Price asymmetry in the Dutch retail gasoline market

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Abstract

This paper analyses retail price adjustments in the Dutch gasoline market. We estimate an asymmetric error correction model on weekly price changes for the years 1996 to 2001. We construct five datasets, one for each working day. The conclusions on asymmetric pricing are shown to differ over these datasets, suggesting that the choice of the day for which prices are observed matters more than commonly believed. In our view, the insufficient robustness of outcomes might explain the mixed conclusions found in the literature. Using two approaches, we also show that the effect of asymmetry on Dutch consumer costs is negligible.

Key words: Asymmetry; retail gasoline prices; sensitivity analysis

JEL classification: D43; E31; L71

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Contents

1 Introduction

Retail gasoline prices were characterized by high volatility in 2001. In the Netherlands, the retail price rose to a new record level of 2.81 guilders per litre in May, followed by a sharp fall to 2.10 guilders per litre in December.[1] Due to this price volatility, Dutch consumers have become more suspicious of the oil companies' price setting behaviour. To the public, it seems that oil companies adjust the retail gasoline price more quickly to cost increases than to cost decreases. The phenomenon whereby prices tend to adjust differently depending on their direction is known as *price asymmetry*. Several empirical studies have explored the price setting behaviour in the gasoline market.[2] The findings of these studies have been mixed. Some reject symmetric price adjustment and find evidence that the price reacts more rapidly to cost increases. However, it should be noted that the studies differ greatly in data frequency, sample period, choice of the input price and of the model specification, which may account for the different conclusions on price asymmetry. The following overview focuses on these differences. All studies discussed below apply an error correction model, unless stated otherwise.[3]

In a study of the gasoline market in the UK, Bacon (1991) analyses semi-monthly data from 1982 to 1989 and reports evidence of a faster and more concentrated response of the retail price to spot price increases. Bacon uses a quadratic quantity adjustment function to test for price asymmetry. Manning (1991), exploiting monthly data on crude oil prices and retail prices from an even earlier period (1973–1988) concludes that price asymmetry in the UK, though present, is relatively short-lived. While his results indicate a total adjustment period of two years, any asymmetry is virtually absent after four months. Reilly and Witt (1998) also report asymmetric pricing in the UK, using monthly data on the retail price, the crude oil price and the dollar/sterling exchange rate from January 1982 to June 1995. Their estimates provide evidence of an asymmetric response among retailers to changes in both crude oil prices and the exchange rate. A 10% fall in the crude oil price leads on impact to an estimated 1.9% fall in the retail price, while a corresponding rise in the crude oil price leads to a 4.1% rise in the retail price. The long run response equals 5.8%

[1] All prices are expressed in guilders per litre; 1 euro = 2.20 guilders.

[2] The question whether prices rise and fall at different speeds has also been examined in other markets. See for example Von Cramon-Taubadel (1998) who studied the German pork market and Peltzman (2000) who examined a large sample of consumer and producer markets in the US.

[3] Von Cramon-Taubadel (1998) shows that only an ECM is appropriate for testing asymmetries.

in both cases. The sizes of the estimated responses indicate that most of a crude oil price increase appears to be passed through within one month, while the response to a crude oil price decrease is distributed over a longer period. In other words, in the British gasoline market asymmetries both with respect to the duration and the pattern of the adjustment are found to exist.

Borenstein and Shepard (1996) find evidence of asymmetric adjustment of retail prices to terminal price changes in the US. For this analysis they use average monthly prices in 43 cities from 1986 to 1991. Borenstein *et al.* (1997) estimate a vector autoregression (VAR) model for the American gasoline market using semi-monthly data over the period 1986–1990. Their results also indicate that retail prices adjust more quickly to crude oil price increases than to decreases. They also discuss possible reasons for the asymmetric price adjustments in the gasoline market.[4] They argue that price asymmetries might have different sources at different stages in the distribution chain. The adjustment of the spot price to changes in the crude oil price seems to be responsible for some of the asymmetry, which may reflect inventory adjustment effects. In the next stage, there appears to be no asymmetry between the spot price and the wholesale price. Finally, retail prices show asymmetry in responding to wholesale price changes, possibly indicating short run market power among retailers. Borenstein and Shepard (2002) estimate an asymmetric partial adjustment model and a VAR model on weekly observations at 188 terminals for the period 1986-1992. They find that the terminal price responds asymmetrically to changes in the crude oil price.[5]

Kirchgässner and Kübler (1992) investigate the gasoline market in Germany exploiting monthly data to determine how both the wholesale and retail price react to spot price changes. They distinguish the subperiods of the seventies (1972–1979) and the eighties (1980–1989). In contrast to other studies, their results indicate that during the seventies the short run response of the wholesale price to a decrease of the spot price was greater than to an increase. They offer the explanation that fuel distributors may hestitate to raise prices quickly to avoid allegations of abusing their price setting power. Such an incentive would not exist when costs are falling.

[4] Johnson (2002) stresses the importance of search costs in explaining asymmetric price responses in US gasoline and diesel markets.

[5] Borenstein *et al.* (2002) also estimate a simple lagged adjustment relationship between daily, futures gasoline prices and crude oil prices (1985-1995). The estimates confirm the hypothesis that the lagged response of gasoline prices is due to supply adjustment costs. However, asymmetry of the pass-through is not statistically significant on these efficient future markets.

The hypothesis of symmetry is also rejected for retail prices.[6] For the eighties, they report evidence of a rapid and symmetric adjustment of both prices. Kirchgässner and Kübler argue that this structural break indicates that the market has become more competitive over time.

Asplund *et al.* (2000) use monthly data during 1980–1996 to explore the Swedish gasoline market. They find support for the hypothesis that the retail price is stickier downwards than upwards in response to cost shocks. Furthermore, they examine the separate effect of changes in the spot price in dollars and in the Swedish crown/dollar exchange rate. It appears that the retail price responds more quickly to changes in the exchange rate than to spot price movements. Prices are adjusted to an exchange rate movement in the same month as it occurs, whereas the adjustment to spot price changes is found to be asymmetric both with respect to the duration and the pattern. In case of a spot price increase, over 60% of the total adjustment takes place within the same month, whereas a decrease passes through for only 30%. The authors explain the different price response to exchange rates and spot prices by means of the volatility of both series. The spot price proved to be more volatile than the exchange rate, creating more uncertainty for the firm. Therefore, firms may wait to see whether the spot price reverts, but react faster to the less volatile exchange rate.

Godby *et al.* (2000) apply a threshold error correction model to test for asymmetric pricing in the Canadian gasoline market, using weekly data on retail prices and crude oil prices from January 1990 to December 1996. In contrast to other studies they report no evidence of price asymmetry. They suggest that the reason for this different result is related to differences in market structure, in dataset and in the methodology.

