Third Biannual Update – August 2020

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A Mid-term Assessment of the Queensland Fuel Price Reporting Trial

For the Department of Natural Resources, Mines and Energy

Know more. Do more.

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Contents

Executive Summary

- This mid-term review studies the impact of the Queensland Fuel Price Reporting Trial (QFPRT) on state-wide retail fuel prices since its initial roll-out (3 December 2018) and its full compliance from 15 April 2019. It specifically considers whether the trial has either put upwards or downwards pressure on average fuel prices in Queensland.

- This report examines the impact of the QFPRT on retail fuel prices by considering trends in the average retail fuel prices using both ARDL modelling, and new to this report, panel (longitudinal) modelling. It also investigates the spread of fuel prices, to highlight opportunities for savings to be made at the bowser. Finally, it highlights the role both price surges and price leadership play in setting retail fuel prices and the opportunities to save at the bowser.

- Empirical results (using time-series based ARDL modelling) show that the trial generated a small but statistically significant decline in the average daily retail prices of regular unleaded (ULP91), premium unleaded (PULP) and ethanol (E10) petrol fuels in most regions across Southeast Queensland. Additionally, enough data points were available to undertake a panel (longitudinal) study on the impact of the trial on monthly average fuel retail prices. Results for both petrol prices (all types across both models) and diesel prices (panel model only) indicate that the trial reduced average fuel retail prices.

- Retail fuel price cycles are a well-documented phenomenon in the Southeast Queensland retail fuel market. The commencement of price reporting compliance midway through April 2019 allowed for a detailed analysis of these cycles as well as price surges. 13 price surges have been identified, initiated by three companies, each owning numerous petrol stations across Southeast Queensland. Price surges are triggered by the leader increasing price at 3-4 strategic locations, and this geographically spreads out price signals to neighbouring stations, who react quickly.

- This report finds evidence of a statistically significant increase in the spread of prices (price dispersion) in a majority of investigated LGAs. A rise in the spread of prices increases the potential savings for motorists actively seeking lower prices. Examining differences between minimum and average (July 2019 to June 2020) ULP91 fortnightly prices, this report finds that in Brisbane, motorists filling up at the minimum (relative to mean) price can save up to $147.17 per annum. A lack of competition,

plus higher cost structures for retail fuel stations reduces, but does not eliminate this opportunity outside of Southeast Queensland. For example, motorists in Rockhampton could save up to $36.47 per annum, while in Cairns motorists could save up to $35.18 per annum.

- Relative to the pre-trial average daily price of petrol variants, regular unleaded users in Brisbane can, on average, save $6.18 per annum per passenger vehicle, and for Southeast Queensland the estimate is $5.51. For PULP, the annualised savings per passenger vehicle is estimated to be $6.97 in Brisbane and $6.18 in Southeast Queensland whereas for E10 the savings are $6.40 in Brisbane and $5.95 in Southeast Queensland. Aggregated, this provides for a total estimated gain in consumer surplus of $7,656,841.81 per annum in Brisbane and $9,844,506.96 per annum in Southeast Queensland.
- These empirical findings should be treated cautiously as the longer-term impact of COVID-19 is currently unknown. A clearer picture of the long run effect should emerge in the next 6 to 12 months when more data become available.

1. Introduction

The QFPRT commenced on 3 December 2018, with full legal and enforceable compliance commencing 15 April 2019 (DNRME, 2018). It requires retail fuel stations to publish their fuel price changes within 30 minutes. An aggregation system collates this information, which is then made accessible to motorists via established third party fuel apps such as Motormouth, RACQ Fair Fuel, and Petrol Spy that already had a significant customer base.

This third biannual update provides a detailed empirical assessment of the impact of the trial on average daily retail fuel prices across Queensland over an eighteen-month period (December 2018 to June 2020). The impact of the QFPRT is assessed empirically by comparing pre-trial fuel prices with prices published during the current trial period-, using both time-series (ARDL) and panel models, as well as by utilising other quantitative and qualitative methods to study opportunities for motorists to save at the bowser. This assessment considers several other factors that also impact upon retail fuel prices, such as international oil prices, exchange rates and changes in excise tax. Specific also to this report is an initial look at the imported and local impacts of COVID-19 on fuel prices in Queensland.[1]

For the trial to generate declines in average retail fuel prices, a number of conditions need to be fulfilled. First, fuel prices would have to be disseminated to the public in a timely and accurate manner, a finding confirmed by other data sources. Second, a substantial proportion of consumers would need to utilise this information to identify which fuel stations offered the cheapest fuel in the region. Results from the RACQ app survey (2019c) suggests that this is indeed the case for a significant number of motorists in urban centres, though a not dissimilar number would still tend towards their usual retailer, even if they knew that the price differential did not favour them. Third, a sufficient level of competition would need to exist amongst retail petrol stations to make it possible for motorists to identify cheaper petrol prices amongst local competitors. Finally, there is the potential that all of the above could be significantly impacted by unanticipated exogenous events, such as the COVID-19 epidemic that led to lockdowns, which heavily impacted on fuel prices globally and sharply decreased the demand for fuel domestically (ACCC, 2020a; RACQ, 2020).

[1] The 'imported impact' refers to the impact on Brent crude oil prices, which influence the domestic price at the bowser, whereas the 'local impact' refers to a further round of COVID-19 impacts caused by various factors such as the decreased demand for fuel due to the lockdown, among others.

2. Update on the Queensland Fuel Market

The earlier two reports (Griffith University, 2019, 2020) provided an overview of the key factors influencing retail fuel prices in Queensland. In the following we provide a brief update on new relevant information and trends that have since emerged:

- **Retail competition levels:** There has been an increase in the number of participating fuel stations. As of June 2020, there are approximately 1,596 retail fuel sites and are reporting prices according to the trial data. Of these, approximately half are in metropolitan locations, with 500 in regional areas and a further 200 in remote localities. It is notable that in the Brisbane area, the ACCC (2019) reported a 12% rise in retail sites between 1 January 2017 and 30 September 2019, which they note has likely increased competition and lowered prices. Given the overlap with the current trial, they also note the potential impact of the trial (on top of likely greater competition due to the rise in retail sites) to the lowering of fuel prices in Brisbane. This meshes in well with the rise in users of fuel price apps (RACQ, 2019c), which could have raised greater awareness of the competitive pricing strategies of independent fuel retailers.

- **International oil prices:** The relative stability of international oil prices witnessed during the second half of 2019 ended during the second quarter of 2020 due to significant shifts in both demand and supply factors (more specifically falling demand and rising supply), and took a particularly sharp downward turn around the months of March and April, before recovering some ground from mid-May onwards (see Figure 1). Brent crude oil prices were gently falling from US$67.05 on 2 January to US$51.29 on 5 March, at which point sharp falls and increased volatility became a feature of the data. Prices reached an initial low of US$14.85 on 31 March though Brent crude oil largely traded around the US$20s mark in March and April despite recording another substantial low of US$9.12 on 21 April, emphasising the volatility experienced in these two months. A more stable recovery then followed with prices moving steadily upwards from the mid-US$30 mark in mid-May to the low-US$40 mark by the end of the second quarter. According to the ACCC (2020a) and The World Bank (2020), the initial steady fall in crude oil prices in January was partially attributable to the impact COVID-19 was having on Chinese economic activity. This exacerbated on 30 January 2020, when the World Health Organisation declared the virus a 'Public Health Emergency of International Concern'. This led to many countries initiating travel restrictions and bans, on top of lockdown measures that curtailed economic activity, which significantly depressed the demand for oil. This fall in prices due to the decrease in demand was amplified by the fact that OPEC and Russia failed to reach an agreement in early March on crude oil production cuts, thus widening the global supply surplus.

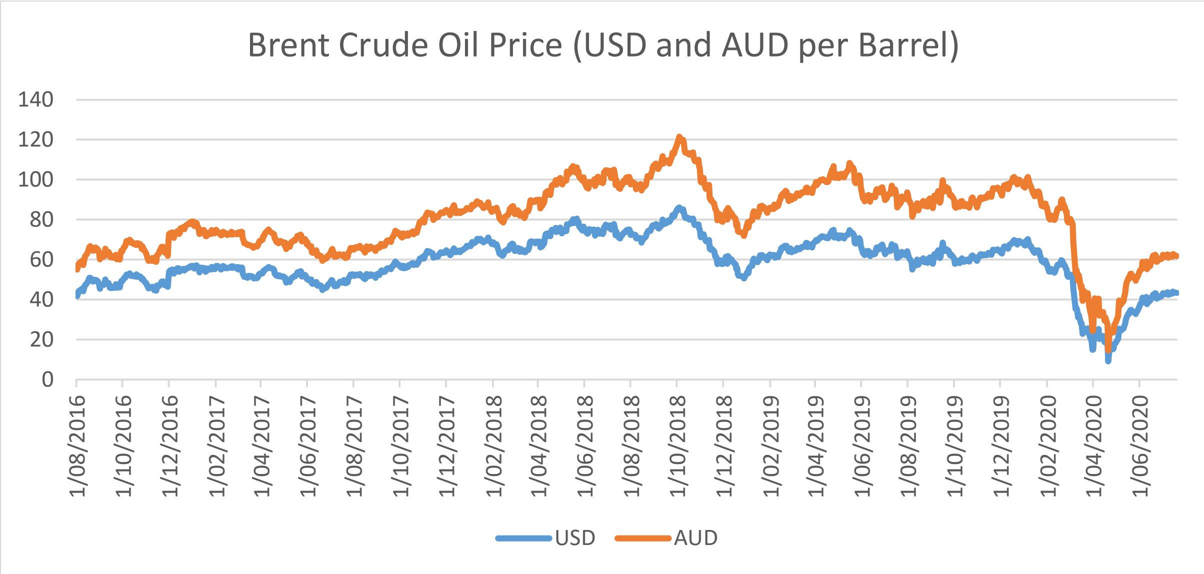

Figure 1: Brent crude oil prices in both USD and AUD from 1 August 2016 to 20 July 2020. AUD figures imputed from the daily USD-AUD exchange rate (source for both Brent crude oil process and the USD-AUD exchange rates: Macrotrends.net).

- **Refined Fuel Costs and Refinery Cost Margins.** As noted in the previous report (Griffith University, 2020), these account for a large share of retail fuel prices.[2] Figure 2 highlights how wholesale fuel prices (TGPs) move consistently with international refined fuel prices in the Asia-Pacific region, albeit with a short time lag. It also shows how regulatory charges such as excise tax make up a substantial portion of wholesale prices, and that refiner mark-ups appear to be relatively small. Refinery cost margins have remained relatively stable for a sustained period, and it was only around the period that international oil prices began to tumble sharply that we witnessed a sharp decline in margins (see Figure 3). However, an upward trajectory in margins, consistent with rising international oil prices has been evident since then, albeit still below the average. However, we are unable to state with any certainty if this initial impact is transitory or permanent and data from future points are required before a more definitive statement can be made.

[2] These vary over time. They are partially accounted for by fluctuations in both international prices and exchange rates (which as previously noted have both been relatively stable in recent months) but have been estimated to average around 57% (AIP, 2018) of the final retail price.

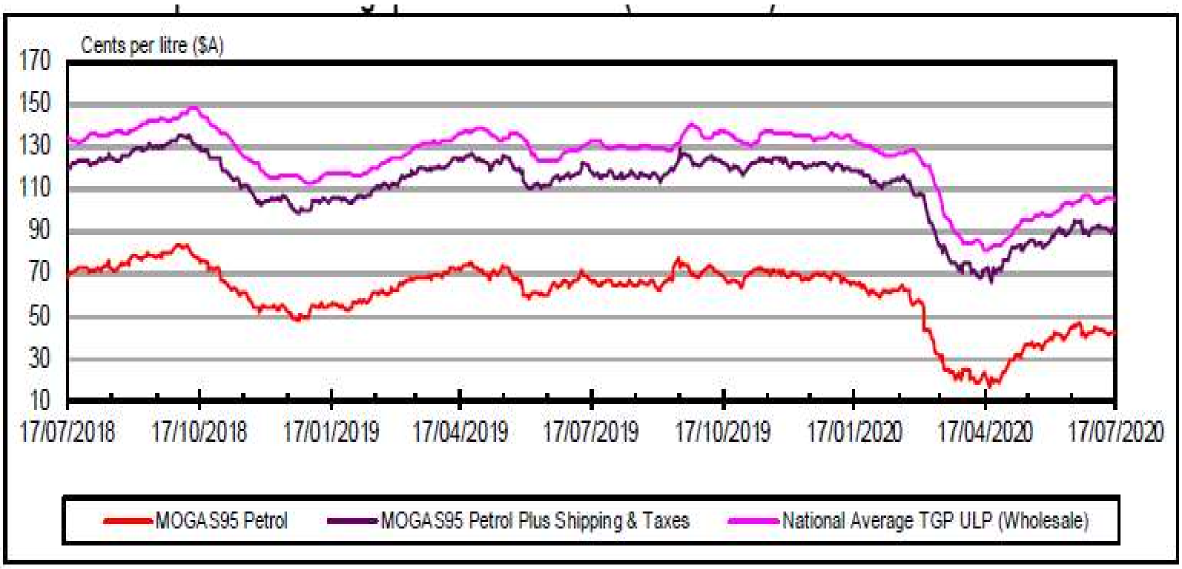

Figure 2: Comparison of Singapore Fuel Prices (MOPS95 Fuel) with Australian fuel TGP (source: AIP, 2020, 2020a).

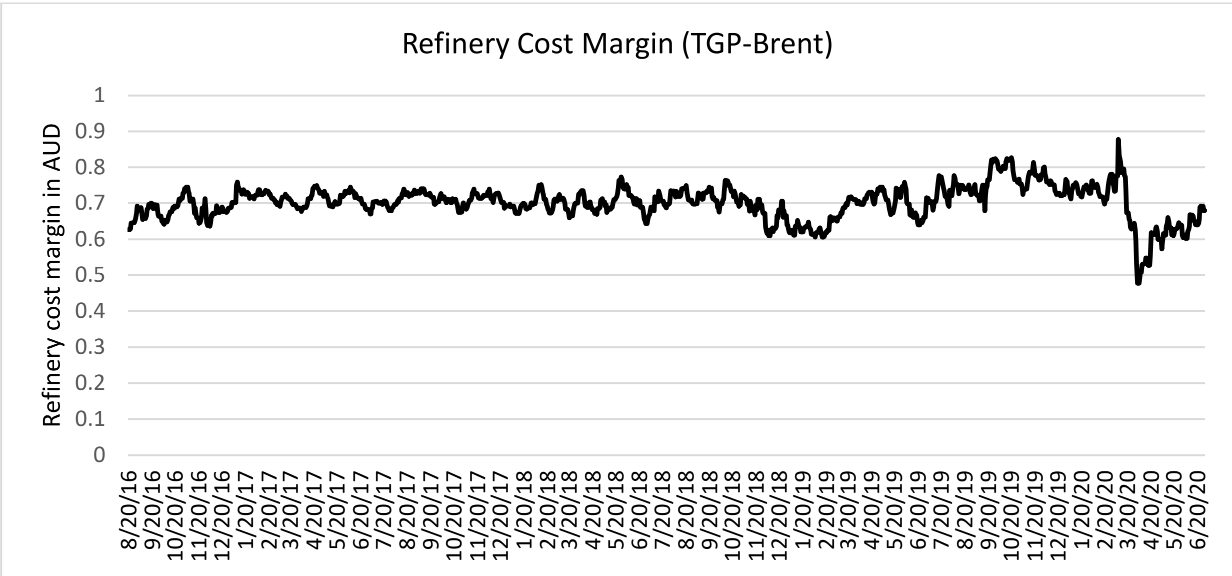

Figure 3: Refinery cost margins, August 2016 – June 2020.

- **Retail Gross Margins**[3] can vary substantially both across price cycles and between retailers, with market leaders being more likely to charge higher peak prices at the bowser relative to retail discounters (ACCC, 2019; RACQ, 2019a, 2019b). This is suggestive of a wide variation in margins across retailers (ACCC 2020a), and incidentally is also the case with variation in actual retail profits between retail stores as well (ACCC, 2020).[4] Figure 4 below features a rough approximation of retail gross margins in Brisbane by comparing the difference between ULP91 retail prices and the reported TGP. There is evidence of greater price spreads

[3] This is basically the difference between the retail fuel price and the published TGP price.
[4] This report does not investigate retail profits.

since the introduction of price reporting compliance, leading to greater scope for consumer savings should the near live app information be utilised by motorists.

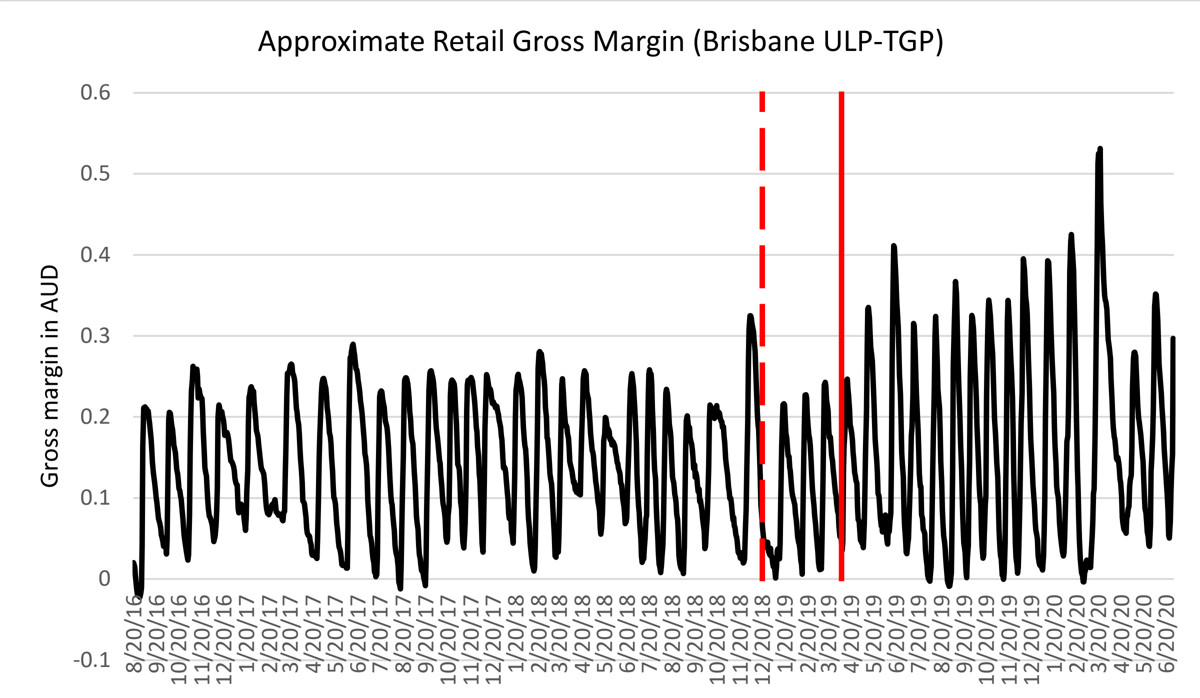

Figure 4: Approximate retail gross margins for ULP91 in Brisbane. The red dashed vertical line represents the period just after the trial commencement date and the solid red vertical line represents the period roughly coinciding with the compliance date.

- **Evidence on consumer use of retail apps.** As noted in our previous report, the RACQ (2019c) survey on fuel price app usage found a marked increase (*circa* 250%) in the utilisation of such apps and websites between 2017 and 2019. This overlaps with the implementation of the scheme, with reported perceived accuracy jumping from 73.5% in 2017 to 93.5% in 2019. Using data provided by the DNRME, we witness, in Brisbane a coinciding increase in users and sessions with some of the identified price surges (discussed in greater detail in Section 3). It is important to note that this does not occur with every price hike, indicating that the presence of other factors also influence the increase in retail app usage, which entails further investigation beyond the scope of this report. Furthermore, we observed increased usage across all six LGAs with app usage data (Brisbane, Gold Coast, Sunshine Coast, Cairns, Toowoomba and Townsville) during the Covid-19 lockdown in March and April 2020 (see Appendix A for visual representations). This might have been due to increased news coverage of low fuel prices or that motorists had more time to search for cheap fuel during this period.

3. Data and Methodology

3.1 The Dataset

To study retail fuel price trends before and after the introduction of the QFPRT, three different data sources have been integrated:

- Baseline legacy data supplied by Informed Sources that reported fuel prices across all major grades of fuel from December 2017 to December 2018. This consisted of 398,531 observations across 857 fuel stations.
- Baseline data sourced from point of sale data provider, Oil Pricing Information Service (OPIS). These data also reported fuel prices across all major grades of fuel from December 2016 to end of March 2019 and consisted of 3,470,641 observations across 1,544 fuel stations.
- API Data from the Queensland Fuel Price Reporting Trial (www.fuelpricesqld.com.au) that covers the period of December 2018 to the end June 2020. This covers 1,596 stations; this number increased over the period of the trial.

In terms of the regional distribution of fuel stations, these remain highly concentrated in the Southeast Queensland regions as approximately half of all fuel stations in Queensland are in this region. 24.75% of retail stations are in the Brisbane and Gold Coast LGAs, while LGAs close to Brisbane, such as Ipswich, Logan, Moreton Bay, Redland and the Sunshine Coast account for a further 22.68% of retail stations. 32 of the 70 LGAs (45.71%) have (individually) only between 1 and 8 retail stations.[5]

3.2 Basic Trends: Price Cycles, Price Surges and Price Leaders

This sub-section highlights a series of trends that can be observed at the most disaggregated fuel station level. Figure 5 provides a typical overview of fuel station level fuel price trends observable in Southeast Queensland between the second half of 2016 and mid-2020.[6]

[5] There are 77 LGAs in Queensland, but fuel data is only available for 57 LGAs. The LGAs with missing data are Aurukun Shire, Barcoo Shire, Boulia Shire, Burke Shire, Cherbourg Aboriginal Shire, Croydon Shire, Doomadgee Aboriginal Shire, Hope Vale Aboriginal Shire, Kowanyama Aboriginal Shire, Lockhart River Aboriginal Shire, Mapoon Aboriginal Shire, Mornington Shire, Pormpuraaw Aboriginal Shire, Richmond Shire, Torres Strait Island Regional, Weipa Town, Woorabinda Aboriginal Shire, Wuial Aboriginal Shire and Yarrabah Aboriginal Shire.

[6] Appendix B reports more aggregated LGA level price trends for several LGAs.

