International Journal of Energy Economics and Policy

ISSN: 2146-4553

available at http: www.econjournals.com

International Journal of Energy Economics and Policy, 2021, 11(4), 383-397.

Regional Patterns for the Retail Petrol Prices

Arezoo Ghazanfari*

School of Economics, Finance and Marketing, RMIT University, Victoria 3000, Australia. *Email: Arezoo.ghazanfari@rmit.edu.au

Received: 02 June 2020 **Accepted:** 08 September 2020 **DOI:** https://doi.org/10.32479/ijeep.10132

ABSTRACT

Costs of transport fuels are the most significant components of household expenditures, and the price of petrol is of particular importance for commercial and residential sectors in Australia. Regarding the central role of petrol, an in-depth understanding of petrol price behaviours is essential. Previous studies mostly focused on the petrol markets in metropolitan areas, and there exists a significant gap in the regional literature. Therefore, this paper is aimed to develop a clearer understanding of petrol price patterns in urban and rural areas in Western Australia. This study finds a mismatch between pricing patterns across various regions and cities. There are cities with two types of price patterns, cities with price cycles and cities without. Most cities have not excessive fluctuations, and their price patterns are almost smooth. This group of cities have different levels of petrol prices. The greater distance with Perth raises petrol prices in these groups of cities. Cyclical patterns have been observed only in Murray, Mandurah and Geraldton. Comparative analysis reveals that asymmetric and frequent weekly cycles in three cities are similar to the cycle in Perth. It can be argued that there exist no specific differences in petrol price patterns among cities with cycle.

Keywords: Petrol Prices, Regional Markets, Markov Switching Models, Australia
JEL Classifications: C22, D40, L11, Q41, R10

1. INTRODUCTION

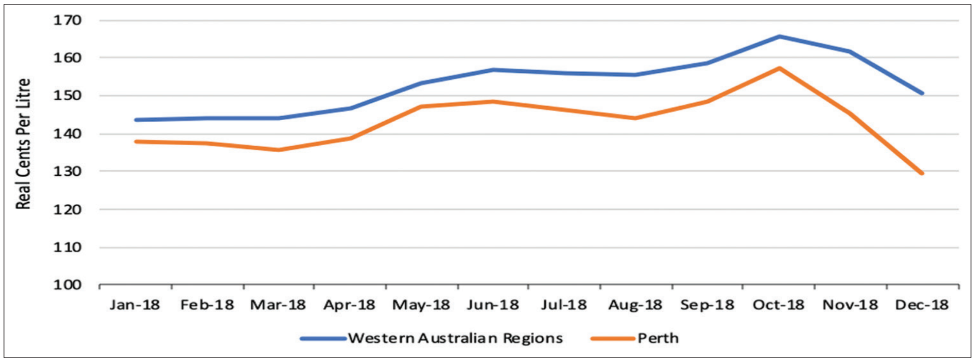
As reported by the Australian Competition and Consumer Commission (ACCC), petrol price cycles mostly occur in the five Australian capital cities including Adelaide, Brisbane, Melbourne, Sydney, and Perth, but not in the smaller cities such as Canberra or Darwin. In contrast with these five capital cities, petrol prices in the regional areas are higher and less fluctuated (Australian Competition and Consumer Commission, 2019). For instance, Figure 1 indicates the time-series pattern for the monthly average prices of petrol inner and outer the Perth metropolitan area in Western Australia (WA). As shown, regional prices of petrol are significantly higher than in the Perth metropolitan area.

Regarding these issues, the following research questions arise: How petrol prices behave in regional areas? And, is there dispersion in petrol prices? In part, the ACCC conducted studies in regional petrol markets and found that petrol prices are higher compared with capital cities which may be a result of less competition. But despite the influence of high petrol prices on households, businesses, purchasing power, travel patterns and even economies, there are no significant studies to examine pricing patterns in the Australian regional markets. Thus, this study is motivated to analyse the petrol price patterns across all regions in Western Australia, a subject which was less-focused by previous scholars.

Australian households allocate a significant portion of their income to petrol purchase and increases in its prices have a noticeable impact on the family budget, welfare and living standards, especially in regional areas where the public transport facilities are inadequate (Dodson and Sipe, 2008). Therefore, it can be noted that rising petrol prices impact on motorists in regional areas more severely than in capital cities. Therefore, analysing petrol price behaviours in rural and regional areas is very critical, which will be examined in this paper.

This study aims to examine regional patterns of petrol prices by using a novel dataset for all cities across all regions in Western

Figure 1: The average ULP prices (real term) in regional and metropolitan areas, 2018



Provided by Author

Australia. I apply a Markov regime-switching model to estimate characteristics of petrol prices cycles in cities with cyclical pattern. The scope of this research is WA because the economy, demography and geography condition of this state are unique. Also, there is a petrol price legislation in WA which distinguishes this state from other Australian states. "Fuel-Watch" is the only service in Australia which allows consumers to access tomorrow's petrol prices today. It is a fuel monitoring service designed by the Western Australian government in January 2001. This website presents the daily price of petroleum products related to 80% of stations in regional areas and all stations in Perth in WA. Based on this 24-h price legislation, petrol retailers must report their prices for the next day on the "Fuel-Watch" website before 2:00 pm. Also, retailers are obligated to stay at this price for 24 h. Hence, Fuel-Watch provides advantages for researching the retail petrol markets in this state. It provides perfect price information for all petrol stations in Western Australia which makes this state beneficial in economic analysis. Furthermore, in contrast with previous studies that analyse price patterns in the retail petrol markets with no pricing restrictions, this study enables us to examine the petrol price behaviours in a unique petrol market.

The research novelties can be represented as follows. First, this study mainly contributes to the empirical literature about the retail petrol markets. Analysis of the petrol price dynamic in Australia has been the topic of several studies (i.e. de Roos and Katayama, 2013; Valadkhani and Smyth, 2018; Byrne and De Roos, 2019) and it remains a considerable issue among drivers in Australia. But, the consideration of all Australian scholars was on capital cities not rural and regional areas which led to a gap in the regional petrol studies. Analysing how petrol price behaves at different locations – from small remote cities to the regions– is a key factor which was neglected in the previous studies. Hence, this study evaluates petrol price patterns in the regional areas for the first time in Australia.

Second, this research shed some light on the regional petrol markets of which regions need more accurate scrutiny and price monitoring by the regional authorities. They can use the findings of this study which has a meaningful contribution to their future decisions about petrol markets. Third, in contrasts with previous literature which only used petrol price information of urban areas, the innovation of our dataset is it provides a comprehensive report of price information for all petrol stations across all regional and rural cities in WA. The dataset enables us to isolate the retail petrol markets in different locations to identify disparities in pricing behaviours among them. It should be noted that the implementation of aggregated data at the state level may mask the presence of regional differences in different locations. Using this unique dataset, we can examine pricing behaviours in each city separately and also assess the differences in the price patterns inner and outer the Perth metropolitan area by detail, a subject that has been ignored in the previous studies.

As mentioned by previous studies, a high level of competition in the retail petrol markets in capital cities results in competitive behaviours among stations and cyclical price pattern. In contrast, due to the low level of population and demand for petrol in regional and rural areas, numbers of stations are lower than capital cities which lead to less competition in the regional petrol markets. The lack of severe competition can be the main reason for higher petrol prices in regional areas. Hence, it can be expected that less-populated cities with low-levels of competition have no cyclical pattern in their petrol prices.

The findings reveal that regional cities have higher petrol prices compared with Perth. It also shows that petrol prices have been varied across western Australian cities; regions with the highest distance from Perth exhibit the highest petrol prices. Cities located in regions including Kimberley, Pilbara and Gascoyne, have the most expensive petrol compared with others. Indeed, it can be noted that as much as the distance between Perth and regions increase, the price of petrol increase more and more. For instance, over the last 10 years, Kimberley, with the highest distance of Perth, has had the highest petrol prices. The average price of one litre of petrol in the Kimberley was approximately 29 CPL higher than in Perth over the last decade[1]. Findings have some positive practical implications. This research point about some specific regions with the highest petrol prices. Thus, ACCC can potentially target these regional centres more accurately. These findings are very vital because, from a policy perspective, it reveals that regulators cannot apply one specific pricing legislation in a targeted way across all cities in WA. The findings suggest that authorities can specifically focus on petrol markets in cities with

1 - In some specific days, the petrol price difference between the Kimberley and Perth was more that 40 cents in 2017.

the highest petrol prices, which may have more anti-competitive pricing behaviour, to prevent price gouging. Also, the approach of this study can be replicated in other Australian states to find regions which need more price monitoring.

The study is structured as follows: Section 2 provides a review of literature. A summary of WA will be presented in section 3. Empirical framework and data explanation are provided in section 4 and 5, respectively. Section 6 includes empirical results, and finally, section 7 comprises conclusion and policy implications.

2. THEORY AND LITERATURE

Despite extensive studies on petrol price behaviours in metropolitan areas, petrol price patterns in less-populated regional and rural areas have not been explored adequately. The main question which should be answered is how petrol prices behave in less-competitive markets in regional or rural areas?

There are various theories to evaluate price behaviours, but the most accepted theory in petrol studies is the Edgeworth cycle which was declared in 1925 by Francis Ysidro Edgeworth, and then formalised by Maskin and Tirole (1988). The role of competition in the Edgeworth price cycle is very significant. Edgeworth cycles refer to a regular and asymmetric pattern of prices that stem from stronger competition among companies who sell homogeneous products. Given this theory, companies undercut their prices over a period which called the undercutting phase. The undercutting period proceeds continuously until companies' profits are decreased to zero, or at least near that. At the margin cost, companies are more interested in relenting and returning to higher prices. So, one company becomes a leader in increasing its price, and other rivals follow it, and another similar cycle starts again (Noel, 2007b).

