PRICE ADJUSTMENTS AND ASYMMETRY IN THE PHILIPPINE RETAIL GASOLINE MARKET

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Abstract

This paper employs ordered probit, partial adjustment, and vector error correction models to characterize price adjustments in the Philippine retail gasoline market since its deregulation. We find that pricing decisions of oil firms depend significantly on eight weeks of previous changes in crude cost. We show that the speed of adjustment of retail prices to its long-run equilibrium relation with crude cost has been following an accelerating trend but is vulnerable to intervening factors. Lastly, we provide empirical evidence that pump prices respond quicker and more fully to increases in crude cost rather than to decreases.

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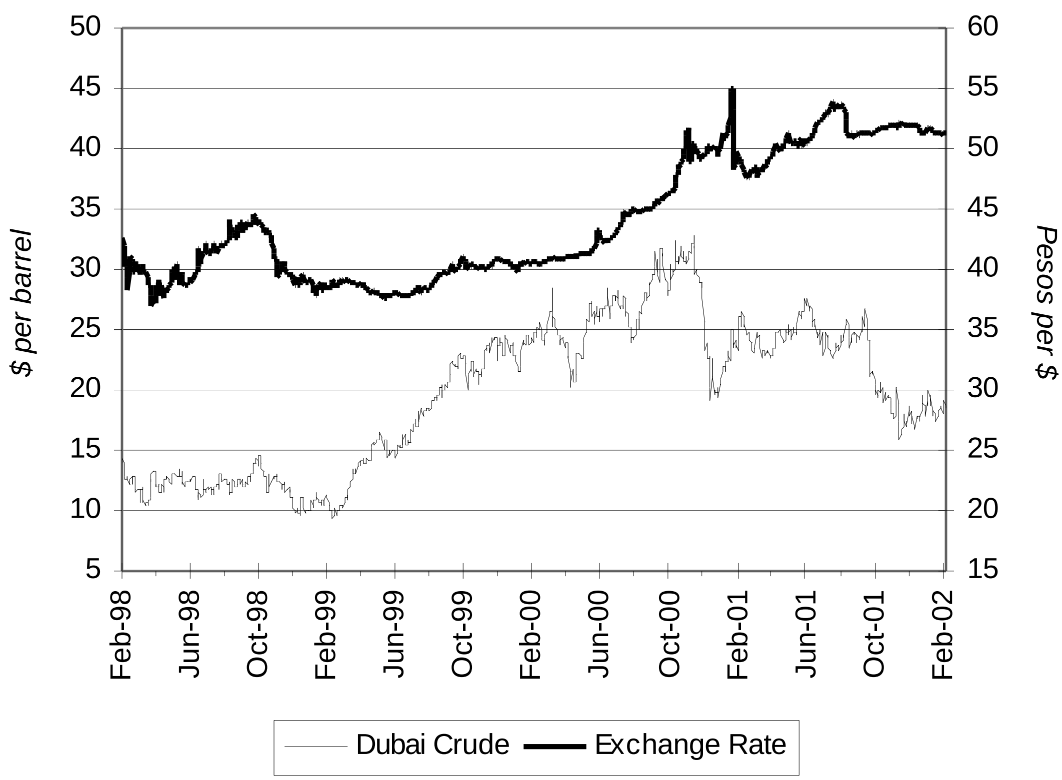
1 Introduction

The Philippine downstream oil industry was deregulated in February 1998 as part of a general reform policy of liberalization and the retreat of the government from intervention in the market.[1] It was enacted to spur competition in the local market that has been dominated by three major firms, and also to unload the government of the burden of price subsidy as the Oil Price Stabilization Fund (OPSF) went into deficit. The primary decontrol measure was that oil companies were now allowed to set prices, whereas before, the government fixed prices through the Energy Regulatory Board (ERB).

Figure 1: Daily Movements of Crude Price and Exchange Rate



[1] This is not entirely correct since RA 8180, which was passed by Congress on April 1996, preceded the currently observed RA 8479. The two essentially put forward the same action, but the former was nullified on November 1997 as the Supreme Court found in it provisions that "inhibit fair competition, encourage monopolistic power and interfere with the free interaction of market forces." However, while the previous law was in effect, and even after it was struck down, partial deregulation has actually taken place. See U (2000) for an extended discussion of the history of the oil industry and this "landmark" antitrust decision.

With the entry of new players in the country's retail gasoline market, the public expectation was that competitive pressures would push pump prices down; however, such an event wasn't actually in the offing. World crude prices started climbing in February 1999 and peaked only in November 2000 at more than thrice its previous value, no small thanks to the output tightening orchestrated by the Organization of Petroleum Exporting Countries (OPEC) cartel, while the peso steadily slid against the dollar since June 1999 (Figure 1). As crude import costs soared, so did retail gasoline prices move in a similar trend.[2] Some consumers, however wrongly, took this as a *post hoc ergo propter hoc* evidence of the folly of deregulation.

More so, there is an apparent consumer sentiment that pump prices are raised as soon as crude oil prices have increased and/or the peso has depreciated, and they are kept high for some time even if a rollback appears warranted given lower crude prices and an appreciating peso. Not only that, the naïve observation is that the magnitudes of price changes are relatively biased upwards for price hikes. Together with the coincidental if not simultaneous[3] price adjustments of Petron, Shell and Caltex (the so-called Big Three), not a few saw this as an indication of collusion among the dominant firms[4] to increase

[2] The country relies on the foreign market for practically all of its crude requirements; domestic upstream operations contributed just a little over one percent of total supply from 1990-2000.

[3] Because of the public sensitivity to oil price hikes, the Department of Energy (DoE) monitors retail prices and requires oil companies to give notice before any price adjustment is made, which is then relayed to the media. Most of the time the public gets to know this even earlier since the retailers directly inform the press ahead of any adjustment, possibly to gauge market response and condition the public of the eventual change, or perhaps a signal to other firms of their action. See U (2000) for a discussion of game theoretical focal pricing.

[4] To break up such an oligopoly, there have been attempts in the legislature moving for the creation of a National Oil Exchange, a company that will be given the sole authority to import crude oil and petroleum products and manage the biggest oil depots. Downstream industry operators will then pay the same price for the commodities, mainly competing in retailing. However, this does not address the issue of first-mover advantages for the established firms, besides the usual arguments against a monopoly, government-owned at that.

profits, a worse situation than when prices were set by the government and mark-up was maintained at a certain level.

These observations were rather uninformed because no empirical bases were adequately provided. Pronouncements of the Consumer and Oil Price Watch (COPW) regarding expected price adjustments merely noted cold calculations on the changes in crude costs with allowances for some lag, and as such were static in nature, meaning no corrections were considered to result from previous pricing actions.[5]

In this paper we will seek to characterize retail gasoline price adjustments in the country and determine if the deregulation of the industry has resulted in a faster adjustment of retail prices to crude cost changes through time. Also, we investigate if an asymmetric pricing behavior indeed prevails, wherein retail prices respond more quickly to an increase in crude prices than to a decrease. These are done for the Big Three as well as for minor players for comparison.

The paper is organized as follows. Section 2 presents a short review of related literature. Section 3 introduces the data used and some preliminary observations from a cursory inspection. Section 4 summarizes the econometric models employed in this paper to model the response structure of retail gasoline prices to crude oil price changes and to check the existence of price asymmetry. Section 5 discusses the results of the models and some implications. Finally, Section 6 concludes.

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[5] Using a base point is helpful, but its arbitrariness is untenable.

2 Theory and Literature

There has been a fair amount of literature devoted to the study of pricing behavior in retail gasoline markets. This is driven by social sensitivity to any kind of price volatility or downward stickiness, more so in this case since gasoline is considered a vital commodity for the movement of goods and people.

Gasoline sold in retail markets is a fairly homogenous good, with the additives included in premium brands important to the average consumer only on the margin. With many sellers and low entry and exit barriers, one would thus expect a competitive outcome where retail prices are set equal to marginal cost and industry economic profits are zero.

However, the demand for gasoline is price inelastic in the short run[6] and there are significant costs associated with entering the industry, as well as locational advantages for incumbent players. There is also the peculiarity of a supply structure that relies on a depletable nonrenewable resource controlled by but a few extractors. Hence the situation can actually deviate from the competitive outcome.

One indication of this is the phenomenon of asymmetric pricing wherein retail gasoline prices respond more quickly when crude cost is rising than when it is falling. Bacon (1991) found support for such a claim in the UK gasoline market. Karrenbrock (1991); Borenstein, Cameron, and Gilbert (1997); Balke, Brown, and Yücel (1998); and the Energy Information Administration (1999) all found similar results for the US market.

[6] Estimates range from –0.1 to –0.2 (Dahl and Sterner, 1991).

In contrast, Godby, Lintner, Stengos, and Wandschneider (1998) and the Conference Board of Canada (2001) did not find any evidence in favor of such; the Canadian retail gasoline market seemed competitive enough to eschew such a response pattern.

Some explanations posited for such a phenomenon are tacit collusion, search costs, consumer response to changing prices, and market power. Industry players signal their continued adherence to an unspoken agreement to maintain high profit margins by hiking pump prices when crude prices increase, and reluctantly or slowly adjusting prices downwards when crude costs decrease. Search costs concern the expensive and time-consuming process consumers must engage in to find a lower-priced gasoline, the gain from which is but a few centavos per liter, so that it will take some time before stations are forced to lower their prices. Consumers may also accelerate their purchase of gasoline when prices are rising thereby facilitating price hikes, and may buy gasoline much faster when prices are falling so that prices fall slower.

Noel (2001) examined the dynamic pricing behavior in Canadian retail gasoline markets and found that three distinct pricing patterns exist: (1) standard cost-based pricing, (2) sticky pricing, and (3) steep, asymmetric retail price cycles. The latter had a short and quick relenting phase followed by a long and slow undercutting phase and was characterized by lower average markups compared to the other two. These were found to be prevalent in markets with a greater penetration of small, independent firms. Borenstein and Shepard (2002) studied the wholesale US gasoline market and showed that prices adjusted more slowly in markets where there are higher price-cost margins, a proxy for market power.

3 Data and Preliminary Observations

This study examines retail pricing of unleaded gasoline in Metro Manila[7] for the period beginning the third week of January 1999 (1/16/1999) and ending the first week of February 2002 (2/02/2002), consisting of 160 observations. Prior to this date, only partial deregulation has taken place, in the sense that an automatic pricing mechanism (APM) put in place by the government as a pricing guide was observed.

DATA

Data were collected on daily crude cost from the Energy Industry Administration Bureau (EIAB) of the Department of Energy (DoE). The price of medium Dubai crude with API of 30.7 was used since it is regarded as the benchmark in Asia. Until July 1999 the EIAB used quotations from Reuters, they subscribed to Platts the month thereafter; however, the correlation of the two price series from August to December 1999 (the available overlap) was 94.3%.

Data on the daily exchange rate (weighted average) between the Philippine peso and the US dollar were obtained from the Institute for Development and Econometric Analysis, Inc. (IDEA) which archived it from the Bangko Sentral ng Pilipinas (BSP).