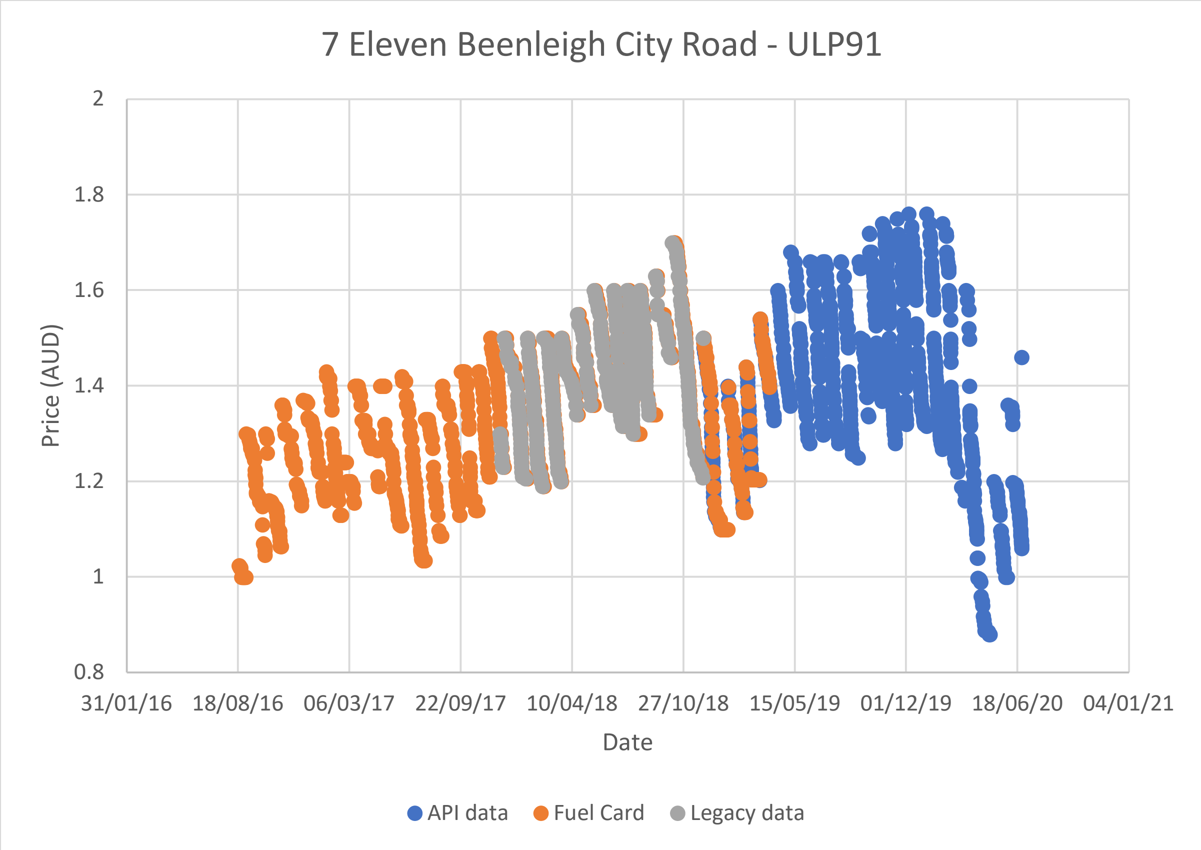

Figure 5: Average daily ULP 91 fuel price (cents per litre) points over time for one fuel station in Southeast Queensland.

Figure 5 provides a snapshot of how retail petrol prices exhibit price cycles: sudden, sharp increases in the price of petrol, followed by a gradual decline. These are a prominent, and longstanding, feature of retail petrol prices in urban areas across the country (ACCC, 2018). These cycles occur due to competitive pressures, which is why they are often observed in urban areas where retail competition is more pronounced. These competitive pressures encompass the need to capture market share whilst at the same time maintain retail margins. In fact, a known feature of these cycles is periods of negative retail margins, suggesting that the trade-off between market share and retail margins are a live feature of these cycles.

A visual inspection of this figure indicates a small rise in the difference between the peak and trough of price cycles since December 2018. This is also found in figures 6 and 6a (selected Brisbane fuel stations).[7] The fuel stations in these figures were selected to compare price cycles across independent retailers and larger brands. However, it is not clear to what extent these changes are

[7] See Appendix C for LGA level results.

statistically significant. As such, the trends in price dispersion are empirically examined and discussed in Section 4.

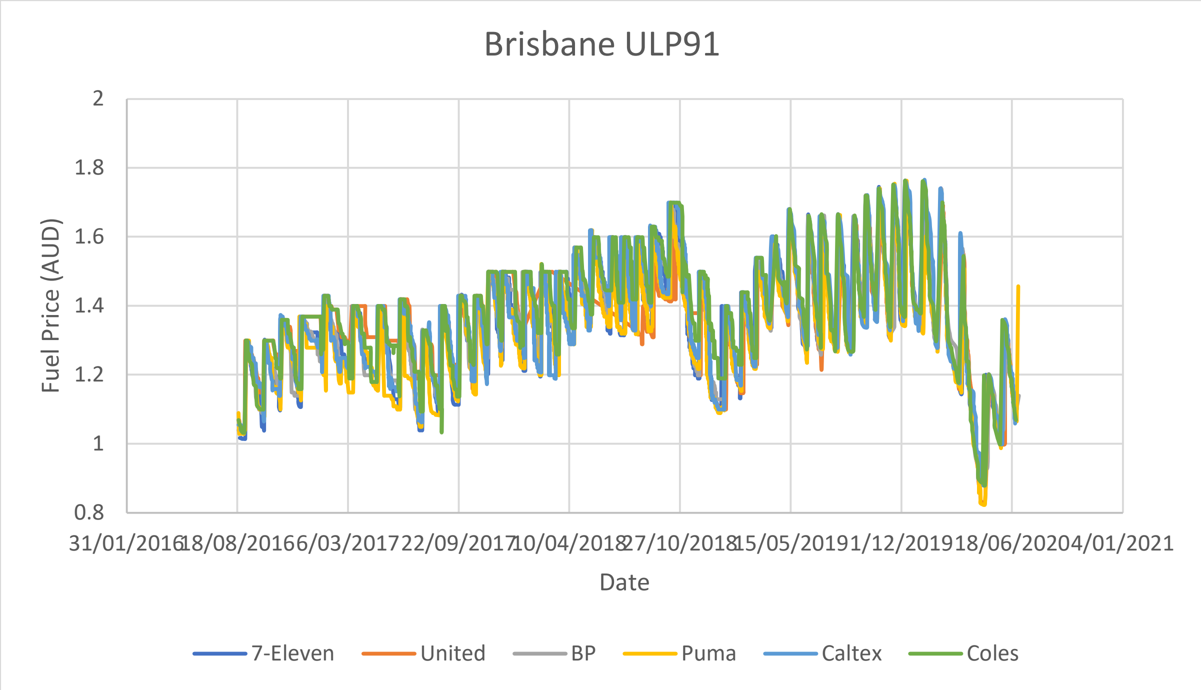

Figure 6: Average daily fuel price (cents per litre) over time (i.e. price cycles) for selected fuel stations per selected brand in Brisbane, August 2016 – June 2020.

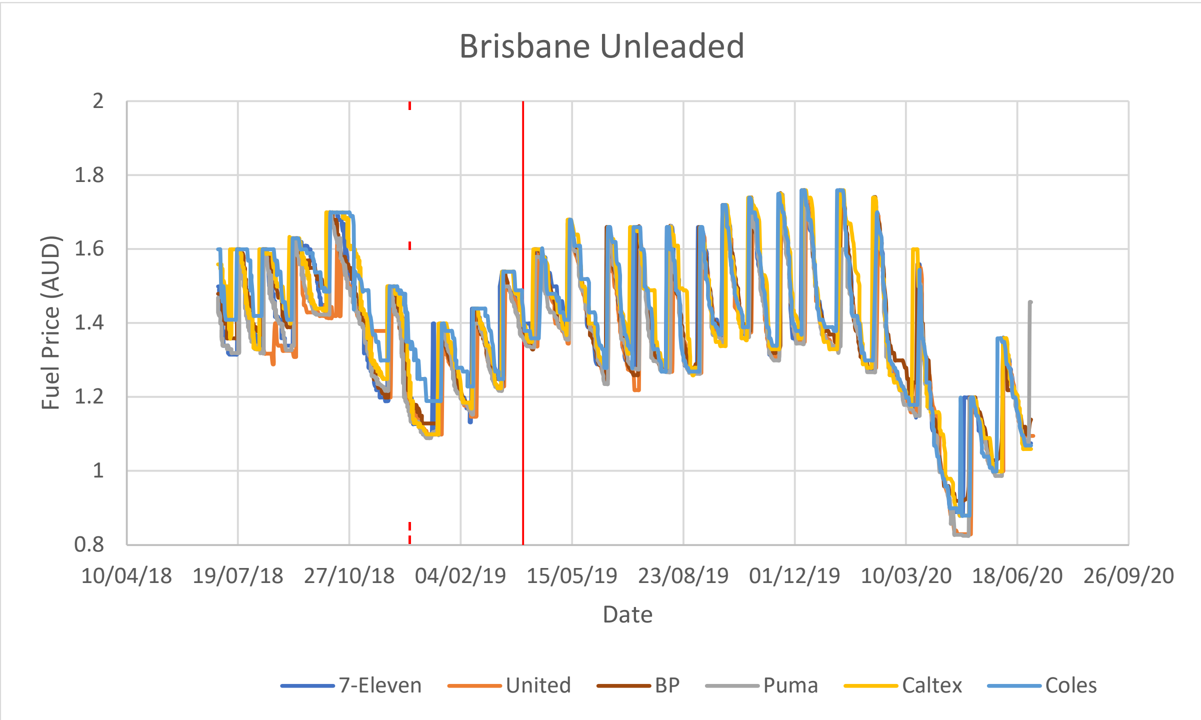

Figure 6a: Average daily fuel price (cents per litre) over time (i.e. price cycles) for selected fuel stations per selected brand in Brisbane for a more concentrated timeframe: August 2018 - June 2020. The red dashed vertical line represents the period just after the trial commencement date and the solid red vertical line represents the period roughly coinciding with the compliance date.

The RACQ (2019a, 2019b) observed changes in the Brisbane fuel price cycle post compliance. In 2019 for example, retailers appeared to maintain cheaper prices for longer periods, with more gradual rises in prices. When prices did rise, the rise also appeared to be more gradual. The number of days when cheaper fuel was available in the ULP91 market also rose, potentially due to smaller and/or independent retailers not imitating the higher prices set by major retailers (RACQ, 2019c), thus indicating a rise in competitive pressures, not otherwise observed in less urban centres.

Our own analysis (see Figure 7) suggests that the average daily price for unleaded fuel in Brisbane and surrounding regions, including Gold Coast, Ipswich, Logan, Moreton Bay and Redland (henceforth denoted as Greater Brisbane to differentiate from the broader Southeast Queensland coverage area) exhibit clear cyclical patterns. The cyclical pattern is characterised by a steep spike in price, followed by a gradual price reduction until the baseline price is reached, after which we see the cycle restart. Similar price cycles have been identified in other unleaded fuel markets in Australia and abroad, although the patterns in and around Brisbane have some unique qualities potentially due to differences in legislation and reporting. The focus of this analysis is on price cycles occurring post-compliance.[8]

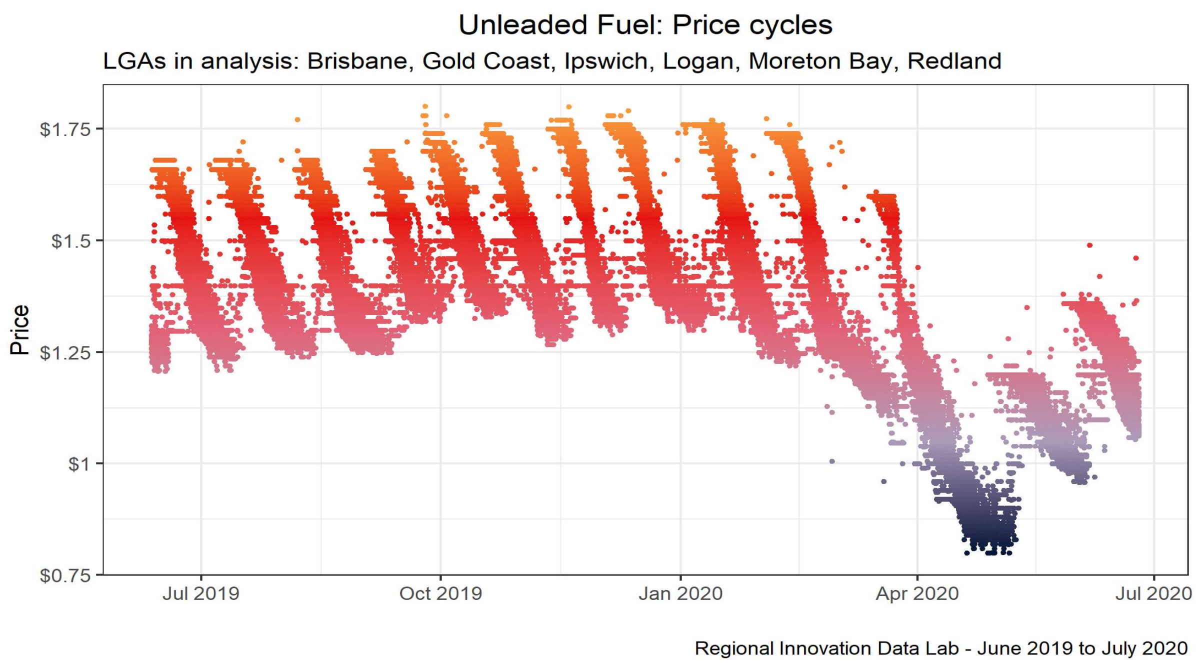

Figure 7: Individual unleaded fuel price points over time (i.e. price cycles) in the Greater Brisbane LGAs: May 2019 - June 2020.

[8] The cyclical pattern in unleaded fuel prices is visible prior to the legislation in our data but as we combine peer reported fuel pricing with non-mandatory price updating till May 2019 it is not possible to identify first movers. For that reason, we start the analysis from May 2019.

The analysis is focussed on the Greater Brisbane LGAs as the pattern dissipates the further one moves away from these LGAS, which does not aid in investigating which stations are driving these prices surges (and subsequent reset) cycles[9] and which and how quickly other stations respond. For example, the cyclical pattern is most pronounced in Brisbane, starts to diminish at the Sunshine Coast, and is no longer evident in Toowoomba. These are highlighted in Figure 8 below.

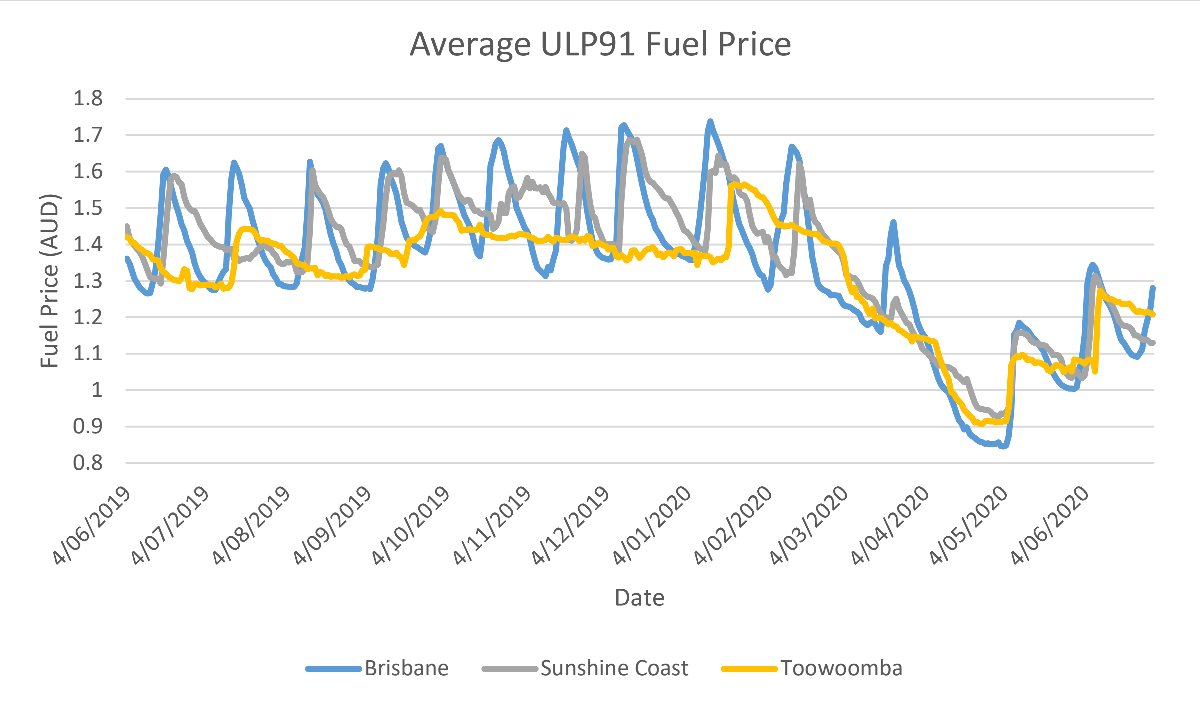

Figure 8: Average daily fuel price (cents per litre) over time (i.e. price cycles) for Brisbane, Sunshine Coast and Toowoomba: May 2019 - June 2020.

To ensure focus is maintained on the stations which are participating in and/or driving the price reset cycles, we classify a fuel station as 'participating' based on whether their price increased by $0.15 or more (this cut-off was determined based on the detailed analysis depicted in Figure 9). Based on this logic and by visualising changes in price, 13 clear price reset cycles were identified. There were 608 unleaded fuel stations in Greater Brisbane and practically all of them (604) participated in the reset cycles.[10] Of these 604, 543 or 90% of stations participated in all 13 of price cycles. [11]

[9] By driving the cycle, we refer to stations that first hike up prices, which then initiate and subsequently perpetuate the cycle.

[10] 3.3 % or 20 sites participated in 12 out of the 13 cycles. 1.6% or 10 sites participated in 11 of the 13 surges and 5% or 31 sites participate in 10 or less of the 13 cycles. The non-participating stations are located in North Stradbroke island.

[11] It is worth noting that we also identified a failed cycle or false start of a cycle during the initial Covid-19 restrictions in March 2020. The reason we excluded this cycle from our analysis is that only 13 stations participated in the cycle, when usually there are 543. What makes this failed

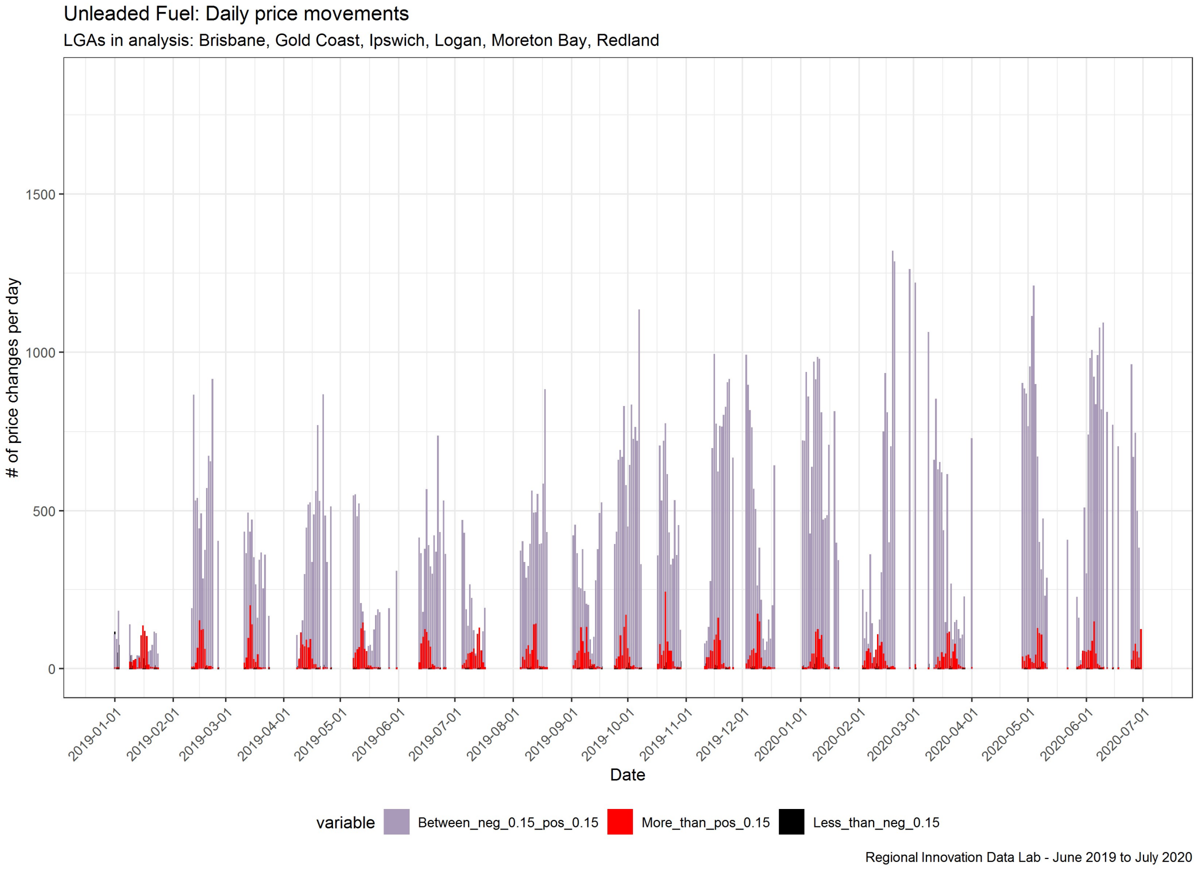

Figure 9: Price changes demonstrating the limited number of price hikes exceeding $0.15 cents and numerous small adjustments between -$0.15 and +0.15.

By applying a relative scoring mechanism to accurately capture how quickly retail stations adjust their price following the initial price hike, we were able to identify exactly which sites repeatedly drive the price reset cycles and how quickly other stations respond. In Greater Brisbane, a few businesses own the majority of the stations, and interestingly the businesses that own numerous stations do not apply a blanketed pricing strategy across all the stations they own, indicating the presence of well-thought out and considered pricing strategies. The analysis suggests that while three retailers have led price surges, one specific retailer has led ten of the thirteen surges. The first and second surges (15% of the surges) are led by a repeated set of Caltex stations (Caltex Australia Petroleum Pty. Ltd., owns 100 stations), whereas the third through to tenth cycles are driven by a key set of Coles Express stations (Eureka Operations Pty. Ltd., owns 89 stations). The 11th surge cycle (8%) is led by 7 Eleven branded stations (7-Eleven Stores Pty. Ltd., owns 134 fuel stations) prior to the aforementioned Coles Express stations resuming the lead for the final two surges (77% of the surges in total). 30 stations have been used to drive the

attempt interesting is that the same key stations which drove the preceding surges also drove this failed attempt, but then quickly adjusted their prices when no other stations followed suit.

price cycles.[12] A static description of the locations and number of sites used by retailer is viewable below in Figure 10. [13]

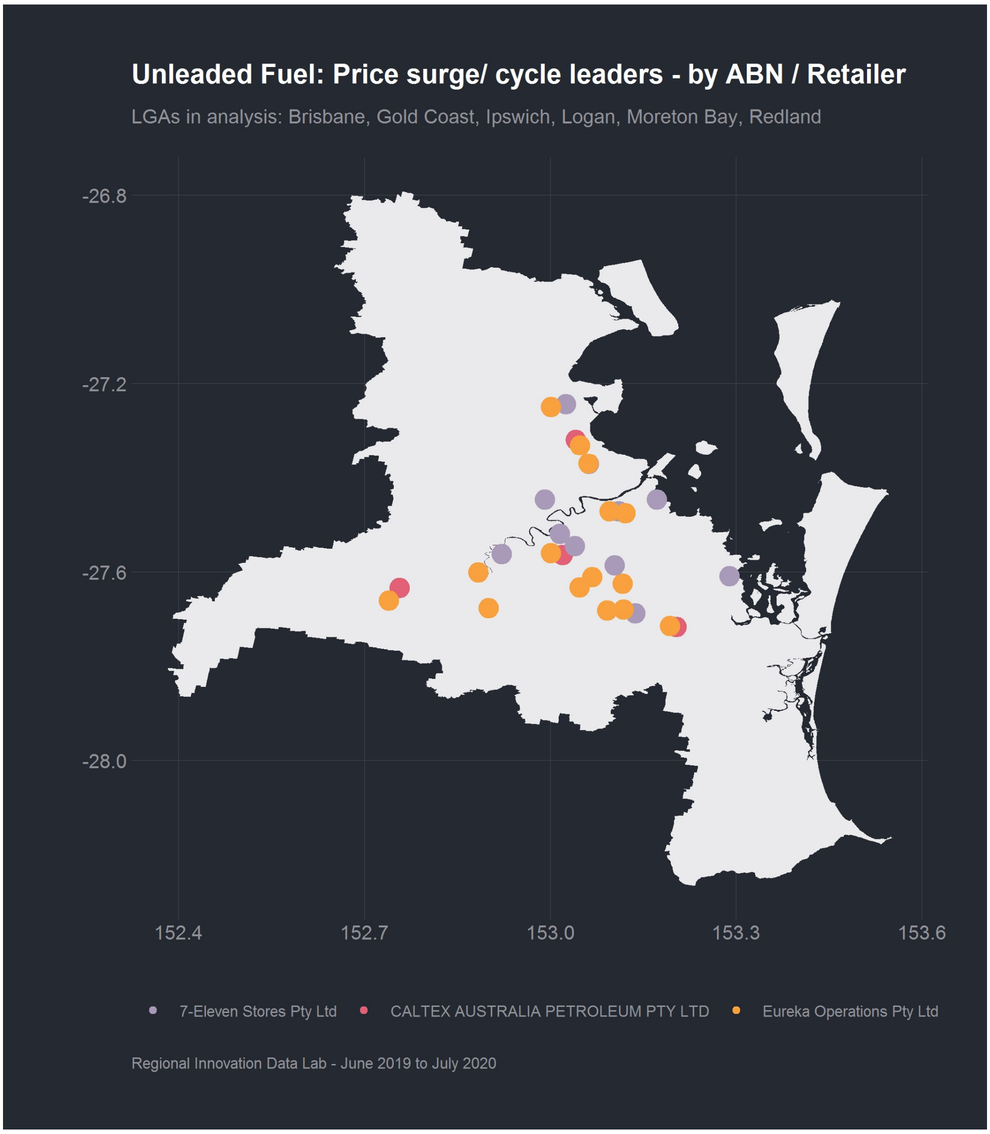

Figure 10: Fuel stations leading price surges.