Most studies have examined the existence of petrol price cycles by considering the Edgeworth theory in high-competitive markets. In the markets with high levels of competition, consumers are very sensitive to petrol prices. They can easily search into the market to find low-priced stations in their proximities and prefer to switch among stations to find the best prices. For this reason, petrol stations located in the high-competitive markets should compete together, monitor each-others prices and opportunistically reduce their prices to gain the share of the market. Petrol price cycles have been observed in capital cities of the U.S., Canada and Australia. For example, Lewis (2008), Doyle et al. (2010), Lewis (2012), Zimmerman et al. (2013) and Noel and Chu (2015) in the U.S.; Eckert and West (2004), Atkinson (2009), Byrne and de Roos (2017) in Canada; Wang (2009), Bloch and Wills (2010a and 2010b), de Roos and Katayama (2013) in Australia; and several European countries have been detected such as Siekmann (2017), and Alderighi and Baudino (2015).

In contrast with capital cities, petrol markets in regional and rural areas are entirely different. Low level of population and demand in these areas leads to the low concentration of stations that result in less competition in the retail petrol markets. Due to the limited number of stations in regional markets, consumers have fewer options and or even only one choice. Hence, they don't have the opportunity to search in the market to find the lowest petrol prices, and they have to buy petrol from their nearest station. Consequently, consumers can't stimulate stations to change their prices and stations also don't need to compete together. Regarding these conditions, it is expected that petrol stations in regional locations have fewer or even no price cycles. Petrol prices in these areas are expected to be more stable compared with Australian metropolitan areas. This hypothesis will be examined in this study. A report presented by Australian Competition and Consumer Commission (2018) mentioned that "Petrol prices in Australian regions change more slowly than in the five largest cities—both up and down—because retailers in many regional areas tend to have lower stock turnover than city sites. Regional prices tend to be more stable than prices in the five largest capital cities, which generally move in cycles."

Furthermore, transportation or distribution costs in regional areas are higher than in central cities. Stations must pay more for obtaining petrol, and they can pass this cost through their consumers by increasing their prices. Thus, it is expected that petrol stations located in regional areas have higher petrol prices compared with central cities. Therefore, the second hypothesis assumes the existence of different price patterns in different areas which will be analysed in this study.

Scholarly understanding of petrol price dynamic in regional areas has received very little attention in the empirical studies, particularly in Australia. For instance, Byrne (2019) extended the scope of his study and analysed the collusive channel using petrol price data for all stations located in rural and urban areas in Ontario, Canada. He found pricing asymmetry, collusive and search-based explanations in rural areas. In the U.S., Ye et al. (2005) and Blair et al. (2017) studied the pass-through behaviour of the retail petrol price and found the existence of regional differences in price adjustment processes. But the limitation of these mentioned studies is that they mainly focused on the pass-through patterns in the retail petrol markets (i.e. Deltas, 2008; Meyler, 2009; Chesnes, 2016; Kpodar and Abdallah, 2017).

In the Australia, Valadkhani (2013) analysed the days of the week effect in retail petrol prices. He used a dataset contains the daily price information for 114 Australian cities and town from 2005 to 2012. He found that Fridays or Thursdays were the most expensive days and Sundays or Tuesdays were the cheapest days for purchasing petrol in most areas. Valadkhani et al. (2014) also examined petrol profit margins across 109 urban and regional areas in Australia using hierarchical cluster analysis. Their findings provided new pieces of evidence that show high petrol margins are not seen only in isolated and rural areas. INDEED, urban locations including North Coast, Newcastle, Rockhampton, Geelong, Shepparton, Wangaratta, Bega and Geraldton have the largest margins. These studies analysed different aspects of the regional petrol markets and there has been no research on how the petrol price behave in regional Australian cities, while the implication of this concept is essential for regional citizens, policymakers, and also regional authorities. Therefore, this research is motivated to find how petrol prices behave in regional areas. Following previous studies, this study considers the Edgeworth theory to analyse pricing behaviours in cities with cyclical patterns.

2.1. Edgeworth Price Cycle Theory

The context of a competitive and asymmetric price cycle goes back to Edgeworth (1925). He argued that prices in a competitive oligopolistic system would not be stable according to the Cournot model[2] and they would frequently modify in an asymmetric cycle, which he considered as cycle disequilibrium (Reilly and Witt, 1998). Maskin and Tirole (1988) developed the theory of Edgeworth, and their approach demonstrates the probability of two possible types of Markov equilibrium. The first one illustrates price stickiness over time, while another one shows an asymmetric cycle (Noel, 2007a). The Markov perfect equilibrium means that a company's pricing strategy only depends on the current price decisions of other companies rather than the entire history of pricing actions (He and Sun, 2017, Maskin and Tirole, 1988).

In the Edgeworth price cycle, firms consecutively undercut one another by offering goods at a lower price than their rivals to gain the market share, until the price reaches marginal cost. At this point, firms increase their prices in a single step, and then another undercutting phase starts again (Noel, 2007b). Figure 2 illustrates an example of the Edgeworth price cycle when there are only two firms in the market. Maskin and Tirole determined that firms with Edgeworth price cycle follow three main predictions of the theory, which are as follows. (1) The reaction of firms is fast, but not simultaneous, (2) Small-sized companies tend to decrease prices in the undercutting phase, and (3) Large companies are more interested to be a leader in increasing prices in the relenting phase (Noel, 2007b).

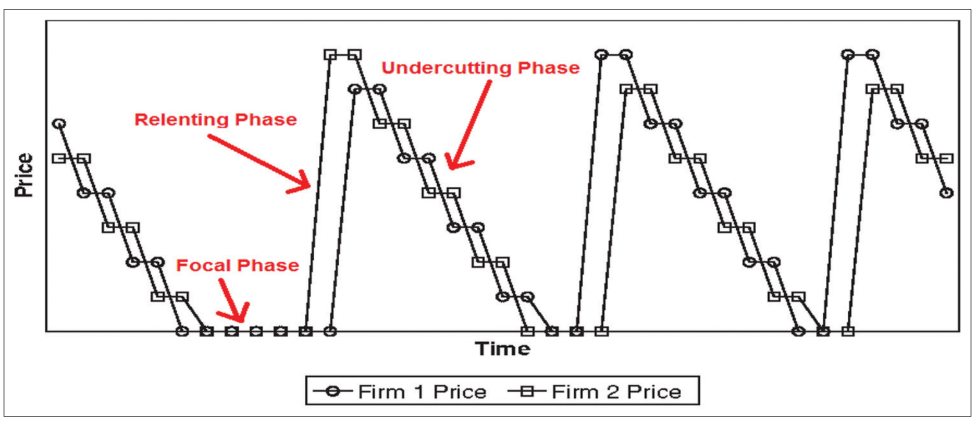
2 -Cournot is an imperfect competition model which was introduced by Antoine Cournot (1838). In this model, two companies with similar cost functions contend in a static environment with similar goods.

The Edgeworth theory is currently the leading theory for explaining the cyclical pattern in the retail petrol markets (Eckert, 2013). Petrol price cycles have been observed mostly in the capital and large cities of the U.S., Canada, and some European countries. Moreover, retail petrol prices move in regular cyclical patterns in the Australian metropolitan areas, including Melbourne, Sydney, Adelaide, Brisbane and Perth. To show petrol price cycles in the real market, please see Figure 3 that demonstrates an asymmetric petrol price cycle in Perth. This graph contains the time-series pattern of the average petrol price for wholesalers and retailers in Perth for the year 2018. As shown, the pattern of wholesale petrol price is more stable, and it doesn't have daily fluctuation. In contrast, the retail petrol price move in a cyclical pattern like the Edgeworth price cycle.

3. WESTERN AUSTRALIA

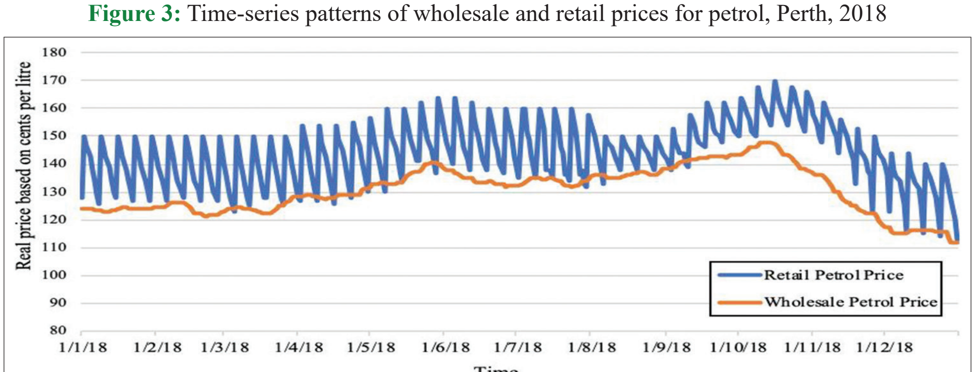
The focus of this study is on the retail petrol markets in Western Australia (WA). Considering the geographical and economic conditions of WA, this state is a unique case for study. Western Australia is the largest state in Australia; its area is 2.646 million km². Moreover, WA is the second-largest country subdivision in the

Figure 2: Edgeworth price cycle



Source: Noel (2007b)

Figure 3: Time-series patterns of wholesale and retail prices for petrol, Perth, 2018



world, after the Yakutia region in Russia (Australian Bureau of Statistics, 2018). This state contains nine regions with different socio-economic characteristics. For example, the Pilbara's economy heavily relies on mining of oil and gas whereas the economy of Wheatbelt is based on the agriculture industry. These nine specified regions are: Gascoyne, Goldfields-Esperance, Great-Southern, Kimberley, Mid-West, Peel, Pilbara, South-West, Wheatbelt.

