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

BY

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

Discussion Paper NHH SAM 04/2008

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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. We also show that gasoline prices follow a fixed weekly pattern, with prices increasing significantly every Monday at noon, and that gasoline companies appear to use the recommended price as a coordination device with a fixed link between the retail and recommended prices. Moreover, the weekly pattern changed in April 2004; whereas Thursday had been the high-price day, Monday now became the high-price day. The price–cost margin also increased significantly after the weekly pattern changed in April 2004.

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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…It is very seldom that we 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

We use daily station-specific observations of gasoline pump prices from a large number of Norwegian stations from March 2003 to April 2005. Consumers reported prices to a website. In addition, we collected time series of daily prices at a smaller number of stations for two periods of 4–5 months during 2005 and 2006. In sum, and after analyzing in the order of 28,000 price observations, the short message to consumers in Norway is, “*Don’t fill your tank on Monday afternoon.*”

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 (Wang, 2005, 2006), among others. 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.

In contrast to other analyses of daily data, we find that the cycle period is exactly one week. Since April 2004, prices have, almost without exception, increased sharply at noon on Mondays. Prices then gradually decline over the week (with a few exceptions), and are at their lowest level on the weekend and Monday morning. The day of the week then triggers the sharp increase in prices, rather than the lower boundary of prices. After Easter 2004, we find a remarkable change in price fluctuations. Before April 2004, we also observed weekly cycles, but from March 2003[2] to April 2004, almost all stations had their highest weekly price at noon on Thursdays. Moreover, before April 2004, Monday was the low-price day. Hence, Monday changed from being the low-price day to the high-price day almost ‘overnight’. We do not have quantity data, but because of the shift in the focal day for

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

[2] Of course, the pattern could have been present earlier, but our data only begins in March 2003.

price increases in 2004 and other general information about the demand pattern, the hypothesis that there is a day-of-the-week demand cycle appears implausible. As in previous analyses of daily retail gasoline prices (Eckert and West, 2004, and Noel, 2007a), we rule out fluctuations in the wholesale price as a cause of the price cycles observed.

Maskin and Tirole (1988) show that these asymmetric cycles, labeled Edgeworth cycles owing to Edgeworth (1925), may arise from intense competition where firms have an incentive to undercut each other in order to achieve an immediate and large increase in market share. They then 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 assumes 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.[3]

The price reductions we observe in the Norwegian daily retail pump prices from Monday afternoon to the following Monday morning are consistent with the undercutting phase in the Edgeworth cycle model. Retail outlets decide their retail prices, and have an incentive to undercut each other. However, scrutiny shows that the fixed pattern of repeated weekly price increases on Mondays is hardly consistent with some of the key assumptions in Edgeworth cycle theory. As mentioned earlier, it is the day of the week rather than the level of prices that initiates new cycles, and the focal day for price increases has shifted from Thursday to Monday.

Finally, while we observe local competition among retail outlets that set retail prices independently during the week, we find a striking fixed link between retail pump prices and the recommended price after prices have increased on Mondays. The headquarters of each brand of gasoline decide the recommended prices.[4] What

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[3] Eckert (2003) and Noel (2007b, 2006) show that Edgeworth cycles in equilibrium are not restricted to a symmetric duopoly with homogenous goods, as assumed by Maskin and Tirole (1988). Eckert (2003) and Noel (2007b) allow for different firm sizes, and show that smaller firms (independent brands) have greater incentive to undercut equal prices than larger firms (major brands). Noel (2006) shows Edgeworth cycle theory is robust with respect to some degree of product differentiation and different assumptions about aggregate demand elasticities.

[4] In the Norwegian market, the big four companies have a combination of fully owned retail outlets and franchisees. Franchise managers as well as fully owned outlets appear to have substantial autonomy

apparently happens is that local Edgeworth cycle competition takes place, but stops every Monday with a coordinated price increase. When combined with the shift in the high-price day in 2004, this suggests there is more to Norwegian price cycles than aggressive competition. We thus observe that companies appear to harmonize Monday as the high-price day. Furthermore, we find indications that the change in price patterns was profitable, with the gross margin of gasoline stations increasing after the change in the weekly pattern in April 2004 by as much as 14–23% on average on weekdays.

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 one potential one. Informally, Eckert and West (2004) suggest that the price patterns observed in a period with a high price 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. These models assume durable goods in the sense that consumers have the ability to either wait or possess inventory capacity. Dutta *et al*. (2007) generalize the standard repeated game model and allow for consumers who are long lived and forward looking. They thereby combine elements from the Coase-conjecture literature and the literature on repeated games. Dutta *et al*. find that under certain circumstances, there are equilibria with temporary price cuts where firms make higher profits than under uniform collusive pricing. We may consider these equilibriums as intertemporal price discrimination.

Noel (2007a) suggests that one of the reasons why it is improbable that collusion can explain price cycles elsewhere is the complexity involved in price patterns.[5] What we observe in the Norwegian market is a coordination of price increases only on Monday afternoons. This is clearly a simpler form of price coordination that encompasses both strong local competition and centrally coordinated prices. By using this simple coordination rule, the headquarters may put into practice a price structure that largely

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with respect to their decisions on retail prices and following local rivals. In 2006, 37% of retail outlets were franchises (source: Norwegian Petroleum Industry Association).

[5] ‘*[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)

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 weekends prices will be low.