The businesses driving the cycles do not use a single petrol station to initiate price hikes. Instead, a combination of 3-4 stations are used to repeatedly drive the surges, indicating a considered pricing strategy. Furthermore, retailers operating numerous stations respond to cycles by raising their prices more quickly than retailers operating fewer or indeed, single stations.

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[12] We note however that the 11th surge driven by the 7 Eleven branded stations is less characteristic of the overall pattern because it occurred after the Covid-19 restrictions began to relax. If that surge was to be excluded, then an even smaller number of stations (19) are identified as having been used to drive the price cycles.
[13] For a superior visualisation, see the two animated illustrations sent alongside this report, which show the way the leading ABNs utilise selected stations to repeatedly drive the cycles.

On average, a reset cycle happens every 27 days (median number of days is also 27). The beginning of a surge is defined as a sharp price increase of over $0.15 per litre initiated by a few fuel stations, which is then followed by the majority of the market. The end of a surge is defined when the prices return to a common low point or baseline price. Surge lengths are measured by counting the days between the first day of one surge through to the first day of the following surge (e.g. the difference in days between surge 2 start date and surge 1 start date = surge length). Covid-19 had a visible impact of the length and frequency of the cycles. Between 2 February 2020 and 13 March 2020 there was a 40-day span between surge starts, followed by the longest cycle lasting 45 days between 13 March 2020 and 27 April 2020. During the 10th surge/cycle lasting 40-days between 2 February 2020 and 13 March 2020 , the Coles Express and Caltex branded stations that typically drive the surges attempted a new surge, but only 13 sites participated (i.e. the failed or false reset cycle). For details on each surge please see Table 1 and Figure 11 below.

Surge ID	Cycle start: Price increase > $0.15	Cycle end	Cycle length (days)	Date prices stop increasing > $0.15	No. of days prices $0.15
1	11/06/2019	3/07/2019	23	25/06/2019	14
2	4/07/2019	4/08/2019	32	17/07/2019	13
3	5/08/2019	31/08/2019	27	18/08/2019	13
4	1/09/2019	22/09/2019	22	16/09/2019	15
5	23/09/2019	15/10/2019	23	8/10/2019	15
6	16/10/2019	9/11/2019	25	28/10/2019	12
7	10/11/2019	1/12/2019	22	25/11/2019	15
8	2/12/2019	31/12/2019	30	18/12/2019	16
9	1/01/2020	1/02/2020	32	20/01/2020	19
10	2/02/2020	12/03/202	40	11/03/2020	38
11	13/03/2020	26/04/2020	45	1/04/2020	19
12	27/04/2020	25/05/2020	29	21/05/2020	24
13	26/05/2020		0	18/06/2020	23

Table 1: Start and end date of identified price cycles.

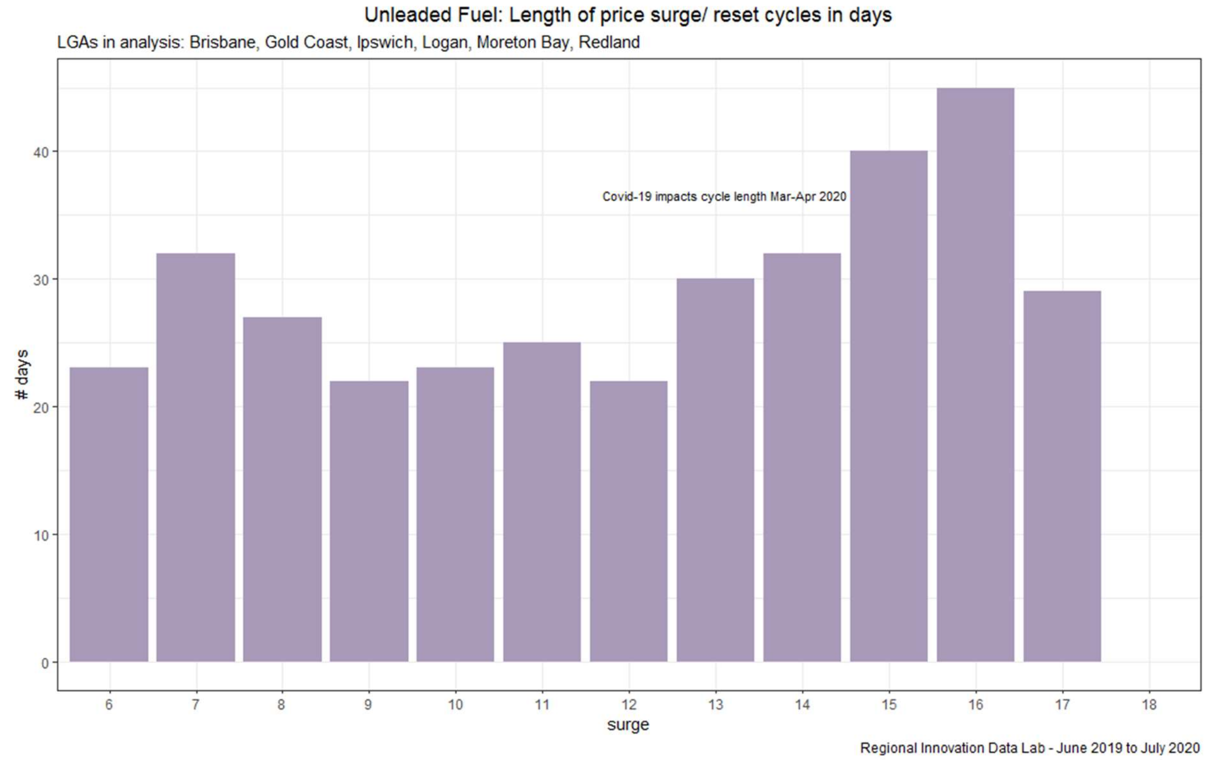

Figure 11: Length of identified price cycles.

Returning to more aggregated numbers, figures 12 and 12a provide a snapshot of the observed regular unleaded fuel price (i.e. ULP91) across Queensland comparing fuel prices prior to and during the current trial period (1 December 2017 to 20 June 2020). The first set of numbers for each LGA show the minimum price observed during each period, followed by the maximum price and then the average (mean) price of the period. The colours denote average prices (e.g. green denotes average prices are around the $1.40-$1.60 litre mark).[14]

While these show that average prices have generally declined, it is worth pointing out that the declining trend in international oil prices have been a significant contributing factor, though there is also some evidence of the trial leading to more competitive pressures in the Southeast Queensland region (see Section 4 for a detailed exposition on this). As well, there has been a fall in minimum prices alongside a rise in maximum prices since the trial commenced (Section 4 also tests for price dispersion across the state). For example, looking at Ipswich LGA, the minimum price reported fell from $1.23 in the pre-trial period to $0.88 since commencement, and the maximum price was higher since commencement ($1.71 as opposed to $1.67 pre-trial). These

[14] The LGAs without data are denoted in white in the maps.

greater dispersions are believed to allow for fuel price app users to make savings at the bowser.

We note here, that as opposed to our previous report (Griffith University, 2020), minimum prices have fallen even further in the first half of 2020, though minimum prices post-commencement were already lower relative to pre-trial minimum prices. This begs the question of the role COVID-19 played in lowering prices, and we caution, that at this early stage, it's role in contributing to falls in minimum prices cannot be stated with any significant level of confidence. This is as local prices are largely influenced by international prices, and international prices were already facing substantial downward pressure even prior to the pandemic, thus making it difficult to isolate its true effect. Any further downward pressure on prices domestically due to the local impact of COVID-19 cannot also be isolated from other factors as well.[15]

[15] Nevertheless, an attempt to study its impact on prices was undertaken and found to be generally insignificant. This is discussed in greater detail in Section 4.

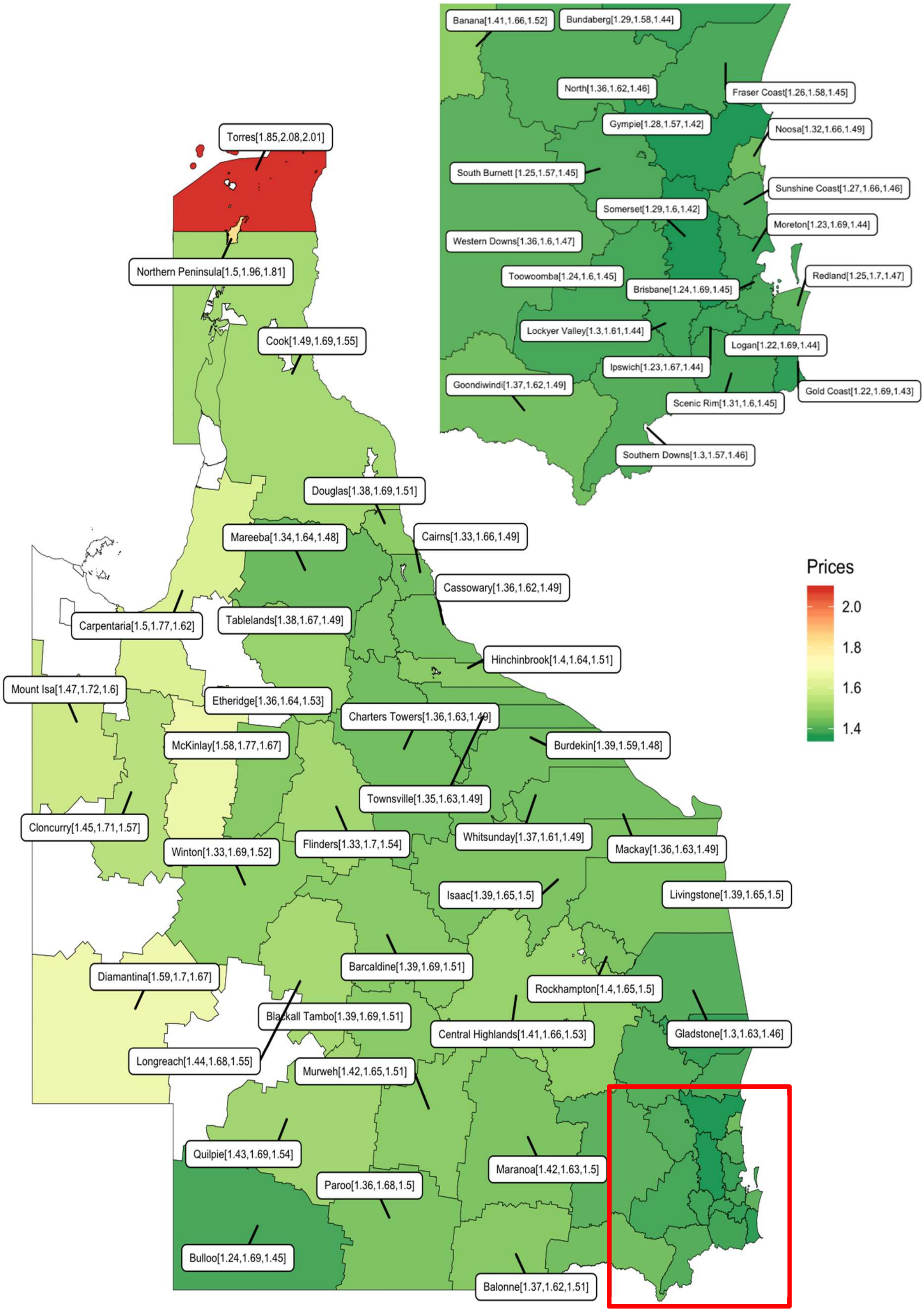

Figure 12: A snapshot of the observed regular unleaded fuel price across Queensland in the pre policy implementation periods (December 2017 to December 2018) The first set of numbers for each LGA show the minimum price observed during each period, followed by the maximum price and then the average (mean) price of the period. The colours denote average prices (green indicates a low price, yellow medium, red high).

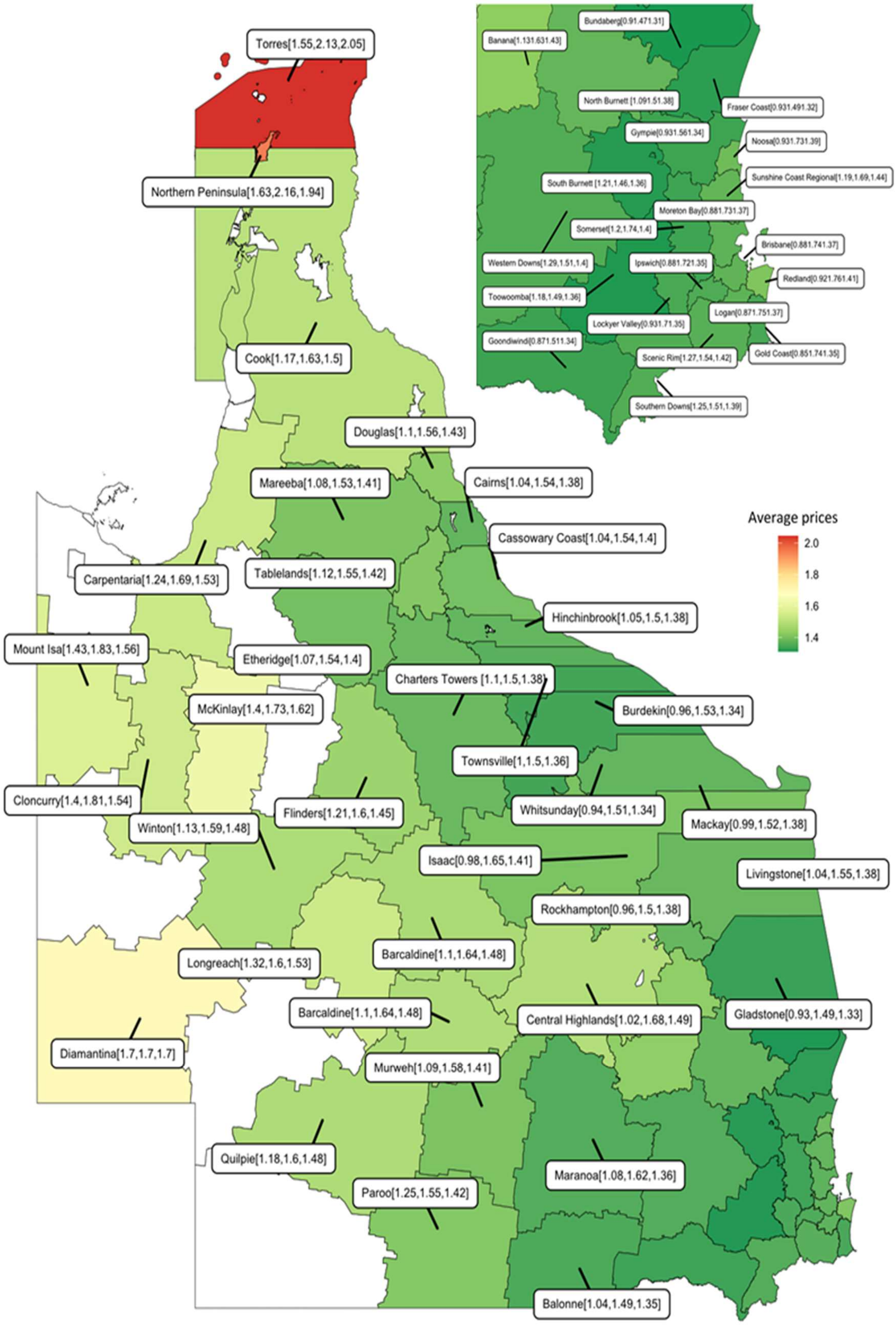

Figure 12a: A snapshot of the observed regular unleaded fuel price across Queensland in the post policy period (December 2018 to June 2020). The first set of numbers for each LGA show the minimum price observed during each period, followed by the maximum price and then the average (mean) price of the period. The colours denote average prices (green indicates a low price, yellow medium, red high).

4. Empirical Modelling and Results

4.1 Time-series (Auto Regressive Distributed Lag [ARDL]) Model

A time series model of the log average daily retail price[16] by LGA and petrol type is constructed in order to empirically verify the impact of the trial on retail fuel prices. This is done using tests for structural breaks that coincide with the commencement of the QFPRT. It incorporates the main drivers of price fluctuations, including international oil prices, retail margins, demand conditions, changes in excise tax and exchange rates, which already subsume the impact of COVID-19 on international fuel prices.[17] The average daily petrol price for each fuel type and LGA is converted into natural-logged variables.

As this analysis uses time series data, it is necessary to investigate the presence of unit roots and/or co-integration relationships among variables. This is as we need to identify whether the time series variables in the model are either stationary or non-stationary[18] as well as whether there are long run equilibrium relationships among variables. The preliminary analysis suggests that price variables in some LGAs are stationary, whereas the Australian dollar value of the international oil price is non-stationary (integrated of order 1).

The dependent variable (retail fuel price) is regressed over its own past values (lagged values) as well as current and lagged values of other independent variables (in this case, the domestic currency value of international oil prices). The model is augmented via the incorporation of a further set of dummy variables that control and account for excise taxes imposed by the government that occur on a biannual basis.

4.1.1 ARDL Model Results – Retail Fuel Price Changes

Table 2 summarises the impact of the commencement of the trial on 3 December 2018 using the ARDL model. The model covers logged average daily prices per LGA and petrol type. Appendix D provides detailed modelling results by region and fuel type (Tables D1–D4). The negative (minus) sign

[16] Transforming variables into natural logs helps to handle non-linear relationships within linear models. Similarly, logarithmic transformations help to convert highly skewed variables into more approximately normal variables.

[17] As such, introducing COVID-19 controls would produce unreliable estimates as collinearity may be present between the COVID-19 controls and other controls like international oil prices.

[18] Stationarity means that the statistical properties of a process generating a time series do not change over time. A stationary time series tends to revert to a long run mean and has constant variance. When there is a mix of stationary and non-stationary variables as well as co-integration association among variables, the well-known ARDL model becomes a suitable modelling framework for the analysis.

indicate that the model has detected a decline in retail fuel prices since the introduction of the trial, with a positive (plus) sign indicate the reverse scenario.

	Independent variable: Brent Price			
	ULP 91	PULP	E10	Diesel
Southeast Queensland LGAs				
Brisbane	-**	-**	-*	
Gold Coast	-*	-**	-*	
Ipswich	-**	-**	-**	
Logan		-**	-*	
Moreton Bay	-**	-**	-**	
Lockyer Valley	-*	-**	-*	
Noosa	-*	-**	-**	
Scenic Rim			-*	
Sunshine Coast				
Redland	-**	-**	-**	
Average	-**	-**	-**	
Other LGAs				
Townsville				
Rockhampton				
Bundaberg				
Cairns	-**	-**	-**	-**

Table 2 Impact of the trial on retail fuel prices.
Note: ** refers to policy effect at 5% level of significance and * refers to policy effect at 10% level of significance. Levels of significance indicate the level of confidence in the accuracy of the result, with 5% indicating strong confidence and 10% weaker confidence.

Results indicate that retail petrol prices have declined in a statistically significant manner since the introduction of the trial across most of Southeast Queensland. However, the impact of the trial seems to be relatively confined to this region only, as most other selected LGAs indicate no statistically significant decline in retail prices. This evidence suggests that the more competitive nature of the retail fuel market in the southeast relative to other Queensland regions, and the higher utilisation of fuel price apps (RACQ, 2019c) has enabled the implementation of the trial to generate consumer savings in Southeast Queensland.

The estimated magnitude of the impact of the QFPRT on retail fuel prices is relatively small. The estimated fall in the ULP91 price due to its implementation in the Brisbane LGA is approximately 0.40% (less than one per centage point). The impact is marginally lower for the Southeast Queensland average (0.36%).[19] The greatest observed fall in average daily ULP91 price was in Ipswich, where the estimated impact of the trial on regular unleaded fuel prices was 0.69%. Percentage falls were also sizeably greater than Brisbane's on the Gold Coast (0.47%), Moreton Bay (0.55%), Noosa (0.59%) and Redland (0.66%), with the Lockyer Valley's fall (0.42%) approximating that of Brisbane's. In dollar terms, relative to the pre-trial average ULP 91 price, this equates to a

[19] Note that the average results for Southeast Queensland are weighted to account for the number of retail fuel stations in each LGA. Therefore, the Brisbane LGA results have a higher weighting than other LGAs, as Brisbane is part of Southeast Queensland.

fall of 0.55 cpl ($0.0055) in Brisbane and 0.49 cpl ($0.0049) for the Southeast Queensland average. Bar Cairns LGA[20] where there is evidence of a statistically significant downward pressure on price, the effect of the trial on diesel pricing is non-existent. This outcome is expected, given that only approximately one quarter of diesel consumed is sold through retail outlets.

A further extension was undertaken whereby a COVID-19 dummy was incorporated in order to investigate its local impact. It was not utilised in the main model as (a) the main driver of prices at the bowser are international prices, which already evince the impact of COVID-19 on global fuel prices, (b) it is not evident at this stage if the impact of COVID-19 is transitory or more permanent, and (c) introducing COVID-19 controls potentially produces unreliable estimates as collinearity may be present between the COVID-19 controls and other controls like international oil prices. Indeed, according to results in Table 3, the level of significance of the COVID-19 dummy is almost always insignificant across all petrol variants. The policy dummy also remains largely unchanged. For diesel however, the COVID-19 dummy is generally positive and statistically significant, suggesting that the impact of COVID-19 was to increase diesel prices, albeit not enough to make the policy impact significant. As the model with COVID-19 dummy variable seems to produce inconsistent and unreliable results, largely due to modelling issues highlighted above, the report mainly relies on the ARDL model results without COVID-19 dummy variable for analysis of the impact of the QFPRT.