Contrary to the massive size of this state, only 11% of Australian inhabitants, around 2.5 million, live in this area. The majority of WA's population, around 74%, centralize in Perth, and the remaining of that is dispersed in different regions (Australian Bureau of Statistics, 2018). Although South-West and Peel have the smallest size in WA, approximately 90 per cent of the regional residents are settled in these two regions. Moreover, this state is one of the most isolated areas in the world. Many lands in WA are deserts that are not suitable for life. However, this state provides 85% of Australian mineral and energy exports. This state also has a vital role in the Australian economy.

Furthermore, as mentioned before, there is a petrol price legislation in WA which distinguishes this state from other states. "Fuel-Watch" is the only service in Australia which allows consumers to access tomorrow's petrol prices today. "Fuel-Watch" provides advantages for researching the retail petrol markets in this state. Using this website, we can find complete information about petrol prices in a clear and discrete-time environment. Second, this website gives a comprehensive dataset of daily petrol prices which contains price data for 80% of petrol stations in Western Australia (80% of regional and all metropolitan retail outlets).

4. EMPIRICAL FRAMEWORK

In this study, I follow Noel (2007a and 2007b), as well as, de Roos and Katayama (2013) to estimate petrol price cycles by using a Markov regime-switching model. Following Noel (2007b), I define three separate regimes in the framework of the Markov regime switching model in this study, i.e., undercutting (U), relenting (R) and focal phases (F).

- The undercutting regime illustrates the continuous decrease in petrol prices
- The relenting phase corresponds to a sharp rise in prices
- A non-cycling or focal regime is the periods that the price is stable.

In this study, I determine the characteristics of price cycles in each regime separately.

4.1. Undercutting and Relenting Regimes

The relenting or the undercutting regimes are determined as follows in equation (1):

$$\Delta P_{st} = \beta_i X^i_{st} + \varepsilon^i_{st} \tag{1}$$

Where

$$\Delta P_{st} = P_{st} + P_{s,t-1} \tag{1a}$$

$$Let\,\alpha^i = E(\Delta P_{st} \mid X^i_{st})\;;\; i: R, U \tag{1b}$$

In the equation (1), P_{st} is the retail petrol price of station s at time t, ΔP_{st} is the difference between the retail petrol price for station s at times t and t–1, and $X_{st}^{\,i}$ is a vector of explanatory variables. In equation (1), α^i is the expected per day price change considering explanatory variables ($X_{st}^{\,i}$) in each regime. Therefore, α^R shows the daily price change in a relenting phase and α^U defines likewise for undercutting phase. The error term, $\varepsilon_{st}^{\,i}$ is assumed to follow the normal distribution with mean zero, and variance $\sigma_i^{\,2}$:

$$\varepsilon^i_{st} \sim N\left(0,\left(\sigma_i^2\right)\right)\;;\; i: R, U$$

I assume that the average petrol price changes in each regime ($\alpha^i = E\ (\Delta P_{st}|X_{st}^{\,i}),\ i=R,\ U$), the switching probabilities ($\lambda_{st}^{\,ij}$) and the probability of price stickiness are steady. In this condition, I consider a constant term (a vector of ones) and the dummy variables for cities which will be included in X^R and X^U as the explanatory variables ($X_{st}^{\,i}$) in equation (1) for modelling the undercutting and the relenting phases.

4.2. Focal Regime

In equation (2), γ^i_{st} displays the probability of price stickiness, conditional on being on the focal or the undercutting regimes using the logistic model:

$$\Pr(J_{st} = S | I_{st} = i,\, V^i_{st}) = \gamma^i_{st} = \frac{\exp(V^i_{st}\tau)}{1+\exp(V^i_{st}\tau)'}\;;\; i: F, U \tag{2}$$

γ^i_{st} indicates the probabilities that a station does not change its prices during the undercutting[3] or the focal regimes. The indicator variable J_{st} is equal to S (price stickiness) when the market is in the focal (F) or undercutting (U) regimes. $V_{st}^{\,i}$ is a vector of explanatory variables of station S at time t, and ζ is a (Q×1) vector of parameters. In this specification, V^U and V^F contains only a constant term (a vector of one). When petrol prices are stable during a focal regime, it is explained that the wholesale prices influence retail petrol prices. Thus, the following equation shows a model of the focal regime:

$$P_{st} = \beta_i X^F_{st} + \varepsilon^F_{st}\,;\, with\ prob = \gamma^i_{st}\,;\; i: F \tag{3}$$

$$\varepsilon^i_{st} \sim N\left(0,\left(\sigma_i^2\right)\right)\;;\; i: F$$

Where:

ΔP_{st}=0 for Focal regime

$X_{st}^{\;F}$ is an explanatory variable and the error term, $\varepsilon_{st}^{\,i}$, is assumed to follow the normal distribution with mean zero, and variance σ_i^2 (Noel, 2007b). The constant term and the wholesale petrol price (terminal gate price [TGP]) are the explanatory variables $X_{st}^{\;F}$.

3 - It is anticipated that the price increase occurs in a single time (Noel, 2007b), thus, I do not consider sticky prices within the relenting regimes.

4.3. Switching Probability

In the Edgeworth cycles, prices move between different regimes. Following the approach of Hamilton (2005), this literature examines the transition matrix as follows:

$$P=\begin{bmatrix} P\left(s_t=1|s_{t-1}=1\right) & P\left(s_t=2|s_{t-1}=1\right) & P\left(s_t=3|s_{t-1}=1\right) \\ P\left(s_t=1|s_{t-1}=2\right) & P\left(s_t=2|s_{t-1}=2\right) & P\left(s_t=3|s_{t-1}=2\right) \\ P\left(s_t=1|s_{t-1}=3\right) & P\left(s_t=2|s_{t-1}=3\right) & P\left(s_t=3|s_{t-1}=3\right) \end{bmatrix}$$

$$=\begin{bmatrix} p_{11} & p_{21} & p_{31} \\ p_{12} & p_{22} & p_{32} \\ p_{13} & p_{23} & p_{33} \end{bmatrix} \quad (4)$$

The transition probability (λ_{st}^{ij}) that a station switches from regime *i* in period (*t-1*) to regime *j* in period *t* is given by equation (5):

$$\lambda_{st}^{ij}=\Pr(I_{st}=j|I_{s,t-1}=i,\,W_{st}^{i}) \quad (5)$$

$$\frac{exp(W^i st\theta^{ij})}{1+\exp\left(W^i st\theta^{iR}\right)+exp(W^i st\theta^{iU})}$$

Where

$i=R,U,F \quad ; \quad j=R,U$

$$\lambda_{st}^{iF}=1-\lambda_{st}^{iR}-\lambda_{st}^{iU} \quad ; \quad for\, i=R,U,F \quad (6)$$

I_{st} utilize as an indicator function equivalent to R, U, and F when station s, at time t is in the phase of the relenting, the undercutting, or the focal regime, respectively. W^i_{st} is a vector of explanatory variables which influences switching from regime *i*, θ^{ij} is a vector of parameters and λ_{st} is a switching 3×3 matrix (Noel, 2007b). W^i contains the constant term (a vector of ones) and city-specific dummy variable. The parameters β_i, θ_i, ζ_i and σ_i for each specification are estimated by maximum likelihood[4].

$$\lambda_{st}=\begin{bmatrix} \lambda_{11} & \lambda_{21} & \lambda_{31} \\ \lambda_{12} & \lambda_{22} & \lambda_{32} \\ \lambda_{13} & \lambda_{23} & \lambda_{33} \end{bmatrix}=\begin{bmatrix} \lambda_{st}^{RR} & \lambda_{st}^{RU} & \lambda_{st}^{RF} \\ \lambda_{st}^{UR} & \lambda_{st}^{UU} & \lambda_{st}^{UF} \\ \lambda_{st}^{FR} & \lambda_{st}^{FU} & \lambda_{st}^{FF} \end{bmatrix} \quad (7)$$

4 - Equations related to cycle characteristics such as cycle duration equation are explained in Chapter two. For more information, please refer to the previous chapter.

5. DATA

The purpose of this study is finding a regional pattern of petrol prices in WA. To do so, I use a dataset contains the daily price information of petrol for all stations in 51 cities across 9 regions in WA. I also apply the petrol price data for stations located in the Perth metropolitan area. Unleaded petrol (ULP) is the most common type of petroleum products in Australia. Hence, the price of ULP is the main focus of this paper. The retail ULP prices are defined based on cents per litre (CPL) in real term. Price information of ULP was obtainedfrom "Fuel-Watch" website (https://www.fuelwatch.wa.gov.au/). The sample period in this study spans from 1 January 2017 to 31 August 2018. Figure 4 presents a map of the geographical divisions of 52 cities in WA. Although there are more than 300 stations in regional cities, the full information of 249 stations was available in the Fuel-Watch website.

In the dataset, stations are classified into two groups; the major-branded stations and independent stations. The branded stations are affiliated to the major oil companies including BP, Caltex, Shell and Mobil; and also two major supermarket chains, Woolworths and Coles. The remaining stations consider as independent petrol stations. Table 1 presents a summary of regions, cities and the number of stations in each region.

