' prices*) on Mondays. As described above, the headquarters send faxes to their retailers in order to instruct them to raise pump prices around noon on Mondays. These faxes are sent from the headquarters well

before the prices actually jump around noon. The faxes are typically sent (from the headquarters) during the night between Sunday and Monday, specifying which prices are to be set at noon the next day, a practice that can hardly be reconciled with sequential behavior. Thus, in reality, all the 1800 retail outlets in Norway simultaneously raise their prices to recommended prices on Mondays.

Let us now turn to the price determination process in the part of the week where the price support scheme is in force. Independent retail outlets are obligated to collect price information from a given number of rivals (classified as *marker stations*). The information is reported to the upstream headquarters. The interviews with station managers reveal variations with respect to retail outlets' control of the end-user prices.

First, towards a number of independent retailers (franchisees) the headquarters have imposed a pure RPM also when the price support scheme is in force. Collected price information from the marker stations is reported to the headquarters. Based on this information the pump prices are set directly by the headquarters.[23]

Second, towards another group of retailers the upstream headquarters give a "suggested" new price, where the price support scheme (M^{ps}) is provided on condition that the retailer follows the suggested price. When such contracts are in force, the upstream headquarters in reality determine the pump price reductions (RPM) throughout the week (also when the price support schemes are in force).[24]

[23] For some stations this system is implemented such that they receive a "suggested price" from the headquarters, but they have no other available options than to press the "accept"-key.

[24] A similar arrangement was stopped by the Irish competition authorities in 2003 (The Irish Competition Authority, 2003).

Third, towards some retailers the price support scheme includes a price floor. The retailers then decide pump prices until the price floor is reached, and needs to ask the (upstream) headquarters for permission to reduce the price further. If they reduce the price below the price floor without permission, the price support scheme is withdrawn.

Finally, we have a group of retail outlets that are *classified as being outside price war zones*. These outlets are not part of the price support scheme at all, and they therefore charge the recommended price throughout the week. This is also confirmed by the NCA's 2010 findings.

Regardless of whether the pump price is set by the headquarters or the retailers, pump prices during the decreasing phase are set sequentially and may vary significantly from site to site.

Agency theory has been applied to answer how firms choose between different forms of ownership structure in gasoline retailing. Shepard (1993) finds empirical support in the US-market that upstream headquarters are choosing contracts with strong incentives and less direct control when retail outlets' unobservable effort is important.[25] A common problem for the upstream headquarters is that RPM is not allowed towards vertically separated outlets. However, the combination of the maximum RPM and the profit sharing arrangement (the price support system) seemingly provides a perfect substitute for setting the retail pump price directly.[26]

[25] Dahlstrom and Nygaard (1994) find similar results for the Norwegian gasoline market.

[26] From the strategic delegation literature, we know that vertical separation may also be used to soften retail competition (Bonanno and Vickers, 1988, Shaffer, 1991, and Rey and Stiglitz, 1995, among

5. Alternative explanations

In this section we discuss alternative explanations for the jump in prices on Mondays described in the previous sections.

5.1. The Edgeworth cycle theory

A critical assumption in Maskin and Tirole (1988) is that firms set prices sequentially in both the increasing phase and the decreasing phase. In the war of attrition phase, Maskin and Tirole assume that firms play a mixed strategy game. However, firms have incentives to end the war of attrition game as soon as possible, and a firm may take the role as the price leader (Wang, 2009). A main contribution of the present paper is to show how the headquarters in Norway have managed to establish an arrangement where they simultaneously decide to increase pump prices to a given level (the recommended price). Consequently, the firms have established an industry-wide practice that ends the war of attrition phase on Mondays.

In the decreasing phase prices are set sequentially, and this part of the cycle seems to be consistent with the Maskin and Tirole approach. As described above, the price support system moves price control from the hands of the retailers to the hands of gasoline headquarters. Instead of hundreds of price setters, there are four big companies (and a few small companies) that decide pump prices. While it may be difficult to see how hundreds of independent retailers set prices according to the Edgeworth cycle theory, the Edgeworth cycle explanation becomes more appealing when four quite symmetric players decide pump prices.

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others). Slade (1998) finds empirical support for this rationale using data from the Canadian retail gasoline market.

5.2. Demand fluctuations

Still maintaining low weekend prices, in April 2004 Monday changed from being the low-price day to becoming the high-price day. It is very unlikely that the weekly demand pattern changed as abruptly as the price pattern after Easter 2004 would suggest. In general, it is also unlikely that we have a large increase sudden in demand on one day of the week followed by six days with small reductions in demand (see also discussion in Noel (2007a). This is, indeed, not the case in Norway either, which is confirmed by the volume figures from the Nowegian Competition Authority (2010); see Figure 6 in Section 3 above.

5.3. Input price variation

In Figure 1, we showed the average weekly pattern in retail price and taxes plus the Rotterdam spot price. We do not observe a weekly pattern in the cost components. Analogous to Noel (2007a), we dismiss the explanation that gasoline inventories at the retail stations influence retail prices.