The crude cost in pesos per liter (denoted as *CRUDE*) was computed by getting the product of Dubai crude prices ($/barrel) and the exchange rate of the peso against a dollar (P/$) and dividing it by 158.9 liters, the equivalent of a barrel.

[7] Unleaded gasoline was chosen because it was a standard product offered by all retailers; leaded gasoline was phased out starting April 2000. Data on retail prices were available only for Metro Manila.

Data on the retail prices (pesos per liter), exclusive of the P4.35 excise tax levied on unleaded gasoline throughout the period, of five downstream oil firms, namely Petron Corporation, Pilipinas Shell Petroleum Corporation, Caltex (Philippines) Incorporated, TWA Incorporated (Flying V), and Seaoil Petroleum Corporation, were likewise sourced from the EIAB-DoE.[8] As of yearend 2001, the last two have the most number of retail gasoline stations in Metro Manila among the new players.

Weekly averages were computed for all the series to minimize the noise in daily frequency data, with Saturday denoting the average of the day itself and the six days prior to it. The crude price and exchange rate of the previous workday was used for weekends and holidays. Since we are interested in the difference of pricing behavior between big and small players, the unweighted mean of the retail prices of Petron, Shell and Caltex (denoted as RP_{BIG}) and of Flying V and Seaoil (RP_{SMALL}) were computed. The correlations between prices of the groups' members were very high at 99.9%.

Throughout the period studied, the importation tax on both crude oil and petroleum products has been a uniform 3% as mandated by Republic Act No. 8479. However, former President Estrada reduced this to 0% for three months starting November 8, 2000 via Executive Order No. 314 in an effort to contain the impact of rising crude prices. Hence a dummy variable S was defined for the period 11/11/2000-

[8] The bureau monitored prices by calling the retail gasoline stations of the different oil players in a randomly chosen area within Metro Manila on the date of effectivity of the price adjustment given notice them. Since locational differences had an effect on posted prices, ranges (price from lowest to highest) were recorded for every petroleum product. The median of this was used as the retail price in the study. A key assumption made was that no significant deviations from the recorded price happened in the period between announced price changes. On-site monitoring of posted prices was also randomly done by the EIAB to check on this.

2/10/2001 since the import duty on crude oil and petroleum products was suspended roughly during this period.

PRELIMINARY OBSERVATIONS

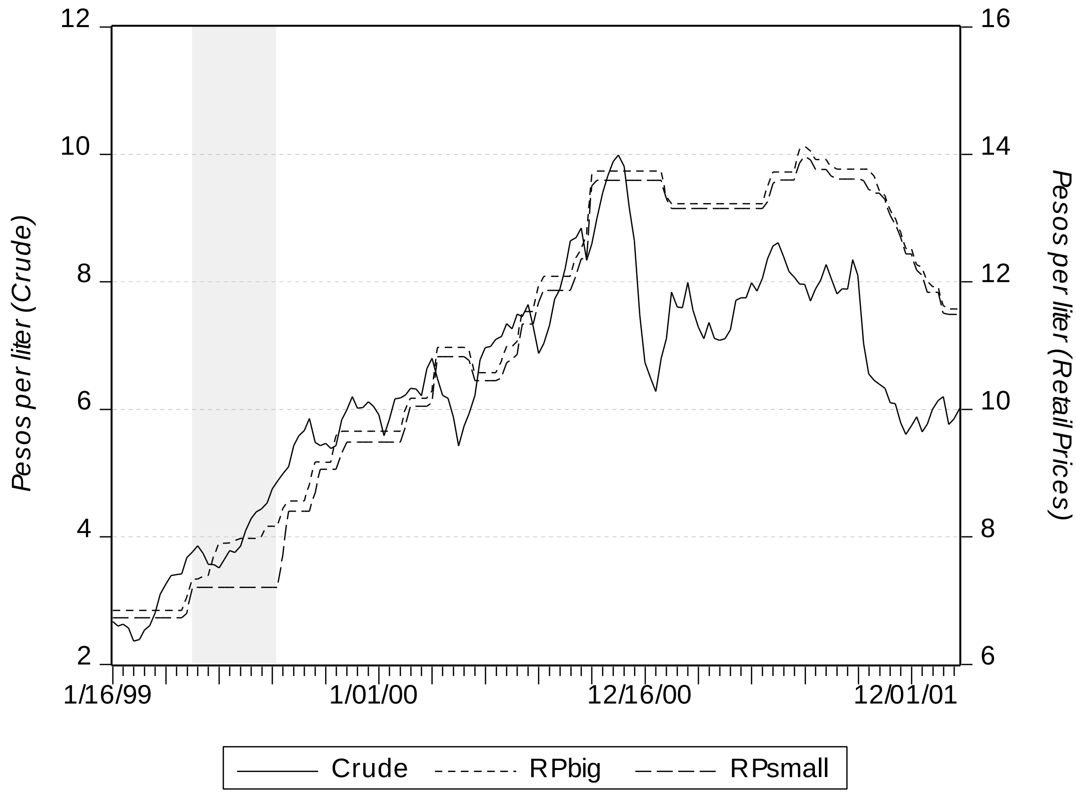
Using daily observations from 1/10/1999-2/2/2002, there have been 45 price adjustments for major oil firms and 35 for new entrants (Table 1), once every 25 days for the former and about once in every month for the latter. Prices can thus be considered fixed or unchanging for about 96.5% of the time. Around 60% of price movements were accounted for by upward adjustments. The absolute value of price adjustment is greater for increases rather than decreases, with mean changes higher for small players.

Table 1: Descriptive Statistics of Price Adjustments (Daily)

	?RP_{BIG}			?RP_{SMALL}		
	?0	>0	<0	?0	>0	<0
Mean	0.1051	0.2874	-0.2253	0.1358	0.3837	-0.2361
Median	0.1267	0.3333	-0.2633	0.2500	0.3700	-0.2275
Minimum	-0.4000	0.0017	-0.4000	-0.3775	0.1475	-0.3775
Maximum	0.8033	0.8033	-0.0450	0.7800	0.7800	-0.0925
Standard deviation	0.3022	0.1990	0.1147	0.3364	0.1611	0.0883
Skewness	0.0891	0.4142	0.3594	-0.0537	0.7196	0.0028
Kurtosis	2.0797	2.6641	1.8373	1.7033	2.9812	1.7876
No. of cases	45	29	16	35	21	14

Now using weekly data, if we observe closely the concurrent movements of retail prices and crude cost through time (Figure 2), it appears that retail price adjustments do not fully coincide with the direction of change in crude prices, especially at some turning points. This mismatch indicates that there is a lag between gasoline prices and the effective crude price relevant to the oil firms' pricing decision; we would determine how long this is in the study.

Figure 2: Weekly Movements of Crude and Retail Prices



All throughout the sample, the gasoline prices posted by both groups have moved closely together with one exception, the period between the weeks of 5/1/1999 and 8/21/1999 (the shaded area) when the retail price of the small players remained unchanged while that of the big players steadily climbed. We may interpret this move as an initial effort by the new entrants to gain market share[9] and assess the receptiveness of the market, as a test of the incumbents' market power.

The mean difference between retail prices and concurrent crude cost throughout the period was P4.75 for the Big Three and P4.55 for the minor firms (Table 2). The

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[9] Indeed the combined market share of all industry players excluding the Big Three doubled in 1999 to 8.7% from 4.3% in the previous year, the highest yearly increment realized by the new players since their entry in 1996 (see Table 18).

minimum and maximum values were just the same higher for the former, with the latter having a higher standard deviation. This represents the profit margin of the group *and* other input costs[10] in the production of gasoline; if there are no significant changes in input costs affecting the cost structure of the oil players, then we hypothesize that the fluctuations reflect changes in the profit margin.

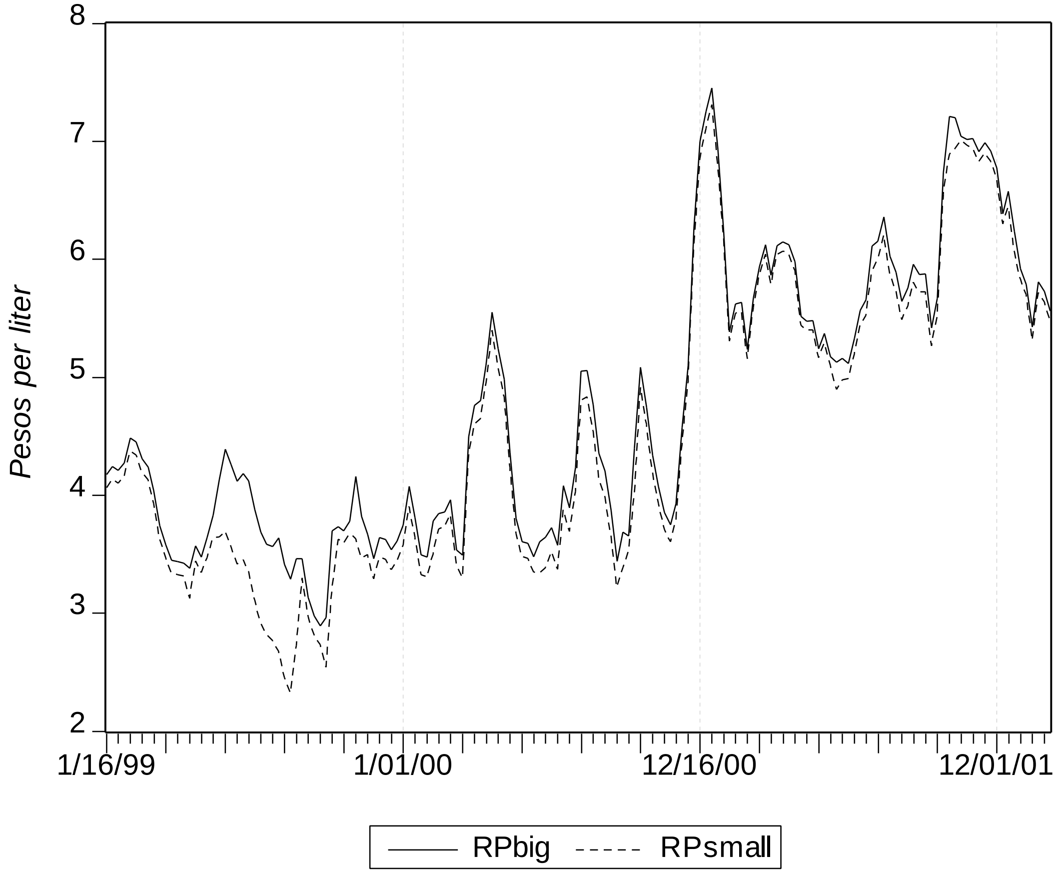
Table 2: Descriptive Statistics of Differentials

	$RP_{BIG} - CRUDE$	$RP_{SMALL} - CRUDE$	$RP_{BIG} - RP_{SMALL}$
Mean	4.7514	4.5457	0.2057
Median	4.3587	4.1794	0.1454
Minimum	2.8928	2.3243	0.0375
Maximum	7.4548	7.3123	0.9633
Standard deviation	1.1735	1.2537	0.1934
Skewness	0.5097	0.3998	2.5076
Kurtosis	2.0756	2.0017	8.5172
No. of observations	160	160	160

Looking at the graph in Figure 3, there is a marked widening in the average level of this differential in January 2001 that clearly appears to have persisted since then. This shift may be considered structural and hence can be attributed to a factor or combination of factors that were introduced or that occurred in this point in time (or near it); however, the appropriate lag length needs to be taken into account before any inference can be reliably given.