This research uses a dataset of wholesale petrol prices (TGP[5]) from January 1, 2017, until August 31, 2018. The information of TGPs are required to estimate the characteristics of the retail petrol prices when stations are in the focal regime. In the focal regimes, prices are stable and dependent on the wholesale prices. There are sixteen wholesalers with five specific brands (BP, Caltex, Shell, Mobil, and Puma) that supply the entire petrol for all retail stations in WA. I matched wholesalers to the stations based on distance and brand. For instance, I assumed that BP stations purchase petrol from BP wholesalers, while independent stations buy petrol from the nearest wholesalers. Moreover, GIS software is applied to find geographic information.

6. EMPIRICAL RESULTS

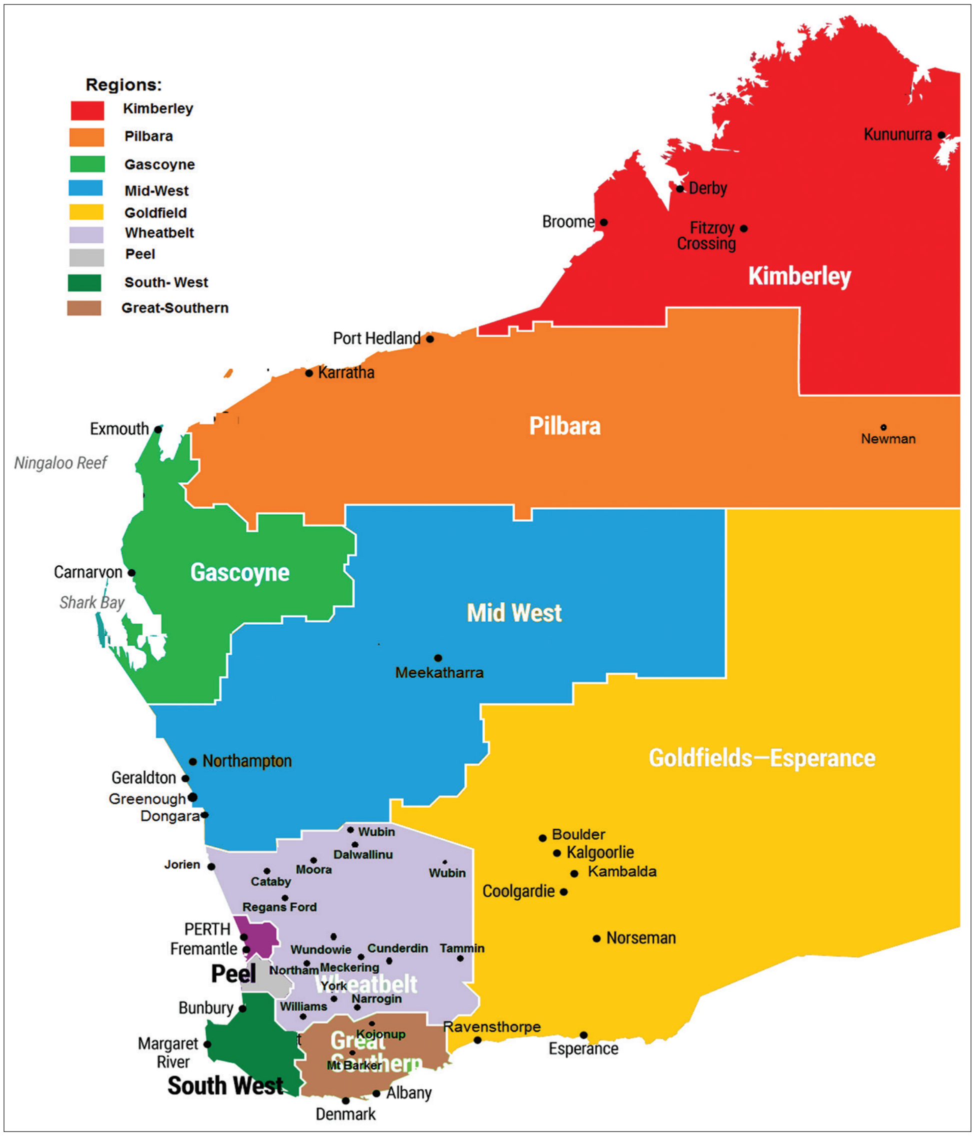
This paper is aimed to provide a contextual setting of retail petrol price behaviours across rural, regional and urban markets in WA.

5 - Terminal Gate Price (TGP)

Table 1: Characteristics of petrol stations in 52 cities in WA, 2017-2018

Regions	Cities	Stations (number)
Pilbara	Dampier-Newman-Karratha-Hedland	21
Kimberley	Broome-Derby-Fitzroy-Kununurra	20
Gascoyne	Carnarvon-Exmouth	7
Mid-West	Dongara-Geraldton-Greenough-Meekatharra	24
Goldfield-Esperance	Boulder-Coolgardie-Esperance-Kalgoorlie-Kambalda-Norseman-Ravensthorpe	25
Wheatbelt	Cataby-Cunderdin-Dalwallinu-Jurien-Meckering-Moora-Narrogin Northam-Tammin-Williams-Wubin-York	24
South-West	Bunbury-Manjimup-Bridgetown/Greenbushes-Busselton-Busselton/ Shire-Capel-Collie-Dardanup-Donnybrook/Balingup-Harvey-Augusta	63
Peel	Murray-Waroona-Mandurah	33
Great Southern	Albany-Denmark-Kojonup-Mt Barker	32
Perth	Perth	125

Figure 4: Local government and regional boundaries



At first, I classify cities into two specific groups: cities with petrol price cycles and cities without specific patterns. In the next stage, the characteristics of petrol price cycles will be examined for each city separately and then, I will compare cycles inner and outer the Perth metropolitan area.

6.1. Classification of Cities

The summary statistics of city-specific petrol prices are presented in Table 2. Findings show that the ULP prices in regional cities are generally higher than Perth.

Figure 5 presents time-series patterns of the average price of ULP in all regions in WA from Jan 2010 to Apr 2019. As illustrated, all regions have higher average prices compared with Perth. Also, the results of demonstrates that remote regions like Kimberley, Pilbara and Gascoyne have the highest average of petrol prices compared with other regions. Over the last 10 years, Kimberley has had the highest petrol price in WA. The average price of a litre of petrol in Kimberley was approximately 29 cents higher than in Perth over the last decade, while in some specific days, the price difference was around 40 CPL.

As illustrated by Table 2, the most expensive cities are located in regions with the highest distance from Perth metropolitan area, including Kununurra (168.44), Derby (167.44), Fitzroy (161.44), Exmouth (158.67), and Meekatharra (154.75). In contrast, cities with the lowest petrol prices have the shortest distance from Perth; including Cataby (126.92), Narrogin (133.54), Moora (133.54), York (133.78) and Harvey (134.09). It can be argued that the most-expensive petrol stations are placed in less populated regions with the highest distance from Perth, where the extent of economies of scope and scale is limited. Also, standard deviations show that the most and the least volatile petrol prices are in Mandurah (11.51) and Fitzroy (3.96), respectively.

Then, I classify cities based on their price observations and daily price changes. The price information shows that in the markets with the cyclical price pattern, prices change every day and are not stable. Our findings show that petrol prices tend to be constant in most regional cities in WA. Figure 6 shows petrol price patterns for all regional cities in WA from 1 January 2017 to 31 August 2018. As you can see, there are not excessive fluctuations in petrol prices, and price patterns are

Table 2: Descriptive statistics of the average ULP prices for 52 cities in WA, January 2017-August 2018

