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Deregulation of wholesale petrol prices: what happened to capital city petrol prices?

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Wholesale petrol prices were deregulated in August 1998. This paper will quantify the effect associated with the deregulation of wholesale petrol prices on relative retail prices for unleaded petrol in Adelaide, Melbourne and Sydney. This is done through Box–Jenkins autoregressive integrated moving average methodology coupled with Box and Tiao intervention analysis. Weekly price data will be used for Adelaide, Melbourne, and Sydney. It finds that from the beginning of 1999, deregulation coincided with relatively lower retail petrol prices for all three cities. In the absence of any other possible alternative explanation for the simultaneous fall in relative retail petrol prices across all three cities, it is concluded that this change was most likely associated with deregulation. These results suggest that regulation of wholesale petrol prices were ineffectual in terms of constraining capital city retail petrol prices at the very least and may have actually contributed towards relatively higher retail petrol prices. This also suggests that future policy interventions designed to constrain prices in the downstream petroleum industry should be very carefully considered.

Key words: competition, deregulation, petrol prices.

1. Introduction

Wholesale petrol prices were subject to either price control or price surveillance mechanisms by either the Commonwealth or state governments from February 1940 until July 1998. The regulation was usually justified over concern about the degree of effective competition in the downstream petroleum industry and the need to protect against monopolistic pricing (Royal Commission on Petroleum 1976, p. 347). The regulation had generally been based on setting a maximum wholesale price calculated by a formula estimating the cost of importing fuel to the Australian seaboard and the associated costs of distribution. However, in July 1998, the Commonwealth Government announced that it was deregulating wholesale petrol prices from the beginning of August 1998 (Costello and Moore 1998).

The only previous study of deregulation came to a negative assessment of its consequences. Based on a partial adjustment model comparing wholesale petrol prices during a period of regulation to a period following deregulation, Delpachitra and Beal (2002) concluded that deregulation had benefited oil companies more than consumers and had not increased price competition.

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The purpose of this paper is to quantify the impact of deregulation on relative retail prices for unleaded petrol in Adelaide, Melbourne and Sydney. This will be investigated through a time series or *before-and-after* analysis with any difference in relative retail petrol prices before and after deregulation being interpreted as the effect of the policy change.

The structure of this paper is as follows. Section 2 will provide a brief outline of the downstream petroleum industry in Australia in capital cities. Section 3 describes the data to be used in this study. Section 4 will provide the model specification. Section 5 will present the results and Section 6 will provide the conclusions.

2. Australian downstream petroleum industry

The Australian downstream petroleum industry is dominated by four vertically integrated companies that operate in oil refining, petroleum product distribution and wholesale, and retailing sectors: Caltex, BP, Mobil and Shell (collectively known as the oil majors). The oil majors operate wholly owned wholesale or distribution companies separate from their refining operations through which they distribute petrol to retailers. The oil majors' distribution companies typically supply their own branded retail service station networks as well as other metropolitan area customers. In 2000, around 90 per cent of retail service stations were part of branded networks of the oil majors (Australian Institute of Petroleum 2006, p. 18).

To gain access to petrol supply in states where they did not possess a refinery, the oil majors used supply swap arrangements known as refinery exchange agreements (REAs) where product was exchanged between them on a litre-for-litre basis. While this enabled the oil majors to save on transportation costs, the Australian Competition and Consumer Commission (ACCC) (1996, p. 31) opined that REAs 'may have potentially anti-competitive effects'. In January 2000, REAs for the Mobil Port Stanvac refinery near Adelaide were terminated although they remained in place for other cities (Cummins 1999).

An *independent* refers to market participants that are not vertically integrated from refining to retailing, although they are sometimes reliant on oil majors for fuel supply. Despite accounting for less than 10 per cent of retail service stations throughout Australia, independent retailers have traditionally had a stronger presence within capital cities. In 1996, the ACCC (1996, p. 77) observed that independent retailers imposed a significant competitive constraint on the oil majors' retail petrol pricing.

Given the absence of an independently operated fuel import terminal in Adelaide, independent petrol wholesalers and retailers were entirely dependent on supply from the oil majors to sustain their operations. However, independently operated fuel import terminals near Melbourne and in Sydney could supply independent wholesalers and retailers with imported fuel. In 1996, the ACCC (1996, p. 57) expressed optimism regarding the ongoing capacity of independent petrol imports to impose a competitive constraint on the oil majors.

Within major capital cities, the ACCC (1996, p. 77) has observed there are regular retail petrol price cycles. These price cycles generally follow a recurring sawtooth pattern where prices rise rapidly and then steadily decrease over time (ACCC 2005, p. 6).

There are several different types of retail service stations operating in Australia's capital cities:

- Company operated stations.
- Commission agent stations that sell branded petrol at prices set by their fuel supplier with the operator receiving a fixed commission on petrol sales.
- Franchise stations where the franchisee has a contractual agreement with a franchisor. The majority of sites owned by the oil majors during this study were operated through franchise agreements.
- Dealer-owned stations where the operator has an agreement with a supplier to carry a supplier's brand.