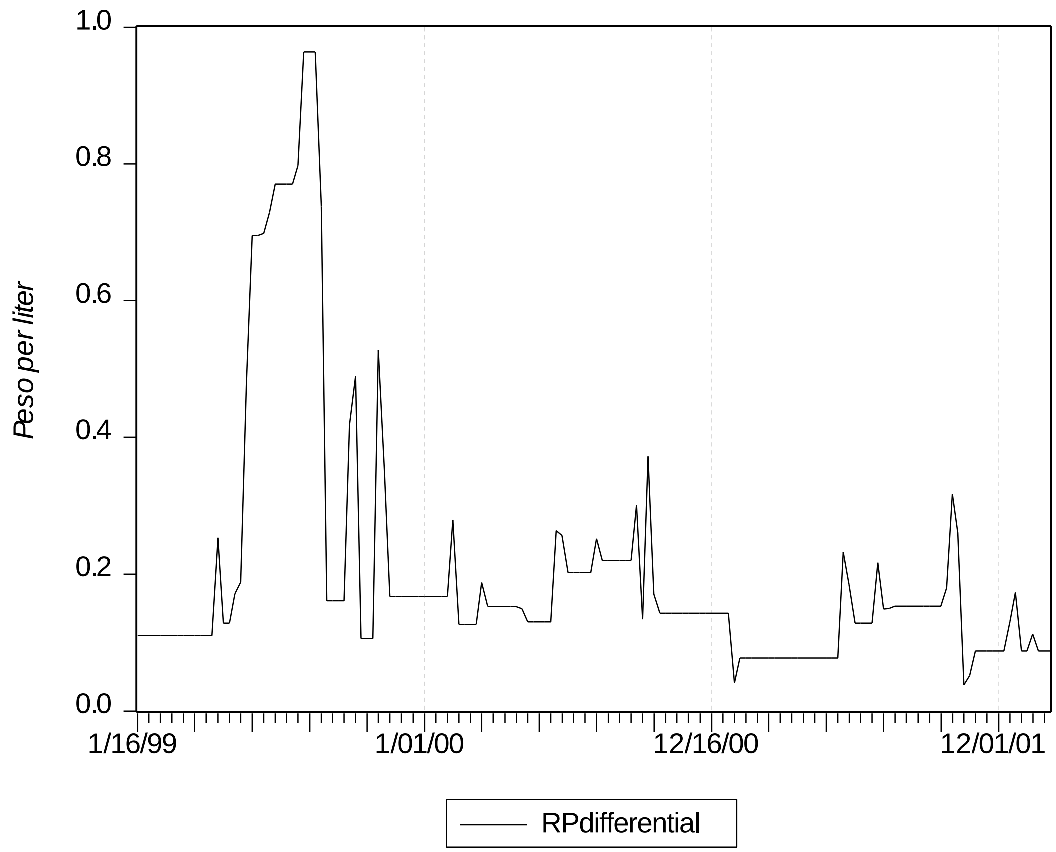
[10] One such input cost is the wages/salaries paid by the oil companies. During the period covered by the study, there have been three adjustments in the minimum wage in the National Capital Region (NCR): on October 31, 1999 (P198 increased to P223.50), November 1, 2000 (raised to P250), and on November 5, 2001 (hiked to P265).

Figure 3: Weekly Movements of Differentials between Crude and Retail Prices



For the differential between the retail prices of big and small players, it is clear that this has been following a declining trend, with the former consistently charging higher pump prices than the latter (Figure 4). The average differential throughout the period was 21 centavos (last column of Table 2), and this has narrowed down to around 9 centavos for the last 14 weeks of the sample. Generally, when one group initiates a price adjustment that results in a spike in the differential, it elicits an instant reaction from the other group so that the price differential stabilizes quickly to some previous or new level.

Figure 4: Weekly Movements of Differentials between Retail Prices



4 Econometric Models

To model the response structure of retail gasoline prices to crude oil price changes, three econometric specifications were estimated. Each model contributed a critical piece in the determination of the exact nature of retail price adjustments. We present here a brief discussion of the outputs of these models and some qualifications; detailed exposition is given in the appendix.

In the first model, an ordered probit regression is employed to capture the decision of the oil players to decrease, maintain or increase retail prices given contemporaneous and lagged changes in crude cost. This exercise is meant to determine the appropriate and relevant lag length. It also lends itself to a determination of the influence of the import duty suspension in the consideration of price adjustments.

In the second, we estimate a partial adjustment model (PAM) that gives us a single parameter that measures the adjustment rate of retail prices to its long-run equilibrium relation with crude cost. This is assumed to be of equal proportion in every period, hence the caveat that price adjustments are constrained from behaving differently in magnitude from one period to another. Also, it implies the counterintuitive circumstance that the direction of the adjustment path is reversed when crude oil price does, with the same proportion.

We extend this model by segregating positive and negative deviations from the equilibrium relationship with crude cost and getting the corresponding adjustment rate estimate. We compare the two parameter estimates to determine if price response speeds differ when the retail price is above the long-run equilibrium path and when it is below it.

Lastly, we use a vector error correction model (VECM) to provide us with a dynamic specification that captures the effects to current retail price adjustments of current and lagged changes in crude cost and previous price movements, together with an error-correction term. The resulting coefficient estimates will then be used in a cumulative adjustment function that will show the cumulative response of gasoline prices to an equivalent increase and decrease in crude cost. We compare the two resulting cumulative response paths through time which will allow us to resolve the question of the existence of price asymmetry in the Philippine retail gasoline market.

The caveat in using the cumulative adjustment function is that there is no accommodation for the relative significance of the estimates and hence reliability may be a problem as insignificant adjustments accumulate over time. Also, incremental steps may make it appear that adjustments do happen each period, when in fact prices are sticky or unchanging in the short run.[11]

5 Results and Implications

After going through the various models, we now present the results and findings, followed by a discussion of implications. We find strong support for the validity of these specifications as evidenced by highly significant *t*- and *F*-statistics, with Durbin-Watson statistics that are sufficiently close to 2. Varying degrees of R^2 and Adjusted R^2 were obtained, some very high and others not, but this should not be seen as a handicap since the theoretical grounding of the models are sound.

RESULTS AND FINDINGS

The results of the ordered probit model (Table 3) show that the firm's decision to decrease, maintain or increase prices is influenced by up to eight weeks of prior changes in crude cost; beyond that, the coefficient estimates are insignificant. The Akaike Information Criterion (AIC) is also at its lowest at this eight-week lag length.

[11] If price adjustments are far in between, which were in fact observed, an appropriate extension would be the modeling of a threshold autoregression (TAR).

Table 3: Ordered Probit Model

Dependent Variable:	Z_{BIG}		Z_{SMALL}	
Variables	Estimate	*p*-value	Estimate	*p*-value
?$CRUDE_{0}$	0.7068	0.0832	1.2366	0.0043
?$CRUDE_{-1}$	0.3010	0.4866	0.5977	0.1826
?$CRUDE_{-2}$	0.3050	0.4785	0.2361	0.5977
?$CRUDE_{-3}$	0.9138	0.0331	0.4190	0.3465
?$CRUDE_{-4}$	0.6452	0.1284	0.7785	0.0798
?$CRUDE_{-5}$	0.8108	0.0636	1.3907	0.0035
?$CRUDE_{-6}$	0.9549	0.0327	1.0326	0.0286
?$CRUDE_{-7}$	1.0457	0.0213	1.2403	0.0103
?$CRUDE_{-8}$	1.0573	0.0129	0.8160	0.0665
?$_1$	-1.2192	0.0000	-1.3361	0.0000
?$_2$	1.0830	0.0000	1.3813	0.0000
Akaike info criterion	1.6172		1.4136	
Log likelihood	-111.0952		-95.7266	
Pseudo R^2	0.2011		0.2558	
No. of observations	151		151	

All the coefficients have positive signs, consistent with the ordered dependent variable *Z* wherein increases in crude prices will lead to increased chances of an upward adjustment in retail prices. The most significant variable influencing the pricing decision of the Big Three is the eighth-week lagged change in crude prices followed by the seventh-week, while it is the fifth-week lagged change followed by the first-week for the minor players. This result reflects the fact that the former group refines the gasoline that they sell in the market, and hence some time elapses before the purchased crude gets to the pump, in contrast to the new entrants who do not engage in processing but merely import finished petroleum products for storage and resale.[12]

[12] According to a January 8, 2001 press release from Petron, it takes 45-55 days before the crude oil the majors import gets refined and reaches retail stations, hence they face a long price adjustment timeframe compared with a distribution time of as short as five days for new players that import already finished fuel products.

Figure 5 shows the estimated *Z** for big and small players with the corresponding limit points. Table 4 shows how the predictions from this regression fare with actual observations; the estimated model has a positive bias for firms deciding to maintain prices, with underestimation errors higher for the decision to increase retail prices.

