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Gasoline prices jump up on Mondays: An outcome of aggressive competition?

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Gasoline prices jump up on Mondays: An outcome of aggressive competition?[Ψ]

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Abstract

This paper examines Norwegian gasoline pump prices using daily station-specific observations from March 2003 to March 2006. Whereas studies that have analyzed similar price cycles in other countries find support for the Edgeworth cycle theory (Maskin and Tirole, 1988), we demonstrate that Norwegian gasoline price cycles involve a form of coordinated behavior. Retail gasoline prices follow a fixed weekly pattern, where retail outlets all over Norway simultaneously increase their prices to the same level every Monday at noon. Consequently, the sharp price increase is tied to time rather than the current price level. The gasoline companies' headquarters publish a recommended price that *de facto* is a RPM arrangement towards the retail outlets. The vertical arrangement is industry-wide adopted, and is used to coordinate the time and the level for retail price increases among the big four gasoline companies. Monday changed from being the low-price day to becoming the high-price day almost 'overnight' in April 2004, and we empirically establish that the change corresponds to a significant jump in the gross margin.

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'Increases in local retail gasoline prices are set centrally in Oslo. When we receive the instruction on price increases on Mondays, we increase the price to the recommended price…We very seldom receive instructions on price reductions, thus it is the local market that decides whether prices should fall.'

Manager of a Hydro-Texaco outlet in Norway[1]

1. Introduction

All over Norway we observe gasoline price cycles that last exactly one week. Every Monday at noon, 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 on Monday morning.

A vertical arrangement, which *de facto* is a Resale Price Maintenance (RPM), is industry-wide adopted by the headquarters of the big four gasoline companies in Norway. The upstream headquarters use a maximum resale price restraint (labeled a recommended price)[2] tied with a profit-sharing scheme (labeled price support) that force the retail outlets to simultaneously raise their prices to the same level every Monday at noon. The big four gasoline companies have arrived at an outcome that seemingly suits all of them, and the arrangement is robust, allowing retail prices to adjust for changes in demand or cost conditions without triggering deviations. To show this we utilize two large data sets with daily station-specific observations of gasoline pump prices from 2003 to 2006. We also have detailed information about the vertical restraints used by the gasoline companies' headquarters towards their retail outlets.

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), Canada (Eckert, 2002, 2003, Eckert and West, 2004, and Noel, 2007a, 2007b) and Australia (ACCC, 2007 and Wang, 2008), among others. In contrast to our findings,

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[1] Ole Tofsrud, Trønderbladet (newspaper), December 7, 2004.

[2] The headquarters of each brand of gasoline decide the recommended prices, and the recommended prices are available on public websites. Recommended prices are observed used in several countries; e.g. Australia, (ACCC, 2007), Ireland (The Irish Competition Authority, 2003), Netherlands, Germany and Italy (Faber and Janssen, 2008).

the price cycles observed in other markets are typically significantly longer than a week, and they do not have a fixed duration like the Norwegian price cycles.[3]

The majority of these studies find empirical support for the notion that these cycles are the outcome of aggressive competition à la Maskin and Tirole's (1988) Edgeworth cycle theory.[4] In Maskin and Tirole (1988) firms successively undercut each other in a price war phase, until further undercutting becomes too costly. Then we have a war of attrition phase until one firm takes the burden and raises 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. 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.

The industry-wide adoption of an arrangement that every Monday simultaneously raise prices to the same level (the recommended price) makes the Norwegian price cycles distinctive. Moreover, after Easter 2004, we find a remarkable change in price fluctuations. Monday changed from being the low-price day to becoming the high-price day almost 'overnight'. Before April 2004, we also observed weekly cycles, but from March 2003[5] to April 2004, Thursday was the high-price day. We establish empirically that the change in price patterns was also profitable, with the gross margin increasing by as much as 14–23% on average.

The simultaneous Monday jump in retail prices is hardly consistent with some of the key assumptions in Edgeworth cycle theory. This suggests that there is more to Norwegian price cycles than aggressive competition. This begs the question as to why a coordinated restart on Mondays is profitable. We do not have a unique explanation, though intertemporal price discrimination may be a potential one. Informally, Eckert and West (2004) suggest that the price patterns observed in a period with a high price

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[3] Weekly price cycles have recently been observed in Australia, where Thursday is the high-price day (ACCC, 2007).

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

[5] Obviously, the pattern could have been present earlier, but our data only begin in March 2003.

succeeded by a period with a lower price may be used to price discriminate between shoppers and loyal consumers, as shown by Conlisk *et al*. (1984) and Sobel (1984), among others.

Noel (2007a) suggests that one of the reasons why it is improbable that collusion can explain price cycles is the complexity involved in the price patterns.[6] Coordination of price increases only on Monday afternoons is clearly a simpler form of price coordination. By using this simple coordination rule, the headquarters may put into practice a price structure that largely resembles what they would have done to undertake intertemporal price discrimination. During the first part of the week, prices will be high, while in the latter part of the week and during the weekend prices will be low. When we scrutinize on the vertical restraints between the major gasoline companies and their retail outlets we find features that may facilitate collusive behavior.[7]

As in other retail gasoline markets (see e.g. Shepard, 1993) there is a mixed ownership structure. Each of the big four gasoline companies in Norway has a combination of fully vertically integrated retail outlets and vertically separated retail outlets, and for the majority of retail outlets there is some degree of delegation of retail pricing. A vertically separated retail outlet will typically ignore the effect its own pricing decisions have on the other outlets. The upstream headquarters and the retail outlets may thus differ in their incentives to increase retail prices. The upstream headquarters may have stronger incentives to increase prices and restart the price cycles than each of the retail outlets. Consequently, the headquarters may use the coordinated practice of raising prices on Mondays as a device to internalize externalities among the retail outlets within the same chain.

The empirical studies closest in spirit to the current paper are Eckert and West (2004) and Noel (2007a), both of whom use daily retail prices from the Canadian market.

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[6] '*[S]etting up and policing a complicated system of differentially and fast-moving prices among hundreds of stations would be very difficult and require plenty of explicit communication.*' Noel (2007a, p. 17)

[7] Dutta *et al*. (2007) combine elements from the Coase-conjecture literature and the literature on repeated games, and show that there are equilibria with temporary price cuts (intertemporal price discrimination) where firms make higher profits than under uniform collusive pricing.

While consistent with Edgeworth cycle theory, Eckert and West (2004) and Noel (2007a) find evidence inconsistent with several alternative explanations, including day-of-the-week demand cycles, menu and inventory costs, rack price discounts, and collusion. The main distinction between our observations and those of Eckert and West (2004) and Noel (2007a) relates to the process when prices increase sharply. A recent study by Wang (2008) shows how phone activity by the market leader resets Edgeworth cycles in the Australian retail gasoline cartel. Some other empirical studies have considered weekly retail gasoline prices. 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.[8]

The rest of the paper is organized as follows. Section 2 presents details of the price cycle pattern in Norway. In Section 3, we describe how retail prices are determined. Sections 2 and 3 clearly indicate that the major upstream headquarters have established a focal point for when they increase prices to the recommended prices. In section 4 we discuss potential alternative explanations for the pattern observed. In Section 5, we further scrutinize the coordination process and present an empirical analysis of developments in the gross margin. Finally, Section 6 summarizes and concludes the paper.

2. Price cycles

2.1. 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.

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[8] 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 remaining 5.1% of the market was controlled by Jet (automated stations).[9] The market is thus highly concentrated, and there is a high degree of symmetry among the four major gasoline companies.

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.[10] In addition, we collected a time series (LTS) of daily prices from local stations for two periods of 4–5 months over 2005 and 2006.[11] This yielded 1,067 observations from seven stations, with daily time series of pump prices varying between 50 and 312 days.[12]

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.

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. The price changes for all stations and weeks for the LTS data are summarized in Table 1. There are potentially 149 observed prices where the Monday price can change, and as many as 117 (79%) price increases, with the

[9] Source: The Norwegian Petroleum Industry Association.

[10] Eckert and West (2004) use data on daily retail gasoline prices for the period July–December 1999 for 8 regions in the Vancouver metropolitan area. Analogous to our NWB data set, Eckert and West use data reported by consumers to a website (some 16,671 unique reports).

[11] Noel (2007a) uses daily pump prices from 22 stations over 131 days in Toronto in 2001; this corresponds to this LTS data set.

[12] In the LTS data, six stations are located in Bergen (Norway's second largest city) and one station in Oslo.