If the oil major were able to exercise any market power at the wholesale level, then it would reduce their profitability to have franchised service stations also exercising market power as double marginalisation would occur. Double marginalisation occurs wherever market power is exercised at successive vertical stages of production. For example, with petrol, if market power is exercised at the distribution and wholesale level and then again at the retail level, the petrol wholesaler will mark up the product and the petrol retailer will then take the wholesale price and mark it up again. This double mark-up results in lower total sales and lower total profit than if wholesaler and retailer were vertically integrated.

To avoid double marginalisation, Rose (1999, pp. 18–19) argued the oil majors seek to maximise competition among firms operating at the retail level through utilising multiple sources of distribution such as franchisees, company-owned sites, commission agent sites and independents. This is consistent with the observations of Roarty and Barber (2004) that petrol retailing is a low-margin business.

To prevent double marginalisation, the oil majors are probably forcing the retail petrol price down to marginal cost. On this basis, competition within retail petrol markets would approximate perfect competition where price is equated to marginal cost. If petrol is retailed at marginal cost, then retail petrol prices should convey information regarding the interactions of participants in wholesale petrol markets and should closely follow and reflect changes in wholesale petrol prices.

3. Data construction

To undertake a direct analysis of any price effect associated with deregulation would require wholesale price data both before and after deregulation.

However, wholesale price data is not generally available because of high commercial sensitivity (Delpachitra and Beal 2002, p. 60).

This arguably leaves the retail price as the only other price indicator available to undertake the analysis. As concluded in Section 2, if petrol is retailed at marginal cost, then prices should closely follow and reflect changes in wholesale prices. Unlike wholesale prices, retail prices are publicly available information. Therefore, deregulation will be tested through its effect on the retail price of regular unleaded petrol sold in Adelaide, Melbourne and Sydney. Provided all other things are equal (the *ceteris paribus* assumption), the effect of deregulation on wholesale petrol markets in Adelaide, Melbourne and Sydney should be measurable through changes in retail petrol prices.

However, the *ceteris paribus* assumption is often violated as retail petrol prices are subject to influences aside from structural change affecting capital city wholesale petrol markets. These other influences include the international crude oil price, which is the major input into petrol production, and refining margins, the difference between refined petroleum product prices and crude oil prices.

To extricate these other influences from the retail petrol price, a notional industry margin (*NIM*) has been constructed by subtracting a proxy for the wholesale petrol price unaffected by developments in Australian wholesale petrol markets from the retail petrol price. The NIM estimates the total notional margin accruing to petrol suppliers at various stages in the supply chain. Thus, assuming that petrol is retailed at marginal cost, the level of the NIM should reflect developments and changes in capital city wholesale market conditions and generally provide an indication of the returns accruing to the oil majors.

Weekly average retail unleaded petrol price data (*RP*) was obtained from market research company *Informed Sources*. The proxy used for the wholesale unleaded petrol price was the import parity indicator price (*IPI*) calculated by the ACCC.[1] The IPI was the instrument used by the ACCC to set the maximum wholesale petrol price under regulation. The calculation of the IPI is composed of three components:

- The import parity component – the 'landed cost' for ex-refinery petrol stock from Singapore (incorporating the spot price for fuel, freight, wharfage, insurance and loss, and the Australian/US dollar exchange rate);
- The assessed local component – reflecting influences such as downstream terminalling, marketing and distribution costs as well as return on assets employed in that sector; and
- Excise and state subsidies, and the goods and services tax (GST) (ACCC 2001, p. 10).

[1] The IPI was provided to the researcher by the ACCC on a confidential basis.

Singapore is considered the appropriate benchmark for Australian petrol prices as it is the closest major refining and marketing centre and the most common source for imported petrol.

An adjustment was made to the IPI to remove the local component because, more often than not, the NIM calculated from an IPI including the local component was negative. Persistent ongoing negative NIM observations are a perverse result, as firms cannot continue in business indefinitely if they cannot cover their costs. This suggests the local component of the IPI, that was 7.1 cents per litre (cpl), had probably been set too high. Rather than having a data series consisting largely of negative NIM observations, it was considered preferable to remove the local component from the IPI. Removal, however, does not change the relativities between the NIM observations.

The Commonwealth Government levies an excise tax on petrol sales, set at a particular rate in cpl. Responsibility for paying the excise rests with refiners.[2] Refiners pass the cost of the excise on to buyers of petrol, so that the excise is eventually passed on to consumers. Because petrol excise is applied on the basis of a fixed amount, the excise applying to both the IPI and the RP is the same. Consequently, in calculating the NIM, the impact of petrol excise is removed when subtracting the IPI from the RP.

The Commonwealth Government introduced a GST on 1 July 2000 which applied to petrol. The GST is an *ad valorem* tax set at 10 per cent. Because the GST is applied to each transaction in a supply chain on an *ad valorem* basis, any difference between the IPI and the RP will result in a discrepancy in the amount of GST applying to the IPI when compared with the RP. Because the amount of GST applying to the IPI and the RP could differ, the level of the NIM could either increase or decrease directly as a result of the imposition of the GST, thus resulting in a distortion in the estimation of the NIM. An adjustment was made to both the IPI and the RP to remove the GST impact on the NIM.