Figure 5A: Estimated Latent Variable for Big Players

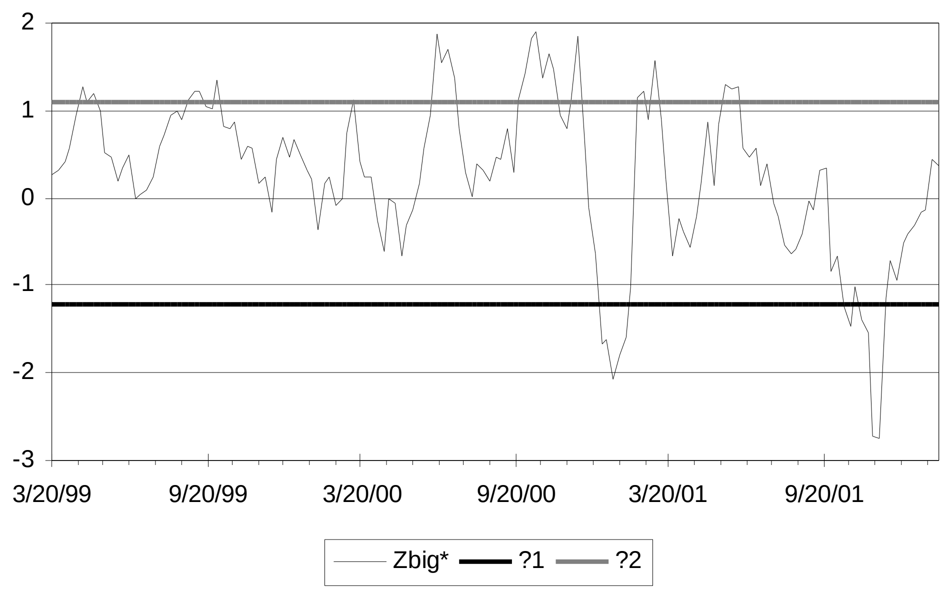


Figure 5B: Estimated Latent Variable for Small Players

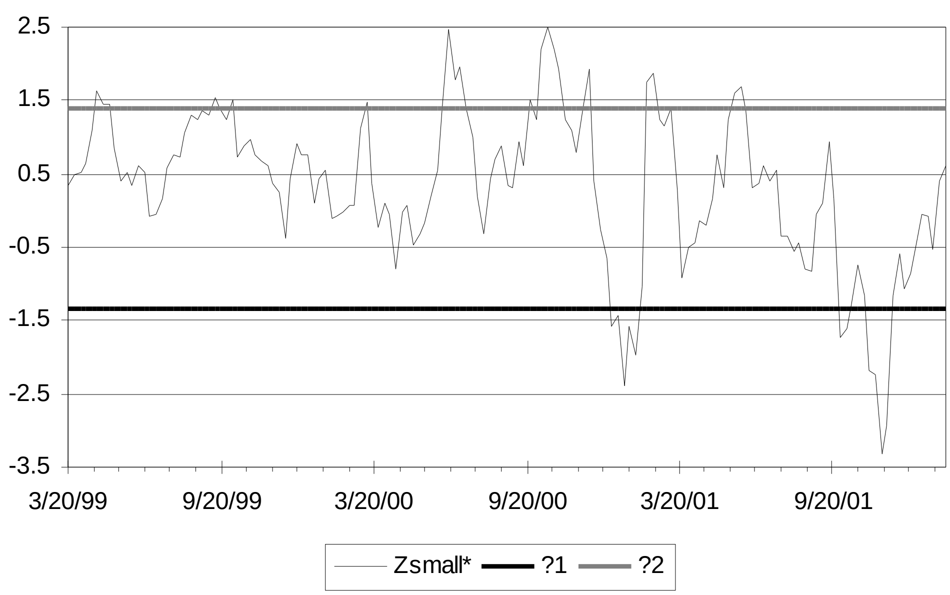
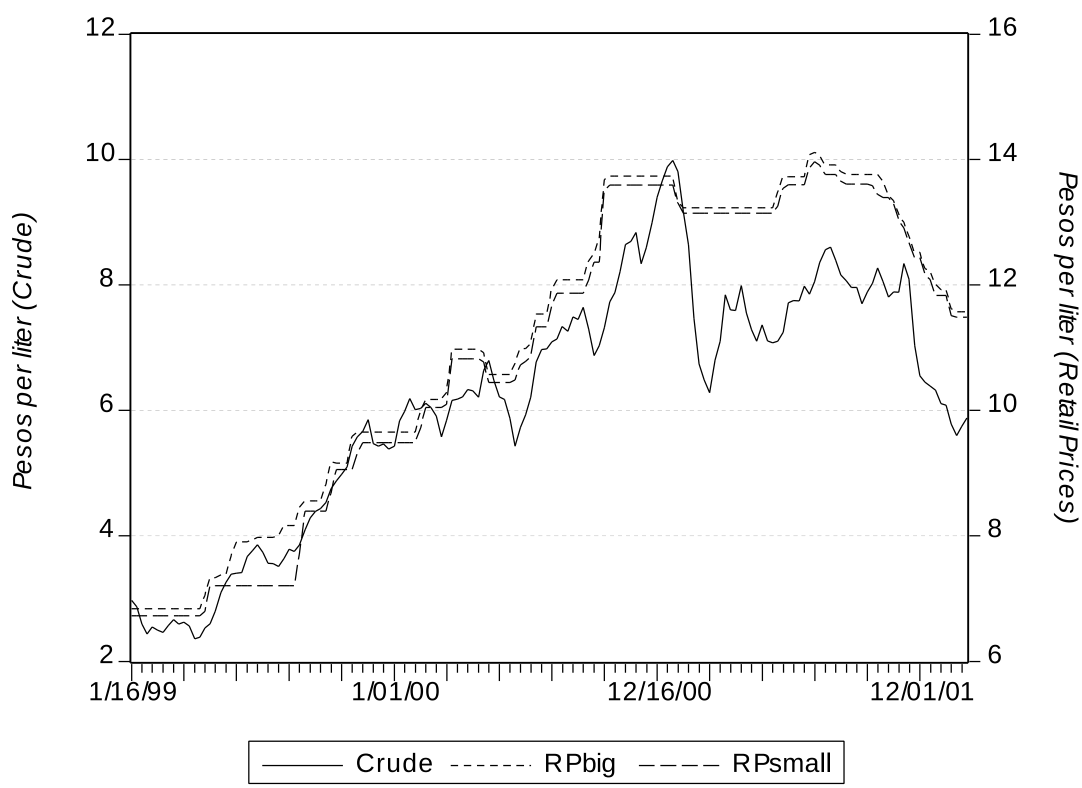


Table 4: Estimation Errors in the Ordered Probit Model

Dependent Variable:		Z_{BIG}			Z_{SMALL}	
	1	2	3	1	2	3
Actual count	22	93	36	21	102	28
Count of obs with Max Prob	10	128	13	12	132	7
Error	12	-35	23	9	-30	21
Sum of all Probabilities	21.175	94.198	35.627	20.047	103.09	27.863
Error	0.825	-1.198	0.373	0.953	-1.09	0.137

If we graph the movement of retail prices with that of crude cost adjusted eight weeks forward to account for the estimated response lag, we find that price adjustments now move in the same direction as the underlying input cost (Figure 6). The fact that visible turning points more or less coincide for both series lends credence to our determination of an eight-week lag.

Figure 6: Weekly Movements of Current Retail Prices and Lagged Crude Cost



We also find that the import duty suspension dummy *S* is significant and positive when included in the ordered probit model (Table 5). This means that such action has resulted in increased probability of oil firms deciding to increase prices, or maintain prices since the middle ranking is ambiguous, instead of lowering gasoline prices as intended. This is statistically more significant for small players than big players.

Table 5: Ordered Probit Model with Import Duty Suspension Dummy

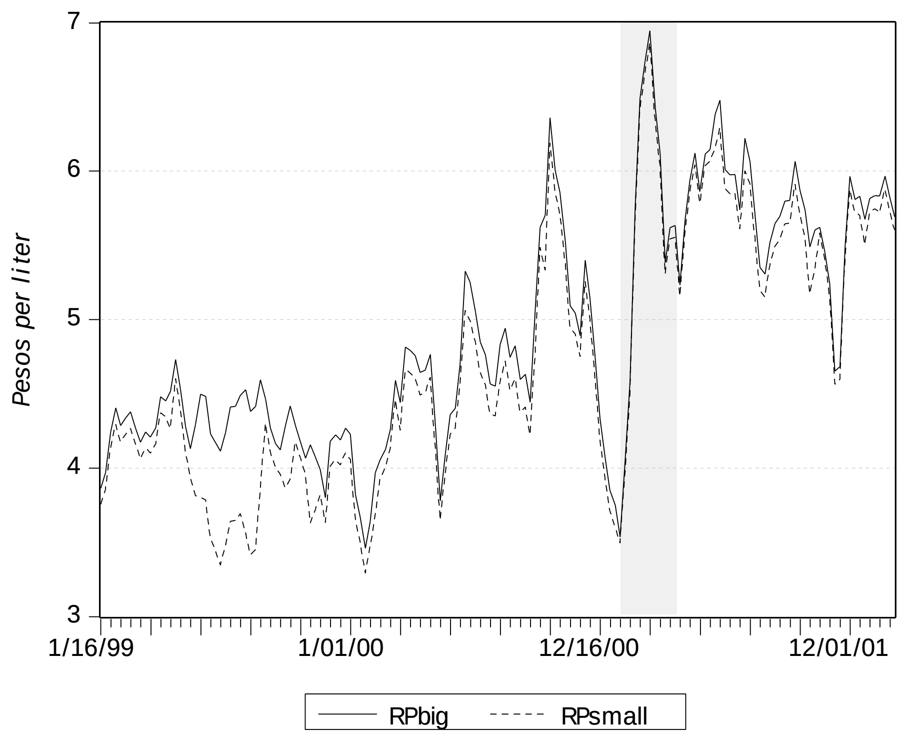
Dependent Variable:	Z_{BIG}		Z_{SMALL}	
Variables	Estimate	*p*-value	Estimate	*p*-value
? $CRUDE_{0}$	0.8836	0.0367	1.5090	0.0009
? $CRUDE_{-1}$	0.4023	0.3603	0.7559	0.1037
? $CRUDE_{-2}$	0.4187	0.3398	0.4026	0.3816
? $CRUDE_{-3}$	0.9469	0.0286	0.4720	0.2948
? $CRUDE_{-4}$	0.7318	0.0897	0.9190	0.0442
? $CRUDE_{-5}$	0.8138	0.0626	1.4182	0.0030
? $CRUDE_{-6}$	1.1193	0.0148	1.3180	0.0075
? $CRUDE_{-7}$	1.1564	0.0128	1.4284	0.0044
? $CRUDE_{-8}$	1.2131	0.0059	1.0525	0.0236
S	0.6828	0.0855	1.0154	0.0154
$?_1$	-1.1600	0.0000	-1.2583	0.0000
$?_2$	1.1836	0.0000	1.5515	0.0000
Akaike info criterion	1.6108		1.3880	
Log likelihood	-109.6181		-92.7907	
Pseudo R^2	0.2118		0.2786	
No. of observations	151		151	

For the difference between prevailing retail prices and the crude cost quoted eight weeks before, it is apparent that this differential rose to a higher mean starting the week of 1/13/2001 (period II in Table 6), by about P1.20 per liter for the Big Three and P1.40 per liter for the new players, about eight weeks after the onset of the import duty suspension. The shaded area in Figure 7 indicates the three-month period this was in effect after a lag of two months. This confirms the hypothesis that this institutional factor brought about a significant change in the average level of the differential, with hints of erosion and return to previous levels slow in coming. We further check on this in the next model.