We establish that different stations have an individual pricing rule that they strictly follow according to the recommended price. Communication about prices, which provides commitment value and more information to consumers about retail price differences, may well be welfare enhancing. However, in the case at hand, it is difficult to see these efficiency effects from the 'public' announcement of recommended prices. There is no benefit to consumers, and recommended prices are made public primarily to increase transparency among competitors and facilitate potential horizontal coordination. Even if the company headquarters are not allowed to post recommended prices on public websites, they may still give information about recommended prices to their own outlets. However, a ban on the public announcement of recommended prices may make it significantly more difficult/costly to coordinate a focal day and level for price increases across companies.

The paper is organized as follows. Section 2 presents details of related empirical studies and the observed price cycle pattern in Norway. In Section 3, we descriptively and econometrically establish the cycle pattern, and dismiss demand and cost shifters as potential explanations for the pattern observed. In Section 4, we show how recommended prices are employed as a coordination device to decide the price level every Monday and present an empirical analysis of developments in the gross margin. Finally, Section 5 summarizes and concludes the paper.

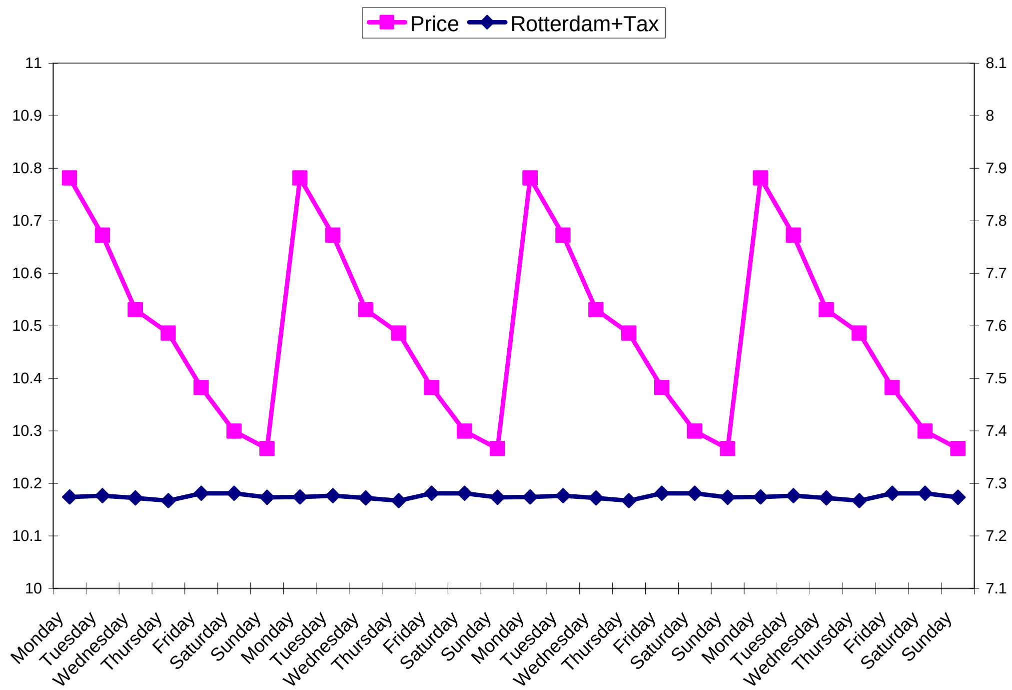
2. Norwegian price cycles and a comparison with previous studies

2.1. Price cycles in the Norwegian retail gasoline market

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 (via text messages or emails) reported prices. 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. 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. This yielded 1,067 observations from seven stations, with daily prices varying between 50 and 312 days.[6]

The NWB and LTS data sets are complementary in the sense that, whereas the web-based data allows us to examine a wider set of stations over a longer time period, the local data 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.

Figure 1 Weekly price and cost patterns based on the local time series 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), illustrated for four weeks)



The average daily prices over all seven local gasoline stations are illustrated in Figure 1. Clearly, the price is at its highest on Monday before gradually returning to its lowest level over the week. The difference between Monday and Sunday is NOK0.52, compared to the weekly average price of NOK10.49 (about 5%). The pattern has clear

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

similarities to an Edgeworth cycle pattern, except that the cycle appears to repeat itself over a fixed seven-day pattern.[7]

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%)

Figure 1 presents the average price changes. 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 average price increase being quite high, with an average of NOK0.68. 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, but there are as many as 384 price reductions on other weekdays, amounting to 42% of the 907 potential days. On the remaining weekdays, we observe no price changes.[8] The price decreases are also lower in magnitude than the price increases, ranging from NOK0.16–0.31 on average between Tuesday and Sunday.

[7] The pattern is for prices collected between January 4, 2005 and March 15, 2006, with prices collected every afternoon.

[8] Decreases predominantly take place from Tuesday to Friday, accounting for 44–57% of potential cases. On weekends, some action also takes place, but once again these are overwhelmingly price decreases.

This suggests a clear pattern, with prices showing increases on Mondays and then gradually decreasing over the remaining weekdays.

We now turn to the NWB data, where we find an identical pattern. 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 highest on Mondays.