The aim of this paper is threefold. First, we explore whether asymmetric pricing can be identified in the Dutch gasoline market by estimating an asymmetric error correction model on weekly price changes. This analysis has not yet been done for the Netherlands. Second, from daily data we construct five different datasets since it is a priori not clear which day of the week should be selected. Each dataset contains the prices observed on one of the five working days. The conclusions on asymmetric pricing are shown to be not uniform across these datasets. Hence, our findings suggest that the selection of the dataset is not as harmless as it seems. Unfortunately, we do not have hard evidence on the causes of these mixed results.[7]

[6]However, it is not clear how the analysis takes into account the large tax changes that occurred in the sample period.

[7]A possible explanation is that the price setting strategies of the oil companies are different

Third, we present in this paper two different approaches to assess the implications of asymmetric price transmission for consumers. We conclude that the effect on consumer costs is negligible.

The remainder of the paper is organized as follows. Section 2 starts with a brief description of the Dutch gasoline market. In section 3, we present the model specification, describe the data used and report our estimation results. In section 4, we assess how price asymmetry affects consumer costs. Finally, some concluding remarks are offered in section 5.

2 The Dutch retail market for gasoline

2.1 Market description

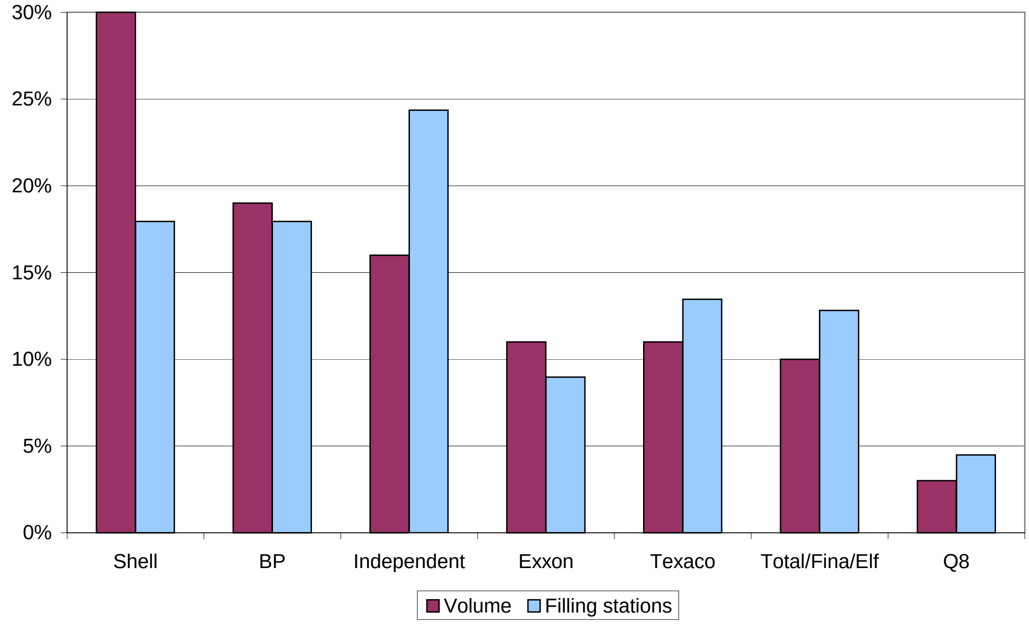
In the Dutch retail market for gasoline two types of players are present: integrated oil companies and independent retailers. The integrated oil companies are the most important players. Shell is the market leader with a market share of 30 percent in terms of volume (see Figure 1). The next largest player is BP (19%), followed by Exxon (11%), Texaco (11%), Total/Fina/Elf (10%) and Q8 (3%). Each sell their gasoline through branded filling stations. Three types of filling stations can be distinguished (NMa, 2001): (i) filling stations owned and operated by the oil companies; (ii) filling stations owned by the oil companies and operated by independent operators; and (iii) filling stations owned and operated by the proprietor. The last two types of branded filling stations have exclusive and often long lasting supply contracts with one of the major oil companies. The oil companies issue recommended retail prices to their filling stations. Standard margins for filling station operators are agreed beforehand. The Netherlands Competition Authority (NMa) has concluded recently that the differences between the prices of the various oil companies are marginal (NMa, 2001). Market leader Shell publishes changes to the recommended prices on its website and the other companies usually follow. The recommended price is generally charged to consumers, except for some stations in areas near the Belgian and German border and in rural areas (Ministry of Economic Affairs, 2002).

The major oil companies account for some 85 percent of the gasoline sold. The remainder is shared among non-integrated independent retailers. Despite their market

around the weekends.

share of around 15 percent in terms of volume, these independents operate almost 25 percent of the filling stations (see Figure 1). This indicates that these so called 'white pumps' realise a relatively small volume per site. The most likely explanation is that branded filling stations, unlike the non-branded ones, are mostly located at prime locations like motorways (European Commission, 1999).

Figure 1: Market shares in 2000



2.2 Competition intensity

In addition to the high degree of concentration, the European Commission (1999) mentions that despite the asymmetry of market positions, market shares are stable. It also states that wholesale and retail margins appear to be inexplicable higher in the Netherlands than in other European countries. The Commission argues that the resulting high pump prices cannot be attributed to higher taxes or costs. The conclusion they draw upon these findings is very clear (p.138): "In sum, the higher price environment in the Netherlands shows a deficit of competition." The European Commission further concludes that the restrictive planning and permission policy of the Dutch government makes the prospects for stronger competition look poor. Partly as a result of this policy, the number of filling stations in the Netherlands has been strongly reduced over the last ten years: from 6600 in 1990 to 3900 in the year 2000. As a consequence of strict legislation, supermarkets are not an active force in fuel retailing, unlike in for example France or the United Kingdom. Potential competition is even further reduced because the independent non-integrated retailers obtain almost all their fuels from the major oil companies. If these independents should decide to start a price war against their integrated competitors, this would put their future supply contracts in jeopardy. Independent retailers are therefore reluctant to do so and have in fact become price followers.

NMa also concludes that competition is considerably restricted in the Netherlands. Its recent investigation reports that the large oil companies (Shell, BP, Exxon, Texaco and Total/Fina/Elf) keep the price of motor fuels artificially high (NMa, 2001). Oil companies support their filling stations when competitors temporarily reduce prices to increase sales, requiring that the discount is passed on to the consumer. However, support is not given when a filling station itself initiates a price reduction. NMa states that as a consequence filling station operators have no incentive to cut prices. Not only do they not receive a discount, but also the operators know that their competitors are able to follow any price reduction immediately. These so called vertical agreements therefore result in higher consumer prices and obstruct entry into this market (NMa, 2001). Although these agreements are not prohibited, NMa aims to declare that the European exemption to vertical relationships does not apply to the Dutch prohibition on cartels.