5.4. Price discrimination

Intertemporal price discrimination has also been suggested as an alternative explanation for price patterns that appear as Edgeworth cycles (see discussion by Eckert and West, 2004).[27] In contrast to the Maskin and Tirole model, the firms'

[27] Conlisk *et al.* (1984) consider a monopoly provider of durable goods that uses periodic reductions in price to discriminate between low- and high-value consumers. Sobel (1984) extends Conlisk *et al.* (1984) to the case of competition. In Conlisk *et al*. (1984) and Sobel (1984), new consumers enter the market in each period, but consumers who do not buy, remain in the market, and the residual demand builds up until price cuts become profitable. Dutta *et al*. (2007) combine elements from repeated game and durable goods models where the residual demand is bounded by the 'death' of consumers. However, residual demand may be large enough to ensure temporary price cuts in equilibrium. Roughly speaking, Dutta *et al*. (2007) show that the existence of an equilibrium with temporary price cuts depends on the fact that firms are more patient than consumers. The result is qualitatively in line with Sobel (1984), and may be viewed as a form of intertemporal price discrimination. Note that

incentive to gradually reduce the price in price discrimination models comes from the existence of heterogeneous consumers; e.g. different degrees of patience. The practice by which price cycles restart on Mondays ensures a period with relatively high prices in the first part of the week and a period of lower prices towards the end of the week. This may imply a price structure that largely introduces intertemporal price discrimination between consumers that differ in their willingness or ability to wait.

Even if price discrimination is not the driving force behind the cycle, price discrimination may explain why the firms coordinate, with Monday as the high price day. The Norwegian Competition Authority (see Figure 6 above) shows how customers have adapted to the weekly price pattern. From 2005 to 2008 we observe that in periods volumes on Sunday and Mondays have increased by around 50% from approximately 3% to 4-5% of weekly consumption, and total Sunday consumption has increased by as much as 20%. However, we do not observe a similar reduction in demand during the day on weekdays where a large portion of the consumers is business customers less prepared or able to adapt their purchasing pattern to the price cycle.

In terms of gasoline, the cost of inventorying relates to how much people drive. The Norwegian price pattern clearly suggests a fixed seven-day cycle. People who use less than a tank of gasoline per week (the average driver in Norway) may therefore wait until the price falls, but people with a higher usage cannot. When prices increase on Mondays, retail prices are at their lowest level during the weekends, when less price sensitive business customers are not present in the market.

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consumers expect a price increase in the next period, and temporary price cuts in equilibrium are thus different from equilibrium price wars.

Analogous to the findings from Canada by Eckert and West (2004), the NCA (2010) reveals that in some regions with high concentration, we do not observe cycles. The prices are then always equal to the recommended prices (plus transportation costs). This observation speaks against the price discrimination explanation.

5.5. Collusive behavior

It is implausible that the change in the price pattern in 2004, coinciding with an increase in markup, was a pure coincidence. The pattern may have been established by explicit communication, implicit collusion or by one of the big four oil companies behaving as a leader. From our interviews with the managers and other available information we have not been able to find a clear answer to this.

Since it was first established, the information exchange arrangement described in Section 4 has proved to be robust, and it helps players both at the upstream and downstream level to detect deviations from the rule of increasing prices to recommended prices on Mondays. The arrangement also allows retail prices to adjust for changes in demand or cost conditions without triggering deviations from the rule.

6. Summary and conclusions

By using daily station-specific observations of gasoline pump prices from a large number of Norwegian stations from March 2003 to March 2006 we find price cycles that last exactly a week. Retail outlets increase their pump prices to the recommended price posted by the major oil companies' headquarters around noon on Mondays. We describe how the headquarters have managed to establish an industry-wide pattern where all retail outlets raise their pump prices around noon every Monday according to the recommended prices set by the headquarters. Furthermore, we describe how

the big four gasoline companies use vertical restraints to transfer price control from the hands of independent retailers into the hands of the headquarters.

An interesting issue is obviously the impact for competition policy. Communication about prices, which provides commitment value and more information to consumers about retail price differences, may very well be welfare enhancing (Motta, 2004, and Kühn, 2001). In the current context, however, it is difficult to see the efficiency effects of the 'public' announcement of recommended prices. The recommended prices appear to be made public primarily to increase transparency among competitors and facilitate potential horizontal coordination. As argued by Motta (2004) and Kühn (2001), communication directed only at rivals should be banned.

As a response to the first version of the present paper (Foros and Steen, 2008) the Norwegian Competition Authority initiated an inquiry into the Norwegian gasoline market during spring 2008 (reported in NCA 2010). The inquiry confirms our findings that retail pump prices for almost all retail outlets in Norway are adjusted to the recommended prices on Mondays. Not surprisingly, the competition authorities did not find hard evidence for overt collusion between the major oil companies, but proposes that intertemporal price discrimination may be the main motivation behind the arrangement. In their inquiry, the Norwegian Competition Authority did not make any comment on the price support system scrutinized in the present system.