Until August 1997, all state governments except Queensland levied business franchise fees on the sale of petrol. In New South Wales, Victoria and South Australia, the petrol franchise fee was levied in two parts. The first part was a flat nominal fee imposed on retailers who purchased their petrol from a licensed wholesaler (Gabbitas and Eldridge 1998, p. 231). The second part was a fee payable as a given percentage of the *declared value* – in this case the price in cpl as determined by the state government (Gabbitas and Eldridge 1998, p. 231). The variable component of the petrol franchise fee applying in Sydney in 1997 was 7.88 cpl, in Melbourne it was 9.28 cpl at the start of 1997 and fell to 7.67 cpl on 1 June 1997 and in Adelaide it was 9.77 cpl at the beginning of the year and rose to 9.85 cpl on 1 July 1997 (Australian Institute of Petroleum 1998).

On 5 August 1997, a High Court ruling on the legality of tobacco business franchise fees in New South Wales cast doubt on the constitutional validity

[2] Customs duty is levied on comparable imports at the same rate.

of petrol franchise fees. Consequently, all state governments ceased their collection. On 6 August 1997, the Commonwealth Government announced *safety net* arrangements whereby it would increase the rate of petrol excise levied and return the revenue collected to the states.

Each state had set a different level for its petrol franchise fee, but because the Commonwealth Government is unable to discriminate between states under the Constitution, the Commonwealth Government increased its excise rate by 8.1 cpl across the board. A condition of the Commonwealth Government's safety net arrangements was that petrol prices not increase because of this arrangement. To meet this condition, the New South Wales Government provided an interim subsidy of 0.22 cpl to petrol wholesalers from August 1997 until November 1997 and the Victorian Government provided a subsidy of 0.43 cpl to petrol wholesalers from August 1997 until July 2007.

To account for the period in which petrol franchise fees applied, the relevant amount of the variable rate of the petrol franchise fee applying in each city has been added to the IPI (as the IPI was provided exclusive of petrol franchise fees). To account for the interim subsidies, 0.22 cpl has been subtracted from the IPI for Sydney between August and November 1997, and 0.43 cpl has been subtracted from the IPI in Melbourne from August 1997 onwards, rising to 0.473 from July 2000 to account for the imposition of the GST.

After the adjustments described were made, the NIM was estimated through the following equation:

$$\mathrm{NIM} = \mathrm{RP} - \mathrm{IPI} \tag{1}$$

The NIM data set for Adelaide covers the period from the week beginning 30 June 1997 until the week beginning 3 June 2002, representing 13 months before deregulation and 46 months after. The NIM data set for Melbourne covers the period from the week beginning 6 January 1997 until the week beginning 23 July 2001, representing 19 months before deregulation and 36 months after. The NIM data set for Sydney covers the period from the week beginning 6 January 1997 until the week beginning 24 June 2002, representing 19 months before deregulation and 47 months after. It was decided to conclude the study for Melbourne and Sydney to control for the influence of other events that could result in structural change. For Melbourne, this arises from the regulatory imposition of terminal gate pricing in Victoria in August 2001. For Sydney, this arises from the termination of REAs in July 2002.

Figures 1, 2 and 3 shows that the NIM in all three cities oscillates through time.

For all three cities, the pattern of the NIM data displays no obvious signs of seasonality although the trend appears to be heading downwards over time with the exception of Adelaide from March 2001 onwards, suggesting that deregulation generally coincided with falling average levels for the NIM.

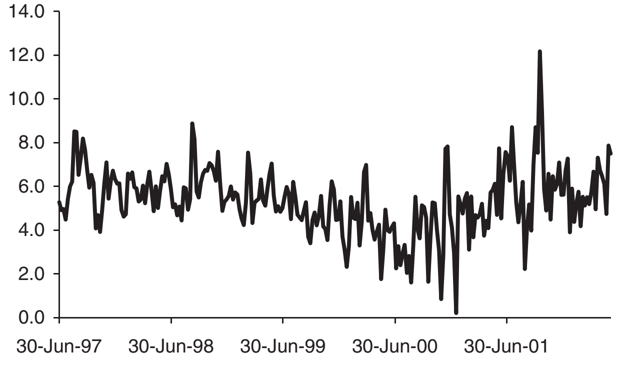

Figure 1 Adelaide NIM in cpl.
Sources: NIM estimated from data provided by the ACCC and Informed Sources.