3 Empirical analysis

3.1 The model

The standard procedure for studying dynamic price adjustment is to use an error correction model (ECM). In this model short run dynamics are linked to the long run equilibrium. The latter is specified by a relationship in levels between the output price and cost variables:[8]

$$RPE_t = \gamma + \beta\, WP_t + \tau EXC_t + u_t \tag{1}$$

where γ is the constant term, RPE denotes the retail price of one litre of gasoline excluding the value-added tax, WP is the spot price and EXC stands for the excise

[8]This specification can be derived from (static) profit maximization by an oligopolist when market demand is assumed log linear (see Appendix I). Other cost indicators, like wage and aggregated price level, turned out to be not significant.

taxes on gasoline. All variables are expressed in guilders per litre. These series should be integrated of order one and cointegrated to utilize an error correction model (Engle and Granger, 1987). The use of the spot price of gasoline is preferred over the use of the crude oil price. When the crude oil price is used for the analysis, the retail price of gasoline will depend to some extent on the demand for other refined products due to joint production (Borenstein *et al.*, 1997). Notice that excise taxes are included on the left hand side, as well as on the right hand side of the equation. This specification allows for the non-neutrality of excise taxes within an oligopolistic price setting (see Keen, 1998). Furthermore, we assume that marginal costs are independent of the production level.

The short run dynamics are captured by a relationship in first differences:

$$\Delta RPE_t = \sum_{i=0}^{m} \alpha_i^- \Delta WPN_{t-i} + \sum_{i=0}^{n} \alpha_i^+ \Delta WPP_{t-i} + \omega \Delta EXC_t + \lambda u_{t-1} + v_t \quad (2)$$

The term u_{t-1} is the one-period lagged deviation from the long run equilibrium. Its coefficient λ is an estimate of the fraction of the maladjustment (relative to the long run equilibrium) in the previous period that is corrected in the current period. Convergence to the long run equilibrium requires that $-2 < \lambda < 0$. As λ approaches -1, the adjustment period becomes shorter.

In this asymmetric ECM, changes in the spot price are split into two variables: ΔWPN and ΔWPP represent the negative and positive changes, respectively.[9] The number of lagged variables for decreases and increases in the spot price is equal to m en n, respectively. This number is determined by the Akaike Information Criterion. In view of the limited number of changes in excise taxes, lags are not included for this variable.

Using a Wald test, we test for equality of the coefficients of increases and decreases of WP.[10] Rejection of this joint hypothesis indicates asymmetry in retail price adjustments. Asymmetries are further characterized by comparing the cumulative adjustment functions for each period after the spot price change.

[9] Hence, $\Delta WPN = \Delta WP$ if $\Delta WP < 0$; $= 0$ otherwise. The reverse holds for ΔWPP.

[10] In case of an unequal number of lagged variables for increases and decreases, the coefficients of the 'missing' lagged variables are set to zero. More precisely, $\alpha_i^- = \alpha_i^+$ if $i \leq \min(m, n)$; $\alpha_i^- = 0$ if $i > n$ or $\alpha_i^+ = 0$ if $i > m$.

3.2 The data

This paper studies the *retail price* of unleaded gasoline (Euro95) in the Netherlands for the period 1 January 1996 to 31 December 2001. Euro95 is by far the most important type of gasoline in the Netherlands (about 85% of total gasoline sales). The analysis uses the retail price which market leader Shell recommends to its filling stations. Price changes are published on the company's website (www.shell.nl). This retail price is representative of the prices of other firms in the Netherlands, because they usually follow the adjustments Shell makes.

Table 1: Number of price adjustments

	1996	1997	1998	1999	2000	2001	Total
Total	44	38	33	60	85	56	316
Increases	25	19	10	42	47	27	170
Decreases	19	19	23	18	38	29	146

Table 1 shows the number of retail price adjustments per year. During the sample period Shell made 316 changes to its recommended retail price for Euro95: 170 adjustments (54%) were upward and 146 adjustments (46%) were downward.[11] This means that on average the price was adjusted once a week. The distribution of the size of the adjustments is presented in Table 2. In this table the two largest price increases of 13 and 6 cents per litre are excluded, because these were caused by substantial changes in taxes. Table 2 shows that price adjustments in general are quite small.

Table 2: Distribution of the size of price adjustments (cents/litre)

	-5	-4	-3	-2	-1	+1	+2	+3	+4	+5
Frequency	8	12	18	43	65	79	51	24	10	4

We find some variation in the frequency of price adjustments over the week. Table 3 shows that the retail price is most frequently adjusted on Fridays. Remarkably, only a few changes were made on Tuesdays. On Sundays the retail price is never adjusted, probably because both the Rotterdam spot market and the financial markets are

[11] This includes adjustments resulting from changes in taxes.

Table 3: Number of price adjustments per day of the week

	Total		Increases		Decreases	
	Number	Perc.	Number	Perc.	Number	Perc.
Monday	50	16%	31	18%	19	13%
Tuesday	15	5%	6	4%	9	6%
Wednesday	65	21%	35	21%	30	21%
Thursday	60	19%	31	18%	29	20%
Friday	71	23%	33	19%	38	26%
Saturday	55	17%	34	20%	21	14%
Total	316	100%	170	100%	146	100%

closed during weekends. Prices often do change on Saturdays to incorporate Friday's closing spot prices and exchange rates.

The most important input for the price of Euro95 is the *Rotterdam spot price for premium unleaded gasoline*. Every day - except weekends and holidays - this price is assessed by Platt's London in US dollars. To convert this price to guilders per litre, we use the closing dollar/guilder *exchange rate* as collected by Datastream. Spot prices and Dutch retail prices are highly correlated as the correlation coefficient of both series equals 0.93. Figure 2 illustrates that both prices follow each other closely.

The retail price data includes consumer taxes. In the sample period the *value added tax* (VAT) on gasoline changed from 17.5% to 19.0% on 1 January 2001. Besides VAT, the retail price data also includes *excise taxes*.[12] The value of these taxes is obtained from Statistics Netherlands. Excise taxes on unleaded gasoline changed substantially during the sample period: from 1.14 guilders per litre on 1 January 1996 to 1.34 guilders per litre on 31 December 2001.[13] Besides political adjustments, excise taxes are also corrected for inflation every year.

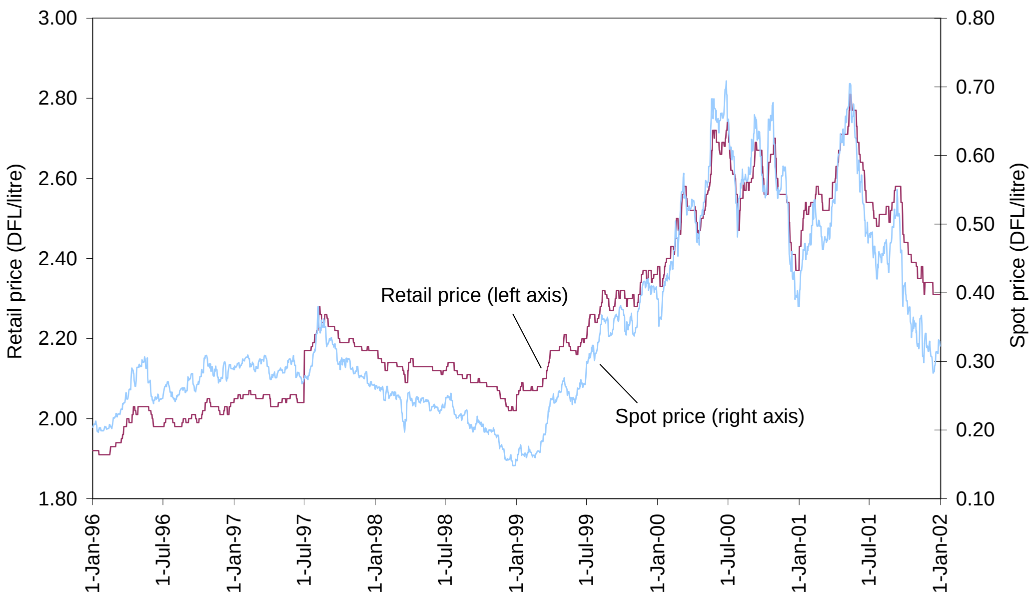
Although the data is available on a daily basis, we estimate the model on weekly price changes.[14] Since it is a priori not clear which day of the week should be selected, we construct five datasets with weekly data. For each dataset another working day's

[12] VAT is also levied on the excise taxes.

