final report

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FINAL REPORT Economic Assessment of Commonwealth and State Biofuel Policies

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Executive summary

The objectives of this project were to determine the market impact and influences of biofuel mandates on the feedlot sector and the broader Australian community.

The current state of play in the Australian biofuels industry and interactions with agriculture are presented. This material is accompanied by a detailed history of Commonwealth, Queensland and New South Wales biofuels policies and governments' justifications for these policies. The justifications are critically analysed.

ACIL Allen Consulting Pty Ltd (ACIL Allen) examined the economic impact of biofuels policy and its interactions at state and national levels through a comprehensive literature review and qualitative economic analysis (economic reasoning). In addition, it used these techniques and econometric modelling to determine the impact of biofuels mandates on feed grain prices using available data. Official data was available up to 2016-17 and ACIL Allen forecasted estimates out to December 2017. It should be noted that the Queensland mandate was not introduced until 1 January 2017. This means that any findings regarding the effects in Queensland are preliminary, and a longer data time series is needed to verify what the impacts will be on sorghum, sugar cane and/or wheat starch. Further, climatic conditions have recently changed, and parts of New South Wales and Queensland are now in drought. This effect is not captured in this analysis due to lack of data for the period after 30 June 2017.

The key findings of the analysis are summarised below.

With regard to the scale of the Australian biofuels sector and its relative importance, findings of the analysis follow. These findings were based on data available at the time of writing the report.

- Australia is a very small producer of biofuels, accounting for 0.2 per cent of world bioethanol production and 0.1 per cent of world biodiesel production.
- The Australian biofuels industry consists of three fuel ethanol producers and two biodiesel producers.
- The industry is dominated by one ethanol producer, the Manildra Group, which accounts for about 74 per cent of domestic fuel ethanol supply of around 250 million litres per year.
- Total biodiesel production is around 15-20 million litres per year.
- The biofuels industry in Australia has been estimated to use less than 0.5 per cent of grain produced.
- The gross value of production of the Australian biofuels industry was just $166 million in 2016-17.
- In contrast, the feedlot industry had a gross value of production of $2.5 billion in 2016-17.
- 2016-17 was a record year for grain production in Australia, and it was the ninth successive year in which grain production was not inhibited by drought.
- After meeting domestic feed requirements (currently at 13 million tonnes), as well as flour, malt, and ethanol production, it was forecast that the grain surplus would be in the order of 28 million tonnes.
- There was considerable grain available not only for domestic consumption, livestock feed and ethanol production, but also for exports.
- Subsequently, drought conditions have prevailed, but official data regarding effects of the drought were not available.

With respect to the potential environmental and human health benefits of including 10 per cent ethanol in petrol-based fuel or 5 per cent biodiesel in diesel fuel, it was found that:

- the extent of any climate change benefit remains unresolved with estimates ranging from small positive effect to large negative effect
- the cost of achieving optimistic estimates of climate change benefits through government support is very high
- any health benefits are minimal.

The econometric analysis of the effects of biofuels mandates on feed grain prices was undertaken to identify the existence of any valid statistical relationships between domestic wheat and sorghum feed grain prices and the establishment of the New South Wales and Queensland mandates. Separate models were estimated for Riverina wheat prices and Darling Downs sorghum prices. They used indicator variables to denote the time when the mandates were deemed to be in operation, as well as the ethanol-blended fuel share of total automotive fuel sales, to estimate whether there is a general relationship between the use of ethanol in petrol-based fuel and feed grain prices.

This analysis showed there is very little compelling evidence to suggest that the introduction of biofuel mandates in New South Wales and Queensland had any significant impact on the price of domestic feed grains. It is clear that the New South Wales mandate has not affected the wheat price.

The effect of the Queensland mandate on the sorghum price is less clear. This is because the data display an increase in the uptake of ethanol in the lead up to the introduction of the mandate, at the same time as a significant fall in domestic sorghum production, and an increase in the domestic sorghum price relative to the international price. Additional data are required to determine if the price premium for domestic sorghum will persist even after domestic production returns to normal.

However, the additional 117.7 kilo tonnes required to meet the 3 per cent mandate in Queensland and 193.1 kilo tonnes required for the 4 per cent mandate represent 11.5 per cent and 19.0 per cent respectively of Australian sorghum production in 2016-17. This shows that sorghum use for biofuels is not a high proportion of sorghum production. In fact, most sorghum is exported and Australia is a ‘price taker’ in international markets. In this context it is hard to imagine there would be upward pressure on sorghum prices, with the exception of limited supply in a drought year. The Queensland mandate increased to 4 per cent on 1 July 2018. Data are currently unavailable for the subsequent time period and an assessment as to whether or not the ethanol industry has consumed more sorghum, sugar cane or wheat starch (or a combination of the three) is not yet known.

Given data availability and limitations, ACIL Allen conducted qualitative economic analysis of the effects of biofuels tax concessions and mandates in Australia and the targets and justifications for protection of the Australian biofuels industry. This analysis assessed the various policy instruments based on economic efficiency, administrative efficiency, and equity. The main results of this analysis at a Commonwealth level were as follows:

- Commonwealth policies of concessionary taxation of domestically-produced biofuels cannot be regarded as fair as most of the gains accrue to owners of single entity that employs a relatively small number of people.
- It is clear that such a taxation regime is not economically efficient as it creates an excess burden or deadweight loss by reallocating resources from economic activities to uneconomic activities.

The Commonwealth Government’s biofuels tax regime performs poorly in terms of its own nominated assessment principles of:

- *equity* – fairness in the distribution of the tax burden
- *economic efficiency* – imposing the lowest possible cost on the economy over and above the revenue raised
- *simplicity* – a tax system that is easy to understand and comply with.

At a State level, it is difficult to reconcile the Queensland and New South Wales Governments' justifications for its biofuels mandate with assessment criteria for designing and assessing regulatory actions by government that have been endorsed by those governments and are similar to those nominated by the Commonwealth. There is no sound case for government intervention in the form of a biofuels mandate.

Further:

- the mandates in New South Wales and Queensland may not have been binding as ethanol's market share has followed a downward trend in New South Wales and Queensland despite introduction and tightening of the mandates
- New South Wales and Queensland mandates have resulted in only marginal increases, at most, in consumption and production of ethanol.

The implications of this work for the Australian feedlot sector and the broader Australian community are as follows:

- Australian biofuels policies have resulted in significant nett social cost to the broader Australian community, which includes the Australian feedlot sector.
- Given current data, it does not appear that current biofuels policies are having a negative impact on the Australian feedlot sector through the price of grain for feed. Further analysis is desirable, using a reasonably long data time series after introduction of the Queensland mandate, and taking into account a prolonged drought period.
- Even if Australian biofuels policies were greatly strengthened to be more like those in the United States and Europe that shifted domestic and international grain and oil seed prices, and fuel prices, the much smaller Australian economy would remain a price taker in those markets.

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1 Introduction

New South Wales and Queensland Governments have mandated blending of unleaded petrol and diesel fuel with biofuels. Unfortunately, the effects of biofuels policy on the broader community are not well understood.

Mandates should be considered in the context of subsidy or tax rebate policies of the Commonwealth Government, as economic effects of biofuels policies can differ significantly between the mandate-only case and the combined policy case.

Biofuels mandates, in conjunction with Commonwealth protection of domestic biofuels production, raise the cost structure of the economy, particularly in industries that use transport services intensively. They also raise costs in sectors that compete directly or indirectly with biofuels industries for inputs characterised by costs that rise with output. Lot-feeding is a prime example of an industry in that category. Jobs created in the biofuels industry are likely to be more than offset by destruction of jobs in other activities that are disadvantaged by higher costs and higher taxes resulting from support for biofuels production. Also, the economic and budget cost of creating each direct job in the biofuels industry is extraordinarily high. Moreover, existing biofuels policies in the US and Europe have been shown to raise consumers' costs of living through increases in prices of fuel, food, and transport-intensive non-food products.

The rest of this report is structured as follows:

- Section 2 – Background
- Section 3 – Project Objectives
- Section 4 – Methodology
- Section 5 – Analysis and Results
- Section 6 – Conclusions / Recommendations
- Section 7 – Key Messages
- Section 8 – Bibliography

2 Background

This section examines the current state of play in the Australia biofuels industry and interactions with agriculture. It then presents a detailed review of the history of biofuels policy in Australia, Queensland and New South Wales.

2.1 What Are Biofuels?

Biofuels are liquid or gaseous fuels manufactured from plant material or biomass. Biofuels can be categorised by the chemical composition of the product, the type of feedstock used, and the process used for fuel generation. Ethanol and biodiesel are the most common biofuels.