[20] Prices declined in a statistically significant manner for the three petrol variants in Cairns LGA as well. While this report has not specifically studied the retail fuel market in Cairns LGA, we note that a quarter of retail stations there are branded as Puma, United and 'other unbranded', which is a sizeable proportion of the market relative to the larger brands, suggesting competitive pressures are at play.

	Independent Variable: Brent Price							
	Policy Dummy				Covid-19 Dummy			
	ULP 91	PULP	E10	Diesel	ULP 91	PULP	E10	Diesel
Southeast Queensland LGAs								
Brisbane		-**	-*					+*
Gold Coast	-*	-*	-*					+**
Ipswich	-**	-**	-**					+**
Logan		-*	-*					+*
Moreton Bay	-**	-**	-**					+**
Lockyer Valley	-*	-*	-*					+**
Noosa	-**	-**	-**					
Scenic Rim			-*					+**
Sunshine Coast								+**
Redland	-**	-**	-**					+*
Average	-**	-**	-**					+*
Other LGAs								
Townsville								
Rockhampton								
Bundaberg								+**
Cairns	-**	-**	-**	+**				+**

Table 3 Impact of the trial on retail fuel prices, with COVID-19 dummy.
Note: ** refers to policy effect at 5% level of significance and * refers to policy effect at 10% level of significance. Levels of significance indicate the level of confidence in the accuracy of the result, with 5% indicating strong confidence and 10% weaker confidence.

4.2 Panel Model

Panel models are estimated with longitudinal data where observations span across both time and individuals/entities in a cross-section. Among the advantages of panel models include the capability of capturing unobservable or unmeasurable sources of heterogeneity across individuals or entities and controlling omitted variable bias. In this study, a panel data model has been estimated as a robustness check for the ARDL time series model outcomes. In this panel model, the same LGAs used in the ARDL time series models are considered as entities. Instead of daily retail prices, monthly average retail prices by LGAs are considered in order to check the robustness of time series model (i.e. ARDL) outcomes by using a different level of aggregation. The panel model sample period runs from August 2016 to June 2020.

Similar to time series models, the average retail fuel prices are assumed to be driven by international oil prices, retail margins, demand conditions, changes in excise tax and exchange rates. Further, in order to empirically verify the impact of the trial on retail fuel prices, a dummy variable has been included in the model to test for structural breaks that coincide with the commencement of the QFPRT. The model is augmented via the incorporation of a further set of dummy variables that control and account for excise taxes imposed by the government that occur on a biannual basis. The average monthly retail price for each fuel type within LGA is converted into natural-logged variables.[21]

4.2.1 Panel Model Results – Retail Fuel Price Changes

Variables	Random Effects Model	
	Estimate	**Std. Error**
ULP91		
(Intercept)	0.3687553***	0.017108
Brent	0.1936932***	0.0176687
Policy Dummy	-0.1427571***	0.0166333
Adj. R-Squared	0.44045	
PULP		
(Intercept)	0.6389141***	0.009595
Brent	0.3650698***	0.0090432
Policy Dummy	-0.0398309***	0.0086811
Adj. R-Squared	0.8183	
E10		
(Intercept)	0.5368828***	0.0120596
Brent	0.4241114***	0.0115662
Policy Dummy	-0.0448296***	0.0111031
Adj. R-Squared	0.78983	
Diesel		
(Intercept)	0.4479168***	0.0084143
Brent	0.2808450 ***	0.0082367
Policy Dummy	-0.0390161***	0.0079069
Adj. R-Squared	0.86466	

Note: ***, ** and * refer to effects at 1%, 5% and 10% levels of significance respectively.
Table 4: Panel results

Results are consistent across fuel types. First, we note that across the investigated LGAs retail prices are positively related to Brent prices. This means that retail prices will increase and decrease in line with Brent pricing. Given the established close relationship between Brent and MOGAS95 prices, and thus between MOGAS95 and TGP pricing in Australia (see Figure 13), this reiterates

[21] There are two techniques in analysing panel data: fixed effects and random effects models. In fixed effects model, we assume that some characteristics within the entities may impact the outcome variables, and thus, need to be controlled for. Another, assumption in fixed effects model is those time-invariant characteristics are unique to the entity. The panel model was tested to see whether fixed effect model or the random effect model was suitable for the data. According to the Hausman Test, the random effects model has been identified as the suitable model, and thus we report the results only for the random effects model.

the points made by both the AIP and the ACCC that international pricing is the main contributor to retail fuel prices in Australia.

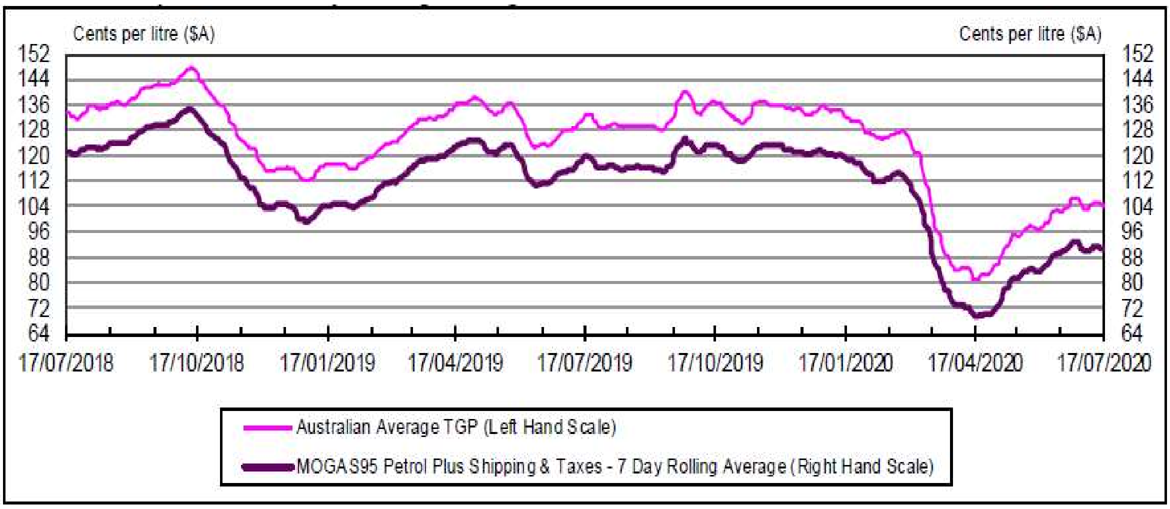

Figure 13: Comparison of 7 Day Rolling Average of MOGAS95 Petrol with Australian ULP TGP (AIP, 2020, 2020a)

Next, we note the negative value of the policy dummy. This indicates that, consistent with ARDL results, the introduction of the QFPRT did lead to a lowering of retail fuel prices post-implementation in the fourteen LGAs noted in the ARDL study. However, in contrast to the ARDL results, the panel results highlight that the trial impacted upon diesel retail prices by reducing prices[22].

4.3 Estimated Potential Savings

Beyond changes in average retail prices, Section 3 noted visible increases in price dispersion in some regions. Increases in the spread of prices suggests that informed consumers have a greater potential to save if they are able to locate the cheapest available price in their area for a given fuel cycle. To find evidence for statistically significant changes in price dispersion, Table 5 summarises results of an ANOVA test[23] with unequal sample sizes that check whether price dispersions (for ULP91) between daily minima and maxima have increased in a statistically significant fashion over time. Three time periods are identified. The pre-trial period (Segment 1, $\bar{\sigma}_{s1}$) from 20 August 2016 to early December 2018, the trial commencement period prior to full enforcement (Segment 2, $\bar{\sigma}_{s2}$) (3 December 2018 to 14 April 2019) and the full enforcement period thereafter (Segment 3, $\bar{\sigma}_{s3}$).

[22] This could be due to data aggregation. Unlike the ARDL time series model that utilise daily data, the panel model uses monthly data. As the number of data points in the panel model are thus more limited, the interpretation of coefficients needs to be treated with caution.

[23] Analysis of variance (*ANOVA*) is a collection of statistical models and their associated estimation procedures (such as the "variation" among and between groups) used to analyse the differences among group means in a sample.

	ANOVA pair-wise comparison		
Periods	S1 and S2	S1 and S3	S2 and S3
Southeast Queensland LGAs			
Brisbane		Higher (S3>S1)	Higher (S3>S2)
Gold Coast		Higher (S3>S1)	
Ipswich		Higher (S3>S1)	Higher (S3>S2)
Logan		Higher (S3>S1)	Higher (S3>S2)
Moreton Bay	Higher (S2>S1)	Higher (S3>S1)	Higher (S3>S2)
Lockyer Valley	Higher (S2>S1)	Higher (S3>S1)	
Noosa	Higher (S2>S1)	Higher (S3>S1)	
Scenic Rim		Higher (S3>S1)	Higher (S3>S2)
Sunshine Coast		Higher (S3>S1)	Higher (S3>S2)
Redland			
Other LGAs			
Townsville	Higher (S2>S1)	Higher (S1>S3)	Higher (S2>S3)
Rockhampton	Higher (S2>S1)		Higher (S2>S3)
Bundaberg		Higher (S3>S1)	Higher (S3>S2)
Cairns	Higher (S2>S1)	Higher (S1>S3)	Higher (S2>S3)

Table 5: ANOVA results for price dispersion. The 'different' notation refers to a statistically significant change in daily minima and maxima price dispersions between selected periods. An empty cell refers to the fact that there was no statistically significant change in daily minima and maxima price dispersions between selected periods.

The main periods of interest would be between the pre-trial and full enforcement period (S1 vs S3 as shown in the middle column). Results indicate that when comparing these two time periods, there has been a significant change in the spread of prices (price dispersion) across ten of the fourteen LGAs, indicating increased potential for savings at the bowser. This is also consistent with the evidence that regions with more competition could benefit from a greater spread of fuel pricing information. However, for Cairns and Townsville, dispersion narrows instead. Nevertheless, it is important to note that this does not necessarily mean that there are savings (or otherwise) to be had as the ANOVA test does not account for any other factors or determinants that may influence price dispersion such as retail competition, transport costs and regulatory charges.

There is also some evidence that price dispersion changed between the initial commencement (S2) and full enforcement (S3) periods. This occurred in a slim majority (six of ten) of Southeast Queensland LGAs and all four non-Southeast Queensland LGAs. However, while price dispersion increased in the six Southeast Queensland LGAs, this occurred for only one of the four non-Southeast Queensland LGAs. While further study is required to better understand these regional differences, we note at this stage that regional areas typically have smaller numbers of retail outlets and thus price changes at any given station could wield a greater effect on overall price trends relative to LGAs with larger number of retail stations. Changes in prices pre- and initial commencement periods (S1 and S2) are, as expected, less apparent given the trial was being bedded in.

Potential to save: An increase in the spread of fuel prices can expand the potential savings that can be made by motorists using fuel price apps to identify cheaper prices available in their local area. A rough indication of the annual potential savings can be derived from measuring the difference between the minimum fortnightly petrol price and the mean petrol price observed in the same period. Using LGA wide ULP91 price cycles between July 2019 to June 2020, we estimate annualised savings based at comparing minimum and mean prices (see Table 6). Savings potential is higher in the more competitive LGAs in Southeast Queensland, whereas we estimate a lower level of savings potential in the less competitive LGAs outside Southeast Queensland. Appendix E discusses the method in greater detail.

LGA	Potential Savings (July 2019 – June 2020)
Brisbane	$147.20
Ipswich	$143.80
Lockyer Valley	$92.30
Rockhampton	$36.50
Gold Coast	$129.20
Cairns	$35.20
Mt. Isa	$12.30

Table 6: Estimated potential Savings accrued to motorists (July 2019 to June 2020) derived from refuelling at the minimum fortnightly observed ULP91 prices in their region, relative to refuelling at the mean fortnightly observed ULP91 price in their region.

4.4 Estimated Consumer Surplus

Consumer surplus arising out of the fall in prices since the implementation of the trial[24] was calculated using both information derived from this study and that provided by the Australian Bureau of Statistics (ABS) 2019 Cat. No. 9208.0 (Survey of Motor Vehicle Use, Australia, 12 months ended 30 June 2018). This is consistent with earlier iterations of these reports (Griffith University, 2019, 2020). Analysis is conducted on the use of passenger vehicles. Note that this is in addition to the potential savings that can be made by motorists using fuel price apps to shop around and identify cheaper prices available in their local area, as discussed in Section 4.3.

[24] Consumer surplus refer to savings that accrue out of the direct downward price impact of the trial on daily retail fuel prices relative to the pre-trial period.

Using information from appendix tables D1-D3, we estimate that the savings at the bowser since the introduction of the trial to be 0.55 cpl ($0.0055) per litre for ULP91 in Brisbane and 0.49 cpl ($0.0049) in Southeast Queensland, 0.62 cpl ($0.0062) per litre for PULP in Brisbane and 0.55 cpl ($0.0055) per litre for Southeast Queensland, and 0.57 cpl ($0.0057) per litre for E10 in Brisbane and 0.53 cpl ($0.0053) per litre for Southeast Queensland.[25]

Brisbane LGA: ABS data reports that the average rate of petrol consumption in Queensland is 10.7 litres per 100 kilometres (or 0.107 litres per kilometre), and this data is assumed to also represent that of the Brisbane LGA, though the rather more urban setting of Brisbane LGA may lead to this average rate of petrol consumption to be a more conservative estimate. The average kilometres travelled within Brisbane for passenger vehicles is 10,500 kilometres per year. Over this distance, the amount of petrol consumed would be 1,123.5 litres (10,500 x 0.107).

Given an estimated savings of $0.0055 per litre using ULP91 in Brisbane, users of this fuel would save $6.18 a year per passenger vehicle from the implementation of the trial.[26] For PULP users, this would be $6.97 and for E10 users, $6.40. Using Southeast Queensland average petrol volume data between January 2017 and March 2020 provided by DNRME, we estimate that 55.76% of these petrol-based passenger vehicles would utilise ULP91, 26.39% PULP and 17.86% E10. Across all the petrol using motorists in Brisbane, this amounts to a total consumer surplus of $7,656,841.81 resulting from the introduction of the trial.[27]

Variations to Consumer Surplus: Changes in the figure for total kilometres travelled will impact consumer surplus, and there is no *a priori* reasoning to use only the 'within Brisbane' average annual kilometre estimate of 10,500 kilometres per annum. Going back to Table 27 of Cat. No. 9208.0, if we include trips not just within Brisbane but also those between Brisbane and other parts of Queensland as well as between Brisbane and other capital cities (as calculated by the ABS), then 15,692,955,000 kilometres are covered. This yields a total consumer surplus of $9,606,395.32.[28] Nevertheless this report opines that the 'within Brisbane' definition is a more accurate depiction of the use of passenger vehicles within the Brisbane LGA, and the presentation of a broader

[25] Note that ARDL results suggested no significant change in diesel retail prices pre- and post-implementation. Thus, consumer savings is only calculated for the three petrol variants.
[26] 1,123.5 litres*$0.0055 and the same amount of litres is utilised is every case (e.g. region and fuel type).
[27] See Explanation 1 in Appendix F.
[28] See Explanation 2 in Appendix F.

measure is used to indicate that aggregated savings can expand if we also incorporate a wider driving range that will better represent a minority of drivers.

Southeast Queensland LGAs Weighted Average: With some variation, the same methodology is used to calculate consumer savings for Southeast Queensland (note that this includes Brisbane).[29] Given an estimated savings of $0.0049 per litre using ULP91 in Southeast Queensland, users of this fuel would save $5.51 a year per passenger vehicle from the implementation of the trial. For PULP users, this would be $6.18 and for E10 users, $5.95. Across all the petrol using motorists in Southeast Queensland, this amounts to a total consumer surplus of $9,844,506.96.[30]

5. Conclusion and Discussion

This report empirically examined the impact of the QFPRT on retail fuel prices across Queensland commencing from 3 December 2018. ARDL model results suggests that the trial generated a small but statistically significant decline in the average daily retail prices of ULP91, PULP and E10 petrol variants in most regions of Southeast Queensland. Panel model results, utilising average monthly data are largely supportive of these findings as well. This has resulted in annual consumer surplus relative to the pre-trial period, both at the Brisbane ($7,656,841.81) and Southeast Queensland ($9,844,506.96) levels. As well, we note that the scope for consumer savings is not uniform across the state and is concentrated in more urban settings. Key conditions to ensure the trial works effectively to lower retail fuel prices include the need to increase the uptake of consumer utilisation of fuel price information via fuel price apps and to ensure greater competition in the retail fuel market outside of the Southeast Queensland region.

This report also investigated price surges and price leaders in the Greater Brisbane region, which has engendered a better understanding of the price cycle phenomenon since the trial commencement. Using data taken from the enforcement period, we find that price cycles are set by a minimum number of players, utilising a select few retail stations in what can potentially be characterised as being a well thought-out and considered pricing strategy. Nevertheless, as volume and sales data are unavailable, the impact of changes in prices on sales remain unknown. In other words, the analysis is silent on the relative success or failure of price surges.

[29] See Explanation 3 in Appendix F.
[30] See Explanation 4 in Appendix F.

Finally, and related to the previous point, in order to better understand the impact of the trial on consumer savings, further research on how the trial influences the timing of fuel purchases and the volumes of petrol purchased is required, and this can also encompass qualitative as well as the more apparent quantitative studies (such as the ones conducted in this report). It is feasible that consumers could delay or move forward their refuelling decisions or reduce/increase the volume of petrol consumed given the rich set of information made available from the trial. Such information may highlight how the scheme could have a deeper impact on consumer savings than is currently estimated in this report.

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APPENDIX A: Retail App Usage (DNRME Data)

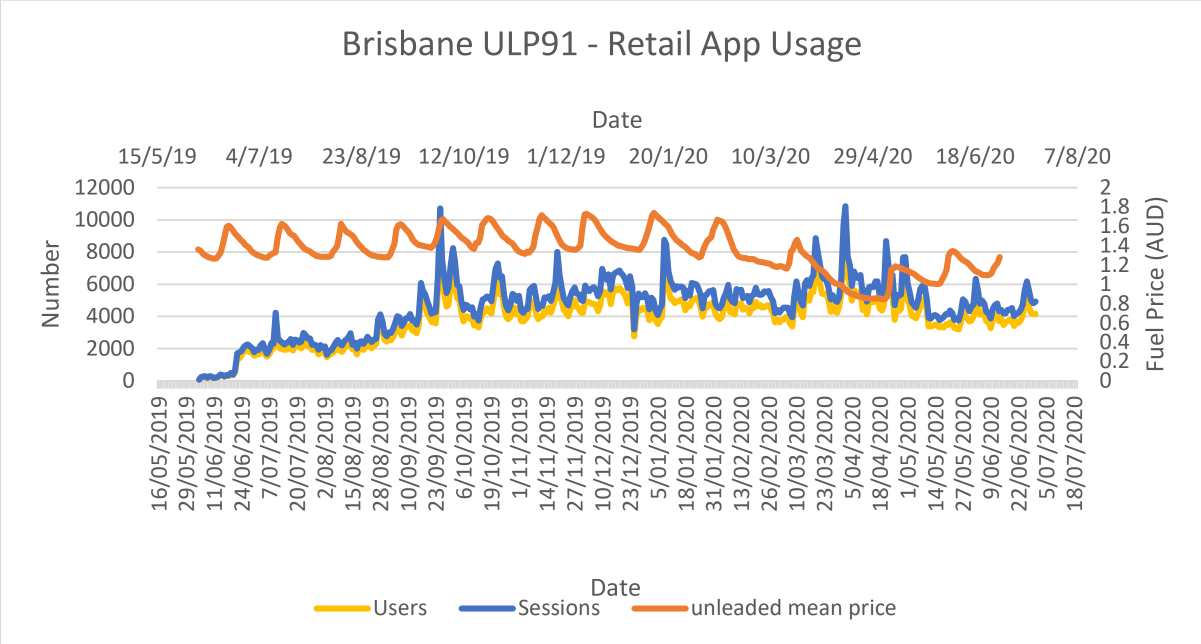

Figure A1: Brisbane average daily price for UP91 and retail app user and session counts

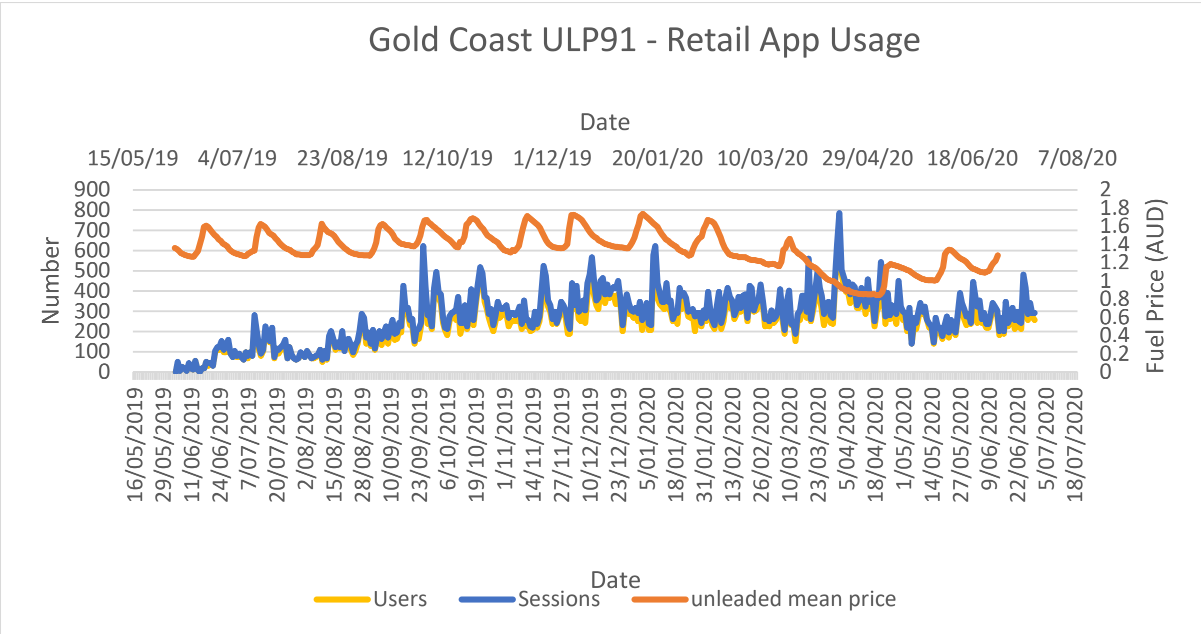

Figure A2: Gold Coast average daily price for UP91 and retail app user and session counts