[13] These excises taxes underwent their most important change on 1 July 1997: from 1.16 guilders per litre to 1.27 guilders per litre.

[14] We did some preliminary experiments with daily price movements, but these did not give plausible estimation results.

Figure 2: Retail and spot price of Euro95



prices are used. In the datasets retail prices and spot prices that are observed on the same day are grouped. Since the retail price is set before that day's closing spot price is known to Shell (Shell, 2001), this implies that perfect expectations for one day is assumed. Tests in which we used yesterday's closing spot price gave qualitively the same results.[15] As the spot market is closed on Saturdays, a dataset for this day is not constructed. In the few other cases where observations are missing (in case of a holiday), prices of the day before are used. Each dataset contains 313 observations, except the one for Monday (314).

3.3 The results

As mentioned in section 3.1, a stable long run relationship is required to estimate the ECM. First, the augmented Dickey-Fuller unit root tests on RPE, WP and EXC strongly indicate that each series is I(1) for all five datasets. As a second step the Johansen cointegration test is used to test for the number of cointegrating relations. In all cases, the test statistics strongly indicate one cointegrating equation between the three variables. As a last step we test the hypothesis that the residuals

[15]Borenstein and Shepard (1996) specify explicitly an equation for the expected spot price. This expected spot price is a function of lagged crude oil prices and lagged spot prices.

of equation (1) are not stationary. In all cases, this hypothesis is rejected.[16] In sum, the three variables are cointegrated and equation (1) represents a stable long run relationship.

The OLS estimation results of equation (2) for each dataset are reported separately in Table 4. First, we discuss the long run coefficient estimates. In all specifications, the estimated coefficient on WP is not significantly different from one at the 5% significance level. In the long run, a change in the spot price of gasoline is fully passed through to the retail price. This implies that the margin is independent of the spot price. Notice that the coefficient on WP represents the combined effect of a change in the world price of gasoline on the cost and on the mark up. The long run effect of a change in the excise taxes is in all specifications significantly different from one at the 5% significance level. This suggests that excise taxes are non-neutral: when excise taxes rise, the producer price (*e.g* retail price net of taxes) rises. However, this coefficient should be interpreted with care since the variable EXC is likely to capture inflation effects as well. Adding a price index did not improve significantly the explanation power of the equation, but did lower considerably the coefficient of EXC.

We now turn to the estimates of the short run coefficients presented in Table 4. In all cases, the coefficient on the error correction term is significantly negative as required. The point estimates vary from -0.836 to -0.918. The Akaike Information Criterion (AIC) is used to identify the length of the lag structure in each specification. Based on the AIC, four lags have to be included for decreases in the spot price and two lags for increases in the specification of Monday and Friday. For Tuesday, we use one lag for decreases and two lags for increases in the spot price. For Wednesday the opposite to Tuesday holds. Finally, the number of lags for spot price increases is three in the specification of Thursday. Notice that not all coefficients on lagged changes in the spot price are significant. Finally, the coefficients on the change of excise taxes are not significantly different from unity, implying that the pass-through rate of excise changes is 100% in the short run.

The p-value of the Wald-test in the last row of Table 4 applies to the restriction that the coefficients of the variables referring to increases and decreases of WP are equal. The p-values reveal that the symmetric specification is rejected at the 1% significance level when observations of Monday, Thursday and Friday are used, whereas the

[16]Since the standard Dickey-Fuller tests would reject the null hypothesis too often, the more negative critical values of table B.9 from Hamilton (1994) are used.

Table 4: Estimation results[a]

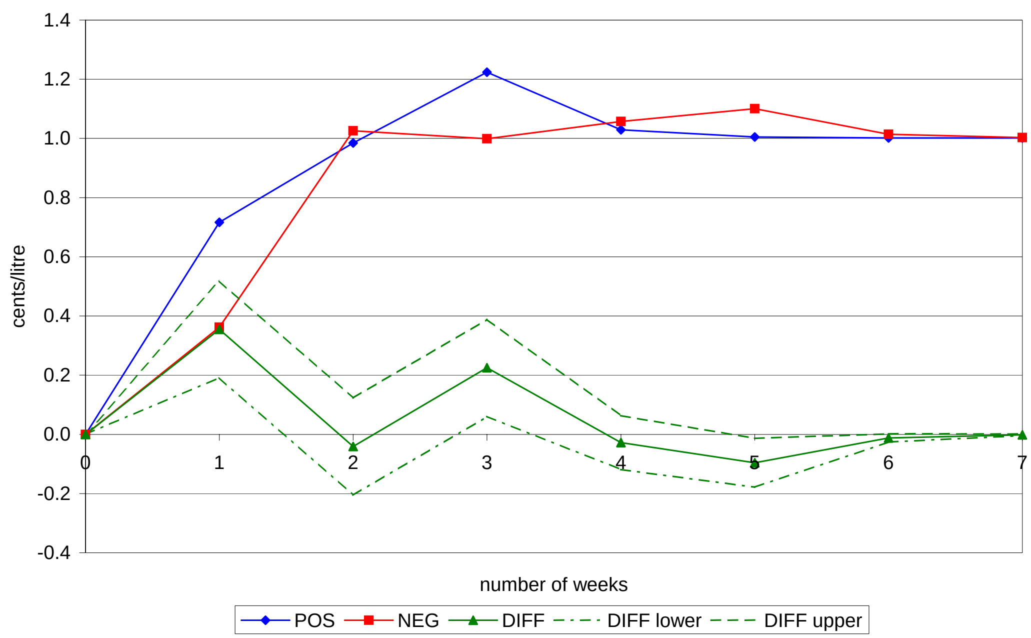
Variable	Monday			Tuesday			Wednesday			Thursday			Friday		
$CONSTANT$	0.173	(0.015)	*	0.152	(0.016)	*	0.133	(0.014)	*	0.143	(0.013)	*	0.159	(0.015)	*
WP	1.001	(0.008)	*	1.005	(0.008)	*	1.005	(0.007)	*	0.997	(0.007)	*	1.003	(0.008)	*
EXC	1.095	(0.013)	*	1.113	(0.014)	*	1.129	(0.012)	*	1.121	(0.011)	*	1.108	(0.012)	*
u_{-1}	-0.874	(0.057)	*	-0.859	(0.057)	*	-0.836	(0.057)	*	-0.918	(0.048)	*	-0.899	(0.058)	*
ΔWPN	0.362	(0.048)	*	0.364	(0.050)	*	0.501	(0.043)	*	0.411	(0.051)	*	0.484	(0.055)	*
ΔWPN_{-1}	0.105	(0.059)		0.184	(0.060)	*	0.132	(0.050)	*				0.145	(0.061)	*
ΔWPN_{-2}	-0.006	(0.046)					0.061	(0.038)					-0.091	(0.053)	
ΔWPN_{-3}	0.056	(0.042)											0.061	(0.049)	
ΔWPN_{-4}	0.093	(0.043)	*										0.071	(0.048)	
ΔWPP	0.717	(0.051)	*	0.440	(0.055)	*	0.409	(0.047)	*	0.265	(0.052)	*	0.336	(0.051)	*
ΔWPP_{-1}	0.019	(0.056)		0.086	(0.067)		0.162	(0.059)	*	0.191	(0.070)	*	0.105	(0.067)	
ΔWPP_{-2}	0.225	(0.053)	*	0.084	(0.052)					0.008	(0.049)		0.208	(0.053)	*
ΔWPP_{-3}										0.107	(0.049)	*			
ΔEXC	1.162	(0.089)	*	1.145	(0.096)	*	1.135	(0.082)	*	1.142	(0.086)	*	1.117	(0.090)	*
D.W.	1.985			2.045			2.033			1.906			1.962		
Adj. R^2	0.803			0.784			0.820			0.817			0.801		
Obs.	309			310			310			309			308		
p-Wald	0.000			0.238			0.269			0.003			0.005		