Figure 2 Weekly price pattern based on web-based panel data where days are defined from noon to noon, showing the series of daily prices, and averages per day per year (n = 26,823, illustrated for four weeks)

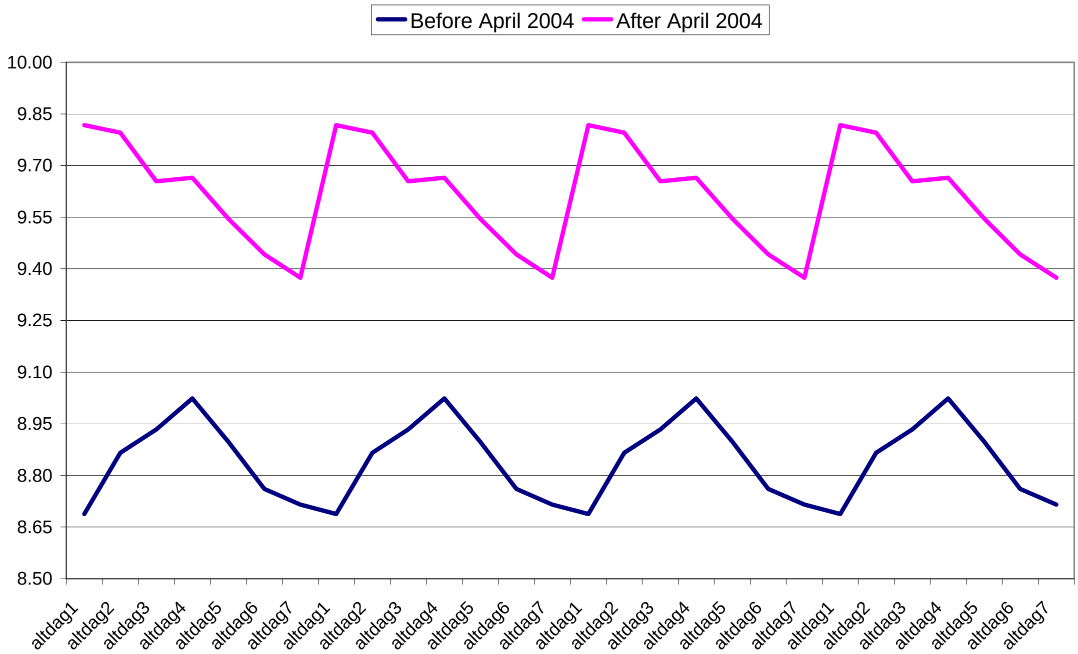


Figure 2 illustrates this for the period before and after April 2004. After Easter, we observe the same pattern as in the LTS data, whereas before Easter 2004, Thursdays were the high-price day.[9] Finally, it is worth noting that the biggest change in the pattern before and after April 2004 is that Monday changes from being the low-price day to the high-price day. We clearly have a pattern shift, but from Figure 2 it is not

[9] Yet another interesting feature is that the amplitude of the weekly cycle increases significantly. Prior to April 2004, the difference between the highest and lowest price day was NOK0.33, whereas after April the difference is as high as NOK0.44, an increase of 32%. This is in line with what we observed in the more recent LTS data, where the amplitude was NOK0.52.

obvious that this happens on a certain date. 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 but after Easter, the price is higher on Mondays. We see this very same pattern in our more recent time series data.[10] 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.[11]

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 a shift in this weekly pattern. Hence, even though the Norwegian price pattern has similarities with findings elsewhere, some important distinctions remain to be understood.[12]

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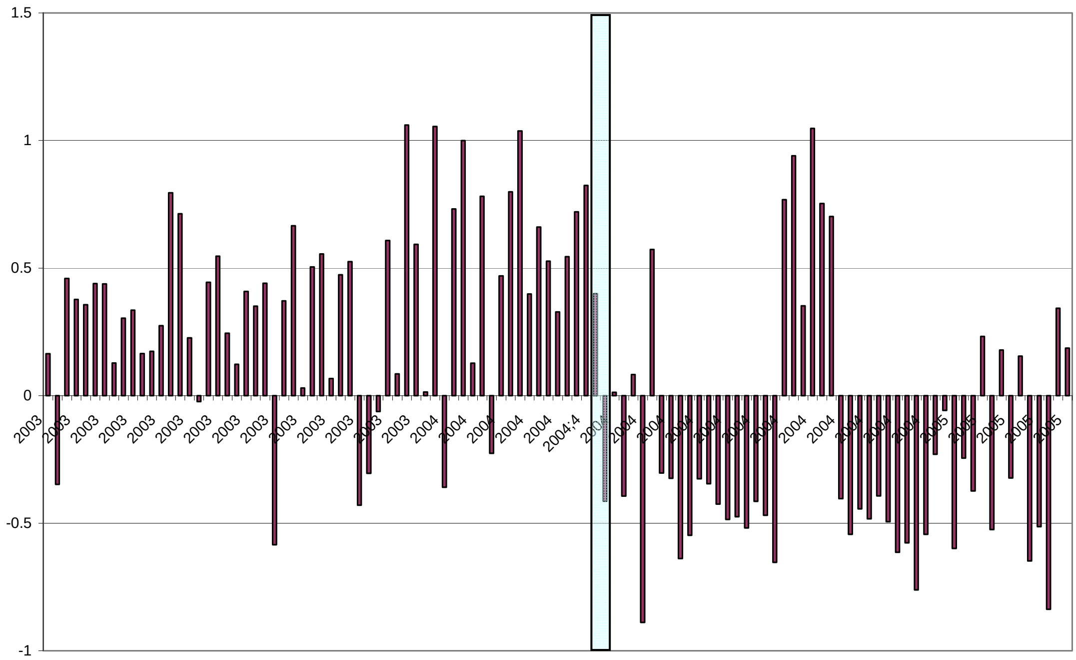
[10] To better understand this pattern shift, we systematically went through the major Norwegian newspapers from 2004. Interestingly enough, the wholesale price of gasoline increased significantly towards the end of March 2004 and retail prices reached the 'symbolic' upper price limit of NOK10 per liter for the first time. For instance, in Dagbladet, a major newspaper: "*We are approaching NOK 10 per litre with express speed; the increasing international gasoline prices affect retail prices also in Norway.*" (Dagbladet, March 23). Other articles on gasoline pricing also appeared during this period, e.g. in *VG*, February 26, *Nordlys*, March 8 and *Nordlys*, March 9.