Figure 1 Weekly price and cost patterns based on the local time series (LTS) of average daily prices over seven stations collected between January 4, 2005 and March 15, 2006 (n = 1,067 (price), n = 1,062 (Rotterdam + tax), same pattern illustrated for four weeks)

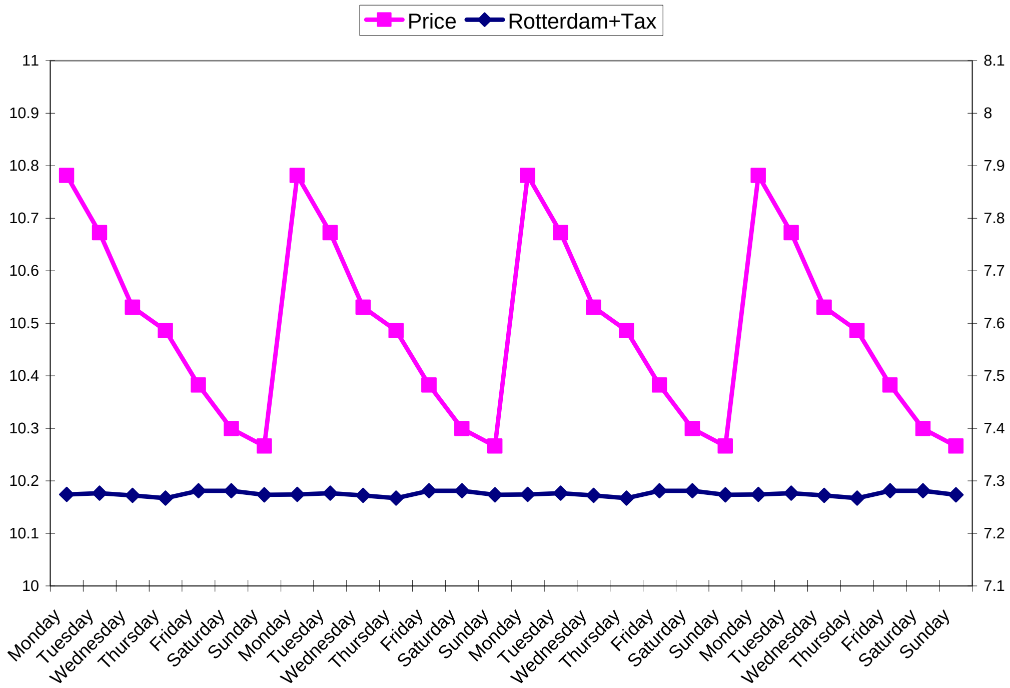

Table 1 Daily price changes across seven gasoline stations for the period January 4, 2005 to March 15, 2006 (n = 1,056)

	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%)

average price increase being quite high, with an average of 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 weekdays, amounting to 42% of the 907 potential days.

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 and is denoted '*AltDay1*'. However, in this dataset the price pattern changes after Easter 2004 from being highest on Thursdays to being highest on Mondays.

Figure 2 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)

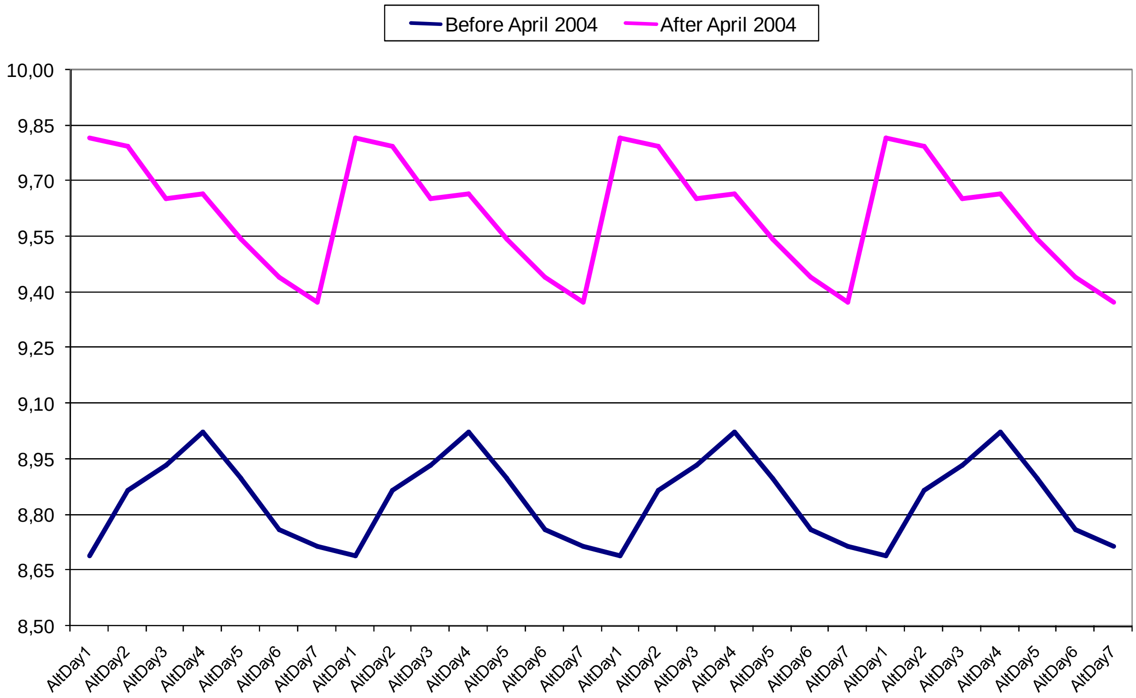

Figure 2 illustrates this for the period before and after April 2004. After Easter, we observe the same pattern as in the LTS data, whereas before Easter 2004, Thursdays were the high-price day.

In fact, in April 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 3. The figure shows a clear pattern whereby the Thursday price is predominantly higher than the Monday price before Easter 2004. After Easter 2004, the price is higher on Mondays. Figure 3 also suggests a return to the previous Thursday pattern over six weeks during the fall of 2004 (Monday 7 September–Sunday 25 October). This may relate to an increased awareness in the Norwegian print media of both the newly adapted Monday pattern and a significant increase in the wholesale price of gasoline.[13]

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 our 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). In Figure 4, 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. The only Monday where we do not observe a price increase is 28 March, which was holiday. In this case, the price instead increased according to the rule on the following Tuesday. Monday May 16th 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. We also observe six price increases on Thursdays. Five out of these follow the individual rule of NOK 0.02 above the recommended price. This pattern is hardly a coincidence. However, to analyze this in a more systematic

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[13] In the fall, attention to the weekly price pattern was particularly intense in the major newspapers. In late July, *Aftenposten* recommended to their readers "*not to fill their tanks on Monday afternoons.*" (July 28, 2004), and one day prior to the return to the old pattern, *Stavanger Aftenblad* pointed out that "*Gasoline is most expensive on Mondays.*" At the same time, the wholesale price continued to increase, and we found several entries on this in the major newspapers during the same period (*VG*, September 10, *NTB*, October 13, *Adresseavisen*, October 14, *Aftenposten*, October 13, *Stavanger Aftenblad*, October 14). By the end of 2004, however, retail gasoline prices above NOK10 had become 'everyday prices', and the attention given to gasoline prices in Norwegian newspapers returned to 'normal'.

Figure 3 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)