Table 6: Descriptive Statistics of Lagged Differentials

	$RP_{BIG} - CRUDE_{-8}$			$RP_{SMALL} - CRUDE_{-8}$		
	I and II	I	II	I and II	I	II
Mean	4.9530	4.4965	5.7184	4.7423	4.2327	5.6026
Median	4.7452	4.4169	5.8016	4.5883	4.1337	5.6621
Minimum	3.4605	3.4605	3.5350	3.2930	3.2930	3.4942
Maximum	6.9448	6.3603	6.9448	6.8673	6.1895	6.8673
Standard deviation	0.7958	0.5218	0.5796	0.8739	0.5790	0.5729
Skewness	0.3291	1.0093	-1.3285	0.2615	0.8834	-1.1974
Kurtosis	2.0041	4.6116	6.4370	1.9014	3.8675	6.1092
No. of observations	152	97	56	152	97	56

Figure 7: Weekly Movements of Lagged Differentials between Crude and Retail Prices



But first, the estimation of the long-run equilibrium relation between retail gasoline prices and crude cost is presented in Table 7. Moving average terms up to the eighth order were included, all highly significant, to accommodate the eight-week adjustment lag the previous model strongly supported. Weekly dummies were not found to be even nearly significant at the 10% level and are excluded in the table.

Table 7: Long-Run Equilibrium Relationship

Dependent Variable:	RP_{BIG}		RP_{SMALL}	
Variables	Estimate	*p*-value	Estimate	*p*-value
constant	4.9581	0.0000	5.5284	0.0000
CRUDE	0.9052	0.0000	0.7063	0.0000
MA (1)	1.4845	0.0000	1.7319	0.0000
MA (2)	1.6926	0.0000	2.1086	0.0000
MA (3)	1.7472	0.0000	2.2884	0.0000
MA (4)	1.8790	0.0000	2.3672	0.0000
MA (5)	1.5278	0.0000	2.1293	0.0000
MA (6)	1.0673	0.0000	1.6918	0.0000
MA (7)	0.8708	0.0000	1.3511	0.0000
MA (8)	0.3150	0.0000	0.6022	0.0000
F-statistic	160.1081	0.0000	203.9557	0.0000
Sum squared resid	9.1581		7.7066	
R^2 / Adjusted R^2	0.9901	0.9839	0.9922	0.9873
Durbin-Watson stat	1.9197		2.0054	
No. of observations	160		160	

The passthrough rate was found to be higher for the Big Three at 90.5% compared with 70.6% for the smaller group. This means that in the sample period considered the big players passed along a bigger proportion of crude cost changes than the small players did.

Figure 8 shows the predicted retail prices from the estimated equation vis-à-vis the actual price. It is apparent from the graphs that the forecasts for both groups during the sample coincided with, were above, or were below the prevailing gasoline prices before crude cost reached its peak; from thereon gasoline prices were never lower than the predicted price. This implies *a priori* that adjustments were slow, or even nil, during the said period.

Figure 8A: Actual and Predicted Retail Prices for Big Players

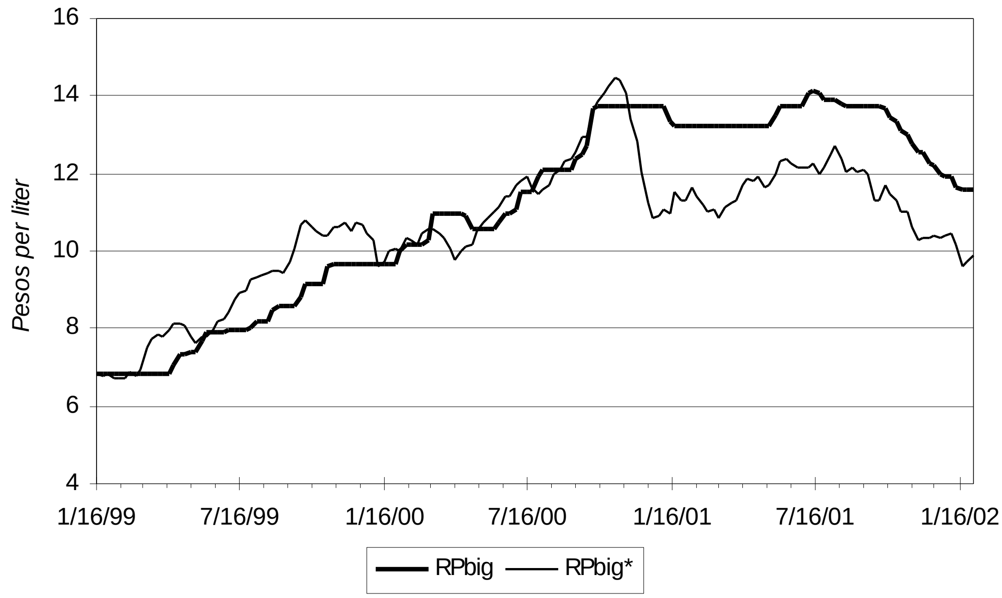
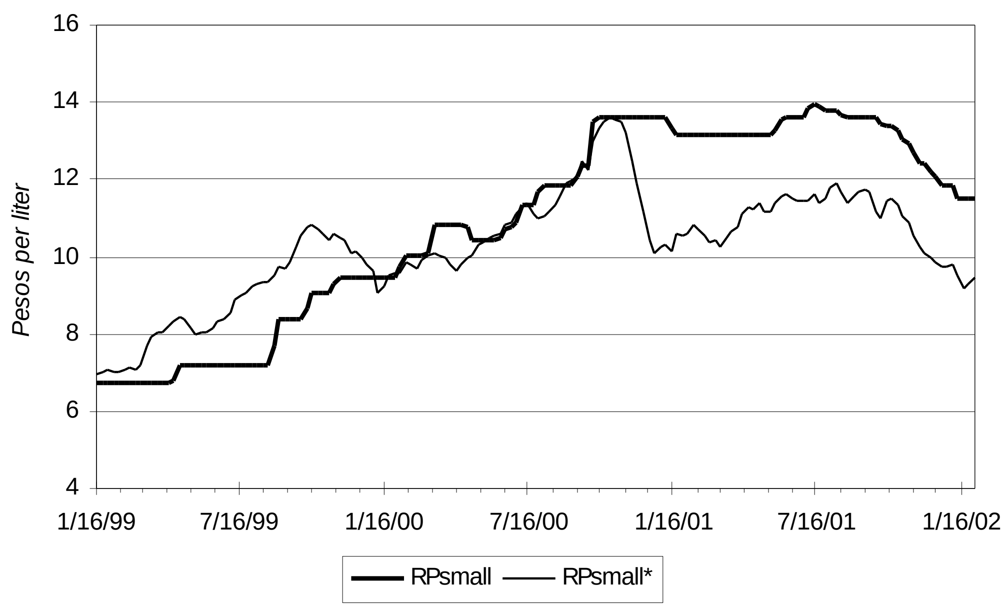


Figure 8B: Actual and Predicted Retail Prices for Small Players



We now present the results of the PAM regression for the whole period in Table 8. The adjustment rates were merely 4.2% for the major players and 3.1% for the smaller ones. For comparison, these are way below the estimates for the US retail gasoline market obtained by Borenstein and Shepard (1996) from 1986 to 1992: 18.4% for branded gasoline and 20.8% for unbranded. However, running a Chow breakpoint test for all observations showed that a highly significant structural shift most likely happened on 10/7/2000.[13]

Table 8: Symmetric Partial Adjustment Model

Dependent Variable:	$?RP_{BIG}$		$?RP_{SMALL}$	
Variables	Estimate	*p*-value	Estimate	*p*-value
$RP^* - RP_{-1}$	0.0424	0.0002	0.0305	0.0016
MA (1)	0.3005	0.0001	0.2397	0.0024
F-statistic	27.4128	0.0000	17.0298	0.0001
Sum squared resid	3.2585		4.1029	
R^2 / Adjusted R^2	0.1486	0.1432	0.0979	0.0921
Durbin-Watson stat	2.0065		1.9817	
Sample period	1/23/99 to 2/2/02		1/23/99 to 2/2/02	
Chow breakpoint	10/7/00	0.0009	10/7/00	0.0000
No. of observations	159		159	

Estimating the PAM for the two subsamples results in an adjustment rate of 9.4% for the big players and 6.8% for the smaller firms in period I, slowing down to 2.4% and 1.7% respectively in period II (Tables 9 and 10). This suggests that *ceteris paribus* deregulation has not resulted in faster adjustment rates throughout the sample period but the reverse, or equally plausible there was a factor or combination of factors that were introduced that intervened with this process.

[13] An assumption of the test is that no structural change happened at observations near and at the endpoints, as observations should at least be as many as the parameters. Also, this excluded observations that returned a near singular matrix and an expected positive or non-negative argument to the function.

Table 9: Symmetric Partial Adjustment Model (Period I)

Dependent Variable:	? RP_{BIG}		? RP_{SMALL}	
Variables	Estimate	*p*-value	Estimate	*p*-value
$RP^* - RP_{-1}$	0.0937	0.0001	0.0676	0.0016
MA (1)	0.2681	0.0132	0.3935	0.0002
F-statistic	6.8808	0.0103	9.9824	0.0022
Sum squared resid	1.6412		1.9939	
R^2 / Adjusted R^2	0.0733	0.0626	0.1029	0.0926
Durbin-Watson stat	2.0175		2.0693	
Sample period	1/23/99 to	9/30/00	1/23/99 to	9/30/00
Chow breakpoint	3/18/00	0.0084	3/18/00	0.0002
No. of observations	89		89	

Table 10: Symmetric Partial Adjustment Model (Period II)

Dependent Variable:	? RP_{BIG}		? RP_{SMALL}	
Variables	Estimate	*p*-value	Estimate	*p*-value
$RP^* - RP_{-1}$	0.0241	0.0069	0.0172	0.0163
MA (1)	0.2662	0.0272	0.3321	0.0053
F-statistic	11.4670	0.0012	11.8817	0.0010
Sum squared resid	0.7299		0.6317	
R^2 / Adjusted R^2	0.1461	0.1334	0.1506	0.1379
Durbin-Watson stat	1.9255		1.9488	
Sample period	10/14/00 to	2/2/02	10/14/00 to	2/2/02
Chow breakpoint	11/10/01	0.0000	11/17/01	0.0000
No. of observations	69		69	

To check on this more thoroughly, we again run the Chow test and find that the *F*-statistic still returns highly significant breakpoints within the two periods: 3/18/2000 for both groups in period I; 11/10/2001 for major players and 11/17/2001 for minor ones in period II. We further break down the sample accordingly to better analyze the adjustment through time. The results in Tables 11 and 12 indicate that the adjustment rate accelerated within the first period: from 7.8% for the former and 6.4% for the latter in period IA, it jumped to 15.9% and 15.6% respectively in period IB. For the second period, the adjustment rates for both groups were not significantly different from zero in period IIA, picking up in period IIB with a 5.1% adjustment rate for the established group and 4.6% for the new entrants (Tables 13 and 14).