[11] In the fall, attention to the weekly price pattern again increased 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'.

[12] 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 change gradually both before and after the higher priced day (Thursday) and prices are 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 employ, however, the observation that there was an abrupt change in the price pattern in 2004 to dismiss alternative explanations for the observed pattern after April 2004.

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 where days are defined as noon to noon, (n = 26,823, area marked is April 2004)



2.2. Comparison with previous studies of retail price cycles

The studies closest in spirit to the current paper are Eckert and West (2004) and Noel (2007a), both of whom find support for the Edgeworth cycle explanation. 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, they use data reported by consumers to a website (some 16,671 unique reports). Noel (2007a) uses daily pump prices from 22 stations over 131 days in Toronto in 2001; this corresponds to our LTS data. While consistent with Edgeworth cycle theory, Noel (2007a) finds 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. We show that the Norwegian price cycles are exactly one week, and identify a change in the weekly pattern from Thursday to Monday as the high-price day. As shown below, we also find evidence of a coordinated process whereby prices on Mondays jump to a level displaying a fixed relationship to the recommended prices set by the majors' headquarters. A recent study by Wang (2006) shows how phone activity by the market leader resets Edgeworth cycles in the Australian retail gasoline cartel.

Some other studies have also 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 we focus on in the present analysis cannot be discovered using weekly data.[13]

3. Empirical analyses of Norwegian price cycles

There are several candidates for explaining the weekly pattern observed. In particular, we consider potential demand and input price patterns and the predictions of Edgeworth cycle theory.

3.1. Demand as a potential explanation for the Norwegian price cycles

The most important feature in the dismissal of a demand pattern explanation is the shift in the weekly pattern. As illustrated in Figures 2 and 3, we show how the price pattern changed significantly after April 2004, with a change in the high-price day from Thursday to Monday. Furthermore, the price pattern on Monday changed the most, from being the low-price day prior to April 2004 to the high-price day after April 2004. It is very unlikely that the weekly demand pattern changed as abruptly as the price pattern after Easter 2004. 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.[14]

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[13] 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*., 2005). Slade (1987, 1992) analyzes separate price wars in the Vancouver area during the summer of 1983, finding that shifts in demand trigger price wars.

[14] See also discussion in Noel (2007a).

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 for that: (i) demand is lowest on weekends, and (ii) demand is either constant or increases slightly from Monday to Friday.[15] 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).

3.2. Input price variation as a potential explanation for the Norwegian price cycles

Another obvious factor that can explain a weekly price pattern is weekly variation in wholesale prices. The two most important cost components are the wholesale price for gasoline, usually measured using the Rotterdam spot price, plus taxes (environment and value-added taxes). Table A4 in the Appendix summarizes the decomposition of the retail price for the LTS data.[16] 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. The LTS data suggests a weekly average of NOK7.28 with a weekly deviation smaller than NOK0.01. Thus, a potential weekly cost pattern (if any) can barely explain a price pattern with a deviation of NOK0.52 in the retail price.

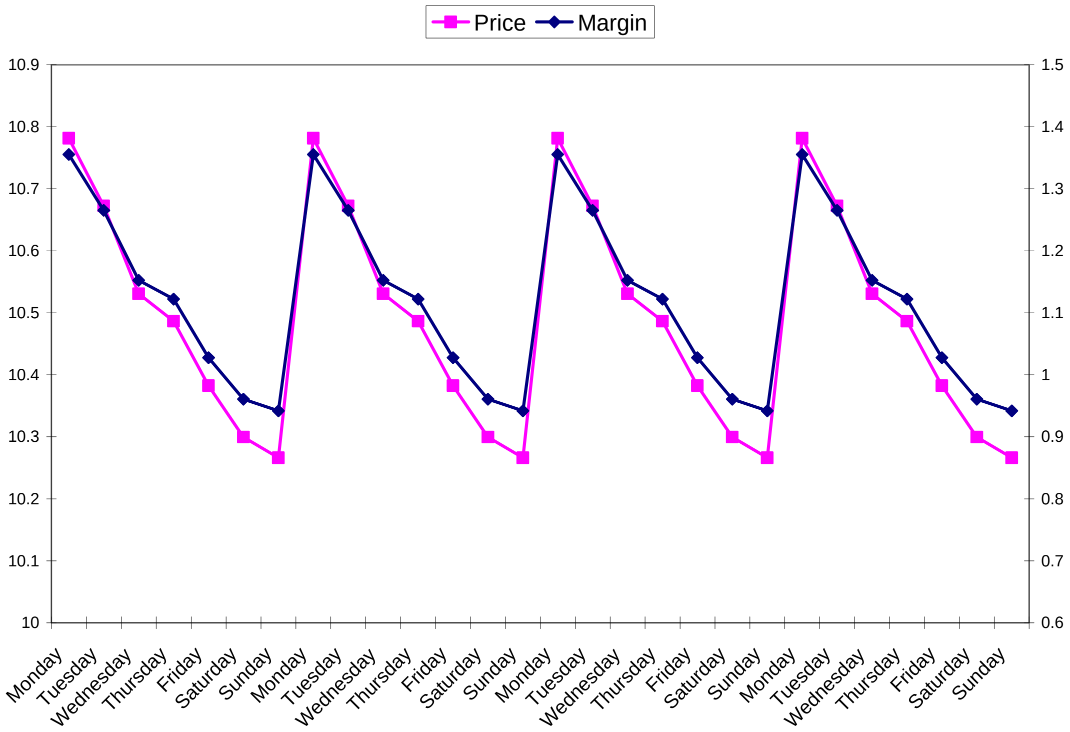
In sum, this means that the pattern we observe in retail prices more or less directly translates into the gross margin of gas stations. This is illustrated for the LTS data in Figure 4. Whereas the deviation over the week only represents 5% of the retail price, the deviation in the margin amounts to 37% of the mean gross margin. Finally, analogous to Noel (2007a), we dismiss the explanation that gasoline inventories at the

[15] According to, e.g., Per Vangen, 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).