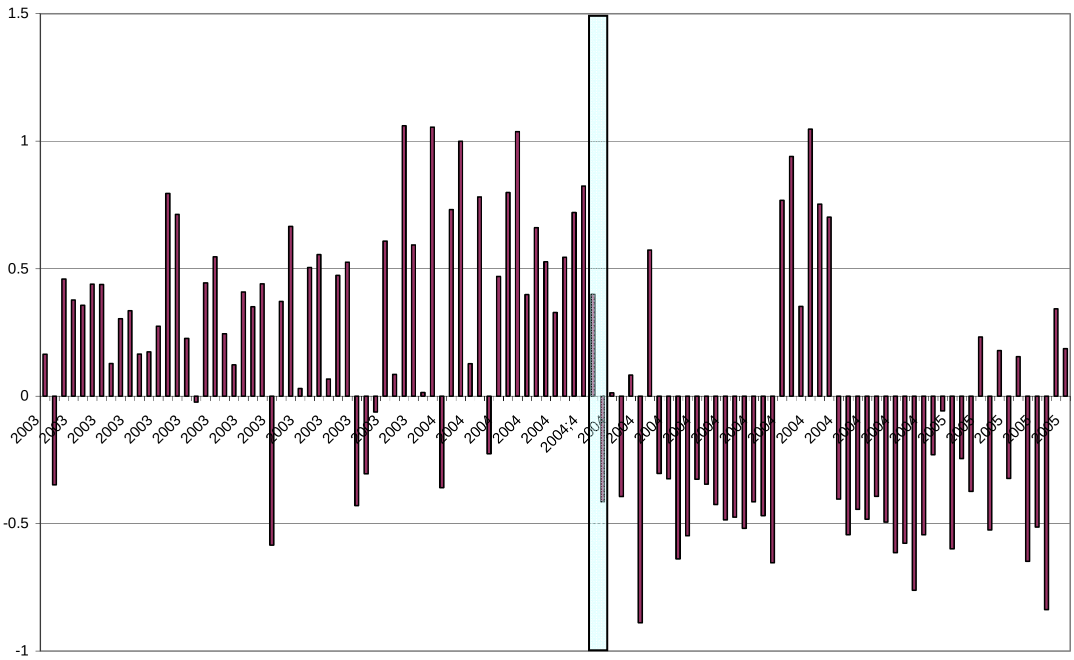
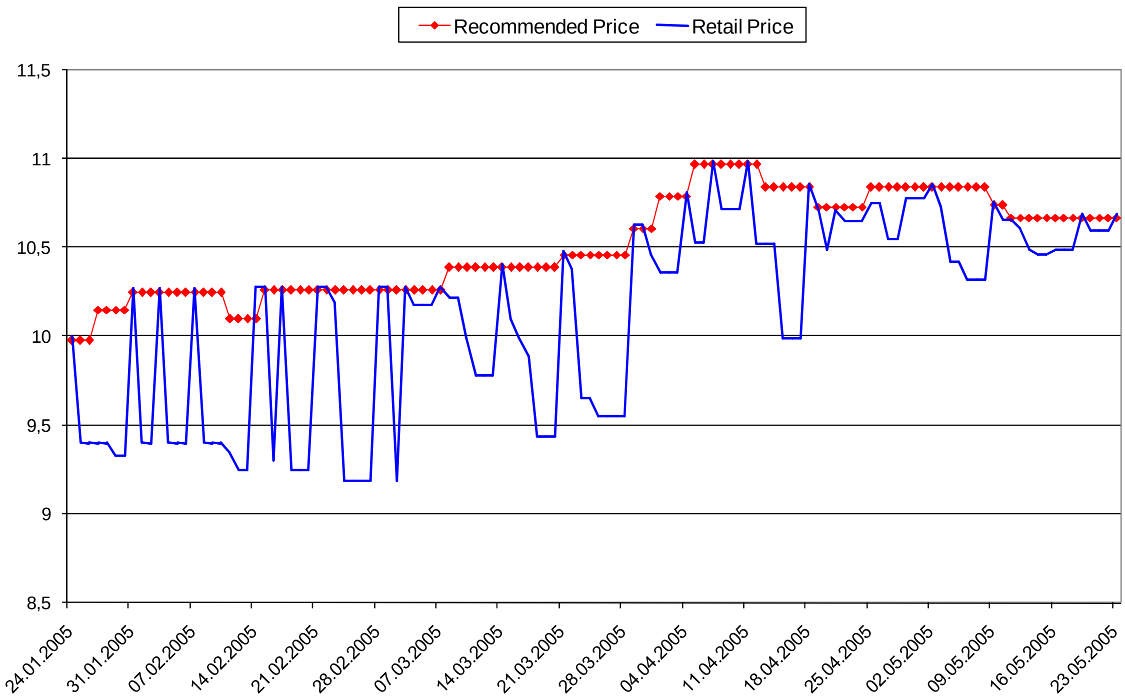
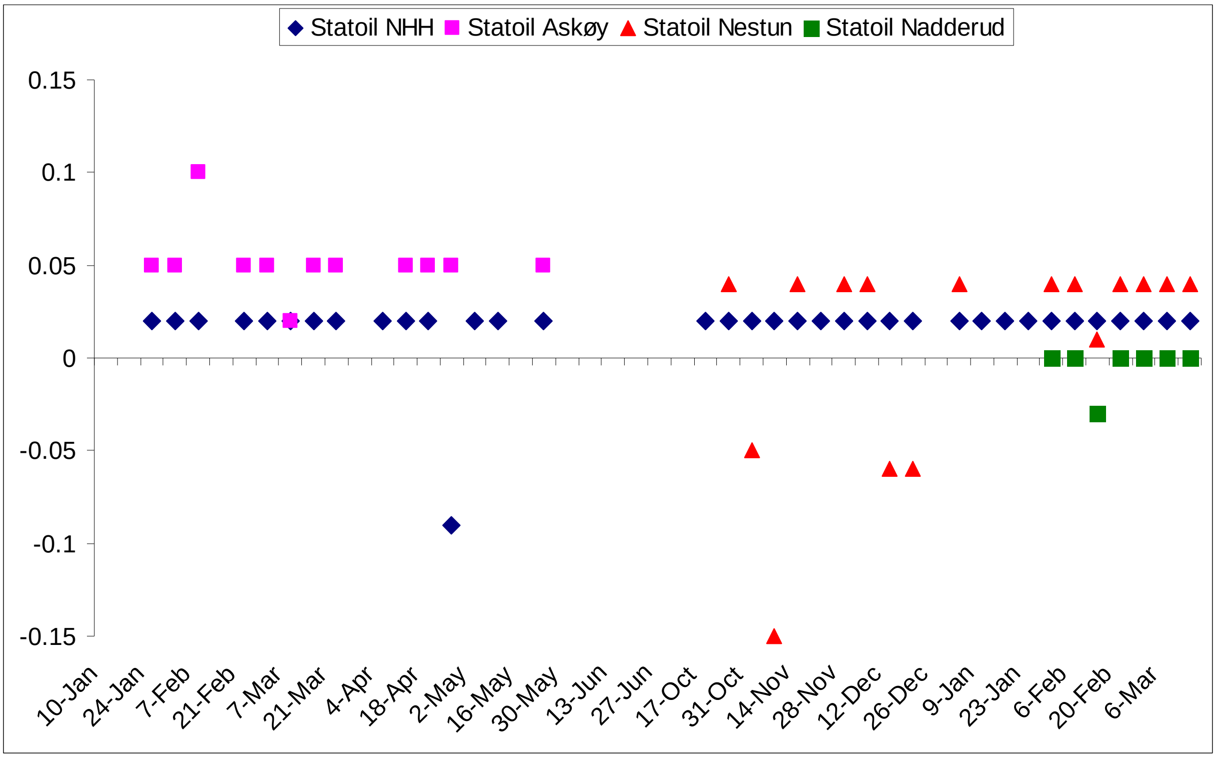


Figure 4: Daily gasoline prices, Statoil gasoline station, NHH, Bergen, January 2005 to May 2005, (n = 120)



manner, we looked at price differences for all Mondays where recommended prices are available, and compared these to the actual retail price in the LTS data. There are 71 Mondays on which we can compare prices, as shown in Figure 5. The pattern is quite striking, with a fixed link between the retail and recommended price on Mondays. Only in nine of the 71 weeks does the pattern deviate. Another thing that is clear from Figure 5 is that different gasoline stations have individual pricing rules. In sum, this appears to suggest that the different gasoline outlets have different pricing rules, but are all related in a fixed proportion to the recommended price. While we have only looked at Statoil stations, where comparisons have been made between recommended and retail prices, the recommended prices displayed at other company websites also appear to be highly correlated.[14]

Figure 5 Price differences between retail and recommended prices on Mondays at four Statoil gasoline stations for the period January 4, 2005 to March 15, 2006 (n = 71)



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[14] The companies only post today's recommended price. Therefore, we cannot find recommended prices for other companies retrospectively.

REMARK: We have also collected some more recent data that resemble the picture in Figure 5. For instance, for 13 Statoil stations and 8 YX stations (previously Hydro-Texaco) in Oslo we have pump prices at 8 am and 2 pm for three consecutive Mondays in April 2008. Thus, there are in total 63 Mondays where we can compare prices at 8 am and 2 pm. At 8 am there was a significant degree of price dispersion, and retail prices were set between NOK 0.29 and NOK 1.97 below the recommended prices. At 2 pm all the 63 observed prices were set above recommended prices, and in *58 of these 63 observations the pump prices were set exactly NOK 0.06 above the recommended price*.[15]

In sum, we can see a pattern of a fixed weekly price cycle whereby after April 2004 prices increase sharply every Monday and then fall during the week. We also have a clear indication in April 2004 of an 'overnight' shift in this weekly pattern. When prices are increased, they are increased according to the level of the recommended price (plus transportation costs). Hence, even though the Norwegian price pattern has similarities with findings elsewhere, some important distinctions remain to be understood.[16]

2.2. Econometric analysis

In this section, we introduce some simple econometric models in order to statistically test the descriptive findings. We begin by analyzing the NWB data set. Since we have

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[15] On Monday April 7, 2008, the recommended prices were 12.49 for both companies. At 8 am prices varied between NOK11.29 and NOK11.99. At 2 pm all the stations had raised their prices according to the recommended prices. In fact 12 out of the 13 Statoil stations and 5 out of 8 YX stations had raised their retail price to NOK12.55; i.e. NOK0.06 above the recommended price. On Monday April 14, 2008, the recommended prices were NOK12.49 (Statoil) and NOK12.57 (YX). At 8 am the retail prices varied between NOK10.79 and NOK12.11, while at 2 pm all except one of the Statoil stations had raised the price to NOK0.06 above the recommended price (NOK12.55 for the Statoil stations and NOK12.63 for the YX stations, respectively). The last Monday we observed, April 21, 2008, the recommended prices stayed the same as the previous Monday. At 8 am prices varied from NOK10.52 to NOK12.28, while at 2 pm all the 21 stations followed the same rule; NOK0.06 above the recommended price (NOK12.55 for the Statoil stations and NOK12.63 for the YX stations, respectively).

[16] In Figure 2, we also see that the price cycles prior to April 2004 had fewer similarities with the predictions of Edgeworth cycle theory. Prices changed gradually both before and after the higher priced day (Thursday) and prices were at their lowest level on Mondays. We wish to show that the pattern after April 2004 is partly the outcome of a coordinated process, as against the price cycles prior to April 2004. We do however employ the observation that there was an abrupt change in the price pattern in 2004 in order to dismiss alternative explanations for the observed pattern after April 2004.

an unbalanced panel with a large number of gasoline stations, we make some simplifications. First, to account for potential regional differences, we regionalize the data set into ten regions, permitting the inclusion of dummy variables. Second, we cannot impose an autoregressive process, since we have a significant number of consecutive observations for only a few stations. Consequently, we estimate the following model:

$$\begin{aligned} (1)\quad & P_{i,t} = \beta_{TAX} TAX_t + \beta_{Rotterdam} Rotterdam_t + \beta_{Trend} Trend_t \\ & + \sum_{d=1}^{6} \phi_d AltDay_{d,t} + \sum_{r=1}^{10} \lambda_r^{REGION} REGION_{i,r} + \sum_{b=1}^{7} \delta_b Brand_{i,b} + \alpha + \varepsilon_{i,t} \end{aligned}$$

In the regional panel model, we have 10 region dummies (*REGION*)[17] and 7 brand dummies (*Brand*).[18] 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 weekly retail price cycle is controlled for using 6 dummies (*AltDay*) for days (noon to noon), with Monday and Thursday as the reference days.