City	Region	Mean	STD	Kurtosis	Skewness	Range	Min.	Max.
Perth	Perth	125.92	8.45	–0.86	0.35	33.00	110.00	143.00
Cataby	Wheatbelt	126.92	8.45	–0.86	0.35	33.00	111.00	144.00
Narrogin	Wheatbelt	133.54	8.45	–0.89	0.48	30.20	121.30	151.50
Moora	Wheatbelt	133.54	8.38	–0.72	0.59	31.00	119.90	150.90
York	Wheatbelt	133.78	8.78	–0.72	0.31	36.00	114.90	150.90
Harvey	South-West	134.09	8.72	–0.83	0.55	30.48	120.91	151.39
Mandurah	Peel	134.22	11.51	–0.38	0.02	57.47	105.79	163.26
Williams	Wheatbelt	134.38	9.14	–0.72	0.68	29.10	122.47	151.57
Mt Barker	Great Southern	134.58	8.87	–0.48	0.74	29.67	122.17	151.83
Tammin	Wheatbelt	134.67	6.80	–0.45	0.85	22.00	127.90	149.90
Dongara	Mid-West	135.15	7.31	–0.79	0.71	21.67	127.10	148.77
Waroona	Peel	135.39	7.49	–0.28	0.76	28.70	124.18	152.88
Busselton	Southwest	135.72	7.73	–0.81	0.76	26.65	124.24	150.89
Northam	Wheatbelt	135.92	10.11	–0.54	0.19	47.00	112.90	159.90
Meckering	Wheatbelt	136.13	7.63	–0.47	0.53	26.00	125.90	151.90
Cunderdin	Wheatbelt	136.37	6.05	–0.55	0.77	20.20	129.70	149.90
Murray	Peel	136.73	7.71	–0.56	0.23	37.63	120.23	157.86
Kojonup	Great Southern	137.04	9.73	–0.77	0.61	30.33	124.57	154.90
Greenough	Mid-West	137.10	8.53	–0.78	0.47	32.23	123.18	155.40
Dardanup	South-West	137.16	8.48	–0.91	0.58	27.74	126.86	154.60
B-Town	South-West	137.20	8.08	–0.90	0.61	24.28	128.10	152.38
Albany	Great Southern	137.57	9.35	–0.81	0.61	31.26	126.27	157.53
Denmark	Great Southern	137.81	9.33	–0.55	0.79	31.83	127.57	159.40
D-Brook	South-West	137.83	7.60	–0.75	0.75	23.24	128.86	152.10
Bunbury	South-West	138.04	8.47	–0.84	0.71	25.18	129.50	154.68
Collie	South-West	138.30	10.20	–0.44	0.95	31.00	126.90	157.90
Augusta	South-West	138.33	6.81	–0.66	0.87	21.90	130.19	152.09
Geraldton	Mid-West	138.36	9.15	–0.74	0.30	38.69	119.62	158.31
Manjimup	South-West	138.48	8.73	–0.95	0.63	27.28	128.36	155.65
Busselton-Shire	South-West	138.64	8.24	–0.59	0.90	25.24	129.28	154.52
Coolgardie	Goldfield	138.91	9.19	–0.97	0.65	26.90	128.90	155.80
Esperance	Goldfield	138.95	9.31	–0.83	0.75	26.90	129.50	156.40
Capel	South-West	139.00	7.80	–0.68	0.74	25.50	130.40	155.90
Kalgoorlie	Goldfield	141.59	8.45	–0.17	1.12	28.57	129.90	158.47
Boulder	Goldfield	141.86	8.45	–0.33	1.04	28.55	129.85	158.40
Dalwallinu	Wheatbelt	141.91	6.94	–0.74	0.63	23.35	132.50	155.85
Kambalda	Goldfield	142.71	10.06	–0.60	0.90	28.00	133.90	161.90
Newman	Pilbara	142.77	4.66	0.10	1.28	15.67	138.23	153.90
Jurien	Wheatbelt	143.48	7.54	–0.76	0.47	27.75	131.95	159.70
Wubin	Wheatbelt	144.16	8.68	–0.47	0.89	26.35	134.55	160.90
Carnarvon	Gascoyne	145.97	5.61	–0.34	1.12	16.20	140.70	156.90
Port Hedland	Pilbara	146.08	9.85	–0.35	1.03	29.81	136.34	166.15
Ravensthorpe	Goldfield	146.83	7.74	0.53	1.46	22.50	140.90	163.40
Karratha	Pilbara	149.80	8.58	–0.63	0.80	26.33	139.90	166.23
Dampier	Pilbara	150.07	8.57	–0.70	0.73	26.00	139.90	165.90
Norseman	Goldfield	154.11	8.21	–0.88	0.43	28.60	141.85	170.45
Broome	Kimberley	154.64	10.92	–1.17	0.61	30.25	143.61	173.87
Meekatharra	Mid-West	154.75	5.71	–0.31	1.03	17.33	149.57	166.90
Exmouth	Gascoyne	158.67	6.78	–0.48	0.60	25.00	148.80	173.80
Fitzroy	Kimberley	161.44	3.96	–1.17	0.17	12.00	156.23	168.23
Derby	Kimberley	167.44	7.57	–0.98	0.65	23.00	157.70	180.70
Kununurra	Kimberley	168.44	7.57	–0.98	0.65	23.00	158.70	181.70

The number of observations: 608

almost smooth. Apart from the weekly petrol price cycle in the Perth metropolitan area, the cyclical pattern has been observed only for three cities including:

- Murray and Mandurah cities in the Peel region
- Geraldton city in the Mid-West region.

As demonstrated in Figure 4, these cities are located in regions which have the lowest distance from Perth. Characteristics of cycles will be examined in the next section.

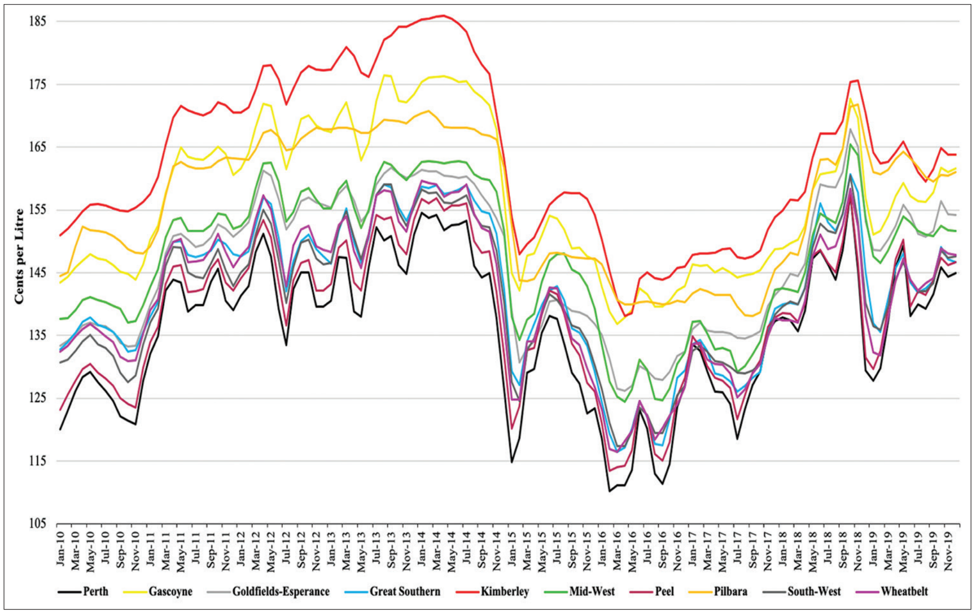
6.2. Identifying Characteristics of Petrol Price Cycles in Cities with Cyclical Pattern

In this part, the characteristics of petrol price cycles will be examined using the Markov regime-switching model.

6.2.1. Murray and Mandurah in the Peel region

I estimate characteristics of petrol price cycles using equations 1 to 7. The features of petrol price cycles in Murray and Mandurah are presented in Table 3. Both mentioned cities are located in the

Figure 5: Time-series patterns of the average ULP prices in all regions, January 2010-April 2019



Source: Findings of this study based on the petrol price data from "Fuel-Watch" website

Table 3: Characteristics of petrol price cycle in Murray and Mandurah, 1 January 2017-31 August 2018

Cycle characteristics	Murray	Mandurah
Relenting regime (R)		
α^R	20.00 (0.003)	22.77 (0.027)
σ^R	6.03 (0.003)	4.66 (0.001)
Undercutting regime (U)		
α^U	–3.82 (0.005)	–3.76 (0.004)
σ^U	0.50 (0.003)	1.31 (0.002)
Pr (ΔP=0 | U)	0.000 (0.00)	0.00 (0.00)
Focal regime (F)		
Constant	21.98 (0.04)	19.63 (0.84)
TGP	1.00 (0.000)	0.93 (0.007)
σ^F	6.02 (0.001)	7.38 (0.073)
Pr (ΔP=0 | F)	0.36 (0.004)	0.36 (0.005)
Switching probabilities		
λ^{RR} (switching probability from relenting to relenting)	0.00 (0.000)	0.00 (0.000)
λ^{RU} (switching probability from relenting to undercutting)	0.95 (0.0003)	0.99 (0.0005)
λ^{RF} (switching probability from relenting to focal)	0.05 (0.0003)	0.01 (0.0005)
λ^{UR} (switching probability from undercutting to relenting)	0.15 (0.0002)	0.16 (0.0002)
λ^{UU} (switching probability from undercutting to undercutting)	0.83 (0.0001)	0.82 (0.0003)
λ^{UF} (switching probability from undercutting to focal)	0.02 (0.0004)	0.02 (0.0005)
λ^{FR} (switching probability from focal to relenting)	0.02 (0.0002)	0.00 (0.000)
λ^{FU} (switching probability from focal to undercutting)	0.07 (0.0006)	0.11 (0.005)
λ^{FF} (switching probability from focal to focal)	0.91 (0.002)	0.89 (0.005)
Duration of phases		
Duration of relenting phase	1.0000 (0.00)	1.0001 (0.00)
Duration of undercutting phase	5.97 (0.008)	6.05 (0.0047)
Cycle duration	6.97 (0.008)	7.05 (0.004)
Stations	3	12
Observations	1824	7296

Peel region. In our equations, W^i, X^R and X^U include constant term, while X^F consists of both constant term and terminal gate prices. One significant finding of this research is, although cities have both major and independent station, cycles mostly have observed in the major-branded stations. There are two independent stations with cyclical pattern, one Puma station in Murray and one Puma in Mandurah. The remaining stations with cyclical patterns in our sample are branded stations.

All estimated parameters are statistically significant except for the constant term in the focal regime. The average increase in petrol price in the relenting phase is shown by α^R. Given the presented results in Table 3, stations in Murray and Mandurah increase their prices 20 and 22.77 CPL on average in the relenting phase, respectively. Also, the daily average price decrease is illustrated by α^U and its amount is -3.82 CPL for Murray and -3.76 CPL for Mandurah. This implies that stations reduce their petrol prices

3.76 or 3.82 CPL by average every single day in the undercutting phase.

The probability of price stickiness in the undercutting regime is presented by Pr ($\Delta P=0|U$), and its amount is zero (0.000) for stations in Murray and Mandurah. When the probability of price stickiness for the undercutting regime is zero, it reveals that stations change their prices every day and the duration of decreasing prices lasts more than one day during the undercutting phase.