[16] 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) shifting 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.

retail stations influence retail prices. There is no clear weekly pattern, with a representative gasoline station filling their tanks 2–3 times per week.[17]

Figure 4 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), illustrated for four weeks)



3.3. *Edgeworth cycle theory as a potential explanation for Norwegian price cycles*

The gradual price reductions from Monday afternoon to the following Monday morning are consistent with the predictions of Edgeworth cycle theory. On the other hand, we cannot rule out alternative explanations like intertemporal price discrimination and/or tacit collusion (see below).

There are strong indications that prices are driven downwards through local competition between Mondays, whereby each retail outlet decides its own retail price independently. In contrast, the sharp jump in prices on Mondays appears to be

[17] We questioned gas station managers and were told that the wholesaler, 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.

inconsistent with the relenting phase in Edgeworth cycle theory. As shown above, it is the day of the week rather than a lower boundary of retail prices that triggers the sharp increase in prices. Combined with the observation that the price cycles changed abruptly after Easter 2004, one potential hypothesis is that local Edgeworth cycle competition takes place, but stops every Monday through a coordinated price increase. In Section 4 below, we scrutinize the coordinated process, and consider why the headquarters may want to coordinate price jumps on Mondays.

Noel (2007a) suggests that fluctuations in weekly demand may have an impact on when firms relent in the Edgeworth cycle model. If we observe that firms are more likely to relent on a given day (period) with low demand, where the loss from being the initiator of a new cycle is lower than when demand is higher, this may be regarded as supporting Edgeworth cycle theory (Noel, 2007a). However, demand does not appear to be particularly low on Mondays (or Thursdays). Moreover, we do not observe price increases during the weekends, when demand is low.[18]

3.4. *Econometric analysis*

So far, we have discussed price cycles in a purely descriptive fashion. In this section, we introduce some simple econometric models which we use to statistically test the descriptive findings. We begin by analyzing the NWB data set. Since we have 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:

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

[18] At first sight, the observation that prices stay constant at their lowest level for some days may be consistent with the war of attrition phase in Edgeworth cycle theory. However, we would expect that at least some firms would increase their prices on, e.g., Sundays rather than Mondays, when the loss from being the first to raise prices is lower than on Mondays. Nevertheless, while we would expect this to happen every now and then, this is not the case.

In the regional panel model, we have 10 region dummies (*REGION*)[19] and 7 brand dummies (*Brand*).[20] 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*). The weekly retail price cycle is controlled for using 6 dummies (*AltDay*) for days (noon to noon), with Monday as the reference day. 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 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 automat stations, as expected, have negative parameters (between –0.173 and –0.102). This suggests that there is an average price differential between majors and automat stations of NOK0.17–0.30. In addition, the regional 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.[21] The explanatory power is reasonably high, even though we were unable to incorporate an autoregressive process into the model.

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[19] 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 og Fjordane & Møre og Romsdal (754), Rural areas (2,410).

[20] 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.

[21] 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.

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)
AltDay2	0.182	***	(0.012)	–0.055	***	(0.014)
AltDay3	0.239	***	(0.012)	–0.201	***	(0.014)
AltDay4	0.342	***	(0.012)	–0.151	***	(0.014)
AltDay5	0.129	***	(0.016)	–0.281	***	(0.018)
AltDay6	0.020		(0.022)	–0.351	***	(0.023)
AltDay7	0.047	***	(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	–1.313	*	(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

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. Thursday is even significantly higher then *AltDay3*, Wednesday, with the second highest price.[22] 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

[22] An *F*-test clearly rejects the null hypothesis of $H^0 : \phi_4 = \phi_3$ with a statistic of 72.67.

negative, and generally increasing in magnitude (negative) until Sunday. The predicted difference between Sunday and Monday is as much as NOK0.43.[23]

The more recent LTS data is 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. The next step is to investigate further whether the price jump that now takes place every Monday afternoon is the result of a coordinated process.

4. Gasoline prices jump on Mondays: An outcome of a coordinated process?

4.1. How to coordinate Monday as the high-price day

The majors all have what they refer to as recommended retail prices. The recommended prices were previously posted for all companies on the same publicly available website.[24] This information is no longer available on the same website due to requirements set by competition authorities, but companies are still permitted to post the same information on the gasoline companies' individual websites with open access to consumers, as well as rivals. We collected some of these prices for the LTS data period. In Figure 5, we show the development of actual retail and recommended prices for one of our Statoil stations. On every Monday, the recommended and the retail price coincide. Thus, every Monday the station increases their price to the same level—the level suggested by the recommended price. The retail price mostly then gradually reduces during the week, and typically will be significantly below the recommended price towards the end of the week.