The results are presented in Table 2. We first estimated both models in (1) with a trend, but since this turned out to be significant only for the period prior to April 2004, we omitted the trend for the second half of the data set. Both tax and the wholesale variables are significant and positive for both periods. The results suggest a weak negative trend prior to Easter 2004. The brand dummies are significant in 12 of 14 cases. The four majors all have positive parameters ranging from 0.074 to 0.128, whereas the lower-priced automated stations, as expected, have negative parameters (between –0.173 and –0.102). This suggests that there is an average price differential between majors and automated stations of NOK 0.17–0.30. In addition, the regional

[17] The 10 regions are (number of observations in parentheses): Oslo West (3,242), Oslo South (2,408), Oslo North (4,884), Akershus North (2,853), Vestfold/Buskerud (3,622), Østfold (2,825), Trondheim (2,444), Bergen (849), Sogn and Fjordane & Møre and Romsdal (754), Rural areas (2,410).

[18] We included 8 brands (number of observations in parentheses): 4 majors; Esso (8,382), Hydro-Texaco (3,167), Shell (3,791) and Statoil (6,831), and 4 automat companies; JET (1,973), UnoX (830), SMART (1,584) and REMA (265). We assign dummies to the first seven.

dummies are significant (in 9 of 10 instances), indicating the presence of regional price differences and that prices are at their highest in rural areas.[19] The explanatory power is reasonably high, even though we were unable to incorporate an autoregressive process into the model.

Table 2 Empirical results for gasoline price models using web-based panel data (n = 26,823)

	Prior to 04:2004			*After 04:2004*		
Tax	1.831	***	(0.172)	0.818	***	(0.079)
Rotterdam	1.428	***	(0.026)	0.873	***	(0.019)
AltDay1	-0.342					
AltDay2	-0.160	***	(0.012)	–0.055	***	(0.014)
AltDay3	-0.103	***	(0.012)	–0.201	***	(0.014)
AltDay4		***	(0.012)	–0.151	***	(0.014)
AltDay5	-0.213	***	(0.016)	–0.281	***	(0.018)
AltDay6	-0.323	***	(0.022)	–0.351	***	(0.023)
AltDay7	-0.295	***	(0.012)	–0.430	***	(0.014)
Esso	0.112	***	(0.035)	0.132	***	(0.047)
Hydro-Texaco	0.128	***	(0.036)	0.151	***	(0.048)
JET	–0.102	***	(0.036)	–0.052		(0.049)
Shell	0.074	**	(0.036)	0.098	**	(0.048)
Smart	–0.103	***	(0.037)	–0.029		(0.051)
Statoil	0.089	***	(0.035)	0.197	***	(0.047)
UnoX	–0.173	***	(0.040)	–0.146	***	(0.054)
Oslo West	–0.532	***	(0.027)	–0.224	***	(0.045)
Oslo South	–0.862	***	(0.018)	–0.212	***	(0.017)
Oslo North	–0.654	***	(0.017)	–0.062	***	(0.021)
Akershus North	–0.798	***	(0.016)	–0.229	***	(0.017)
Vestfold/Buskerud	–0.601	***	(0.017)	–0.169	***	(0.019)
Østfold	–0.639	***	(0.017)	–0.292	***	(0.018)
Trondheim	–0.745	***	(0.018)	–0.382	***	(0.019)
Bergen	–1.031	***	(0.017)	–0.639	***	(0.019)
Sogn/Møre	–0.490	***	(0.025)	–0.238	***	(0.026)
Rural areas	–0.135	***	(0.024)	–0.021		(0.031)
Trend	–0.001	***	(0.00005)			
Constant	–0.971		(0.777)	4.253	***	(0.387)
N	14 746			12 077		
R^2	0.456			0.313		

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

[19] There could be potential local market effects that are unaccounted for by the regional dummies. When we estimated the models including dummy variables for the 116 stations in our sample, the results did not change.

Turning to the weekly cycles, we find results that are in accordance with the average prices reported earlier. Prior to April 2004 *AltDay4*, Thursday, is the high-price day. The price on Thursday is significantly higher than on all the other days. When looking at the weekly pattern after April 2004, the reference day (Monday) is the high-price day, with all *AltDay* dummies being significant and negative, and generally increasing in magnitude (negative) until Sunday. The predicted difference between Sunday and Monday is as much as NOK 0.43.[20]

3. Price determination[21]

At the retail level the big four companies have a combination of fully vertically integrated retail outlets and vertically separated retail outlets. For the majority of retail outlets there is some degree of vertical separation and delegation of retail pricing. 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.

For the customers there are no differences between a vertically separated and a vertically integrated retail outlet. We now scrutinize on the vertical restraints imposed on vertically separated retail outlets to show how the (upstream) headquarters *de facto* instruct a given retail pump price at least for some part of the week.

Let c be the channel's input price per litre 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

[20] The more recent LTS-data are modeled and estimated in Appendix B. This shows a clear pattern of Monday as the high-price day, mirroring the results found for the NWB-dataset after April 2004.

[21] This section is based on interviews with retail outlet managers and press articles. In particular, we also have copies of faxes and communication information between headquarters and retailers provided anonymously by some of these retailer managers.

scheme towards the downstream firm. The first part of the scheme specifies a maximum RPM, which *de facto* is 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. The maximum RPM (p^{rp}) then prevents double marginalization. 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 over the week.

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 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 scheme is withdrawn, the retailer will have the margin $p-w^{rp}$. 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 scheme is not available (the maximum RPM is binding).

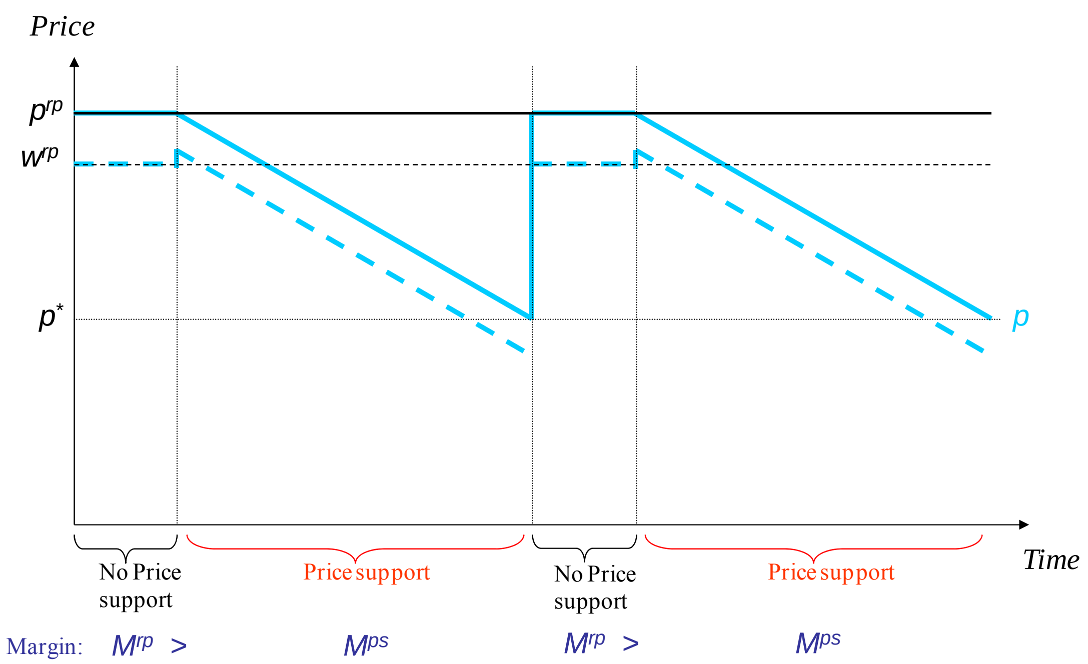
The main ingredients in the profit-sharing scheme described here correspond to what is found in other gasoline markets by The Irish Competition Authority (2003) in Ireland and by ACCC (2007) in Australia.[22] However, the profit-sharing arrangements used in Norway have some distinctive features. These 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. 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

[22] 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.

arrangements appear distinctive in the way that price support is granted and withdrawn on regular basis on given weekdays. Monday has emerged as a focal point for when the upstream firms (the big four) withdraw the price support scheme. On Monday morning all the big four upstream firms inform their retailers through a fax that the price support system will be removed from twelve noon until 5 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 is put into effect again on Monday evening. This is illustrated in Figure 6.

Figure 6 An illustration of the RPM arrangement



Suppose that a retailer's pump price on Monday morning is $p^*=p< w^{rp}$. As long as the price support scheme is present, 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.[23] 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 noon on Mondays, and the restraint may be regarded as an RPM (at least in the periods where the price support scheme is withdrawn).