The switching probability from one relenting phase to another relenting phase is presented by λ^{RR}. By estimating this factor, we can understand that the relenting phase lasts more than one day or not. The size of λ^{RR} is zero for stations located in both cities. It shows that the existence of two continuous relenting phases is impossible. Also, λ^{RU} shows the switching probability from the relenting phase to the undercutting phase and the amount of that is 95% for Murray and 99% for Mandurah. The results indicate that the duration of the relenting phase lasts only one day and then

Figure 6: Petrol price pattern in Western Australian cities, 2017-2018

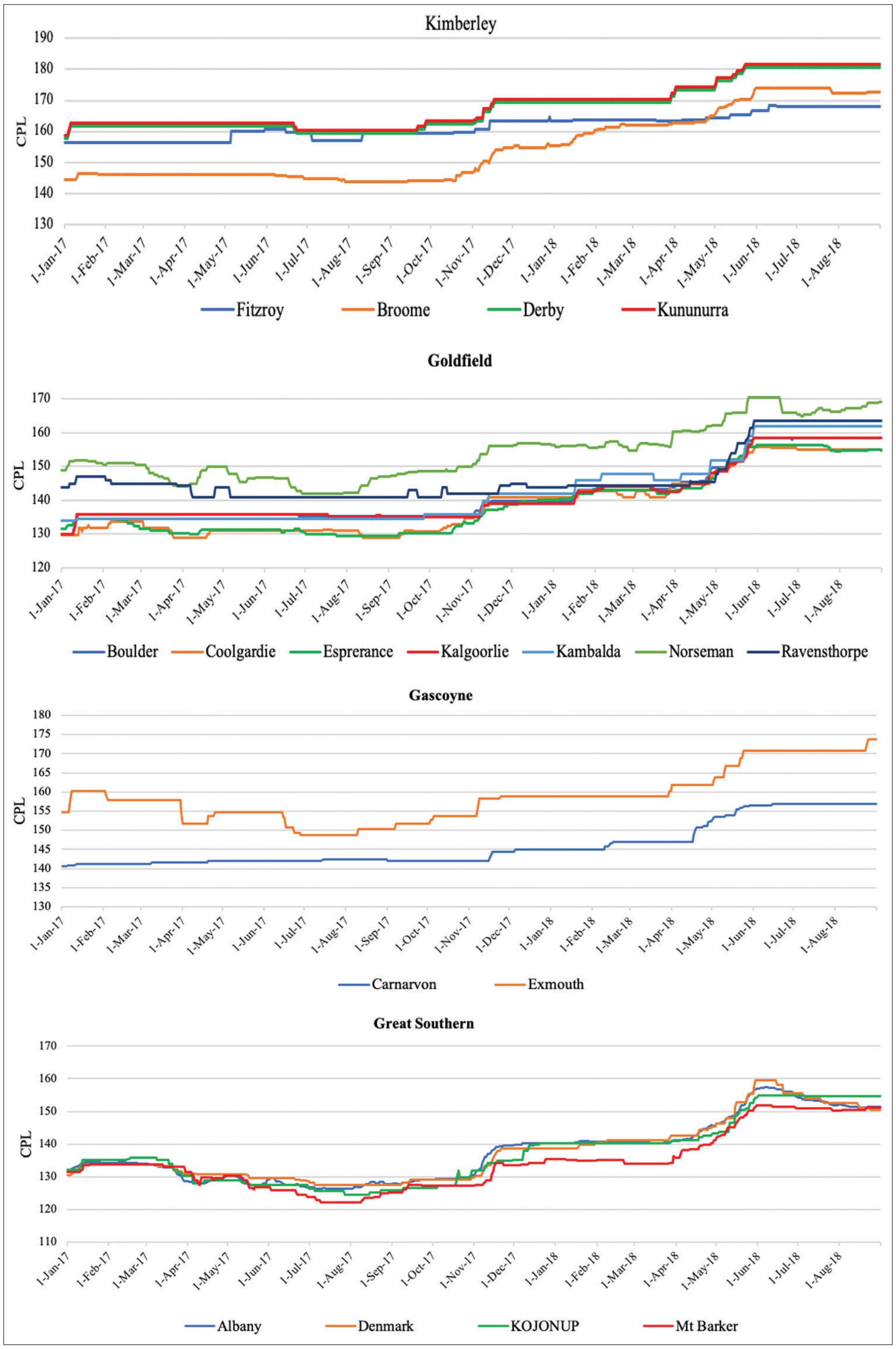
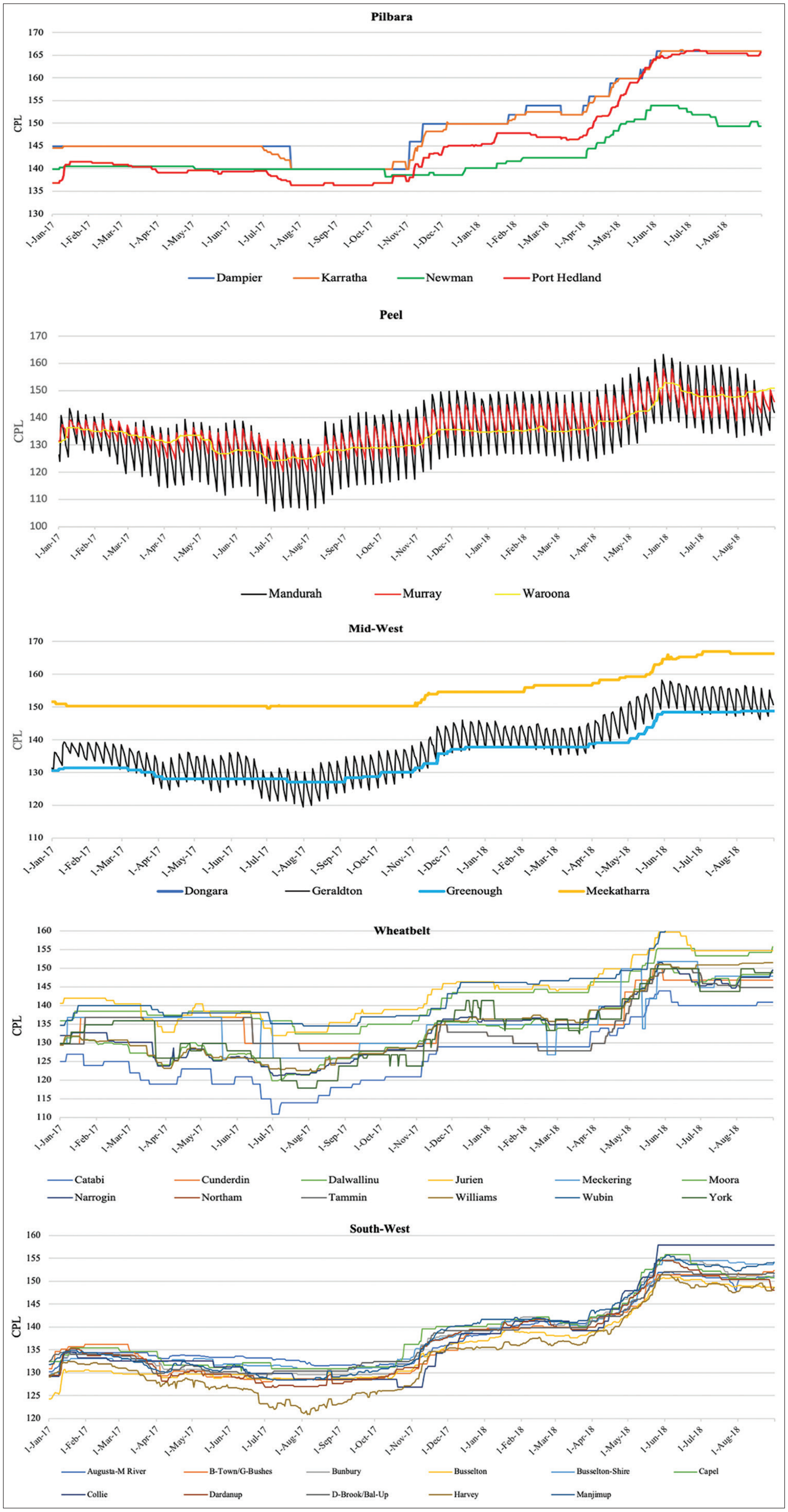


Figure 6: (*Continued*)



stations decrease their prices by the probability of 95% for Murray and 99% for Mandurah for more than one day.

In addition, λ^{UU} shows the probability of switching from one undercutting phase to another undercutting phase and its coefficients are significant for both cities. As shown, by the probability of 83% for Murray and 82% for Mandurah, undercutting phases lasts for more than one day. In contrast, the probabilities for switching from the undercutting to the relenting phase for petrol stations in both cities are insignificant ($\lambda_{Murray}^{UR} = 0.15$ and $\lambda_{Mundurah}^{UR} = 0.16$). These findings again clarify that the duration of the undercutting phase lasts for more than one day in Murray and Mandurah. These results are in line with the prediction of the Edgeworth theory that firms increase their prices very fast in one single period and then decrease their prices for more than one day. Thus, there is an asymmetry in price cycles in the retail petrol markets in Murray and Mandurah.

The probability of price stickiness in the focal regime is presented by Pr ($\Delta P=0|F$). The amount of this variable is 0.36 for both cities. It means that there exists price stickiness for 36 per cent of days during the focal regime and stations didn't change their prices during these days. Moreover, the results show that there is a significant and positive relationship between wholesale petrol prices and retail prices in the focal regime (TGP-coefficient$_{Murray}$=1 and TGP-coefficient$_{Mandurah}$=0.93). As illustrated in the last part of table, the duration of petrol price cycles in Murray and Mandurah lasts seven days (or 1 week) which means that Mandurah and Murray have frequent weekly price cycles. Petrol stations increase their prices sharply in one single day and then decrease their prices for 6 consecutive days.