Ethanol is ethyl alcohol, the intoxicating constituent of alcoholic drinks. It can be used as a substitute for petrol (motor spirit). It can be blended with petrol. Modern petrol engines tuned for 91 research octane number (RON) or regular unleaded petrol can use fuel consisting of up to 10 per cent ethanol blended with 91 RON petrol (E10), without modification. If engines are tuned for 95 RON (premium unleaded) petrol, they can use a blend of up to 10 per cent ethanol with 95 RON petrol, without modification.

Ethanol's energy content is about 68 per cent of the energy content of petrol. Consequently, fuel consumption per litre is about 3.3 per cent higher if E10 is used instead of straight petrol.

Ethanol is a higher-octane fuel than petrol. In an E10 blend with regular unleaded petrol, it raises the fuel's RON from 91 to 94. It lifts the fuel's motor octane number (MON) from 81 to 82 or 83. By way of comparison, the RON standard for premium unleaded petrol is 95 and the MON standard is 85.

Claims that inclusion of 10 per cent ethanol petrol-based fuel would provide health and climate change benefits have been disputed in the context of considerable debate. It has been shown that any health benefits are minimal, as articulated in sub-section 5.4.5. The extent of climate change benefits remains unresolved, but it has been shown that the cost of achieving them through government support is very high. This has been explained in sub-section 5.4.6.

In Australia, the fuel ethanol industry is based on "first-generation" processes involving fermentation of sugars and starches.[*] These are mature or well-developed technologies, some which have been in use for centuries. Feedstocks are crops that are also grown for food for humans or animals, such as corn (maize), wheat, sorghum, and sugar cane or beet. Australian fuel ethanol is produced from sorghum grain (Dalby, Qld), waste material from starch and gluten production from wheat (Nowra, New South Wales), and the sugar production by-product, molasses (Sarina, Qld).

Biodiesel is currently produced commercially from the trans-esterification of plant and animal oils and fats. It involves chemically reacting alcohol (usually ethanol or methanol) with the oils. Catalysts (acids and/or bases) are used to speed up the reaction. Biodiesel consists mainly of fatty acid methyl or ethyl esters. It is similar in composition to conventional diesel.

The energy content of biodiesel has been estimated by various sources to be around 0.91 to 0.93 of the energy content of petroleum-based diesel. The energy content depends on the feedstock.

Claims that inclusion of 5 per cent biodiesel in diesel fuel would provide health and climate change benefits have been contested. Health effects have been found to minimal or negative, as explained in sub-section 5.4.5. To the extent that climate change benefits exist, the cost of achieving them through government support has been shown to be very high, as documented in sub-section 5.4.6.

2.2 Australian Biofuels Industry

Australia is a very small producer of biofuels, accounting for 0.2 per cent of world bioethanol production and 0.1 per cent of world biodiesel production. In 2016-2017, biofuels contributed only 0.5 per cent of the total liquid and gaseous transport fuel energy mix in Australia (APAC Biofuel Consultants, 2017).

[*] Second-generation ethanol production includes processing technologies that are currently under development for production of biofuel from alternative non-food biomass, such as straw, woodchips, and perennial grasses. These cellulosic ethanol technologies are not new. They have been under development for more than four decades, but commercialisation of second-generation ethanol production on a large scale has not eventuated to date. Third-generation biofuels refer to the production of fuels from other novel technologies and plant breeding programs. For example, genetic modification of plants may allow direct production of biodiesel from oil producing plants or algae, saving manufacturing costs and reducing land requirements. Residue may be further processed to produce ethanol. There is a significant amount of research being directed towards these technologies globally, but the cost of production from these processes is still significantly higher than for comparative products from technologies currently in commercial use.

The Australian biofuels industry consists of three fuel ethanol producers and two biodiesel producers. The industry is dominated by one ethanol producer, the Manildra Group, which accounts for about 74 per cent of fuel ethanol supply of around 250 million litres per year. Total biodiesel production is around 15-20 million litres per year (APAC Biofuel Consultants, 2017[†]; Australian Government, Department of Environment and Energy, 2018b).

2.2.1 Ethanol

Ethanol Policy

The Commonwealth Government has fostered domestic ethanol production through excise and customs duty arrangements that discriminate heavily in favour of domestically-produced fuel ethanol and against ethanol imports and domestically-produced and imported refined liquid petroleum products. It began to reduce the extent of the protection of domestic fuel ethanol production from 1 July 2016.

In 2007, the New South Wales Government introduced an ethanol blend mandate. Subsequently, the mandated percentage of ethanol in petrol was raised twice. The mandate was also tightened in other ways. The evolution and settings of the New South Wales policy are outlined in sub-section 2.4.3. Queensland applied a blend mandate in 2017. The Queensland policy regime is outlined in sub-section 2.4.2. New South Wales and Queensland launched advertising campaigns in the second half of 2016 and in 2017 to reinforce tightening and introduction of a mandate, respectively.

Ethanol Consumption

Consumption of fuel ethanol in Australia peaked in August 2010 around 30 million litres for the month. Since that time, consumption has trended down. It was down to 17.6 million litres in June 2016, recovered to 25.5 million litres in December 2017 in the wake of mandate and advertising initiatives in New South Wales and Queensland, and then the downward trend resumed. Fuel ethanol consumption in March 2018 was 20.3 million litres (Australian Government, Department of Environment and Energy, 2018b).

For the last few years, consumption of petrol-based fuels (petrol and petrol-ethanol blends) in Australia has been approximately static. Ethanol's share of this market has trended down. It was 1.84 per cent in August 2010, 1.77 per cent in 2010-11, 1.27 per cent in 2015-16, 1.26 per cent in 2016-17, and 1.3 per cent in March 2018 (Australian Government, Department of Environment and Energy, 2018b).

Figure 1 shows the total demand for automotive petrol-based fuel in Queensland and New South Wales over the last 7 years. An amount of one million litres is shown as ML on the vertical axis.

An interesting feature of this chart is that the demand for petrol-based fuel in Queensland and New South Wales has remained fairly stable over time, despite the fact there has been significant population growth and growth in the number of motor vehicles. This is largely due to increases in the fuel efficiency of motor vehicles and switching towards diesel-fuelled motor vehicles.

† This report is not publicly available and was provided to ACIL Allen Consulting by MLA. The report can be purchased from: http://www.eccoaustralia.com/biofuels.html.

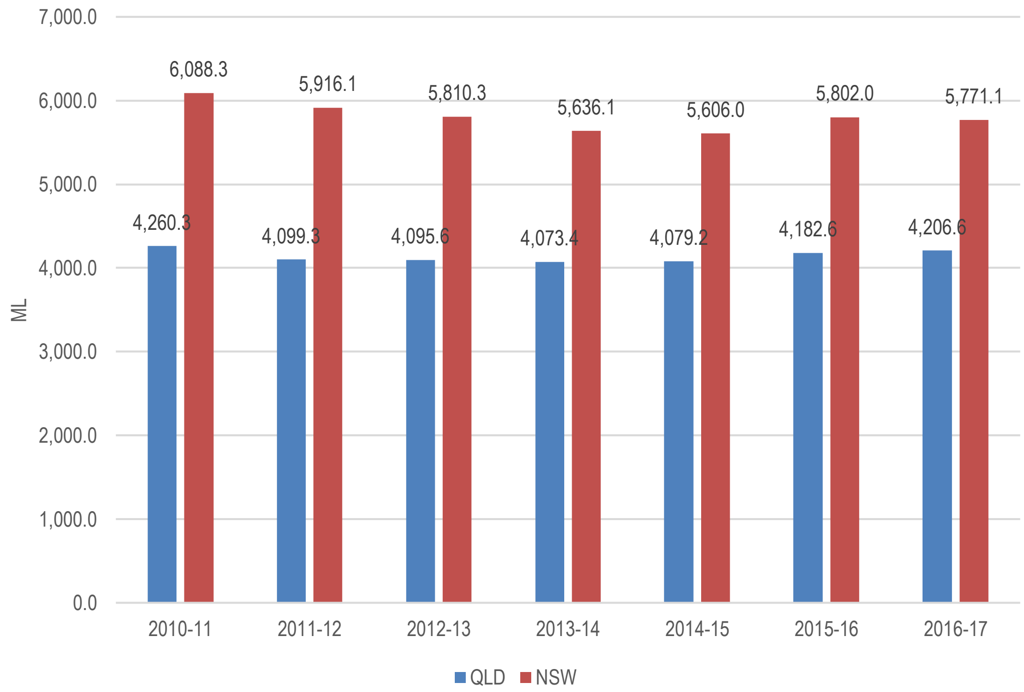

Figure 1 **Total Demand for Automotive Petrol-Based Fuel, NSW and Queensland**

Source: *Australian Petroleum Statistics*

Figure 2 and Figure 3 break down the total automotive fuel demand into premium, regular and ethanol blended fuels. In 2016-17, total consumption of ethanol blended fuel in Queensland was 565 million litres, indicating consumption of 56.5 million litres of ethanol. This was up significantly on 2015-16, when sales of ethanol-blended fuel amounted to 441 million litres.