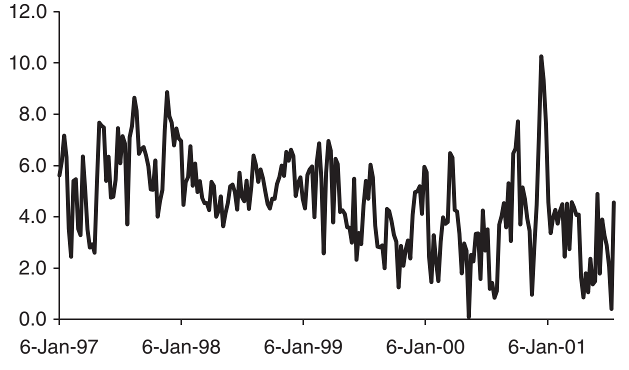

Figure 2 Melbourne NIM in cpl.
Sources: NIM estimated from data provided by the ACCC and Informed Sources.

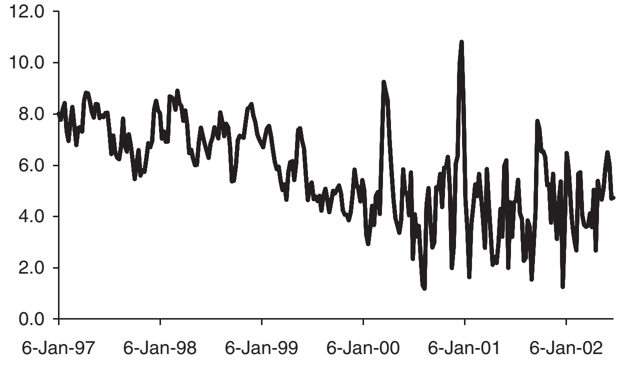

Figure 3 Sydney NIM in cpl.
Sources: NIM estimated from data provided by the ACCC and Informed Sources.

The average NIM for Melbourne is much lower during the first half of 1997 than it is during the second half, rising from 5.1 cpl to 6.6 cpl. During the last 7 months of regulation from the beginning of 1998 to the end of July 1998, the average NIM fell to around 5.0 cpl.

The average NIM for Sydney during regulation from January 1997 until the end of July 1998 is less volatile than for Melbourne, averaging around 7.3 cpl. In Adelaide, during regulation from the beginning of July 1997 until the end of July 1998, the NIM averaged around 5.9 cpl.

During the first period of deregulation from the beginning of August 1998 to the end of December 1998, the average level of the NIM rose in both Adelaide and Melbourne, while it fell marginally in Sydney. The average NIM for Adelaide rose to around 6.3 cpl. This rise may be related to a fire that occurred at the Port Stanvac refinery on 2 August 1998, which closed down the refinery for 2 months. According to the Department of Primary Industries and Resources South Australia (1999, p. 41), petrol stocks remained tight for 2 months following the fire. The average NIM for Melbourne rose to 5.5 cpl, which could be related to a reduced level of petrol discounting following the interruption of Victorian crude oil supplies from Bass Strait in late September 1997 (Shiel 1998). In Sydney, the average NIM fell marginally to 7.2 cpl.

During the first half of 1999, the average NIM fell below the level recorded during the entire period of regulation across all three cities. The average NIM fell to 5.5 cpl in Adelaide, 4.9 cpl in Melbourne and 6.3 cpl in Sydney.

From mid-1999 onwards, the average NIM fell further across all three cities. From July 1999 until the end of July 2001, the average NIM was 3.6 cpl in Melbourne. From July 1999 until the end of June 2002, the average NIM was 4.6 cpl in Sydney. From July 1999 until the end of February 2001, the average NIM for Adelaide was 4.3 cpl, however, the average NIM rose to 5.9 cpl coinciding with the introduction of tighter fuel standards in South Australia.

During 2000, there are several spikes in the NIM that stand out. There was a spike in mid to late March in Sydney, which coincided with newspaper reports of discussions between the two locally based refiners in Caltex and Shell about a possible merger of their refinery operations (Macleay 2000). There is a spike occurring in Melbourne during and in the aftermath of a blockade of Melbourne fuel terminal facilities at the end of September 2000 (ACCC 2000). Finally, there is a spike in Melbourne and Sydney, and to a lesser extent in Adelaide, occurring over the Christmas 2000 and New Year holiday period coinciding with a period of unexpected refinery shutdowns on the Australian eastern seaboard (PM Program 2000). There is also a spike in the NIM for Adelaide in October 2001 coinciding with a maintenance strike at the Port Stanvac refinery that eventually forced the South Australian Government to impose petrol rationing (Eccles 2001).

4. Model specification

To test whether there is a statistically significant difference in the average level of the NIM before and after deregulation, a regression model was constructed. To build a structural model for estimating the NIM would require a reasonably complete knowledge and understanding of the NIM determination process. Given the NIM is determined through the decisions and interactions of numerous wholesale and retail market participants, the information requirements arguably preclude one from attempting to build a structural model.

As an alternative to a structural model, an empirical model was constructed for the NIM using Box–Jenkins methodology, also known as autoregressive integrated moving average (ARIMA) modelling. In ARIMA modelling, a variable is explained by its own past, or lagged, values and stochastic error terms. While not providing a behavioural explanation for the time path of the NIM, an ARIMA model should capture any underlying systematic time series patterns in the data.