The economy and geographical condition of the Peel region are specific. This region also has the nearest distance to Perth. Mandurah is the second fast-growing city in Australia and considered as the regional business hub in WA. Hence, this region has a meaningful contribution to the economy of WA and even Australia. Considering the high density of population and business, the demand for petrol is at the highest level in this region after Perth, which leads to a high level of competition in its retail petrol market. Consequently, competition can results in cyclical patterns in the retail petrol markets in these two cities.

6.2.2. Geraldton in the Mid-West region

6.2.2.1. Description of cycle characteristics in Geraldton

In this section, the cycle characteristics of petrol stations in Geraldton are presented in Table 4. Geraldton has ten petrol stations, but only seven stations have cyclical patterns (2 independent stations[6] and 5 branded stations).

As previously mentioned, α^R demonstrates the average price rise per day in the relenting phase. Given the presented results, Geraldton' stations increase their prices 19.87 CPL on average in the relenting phase. The amount of λ^{RR} is zero which means that the probability of two consecutive relenting phases is rare; increasing price only lasts one day. Also, the amount of λ^{RU} is

Table 4: Cycle characteristics of the retail petrol price in Geraldton, 1 January 2017-31 August 2018

Relenting regime (R)	
α^R	19.87 (0.002)
σ^R	4.42 (0.001)
Undercutting regime (U)	
α^U	–3.19 (0.004)
σ^U	1.31 (0.02)
Pr ($\Delta P=0$ | U)	0.000 (0.00)
Focal regime (F)	
Constant	22.09 (0.9)
TGP	0.90 (0.007)
σ^F	5.83 (0.006)
Pr ($\Delta P=0$ | F)	0.46 (0.002)
Switching probabilities	
λ^{RR}	0.00 (0.000)
λ^{RU}	0.99 (0.001)
λ^{RF}	0.01 (0.001)
λ^{UR}	0.12 (0.003)
λ^{UU}	0.79 (0.003)
λ^{UF}	0.09 (0.001)
λ^{FR}	0.00 (0.000)
λ^{FU}	0.38 (0.002)
λ^{FF}	0.62 (0.001)
Durations of phases	
Duration of relenting phase	1.0000 (0.00)
Duration of undercutting phase	5.96 (0.009)
Cycle duration	6.96 (0.002)
Stations	7
Observations	4256

99%. Which means that the relenting phase lasts only one single day. Stations increase their prices in one single day, and then they start to decrease their prices by the probability of 99%.

The average daily price decrease during the undercutting phase is represented by α^U and its amount is –3.19. This implies that stations decrease their prices by 3.19 CPL by average per day during the undercutting phase. Pr ($\Delta P=0|U$) demonstrates the possibility of price stickiness in the undercutting phase which is zero. It means that the probability of price stickiness during the undercutting phase is impossible and stations decrease their prices for 6 consecutive days.

The switching probability from one undercutting phase to another undercutting phase (λ^{UU}) is 79% that is significant. It means that the duration of undercutting phase by the probability of 79% lasts more than one day. Also, there exists a low probability for switching from the undercutting to the relenting phase ($\lambda_{major}^{UR} = 0.14$) which is insignificant. Based on the results, it can be argued that the characteristics of petrol price cycle in Geraldton are similar to the Edgeworth cycle. Petrol prices increase very fast in one day and then decrease slowly in 6 days and again the cycle repeats.

In addition, Pr ($\Delta P=0|F$) explains the probability of price stickiness in the focal regime. Given the result, there is price stickiness for 46% of days during the focal regimes. However, considering the result in the eleventh line, there is a significant positive relationship between the wholesale petrol prices and the retail prices in the focal regime (0.90). Therefore, 90% of fluctuations in the wholesale prices are eventually passed through to the retail petrol prices in

6 - One Puma station and one United station.

the focal phase. The estimated results related to the duration of different cycle regimes are presented in the last part of Table 4. As presented, the duration of relenting phase is 1 day, and the duration of the undercutting phase is 6 days. It implies that there is a weekly cycle in the retail petrol market in Geraldton.

Based on the data classification of the "Fuel-Watch" website, the Mid-west region is divided into four cities; Dongara, Geraldton, Greenough and Meekatharra. But, Geraldton is the only city in the Mid-West region that has a petrol price cycle. I monitored the petrol price information from 2003 until 2018 and the finding show that Geraldton has not any cyclical pattern for a long term until 2016. After the 8th of April 2016, petrol price of a few number of stations started to move in a weekly cycle. Figure 7 shows the changes in the petrol price behaviour before and after that specific mentioned time. In the 8th of April 2018, one "Coles Express" station joined into the retail market in Geraldton with cyclical pattern. It seems that after establishing that specific Coles station, some of stations adjusted their pricing strategies based on that specific-Coles station. By the end of September 2018, there were ten stations in the retail petrol market in Geraldton; seven stations with cyclical pattern and three stations without. Findings show that one Coles station has changed the pricing behaviour in the retail petrol market in Geraldton. It can be argued that in addition to market condition, the role of stations in pricing strategies in the retail petrol market is significant.

6.2.3. Perth metropolitan area

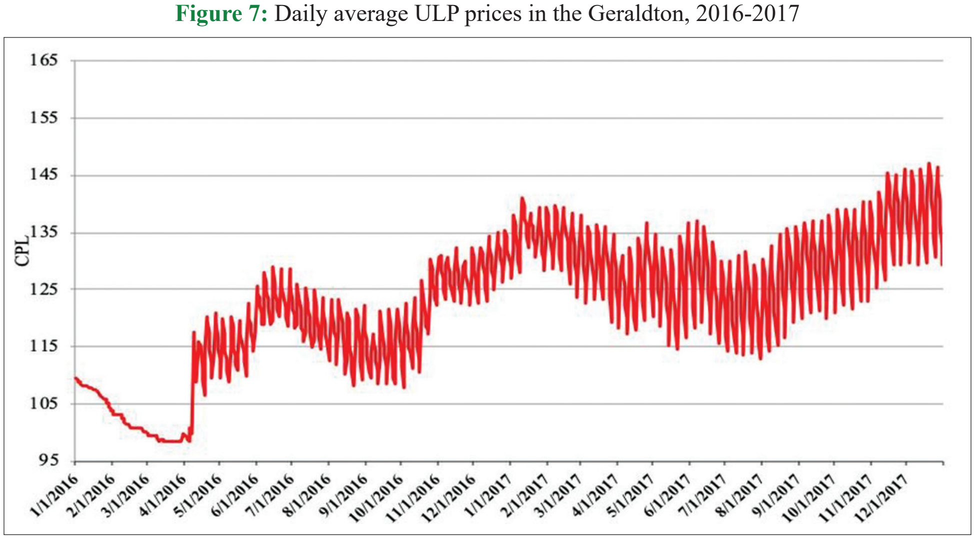
Table 5 contains the cycle characteristics of the retail petrol price in the Perth metropolitan area. I used a sample dataset including petrol price data for 85 stations in Perth from 1 January 2017 to 31 August 2018. As presented by Table 5, the average daily price increase in the relenting phase is 22.43 CPL and the average daily price decrease is 3.54 CPL for stations in Perth. The probability of price stickiness in the undercutting phase is near to zero (Pr (ΔP=0|U) = 0.002) which implies that stations change their prices every day. The probability of price stickiness in the focal regime is 0.71 (Pr (ΔP=0|F=0.71) which means that for 71 percent of days, petrol stations don't change their prices during the focal phase.

The estimated results of the switching probabilities (λ) for the price cycle in the Perth metropolitan area are similar to the Murray, Mandurah and Geraldton. λ^{RR} is zero and λ^{RU} is 0.98 which implies petrol stations by the probability of 98% switch from relenting to the undercutting phase and the duration of relenting phase lasts only one day. Furthermore, the results of cycle durations show that the retail petrol price moves in a regular weekly cycle in Perth, one day price increase and price decreases for 6 consecutive days in an asymmetric pattern.

Table 5: Cycle characteristics of the retail petrol price in Perth, 1 January 2017-31 August 2018

Cycle characteristics	Major stations
Relenting regime (R)	
α^R	21.43 (0.012)
σ^R	4.93 (0.005)
Undercutting regime (U)	
α^U	–3.54 (0.002)
σ^U	1.38 (0.001)
Pr (ΔP=0 | U)	0.002 (0.00)
Focal regime (F)	
Constant	6.58 (0.58)
TGP	1.01 (0.005)
σ^F	8.27 (0.034)
Pr (ΔP=0 | F)	0.71 (0.003)
Switching probabilities	
λ^{RR}	0.000 (0.002)
λ^{RU}	0.98 (0.000)
λ^{RF}	0.02 (0.004)
λ^{UR}	0.16 (0.000)
λ^{UU}	0.81 (0.000)
λ^{UF}	0.03 (0.001)
λ^{FR}	0.04 (0.000)
λ^{FU}	0.07 (0.03)
λ^{FF}	0.89 (0.006)
Durations of phases	
Duration of relenting phase	1.0000 (0.00)
Duration of undercutting phase	6.02 (0.003)
Cycle duration	7.02 (0.002)
Stations	85
Observations	50305

Figure 7: Daily average ULP prices in the Geraldton, 2016-2017



Source: Based on the information from the "Fuel-Watch" website

Table 6: Cycle characteristics for cities with cyclical patterns, 1 January 2017-31 August 2018

Cycle characteristics	Murray	Mandurah	Geraldton	Perth
Average price increase in relenting phase (CPL)	20.00	22.77	19.87	21.43
Average price decrease in undercutting phase (CPL)	3.82	3.76	3.19	3.54
Duration of Relenting Phase (day)	1	1	1	1
Duration of Undercutting Phase (day)	6	6	6	6
Cycle duration=duration (R) + duration (U)	Weekly	Weekly	Weekly	Weekly
Cheapest day	Monday	Monday	Monday	Monday
Peak day	Tuesday	Tuesday	Tuesday	Tuesday

6.3. Comparison of Price Cycles in Perth Capital City with Regional Cities

In the previous sections, characteristics of petrol price cycles determined. In this part, I compare the petrol price cycles inner and outer metropolitan area to find that is there any difference in their features or not. The main characteristics of price cycles in cities with cyclical pattern are presented in Table 6.