Table 11: Symmetric Partial Adjustment Model (Period IA)

Dependent Variable:	? RP_{BIG}		? RP_{SMALL}	
Variables	Estimate	*p*-value	Estimate	*p*-value
$RP^* - RP_{-1}$	0.0780	0.0001	0.0642	0.0014
MA (1)	0.3050	0.0191	0.5367	0.0000
F-statistic	10.3676	0.0021	22.0848	0.0000
Sum squared resid	0.6093		0.8601	
R^2 / Adjusted R^2	0.1516	0.1370	0.2758	0.2633
Durbin-Watson stat	2.0552		2.0757	
Sample period	1/23/99 to 3/11/00		1/23/99 to 3/11/00	
No. of observations	60		60	

Table 12: Symmetric Partial Adjustment Model (Period IB)

Dependent Variable:	? RP_{BIG}		? RP_{SMALL}	
Variables	Estimate	*p*-value	Estimate	*p*-value
$RP^* - RP_{-1}$	0.1591	0.0038	0.1556	0.0176
MA (1)	0.9065	0.0000		
MA (6)			0.2990	0.0101
MA (7)			0.6575	0.0000
F-statistic	26.9094	0.0000	6.4576	0.0055
Sum squared resid	0.3245		0.3918	
R^2 / Adjusted R^2	0.5086	0.4897	0.3406	0.2879
Durbin-Watson stat	1.8598		1.7581	
Sample period	3/25/00 to 9/30/00		3/25/00 to 9/30/00	
No. of observations	28		28	

Table 13: Symmetric Partial Adjustment Model (Period IIA)

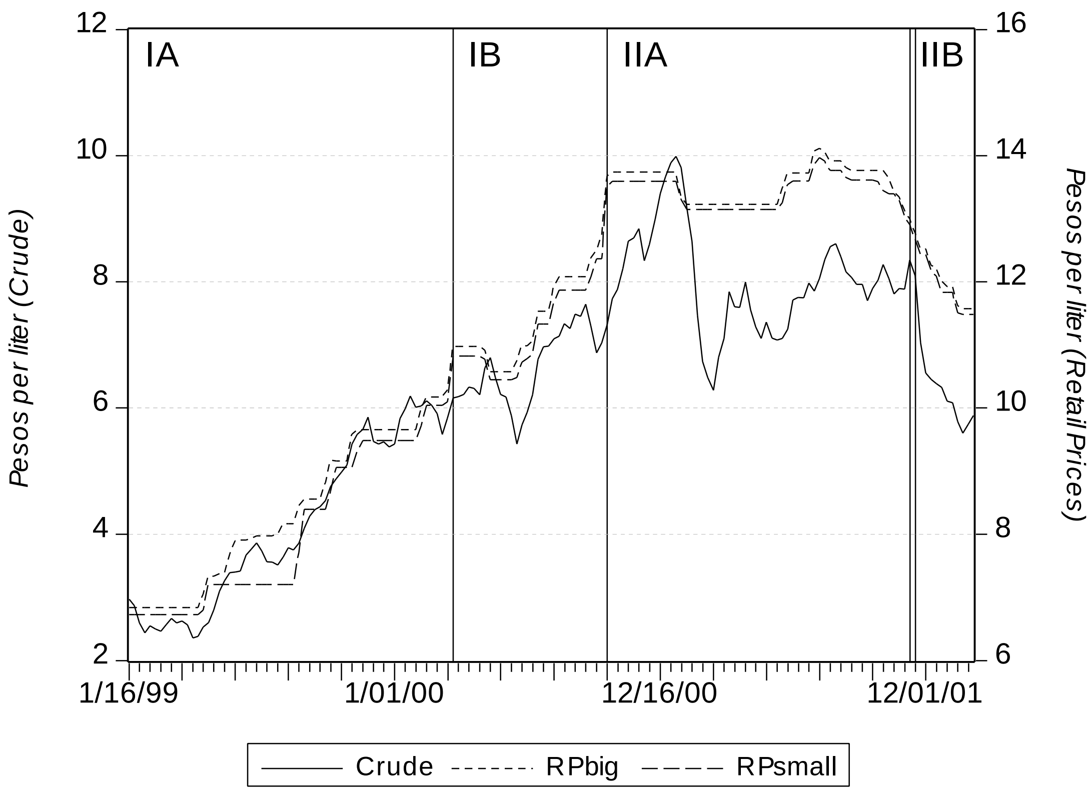
Dependent Variable:	? RP_{BIG}		? RP_{SMALL}	
Variables	Estimate	*p*-value	Estimate	*p*-value
$RP^* - RP_{-1}$	0.0139	0.1517	0.0091	0.2145
MA (1)	0.3687	0.0074	0.6202	0.0000
F-statistic	9.6310	0.0030	22.4282	0.0000
Sum squared resid	0.4820		0.3100	
R^2 / Adjusted R^2	0.1514	0.1356	0.2897	0.2768
Durbin-Watson stat	1.8926		2.0350	
Sample period	10/14/00 to 11/3/01		10/14/00 to 11/10/01	
No. of observations	56		57	

Table 14: Symmetric Partial Adjustment Model (Period IIB)

Dependent Variable:	? RP_{BIG}		? RP_{SMALL}	
Variables	Estimate	*p*-value	Estimate	*p*-value
$RP^* - RP_{-1}$	0.0513	0.0085	0.0455	0.0388
MA (4)	-0.8686	0.0000		
MA (7)			0.8850	0.0000
F-statistic	12.5342	0.0054	19.5108	0.0017
Sum squared resid	0.0703		0.0567	
R^2 / Adjusted R^2	0.5562	0.5119	0.6843	0.6493
Durbin-Watson stat	2.1320		1.7644	
Sample period	11/17/01 to 2/2/02		11/24/01 to 2/2/02	
No. of observations	12		11	

The estimated parameters gain intuitive support by looking at the graph of retail gasoline prices and the eight-week lagged crude cost partitioned according to the four periods (Figure 9). In period IA retail prices mimicked the movement in crude cost, which continued in period IB with more or less pronounced consonance in turning points.

Figure 9: Weekly Movements of Current Retail Prices and Lagged Crude Cost by Period



We now dissect the crucial events that happened in the 13-month long period IIA. On the week of October 7, 2000, the breakpoint to this period, the oil companies sharply raised their retail prices by P1 per liter on account of warranted escalation in crude prices. From thereon it didn't move for 32 weeks, leaving open the question of overshooting considering a continued climb in crude cost, and when it did on the week of January 13, 2001, it was but a meager rollback considering the steep decline in crude prices. Coincidentally, this was also about eight weeks since the suspension of the import duty on crude and finished petroleum products took effect. Retail prices were not adjusted downward at all for the next four months even if crude cost has generally softened; after this, retail prices tracked movements in crude prices albeit at an apparently higher differential.

In period IIB the oil companies seem to have favorably reacted to the decrease in crude prices with continued downward price adjustments that mirrored this decline. As such we have seen a return to an adjustment rate significantly different from zero.

The striking coincidence of the decrease in gasoline prices in period IIA further verifies the eight-week response lag of retail prices to input cost changes. Also, it appears that the temporary suspension of the import duty did not result in a relief for consumers as previously intended, but was instead taken advantage by oil firms to maintain a higher profit margin, assuming changes in other input costs did not significantly enter its basic cost structure. Variables that we surmise have allowed this widening of the differential between retail prices and crude cost to initially happen were the mini-supply shock successfully staged by OPEC and the coincidental depreciation of the peso against the dollar. Obviously, the resulting increase in crude cost was the consideration for the introduction of the institutional factor. The tense political situation in the country during this time may have provided the environment for this to persist and not be checked by the otherwise much-occupied public.

Contrary to public perception, the Big Three had consistently faster adjustment rates than the new oil players in all subsamples. This may indicate that essentially the smaller group is a price follower, always pricing its products a few centavos lower than the Big Three, except perhaps for the not-too-often price decreases it initiates which are minimal and quickly matched.

We now turn to the asymmetric version of the PAM. The results are presented in Table 15, and it clearly shows that for both groups, retail prices adjusted faster when it is below the predicted long-run equilibrium price: 11.4% against 2.6% for big players and 7.7% against a mere 1.8% for smaller ones.

Table 15: Asymmetric Partial Adjustment Model

Dependent Variable:	?RP_{BIG}		?RP_{SMALL}	
Variables	Estimate	*p*-value	Estimate	*p*-value
$(RP^* - RP_{-1})^+$	0.1136	0.0000	0.0769	0.0002
$(RP^* - RP_{-1})^-$	0.0255	0.0291	0.0175	0.0948
MA (1)	0.2771	0.0005	0.2312	0.0037
F-statistic	19.9425	0.0000	12.3604	0.0000
Sum squared resid	3.0482		3.9259	
R^2 / Adjusted R^2	0.2036	0.1934	0.1368	0.1257
Durbin-Watson stat	2.0177		1.9877	
Wald equivalence test	10.8030	0.0013	7.0067	0.0090
Sample period	1/23/99 to 2/2/02		1/23/99 to 2/2/02	
No. of observations	159		159	

Wald equivalence tests were strongly rejected at the 1% significance level so that we conclude that price adjustment speeds differ, conditional on the deviation of the prevailing retail price from the equilibrium price path being positive or negative. When there are so-called under-recoveries, the adjustment speed is relatively fast; however, when it is the opposite, we see a slow adjustment.

Table 16: Vector Error Correction Model

Dependent Variable:	? RP_{BIG}		? RP_{SMALL}	
Variables	Estimate	p-value	Estimate	p-value
$(?CRUDE_{0})^{+}$	0.0746	0.4055	0.0501	0.6240
$(?CRUDE_{-1})^{+}$	0.0491	0.5914	0.1065	0.2932
$(?CRUDE_{-2})^{+}$	0.1090	0.1290	0.1440	0.0508
$(?CRUDE_{-3})^{+}$	0.0628	0.3660	0.0987	0.1860
$(?CRUDE_{-4})^{+}$	0.3184	0.0000	0.2413	0.0012
$(?CRUDE_{-5})^{+}$	0.0780	0.2929	0.1180	0.1080
$(?CRUDE_{-6})^{+}$	0.0910	0.2218	0.0628	0.4124
$(?CRUDE_{-7})^{+}$	0.1469	0.1285	0.1652	0.1251
$(?CRUDE_{-8})^{+}$	0.1143	0.2061	0.0456	0.6569
$(?CRUDE_{0})^{-}$	0.0223	0.7728	0.0995	0.2591
$(?CRUDE_{-1})^{-}$	-0.0113	0.8892	-0.0999	0.2650
$(?CRUDE_{-2})^{-}$	0.0016	0.9794	0.0635	0.3387
$(?CRUDE_{-3})^{-}$	0.1046	0.0832	-0.0265	0.6817
$(?CRUDE_{-4})^{-}$	-0.0281	0.6494	0.0648	0.3034
$(?CRUDE_{-5})^{-}$	0.0859	0.1546	0.0588	0.3624
$(?CRUDE_{-6})^{-}$	0.1317	0.0401	0.1748	0.0094
$(?CRUDE_{-7})^{-}$	0.1587	0.0617	0.0990	0.2946
$(?CRUDE_{-8})^{-}$	0.1017	0.2485	0.1410	0.1449
$(?RP_{-1})^{+}$	0.0726	0.4195	0.0404	0.6466
$(?RP_{-2})^{+}$	-0.1805	0.0233	-0.1242	0.0693
$(?RP_{-3})^{+}$	-0.0587	0.4476	-0.1334	0.0555
$(?RP_{-4})^{+}$	-0.1804	0.0156	-0.1255	0.0750
$(?RP_{-5})^{+}$	-0.0141	0.8490	-0.0975	0.1351
$(?RP_{-6})^{+}$	-0.0250	0.7318	-0.0294	0.6637
$(?RP_{-7})^{+}$	0.3836	0.0000	0.4763	0.0000
$(?RP_{-8})^{+}$	-0.3102	0.0010	-0.2153	0.0187
$(?RP_{-1})^{-}$	-0.2777	0.2188	-0.2901	0.2719
$(?RP_{-2})^{-}$	-0.2543	0.1219	-0.1569	0.3667
$(?RP_{-3})^{-}$	0.3699	0.0256	0.2904	0.0986
$(?RP_{-4})^{-}$	0.0784	0.6574	0.1589	0.4259
$(?RP_{-5})^{-}$	0.0814	0.6418	0.2855	0.1545
$(?RP_{-6})^{-}$	-0.0927	0.5984	-0.3200	0.1086
$(?RP_{-7})^{-}$	0.7425	0.0001	0.8970	0.0001
$(?RP_{-8})^{-}$	-0.0648	0.7825	-0.2284	0.4487
$RP_{-1} - RP_{-1}^{*}$	-0.0141	0.0868	-0.0107	0.0916
$MA(7)$	-0.9317	0.0000	-0.9317	0.0000
F-statistic	4.3835	0.0000	3.4451	0.0000
Sum squared resid	1.6366		2.2165	
R^2 / Adjusted R^2	0.5716	0.4412	0.5118	0.3633
Durbin-Watson stat	1.9918		1.9792	
No. of observations	151		151	