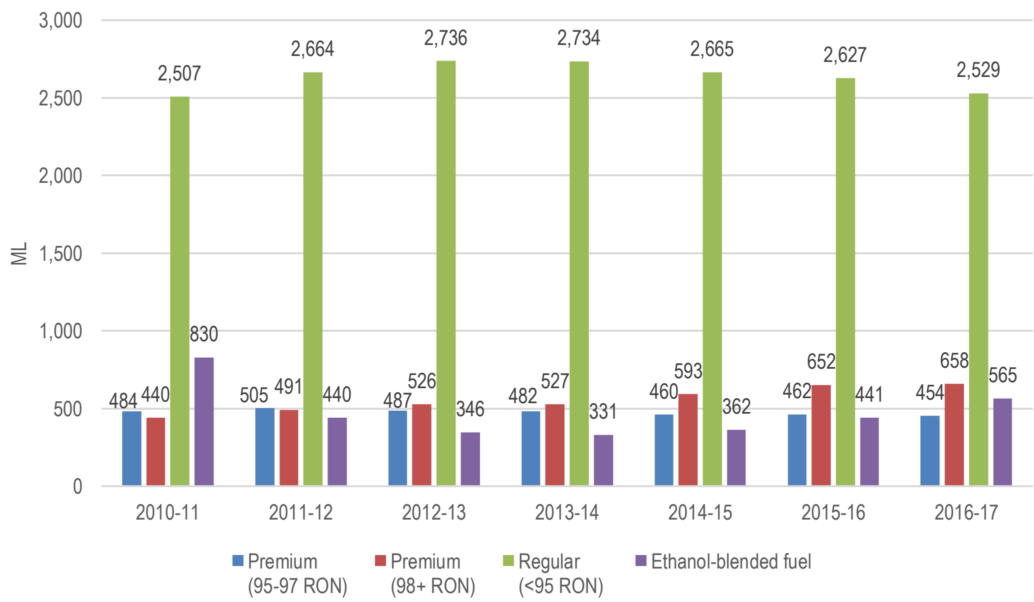

Figure 2 **Breakdown of Automotive Petrol-Based Fuel Demand by Type, Queensland**

Source: *Australian Petroleum Statistics*

New South Wales sales of ethanol-blended fuel were 1,576 million litres in 2016-17, implying 157.6 million litres of ethanol. Ethanol-blended fuel sales have consistently trended down over the last 7 years, with ethanol-blended fuel sales in 2010-11 being 40 per cent more than 2016-17.

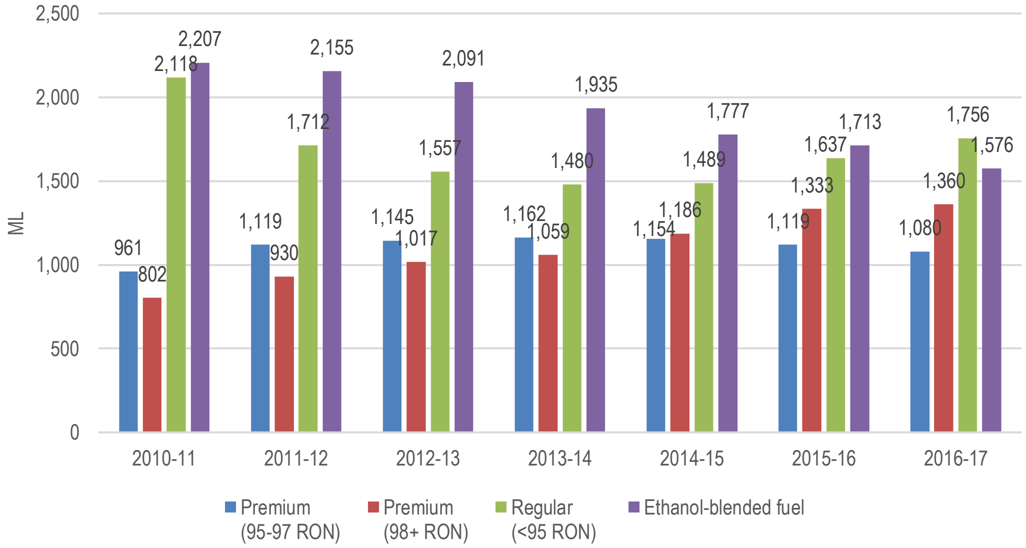

Figure 2 **Breakdown of Petrol-Based Fuel Demand by Type, New South Wales**

Source: *Australian Petroleum Statistics*

Trends in the Use of Ethanol in Automotive Fuel

Figure 4 shows monthly volumes of fuel ethanol used in Queensland from July 2010 to March 2018. Consumption declined significantly between July 2010 and January 2012, from 8.5 million litres to 2.5 million litres per month. Ethanol sales then remained stable around 3 million litres per month to mid-2015 (release of a government discussion paper advocating mandates), before rising to about 3.5 million litres per month. Ethanol sales then commenced an upward trajectory prior to the start of the biofuels mandates in January 2017, and this continued until December 2017, when sales peaked at 7.1 million litres. They fell to 5.6 million litres in March 2018.

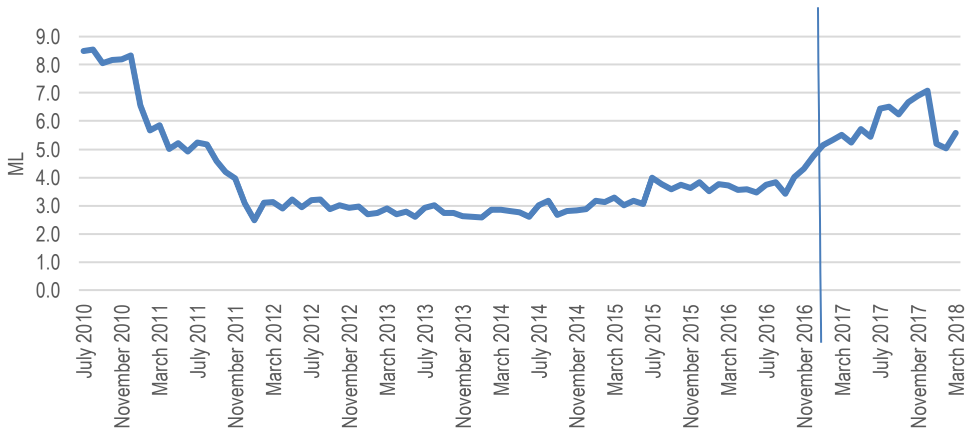

Figure 4 **Consumption of Fuel Ethanol, Queensland**

Source: *Australian Petroleum Statistics*

In the case of New South Wales, monthly ethanol sales have trended downwards consistently since July 2010, peaking at 22.1 million litres in December 2010, just before the increase in the New South Wales mandate from 4 per cent to 6 per cent, and hitting a low of 10.7 million litres in February 2018 as seen in Figure 5.

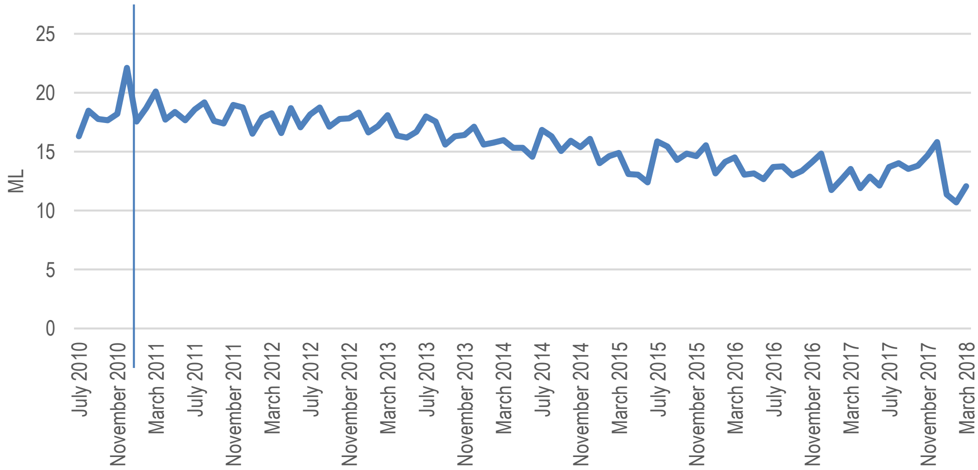

Figure 5 Consumption of Fuel Ethanol, New South Wales

Source: *Australian Petroleum Statistics*

Figure 6 shows the share of ethanol in total petrol-based fuel use in New South Wales and Queensland. In Queensland, ethanol's share declined from a peak of 2.3 per cent in September 2010 to 0.8 per cent in January 2012. In more recent months, the share of ethanol increased, from 1.0 per cent in September 2016, just prior to the commencement of the Queensland mandate, and peaked at 1.9 per cent in November 2017.