[a] Standard errors are in parentheses; * denotes coefficients significant at the 5% level.

estimates on the Tuesday and Wednesday datasets exhibit symmetry. Clearly, the estimation results do not unambiguously point at symmetric nor asymmetric pricing.

We characterize in more detail the adjustment path of each estimated model by examining the cumulative adjustment function. It should be noted that this function is non-linear in the parameters, as the adjustment in the ith period after a change in the spot price will be the sum of the estimated response parameters from equation (2) and the error correction effects over ith period.[17] Figures 3 to 7 present the calculated retail price response (in cents per litre) to a one-time one cent per litre increase (POS) or decrease (NEG) in the spot price. To ease comparison we give the absolute value of the price responses. In each figure the difference between the two adjustment paths (DIFF) and its 95% confidence interval are also shown.[18]

Figure 3: Cumulative adjustment function for the Monday dataset



[17]The calculation of the cumulative adjustment function can be found in Appendix II or in Borenstein *et al.* (1997, p.337).

[18]The standard errors are derived using the Delta method (see Judge *et al.*, 1985, p.205-207).

Figure 4: Cumulative adjustment function for the Tuesday dataset

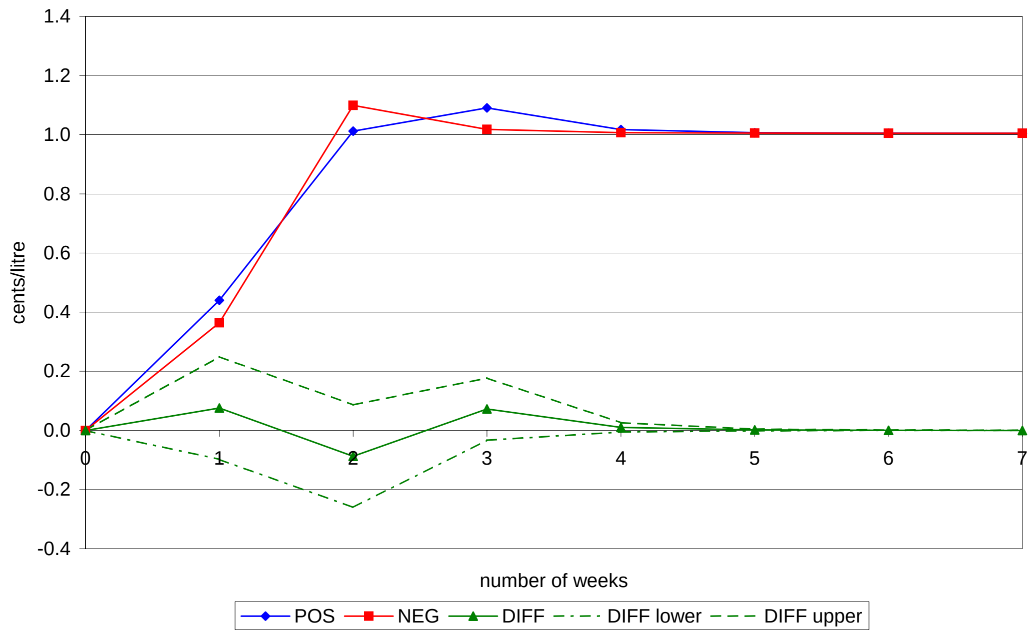


Figure 5: Cumulative adjustment function for the Wednesday dataset

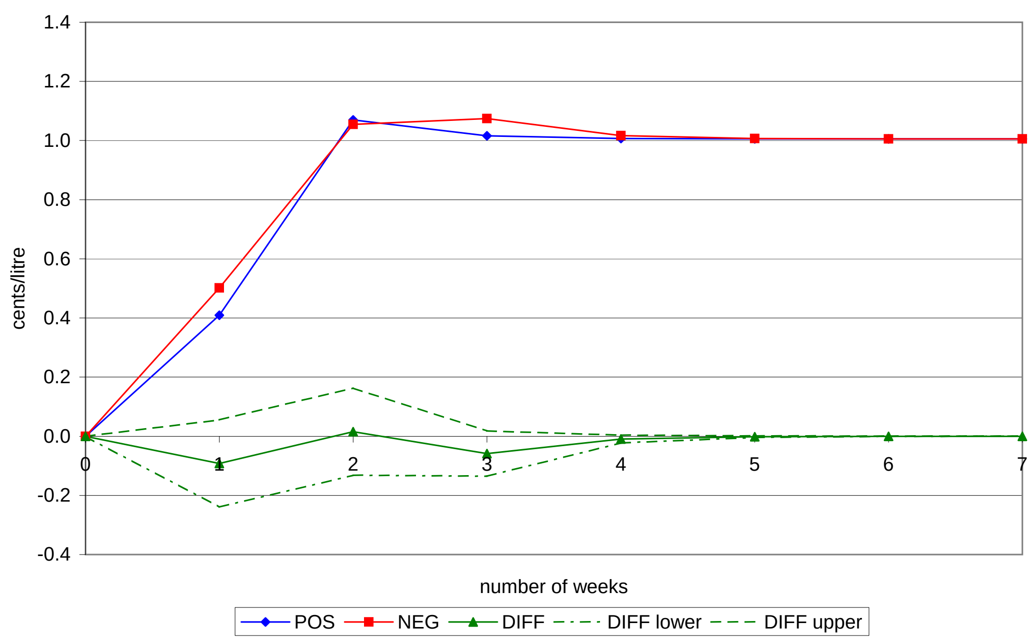


Figure 6: Cumulative adjustment function for the Thursday dataset

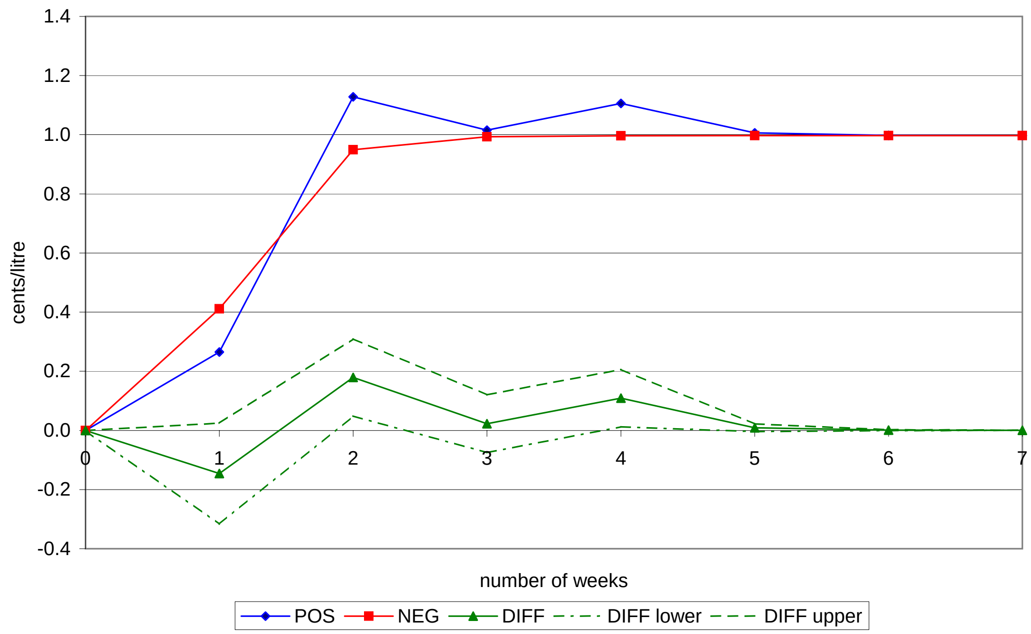
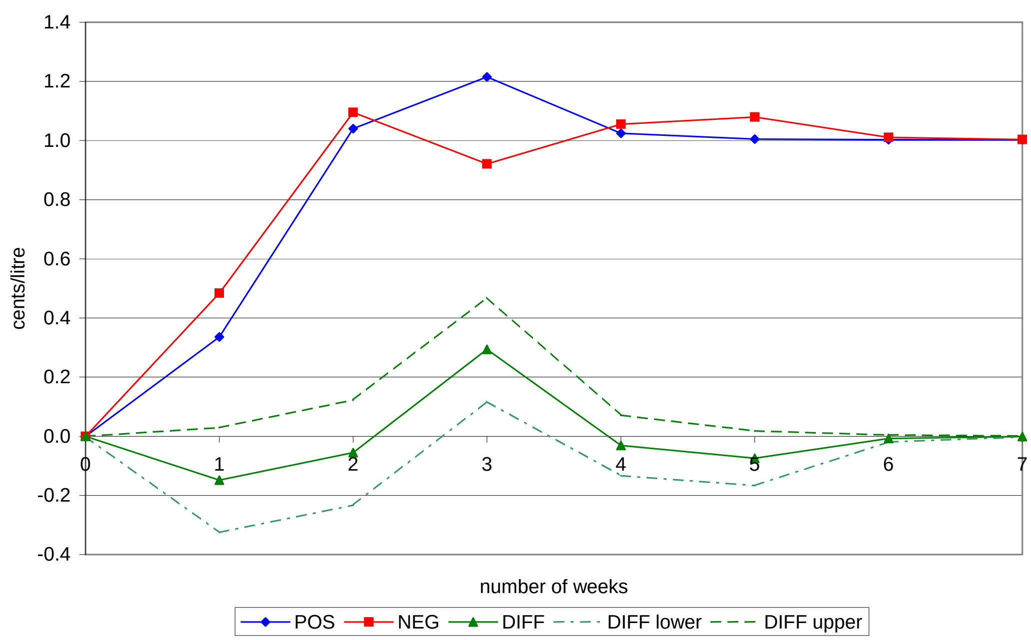


Figure 7: Cumulative adjustment function for the Friday dataset



The significant differences between the cumulative adjustment functions for Monday illustrate the finding of asymmetry by the Wald-test. A one cent increase in the spot price leads to a 0.72 cents increase of the retail price in the first week, whereas the estimated response to a one cent decrease is only 0.36 cents. In the third week the difference in the responses is also significantly different. An increase in the spot price is passed through faster than a decrease. However, in week 5 the opposite holds. After six weeks the long run equilibrium price is