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 (almost) simultaneously increase pump prices to the recommended prices. The timing may also be crucial. At noon on Mondays, after the morning peak, the loss of sale from increasing the price to the recommended price, say, one hour before the rival, will be limited. Since this is off-peak hours, and all firms have raised prices well before afternoon peak hours, the firms in reality raise prices simultaneously. By its very nature, this makes the system robust. There are also several features that facilitate the detection of deviations. The fact that prices are increased to recommended prices is common knowledge. As mentioned in the Introduction, the recommended prices are made public at the upstream firms' websites. Furthermore, the period before the price support scheme is put into effect again helps players to monitor that rivals do not deviate from the established common practice.

For the part of the week where the price support scheme is present, the control of the retail prices is seemingly in the hands of the retailer outlets. There are, however, more elements in these arrangements that limit the retail outlets' control of the end-user prices.

First, the price support scheme includes a price floor. When the price floor is reached, the retailer needs to ask the (upstream) headquarters for permission to reduce the price further. If permission is not given, the price support scheme is withdrawn (and the retailer would get a significant negative margin). The price floor varies according to local competition level but is typically maximum NOK 1.50-2.00 below the recommended price, and thus the price floor is above the input price c.

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

Second, some 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 headquarters then "propose" a new price, but the price support scheme (M^{ps}) is given on condition that the retailer follows the "proposed" price. When such contracts are present, the upstream headquarters in reality determine the pump prices (RPM) throughout the week (also when the price support schemes are in force).[24]

Third, some retail outlets are *classified as being outside price war zones* (see discussion below). These outlets are not part of the price support scheme at all, and they therefore charge the recommended price throughout the week. A manager of a retail outlet explains the following to her local newspaper:[25] *The companies (headquarters) say that we have no competition, and we get no price support to reduce the prices. I am forced to charge the recommended price every day.*

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 for that upstream headquarters are choosing contracts with strong incentives and less direct control when retail outlets' unobservable effort is important.[26] A common problem for the upstream headquarters is that RPM is not allowed towards vertically separated outlets.[27] 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.[28]

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

[25] Anne-Lise Nordsæther (retail outlet manager) to *Sør Trøndelag* (newspaper), 23.09.2005.

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

[27] The definition of what constitutes RPM has subsequently narrowed in both the US and in Europe. The European Commission provides a safe harbor (block exemption) for maximum RPM for firms with market shares below 30%. Minimum RPM is still a hardcore restraint that takes the agreement outside the safe harbor. In the United States the US Supreme Court overruled the nearly one-hundred-year-old per se ban on RPM in June 2007 (Leegin Creative Leather Products, Inc. v. PSKS, 2007). Like other vertical restraints, resale price maintenance in the US is now judged by the rule of reason. For overviews, see Overstreet (1983), Mathewson and Winter (1998) and Motta (2004). The

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

4. Alternative explanations

The description of how retail prices are determined strongly indicates that the major oil companies have established a focal point for when they simultaneously increase prices to the recommended prices. In the present section we analyze whether the jump in prices on Mondays is consistent with alternative explanations as the Edgeworth cycle theory, demand variations, and input price variations.

4.1. The Edgeworth cycle theory

A distinctive feature of the Norwegian cycles is that it is the time rather than the current price level that triggers the sharp increase in retail prices on Mondays. This is not consistent with the war of attrition phase in Maskin and Tirole. However, Noel (2007a) suggests that fluctuations in weekly demand may have an impact on when firms relent in the Edgeworth cycle model. Firms are more likely to relent on a given day (period) with low demand, when the loss from being the initiator of a new cycle is lower than when demand is higher. If demand is particularly low on Mondays around noon, a fixed duration of the price cycles may be consistent with the war of attrition phase in the Edgeworth cycle theory. This explanation does not fit with the change in the pattern during April 2004. Furthermore, demand is most likely at its lowest level during off-peak hours on Saturdays and Sundays, but initiations of new cycles are not observed during the weekends.[29]

Extension of Maskin and Tirole by Eckert (2003) and Noel (2007b, 2008) show that large firms are most likely to initiate price increases and small firms are most likely to initiate price reductions. A large firm may evolve into a price-leader position, but firms will still move sequentially. As with Maskin and Tirole's model with symmetric firms, size asymmetries cannot explain the observed regular duration

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

[29] According to, e.g., Per Vangen (Statoil), their stations have their highest sales on Fridays, and their lowest during the weekend, with a gradual increase during the week (source: Dinside, March 12, 2002).

where all retail outlets increase their prices to the same level every Monday. Furthermore, in the Norwegian market the big four major oil companies are more or less symmetric players.

Finally, as described in Section 3, the headquarters send faxes to their retailers in order to instruct them to raise pump prices about noon on Mondays. Typically, these faxes are sent from the headquarters well before the prices actually jump about noon.[30] Thus, in reality, all the 1800 retail outlets in Norway simultaneously raise their prices to recommended prices on Mondays. Consequently, the simultaneous increase of retail prices to the same level (given by the recommended prices) is inconsistent with the predictions from the Edgeworth cycle theory.

4.2. Demand fluctuations

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 in demand on one day followed by six days with small reductions in demand (see also discussion in Noel (2007a).[31]

4.3. Input price variation

In Figure 1, we showed the average weekly pattern in retail price and taxes plus the Rotterdam spot price. It is difficult to observe a weekly pattern in the cost components. Table A4 in the Appendix summarizes the decomposition of the retail price for the LTS data.[32] The LTS data suggest a weekly average of NOK 7.28 with a

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[30] The faxes are for instance sent from different headquarters during the night between Sunday and Monday, specifying which prices are to be set at noon next day, a practice that can hardly be reconciled with sequential behavior.

[31] Notwithstanding the lack of quantity data, we still have two sources of information on weekly demand patterns. First, we searched Norwegian newspapers and found indications that: (i) demand is lowest on weekends, and (ii) demand is either constant or increases slightly from Monday to Friday. Second, if we assume that the response frequency of prices in our NWB data set relates to how often people fill up with gasoline, we find a somewhat similar pattern (see Table A3 in the Appendix).

[32] As much as 66% are taxes, whereas the wholesale price only amounts to 23% of the retail price. Eleven percent remains as gross margin for the gasoline station to cover wages, rent, etc. Except for value-added tax (VAT) which shifts according to the retail price, tax is fixed, and wages and rent are clearly unlikely to change over the week. Hence, the only candidate remaining to explain weekly variation is the Rotterdam spot price.

weekly deviation smaller than NOK 0.01. Thus, a potential weekly cost pattern (if any) can barely explain a price pattern with a deviation of NOK 0.52 in the retail price. In sum, this means that the pattern we observe in retail prices more or less directly translates into the gross margin – a 5% cycle over the week in retail prices translates to a 37% cycle in the gross margin (See Figure A1 in the Appendix). Finally, analogous to Noel (2007a), we dismiss the explanation that gasoline inventories at the retail stations influence retail prices.[33]

5. Collusive behavior

5.1. Factors that facilitate collusion

Four quite symmetric firms dominate the Norwegian gasoline market.[34] Furthermore, as identified in Sections 2 and 3 the major gasoline companies have established noon on Monday as focal point for when all retail outlets are induced to simultaneously increase pump prices to the recommended prices. As described in Section 3, all the four major firms inform their outlets through a fax on Monday morning that the price support scheme is withdrawn from noon. Since the rule *de facto* instructs a given retail price at noon on Mondays, the restraint may be regarded as RPM.

Three out of the four major firms (Statoil, Shell and YX) make the recommended price publicly available on their website.[35] Until 2005 Shell's recommended price was published on the Norwegian Petroleum Industry Association's website.[36] This information was removed after pressure from the competition authorities, but the companies are still permitted to post the information on their individual websites.

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[33] We questioned gasoline station managers and were told that the oil companies, who can read local station consumption with an automatic meter, controlled the filling of their tanks, and after optimizing on logistics (trucks), continuously filled the station tanks. This took place 2–3 times per week, and involved the delivery of 43,000 liters (a full truck) on each occasion.

[34] Apart from Jet the automated stations in the Norwegian market are owned by the major brands. Barla (2000) find empirical support that symmetry facilitates collusion in the airline industry. See e.g. Compte, Jenny and Rey (2002) for theoretical support for the outcome that symmetry helps collusion.

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

[36] 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 pm, and the Norwegian Petroleum Industry Association announced the new price the next morning. Source: the Norwegian Petroleum Industry Association.

Even if recommended prices are posted on public websites, there are no benefits to consumers, and recommended prices appear to be made public primarily to increase transparency among competitors and facilitate potential horizontal coordination (see discussion by Motta (2004) and Kühn (2001)). When the recommended price is publicly available to rivals, it becomes easy for the various headquarters to monitor each other, and the publicly available recommended price facilitates the detection of deviations from the rule.[37]

Within competition policy, it has often been argued that price restraints, and in particular RPM, could facilitate horizontal agreements. This argument was informally used by Telser (1960), but has only recently been formalized by Jullien and Rey (2007), who show that RPM may facilitate the detection of deviations. In the case at hand, the role of recommended prices appears to make it easier for firms to detect whether rivals defect from coordination on Mondays as the high-price day.

In sum, the information exchange arrangement described in Section 3 is 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 big four oil companies have arrived at an arrangement that seemingly suits all of them, and the arrangement also allows retail prices to adjust for changes in demand or cost conditions without triggering deviations.