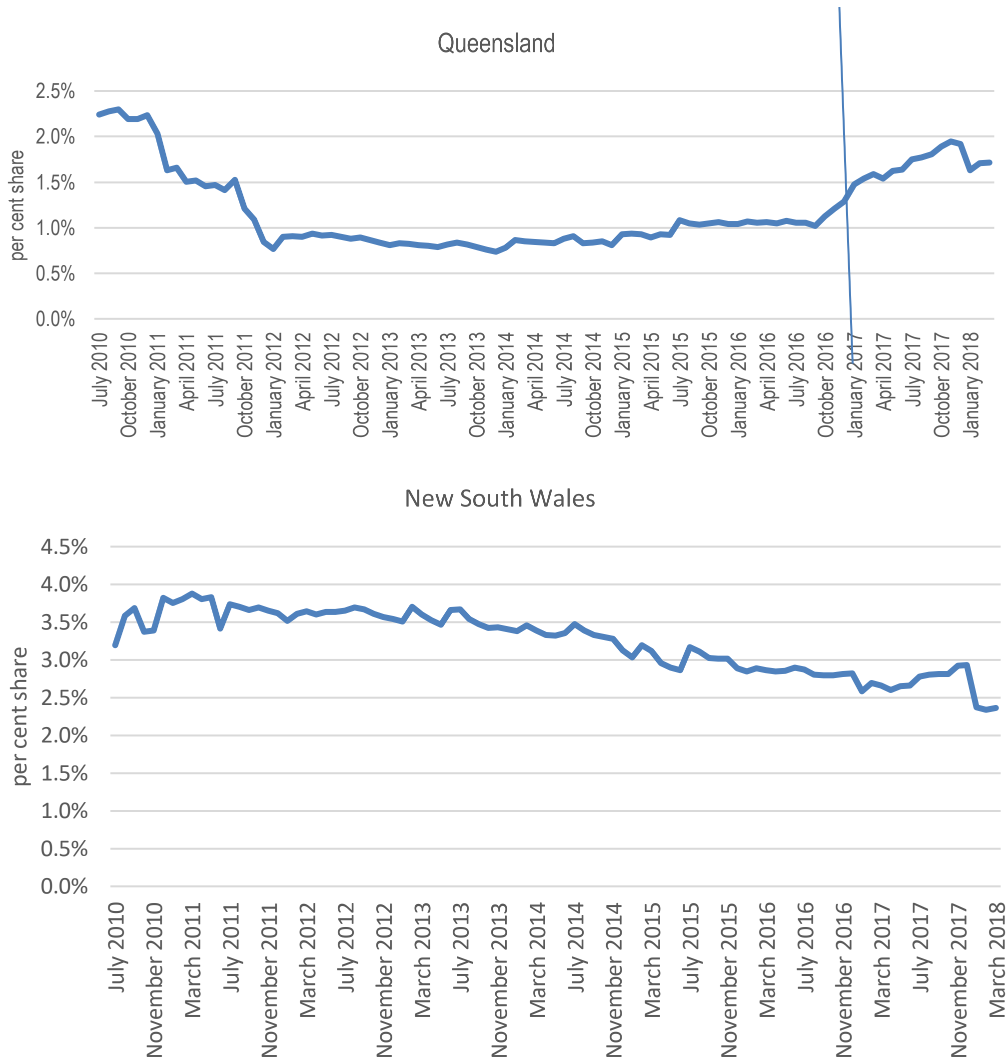

Figure 6 Ethanol's Share of Total Petrol-Based Fuel Use, Queensland and New South Wales

Source: *Australian Petroleum Statistics*

In New South Wales, the share of ethanol in total petrol-based fuel sales peaked at 3.9 per cent in March 2011, two months after the increase in the New South Wales mandate, before commencing a long downward trend, reaching a low of 2.3 per cent in February 2018.

In the case of New South Wales, it is clear that the mandate has been ineffective. The tightening of the mandate from 2016, may have had a slight positive impact up to December 2017, but this upward movement has proven temporary.

In Queensland the mandate percentage is defined as a share of total RULP and E10 sales rather than total petrol-based fuel sales, as is the case in New South Wales.

Figure 7 presents ethanol's share in Queensland on this basis. After the introduction of the mandate, the share of ethanol peaked at 2.6 per cent in November 2017, before falling back to 2.3 per cent in March 2018. The increasing share of ethanol commenced prior to the mandate's introduction, starting off a low of 1.4 per cent in September 2016. The increase in ethanol sales after September 2016 can, to a significant degree, be attributed to a Queensland Government advertising campaign encouraging motorists to fill up with E10. It remains to be seen whether this increase in the share of ethanol will be sustained in the longer run.

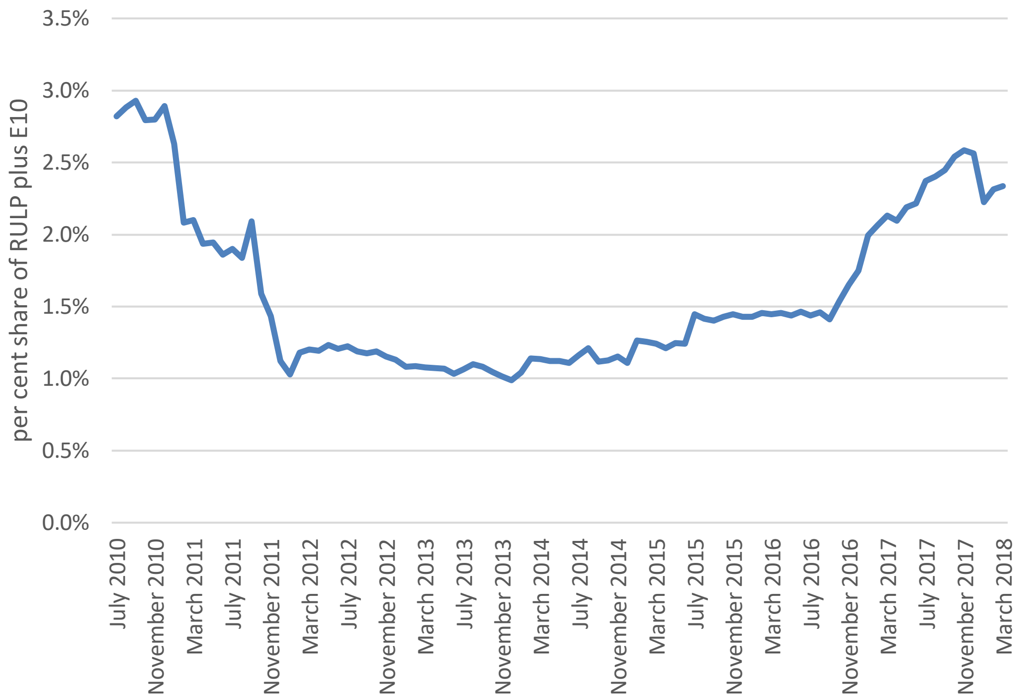

Figure 7 **Ethanol Share of RULP and E10, Queensland**

Source: *Australian Petroleum Statistics*

Sustainability Risk

APAC Biofuel Consultants (2017) pointed out that the cost of feedstock was between 40 per cent and 70 per cent of the cost of producing ethanol. To be competitive with petrol, ethanol needs to be priced to allow for its lower energy content (68 per cent of energy content of petrol) and consequent higher consumption per kilometre of (3.3 per cent more for E10 than straight regular unleaded petrol). If oil prices fall substantially, while feedstock prices do not, producer margins are squeezed. This occurred from mid-2014. Analysis by APAC Biofuel Consultants (2017) indicated that that the margin of petrol-linked ethanol price over stockfeed cost per litre fell by about 18.6 cents per litre for sorghum-based ethanol between 2013 and 2016. For wheat-based ethanol the margin declined by around 20 cents per litre. APAC Biofuel Consultants (2017) argued that such circumstances represented the greatest “sustainability risk” faced by ethanol producers and biofuels producers more generally. It seems that APAC Biofuel Consultants (2017) did not consider risk of removal of protection from the industry to be important.