reached. It appears from Figure 3 that the retail price overshoots the long run equilibrium both in case of a positive and negative change in the spot price. This outcome does not seem consistent with price setting behaviour of an oligopolist. Finally, Figure 3 illustrates that the pass-through of both a decrease and increase in the spot price converges to the estimated long run coefficient on WP. Notice that this symmetric cumulative pass-through is imposed by the model specification. Figure 6 and 7 also illustrate the finding of price asymmetry. The adjustment path of Thursday reveals significant asymmetry in week 2 and 4. The cumulative adjustment function of Friday only shows a significant asymmetry three weeks after the price shock. At that point, the spot price increase is transmitted to the retail price more quickly than a spot price decrease. As Figure 4 and Figure 5 demonstrate, the estimates of Tuesday and Wednesday exhibit symmetry in the adjustment of the retail price to changes in the spot price. The cumulative adjustment functions are not significantly different from one another.

We now briefly discuss the robustness of the results with respect to other lag structures. We considered 36 different lag structures, ranging from a simple specification with no lags to one with five lagged variables for both decreases and increases in the spot price. In the determination of the number of lags, the discriminating power of the AIC is weak (see Table 5 for the ten models with the lowest AIC). We simply select the specification with the lowest AIC. Inspection learns that choosing another lag structure only slightly affects the shape of the cumulative adjustment function. However, in some cases it alters the conclusion on price asymmetry. For example, if we had included only one lag for decreases in the spot price, the conclusion for Tuesday would be asymmetric pricing. For Thursday, including one lag for decreases and four lags for increases would change our conclusion into price symmetry. As a consequence, we have to be cautious in drawing any conclusions on price asymmetry for Tuesday and Thursday. For Wednesday and Friday the results are robust for the models in the top-20 of the AIC rankings, whereas for Monday all models considered indicate price asymmetry.