Petrol prices in Murray, Mandurah and Geraldton move in a regular weekly cycle like Perth. The average daily price decrease in all regional areas are around 3.5 CPL which are much like to Perth. The amount of daily price increase in Geraldton and Murray is less than Perth whereas its amount in Mandurah is higher than Perth. But generally, there is no significant difference in the size of price increases, it ranges from 19.87 to 22.77 CPL. Like Perth, Mondays have the lowest petrol prices and Tuesdays have the highest average petrol prices during the weekly cycles in all three cities. Generally, it can be noted that petrol price cycles in regional areas are very identical to Perth. In all cities, there exist frequent and asymmetric weekly price cycles.

7. CONCLUSION AND POLICY IMPLICATION

This study answers the question of how petrol prices behave in regional areas in Australia. This study contributes to the empirical petrol research by analysing price patterns across all regional cities in WA. A unique city-specific dataset is applied, which included daily wholesale and retail prices of ULP from 1 January 2017 to 31 August 2018. This dataset provides a comprehensive report of price information for all stations across all regional and rural cities in WA. It enables us to isolate the markets in different cities to identify price dispersion. This paper uses the Markov-regime switching model to determine petrol price characteristics. It also conducts analyses to compare pricing behaviour inner and outer the Perth metropolitan area. This study aims to present a new contribution to regional studies for the first time in Australia. Moreover, our findings can assist motorists by providing the necessary information needed for increasing market transparency.

Results of this study clarify that prices of ULP differ across various regions and cities in WA. Even cities located in one specific region possess different petrol prices. Findings show that petrol prices tend to be constant in most areas in WA. There are not excessive fluctuations in petrol prices, and price patterns are almost smooth in cities. Apart from the petrol price cycle in Perth, cyclical patterns have been observed only in Murray and Mandurah in Peel and Geraldton in Mid-West. Comparative analysis reveals that asymmetric and frequent weekly cycles in three mentioned cities are similar to the price cycle in Perth. It can be argued that there exist no specific differences in price cycles inner and outer metropolitan area. But, prices for petrol in the remaining cities were mostly stable and higher than in Perth. The interesting result is that cities located in regions with the highest distance from Perth, had the highest petrol prices, such as Broome, Norseman, Exmouth, Fitzroy and Derby. Given the results, it can be claimed that people in these specific areas have to pay more for purchasing petrol, and their living standards will be affected by high petrol prices.

Findings have some noticeable policy implications for authorities and regulators in WA and even in Australia. In contrast with previous studies which didn't consider regional petrol markets, this study shows a mismatch between pricing patterns across regional cities in WA. There exist three cities with frequent weekly price cycles, while the rest of cities have no specific price pattern. The findings, from a policy perspective, are very vital because it shows that regulators cannot apply one pricing legislation in a targeted way across all cities in Western Australia. Therefore, they must conduct different regulations by considering the condition of each region. The 24-h price legislation was successful in facilitating a more regular cycle and eradicating intra-day price fluctuations in Perth and three mentioned cities. But this legislation has not specific effect on regional petrol prices, especially regions with the highest petrol prices, like Kimberley, Gascoyne and Pilbara. It can be argued that there exist anti-competitive behaviours or monopoly powers in these cities which push prices upward. Thus, these cities should come under closer price scrutiny by the regional authorities to prevent price gouging in their retail petrol markets. Moreover, the approach of this study can be replicated in other Australian states.

REFERENCES

Alderighi, M., Baudino, M. (2015), The pricing behaviour of Italian gas stations: Some evidence from the Cuneo retail fuel market. Energy Economics, 50, 33-46.

Atkinson, B. (2009), Retail gasoline price cycles: Evidence from Guelph, Ontario using bi-hourly, station-specific retail price data. The Energy Journal, 30(1), 85-109.

Australian Bureau of Statistics. (2018), Census Data by Geography. Available from: https://www.search.abs.gov.au/s/search.html?query=the+largest+state+in+australia.+&collection=abs&form=simple&profile=_default.

Australian Competition and Consumer Commission. (2018), Fuel in Regional Australia. Available from: https://www.accc.gov.au/consumers/petrol-diesel-lpg/fuel-in-regional-australia.

Australian Competition and Consumer Commission. (2019), Report on the Australian Petroleum Market, March Quarter 2019. Australia: ACT.
Blair, B.F., Campbell, R.C., Mixon, P.A. (2017), Price pass-through in US gasoline markets. Energy Economics, 65, 42-49.
Bloch, H., Wills-Johnson, N. (2010a), Gasoline Price Cycle Drivers: An Australian Case Study.
Bloch, H., Wills-Johnson, N. (2010b), The Shape and Frequency of Edgeworth Price Cycles in an Australian Retail Gasoline Market.
Byrne, D.P. (2019), Gasoline pricing in the country and the city. Review of Industrial Organization, 55, 209-235.
Byrne, D.P., de Roos, N. (2017), Consumer search in retail gasoline markets. The Journal of Industrial Economics, 65, 183-193.
Byrne, D.P., de Roos, N. (2019), Learning to coordinate: A study in retail gasoline. American Economic Review, 109, 591-619.
Chesnes, M. (2016), Asymmetric pass-through in US gasoline prices. The Energy Journal, 37, 153-180.
de Roos, N., Katayama, H. (2013), Gasoline price cycles under discrete time pricing. Economic Record, 89, 175-193.
Deltas, G. (2008), Retail gasoline price dynamics and local market power. The Journal of Industrial Economics, 56, 613-628.
Department of Primary Industries and Regional Development. (2017-2018), Available from: http://www.drd.wa.gov.au/pages/home.aspx.
Dodson, J., Sipe, N. (2008), Shocking the suburbs: Urban location, homeownership and oil vulnerability in the Australian city. Housing Studies, 23, 377-401.
Doyle, J., Muehlegger, E., Samphantharak, K. (2010), Edgeworth cycles revisited. Energy Economics, 32, 651-660.
Eckert, A. (2013), Empirical studies of gasoline retailing: A guide to the literature. Journal of Economic Surveys, 27, 140-166.
Eckert, A., West, D.S. (2004), Retail gasoline price cycles across spatially dispersed gasoline stations. The Journal of Law and Economics, 47, 245-273.
Hamilton, J.D. (2005), Regime Switching Models. Macro-Econometrics and time Series Analysis. London: Palgrave Macmillan. p202-209.
He, W., Sun, Y. (2017), Stationary Markov perfect equilibria in discounted stochastic games. Journal of Economic Theory, 169, 35-61.
Kpodar, K., Abdallah, C. (2017), Dynamic fuel price pass-through: Evidence from a new global retail fuel price database. Energy Economics, 66, 303-312.
Lewis, M.S. (2008), Price dispersion and competition with differentiated sellers. The Journal of Industrial Economics, 56, 654-678.
Lewis, M.S. (2012), Price leadership and coordination in retail gasoline markets with price cycles. International Journal of Industrial Organization, 30, 342-351.
Maskin, E., Tirole, J. (1988), A theory of dynamic oligopoly, II: Price competition, kinked demand curves, and Edgeworth cycles. Journal of the Econometric Society, 56(3), 571-599.
Meyler, A. (2009), The pass through of oil prices into euro area consumer liquid fuel prices in an environment of high and volatile oil prices. Energy Economics, 31, 867-881.
Noel, M.D. (2007a), Edgeworth price cycles, cost-based pricing, and sticky pricing in retail gasoline markets. The Review of Economics and Statistics, 89, 324-334.
Noel, M.D. (2007b), Edgeworth price cycles: Evidence from the Toronto retail gasoline market. The Journal of Industrial Economics, 55, 69-92.
Noel, M.D., Chu, L. (2015), Forecasting gasoline prices in the presence of Edgeworth price cycles. Energy Economics, 51, 204-214.
Reilly, B., Witt, R. (1998), Petrol price asymmetries revisited. Energy Economics, 20, 297-308.
Siekmann, M. (2017), Characteristics, Causes, and Price Effects: Empirical Evidence of Intraday Edgeworth Cycles, DICE Discussion Paper. Available from: http://www.hdl.handle.net/10419/161673.
Valadkhani, A. (2013), Seasonal patterns in daily prices of unleaded petrol across Australia. Energy Policy, 56, 720-731.
Valadkhani, A., Chen, G., Anderson, J. (2014), A cluster analysis of petrol profit margins across various regional and urban locations in Australia. Australasian Journal of Regional Studies, 20(1), 159.
Valadkhani, A., Smyth, R. (2018), Asymmetric responses in the timing, and magnitude, of changes in Australian monthly petrol prices to daily oil price changes. Energy Economics, 69, 89-100.
Wang, Z. (2009), (Mixed) strategy in oligopoly pricing: Evidence from gasoline price cycles before and under a timing regulation. Journal of Political Economy, 117, 987-1030.
Ye, M., Zyren, J., Shore, J., Burdette, M. (2005), Regional comparisons, spatial aggregation, and asymmetry of price pass-through in US gasoline markets. Atlantic Economic Journal, 33(2), 179-192.
Zimmerman, P.R., Yun, J.M., Taylor, C.T. (2013), Edgeworth price cycles in gasoline: Evidence from the United States. Review of Industrial Organization, 42, 297-321.