In Ireland the competition authorities stopped a practice used by Statoil (The Irish Competition Authority, 2003), and in Denmark the authorities recently forced the headquarters not to use price support arrangements that limit the independent retailers' control of price decisions (The Danish Competition Authority, 2009). Given

that the Norwegian competition authorities have decided to use significant resources on investigating the retail gasoline market, what begs a question is why they use their effort to present alternative explanations for why the established practice *may* benefit consumers. They could simply have asked the oil companies to prove that the vertical restraints used and the publication of recommended prices benefit consumers.

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Appendix A – Data description

The first data set is a website-based panel data set (NWB). This is compiled using a large number of nationwide Norwegian stations covering the period from March 7, 2003 to April 4, 2005, where consumers reported prices via text messages or emails. The original data set had approximately 40,000 observations, but we reduced this to include only gas stations with at least 100 observations. The final sample comprised 26,823 observations in total. We have information on price, station, address, date and exact time of day. The NWB data are quite representative in terms of the main market brands. For instance, the four largest gasoline companies represent 83% of the

observations; over the same period, their market share was close to 95%. The big four have the following market shares in the NWB data: Esso 31.3%, Hydro-Texaco (now YX) 11.8%, Shell 14.1% and Statoil 25.5%. Their corresponding average market shares were 21.7%, 20.8%, 25.8% and 26.9% in 2004.[28] Thus, the share of automated stations in our sample is larger than their market share in the actual market, suggesting a downward bias in the average prices we observe. The distribution of observations across hours suggests a morning and afternoon hump, where approximately two thirds of the observations are reported between 06:00 and 12:00. Our 'noon-to-noon' days capture both humps every day. Only 2% of prices are reported during the night (00:00-06:00).

The other data set consists of collected time series of daily prices at a smaller number of local stations (LTS) for two periods of four to five months during 2005 and 2006, with 1,067 observations from seven stations, varying between 50 and 312 daily prices. The prices were collected in the afternoon. The stations are as follows.

Table A1 The LTS dataset gasoline stations

Name	*Brand*	*Data periods*	*Address*
NHH	Statoil	04.01.05–03.07.05, 17.10.05–15.03.06	Hellev. 34, 5042 Bergen
Askøy	Statoil	04.01.05–23.05.05	Ravnanger, 5310 Hauglandshella
Nesttun	Statoil	17.10.05–15.03.06	Nesttunv. 91, 5221 Nesttun
Nadderud*	Statoil	25.02.06–15.03.06	Nadderudveien 55, 1357 Bekkestua
Nesttun	Shell	17.10.05–15.03.06	Nesttunv. 87, 5221 Nesttun
Askøy	Hydro-Texaco	04.01.05–23.05.05	Davanger, 5310 Hauglandshella
Tertnes	Hydro-Texaco	04.01.05–23.05.05	Botnane 1, 5119 Ulset

* Nadderud, a Statoil station in Oslo, is not local in the sense that it is not located in the Bergen area.

In addition, we used recommended prices from Statoil collected from their web page. To calculate input prices, we used Rotterdam prices 'Conventional Regular Gasoline,

[28] Source: The Norwegian Petroleum Industry Association.

Rotterdam (ARA)' and translated these into NOK using the daily exchange rate between USD and NOK. The environment tax on gasoline is constructed using figures from The Norwegian Petroleum Industry Association. Summary statistics for the two datasets are tabulated below.

Table A2 Summary statistics for retail and wholesale prices, tax and gross margins

	Obs.	*Mean*	*Std. Dev.*	*Min.*	*Max.*
2003 (NWB data)					
Price	10231	8.74	0.56	5.90	12.00
Rotterdam	10231	1.51	0.14	1.25	1.89
Tax	10231	4.64	0.00	4.64	4.64
VAT	10231	1.75	0.11	1.18	2.40
Gross Margin	10231	0.84	0.42	–1.36	3.46
2004 (NWB data)					
Price	13693	9.45	0.61	6.63	13.23
Rotterdam	13693	1.99	0.25	1.45	2.44
Tax	13693	4.72	0.00	4.72	4.72
VAT	13693	1.89	0.12	1.33	2.65
Gross Margin	13693	0.85	0.42	–1.63	3.55
2005 (NWB data)					
Price	2899	9.70	0.58	7.89	11.24
Rotterdam	2899	2.00	0.21	1.55	2.60
Tax	2899	4.85	0.01	4.81	4.85
VAT	2899	1.94	0.12	1.58	2.25
Gross Margin	2899	0.91	0.43	–0.49	1.82
2005/2006 (LTS data)					
Price	1067	10.49	0.53	8.95	11.57
Rotterdam	1062	2.43	0.29	1.86	2.99
Tax	1067	4.84	0.03	4.81	4.89
VAT	1067	2.10	0.11	1.79	2.31
Gross Margin	1062	1.12	0.33	0.66	1.70