Modelling of the NIM time series would appear to be well-suited to ARIMA modelling. The number of observations for Melbourne is 238, for Adelaide it is 258 and for Sydney it is 286. Box *et al*. (1994, p. 17) maintain that ARIMA models should only be used when at least 50 and preferably 100 or more observations are available.

Autoregressive integrated moving average models can also be extended to enable the intervention analysis proposed by Box and Tiao (1975) to be utilised. Under intervention analysis, an indicator (or dummy) variable is included in the model, which takes only the values of 0 and 1 to denote the non-occurrence and occurrence of the intervention as long as the timing of the intervention is known. Intervention analysis will be used to test for the impact of deregulation on the NIM. The impact of regulation is generally measured by a dummy variable, indicating whether the observation occurs during the period of regulation or in an unregulated environment (Joskow and Rose 1989, p. 1458).

One criticism sometimes made of ARIMA models is that they can be prone to disturbances because of 'special' events which it is claimed can invalidate the approach (Gregg 1980, p. 82). However, Jenkins (1979) has shown that intervention analysis can also be used to control for such disturbances provided satisfactory evidence exists to prove the existence of an associated event. In this regard, intervention analysis will also be used to control for the several short-term events impacting upon the level of the NIM, namely the merger discussions between Shell and Caltex in Sydney in late March 2000, the blockade of Melbourne fuel terminals in September 2000, the reported fuel shortages along the Australian eastern seaboard during a period when there were a series of unexpected refinery shutdowns in December 2000, and the maintenance strike at the Port Stanvac refinery in October 2001. It will also be used to control for any impact on the NIM arising from the termination of REAs in regard to the Adelaide Port Stanvac refinery at the beginning of 2000 and the introduction of tighter fuel standards for South Australia in March 2001.

The following general ARIMA process of the order (p, d, q) will be estimated as:

$$\phi_p(B)\Delta^d Z_t = \theta_0 + \theta_q(B)a_t + \beta D_t \tag{2}$$

where $\phi_p(B)$ represents a p-order polynomial lag operator; Δ^d denotes an ordinary difference operator and d is the number of times the difference is applied; Z is the NIM; θ_0 is a constant; $\theta_q(B)$ denotes a q-order polynomial lag operator; 'a' is a white noise process; p is the number of autoregressive terms; q is the number of moving average terms; D represents the dummy variables and t is the period of time.

As part of the ARIMA modelling process, appropriate values for p, d and q need to be chosen. While the identification of an ARIMA process is not an exact science, the plotting of the autocorrelation function (ACF) and the partial autocorrelation function (PACF) can provide guidance.

The first step in the modelling process is to identify the appropriate form of the NIM that should be used for modelling purposes as well as determining whether it follows an autoregressive process, a moving average process, or some combination thereof. This can be undertaken through the identification of the ACF and the PACF and the resulting correlogram and partial correlogram.[3]

The pattern of the ACF for Adelaide, Melbourne and Sydney, which decays in an exponential manner, could be indicative of either a time series for the NIM that is non-stationary or which obeys a low-order autoregressive process. It is not possible to use the ACF to distinguish between a unit root process and a stationary process with an autoregressive coefficient close to unity. If the NIM time series for all three cities is stationary, the PACF dropping off after one lag is suggestive of a straight-forward AR(1) process.

The next stage of the identification process is to determine whether the NIM is stationary for all three cities. This is performed through a unit root test using the Phillips–Perron (PP) test. The PP test was performed using two specifications: the first with the inclusion of a constant term; and second with a constant and a linear trend term. Table 1 below presents the results.

On the basis of the PP test results, it was concluded the NIM is stationary, or I(0), in all three cities. Therefore, the ARIMA specification is most likely to be an AR(1) process in all three cities.

4.1 Specification of dummy variables

In estimating the model for each city, it was decided to include a number of dummy variables to account for several potential periods of structural

[3] The ACF and PACF have not been reproduced here but are available from the author on request.

Table 1 Phillips–Perron test for Adelaide, Melbourne and Sydney NIM

City	PP test with constant	PP test with constant and trend
Adelaide	−8.098*	−8.151*
Melbourne	−6.556*	−7.701*
Sydney	−5.411*	−7.053*

Note: *This indicates that the corresponding null hypothesis of a unit root has been rejected at the 1 per cent significance level.

change. The dummy variable *Regulation* covers the period when wholesale petrol prices were subject to regulation. *Regulation* takes the value of 1 from the week beginning 6 January 1997 in Melbourne and Sydney and from the week beginning 30 June 1997 in Adelaide until the week beginning 27 July 1997 and zero otherwise.

There are two dummy variables covering the period of deregulation from August 1998 until the end of June 1999 for all cities. The dummy variable $Deregulation_1$ takes the value of 1 from the week beginning 3 August 1998 until the week beginning 28 December 1998 and zero otherwise. The dummy variable $Deregulation_2$ takes the value of 1 from the week beginning 4 January 1999 until the week beginning 21 June 1999 and zero otherwise. In measuring the effects of regulatory changes, Joskow and Rose (1989, p. 1458) consider that it is ideal to use a fairly lengthy time series in order to avoid basing conclusions on possible transitional responses.