Our main attention is towards the process regarding the abrupt jump in prices on Mondays. There are some additional features that may facilitate tacit collusion throughout the week. In Section 3 we described how the headquarters require that the retail outlets frequently collect price information from a given number of rival outlets (*marker stations*), and this may obviously allow for timely punishment. Moreover, as

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[37] In a very recent working paper, Faber and Janssen (2008) argue that 'suggested' (recommended) prices in Netherland are used to coordinate retail gasoline prices across Dutch gasoline stations. To show this they estimate a reduced form price model based on daily web-collected gasoline prices (Rotterdam spot prices, retailer prices and the oil-companies' suggested prices) across Netherland over a two-year period. In Norway recommended prices seldom change more than once a week, and then almost always on Mondays resetting the Norwegian cycle. On the contrary, in Netherland the oil companies apparently post 'suggested' prices on the web that fluctuate much more frequently, and some of them send faxes to retailers on updated 'suggested' prices whenever these change. Interestingly, the Dutch data show no weekly pattern.

described in Section 3, some independent retail outlets report the price information to the headquarters, the headquarters then provide a new (and now individual) "recommended" price to the retailer. If the retailer does not follow this "advice", the price support will be withdrawn. Such contracts will thus *de facto* imply that RPM is used throughout the week. If such contracts are widely adopted in some local markets, this may facilitate tacit collusion also when price support schemes are present. Such a restraint seems to correspond to what was stopped in Ireland (The Irish Competition Authority (2003)).[38]

5.2. Why coordinate on Monday as the high-price day?

We do not put forward a unique explanation for the observed coordination on Monday as the high-price day, but propose that intertemporal price discrimination may be one explanation. 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). A potential hypothesis that brings together seemingly competing explanations of the observed price patterns is the following. Assume that at the outset we have local competition between retail outlets in accordance with Edgeworth cycle theory. By creating a coordinated restart every Monday, we have a period with relatively high prices at the beginning of the week, and lower prices towards the end of the week. Consequently, a simple coordination rule that restarts price cycles on Mondays may be sufficient to implement a price structure that largely introduces intertemporal price discrimination between consumers that differ in their willingness/ability to wait.

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. Consumers are then assumed to differ in their reservation price, as well as in their willingness to wait. Low-value consumers will be more willing to wait for price

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[38] The concern was that the system most likely reduced undercutting incentives and facilitated tacit collusion (The Irish Competition Authority, 2003). Even if there was no industry-wide adoption of the system like in Norway, the authorities in Ireland were concerned that the recommended price was a clear focal point that could be a facilitating device to achieve and sustain tacit collusion.

reductions than high-value consumers. We may analogously interpret the willingness to wait as the cost of inventorying. 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, though people with a higher usage cannot.

Sobel (1984) extends Conlisk *et al.* (1984) to the case of competition. As in Conlisk *et al.* (1984), the high-value consumers have a higher reservation price and are less willing to wait than low-value consumers. Moreover, high-value consumers have higher searching costs, and they buy from a given preferred retailer as long as the price is below the reservation price. Put differently, the high-value consumers are locked in. The low-value consumers are shoppers that buy from the retailer with the lowest price. Retailers then charge a high price in the initial phase of the cycle. When the aggregate number of shoppers becomes sufficiently large, it becomes profitable to reduce the price and serve the shoppers. These models assume durable goods in the sense that either consumers have the ability to wait or they have inventory capacity. This is mostly inconsistent with gasoline retailing due to the length of the observed cycles (see Hosken *et al*., 2007, 2008). However, when the cycles are exactly a week, a large fraction of the consumers has the opportunity to shift consumption from one day of the week to another. [39] The choice of Monday as the focal day for price increases is also consistent with intertemporal price discrimination. 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.[40,41]

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

[40] Another reason to use Monday as the high-price day is that there may be a peak load problem. The demand is higher during the weekdays compared with the weekend. If we assume the stations have scarce capacity (e.g., the number of pumps), the price pattern may also be a peak load pricing device.

The effects for the consumers are ambiguous. A weekly pattern will reduce uncertainty, and shoppers may take advantage of the price cycle and move their purchase to the weekends. However, as mentioned above, when the low-price days are during the weekend, by its very nature a large portion of the consumers are less prepared or able to adapt their purchasing pattern to the price cycle.

As a complement to our analysis of the price data, we undertook opinion surveys among customers while they were filling up with gasoline.[42] In 2006, more than two-thirds of consumers were not aware of any weekly pattern of gasoline prices. The surveys were administered between one and two years after the pattern with price increases on Mondays was established in the market. This suggests that at least a large fraction of consumers is less price sensitive than is often assumed in retail gasoline markets. Furthermore, the pattern is subtle enough that less price sensitive consumers might not observe it and adapt to a low-price days filling pattern.[43]

As mentioned in Section 3, some retail outlets are classified as being *outside price war zones,* and these outlets are induced by the headquarters to set a uniform retail price that equals the recommended price throughout the week. This is seemingly inconsistent with the intertemporal price discrimination theories emphasized above, since these theories (e.g. Conlisk et al, 1984) predict that also a monopolist will use

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However, this peak load problem will vary across different stations, while the observed weekly cycle is found throughout Norway. Thus, we do not believe that the main motivation behind the coordination process is the peak load problem.

[41] A large fraction of utility drivers use diesel cars. Thus, one may argue that these do not matter for gasoline pricing anyway. However, diesel prices show a similar weekly pattern (www.din.side.no).

[42] The survey was conducted using two of our local gasoline stations, Tertnes and NHH, and was undertaken on both Monday and Thursday afternoons of four different weeks in the period April/June 2005 and March/April 2006. In total, we received responses from 474 gasoline customers.

[43] We have focused on consumers being heterogeneous in their willingness to wait. Salop (1977) shows that a monopolist may practice price discrimination between informed and uninformed consumers by offering a distribution of prices. Several papers extended Salop's model to a competitive environment, but in these extensions price discrimination occurs across firms rather than at the firm level. A competitive version where each firm provides multiple prices has not been explored (Stole, 2007). The survey findings indicate that consumers also differ according to their information about prices and price patterns. Only 41% of customers check the price sign when entering the station, and only 38% have some notion of a weekly price pattern. Of the latter group, 43% thought that Monday was the high-price day. As expected, customers who check the price sign are also better informed as to the weekly price pattern.

price discrimination. However, in the case at hand, the location of these outlets is such that the fraction of price-sensitive consumers (shoppers) is low. The headquarters may then want to induce such outlets to serve only high-value consumers. One example is a retail outlet located close to a mountain pass. In one direction, this outlet faces local competition, but in the other direction, the next rival is on the other side of the mountain pass. The outlet is forced by the headquarters to charge the recommended price throughout the week, and thereby charge a high price to less price-sensitive consumers. This observation also indicates that the level of the recommended price equals the cartel price for serving the locked-in (high-value) consumers.

Another rationale behind the coordination among the headquarters may be that the upstream headquarters and the retail outlets differ in their incentives to increase retail prices. A vertically separated retail outlet will typically ignore the effect of its own pricing decisions on other outlets within the same chain. Consequently, the headquarters may use the coordinated practice of raising prices on Mondays as a device to internalize externalities among the retail outlets within the same chain.

In order to be a plausible strategy, the coordination process on price jumps on Mondays should be profitable for the major companies. Given the lack of quantity data, we will look at developments in the gross margin before and after the change in pattern in 2004. Before we specify an econometric model, we focus somewhat more closely on what happened in 2004. In Table 3, we present summary statistics on some of the key variables.

The average gross margin across all 26,823 observations is NOK 0.85. If we examine the simple average, it is marginally lower (0.83) prior to April 2004 and marginally higher (0.89) after April 2004. Since the gross margin covers costs, this increase of 7.7% may be due to cost increases (wages, rent, etc.) and it is therefore difficult to conclude anything from these figures. Thus, in Table 3 we also present summary statistics for the one hundred days before and after the shift.

Over a period of six months within the same year, it is difficult to discern whether the cost components covered by the gross margin should change significantly. The retail price increases from NOK 9.14 to 9.73 between 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. However, when we look at the gross margin it has still increased between these two periods by as much as NOK 0.11, or 13.5%, on average. Thus, it appears that some of the price increase was used to obtain higher margins.

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

|	*Number of station price observations*	*Mean*	*Standard Deviation*	*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

* Before Easter 2004 is the period 07:03:2003–27:04:2004.

** After Easter 2004 is the period 28:04:2004–08:04:2005.

However, considering averages does not allow us to control for changes in costs and the weekly price pattern. Thus, we use the web-based panel data set (NWB) to specify a simple econometric gross margin model. This model has the same form as the price model in (1) except that we now use the full data set and introduce a shift dummy that accommodates the change in the price pattern.

$$\begin{aligned} & MARGIN_{i,t} = \beta_{TAX} TAX_t + \beta_{Rotterdam} Rotterdam_t + \beta_{Trend} Trend_t + \theta D_t^{SHIFT} \\ (2) \quad & + \sum_{d=1}^{7} D_t^{SHIFT} \cdot \phi_d^{shift} AltDay_{t,d} + \sum_{d=1}^{7} \phi_d AltDay_{t,d} \\ & + \sum_{r=1}^{10} \lambda_r^{REGION} REGION_{i,r} + \sum_{b=1}^{7} \delta_b Brand_{i,b} + \varepsilon_{i,t} \end{aligned}$$

The shift dummy (D_t^{SHIFT}) takes a value of 0 for the period 'prior to Easter 2004' (07:03:2003–26:04:2004), and 1 for the period 'after Easter 2004' (27:04:2004–08:04:2005). Including the interactions with the daily dummies permits the weekly pattern to change before and after Easter. The shift dummy also measures whether the margin changed after April 2004.