Ethanol Producers

There are three existing ethanol producers in Australia. Each uses a different feedstock. Each plant is profiled below. The Manildra Group’s plant is located in Nowra, New South Wales. It is Australia’s largest producer of fuel-grade ethanol and has been in operation since 1992. Manildra’s process uses residue wheat starch, a waste product from starch and gluten production activities. Manildra produces ethanol for fuel and industrial purposes. It’s ethanol operation also produces dried distiller's grain for use in animal feed. APAC Biofuel Consultants (2017) reported that the Manildra plant produced 163 million litre of ethanol in 2016 and has a production capacity of 300 million litres per year.

Wilmar Bioethanol's Sarina, Queensland plant produces ethanol derived from a sugar-milling by-product, molasses. APAC Biofuel Consultants (2017) reported that Wilmar's 2016 production was 35 million litres and its capacity is 60 million litres per year. Wilmar Bioethanol is a subsidiary of Wilmar International Limited, Asia's leading agribusiness group.

United Petroleum's plant in Dalby, Queensland uses sorghum grain in production of ethanol. The plant was commissioned in 2008. APAC Biofuel Consultants (2017) reported that the Dalby Bio-refinery produced 22 million litres in 2017 and capacity of 90 million litres per year. United Petroleum reported that it produces 76 million litres of ethanol from sorghum per year.[‡]

APAC Biofuel Consultants (2017) estimated the market share of each of these plants as follows. Manildra Group has about 74 per cent of the ethanol market, followed by Wilmar with 16 per cent and United Petroleum at 10 per cent. They also estimated that only about 49 per cent of aggregate plant capacity was used to supply ethanol to the fuel market in 2016.

Despite the existence of substantial spare capacity in existing biofuel plants, APAC Biofuel Consultants (2017) claimed that there are five proposed projects for ethanol production facilities in various stages of planning and development in New South Wales and Queensland, with combined capacity of 368 million litres per year by 2022. Three plants in New South Wales with combined capacity of 118 million litres would use grain as a feedstock. The two Queensland projects would use sugar cane, and have capacity totalling 250 million litres per year.

If all of these projects were actually built, fuel ethanol capacity in Australia would rise from 450 million litres to 818 million litres by 2022. The current circumstances of the industry – declining production and market share and about 51 per cent excess capacity – suggest that substantial expansion of the industry over the next four years is highly improbable.

APAC Biofuel Consultants (2017) also claimed that there are at least three additional possible projects at concept stage in Queensland and New South Wales. Realisation of these projects in the foreseeable future also seems to be highly improbable.

2.2.2 Biodiesel

The biodiesel market in Australia collapsed in 2015-16 following the end of the Clean Energy Grants Scheme, which provided refunds of excise and customs duty to domestic producers and importers of biodiesel, respectively. This occurred in the context of a strong decline in oil prices that commenced in the second half of 2014. The tax new regime involved a highly concessionary excise rate for domestically-produced biodiesel, but applied the full rate of customs duty to imports. This increased protection for domestic producers by effectively shutting out imports. Imports of biodiesel fell from 345 million litres in 2014-15 to almost zero in 2015-16.

Despite the increase in protection for domestic producers of biodiesel, expensive feedstocks, low oil prices, and management issues led to the demise of Australia's largest biodiesel producer (150

‡ See: https://www.unitedpetroleum.com.au/about/ethanol-production/dalby-refinery/

million litres capacity) in 2016, leaving only two other significant producers, and two tiny producers. Production from the remaining biodiesel plants in 2016 was estimated by APAC Biofuel Consultants (2017) to be 15-20 million litres, which is 29 to 39 per cent of aggregate capacity of the operating plants.

Feedstock for the two larger producers is used cooking oil and tallow. The former producer which collapsed in 2016 also processed used cooking oil and tallow. The tiny producers of biodiesel process used cooking oil.

APAC Biofuel Consultants (2017) was not able to identify any potential new "first-generation" biodiesel projects.

2.2.3 Advanced Biofuels

According to APAC Biofuel Consultants (2017), there is interest in "second-generation" biofuels projects, involving non-food feedstocks, coinciding with the launch of the Queensland Biofuels Acceleration Program late 2016. This program aims to support new biorefinery opportunities within the state, such as the advanced biofuels pilot plant and laboratory established by Southern Oil Refining and J.J. Richards at Yarwun, near Gladstone, adjacent to the companies' waste lubrication oil re-refining facility. The companies' aim is to determine the commercial viability of establishing a full-scale plant to produce bio-crude oil that will be refined to diesel and kerosene products. The plant would use waste biomass, prickly acacia, and discarded tyres as feedstock.

Further, in 2016, Virgin Airlines and Air New Zealand began to investigate options for locally produced aviation bio-based drop-in jet fuels (APAC Biofuel Consultants, 2017).

2.3 Effects of a Biofuel Industry on Agriculture

Over the past decade, a substantial body of literature has built up relating to the effects of government protection of biofuels on markets for grains and oil seeds. Most of this literature has been concerned with the consequences of United States and European Union biofuels policies.[§]

The literature has focussed on two perceived linkage mechanisms. First, government support for biofuels leads to increases use of biofuels, which increases demand for agricultural inputs to biofuels production, potentially leading to higher prices of those inputs. Second, government policies supporting biofuels have created a link between oil prices and biofuels input prices through demand for biofuels, with the result that rising (falling) oil prices (and refined petroleum product prices) increase (decrease) demand for biofuels and this affects demand for and prices of agricultural inputs.

There has been general acceptance of the first link. The second one is controversial (Baumeister, Kilian, 2013, 2014).

In relation to the first link, general acceptance has occurred in the context of strong pro-biofuels policies in the enormous United States and European Union economies. The transmission

[§] For example, see Wright (2014) and de Gorter, Drabik and Just (2013, 2015).

mechanism does not automatically apply in the circumstances of the small, open Australian economy and its weaker biofuels policies.

With regard to the perceived link between oil prices and biofuels crop prices, some key contrary points follow. First, it has been noted that there has been low correlation between oil prices and grain prices since 2014, when oil prices commenced a sharp decline (APAC Biofuel Consultants, 2017). Second, during the oil price boom period from 2004 to 2008, oil and agricultural commodity prices were pulled up by growing global demand for industrial and agricultural commodities. There was a common cause of price increases for oil and agricultural commodities, not a causal relationship between oil and crop prices (Baumeister, Kilian, 2013, 2014).

Australia produces about 25 million tonnes of wheat per annum, with grains, oilseeds and pulse crops accounting for around 29 per cent ($18 billion) of the total value of farm production and around 30 per cent of the total value of farm export income (ABARES, 2017). Over 30 million tonnes of wheat and barley were exported globally in 2016-17, worth over $8.5 billion (ABS, 2016-2017). The biofuels industry in Australia has been estimated to account for less than 0.5 per cent of grain produced (Kalisch-Gordon, 2016). The biofuels industry had a gross value of production of just $166 million in 2016-17 (IBISWorld, 2017b). In contrast, the feedlot industry had a gross value of production of $2.5 billion in 2016-17 (ALFA, 2018).

The Feed Grain Partnership Report (JCS Solutions, 2016) concluded that 2016-17 was a record year for grain production in Australia and it is the ninth successive year in which grain production has not been inhibited by drought (JCS Solutions, 2016). This suggests that even after meeting domestic feed requirements (currently at 13 million tonnes), as well as flour, malt, and ethanol production, it is forecast that the grain surplus will be in the order of 28 million tonnes (JCS Solutions, 2016).

The continued increase in grain production mainly through increased cropping efficiency has meant an increase in grain exports to a level that is now over 60 per cent of the total grain crop (JCS Solutions, 2016). This would suggest that in 2016-17 there was considerable grain available not only for domestic consumption, livestock feed and ethanol production, but also for considerable exports.

Feed Grains

Although some crops are grown specifically for stock-feed markets, most feed grain becomes available when grain does not achieve the characteristics required for milling and processing for human consumption. In 2013-2014, an estimated 12.2 million tonnes of raw materials were used for animal feed domestically, with 8.8 million tonnes consisting of raw grains, such as wheat, barley and sorghum, and oilseeds and pulses (Kalisch-Gordon, 2016). By state, the majority of grain produced for feed use is grown in Victoria (28.9 per cent) closely followed by Queensland (27.5 per cent) and New South Wales (24.6 per cent) (Kalisch-Gordon, 2016).

According to IBISWorld (2017b) the feed grain market is dominated by wheat (54.7 per cent), followed by barley (17.2 per cent). Sorghum accounts for just 1.6 per cent of the animal feed market (IBISWorld, 2017b).

The feed grain industry's revenue was $2.2 billion in 2016-17 (IBISWorld, 2017b). Over 80 per cent of feed grains is consumed by the chicken, beef and dairy cattle industries (see Table 1) (Kalisch-Gordon, 2016).