Table 5: Sensitivity to the lag structure[a]

Monday			Tuesday			Wednesday			Thursday			Friday		
m n	AIC	p-value	m n	AIC	p-value	m n	AIC	p-value	m n	AIC	p-value	m n	AIC	p-value
4 2	-6.249	0.000	1 2	-6.094	0.238	2 1	-6.401	0.269	0 3	-6.322	0.003	4 2	-6.227	0.005
5 2	-6.244	0.000	1 1	-6.092	0.443	2 4	-6.398	0.166	1 3	-6.320	0.045	5 2	-6.226	0.008
1 2	-6.244	0.000	1 0	-6.091	0.005	2 5	-6.398	0.182	0 4	-6.318	0.007	4 5	-6.226	0.004
4 3	-6.243	0.000	2 1	-6.090	0.376	2 2	-6.396	0.309	0 5	-6.318	0.016	3 5	-6.225	0.005
3 2	-6.239	0.000	2 0	-6.090	0.008	1 4	-6.396	0.297	1 4	-6.316	0.085	3 2	-6.224	0.005
5 3	-6.238	0.000	2 2	-6.088	0.611	3 1	-6.395	0.341	2 3	-6.315	0.042	2 5	-6.223	0.011
1 3	-6.238	0.000	1 3	-6.087	0.371	2 3	-6.395	0.244	1 5	-6.315	0.134	4 3	-6.221	0.006
2 2	-6.238	0.000	3 0	-6.083	0.020	1 5	-6.395	0.332	3 1	-6.314	0.102	5 3	-6.221	0.009
4 4	-6.237	0.000	3 1	-6.083	0.525	1 1	-6.394	0.508	5 1	-6.314	0.148	1 5	-6.220	0.003
1 4	-6.237	0.000	4 0	-6.083	0.021	5 1	-6.393	0.396	4 1	-6.314	0.106	5 5	-6.220	0.007

[a] m (n) refers to the number of lagged variables for decreases (increases) in the spot price. AIC stands for Akaike Information Criterion. The p-value applies to the restriction that the coefficients of decreases and increases of WP are equal.

4 Implications for consumer costs

The adverse consequences of asymmetric pricing can be evaluated in terms of consumer costs. Since we find the strongest evidence of an asymmetric price adjustment for the Monday dataset, we focus on this case to assess the implications for consumers following two approaches.

The first approach is to compare the gain to consumers from a given decrease in the spot price over the adjustment period with the loss to consumers from an equal size increase in the spot price (see Borenstein *et al.*, 1997). Under simple linear interpolation between the estimated adjustment points, the area under a cumulative adjustment curve equals the change in consumer costs following a change in the retail price when a consumer buys one litre of gasoline each week. An estimate of the asymmetry in total costs is given by the integral of the differences of the two cumulative adjustment functions.[19] Figure 8 presents the consumer cost of price asymmetry (excluding the VAT) and its 95% confidence interval. It indicates that in the first week the difference in consumer costs is 0.18 cents. Two weeks after the spot price change the difference in consumer costs is 0.33 cents per two litres. After week 7 the total cost asymmetry remains constant around 0.40 cents. If a consumer buys in total seven litres of gasoline, a one cent per litre increase in the spot price costs the consumer 0.40 cents more over the adjustment period than a one cent per litre decrease saves her. Thus, price asymmetry implies only a minor loss to consumers.[20] The implications for consumer expenditures are insignificant when using observations of Thursday and Friday. Therefore we do not present these figures.

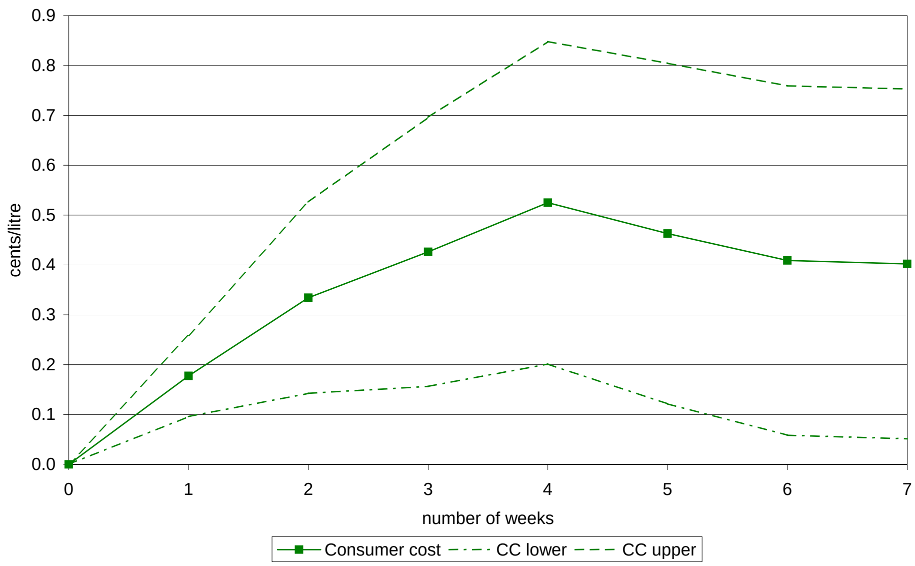
A drawback of the above approach is that it only assesses the effect on consumer costs of a one-time equal size increase and decrease in spot prices. Since it is not based on the actual spot price development, the simply calculated effects on expenditures might be misleading. In the second approach, we therefore perform a dynamic simulation of the retail price with a model on which the symmetry restrictions are imposed.[21] In this simulation the disturbance term of the symmetric

[19] More formally, $\Delta Consumer\ cost = \int_{i=0}^{p}(A_i^+ - A_i^-)di$, where A_i^+ and A_i^- denote the estimated cumulative adjustments for week i to a one cent increase and decrease in the spot price.

[20] Assuming a constant consumption of 96 million litres per week, the oil companies receive extra revenues of 0.4 million guilders (= 96 * 0.4/100) in total over a period of seven weeks (including excise taxes).

[21] The model is estimated with the restrictions stated in note 10.

Figure 8: Consumer costs for the Monday dataset



model is substituted by the disturbance term of the asymmetric model to allow for a pure comparison. Using actual figures on quantities sold[22] we calculate the total of expenditures when price adjustment is symmetric. The observed outlays are taken to represent the asymmetric case. It appears that during the sample period the difference between actual and simulated expenditures is only 0.0001% for the Monday dataset. On Thursday and Friday, the consumer costs proved to be even smaller. Therefore, we conclude that the consumer costs of an asymmetric transmission of spot prices are negligible in the sample period.

5 Concluding remarks

This paper analyses the price adjustments in the Dutch gasoline market by estimating an asymmetric error correction model. Daily data is available for the period January 1996 to December 2001. We estimate the model on weekly price changes. Since it is a priori not clear which day of the week should be selected, we construct five datasets, one for each working day. In the datasets retail and Rotterdam spot prices that are observed on the same day are grouped.

The estimation results show that a spot price change is fully passed through to the

[22]These figures are only available on a monthly basis (obtained from Statistics Netherlands). We assume a constant daily consumption per month.

retail price in the long run. Based on the AIC we find that the number of lagged variables for decreases and increases in the spot price differs in each specification. The estimation results do not unambiguously point at price symmetry nor asymmetry. The Wald test strongly rejects the symmetric specification when observations for Monday, Thursday and Friday are used, whereas for the Tuesday and Wednesday datasets symmetry cannot be rejected. In assessing the implications for consumers, we conclude that the effect on consumer costs is negligible.