The results of the vector error correction model (VECM) are presented in Table 16.[14] The corresponding cumulative adjustments to a one-time change in crude oil prices are shown in Table 17 and illustrated in Figure 10. The regression indicates that after eight weeks,[15] the big and small oil players have passed on almost 90% of the crude cost increase to retail consumers, while they have decreased prices by only 58% and 46% respectively for a similar decrease in crude cost.[16]

Table 17: Cumulative Adjustment Function

	RP_{BIG}		RP_{SMALL}	
Weeks	Increase	Decrease	Increase	Decrease
0	0.0746	0.0223	0.0501	0.0995
1	0.1409	0.0250	0.1657	0.0101
2	0.2519	0.0351	0.3139	0.0946
3	0.3156	0.1510	0.4017	0.0788
4	0.6096	0.1359	0.6098	0.1060
5	0.6820	0.2145	0.6871	0.1396
6	0.7018	0.3563	0.6844	0.2748
7	0.8366	0.5007	0.8082	0.4413
8	0.8994	0.5794	0.8530	0.4586

[14] Since an error correction model is used for cointegrating regressions, we first tested the appropriateness of the model by checking for the nonstationarity, or equivalently the existence of a unit root, of the retail price and crude cost series. Secondly, the first differences were checked for stationarity. The Augmented Dickey-Fuller (ADF) tests revealed that the null hypothesis of a unit root for levels with an intercept and p=8 could not be rejected for all the series at the 1% critical value. For the first differences, the same null hypothesis was rejected at the 1% significance level for crude and at 5% for both retail price series. Hence we treated all of the series as $I(1)$ and proceeded with the VECM. The residual from the estimation of the VECM was indeed found to be stationary at the 1% significance level.

[15] We consider this as the full lifetime of the price adjustments since the cumulative response estimates get noisier and slowly taper off beyond the eighth week.

[16] The two cumulative response paths do not converge unlike that observed by Borenstein, Cameron, and Gilbert (1997) in the US market from 1986 to 1992.

Figure 10A: Cumulative Responses to Equivalent Crude Cost Changes for Big Players

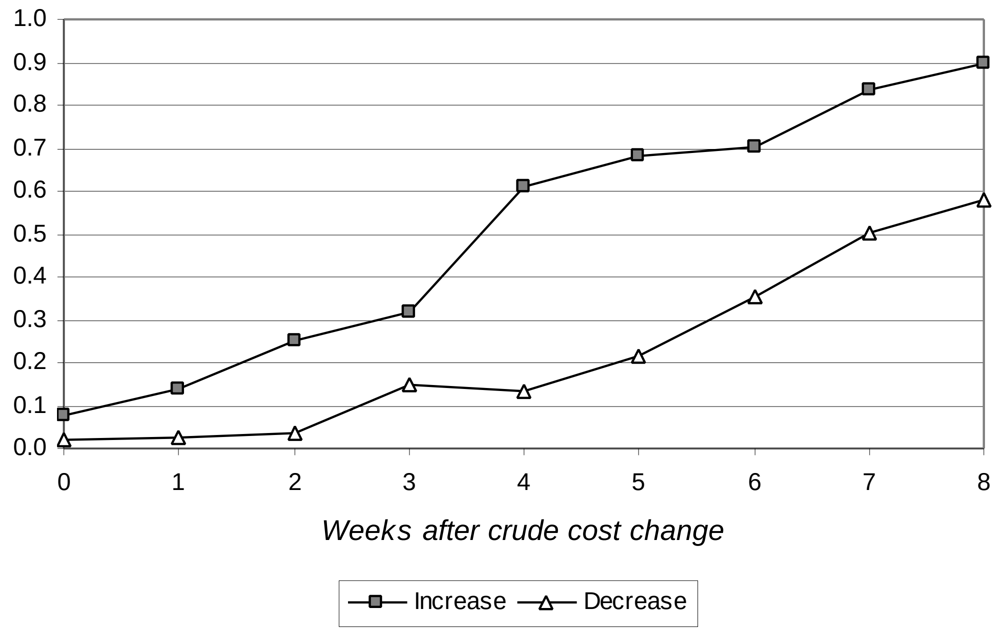
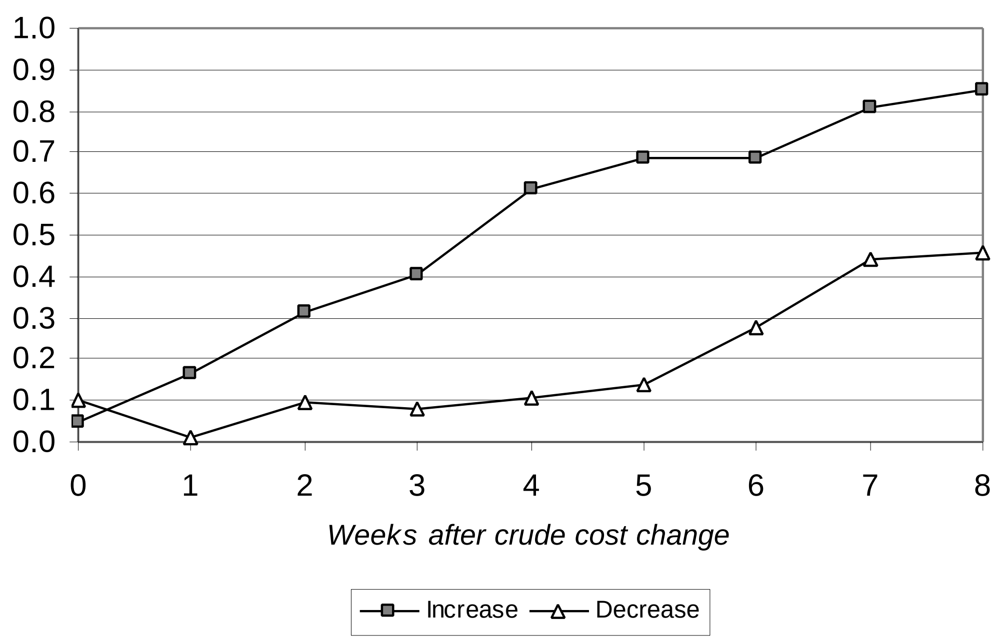


Figure 10B: Cumulative Responses to Equivalent Crude Cost Changes for Small Players

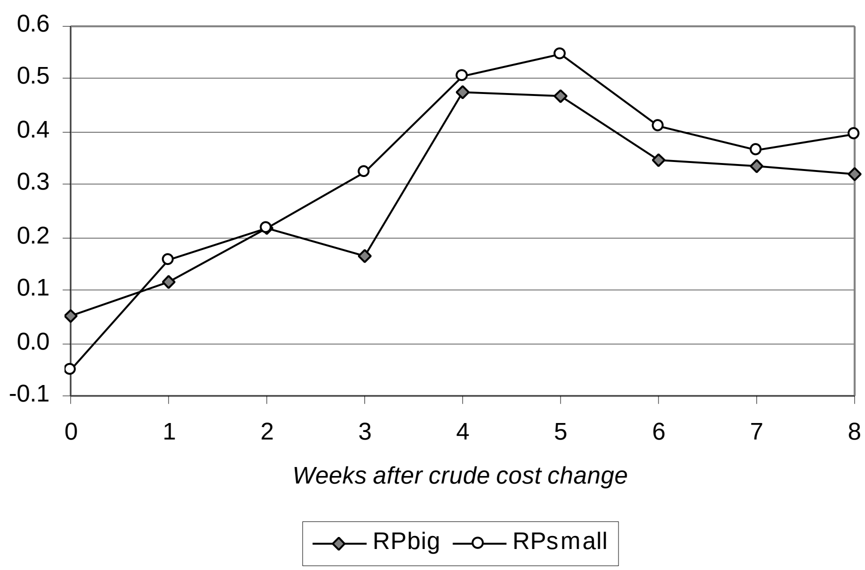


At all periods the adjustment to a crude cost increase is higher than that for a crude cost decrease except for the minor players at the contemporaneous period; the small players appear capable of partially lowering retail prices based on current week decreases in crude cost. However, this action is effectively reversed the next week.

An upward trend is visibly seen for cumulative responses to crude cost increases for both groups across the period, unlike that of downward adjustments that are nil until the second week and above 20% and increasing only on the fifth week for big players. While the price response of new entrants to the crude cost decrease is a 10% adjustment in the second week, it remains in that average level and picks up only in the sixth week.

The two adjustment paths sufficiently support the view that there is indeed an asymmetry in adjustment speed and the resulting terminal cumulative response to an equivalent movement in crude cost favoring retail price increases. This asymmetry is at its highest in the fourth week for major oil players and the fifth week for the small players (Figure 11).

Figure 11: Difference between Cumulative Responses



There has been no indication however of firms increasing prices in response to a decrease in crude cost or an overshooting of price increases for the aggregate sample in this model. The eight-week lag explains the seeming opposite reaction or non-response, but actually gradual adjustment of retail prices to current (and recent) changes in crude cost; prices are still being adjusted for previous changes, with the current change not having much of an effect until later.

The passthrough rate of a crude cost decrease is nowhere close to unity at the end of eight weeks unlike that of a crude cost increase; this suggests market inflexibility and positive economic profits in the downstream oil industry during the period studied.