This pattern is hardly a coincidence. However, to analyze this in a more systematic 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.[25]

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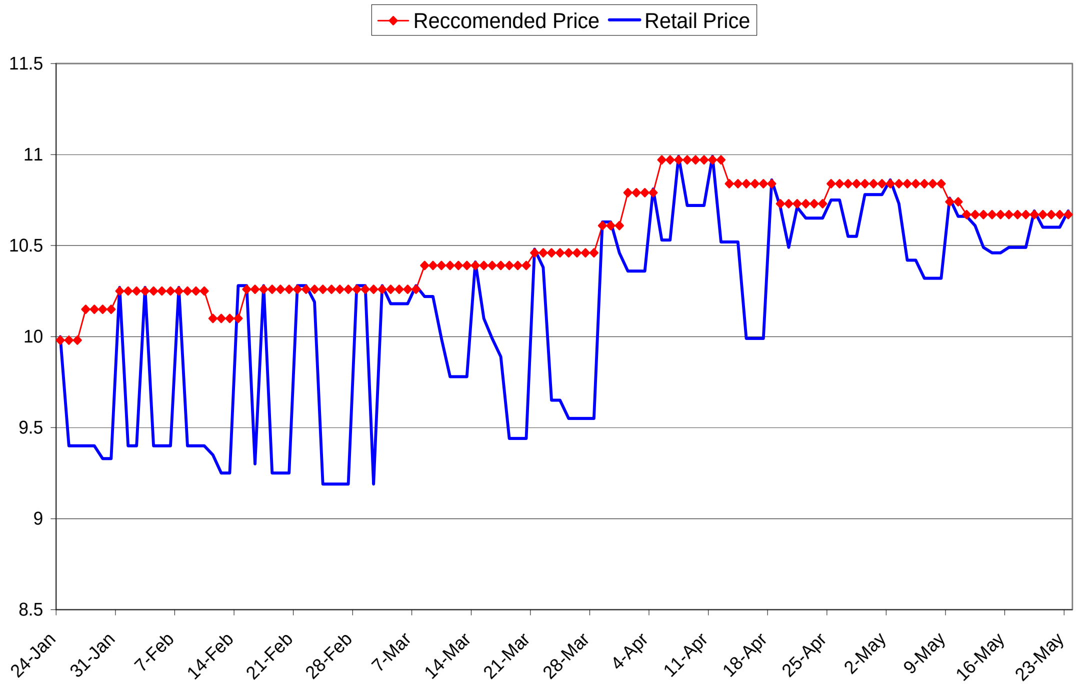
[23] The dataset comprises both majors and low-priced automat stations. One could believe that the latter followed a different price pattern than the majors, however this is not the case. For instance, for the period after April 2004, the price patterns of the majors and automat stations over the week had a correlation of 0.93, whereby the change from Monday to Sunday is NOK0.434 for the majors and NOK0.40 for the automat stations.

[24] The Norwegian Petroleum Industry Association's website.

[25] We only have recommended prices for Statoil.

Figure 5 Daily gasoline prices, Statoil gasoline station, NHH, Bergen, January 2005 to May 2005, (n = 120)

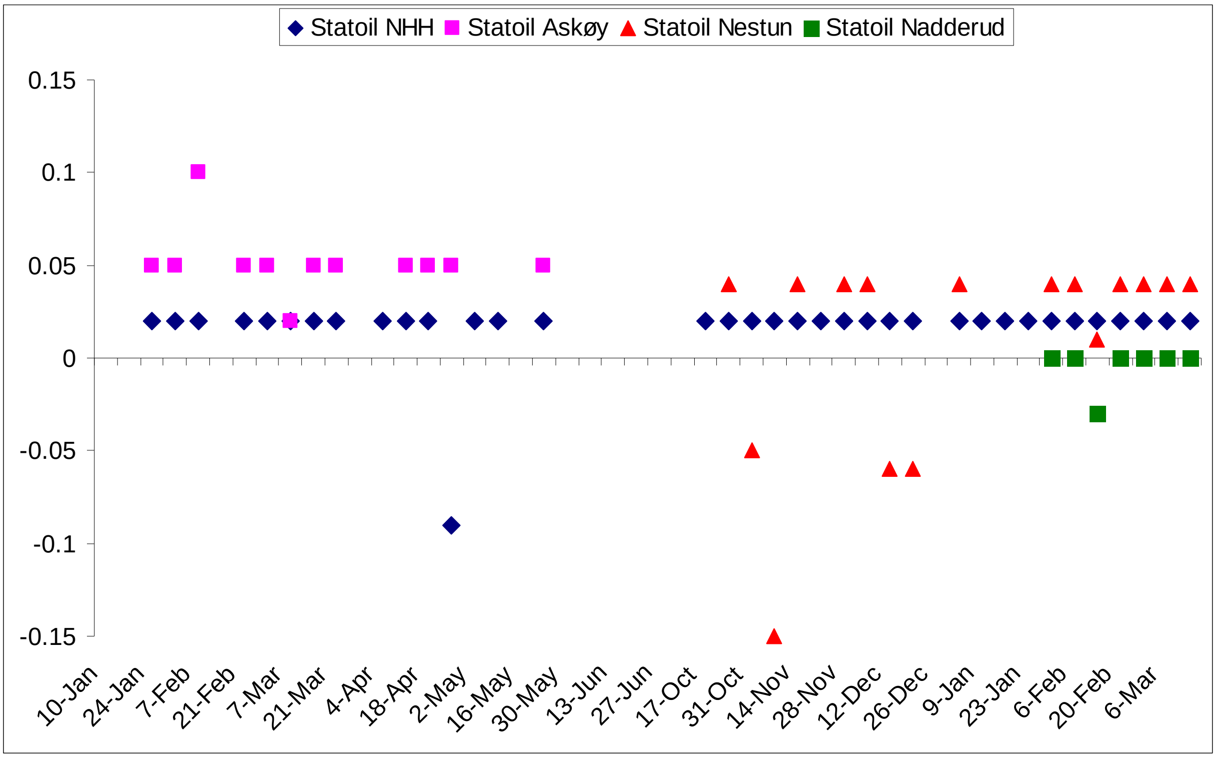


There are 71 Mondays where we can compare prices, as shown in Figure 6. The pattern is quite striking, with a fixed link between the retail and recommended price on Mondays. Only in nine of the 71 weeks does the pattern deviate. Another thing that is clear from Figure 6 is that different stations have individual pricing rules. For instance, on 35 of 36 Mondays the NHH station (the outlet also presented in Figure 5) increases its price to NOK0.02 above the recommended price. Correspondingly, the Nesttun and Askøy stations set their price to NOK0.04 and NOK0.05 above the recommended price. Nadderud sets their price to exactly the recommended price. The prices very probably differ by transportation costs.[26]. 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.[27]

[26] NHH is closest to the central depot (+0.02), Nesttun is somewhat further away (+0.04) and Askøy is the most remote station (+0.05). The companies have very detailed grids for the country where they distinguish between transport costs and differences in competition (Nadderud is an Oslo station and we have no other local stations with which to compare it).