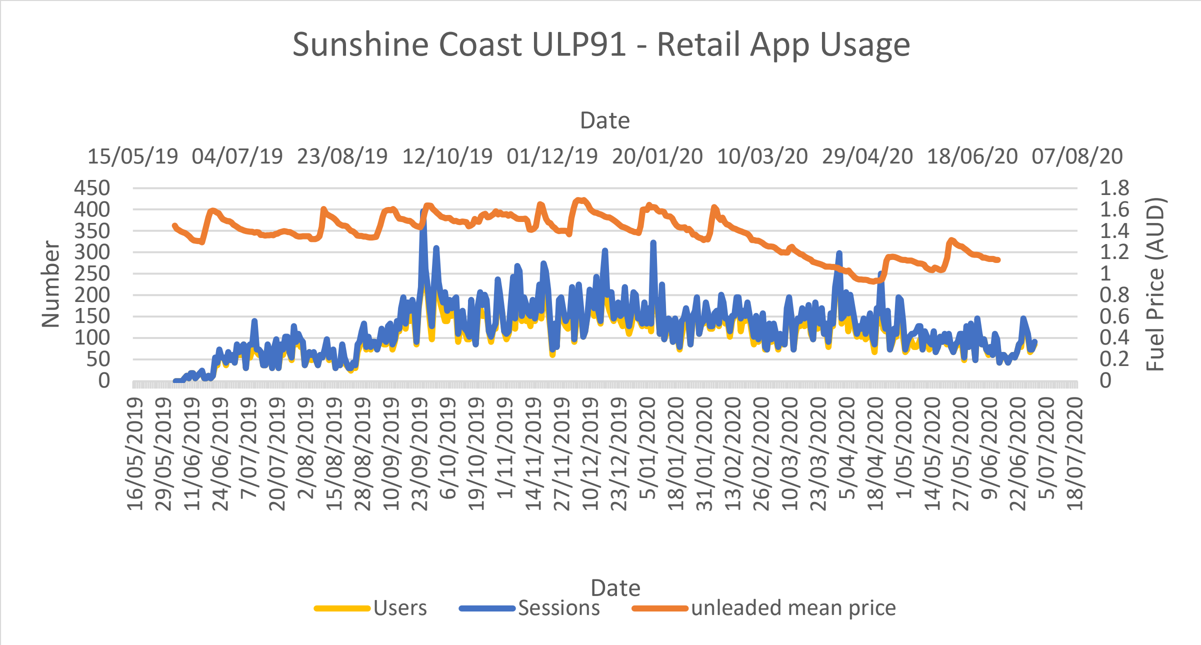

Figure A3: Sunshine Coast average daily price for UP91 and retail app user and session counts

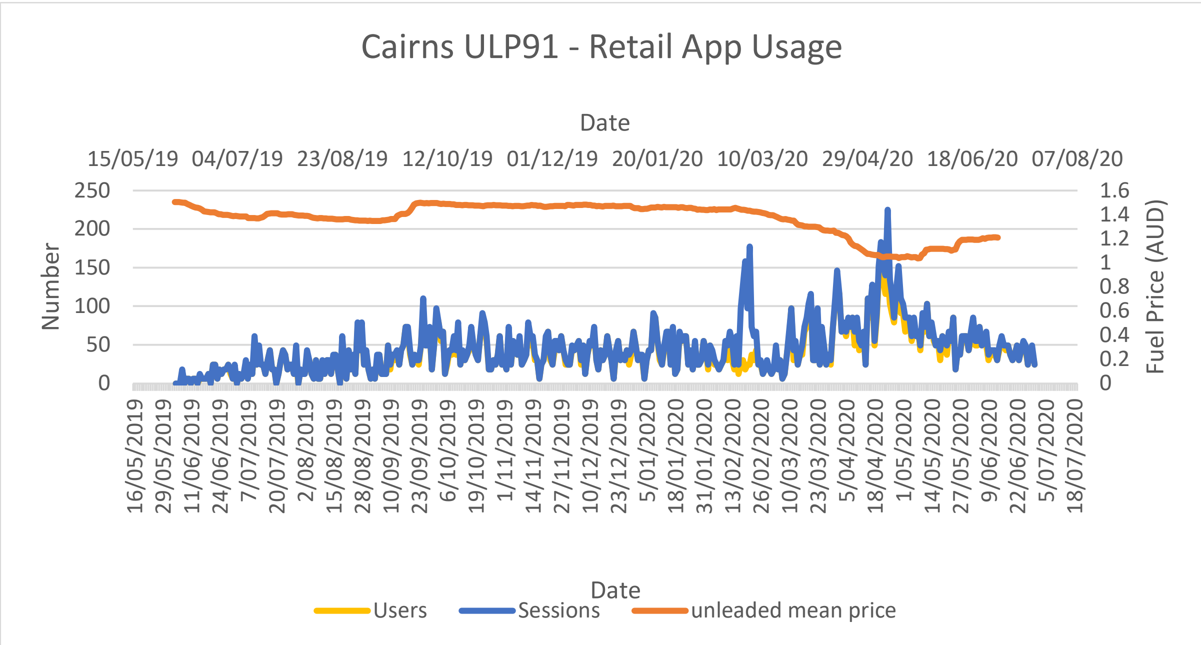

Figure A4: Cairns average daily price for UP91 and retail app user and session counts

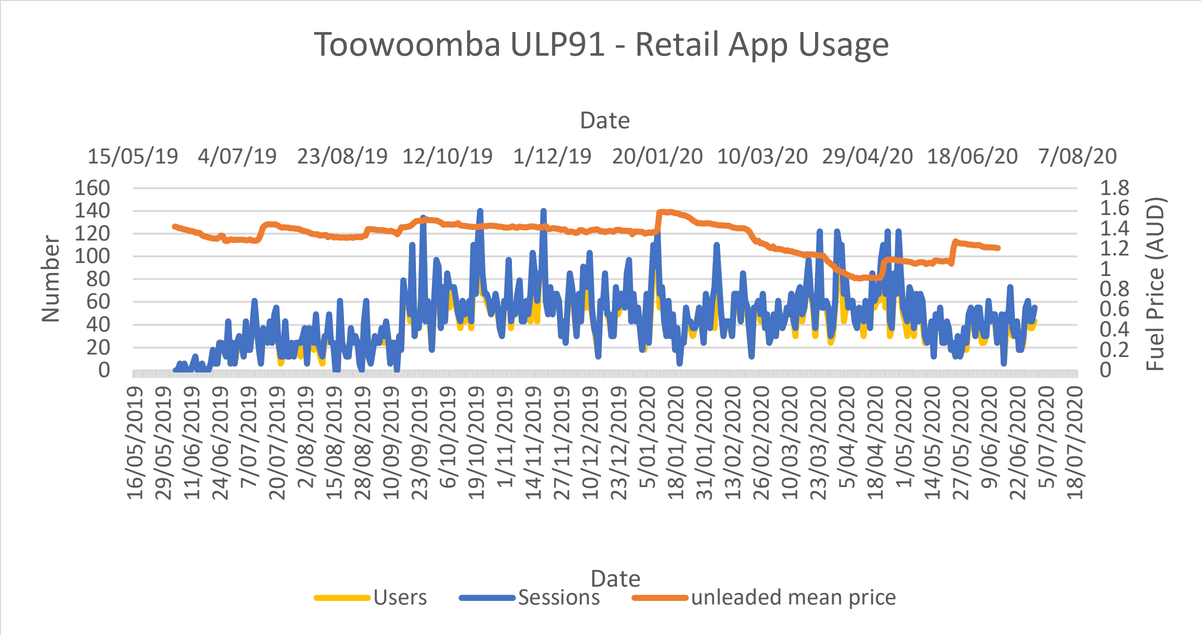

Figure A5: Toowoomba average daily price for UP91 and retail app user and session counts

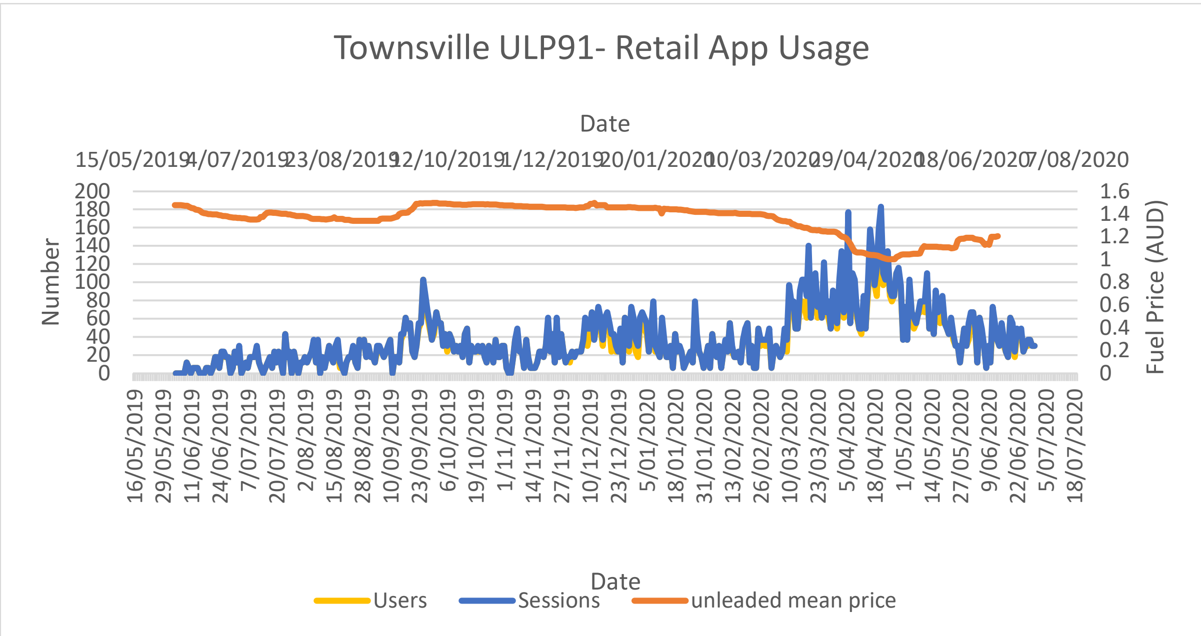

Figure A6: Townsville average daily price for UP91 and retail app user and session counts

APPENDIX B: Average daily ULP prices for selected LGA regions

Note: Vertical (Y) axis refers to AU$. Red dashed vertical line represents the trial commencement and the non-broken red vertical line represents the full compliance date.

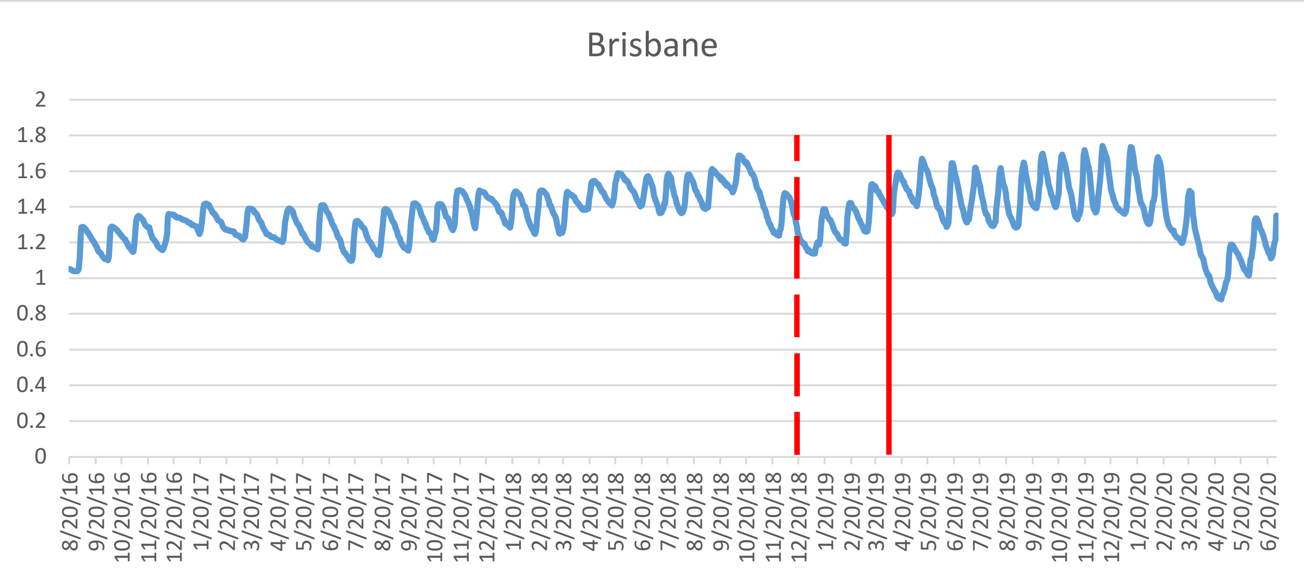

Figure B1: ULP 91 prices for Brisbane LGA.

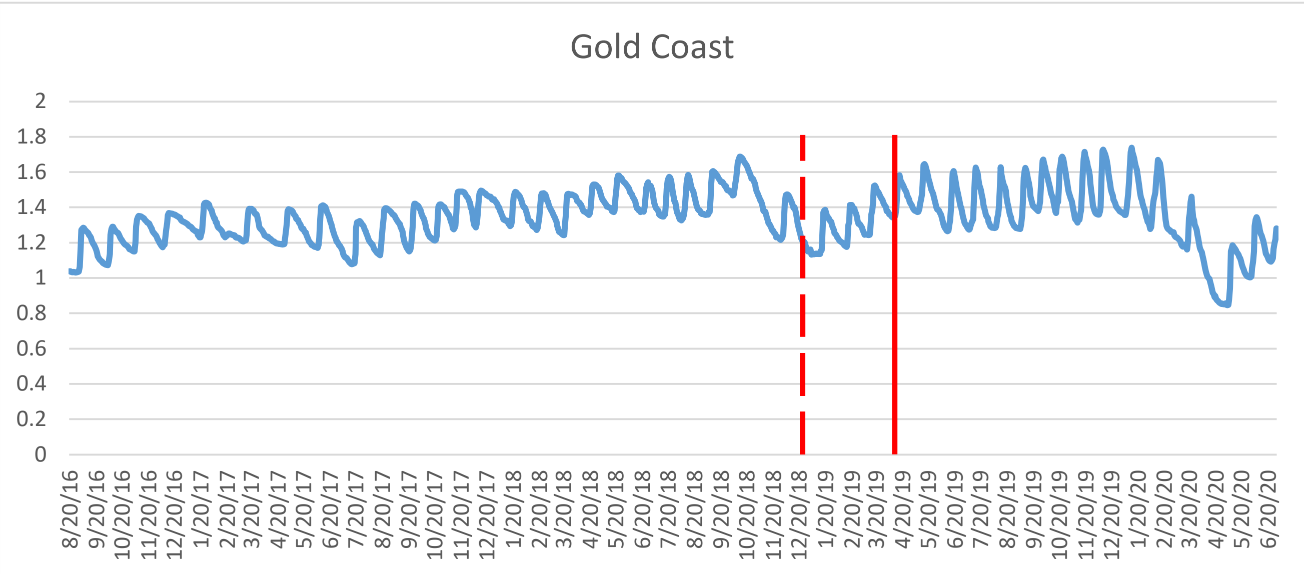

Figure B2: ULP 91 prices for Gold Coast LGA.

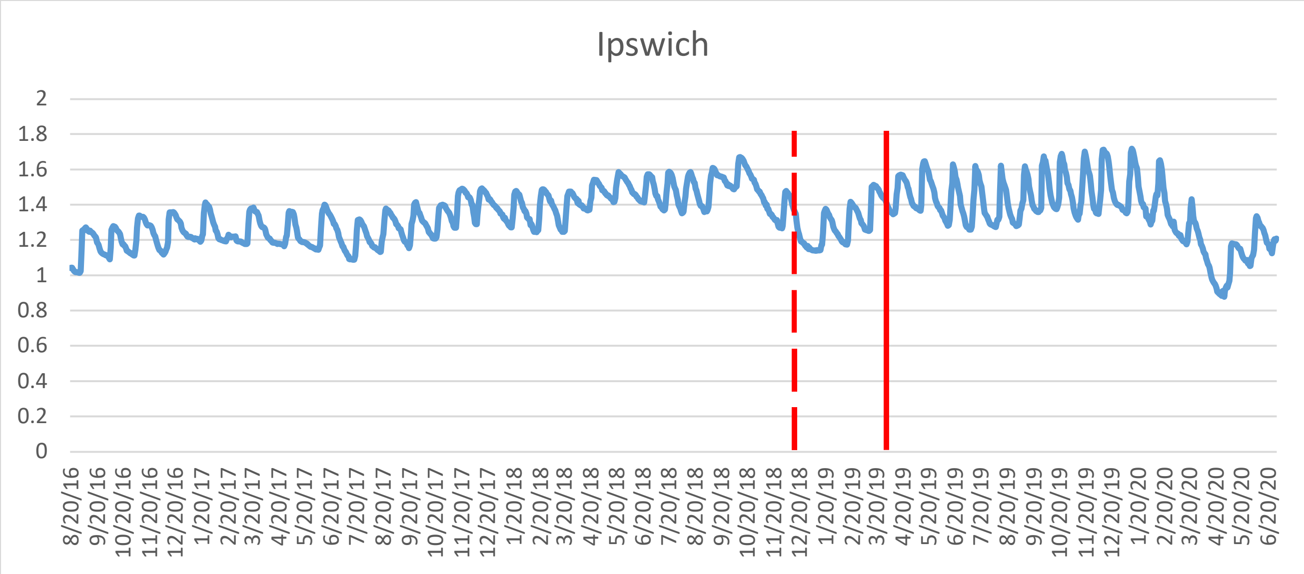

Figure B3: ULP 91 prices for Ipswich LGA.

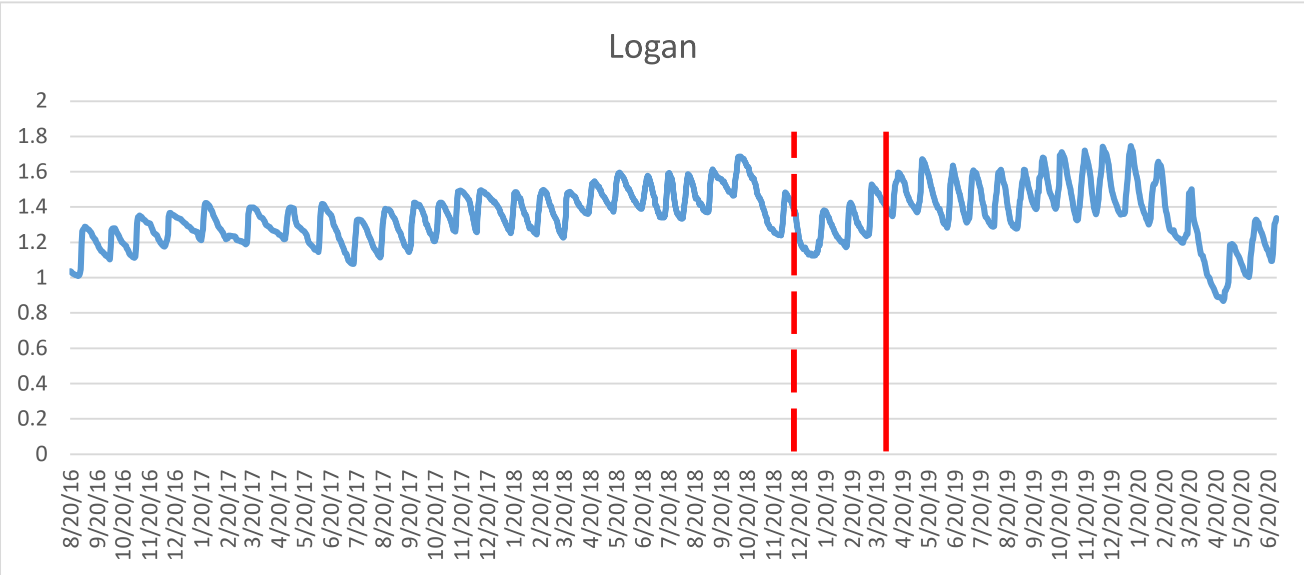

Figure B4: ULP 91 prices for Logan LGA.

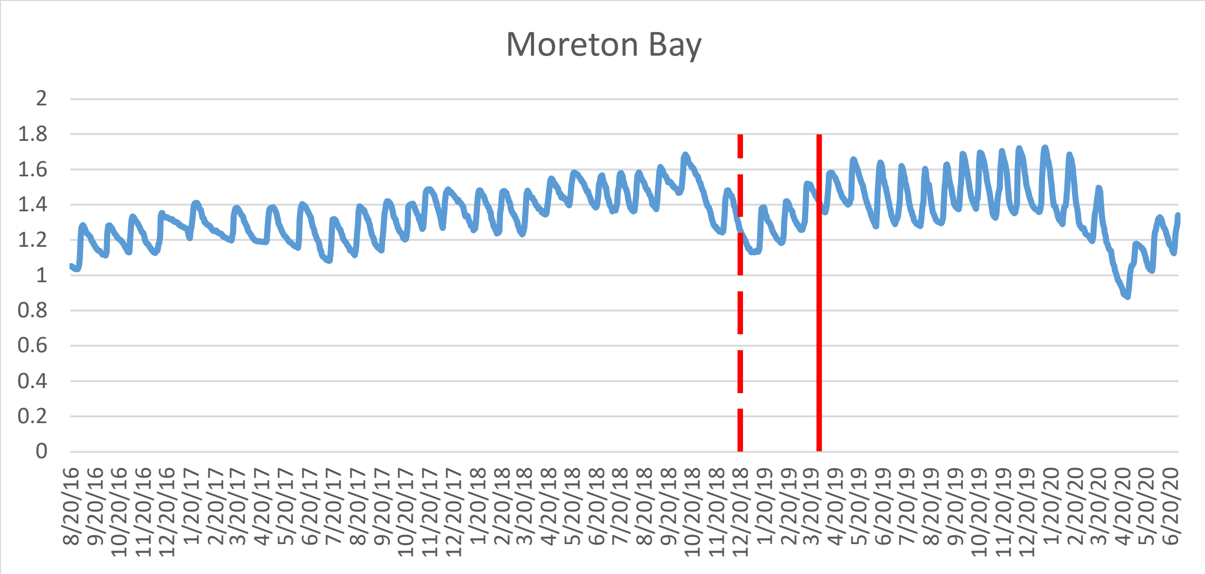

Figure B5: ULP 91 prices for Moreton Bay LGA.

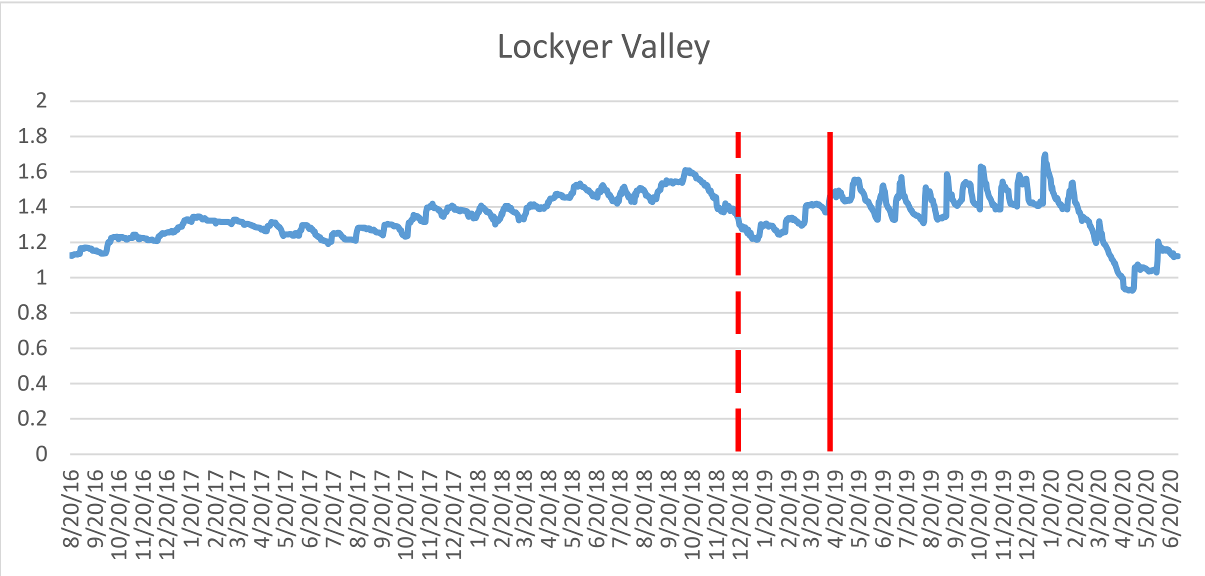

Figure B6: ULP 91 prices for Lockyer Valley LGA.