To account for the impact in Adelaide arising from the termination of REAs, the dummy variable *exREAs* will take the value of 1 in the week beginning 3 January 2000 onwards. To control for the observed spike in the Sydney NIM coinciding with media reports of discussions between Shell and Caltex regarding plans to merge their refineries into a joint venture company, the dummy variable *Merger* will take the value of 1 during the week beginning 13 March 2000 until the week commencing 3 April 2000 and zero otherwise. To account for the period of the Melbourne fuel blockade, the dummy variable *Blockade* will take the value of 1 from the week beginning 25 September 2000 until the week beginning 9 October 2000 and zero otherwise.

To account for the period of unexpected refinery shutdowns on the Australian eastern seaboard in December 2000, the dummy variable *Refinery* has been included which takes on the value of 1 from the week beginning 11 December 2000 until the week beginning 18 December in Adelaide and zero otherwise, and in Melbourne and Sydney which takes on the value of 1 from the week beginning 11 December 2000 until the week beginning 1 January 2001 and zero otherwise. The shorter time period for the *Refinery* dummy variable for Adelaide is justified because the supply disruption was less severe than for the other cities (House of Assembly Select Committee on Petrol, Diesel, and LPG Pricing 2001, p. 56).

To account for the introduction of new fuel standards in South Australia in March 2001 the dummy variable *Fuel Standards* takes the value of 1 from the week beginning 5 March 2001 onwards. The dummy variable *Strike*, which accounts for the maintenance strike at the Port Stanvac refinery in October 2001, takes on the value of 1 from the week beginning 8 October 2001 until the week beginning 22 October and zero otherwise.

A model specification that includes a constant, autoregressive terms and all dummy variables relevant to each city will be estimated. For Adelaide, the following model specification will be estimated:

$$\begin{aligned}\text{NIM} &= \beta_0 + \beta_1 \text{ Regulation} + \beta_2\text{Deregulation}_1 + \beta_3\text{Deregulation}_2 \\ &\quad + \beta_4\text{exREAS} + \beta_5\text{Refinery} + \beta_6\text{Fuel Standards} \\ &\quad + \beta_7\text{Strike} + \text{AR}(1) + \varepsilon_t\end{aligned} \tag{3}$$

For Melbourne, the following model specification will be estimated:

$$\begin{aligned}\text{NIM} = \beta_0 + \beta_1\text{Regulation} + \beta_2\text{Deregulation}_1 + \beta_3\text{Deregulation}_2 \\ + \beta_4\text{Blockade} + \beta_5\text{Refinery} + \text{AR}(1) + \varepsilon_\text{t}\end{aligned} \tag{4}$$

For Sydney, the following model specification will be estimated:

$$\begin{aligned}\text{NIM} = \beta_0 + \beta_1\text{Regulation} + \beta_2\text{Deregulation}_1 + \beta_3\text{Deregulation}_2 \\ + \beta_4\text{Merger} + \beta_5\text{Refinery} + \text{AR}(1) + \varepsilon_\text{t}\end{aligned} \tag{5}$$

4.1.1 Alternative model specifications

To ensure the estimated models are capturing the impact of genuine structural change rather than any underlying trends in the NIM data, two alternative models will be estimated. First, an alternative model specification that nests a linear trend term into each model, *Trend*, will be estimated (Equation (3a) for Adelaide, Equation (4a) for Melbourne and Equation (5a) for Sydney). Second, an alternative model specification that consists of a constant, an autoregressive term and a linear trend term, *Trend*, will be estimated (Equation (3b) for Adelaide, Equation (4b) for Melbourne and Equation (5b) for Sydney).

$$\text{NIM} = \beta_0 + \beta_1\text{Trend} + \text{AR}(1) + \varepsilon_\text{t} \tag{3b, 4b, 5b}$$

5. Results

An ordinary least square regression has been estimated for each equation.[4] Dummy variables should be interpreted as variations from the average level of the NIM from mid-1999 onwards in the case of Melbourne and Sydney, and from mid-1999 to the end of 2000 in the case of Adelaide. Changes in the

[4] EViews 6.0 was used for estimation.

average level of the NIM can also be interpreted as changes in the relative retail price of unleaded petrol.

The estimated Ljung and Box Q-statistics for serial correlation (up to 20 lags) were not statistically significant for any equation except for Equation (3b) (5 lags) and Equation (5b) (18 lags). The Breusch–Godfrey Lagrange multiplier test for serial correlation (Breusch–Godfrey LM test) up to 4 lags were not statistically significant for any equation.

However, the White heteroskedasticity test for all equations reveals that the null hypothesis for the non-presence of heteroskedasticity has to be rejected at least at the 5 per cent level suggesting that all models contain heteroskedasticity. While the presence of heteroskedasticity in the regression does not cause bias nor inconsistency in the parameter estimates, it does invalidate the standard errors, t-statistics, and F-statistics because the standard errors and the confidence intervals calculated will be too narrow.