[27] Interestingly enough, Nesttun has the most deviations relative to their pricing rule. This is what we also found in the econometric time series model, with the Statoil station at Nesttun facing the highest local competition in our sample. What happens here is that even though we collect prices in the

Figure 6 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)



Hence, not only are the companies able to synchronize the day they increase prices, they are also able to coordinate the price level towards which the price should be set. 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.[28]

In sum, the recommended price appears to serve two purposes for the headquarters of the gasoline companies: (i) inform their retail outlets of the price level they should follow on Mondays, and (ii) provide information to rivals that helps them monitor each other. Hence, there is one vertical and one horizontal element of the rule.

In order to maintain the pricing rule, the headquarters of the big four companies induce their retail outlets to increase prices every Monday at noon in accordance with

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afternoon, the local competition has already started 'working' and prices have already started to decrease when we observe the retail price, i.e., the weekly cycle has begun.

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

their individual rules. The recommended price may then be considered as a vertical price restraint. Since the rule *de facto* instructs a given retail price at noon on Mondays, the restraint may be regarded as Resale Price Maintenance (RPM). In the case at hand, it is important to note that about one-third of the big four's retail outlets operate as franchises (in 2006).[29] If the recommended price *de facto* is RPM, this may be in conflict with the competition law relating to retail outlets that operate as franchises. However, we also find strong indications that headquarters, in addition to posting the recommended price on their websites, use fax, email and text messages as ancillary restraints to induce their outlets to keep to the Monday rule. The local manager of a Hydro-Texaco outlet told a newspaper, '*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. The recommended price does not need to be the same everywhere.*'[30] Since, the retail outlets have significant autonomy with respect to retail price reductions throughout the week, headquarters needs to instruct their fully owned retail outlets as well as franchises to increase the price on Mondays in order to uphold the pricing rule.

However, if the only purpose of the recommended price were to inform fully owned as well as franchised outlets of the price level they should use on Mondays, there would be no reason to make the recommended price publicly available to rivals, since the same information could be made available through alternative internal information sources, such as intranets. Hence, public information about the recommended price seems to indicate that the recommended price is used to facilitate horizontal coordination between companies. Without the publicly available recommended prices, the companies would have to make direct contact, and thus engage in collusion that is more explicit.[31]

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[29] Source: Norwegian Petroleum Industry Association.

[30] Ole Tofsrud to the newspaper Trønderbladet, December 7, 2004.

[31] The recommended prices for the different companies are easily found, as they are all made publicly available on their web pages: see, for example, Statoil, (http://www.statoil.no/FrontServlet?s=sdh&state=sdh_dynamic&viewid=drivstoff_priser), Shell (http://www.shell.com/home/content/no-no/shell_for_businesses/priser/veiledende_priser.html) and Hydro (http://www.yx.no/hthjemmeside/internet.nsf/default.htm?OpenPage).

When the recommended price is publicly available for 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 on increasing the retail prices every Monday to a level given by the recommended price.[32] The recommended price as a vertical price restraint that facilitates horizontal coordination also makes the current story topical to one of the most hotly debated issues in competition policy. This is that vertical price restrictions are usually treated less favorably than nonprice restrictions, and RPM has generally been banned *per se*.[33]

This distinction between price and nonprice restraints contrasts with economic theory on vertical restraint, which shows that both types of restraint may improve or reduce economic efficiency. Moreover, they are often viewed as alternative instruments to achieve the same outcome (for overviews, see Overstreet, 1983, and Mathewson and Winter, 1998). 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.

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

We do not put forward any 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

[32] For the same reason, this may explain why headquarters want fully owned outlets, as well as franchises, to have significant freedom in reducing retail pricing throughout the week. Allowing each outlet to reduce their retail price will most likely assist collusion, since it allows for more timely punishment compared with a case where retail prices are centrally decided.

[33] The definition of what constitutes RPM has subsequently narrowed in both the US and in Europe. The most dramatic change occurred in June 2007 when the US Supreme Court overruled the nearly one-hundred-year-old per se ban on RPM (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.

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. As shown above, we observe strong indications of a coordinated restart of price cycles every Monday. By creating this restart every Monday, we have a period with relatively high prices at the beginning of the week. Local competition à la Edgeworth cycle theory will, however, reduce prices throughout 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 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 may relate 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 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). However, when the cycles are exactly a week, a large fraction of the consumers have the opportunity to shift consumption from one day of the week to another.[34]

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) shows 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.[35] 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.[36,37]

As a complement to our analysis of the price data, we undertook opinion surveys among customers while they were filling their vehicles with gasoline.[38] It is remarkable that after such a long period of transparent and predictable weekly cycles

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[34] The average yearly driving distance of privately owned cars in Norway differs according to the different surveys undertaken, but is generally estimated to be in the range of 12,000 to 15,000 km per year. This suggests an average of 250–300 km per week, requiring most consumers to fill their tank only once a week. See http://www.prosus.uio.no/publikasjoner/Rapporter/2004-3/kapittel_5.pdf.