Table 1 Annual Feed Grain Use by Sector 2013-14

Industry	Tonnes per year	Proportion by industry
Chicken	3,735,751	30.6%
Beef	3,175,950	26%
Dairy	3,111,008	25.5%
Other	2,169,461	17.9%
SOURCE: ADAPTED FROM KALISCH-GORDON, 2016		

Beef is one of Australia's largest agricultural commodities by gross production value, accounting for $13.1 billion in 2015-16 (ABS). Fodder costs in Australia were $4.8 billion in 2016-17 (ABS). A substantial portion of this was used in feedlot systems.

Impact of Biofuels Mandates on Feed Grains

This section considers how much additional ethanol is required to be produced to meet the New South Wales and Queensland mandates, and then calculates the volume of feed grain required to meet the mandates. These feed grain requirements are then compared to supply and demand characteristics of the Australian market for sorghum and wheat to assess the likelihood of any supply constraints that could arise, given changes in the production of wheat and sorghum, under both normal and drought conditions.

How much biofuel needs to be produced to meet the mandates?

In New South Wales in 2016-17, 157.6 million litres of fuel ethanol were sold out of total petrol-based fuel sales of 5,771 ML. This was equivalent to a 2.7 per cent share for ethanol. To increase this share to the mandated 6 per cent requires a total of 346.3 million litres of ethanol to be sold, an increase of 188.7 million litres over current sales.

In Queensland, using 2015-16 numbers, to avoid any impact due to the introduction of the 3 per cent mandate and the associated government advertising campaign, ethanol sales of 44.1 million litres in 2015-16 amounted to 1.4 per cent of total RULP and E10 sales. Increasing ethanol sales to meet the 3 per cent mandate requires a total of 92.0 million litres of ethanol to be supplied in Queensland, an increase of 47.9 million litres over 2015-16 levels. The proposed increase in the mandate to 4 per cent from July 1 2018 would require a total of 122.7 million litres of ethanol to be sold, an increase of 78.6 million litres over 2015-16 levels.

How much feed grain is required to meet the biofuel mandate?

To estimate the volume of feed grains required to meet the production of ethanol under the mandate, the study team used the yields applied by Hunter et al (2017) in their study of the impact of grain-based ethanol production on the cattle feedlot industry. The assumed yields from sorghum and wheat are presented in Table 2 below. In the case of sorghum, 1 tonne of grain will yield 407 litres of ethanol, while a tonne of wheat is assumed to yield 364.4 litres of ethanol.

Table 2 Yield of Ethanol per tonne of Feed Grain

	Unit	Sorghum	Wheat
Dry matter [DM]	per cent	88.0	90.0
Starch [DM] in grain	per cent	74.6	65.3
Yields per tonne feed-grain (Ethanol)	Litre	407.0	364.4
SOURCE: HUNTER ET AL. (2017)			

Table 3 below shows the total sorghum and wheat required to meet Queensland's current 3 per cent and future 4 per cent biofuel mandate. While data is presented on wheat also, it is important to note that the main plant operating in Queensland, the Dalby Biorefinery uses sorghum as a feed stock. There is also 35 million litres of ethanol supplied by the Wilmar Bioethanol plant at Sarina which uses molasses as a feed stock. It is reasonable to assume therefore, that future demand for ethanol in Queensland would be supplied by one or both of these existing plants. It was decided to focus on sorghum as the Dalby plant has a large amount of spare capacity, which is likely to be used to meet any additional demand.

If it is assumed that sorghum is the main feed stock used to meet the mandate, then a total 226.1 thousand tonnes (kilotonnes or kt) of sorghum is required to meet the 3 per cent mandate and 301.5 kt is required to meet the 4 per cent mandate. These numbers are an over estimate given that some of Queensland's existing biofuel demand comes from molasses feed-stock, and it's not clear how much of the additional demand for ethanol over the levels that prevailed in 2015-16, prior to the mandate taking effect, will be supplied by the Dalby plant and how much by the Sarina plant.

If we assume that the additional demand for ethanol as a result of meeting the mandate is supplied entirely from sorghum feed stock, then meeting Queensland's mandate requires an additional 117.7 kt of sorghum to meet the 3 per cent mandate and an additional 193.1 kt to meet the 4 per cent mandate, when it takes effect.

Table 3 Sorghum and Wheat Requirements to meet the Queensland Biofuel Mandate

QLD	3per cent mandate	4per cent mandate
Ethanol (ML)-total	92.0	122.7
Ethanol (ML)-extra over 2015-16	47.9	78.6
Sorghum (kt)- total	226.1	301.5
Sorghum (kt)- extra over 2015-16	117.7	193.1
Wheat (kt)-total	252.6	336.8
Wheat (kt)-extra over 2015-16	131.5	215.7
SOURCE: ACIL ALLEN		

Table 4 below shows the total sorghum and wheat required to meet New South Wales's current 6 per cent biofuel mandate. While the theoretical sorghum requirements to meet the New South Wales mandate are presented, it is noted that the New South Wales ethanol market is supplied by the Manildra plant at Nowra in New South Wales that uses wheat for its production of gluten and food starch, and diverts waste starch to the production of ethanol. If all the New South Wales ethanol was produced using wheat as a feed stock, then a total of 950.2 kt would be required to produce the necessary 346.3 million litres of ethanol. However, as stated above, current ethanol production in New South Wales relies on waste starch, with the wheat being used primarily for another purpose. A more reasonable assumption is to assume that the additional ethanol production required to meet the mandate in New South Wales comes directly from wheat feed stocks. This assumes that there is no additional supply of gluten and food starch from the Manildra plant, and that current production levels are sufficient to meet current demand. To meet the additional requirement of 188.7 million litres of ethanol over 2016-17 levels, under the New South Wales mandate, would require 517.9 kt of wheat.

Table 4 Sorghum and Wheat Requirements to Meet New South Wales Biofuel Mandate

New South Wales	6per cent mandate
Ethanol (ML)-total	346.3
Ethanol (ML)-extra over 2016-17	188.7
Sorghum (kt)- total	850.8
Sorghum (kt)- extra over 2016-17	463.7
Wheat (kt)-total	950.2
Wheat (kt)-extra over 2016-17	517.9

SOURCE: ACIL ALLEN

The next question is to consider whether the additional requirement for sorghum in Queensland and wheat in New South Wales to meet each jurisdictions respective biofuels mandate faces any constraints based on current supply and demand conditions of Australia's sorghum and wheat markets.

Table 5 shows the historical production of New South Wales and Australian wheat, exports, domestic use and closing stocks of wheat.

Table 5 Historical Production of New South Wales and Australian Wheat, 2003-04 to 2016-17, KT

Year	New South Wales (kt)	Australia (kt)	Exports	Domestic use	Closing stocks	Stock to use ratio
2003–04	7,288	26,132	17,868	5,357	6,217	1.16
2004–05	7,537	21,905	14,675	6,027	7,424	1.23
2005–06	8,049	25,150	15,969	6,627	9,982	1.51
2006–07	2,568	10,822	8,685	7,420	4,705	0.63
2007–08	2,477	13,569	7,444	6,517	4,319	0.66
2008–09	6,963	21,420	14,707	7,306	3,738	0.51

Year	New South Wales (kt)	Australia (kt)	Exports	Domestic use	Closing stocks	Stock to use ratio
2009–10	5,350	21,834	14,791	4,999	5,798	1.16
2010–11	10,488	27,410	18,584	5,663	8,973	1.58
2011–12	8,473	29,905	24,656	6,334	7,901	1.25
2012–13	7,365	22,855	18,644	6,451	5,678	0.88
2013–14	6,596	25,303	18,612	6,785	5,605	0.83
2014–15	6,654	23,743	16,587	7,154	5,628	0.79
2015–16	6,898	22,275	16,116	7,263	4,550	0.63
2016–17	11,375	35,009	22,640	8,218	8,726	1.06
SOURCE: ABARES						

Since 2003-04, New South Wales wheat production has ranged between 2,477 kt in 2007-08, a year characterised by severe drought conditions and 11,375 kt in 2016-17, a record crop. Under normal conditions, New South Wales wheat production is likely to range between 6,500 kt and 8,500 kt. At these levels of production, an additional demand of 517.9 kt is unlikely to put significant pressure on available supplies, with closing stocks being more than sufficient to soak up the additional demand.

In a drought year, such as 2007-08, stocks are still likely to be sufficient to meet the additional demand, although the additional stock may have to be sourced from WA, the other major source of Australian wheat production. This would add to the cost of supply and put some upward pressure on the wheat price in New South Wales. There is also considerable scope to divert the required wheat from the sizeable amount of exports.