According to Engle (2001, p. 158), provided the sample size is large, robust standard errors give quite a good estimate of standard errors even in the presence of heteroskedasticity which then allows statistical inferences to be made about the true parameter value. The equations were all re-estimated using heteroskedasticity-robust standard errors as proposed by White (1980).

The results for each city are presented in Tables 2, 3 and 4.

For Sydney, the proposition that the decline in the NIM coinciding with deregulation is associated with a trend can be rejected as *Trend* is not statisti-

Table 2 Equation (3), (3a) and (3b) for the Adelaide NIM*

Variable	Equation (3)	Equation (3a)	Equation (3b)
Constant	4.832 (23.821)	4.913 (6.114)	5.652 (15.457)
Trend	NA	−0.001 (−0.102)	−0.002 (−0.942)
Regulation	1.115 (4.211)	1.055 (1.719)	NA
Deregulation$_1$	1.363 (3.667)	1.328 (2.764)	NA
Deregulation$_2$	0.704 (2.435)	0.686 (2.057)	NA
exREAS	−0.917 (−2.887)	−0.887 (−2.123)	NA
Refinery	3.912 (13.493)	3.920 (‘12.468)	NA
Clean Fuel	1.838 (5.489)	1.881 (3.270)	NA
Strike	3.052 (1.730)	3.050 (1.725)	NA
AR(1)	0.328 (4.642)	0.328 (4.587)	0.578 (11.211)
R^2	0.480	0.480	0.342
Adjusted R^2	0.463	0.461	0.337
AIC	3.061	3.069	3.250
SC	3.186	3.207	3.292
Breusch–Godfrey	1.198 (0.878)	1.228 (0.873)	7.462 (0.134)
LM test (4 lags)	NA	NA	NA
White heteroskedasticity test	33.237 (0.0000)	41.926 (0.000)	14.141 (0.000)
F-statistic	28.624 (0.000)	25.343 (0.000)	65.941 (0.000)
Inverted AR roots	0.33	0.33	0.58
Included observations	257	257	257

Note: The figures in brackets are the corresponding heteroskedasticity corrected t-statistics for each variable and the corresponding probabilities for the diagnostic tests.

Table 3 Equations (4), (4a) and (4b) for the Melbourne NIM

Variable	Equation (4)	Equation (4a)	Equation (4b)
Constant	3.408 (14.623)	4.709 (4.622)	6.060 (14.527)
Trend	NA	−0.007 (−1.252)	−0.012 (−3.636)
Regulation	2.111 (6.066))	1.117 (1.478)	NA
$Deregulation_1$	2.182 (7.091)	1.529 (2.738)	NA
$Deregulation_2$	1.351 (2.625)	0.904 (1.519)	NA
Blockade	3.645 (10.164)	3.686 (9.999)	NA
Refinery	4.043 (4.273)	4.172 (4.261)	NA
AR(1)	0.496 (8.176)	0.486 (7.881)	0.595 (9.444)
R^2	0.571	0.574	0.499
Adjusted R^2	0.560	0.561	0.495
AIC	3.219	3.221	3.340
SC	3.322	3.338	3.384
Breusch–Godfrey	2.107 (0.716)	2.464 (0.651)	1.346 (0.854)
LM test (4 lags)	NA	NA	NA
White heteroskedasticity test	12.787 (0.026)	28.692 (0.004)	15.163 (0.001)
F-statistic	50.976 (0.000)	44.028 (0.000)	116.524 (0.000)
Inverted AR roots	0.50	0.49	0.59
Included observations	237	237	237

Note: The figures in brackets are the corresponding heteroskedasticity corrected *t*-statistics for each variable and the corresponding probabilities for the diagnostic tests.

Table 4 Equations (5), (5a) and (5b) for the Sydney NIM

Variable	Equation (5)	Equation (5a)	Equation (5b)
Constant	4.481 (22.745)	5.088 (8.017)	7.757 (20.122)
Trend	NA	−0.003 (−0.903)	−0.014 (−6.138)
Regulation	2.841 (11.840)	2.360 (4.539)	NA
$Deregulation_1$	2.659 (8.970)	2.317 (5.356)	NA
$Deregulation_2$	1.631 (4.806)	1.379 (3.374)	NA
Merger	2.931 (3.622)	2.875 (3.626)	NA
Refinery	3.111 (2.209)	3.106 (2.202)	NA
AR(1)	0.525 (9.032)	0.526 (8.941)	0.688 (15.575)
R^2	0.724	0.725	0.688
Adjusted R^2	0.718	0.718	0.686
AIC	2.804	2.808	2.897
SC	2.894	2.911	2.936
Breusch–Godfrey LM test (4 lags)	1.261 (0.868)	1.483 (0.830)	3.851 (0.427)
White heteroskedasticity test	36.038 (0.000)	57.972 (0.000)	28.252 (0.000)
F-statistic	121.517 (0.000)	104.203 (0.000)	311.415 (0.000)
Inverted AR roots	0.52	0.53	0.68
Included observations	285	285	285

Note: The figures in brackets are the corresponding heteroskedasticity corrected *t*-statistics for each variable and the corresponding probabilities for the diagnostic tests.

cally significant in Equation (5a), while all other parameters are statistically significant at the 5 per cent level. Therefore, Equation (5) is the preferred model specification for Sydney.