IMPLICATIONS

This empirical exercise has demonstrated that contrary to public perception, the deregulation of the downstream oil industry has resulted in acceleration through time of the adjustment speed of retail prices to crude cost changes, if not for an intervening factor. The suspension of the import duty on crude oil and petroleum products, precipitated by a mini-supply shock and currency depreciation, has allowed firms to set prices that strayed away from the long-run equilibrium path. However, we see in the general picture that the basic institutional environment of a deregulated industry has fostered competition and a general trend towards faster adjustment rates through time.

With regards to price asymmetry, we find that this is indeed the case for the country's retail gasoline market. Retail prices are adjusted much faster for an increase in crude cost than for a commensurate decrease, with the cumulative adjustment passed on to consumers in the terminal period significantly higher for the former. The resulting differential is assumed to amount to positive economic profits enjoyed in the industry for the period studied.

The present situation wherein small players seem to be price-followers and do not aggressively cut pump prices may constitute a non-unique Nash equilibrium. In this perspective it is assumed that oil firms are already content with the returns or payoff they are respectively getting, and hence would not deviate from their revealed strategies. This would result in the present market configuration perpetuating itself.

But a very probable challenge to this Nash equilibrium is that market forces, which are continuously at work (i.e. the ubiquitous profit motive), would eventually push industry economic profits to zero given time and an unrestrained environment. This can be achieved either through the entry of more firms, as the industry is in fact contestable, and/or the increased intensity of competition between current players. Hence we can expect that a more competitive industry structure will in due course emerge. Then we might say that the first Nash equilibrium is but temporary, and that the dust will ultimately settle on a socially superior Nash equilibrium imitative of the competitive outcome.

We notice that the small oil players have been continuously gaining market share at the expense of the Big Three (Table 18).[17] Also, some of them have already banded together, establishing the New Petroleum Players Association (NPPA), a move aimed at protecting their common interests and exploring possible linkages and scale economies

[17] The market share of the new players was forecast to reach a low of 12% and a high of 13% in 2001, according to the October 27, 2001 edition of the Philippine Daily Inquirer (PDI).

(e.g. mergers, shared depots and product terminals). Add to that expansion plans that are admittedly ambitious, we see that the minor players are gearing up for a more forceful showing.

Table 18: Market Shares (%)

	1996	1997	1998	1999	2000Q1	2001Q1
Petron	41.1	40.1	39.1	35.7	35.6	34.9
Shell	33.6	33.6	34.5	35.6	32.5	33.3
Caltex	24.6	22.9	22.1	21.0	22.3	21.6
Others	0.7	3.4	4.3	8.7	9.6	10.2

Source: Department of Energy

It is my inference that since the new players only have so many retail stations at present,[18] it is not currently feasible to price gasoline way lower than the big players' posted retail prices. They can only service so much of the market so that effectively, they face a capacity constraint. Thus a critical mass, when reached, is expected to trigger fierce price competition in the industry.

Analogously, we can also observe moves by the Big Three to enhance loyalty among its customers. The usual lot are advertisements, sponsorships of sports activities, membership clubs for certain market segments (e.g. jeepney and tricycle drivers), and raffle promos for its patrons, even credit card tie-ins for fuel rebates. The most substantial move they are now undertaking is the expansion of the gasoline station-cum-convenience store concept by leasing adjacent lots to concessionaires such as fastfoods, restaurants and the like, a not uncertain attempt at affording themselves greater market power through bundling.

[18] Industry players other than the Big Three had only 89 stations in Metro Manila and 441 stations in the country as of yearend 2001, 16.2% and 11.2% of total, respectively.

Thus policy moves should be aimed at fostering greater competition, by perhaps mitigating the incumbent advantages of major oil firms and further lowering entry barriers (e.g. tax perks) if one is an activist, with the attendant danger of introducing new distortions in the market. Otherwise, consumers would fare much better if the downstream oil industry is left alone and the long arm of government intervention is tied,[19] allowing competitive forces to freely carry out its work.

6 Summary and Conclusion

We find in this paper the initial attempt to empirically model the nature of price adjustments in the Philippine retail gasoline market since its full deregulation in 1998, including the relative speed with which this was accomplished through time and the determination of the supposed existence of an asymmetry in price response to crude cost changes.

The decision to adjust retail prices depends on eight weeks of previous changes in crude cost. This lag length explains the seemingly anachronistic response of price adjustments to crude cost changes.

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[19] Assuming a level-playing field is already ensured. The new players have been complaining of unjustly higher access and royalty fees proposed to be levied by the Philippine National Construction Company (PNCC) in setting up service stations in the North and South Luzon Expressways (PDI, July 6, 2001). Apparently, the Big Three had a memorandum of agreement (MOA) with the PNCC for the exclusive rights to build facilities in the said tollways. This was resolved recently with the invalidation of the MOA and the application of uniform tariff rates (PDI, January 16, 2002).

The adjustment of retail prices to crude cost changes has in general accelerated through time. The suspension of the import duty on crude and petroleum products, following a mini-supply shock and currency depreciation, was an intervening factor that disrupted this trend.

We find evidence to support the casual observation that retail prices respond quicker and more fully to an increase in crude prices rather than to a similar decrease. This is indicative of positive economic profits in the downstream oil industry and consequently, there is room for increased competition and efficiency.

Appendix

ORDERED PROBIT MODEL

In the ordered probit model, we considered a $t \times 1$ latent vector Z^* which is linearly dependent on the $t \times k$ explanatory vector X, consisting of the current and lagged changes in crude prices:

$$Z^* = X'\beta + \varepsilon, \tag{1}$$

where e is a random term. The decision of the oil players to decrease, maintain or increase retail prices (j = 1, 2, or 3), the observed Z, was based on Z^* according to the rule

$$Z = \begin{cases} 1 & \text{if } Z^* \le \gamma_1 \\ 2 & \text{if } \gamma_1 < Z^* \le \gamma_2 \\ 3 & \text{if } \gamma_2 < Z^*. \end{cases} \tag{2}$$

Denoting the cumulative normal distribution by F (.), we obtained the probabilities of the outcomes as follows:

$$\text{Prob}(Z = j \mid X, \beta, \gamma) = \begin{cases} \Phi(\gamma_1 - X'\beta) & \text{for } j = 1 \\ \Phi(\gamma_2 - X'\beta) - \Phi(\gamma_1 - X'\beta) & \text{for } j = 2 \\ 1 - \Phi(\gamma_2 - X'\beta) & \text{for } j = 3. \end{cases} \tag{3}$$

The $k \times 1$ parameter vector ß indicates the direction of the change in the probability of falling into the endpoint rankings as X changes; the Prob(Z=1) moves opposite the sign of an estimated $ß_k$ while the Prob(Z=3) changes in the same direction as the sign of an estimated $ß_k$. The magnitude of the $ß_k$ estimates shows the relative importance of the corresponding first difference in crude cost to the decision of the oil players to change gasoline prices.

The lag length k-1[20] was identified using the Akaike Information Criterion (AIC), which selects the value of k that minimizes

$$\text{AIC}(k) = -2\max L(\psi_k) + 2r, \tag{4}$$

where r is the number of parameters and $L(\psi_k)$ is the maximum likelihood function.

PARTIAL ADJUSTMENT MODEL

The partial adjustment model (PAM) involved the estimation of

$$\Delta RP_t = \tau(RP_t{*} - RP_{t-1}) + \mu_t, \tag{5}$$

where $RP_t{*}$ denotes the predicted retail price from the prior estimation of the long-run[21] equilibrium relationship between gasoline and crude prices:

$$RP_t = \alpha_0 + \alpha_1 CRUDE + \sum_{w=1}^{51} \eta_w WEEK_{w,t} + \varepsilon_t, \tag{6}$$

where *WEEK* are dummy variables for the week of the year.[22] The parameter a_1 represents the long-run passthrough rate,[23] while a_0 is included to capture other input costs and the firms' average margin. In (5), t measures the rate of adjustment towards the long-run retail price.

We checked on the asymmetry of partial adjustments by estimating

$$\Delta RP_t = \tau^+(RP_t{*} - RP_{t-1})^+ + \tau^-(RP_t{*} - RP_{t-1})^- + \mu_t, \tag{7}$$

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[20] This is because we indexed the contemporaneous weekly change in crude prices with k=0.
[21] In this case, the long-run spans just a little over three years.
[22] A 53rd week dummy was used for 2000.
[23] Prior studies indicate that this parameter should be nearly equal to one since the production process is capable of converting one barrel of crude oil into close to one barrel of gasoline, with provision for refinery fuels used and losses due to inefficiencies.

in which observations were segregated into positive and negative deviations from the equilibrium relationship estimated in (6) before entering the equation. Accordingly,

$$(RP_t^* - RP_{t-1})^+ = \max\{0, (RP_t^* - RP_{t-1})\} \tag{8}$$

and

$$(RP_t^* - RP_{t-1})^- = \min\{0, (RP_t^* - RP_{t-1})\}. \tag{9}$$

VECTOR ERROR CORRECTION MODEL

In the vector error correction model (VECM), we estimated the cointegrating regression

$$\begin{aligned}\Delta RP_t = {} & \sum_{i=0}^{k} (\delta_i^+ \Delta CRUDE_{t-i}^+ + \delta_i^- \Delta CRUDE_{t-i}^-) + \sum_{i=1}^{k} (\lambda_i^+ \Delta RP_{t-i}^+ + \lambda_i^- \Delta RP_{t-i}^-) \\ & + \theta(RP_{t-1} - RP_{t-1}^*) + \mu_t ,\end{aligned} \tag{10}$$

where k was the lag length determined from the ordered probit model. The parameter d_i captures the current change in retail prices given the change in crude cost t-i periods before. Crude cost movements were separated into positive and negative changes, applying the same procedure as in (8) and (9), to differentiate gasoline price responses between the two.

The effects of previous adjustments in retail prices were added for a richer specification that allows intertemporal response interactions, together with an error-correction term that is the one-period lagged difference between the retail price and its predicted counterpart from (6) to account for the reversion towards the long-run equilibrium.

The estimated VECM is then used to determine the adjustment path of retail prices to crude cost changes through time. The cumulative response *D* of retail gasoline prices to a one-time change in crude oil prices after *k* periods was computed as follows:

$$D_k{}^{\circ} = D_{k-1}{}^{\circ} + \delta_k{}^{\circ} + \theta(D_{k-1}{}^{\circ} - \alpha_1) \\ + \sum_{i=1}^{k} [\lambda_i^+ \max\{0, (D_{k-i} - D_{k-i-1})\} + \lambda_i^- \min\{0, (D_{k-i} - D_{k-i-1})\}], \tag{11}$$

where ° is accordingly replaced by either $^+$ or $^-$ representing the adjustment of interest.[24] This cumulative adjustment function sums up the effects of the contemporaneous change in crude cost, previous adjustments made, previous changes in the resulting retail prices, and the tendency to move towards the long-run equilibrium relation.

[24] This was first used by Borenstein, Cameron, and Gilbert (1997).

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