The results are presented in Table 4, and are much in line with what we found in the price models in Table 2. The weekly pattern does change from Thursday to Monday as the high-price day,[44] and whereas the wholesale price has a negative impact on the gross margin, tax has an opposite effect. The latter can be a trend correlation effect, since we find the trend to be slightly (but significantly) negative (the correlation between *Trend* and *Tax* is as high as 0.86).[45] [46] When we look at the shift dummy, it comes in significantly positive, concluding a substantial increase of NOK 0.20 in the weighted average margin when controlling for week pattern, costs and trend. Directly translated, this means that the average gross margin went up by as much as 23% after April 2004.[47]

Our survey data clearly show that a significant fraction of consumers have spent some time learning the new pattern.[48] Before all of these customers have had time to adapt to the new pattern, the companies increase their sales on higher priced days, thereby increasing their average margin. However, since we do not have sales figures, we cannot calculate the increase in margin, though it would add to the figures presented here. Thus, our estimated margin increase very likely underestimates the full margin effect for companies from the change in the weekly price pattern.

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[44] The week dummies are actually insignificant prior to April 2004, whereas they are highly significant after April 2004. If we exclude the trend variable, they also become significant prior to April 2004. Note also that to find the weekly price pattern after April 2004, we have to calculate the sum of ϕ_d^{shift} and ϕ_d for the respective days. These follow a clear pattern, with Monday as the high-price day followed by gradually decreasing prices. The respective figures are Monday (–0.11), Tuesday (–0.16), Wednesday (–0.28), Thursday (–0.24), Friday (–0.36), Saturday (–0.40) and Sunday (–0.45).

[45] The majors have a higher margin than the automated stations of between NOK0.11–0.24 (13–28%). However, they also have higher costs. The regional dummies are all significant, and stations in rural areas have the highest margins, though they also bear the highest transport costs on their gasoline supplies. If we exclude the trend variable, the tax variable as with the wholesale price, becomes negative and significant (See Table A5 in the Appendix).

[46] In addition, we estimated a model with station-specific dummies. The results are in line with the results using the regional dummies.

[47] If we exclude the trend, the estimated shift parameter is lower (0.12), but still suggests an increase of 14% in the average gross margin.

[48] In the 2005 surveys, 13% of consumers thought that Monday was the high-price day. By 2006, this figure had increased to 23%.

Table 4 Empirical results for gross margin model, web-based panel data (n = 26,823)

	Coefficient	*Standard Error*
D_t^{SHIFT}	0.198***	(0.025)
AltDay 1	–0.441	(0.325)
AltDay2	–0.294	(0.325)
AltDay3	–0.244	(0.325)
AltDay4	–0.166	(0.325)
AltDay5	–0.302	(0.326)
AltDay6	–0.402	(0.326)
AltDay7	–0.409	(0.325)
$\text{AltDay1} \cdot D_t^{SHIFT}$	0.326***	(0.026)
$\text{AltDay2} \cdot D_t^{SHIFT}$	0.139***	(0.026)
$\text{AltDay3} \cdot D_t^{SHIFT}$	–0.031	(0.026)
$\text{AltDay4} \cdot D_t^{SHIFT}$	–0.073***	(0.026)
$\text{AltDay5} \cdot D_t^{SHIFT}$	–0.057**	(0.029)
$\text{AltDay6} \cdot D_t^{SHIFT}$		
$\text{AltDay7} \cdot D_t^{SHIFT}$	–0.044*	(0.026)
Trend	–0.0004***	(0.00003)
Tax	0.383***	(0.071)
Rotterdam	–0.176***	(0.011)
R^2	0.262	
N	26823	

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

6. Summary and conclusions

We use daily station-specific observations of gasoline pump prices from a large number of Norwegian stations from March 2003 to March 2006. Whereas studies that have analyzed price cycles in other countries have concluded that aggressive competition a la Maskin and Tirole (1988) is the driving force, we show that the Norwegian pattern distinguishes itself from what has been found elsewhere in that (i) the cycle lasts exactly one week, (ii) all the 1800 retail outlets present in the Norwegian market simultaneously increase their pump prices to the recommended price posted by the major oil companies' headquarters at noon on Mondays, and (iii) there has been a change from Thursday to Monday as the high-price day during our observation window. Because of these characteristics, it is natural to question whether the price jumps that now take place every Monday are the result of some form of collusive behavior process, rather than the result of fierce competition.

The information exchange arrangement helps players both at the upstream and downstream level to detect deviations from the rule. The big four gasoline companies have arrived at an outcome that seemingly suits all of them, and the arrangement also allows retail prices to adjust for changes in demand or cost conditions without triggering deviations. In sum, the arrangement has shown to be remarkably robust.

Communication about prices, which provides commitment value and more information to consumers about retail price differences, may very well be welfare enhancing (see for example 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. This suggests that it is important to make such communication as difficult as possible. This would make it significantly more difficult/costly to coordinate a focal day and a focal level for price increases across companies. Noel (2007a) suggests that one of the reasons why it is improbable that Edgeworth cycles can be explained by collusion is the complexity involved in price patterns. What we observe in the Norwegian market is, instead, the coordination of price increases on Monday afternoons. This is clearly a simpler form of price coordination.

We emphasize that a regular weekly price cycle may reduce uncertainty for consumers. Price-sensitive consumers may take advantage of the price cycle and move their purchase to the weekend. The fact that Monday has changed from the low-price day to the high-price day implies that retail prices are at their lowest level during the weekend, when less price-sensitive business customers are not present in the market. When the low-price days are during the weekend, by its very nature a large portion of the consumers are less prepared or able to adapt their purchasing pattern to the price cycle. This may make the current arrangement particularly profitable for the big oil companies, but at the same time make it less likely that the present price cycles will benefit consumers in aggregate.

Importantly, we do not question empirical support for the Edgeworth cycle rationale found in several other markets. Our message is, rather, that while we observe price fluctuations that look very much like Edgeworth cycles in Norway, closer examination indicates alternative rationales. Consequently, policy makers and others should be cautious when drawing the conclusion that observation of these cycles is an indication of a market with aggressive price competition.

As a response to the first version of the present paper (Foros and Steen, 2008) the Norwegian Competition Authority initiated a limited inquiry into the Norwegian gasoline market during spring 2008. The inquiry confirms our findings that retail pump prices for 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.

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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 11.8%, Shell 14.1% and Statoil 25.5%. Their corresponding average market shares for the period were 21.7%, 20.8%, 25.8% and 26.9% in 2004.[49] Thus, we have a larger share of automated stations in our sample than their market share in the actual market, suggesting a downward bias in the average prices we observe.

The other dataset consists of collected time series of daily prices at a smaller number of local stations (LTS) for two periods of 4–5 months during 2005 and 2006, with 1,067 observations from 7 stations, varying between 50 and 312 daily prices. The prices were collected in the afternoon. The stations are as follows.

Table A1

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, Rotterdam (ARA)' and translated these into NOK using the daily exchange rate

[49] Source: The Norwegian Petroleum Industry Association.

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 in the two data sets

	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

Table A3 Response frequency in the NWB data set (March 2003 to April 2005, n = 26,823)

	Frequency	*Percent*
Monday	5 027	18.74
Tuesday	4 959	18.49
Wednesday	4 817	17.96
Thursday	4 892	18.24
Friday	5 000	18.64
Saturday	1 112	4.15
Sunday	1 016	3.79
Total	26 823	

Table A4 Gasoline price decomposed into its main cost components (price, tax and Rotterdam prices) averages for the LTS data (n = 1,067)