For Equations (3a) and (4a), neither the *Trend* nor the *Regulation* terms are statistically significant, hence resort must be made to comparing Equations (3) and (4) against the alternative model specifications of Equations (3b) and (4b), respectively, to determine the preferred model specification for Adelaide and Melbourne. For Adelaide, the model specification in Equation (3b) can be rejected as the *Trend* term is not statistically significant, leaving Equation (3) as the preferred model specification.

For Melbourne, resort must be made to choosing the preferred model specification based on the Akaike information criterion (AIC) and the Schwarz criterion (SC) – with smaller values being preferred. Given smaller AIC and SC values for Equation (4) when compared with Equation (4b), it is concluded that Equation (4) is a better fit for the data than Equation (4b) and on that basis is the preferred model specification for Melbourne.

All explanatory variables for the preferred model specifications for each city are statistically significant at less than the 1 per cent level with the exception of $Deregulation_2$ for Equation (4) and *Refinery* for Equation (5) which are statistically significant at less than the 5 per cent level, and *Strike* for Equation (4) which is statistically significant at the 10 per cent level. The inverted AR roots for all equations has a modulus of less than 1, suggesting the estimated models are all stationary.

The positive sign on the *Regulation* explanatory variable in all three cities suggests that the regulation of wholesale petrol prices was associated with relatively higher retail petrol prices than was the case following deregulation after an adjustment period. The modelling suggests that retail prices eventually fell by 1.1 cpl in Adelaide, by 2.1 cpl in Melbourne and by 2.8 cpl in Sydney following deregulation.

Sensitivity analysis was also conducted through running a series of alternative model specifications for each city. First, the autoregressive terms were removed from each model. Second, a basic model specification consisting of a constant term coupled with the *Regulation*, $Deregulation_1$ and $Deregulation_2$ terms both with and without the autoregressive terms was run for each city. Third, a model specification that separated out the impact of a higher average NIM for Melbourne recorded during the second half of 1997 from the rest of the period of regulation was run. The main finding that retail petrol prices eventually fell in all three cities following deregulation is robust under all alternative model specifications.

6. Conclusions

The eventual fall in the average NIM following deregulation lends itself to two possible explanations: first that the reduction was directly associated with deregulation; and second that there was some other structural change that occurred simultaneously across all three cities.

While increased competition from independent petrol importers may provide an alternative explanation for the fall in the average level of the NIM following deregulation, it is unlikely to be the major factor. This is because there were already independently operated fuel import terminals near Melbourne and in Sydney able to receive imported petrol from overseas prior to January 1997, so any impact from independent petrol imports was presumably already present from the beginning of the sample period. Furthermore, increased competition from independent petrol importers does not explain why the average NIM also fell in Adelaide which did not have access to any independent petrol imports.

For Adelaide, another alternative source of structural change may be associated with the termination of REAs from the beginning of 2000. However, even if this event was associated with a decrease in the average NIM, it had already fallen following deregulation prior to the beginning of 2000.

The major shortcoming with trying to identify alternative sources of structural change to explain the fall in the average NIM following deregulation is the inability to identify any alternative event that occurred simultaneously across all three cities. In the absence of an alternative explanation, it is concluded that the fall in the average NIM was most likely associated with deregulation.

If deregulation was associated with relatively lower retail petrol prices, one possible explanation is that it reduced production costs, which were eventually competed away by market participants during the first half 1999 and passed on to consumers in the form of relatively lower retail petrol prices. While the statistical significance of certain dummy variables (*Merger* and *exREAs*) are suggestive of potential competition problems in the downstream petroleum industry, the eventual reduction in relative retail petrol prices following deregulation suggests that capital city retail petrol markets are competitive to some extent, if not immediately in the short term, then at least in the medium term in that retail petrol prices eventually adjusted to reflect possible changes in the cost structure at the wholesale level. If capital city retail petrol markets were not at least competitive in the medium term, then relative retail petrol prices should not have fallen following deregulation, with wholesale market participants, principally the oil majors, simply pocketing any reduction in production costs following deregulation.[5]

The results of this study suggest that consumers in Adelaide, Melbourne and Sydney enjoyed relatively lower retail petrol prices following deregulation than would have otherwise been the case if regulation had continued and were unambiguously better off as a result. An important policy implication is that it suggests that not only was regulation an ineffectual policy instrument in terms of constraining the pricing behaviour of the oil majors, but that the regulation probably imposed increased production costs that were ultimately paid for by consumers through relatively higher retail petrol prices. This also

[5] Given that it is widely believed that demand for petrol is highly price inelastic, it would be irrational for profit maximising firms to reduce their prices unless they were engaging in price competition.

suggests that future policy interventions designed to constrain prices in the downstream petroleum industry should be very carefully considered.

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