From the analysis we highlight two findings. First, the estimation results suggest that the day for which prices are observed matters for the results, since the conclusions on price asymmetry are not uniform across the five datasets. Estimation on higher frequency data could shed light on our finding that outcomes differ over the weekly datasets. Second, the discriminating power of the AIC is weak in determining the number of lags. However, we find cases for which the test on asymmetric price adjustment is sensitive to slight changes in the chosen lag structure. Given these findings, in our view existing studies pay too little attention to the robustness of the results. The mixed conclusions on asymmetry found in the literature might be explained by an insufficient robustness of the outcomes.

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Appendix I

In this Appendix we derive the long run equilibrium relationship between the spot price and the retail price excluding the value-added tax.

The profit of firm i in period t is equal to total revenues minus total costs:

$$\pi_{it} = PP_t(Q_t) \cdot Q_{it} - C(Q_{it}, WP_t) \tag{A.1}$$

where PP denotes the producer price. The producer price is the retail price (RP) of one litre of gasoline excluding the value-added tax (κ) and the excises taxes on gasoline (EXC):

$$PP = \frac{RP}{(1+\kappa)} - EXC \tag{A.2}$$

The retail price depends on total market demand (Q). C is the cost function, depending on output (Q_{it}) and the spot price of gasoline (WP). The firm is assumed to maximize its profit:

$$\begin{aligned}
\frac{\partial \pi_i}{\partial Q_i} &= PP + \frac{\partial PP}{\partial Q} \cdot \frac{\partial Q}{\partial Q_i} \cdot Q_i - \frac{\partial C(Q_i, WP)}{\partial Q_i} \\
&= PP + \frac{RP}{(1+\kappa)} \left(\frac{\partial RP}{\partial Q} \cdot \frac{Q}{RP} \right) \cdot \left(\frac{\partial Q}{\partial Q_i} \cdot \frac{Q_i}{Q} \right) - MC_i \\
&= PP - \frac{RP}{(1+\kappa)} \cdot \frac{1}{\epsilon} \cdot \theta_i - MC_i = 0
\end{aligned}$$

From which follows that:

$$\frac{RP}{(1+\kappa)} = \frac{\epsilon}{(\epsilon - \theta_i)}(MC_i + EXC) \tag{A.3}$$

The parameter $\theta_i (\equiv \partial Q/\partial Q_i \cdot Q_i/Q)$ is the conjectural variation elasticity, measuring the degree of competition. An estimate of θ_i close to one indicates oligopolistic behaviour, while a value close to zero reflects competitive behaviour in the market. ϵ is the price elasticity of demand, defined as $-\partial Q/\partial RP \cdot RP/Q$ with $\epsilon > \theta_i$. Finally, MC stands for marginal costs.

The retail price excluding value added tax is greater than or equal to the sum of the marginal costs and excise taxes, since $m \equiv \epsilon/(\epsilon - \theta_i) \geq 1$, where m denotes the mark up ratio.

Let the marginal costs be assumed independent of Q_{it}:

$$MC_{it} = \alpha + \beta WP_t \tag{A.4}$$

The effect of a spot price change on the marginal cost is equal to β. Under the assumption of a constant price elasticity and stable competition in the market, the long run relationship can be rewritten as follows:

$$RPE_t = m\alpha + m\beta \cdot WP_t + m \cdot EXC_t \tag{A.5}$$

Equation (A.5) is the long run relationship (1). For $m > 1$, it shows that excise tax changes are more than proportionally passed through to the retail price. Moreover, the coefficient on WP is the product of the effect of a spot price change on the marginal costs (β) and the mark up (m).

Appendix II

In this Appendix we derive from an asymmetric ECM with two lagged variables the response of the retail price in the ith period after an one-time decrease in the spot price.[23] The model is as follows:

$$\begin{aligned} \Delta RPE_t &= \sum_{i=0}^{2} \alpha_i^- \Delta WPN_{t-i} + \sum_{i=0}^{2} \alpha_i^+ \Delta WPP_{t-i} + \omega \Delta EXC_t + \\ &\quad \lambda(RPE_{t-1} - RPE_{t-1}^*) \\ RPE_t^* &= \gamma + \beta\, WP_t + \tau EXC_t \end{aligned} \tag{A.6}$$

where ΔRPE and ΔEXC denote the change in the retail price and excise taxes on gasoline, respectively. ΔWPN and ΔWPP represent the decreases and increases in the spot price, respectively and RPE^* is the retail price level in the long run.

The change of the retail price in period t resulting from the period t decrease in the spot price is given by:

$$\frac{\partial \Delta RPE_t}{\partial \Delta WPN_t} = \alpha_0^- \tag{A.7}$$

[23] The derivation of the responses of the retail price to an one-time increase in the spot price is similar.

The coefficient α_0^- is the contemporaneous response of retail price to the spot price decrease. The adjustment in period $t+1$ is the sum of the contemporaneous impact and the effect on the error correction term:

$$
\begin{aligned}
\frac{\partial \Delta RPE_{t+1}}{\partial \Delta WPN_t} &= \alpha_1^- + \lambda \left(\frac{\partial RPE_t}{\partial \Delta WPN_t} - \frac{\partial RPE_t^*}{\partial \Delta WPN_t} \right) \\
&= \alpha_1^- + \lambda \left(\frac{\partial (RPE_{t-1} + \Delta RPE_t)}{\partial \Delta WPN_t} - \beta \cdot \frac{\partial (WPN_{t-1} + \Delta WPN_t)}{\partial \Delta WPN_t} \right) \\
&= \alpha_1^- + \lambda(\alpha_0^- - \beta) \qquad \text{(A.8)}
\end{aligned}
$$

In period $t+2$ the adjustment is equal to:

$$
\begin{aligned}
\frac{\partial \Delta RPE_{t+2}}{\partial \Delta WPN_t} &= \alpha_2^- + \lambda \left(\frac{\partial (RPE_{t-1} + \Delta RPE_t + \Delta RPE_{t+1})}{\partial \Delta WPN_t} - \beta \right) \\
&= \alpha_2^- + \lambda(\alpha_0^- + \alpha_1^- + \lambda(\alpha_0^- - \beta) - \beta) \qquad \text{(A.9)}
\end{aligned}
$$

The adjustment in the third period after the decrease in the spot price is only the error correction effect:

$$
\begin{aligned}
\frac{\partial \Delta RPE_{t+3}}{\partial \Delta WP_t} &= \lambda \left(\frac{\partial (RPE_{t-1} + \Delta RPE_t + \Delta RPE_{t+1} + \Delta RPE_{t+2})}{\partial \Delta WP_t} - \beta \right) \\
&= \lambda(\alpha_0^- + \alpha_1^- + \lambda(\alpha_0^- - \beta) + \alpha_2^- + \\
&\quad \lambda(\alpha_0^- + \alpha_1^- + \lambda(\alpha_0^- - \beta) - \beta) - \beta) \qquad \text{(A.10)}
\end{aligned}
$$

Adjustments in the subsequent periods can be derived in the same way.