Table 6 shows the historical production of Queensland, New South Wales and Australian sorghum as well as exports. Nearly all of the sorghum produced in Australia comes from northern New South Wales and southern Queensland. In 2016-17, Australia produced 1,017 kt of sorghum, representing a poor harvest and the lowest level of production since 2010-11. In fact one has to go back to 1992-93 to find a year when sorghum production was lower. Then, domestic production was just 546 kt.

The additional 117.7 kt required to meet the 3 per cent mandate in Queensland and 193.1 kt required for the 4 per cent mandate represent 11.5 per cent and 19.0 per cent respectively of Australian sorghum production in 2016-17. They also represent 16.1 per cent and 26.4 per cent of sorghum exports in 2016-17, respectively. Under this scenario, it is hard to imagine that there would not be some upward pressure on domestic sorghum prices, at least if the economy was closed or self-sufficient.

Under more normal conditions, when Australian sorghum production might be expected to be around 2,200 kt with exports of about 1,200 kt, the additional demand for sorghum to meet the Queensland biofuel mandate could be expected to have less impact on domestic sorghum prices (assuming a closed economy).

Table 6 Historical Production of New South Wales, Queensland and Australian Sorghum, 2010-11 to 2016-17, KT

Year	New South Wales (KT)	QLD (KT)	Australia (KT)	Exports (KT)
2010–11	748	1,183	1,935	553
2011–12	814	1,416	2,239	1,112
2012–13	747	1,475	2,229	1,291
2013–14	419	860	1,282	701
2014–15	586	1,618	2,209	1,205
2015–16	604	1,177	1,791	1,075
2016–17	365	650	1,017	729
SOURCE: ABARES				

Recent Literature on the Impact of Biofuels on Agriculture

There is limited literature relating to the effects of biofuels mandates on feedstock prices, and livestock and associated industries in Australia. Most of the available literature focuses on the potential impacts of the introduction of the New South Wales mandate using data from 2007-2008, and a few early assessments of the mandate's effects through till about 2010.

At that time and subsequently, suppositions were made on the basis of international grain market effects of government policies discriminating in favour of domestic biofuels production in the very large economies of the United States and the European Union. Biofuels policies implemented in those giant economies drove up domestic and international prices of grain and plant-based oils substantially. The size of those economies and the magnitude of their governments' support for domestic biofuels production made them price makers in international grain and plant-based oil markets. The same factors also made them price makers in the international market for refined petroleum products, which was affected by substitution of biofuels for petrol and diesel (de Gorter, Drabik, Just, 2015).

The Australian economy is very much smaller. It is also a very open economy. Australia is a price taker in international markets for grains and refined petroleum products.

Although the Australian biofuels industry has been protected for 15 years, and there has been international concern for a decade about the effects of biofuels protection policies on prices of food for humans and feed for animals, there is still limited information available about effects of biofuels policies in Australia on prices of agricultural products used as feedstocks for the domestic biofuels industry. However, predictions by some parties of grain shortages for human and animal consumption as a result of biofuels production, and the consequent expected impact on the livestock industry have not eventuated.

Generally, as noted in the above, due to the small size of the biofuels industry relative to the grains industry (revenue of $18 billion for grains and $166 million for ethanol), and in periods of high grain prices and no drought,[**] the implication is that there has been little, or no, direct impact of biofuels policy on feed grain prices. However, the general distortionary effects of ethanol mandates and other compounding legislative arrangements such as highly discriminatory and expensive tax treatment of domestic production of biofuels have placed significant costs on Australian society, which includes Australian lot feeders.

There has been much debate over the last decade regarding the risk that ethanol and biodiesel production may compete with food and/or stock-feed production. However, in the context of the relatively small scale of current ethanol production in Australia, and Australia's status as a small, open economy, it is difficult to find evidence that ethanol production is competing directly or indirectly with food or feedstock supply, at least while mandates are not binding. This situation could change if blend mandates were enforced, exemptions were removed, and blend mandate rates were increased to push up biofuels production substantially.

There are two main reasons why there is little evidence of ethanol production competing with supply of food to humans and animals. There is also one potential exception.

One reason is that demand for ethanol has not increased over the past 15 years at the rates expected by governments that have assisted the ethanol industry. In fact, consumption of fuel ethanol was 30.2 per cent lower in 2016-17 than in the peak year, 2010-11 (Australian Government, Department of Environment and Energy, 2018b).

The second reason is that the primary ethanol producer, Manildra, uses a waste product (residue starch) of its gluten and starch production activity based on industrial grade wheat flour (residue starch) to produce ethanol in New South Wales. In other words the ethanol is not being produced from wheat that could be used for another purpose, such as grain for human consumption.[††] Moreover, Wilmar, in Far North Queensland produces ethanol from molasses, a sugar by-product, at its Sarina plant, not by processing additional sugar cane.

The exception is United Petroleum's Dalby Biorefinery in Queensland, as the Dalby plant uses sorghum grain to produce ethanol.

Sorghum is a direct input into animal feed. Some research has indicated that sorghum-based ethanol production supported by a blend mandate would exert upward pressure on sorghum prices, to the detriment of feedlot operators. [‡‡] According to Piggott, Lane and Ray (GHD) (2010) and Cuevas-Cubria (2012) there is potential for an increase in the price for sorghum under a binding ethanol mandate. This may benefit grain growers, as sorghum is a comparatively low priced grain, but will likely increase costs to livestock producers, and in turn, consumers.

Piggott, Lane and Ray (2010) investigated the impact of mandating 5 per cent and 10 per cent ethanol in regular unleaded petrol on Queensland sorghum prices, as well as food prices. The modelling approach adopted involved the use of a 'disequilibrium displacement model', in which the specific market relationships and variables of interest are presented as proportionate changes and

[**] Research in 2005 by the Centre for International Economics (CIE) showed that in times of drought, these conditions may be completely different. CIE reported a finding that the convergence of drought and ethanol mandating at the E10 level would result in feed grain prices reaching $450 per tonne (Coombs, 2005).

[††] Manildra also produces dried distillers grain that is a stock feed by-product of its ethanol process.

[‡‡] Dalby Biorefinery, which uses sorghum grain as feedstock, accounts for just 10 per cent of the ethanol currently produced in Australia, but is producing at less than a third of its capacity (APAC Biofuel Consultants, 2017).

are a function of elasticities of demand and supply. The elasticities were chosen according to what the authors describe as 'best bet values' based on a combination of judgement, theory and empirical evidence if available. The model contained 31 endogenous variables and 31 equations, and worked by specifying an initial equilibrium and then administering a 'shock' to the system generated by the extra sorghum demand generated by the ethanol mandate. Two sets of results were presented, one under normal operating conditions and one under severe drought conditions matching the severity of the 2002-03 drought.

The approach adopted is essentially a simulation-based approach that is heavily dependent on a set of underlying assumptions and not based on empirical evidence to any significant degree. Moreover, the authors themselves point out that the approach is most accurate when the changes in the underlying variables are small. Under the 10 per cent mandate, demand for sorghum is expected to increase by 50 per cent, which is a significant shift in the model's initial equilibrium and can hardly qualify as a small incremental shift in demand. However, this is not an issue under the 5 per cent mandate, where demand for sorghum is projected to increase by only 2 per cent.

Piggott, Lane and Ray (2010) estimated that under a 5 per cent ethanol mandate, additional ethanol production would increase sorghum demand by 2 per cent, suggesting a price increase of 0.06 per cent in north Queensland, and 0.05 per cent in south-east Queensland.[§§] If the mandate was increased to 10 per cent, the estimated increase in demand for sorghum was 50 per cent, with an associated price increase of 1.4 per cent in north Queensland and 1.29 per cent in south-east Queensland. These estimates are based on a year of 'normal' (non-drought conditions). With drought conditions, the price increases are substantially greater, especially under the 10 per cent mandate scenario (23.22 and 22.06 per cent for North and Southeast Queensland respectively). The reasons for the significant increase in price is that in non-drought years (i.e. years of normal rainfall) there are significant exports of sorghum (i.e. excess supply) that are not apparent in drought conditions (Piggott, Lane, Ray, 2010). Under the 5 per cent mandate in a drought year, price increases of sorghum are still relatively modest, rising by 0.93 per cent in north Queensland and 0.88 per cent in south-east Queensland. The actual ethanol mandate in Queensland was 3 per cent from 1 January 2017, and increased to just 4 per cent from 1 July 2018, with no indication of any policy shift towards a 10 per cent mandate. Moreover, based on historical behaviour in NSW, there is no guarantee that a higher mandate would be strictly applied without exemptions.

The modelled price effects were assumed to be immediate. The study authors themselves pointed out that price impacts over the medium term would depend on other factors, such as switching to the use of non-sorghum feedstocks, as well as new and emerging technologies for ethanol production. Changes in trade policies could also play a role, particularly if tariffs on ethanol imports are removed. Higher sorghum prices apart from eliciting a demand response away from the use of sorghum, are also likely to result in increased supply as growers seek higher returns by shifting to higher value crops.