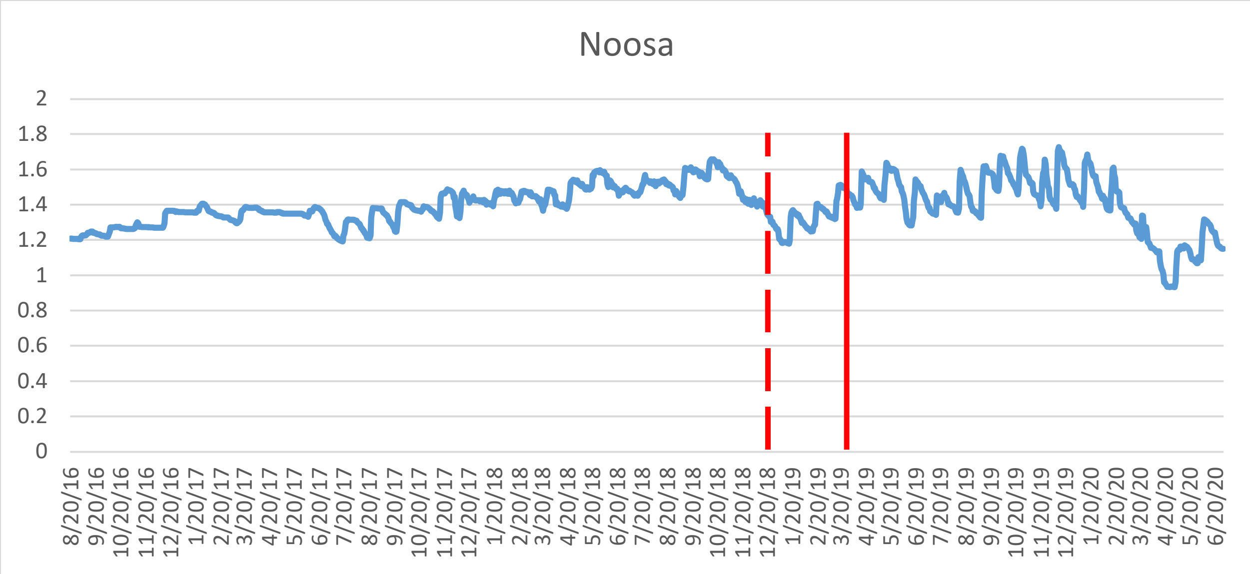

Figure B7: ULP 91 prices for Noosa LGA.

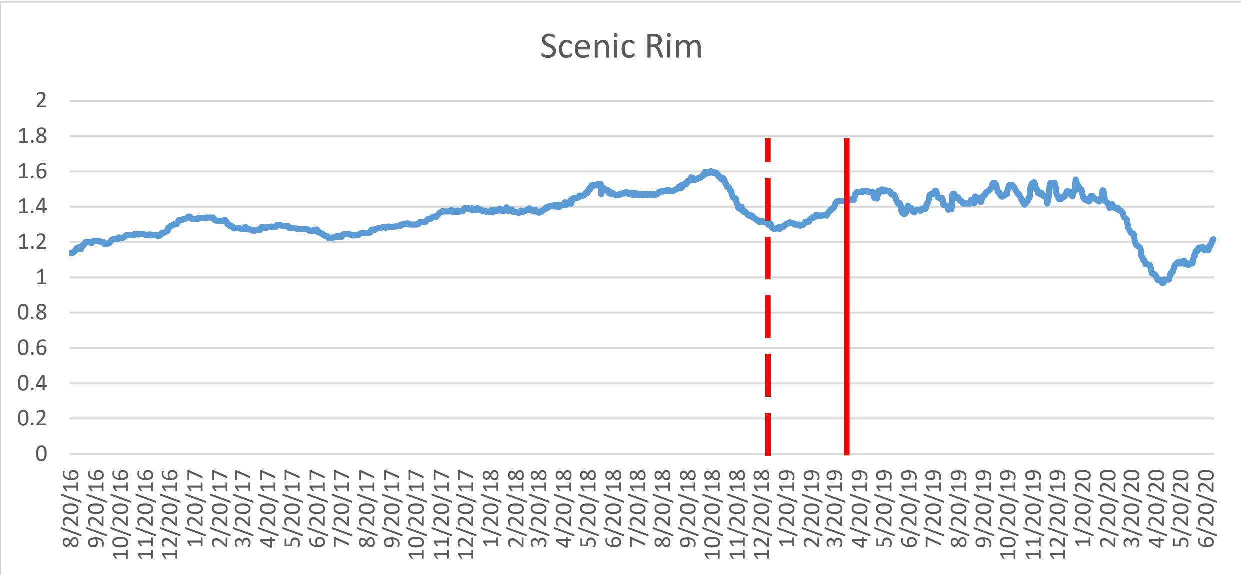

Figure B8: ULP 91 prices for Scenic Rim LGA.

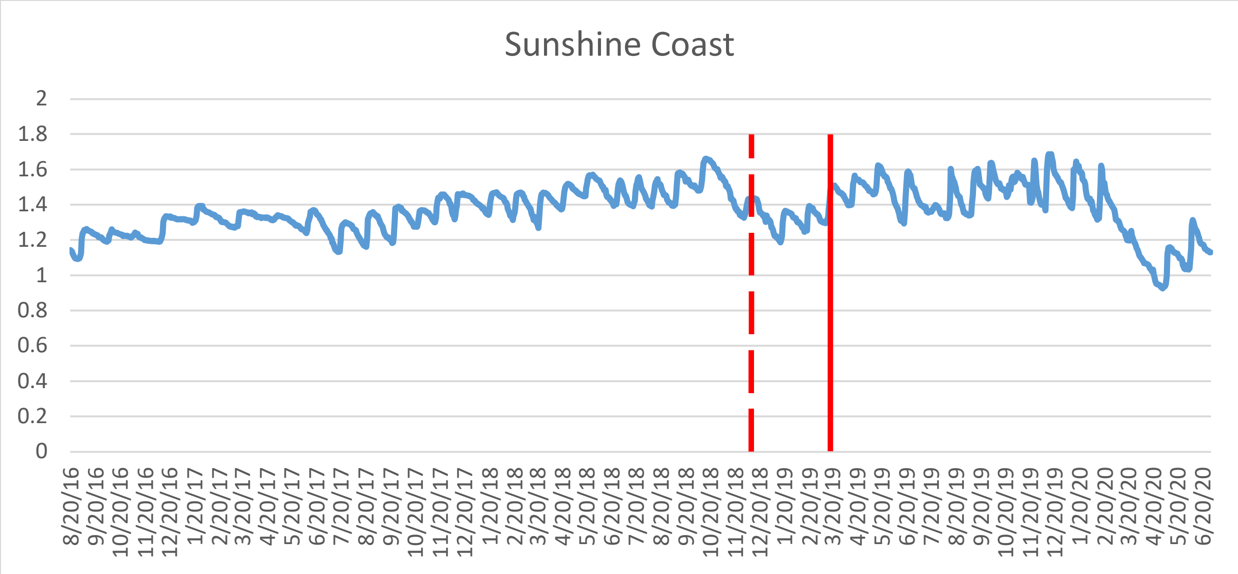

Figure B9: ULP 91 prices for Sunshine Coast LGA.

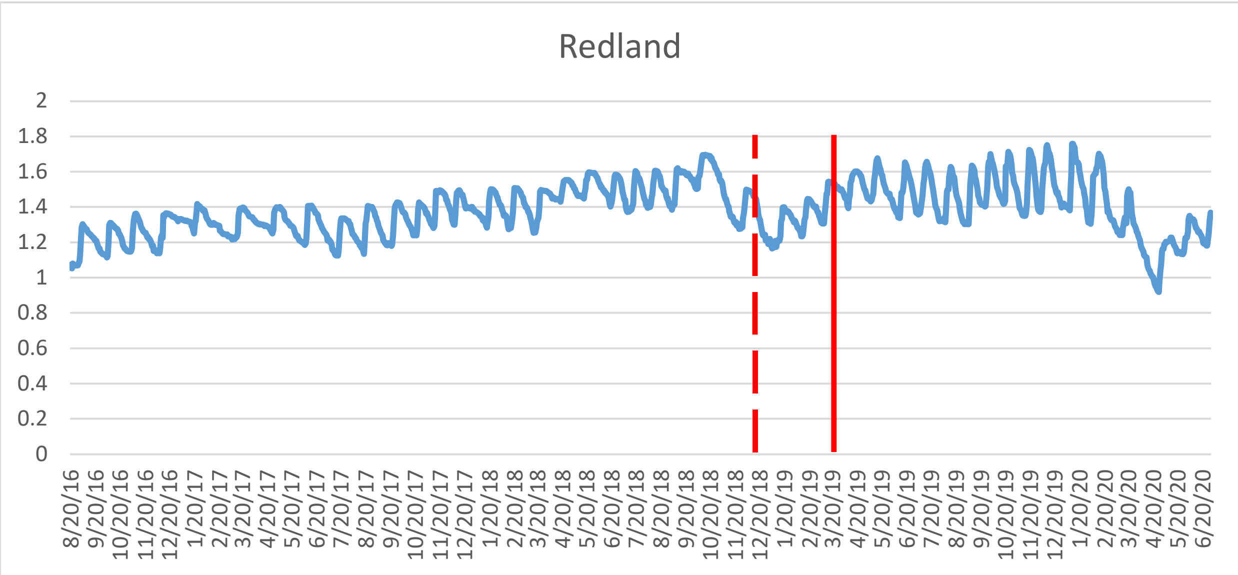

Figure B10: ULP 91 prices for Redland LGA.

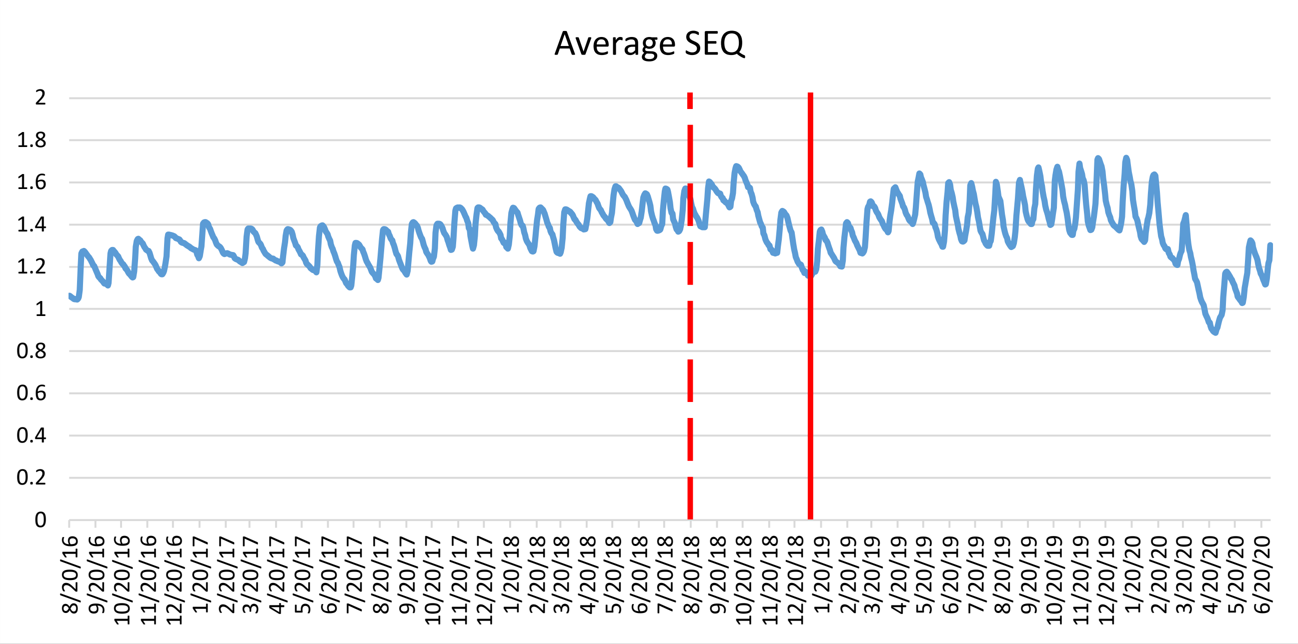

Figure B11: ULP 91 prices for Southeast Queensland LGAs (weighted average).

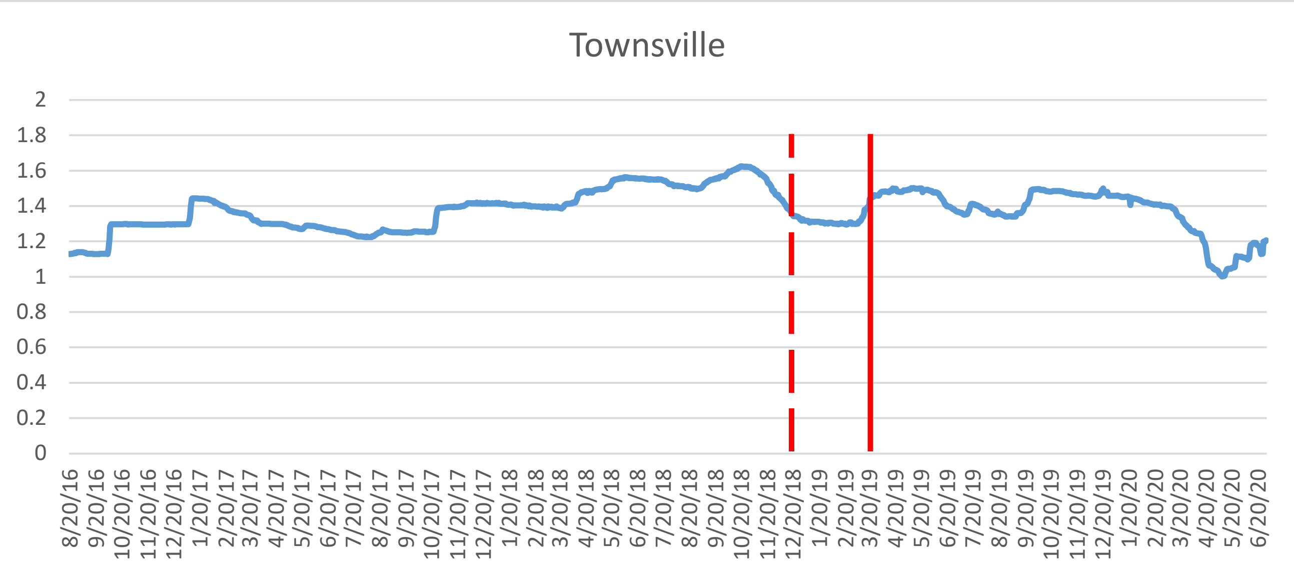

Figure B12: ULP 91 prices for Townsville LGA.

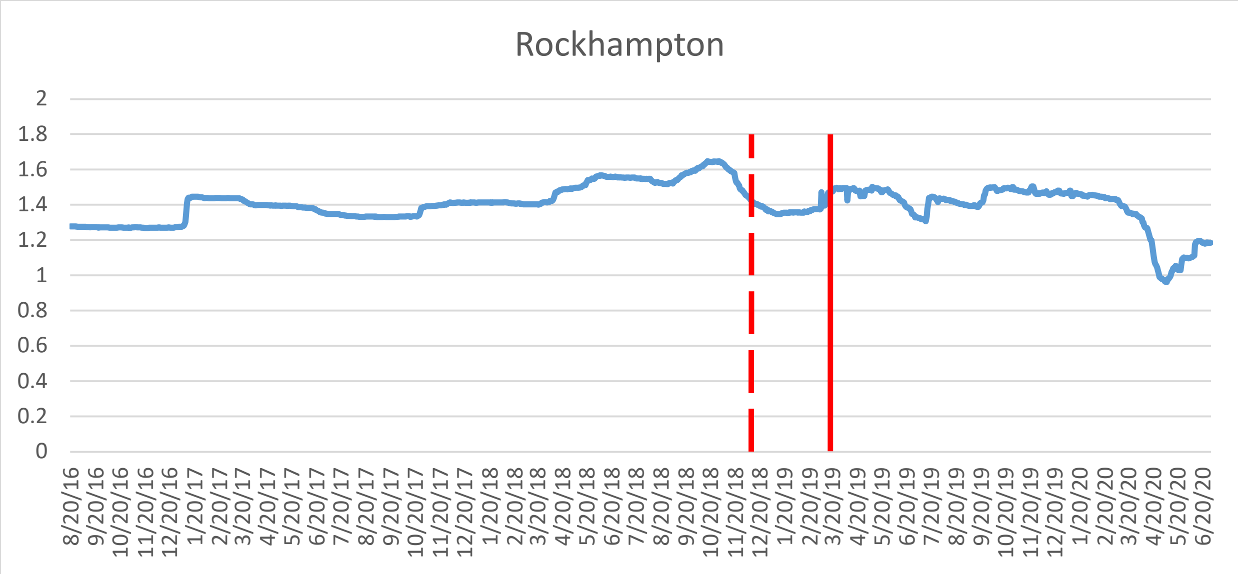

Figure B13: ULP 91 prices for Rockhampton LGA.

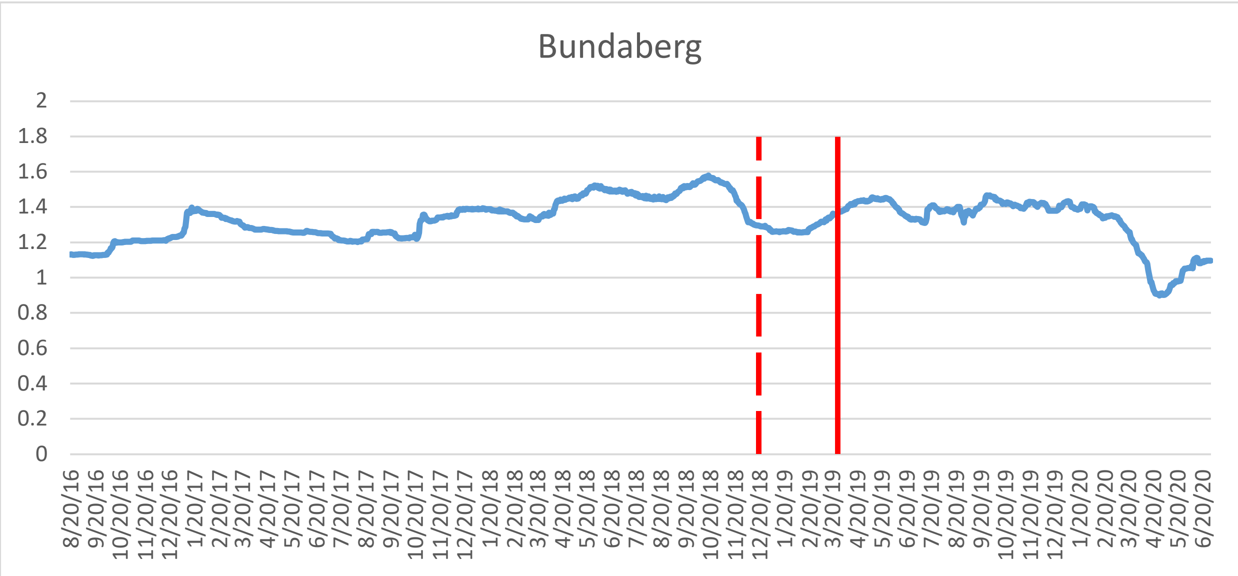

Figure B14: ULP 91 prices for Bundaberg LGA.

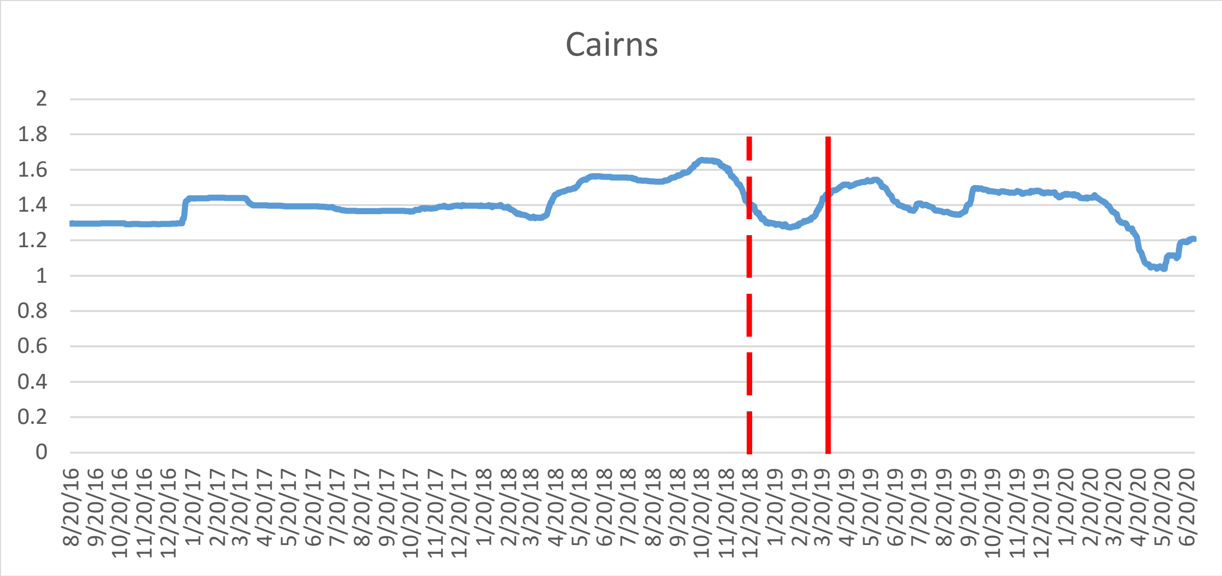

Figure B15: ULP 91 prices for Cairns LGA.

APPENDIX C: Trends in Price Dispersion across selected regions.

LGA level figures for ULP 91. Vertical (Y) axis refers to daily standard deviation, which represents the volatility in ULP 91 prices per region. Red dashed vertical line represents the trial commencement and the non-broken red vertical line represents the full compliance date.