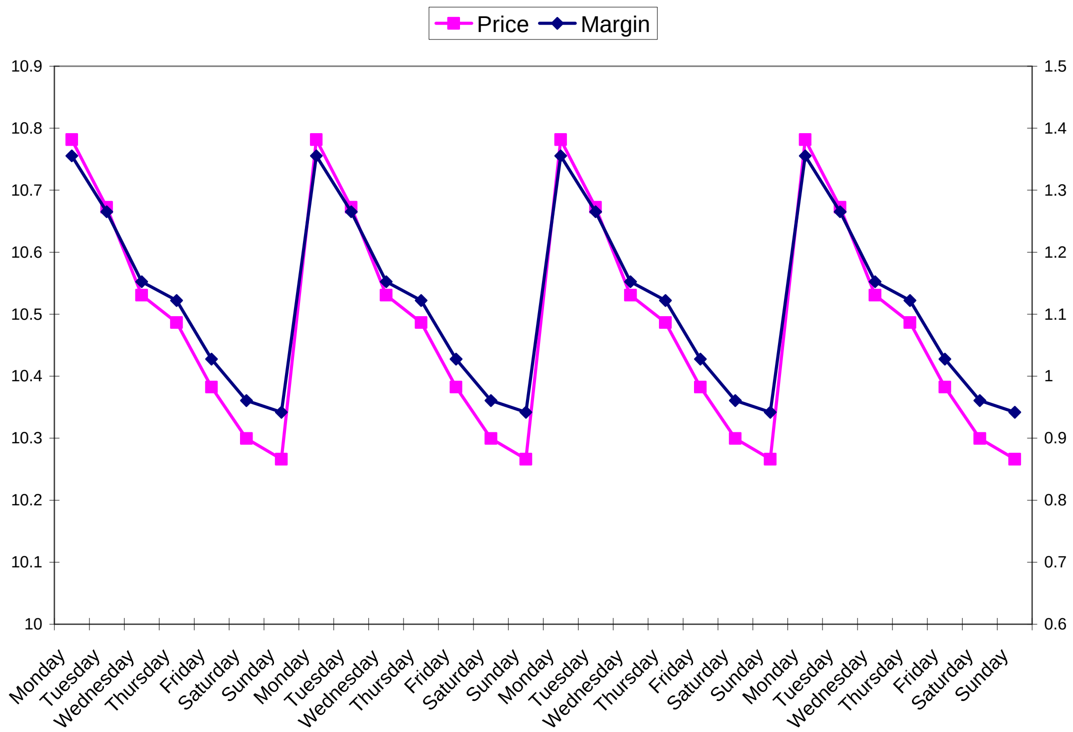
	Value	*% of Price*
Price	10.49	100%
Tax	4.84	46.1%
VAT	2.10	20.0%
Rotterdam price	2.43	23.2%
Gross Margin	1.12	10.7%

Table A5 Brand and regional dummy results for the gross margin model, web-based panel data (n = 26,823)

	Coefficient	*Standard Error*
Esso	0.103***	(0.023)
Hydro-Texaco	0.120***	(0.024)
JET	–0.058***	(0.024)
Shell	0.072***	(0.024)
Smart	–0.041*	(0.025)
Statoil	0.117***	(0.023)
UnoX	–0.119***	(0.026)
Oslo West	–0.292***	(0.019)
Oslo South	–0.398***	(0.010)
Oslo North	–0.307***	(0.011)
Akershus North	–0.418***	(0.009)
Vestfold/Buskerud	–0.312***	(0.010)
Østfold	–0.370***	(0.010)
Trondheim	–0.451***	(0.011)
Bergen	–0.659***	(0.011)
Sogn/Møre	–0.292***	(0.015)
Rural areas	–0.033**	(0.015)

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

Figure A1 Weekly price and margin pattern based on the local time series of average daily prices over seven stations collected between January 4, 2005 and March 15, 2006 (n = 1067 (price), n = 1,062 (Rotterdam + tax), same pattern illustrated for four weeks)



Appendix B – Econometric evidence for the local time series (LTS) data

The local time series data allow us to specify a dynamic model that also accounts for serial correlation in the gasoline prices. However, we start by specifying a static model, and extend this with different autoregressive processes. In the dynamic models, the retail price today is modeled as a function of yesterday's retail price and that of seven days ago (P_{t-1} and P_{t-7}). Price is assumed to depend on tax. We model the tax effect through two dummy variables; the first (*TAX05*) takes a value of 1 for the period after April 1, 2005, and the second (*TAX06*), takes the value of 1 for all 2006 observations.[50] We also control for changes in the wholesale price (*Rotterdam*) and potential brand effects (*Brand*)[51] through dummy variables, and include a separate dummy for our two stations at Nesttun (*Nesttun*) which are very closely located and compete more fiercely than any of our other 7 gasoline stations.[52,53] The weekly gasoline cycle is controlled for using six daily dummies (*Day*) where Monday is the reference day. The models we estimate are various versions of:

$$P_{i,t} = \gamma_1 P_{i,t-1} + \gamma_7 P_{i,t-7} + \beta_{TAX05} TAX05_t + \beta_{TAX06} TAX06_t + \beta_{Rotterdam} Rotterdam_t$$
$$+ \sum_{i=1}^{6} \phi_i Day_i + \beta_{Nestun} Nesttun_i + \sum_{j=1}^{2} \delta_j Brand_{i,j} + \alpha + \varepsilon_t$$

The results are presented in Table 1B. In column (i), a static model is presented where both lagged price variables are omitted. While the static model fits the data reasonably well, it fails to survive the autocorrelation tests. In column (ii), we also include the lagged price, and we can see that the model both improves in explanatory power and has far less autocorrelation in the error term. However, the Box-Pierce test still suggests some autocorrelation for station 1. Since we observe a weekly pattern in

[50] The environmental tax was changed twice during the sample period, on April 1, 2005 and on January 1, 2006.

[51] We have three brands represented by Statoil (4 stations), Hydro-Texaco (2 stations) and Shell (1 station). Statoil is specified as the reference category, so we only include dummies for Hydro-Texaco and Shell.

[52] The Nesttun stations consist of a Statoil station and a Shell station that are located on the same highway with a common exit, both with clearly visible price signs when drivers enter the exit. The location of the stations is also discussed in Appendix A.

[53] Box-Pierce tests of autocorrelation are performed for each individual station. Since we have two periods of data for one of our stations, we conduct separate Box-Pierce autocorrelation tests for each, giving eight Box-Pierce test results.

prices, we therefore extend the AR(1) model with $P_{i,t-7}$, as presented in column (iii). The autocorrelation reduces marginally, but we still have some autocorrelation remaining. Thus, the dynamic models in columns (ii) and (iii) are our preferred models. Their statistical properties are generally good, with an explanatory power of between 0.73–0.74 percent and autocorrelation rejected for 6–7 of the 8 stations. We also estimated the models by including a linear trend, but it was not significant.

The Rotterdam price impacts significantly and suggests that the pass-through from changes in the wholesale price in the very short run is low, but closer to one in the long run ($Rotterdam^{lr}$).[54] The TAX dummies are positive, but are only significant for the 2005 dummy. This is not surprising, as only very small changes in tax level were imposed in the sample period, and therefore the variation in price due to tax changes is very low. The competition dummy (*Nesttun*) is negative for all three models, but significant only in models (i) and (iii), suggesting a retail price that is, on average, between NOK 0.04 and NOK 0.09 lower. The brand dummies are not significant in any of our models, suggesting only minor brand effects.[55]

Turning to the dummies representing the potential price cycle, the same clear and significant weekly pattern in prices as shown in Figure 1 is confirmed using the econometric model. Prices are, on average, between NOK 0.50 and 0.54 higher on Mondays compared with Sundays. Prices fall gradually over the week from Tuesday towards the weekend, and every Monday prices again increase abruptly. Thus, the weekly price pattern we established in section 2.2 for the NWB data also exists in our local time series data for 2005 and 2006.

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[54] If we test whether the long-run parameter is equal to one, we fail to reject the null hypothesis at approximately the 1% level.

[55] An alternative would have been to include separate station dummies and estimate a fixed effects model. However, this would not allow the inclusion of both brand dummies and the Nesttun dummy, since the three sets of dummies would be highly correlated. However, we also estimated the models with fixed effects station dummies and the results did not change.

Table B1 Empirical results for gasoline price models using local time series data

	Static model (i)	*Dynamic model (ii)*	*Dynamic model (iii)*
tax05	0.636***	0.253***	0.226***
	(0.042)	(0.039)	(0.044)
tax06	0.042	0.00007	0.014
	(0.031)	(0.027)	(0.027)
Rotterdam	0.479***	0.281***	0.227***
	(0.077)	(0.066)	(0.067)
Tuesday	–0.111***	–0.404***	–0.378***
	(0.037)	(0.034)	(0.035)
Wednesday	–0.257***	–0.493***	–0.461***
	(0.037)	(0.033)	(0.034)
Thursday	–0.294***	–0.442***	–0.425***
	(0.038)	(0.032)	(0.033)
Friday	–0.422***	–0.533***	–0.494***
	(0.038)	(0.032)	(0.034)
Saturday	–0.505***	–0.567***	–0.532***
	(0.038)	(0.032)	(0.034)
Sunday	–0.526***	–0.536***	–0.503***
	(0.037)	(0.031)	(0.034)
Nesttun	–0.090***	–0.043	–0.059**
	(0.032)	(0.027)	(0.027)
Shell	–0.019	–0.009	–0.008
	(0.038)	(0.032)	(0.031)
Hydro-Texaco	0.013	0.01	0.013
	(0.026)	(0.022)	(0.022)
$Price_{t-1}$	0.551***		0.510***
	(0.026)		(0.027)
$Price_{t-7}$			0.086***
			(0.025)
Constant	9.163***	4.280***	3.938***
	(0.162)	(0.268)	(0.354)
R^2	0.631	0.74	0.734
n	1062	1052	996
$Rotterdam^{lr}$		0.625***	0.561***
		(0.147)	(0.168)
Box-Pierce, station 1	13.594	8.037	7.354
Box-Pierce, station 2	36.010	0.068***	0.019***
Box-Pierce, station 3	18.239	0.778***	0.002***
Box-Pierce, station 4	45.577	0.542***	0.368***
Box-Pierce, station 5	78.884	5.348*	6.879
Box-Pierce, station 6	51.486	2.638***	4.664**
Box-Pierce, station 7	56.376	0.123***	0.011***
Box-Pierce, station 8	6.694*	1.002***	1.097***

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