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

[36] 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 weekends. 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. 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.

[37] A large fraction of utility drivers use diesel cars. Thus, one may argue that these do not matter for gasoline pricing anyway. However, according to simple average statistics provided by DinSide, diesel prices show a similar weekly pattern.

[38] The survey was conducted using two of our local gasoline stations, Tertnes and NHH, and 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.

as observed in Norway, close to 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.

So far, 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.[39] 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.[40]

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 NOK0.85. If we examine the simple average prior to April 2004, it is marginally lower (0.83) and afterwards is marginally higher (0.89). 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

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[39] 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).

[40] As expected, customers who check the price sign are also better informed as to the weekly price pattern. From those checking prices with a notion of a weekly price pattern, 49% believed the high-price day was Monday, whereas within the group of customers who did not check the price sign, fewer had a notion of a weekly price pattern. Of these, only 35% thought that the high-price day was Monday.

anything from these figures. Thus, we also present summary statistics for the one hundred days before and after the shift.

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.*
Whole sample	26823	0.854	0.423	–1.634	3.554
Before Easter 2004*	14746	0.825	0.429	–1.356	3.456
After Easter 2004**	12077	0.889	0.413	–1.634	3.554
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.

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 NOK9.14 to 9.73 between these two periods (6.4%). However, whereas the tax does not change during these two hundred days, the wholesale price does, increasing from NOK1.80 to NOK2.16. 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 NOK0.11, or 13.5%, on average. Thus, it appears that some of the price increase is used to obtain higher margins.

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 will use the full data set and introduce a shift dummy that accommodates the change in the price pattern.

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

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,[41] 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).[42] The majors have a higher margin than the automat 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.[43]

[41] 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).

[42] If we exclude the trend variable, the tax variable as with the wholesale price becomes negative (and significant).

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

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)
AltDay1 $\cdot D_t^{SHIFT}$	0.326***	(0.026)
AltDay2 $\cdot D_t^{SHIFT}$	0.139***	(0.026)
AltDay3 $\cdot D_t^{SHIFT}$	–0.031	(0.026)
AltDay4 $\cdot D_t^{SHIFT}$	–0.073***	(0.026)
AltDay5 $\cdot D_t^{SHIFT}$	–0.057**	(0.029)
AltDay6 $\cdot D_t^{SHIFT}$		
AltDay7 $\cdot D_t^{SHIFT}$	–0.044*	(0.026)
Trend	–0.0004***	(0.00003)
Tax	0.383***	(0.071)
Rotterdam	–0.176***	(0.011)
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)
R^2	0.262	
N	26823	

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

When we look at the shift dummy, it comes in significantly positive, concluding a substantial increase of NOK0.20 in the weighted average margin when controlling for week pattern, costs and trend. Directly translated, this means that the average gross margin went up as much as 23% after April 2004.[44]

Our survey data clearly show that at least a significant fraction of consumers spends some time learning the new pattern.[45] Before all of these customers 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 we present here. Thus, our estimated margin increase will very likely underestimate the full margin effect for companies from the change in the weekly price pattern.

5. 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 aggressive competition as the driving force, we show that some form of coordinated behavior is present in the Norwegian market. The coordinated restart of price cycles every Monday seems to increase the margins of gasoline companies.

We establish that there is a weekly pattern in Norwegian gasoline prices, with some similarities to so-called Edgeworth cycles. However, the Norwegian pattern distinguishes itself from what has been found elsewhere in several respects. First, the cycle is fixed, in the sense that it lasts exactly one week. Second, there has been a change from Thursday to Monday as the high-price day during our observation window of approximately four years. Because of these characteristics, it is natural to question whether the price jumps that now take place every Monday are the result of a coordinated process, rather than the result of fierce competition.

We find a rather striking pattern, whereby there is a fixed link between the retail price and the recommended price after the prices jump on Mondays. Further, we establish

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[44] 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.

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

that the different stations have an individual pricing rule that they strictly follow. 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. There is no benefit to consumers, and 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 to rivals should be banned. This suggests that it is important to make such communication as difficult as possible. However, even if the various company headquarters are not permitted to post recommended prices on public websites, they may still give information about recommended prices to their own outlets (or alternatively send faxes, text messages and emails[46]). However, this may 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 that encompasses both strong local competition and centrally coordinated prices.

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.

[46] This may also be illegal to franchised outlets not owned by the headquarters.

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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 the day. The NWB data is 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 21.6%, 20.8%, 25.8% and 26.6%. Thus, we have a larger share of automat 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 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	5027	18.74
Tuesday	4959	18.49
Wednesday	4817	17.96
Thursday	4892	18.24
Friday	5000	18.64
Saturday	1112	4.15
Sunday	1016	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%

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

The local time series data allows 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 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.[47] We also control for changes in the wholesale price (*Rotterdam*) and potential brand effects (*Brand*)[48] 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.[49,50] 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

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

[48] 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.

[49] 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.

[50] 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.

suggests some autocorrelation for station 1. Since we observe a weekly pattern in 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 ($Rotterdam^{lr}$).[51] 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 NOK0.04 and NOK0.09 lower. The brand dummies are not significant in any of our models, suggesting only minor brand effects.[52]

Turning to the dummies representing the potential price cycle, the same clear and significant weekly pattern in prices as shown in Figure 2 is confirmed using the econometric model. Prices are, on average, between NOK0.50 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 3.4 for the NWB data also exists in our local time series data for 2005 and 2006.

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

[52] 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

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