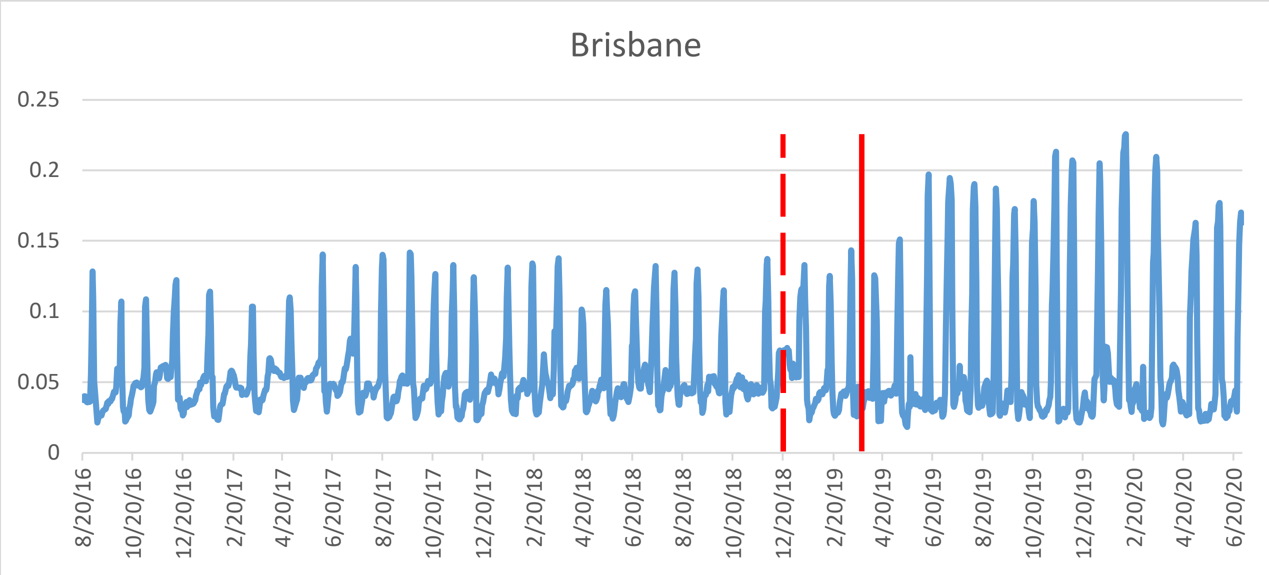

Figure C1: Standard deviation of daily prices for Brisbane LGA

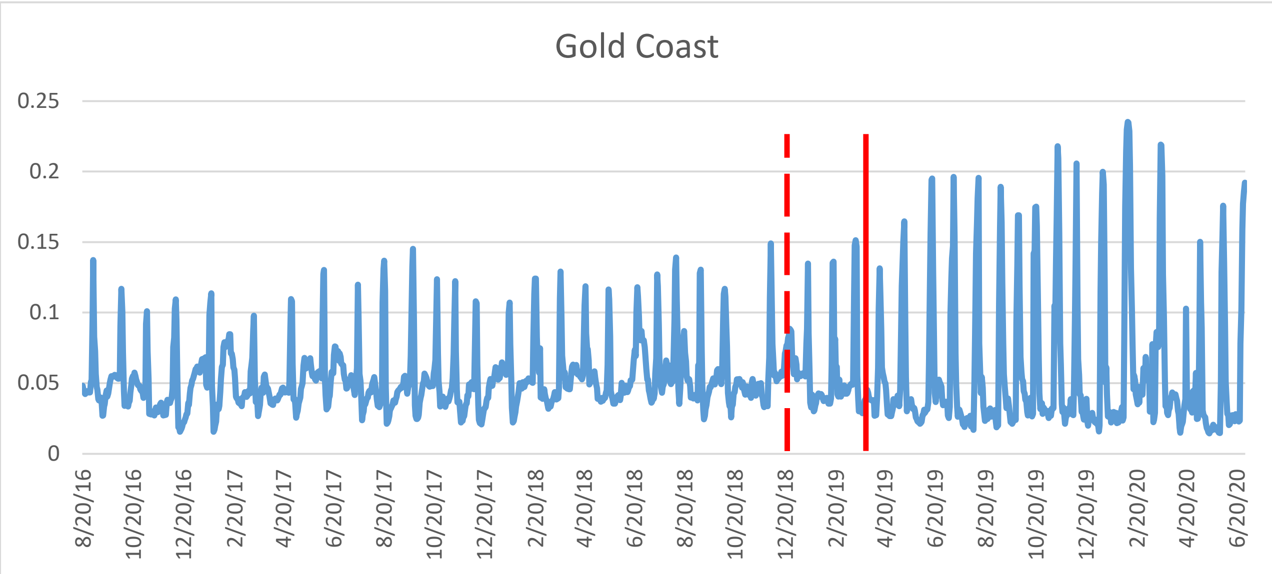

Figure C2: Standard deviation of daily prices for Gold Coast LGA

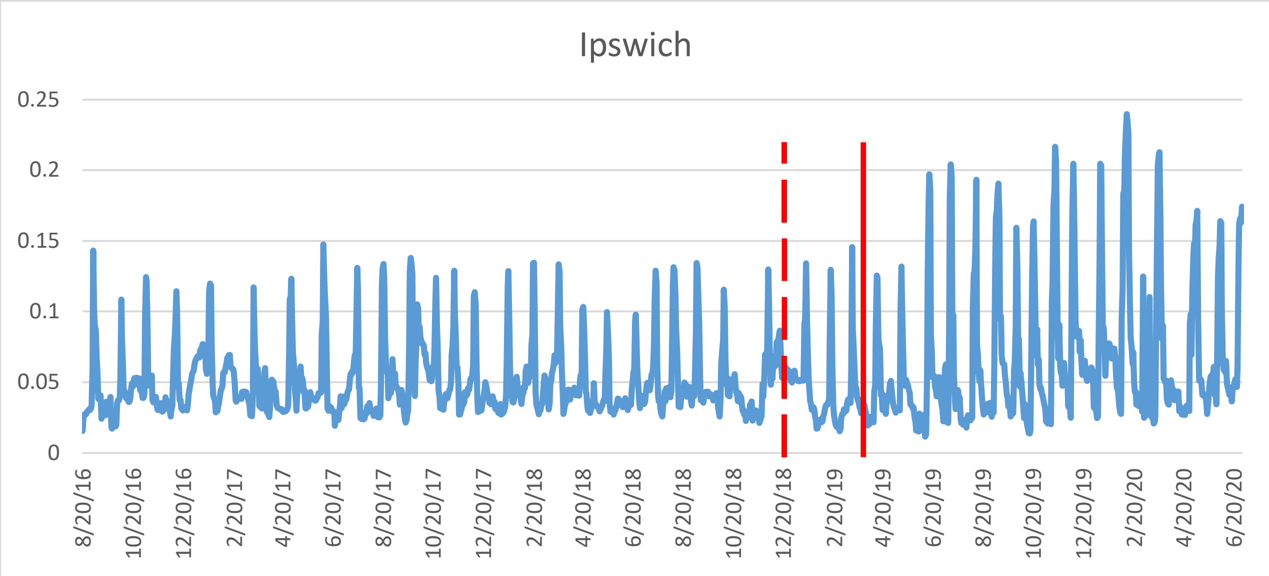

Figure C3: Standard deviation of daily prices for Ipswich LGA

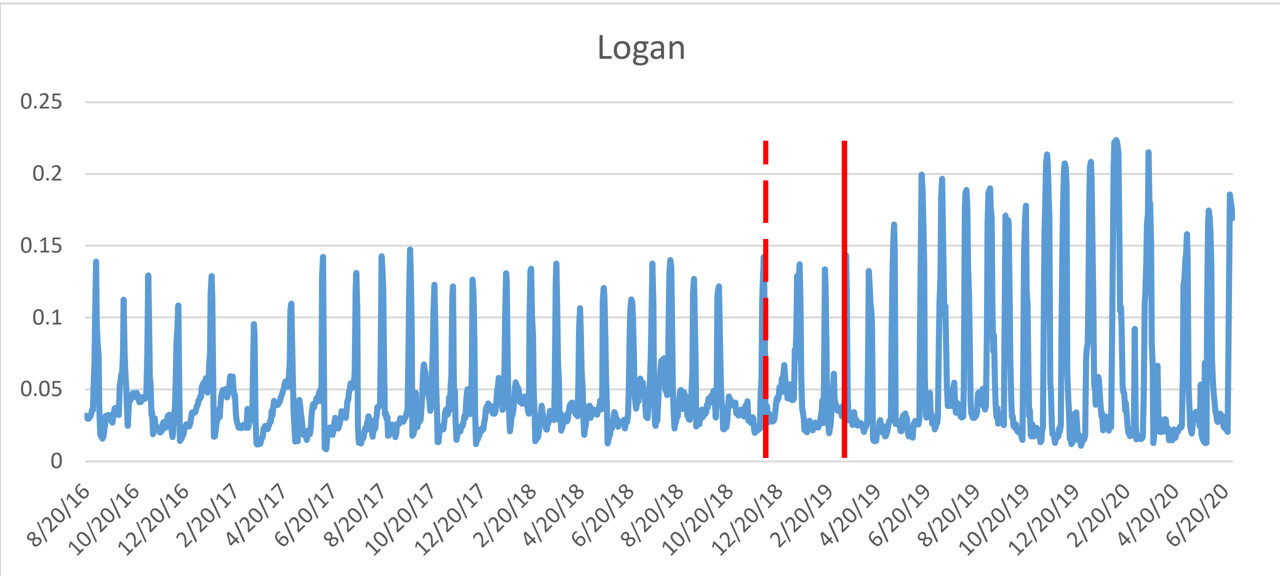

Figure C4: Standard deviation of daily prices for Logan LGA

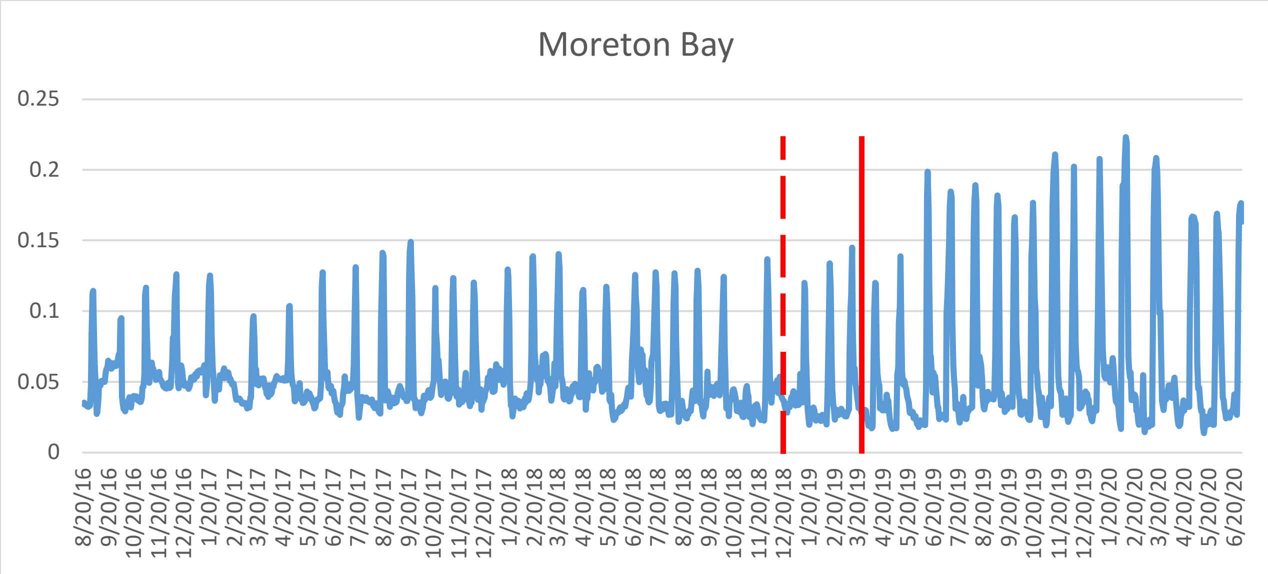

Figure C5: Standard deviation of daily prices for Moreton Bay LGA

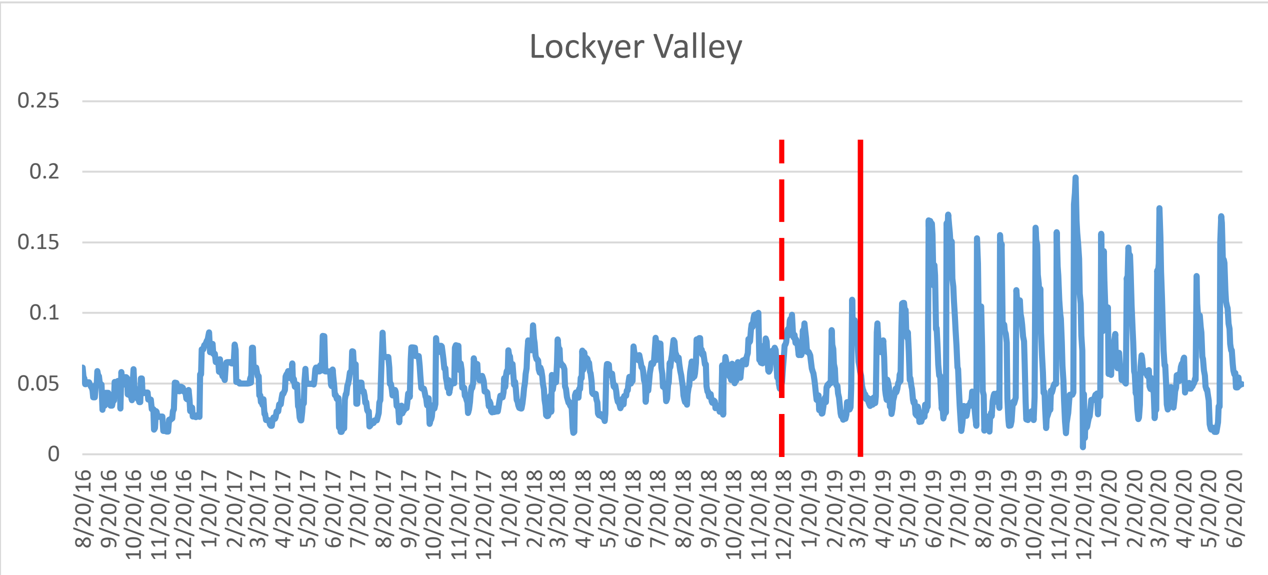

Figure C6: Standard deviation of daily prices for Lockyer Valley LGA

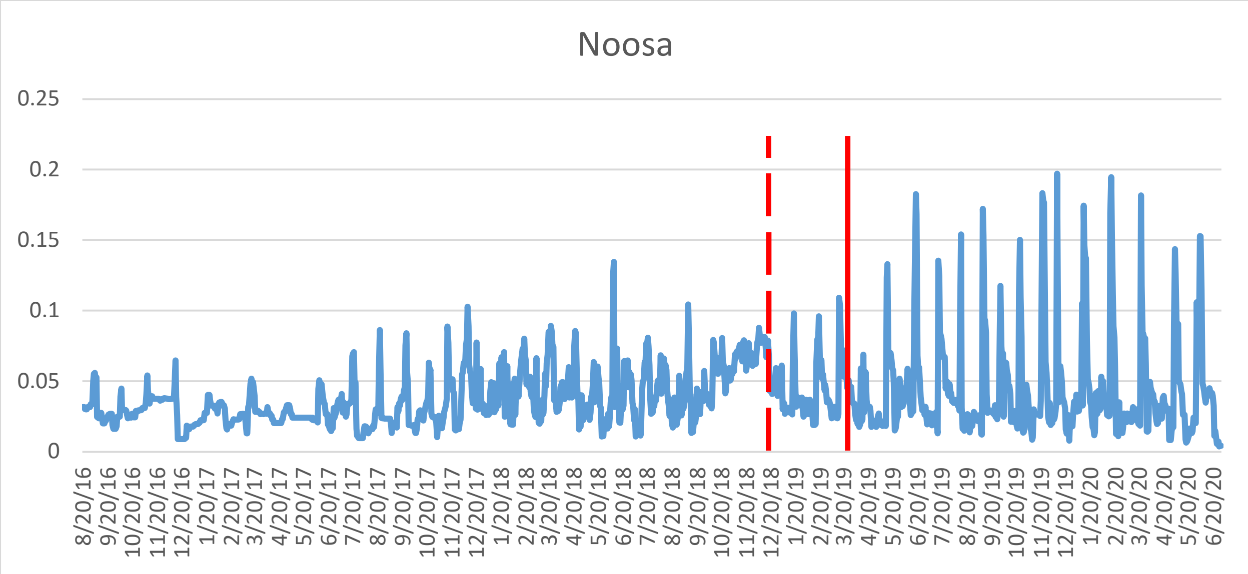

Figure C7: Standard deviation of daily prices for Noosa LGA

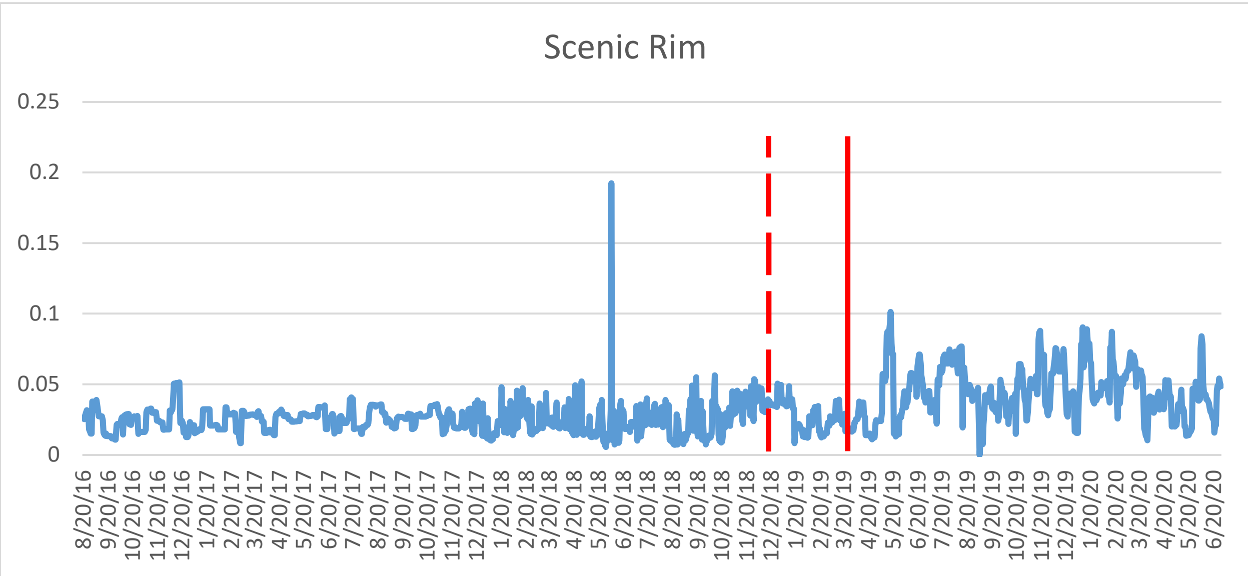

Figure C8: Standard deviation of daily prices for Scenic Rim LGA

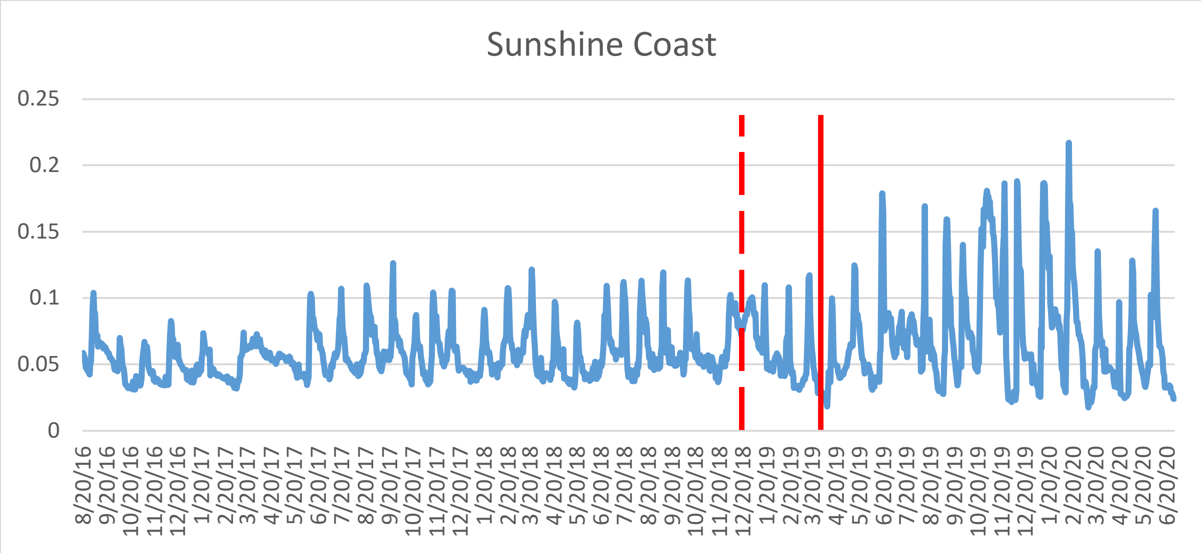

Figure C9: Standard deviation of daily prices for Sunshine Coast LGA

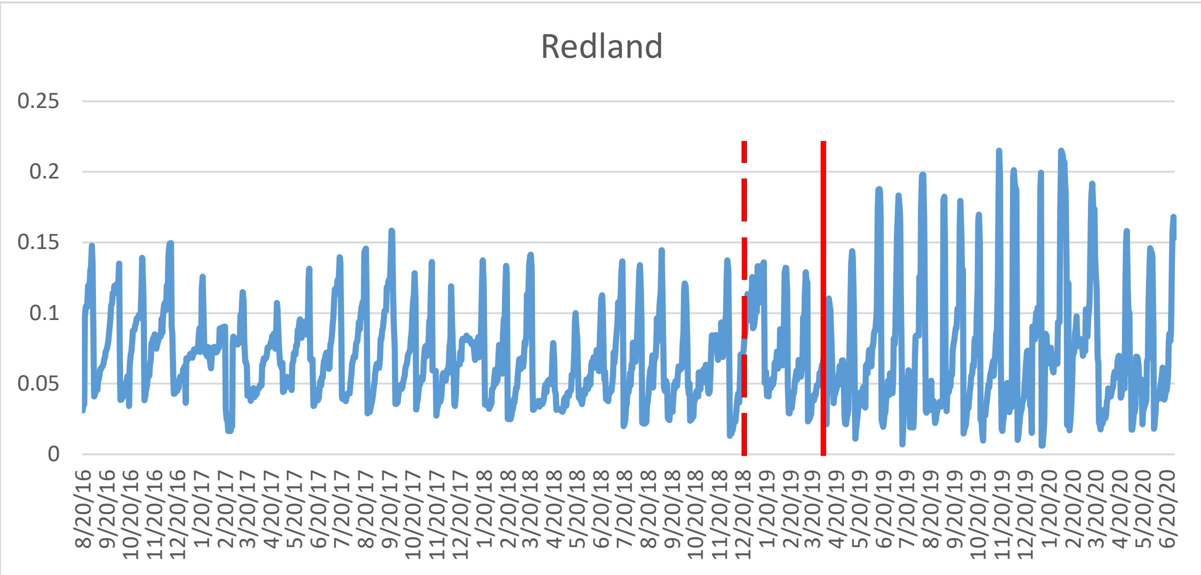

Figure C10: Standard deviation of daily prices for Redland LGA

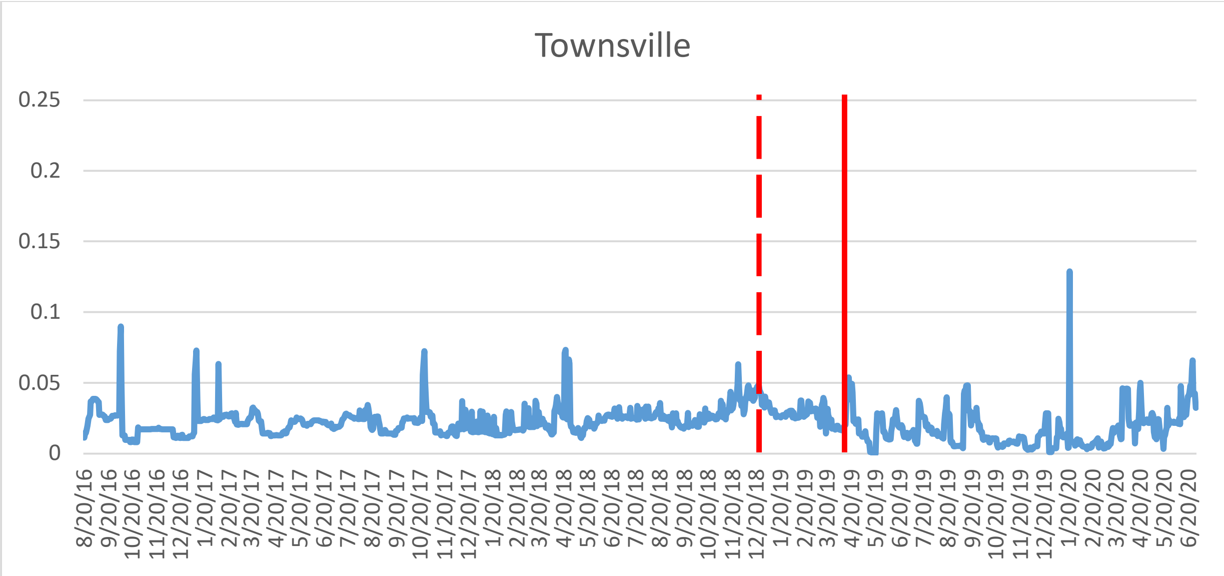

Figure C11: Standard deviation of daily prices for Townsville LGA

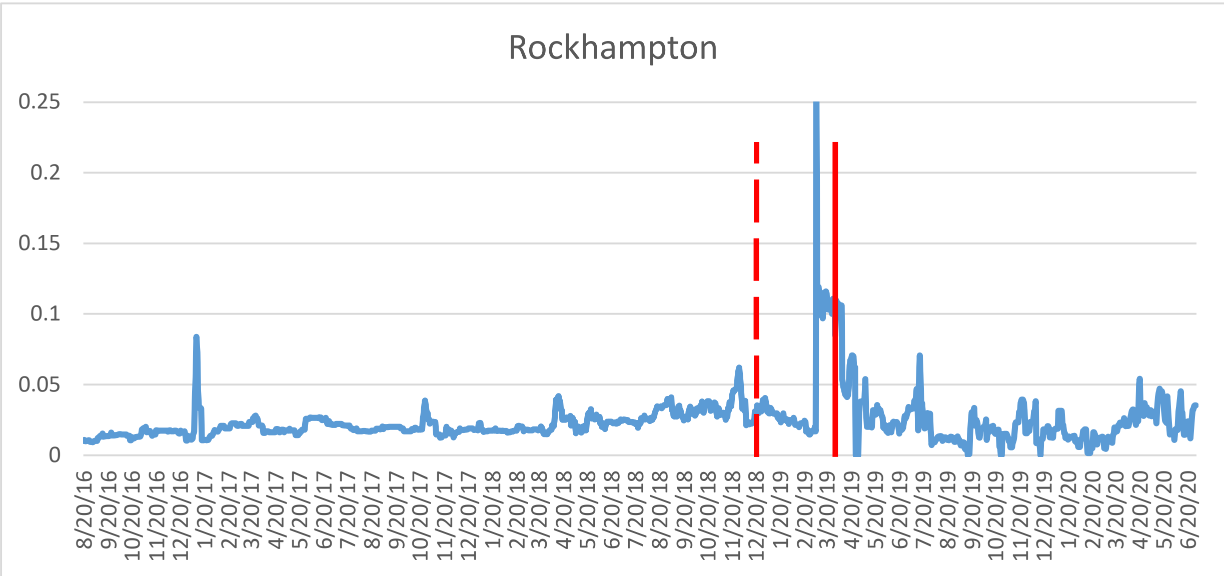

Figure C12: Standard deviation of daily prices for Rockhampton LGA

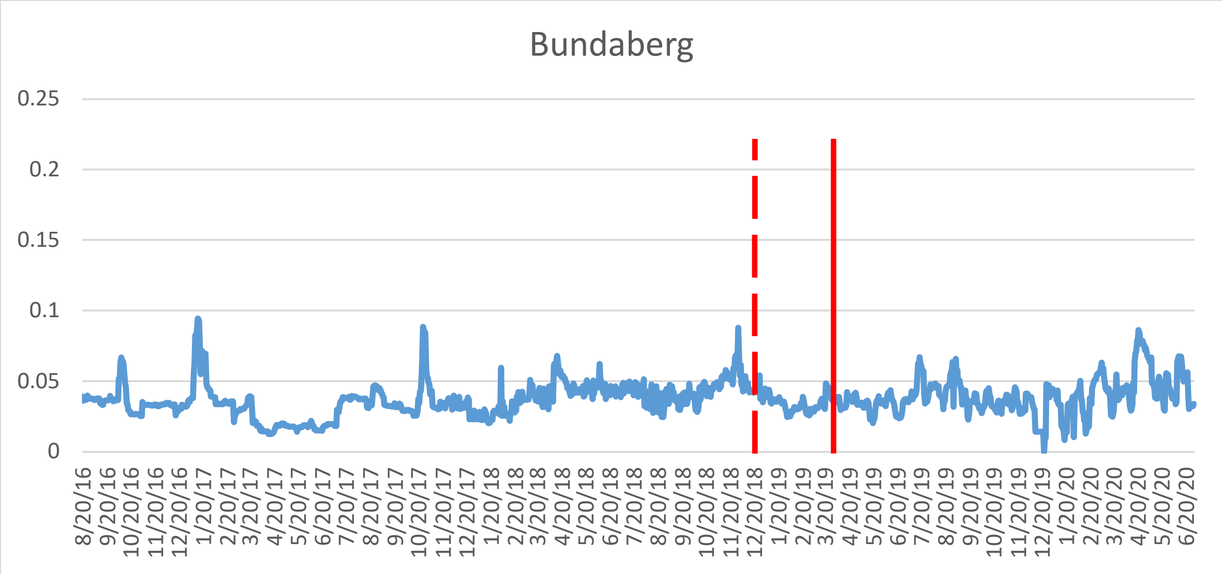

Figure C13: Standard deviation of daily prices for Bundaberg LGA

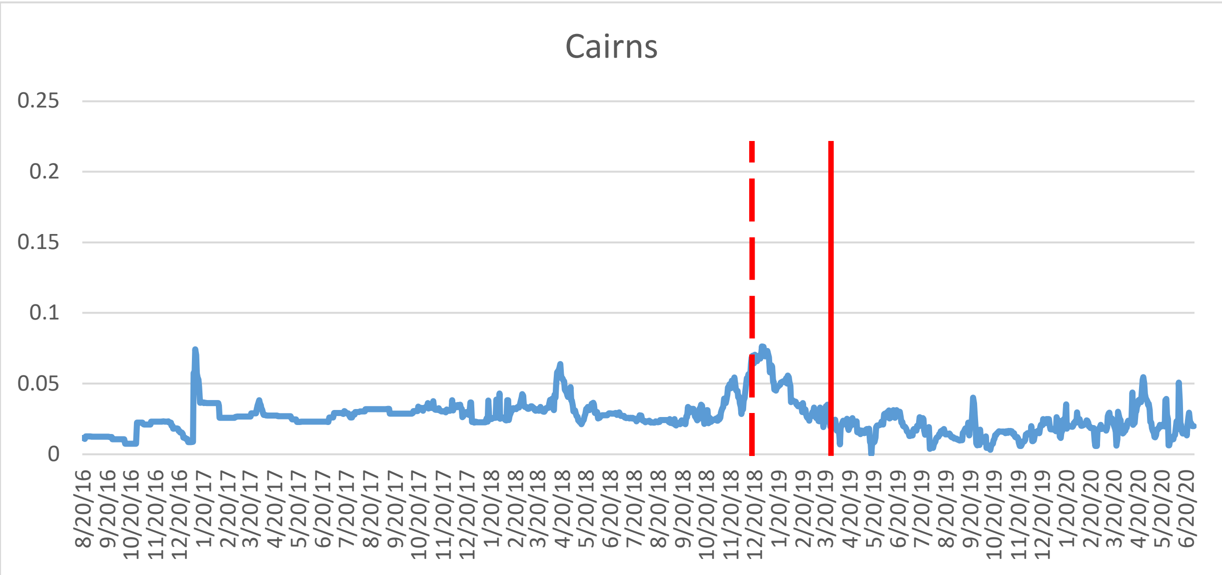

Figure C14: Standard deviation of daily prices for Cairns LGA

APPENDIX D: ARDL Model Results

Table D1: ULP 91 Results. ** and * refer to 5% and 10% levels of significance respectively.

LGA	Independent variable: Brent Price (with dummies)			
	Selected ARDL model using BIC	Existence of co-integration F statistic [95% interval]	Coefficient of dummy variable [P-value]	Policy effect
SEQ LGAs				
Brisbane	ARDL (2,0)	74.3126 [13.8688, 14.4201]	-.0040362** [.049]	Significant reduction in prices at 5% l.o.s
Gold Coast	ARDL (2,0)	65.3182 [13.8688, 14.4201]	-.0046962* [.080]	Significant reduction in prices at 10% l.o.s
Ipswich	ARDL (3,0)	60.1746 [13.8688, 14.4201]	-.0069637** [.021]	Significant reduction in prices at 5% l.o.s
Logan	ARDL (2,0)	59.0301 [13.8688, 14.4201]	-.0043459 [.102]	
Moreton Bay	ARDL (2,0)	65.3106 [13.8688, 14.4201]	-.0054816** [.025]	Significant reduction in prices at 5% l.o.s
Lockyer Valley	ARDL (2,0)	38.5065 [13.8688, 14.4201]	-.0042381* [.084]	Significant reduction in prices at 10% l.o.s
Noosa	ARDL (2,0)	48.7934 [13.8688, 14.4201]	-.0059454* [.017]	Significant reduction in prices at 10% l.o.s
Scenic Rim	ARDL (3,0)	45.2340 [13.8688, 14.4201]	-.0010655 [.311]	
Sunshine Coast	ARDL (2,0)	62.8451 [13.8688, 14.4201]	-.0028256 [.193]	
Redland	ARDL (3,0)	56.3424 [13.8688, 14.4201]	-.0066099** [.022]	Significant reduction in prices at 5% l.o.s
Average	ARDL (2,0)	83.2681 [12.5407, 13.0825]	-.0036079** [.028]	Significant reduction in prices at 5% l.o.s
Other LGAs				
Townsville	ARDL (3,0)	33.7032 [13.8688, 14.4201]	-.0011499 [.187]	
Rockhampton	ARDL (3,0)	36.9383 [13.8688, 14.4201]	-.6071E-3 [.499]	
Bundaberg	ARDL (3,0)	40.4736 [13.8688, 14.4201]	-.6848E-3 [.427]	
Cairns	ARDL (3,0)	32.7349 [13.8688, 14.4201]	-.0016048** [.011]	Significant reduction in prices at 5% l.o.s

Table D2: PULP Results. ** and * refer to 5% and 10% levels of significance respectively.

LGA	Independent variable: Brent Price (with dummies)			
	Selected ARDL model using BIC	Existence of co-integration F statistic [95% interval]	Coefficient of dummy variable [P-value]	Policy effect
SEQ LGAs				
Brisbane	ARDL (3,0)	71.0436 [13.8688, 14.4201]	-.0041098** [.043]	Significant reduction in prices at 5% l.o.s
Gold Coast	ARDL (3,0)	66.0285 [13.8688, 14.4201]	-.0046954* [.063]	Significant reduction in prices at 10% l.o.s
Ipswich	ARDL (3,0)	61.3615 [13.8688, 14.4201]	-.0071586** [.014]	Significant reduction in prices at 5% l.o.s
Logan	ARDL (3,0)	60.1071 [13.8688, 14.4201]	-.0045584* [.088]	Significant reduction in prices at 10% l.o.s
Moreton Bay	ARDL (3,0)	61.8216 [13.8688, 14.4201]	-.0057975** [.019]	Significant reduction in prices at 5% l.o.s
Lockyer Valley	ARDL (1,0)	34.9985 [13.8688, 14.4201]	-.0050877** [.094]	Significant reduction in prices at 5% l.o.s
Noosa	ARDL (2,0)	43.5446 [13.8688, 14.4201]	-.0056963** [.012]	Significant reduction in prices at 5% l.o.s
Scenic Rim	ARDL (1,1)	46.5861 [13.8688, 14.4201]	-.0015434 [.252]	
Sunshine Coast	ARDL (3,0)	58.2866 [13.8688, 14.4201]	-.0031062 [.148]	
Redland	ARDL (3,0)	54.5622 [13.8688, 14.4201]	-.0059940** [.034]	Significant reduction in prices at 5% l.o.s.
Average	ARDL(3,0)	71.2287 [12.5407, 13.0825]	-.0036147** [.029]	Significant reduction in prices at 5% l.o.s
Other LGAs				
Townsville	ARDL (3,0)	32.9542 [13.8688, 14.4201]	-.0013809 [.142]	
Rockhampton	ARDL (3,0)	36.2281 [13.8688, 14.4201]	-.8301E-3 [.459]	
Bundaberg	ARDL (1,0)	34.2795 [13.8688, 14.4201]	-.0014673 [.306]	
Cairns	ARDL (3,0)	35.1101 [13.8688, 14.4201]	-.0024336** [.005]	Significant reduction in prices at 5% l.o.s.

Table D3: E10 Results. ** and * refer to 5% and 10% levels of significance respectively.

LGA	**Independent variable: Brent Price (with dummies)**			
	Selected ARDL model using BIC	Existence of co-integration F statistic [95% interval]	Coefficient of dummy variable [P-value]	Policy effect
SEQ LGAs				
Brisbane	ARDL (2,0)	67.4270 [13.8688, 14.4201]	-.0043248* [.054]	Significant reduction in prices at 10% l.o.s
Gold Coast	ARDL (2,0)	62.0748 [13.8688, 14.4201]	-.0049314* [.083]	Significant reduction in prices at 10% l.o.s
Ipswich	ARDL (3,0)	60.2591 [13.8688, 14.4201]	-.0077540** [.015]	Significant reduction in prices at 5% l.o.s
Logan	ARDL (3,0)	62.0031 [13.8688, 14.4201]	-.0051049* [.071]	Significant reduction in prices at 10% l.o.s
Moreton Bay	ARDL (3,0)	62.1329 [13.8688, 14.4201]	-.0064162** [.018]	Significant reduction in prices at 5% l.o.s
Lockyer Valley	ARDL (3,0)	41.8947 [13.8688, 14.4201]	-.0064386* [.062]	Significant reduction in prices at 10% l.o.s
Noosa	ARDL (2,0)	48.8902 [13.8688, 14.4201]	-.0090160** [0.007]	Significant reduction in prices at 5% l.o.s
Scenic Rim	ARDL (1,0)	45.4496 [13.8688, 14.4201]	-.0046722* [0.075]	Significant reduction in prices at 10% l.o.s.
Sunshine Coast	ARDL (2,0)	62.1133 [13.8688, 14.4201]	-.0034743 [.165]	
Redland	ARDL (3,0)	61.6685 [13.8688, 14.4201]	-.0071267** [.017]	Significant reduction in prices at 5% l.o.s
Average	ARDL(2,0)	80.1752 [12.5407, 13.0825]	-.0039826** [.027]	Significant reduction in prices at 5% l.o.s
Other LGAs				
Townsville	ARDL (3,0)	30.4582 [13.8688, 14.4201]	-.0016058 [.179]	
Rockhampton	ARDL (2,0)	37.8765 [13.8688, 14.4201]	-.4666E-3 [.657]	
Bundaberg	ARDL (2,0)	34.7220 [13.8688, 14.4201]	-.8566E-3 [.476]	
Cairns	ARDL (3,0)	33.5065 [13.8688, 14.4201]	-.0022094** [.025]	Significant reduction in prices at 5% l.o.s.

Table D4: Diesel Results. ** and * refer to 5% and 10% levels of significance respectively.

LGA	Independent variable: Brent Price (with dummies)			
	Selected ARDL model using BIC	Existence of co-integration F statistic [95% interval]	Coefficient of dummy variable [P-value]	Policy effect
SEQ LGAs				
Brisbane	ARDL (3,0)	47.8102 [13.8688, 14.4201]	-.2984E-4 [.951]	
Gold Coast	ARDL (1,0)	54.5630 [13.8688, 14.4201]	.1603E-3 [.776]	
Ipswich	ARDL (3,0)	41.5865 [13.8688, 14.4201]	.4723E-3 [.512]	
Logan	ARDL (1,0)	50.2233 [13.8688, 14.4201]	-.1283E-3 [.839]	
Moreton Bay	ARDL (3,0)	48.9486 [13.8688, 14.4201]	-.1157E-3 [.842]	
Lockyer Valley	ARDL (2,0)	58.6331 [13.8688, 14.4201]	-.5498E-3 [.401]	
Noosa	ARDL (2,0)	69.0795 [13.8688, 14.4201]	-.4930E-3 [.468]	
Scenic Rim	ARDL (2,0)	53.2845 [13.8688, 14.4201]	-.5934E-3 [.416]	
Sunshine Coast	ARDL (2,0)	58.9939 [13.8688, 14.4201]	-.4936E-3 [.405]	
Redland	ARDL (3,0)	28.3370 [13.8688, 14.4201]	-.8807E-3 [.461]	
Average	ARDL (3,0)	62.4341 [12.5407, 13.0825]	-.5161E-4 [.898]	
Other LGAs				
Townsville	ARDL (1,0)	33.1421 [13.8688, 14.4201]	.2596E-3 [.726]	
Rockhampton	ARDL (2,0)	50.6838 [13.8688, 14.4201]	.4037E-3 [.610]	
Bundaberg	ARDL (2,0)	52.1449 [13.8688, 14.4201]	.2811E-3 [.657]	
Cairns	ARDL (2,0)	42.0487 [13.8688, 14.4201]	-.0013383** [.031]	Significant reduction in prices at 5% l.o.s

APPENDIX E: Savings from Greater Price Dispersion: Method

Daily price minima and maxima per area of interest was identified and the mean was subsequently estimated. A visual inspection of minimum and maximum curves allowed for the removal of unrealistic low and high price points (outliers) that could have arisen out of input errors. In the case of missing observations, an assumption was made that in time periods where no price changes were reported, the price remained unchanged from the last reported price change. These removals were validated by investigating the length of time these prices remained unchanged, and in all cases, they occurred within a 2-hour window. This resulted in the removal of 15 price points.

An average unleaded petrol passenger vehicle in Southeast Queensland uses 1123.5 litres per annum (see Section 4.2 on the sourcing of this figure). We estimated 26 annual fuel stops (i.e. fortnightly fill-ups) resulting in 43.21 litres being pumped every fortnight. Daily simulations were executed using this amount of fuel at minimal, mean and maximal price point.

14 series were created, each containing 26 petrol station visits. Series 1 starts with fuel purchase being undertaken on day 1, followed by day 15, day 29 and so forth. Series 2 started with day 2, then day 16 and so forth. This resulted in 14 set of 26 simulated petrol purchases at daily minimum, maximum and mean prices.

These simulated purchases were summed to create 14 minima, maxima and mean yearly fuel expenditures. These prices were averaged across the 14 sets to create average minima yearly fuel expenditure, average maxima yearly fuel expenditure and average mean yearly fuel expenditure.

Realistic savings was calculated by subtracting this average mean yearly fuel expenditure with average minima yearly fuel expenditure.

APPENDIX F: Consumer Surplus Calculations and Explanations

Explanation 1

According to the ABS, the total distance travelled within Brisbane using passenger vehicles is 15,490,000,000 kilometres. Approximately 80.75% of passenger vehicles in Queensland use petrol as opposed to diesel, LNG and hybrid fuels, (Table 5, Cat. No. 9208.0).

We assume the same proportion for Brisbane. Thus, we estimate total kilometres for petrol driven passenger vehicles in Brisbane to be 15,490,000,000*0.8075 = 12,508,175,000 kilometres.

Given this information and the volume breakdown provided by the DNRME we estimate total kilometres travelled for ULP users to be 12,508,175,000*0.5576 = 6,974,558,380. For PULP, this would be 12,508,175,000*0.2639 = 3,300,907,382.5 kilometres and 12,508,175,000*0.1786 = 2,233,960,055 for E10 users.

This would yield a total consumer surplus of $7,656,841.81, consisting of 6,974,558,380*0.107*0.0055 = $4,104,527.61 for ULP users, 3,300,907,382.5*0.107*0.0062 = $2,189,821.96 for PULP users and 2,233,960,055*0.107*0.0057 = $1,362,492.24 for E10 users.

Explanation 2

19,434,000,000*0.8075 = 15,692,955,000 kilometres for petrol. Delineated by petrol type, this is 15,692,955,000*0.5576 = 8,750,391,708 kilometres for ULP, 15,692,955,000*0.2639 = 4,141,370,824.5 kilometres for PULP users and 15,692,955,000*0.1786 = 2,802,761,763 kilometres for E10 users.

The consumer surplus figure is aggregated from the following:

ULP: 8,750,391,708*0.107*0.0055 = $5,149,605.52

PULP: 4,141,370,824.5*0.107*0.0062 = $2,747,385.40

E10: 2,802,761,763*0.107*0.0057 = $1,709,404.40

Thus adding up to $9,606,395.32.

Explanation 3

To get total consumer surplus we need to estimate the average per annum kilometres covered by passenger vehicles in Southeast Queensland in this time. However, only information for Brisbane is available from Table 27 of Cat. No. 9208.0. While not ideal, this report also incorporates total kilometres travelled outside the capital city (within a 100 kilometres of base) using passenger vehicles (11,388,000,000 kilometres*0.8075 = 9,195,810,000).

Using ABS population data from Table 3 of Cat. No. 3218.0 (ABS, 2019a), we weight this latter figure to encapsulate the share of the non-Brisbane Southeast Queensland population relative to the rest of Queensland.

Given our non-Brisbane Southeast Queensland population is 2,222,360 and the rest of Queensland is 1,557,251, this gives non-Brisbane Southeast Queensland a weighting of 0.59.

Multiplying this (i.e. 0.59) by 11,388,000,000 yields 5,425,527,900 kilometres. Thus, the total kilometres travelled in Southeast Queensland (including Brisbane's 12,508,175,000 obtained in Explanation 1) is estimated at 17,933,702,900 kilometres.

Explanation 4

We estimate total kilometres travelled for ULP users to be 17,933,702,900*0.5576 = 9,999,832,737.04. For PULP, this would be 17,933,702,900*0.2639 = 4,732,704,195.31 and 17,933,702,900*0.1786 = 3,202,959,337.94 for E10 users.

This would yield a total consumer surplus of $9,844,506.96 consisting of:

ULP users: 9,999,832,737.04*0.107*0.0049 =$5,242,912.30

PULP users: 4,732,704,195.31 *0.107*0.0055 = $2,785,196.42, and

E10 users: 3,202,959,337.94 *0.107*0.0053 = $1,816,398.24.