The study made the strict assumption that there would be no exports of sorghum in a drought year, in which they assumed grain production to be 60 per cent of that in a normal year. This assumption

[§§] GHD's results are limited by assuming a closed economy , no exports during a drought event and a mandate of 5 per cent and 10 per cent (greater than the current mandate of 3 per cent).

is quite restrictive. A very large increase in the demand for sorghum would be required before any shortages occurred

From 2000-01 to 2016-17, average Australian sorghum production was 1,962 kt per year, while average exports over the same period were 634 kt. Sorghum production in 2002-03 (a drought year) was 1,465 kt and exports fell to 70 kt. This is slightly misleading, however, as there have been other years in which production has been at or below the 2002-03 level, and exports have still occurred. In 2013-14, sorghum production was 1,262 kt, while exports were 701 kt. In 2009-10, production fell to 1,508 kt, while exports in the same year were 487 kt. In 2016-17, sorghum production fell to 1,017 kt, while exports were 729kt. The data show that even in years with lower production, there has still been sufficient supply available for exports of sorghum to be possible. Stocks may be playing a role here to smooth out annual variations in supply in response to demand. This suggests that a drought may need to be protracted (last longer than a single season) before it starts to impact on the price of sorghum. In the four separate seasons after 2000-01 in which production has been at or below 1,485kt, sorghum exports have averaged 386.5kt. This suggests that an assumption of no exports in a drought year may be too restrictive.

Using ACIL Allen's calculations in section 2.3, a 3 per cent mandate requires 226.1 kt of sorghum and 4 per cent requires 301.5 kt. Under a 5 per cent and 10 per cent mandate, 376.9 and 753.8 kt of sorghum would be required, respectively. Using the same assumption adopted by GHD, which is that only half the ethanol produced under the mandate would use sorghum, the requirements shown above can be halved. A 5 per cent ethanol mandate requires 188.5kt of sorghum while a 10 per cent mandate requires 376.9 kt.

The calculations above show that even in a drought year there are likely to be sufficient exports to meet the extra demand, even potentially under a 10 per cent mandate, although it important to note that in two of the four years after 2000-01 in which production was at or below 1,465 kt, exports did in fact collapse, to 70.4kt in 2002-03 and 45.6 kt in 2006-07. Under this scenario, a 10 per cent mandate would in fact pose problems, particularly as the analysis precluded the possibility of sorghum imports, another unnecessarily restrictive assumption.

Piggott, Lane and Ray (2010) noted that sorghum could be imported to Australia[***], particularly from Argentina, however, this may not be a direct substitute as the tannin levels and moisture content in Argentine sorghum are lower than in locally produced sorghum. This would suggest that Argentine sorghum may not be appropriate for use in animal feed: "tannins in sorghum grains have been shown to decrease protein digestibility and feed efficiency in humans and animals, grain sorghum production as a feedstock in the United States has been almost entirely restricted to non-tannin types" (Wu et al, 2012). However, there is some indication that lower tannin levels may be beneficial for ethanol production (Ramierez et al, 2016).

Estimated changes on food prices, where sorghum is a feed input, were further modelled by Piggott, Lane and Ray (2010). The results suggested that, even in drought years, with a 10 per cent mandate, the price increase in retail food would be modest at a maximum of 3.8 per cent for chicken and a minimum of 0.655 per cent increase on retail beef prices. The research also noted that there is a

[***] It should be noted that it is not currently possible for sorghum to be imported to Australia as there are phytosanitary barriers in place to protect the local industry from biosecurity concerns.

potential for a reduction in the export competitiveness of livestock production in Queensland over time, but this was expected to be modest, as there are substitutes for sorghum, and technological development may shift ethanol production away from reliance on sorghum (Piggott, Lane and Ray, 2010). Clara Cuevas-Cubria (2012) also noted that the substitutability of grains is high.

The Bureau of Resources and Energy Economics (2014) noted that in the context of the small scale of the ethanol industry in Australia and the relatively small amount of sorghum currently used to produce ethanol at the Dalby Biorefinery, effects on prices of producers of food, including producers of animal products using grains as feed, did not appear to be a significant issue. However, it was suggested that there was potential for some localised price pressure on sorghum prices in the Dalby area, particularly if sorghum-based ethanol production expanded significantly. Bureau of Resources and Energy Economics (2014) considered that significant effects on the feedlot industry might occur in the short term, but were unlikely over the medium term.

Why is Australia Different?

It is worthwhile to reiterate that it is not appropriate to assume that substantial grain and oil seed price increases attributed to biofuels protection policies in the United States and Europe. The Australian situation is different for several reasons:

1. Australia is a price taker in international fuel, grain markets and oil seed markets. This means that any local biofuels policies will not have a significant impact as the prices for petroleum and agricultural inputs to biofuels are determined outside Australia's domestic market.
2. Australia is a small country that generates relatively low domestic demand for both fuel and food. The majority of Australian grain production is exported.
3. In contrast, the Unites States and Europe are very large markets for grain, plant-based oils and fuel. Consequently, their biofuels policies can significantly affect international prices of those products. Those economies are price makers in international markets.
4. Biofuels production in Australia currently uses less than 0.5 per cent of all grain produced. Even if Australian biofuels policies were greatly strengthened to be more like those in the United States and Europe that shifted domestic and international grain and oil seed prices, and fuel prices, the Australian economy would remain a price taker in those markets.
5. Most biofuel in Australia is produced from waste products (residue wheat starch, used cooking oil and tallow) which is not used in human consumption and therefore doesn't compete with human food. Moreover, Wilmar produces ethanol from molasses, a sugar cane processing by-product, not by processing additional sugar cane. Also, a by-product of manufacture of ethanol from waste starch and molasses adds to the supply of animal feed. A by-product of manufacture of ethanol from molasses has an offsetting effect on reduced supply of molasses as a stockfeed supplement.

Australian biofuels policies have still misallocated resources. Several studies have shown that these policies have resulted in nett social cost. Biofuels producers have benefited at the cost of the rest of the Australian community.

These issues are explored in detail in sections 4 and 5 of this report.

2.4 Australian Biofuels Policy

2.4.1 Commonwealth Policy

Exemption of Ethanol from Customs and Excise Duty, 1980-2002

In the context of very high oil prices during the "oil crisis" period of 1973-1983, the Commonwealth Government implemented a package of policy measures designed to encourage research into production of ethanol for use in internal combustion engines. The ultimate aim was to diversify Australia's liquid fuel sources (Garland, 1980a, b).

In 1980, the Commonwealth Parliament legislated to exempt ethanol used as fuel in internal combustion engines from excise and customs duty of $19.25 per litre that applied to ethanol used as drinking alcohol. It also legislated to introduce a new class of distilling licence, labelled "experimenter's licence", to authorise distillation of spirits from any material for the purposes of research into production of ethanol for use as a fuel for internal combustion engines. This type of licence was designed to encourage and control small-scale ethanol production for producers' own use (such as, on-farm production and use), as well as commercial ethanol production (Garland, 1980a, b).

Fuel Ethanol Production and Bounty, 1993 to 1996

In the context of the exemption of fuel ethanol from excise and customs duty, and two years after commencement of production of fuel ethanol on a commercial scale by the Manildra Group at one of its flour mills in New South Wales, the Commonwealth Government legislated in 1994 to establish a fuel ethanol bounty scheme. It offered a bounty of 18 cents per litre for new fuel ethanol of at least 350,000 litres per year produced domestically from biomass feedstocks. The bounty arrangement commenced on 23 June 1994 (Quirke, Steenbik, Warner, 2008).

In 1996, following a change of government, a review of the ethanol bounty scheme by five government agencies concluded that while the bounty scheme had prompted new production, distribution, and use of fuel ethanol, an economically viable industry had not been established. This supported a decision by the Government in 1996 to abolish the fuel ethanol bounty scheme (Roarty, Webb, 2003).

Biofuels Target and Capital Subsidy

Prior to the November 2001 federal election, the (Howard) Government released a biofuels action plan, entitled *Biofuels for Cleaner Transport* (Liberal Party, National Party, 2001). It promised to set an objective that biofuels would contribute at least 350 million litres per year to the supply of fuel by 2010. To support this objective, the Government promised a capital subsidy of 16 cents per litre for new or expanded domestic ethanol production capacity until the sooner of domestic production capacity of 310 million litres per year or 30 June 2007 was reached. To be eligible, a new plant or capacity expansion was to have a minimum capacity of 5 million litres per year. A maximum grant of $10 million would be available for each new plant or capacity expansion (Roarty, Webb, 2003; McPhee, Mallett, Preston, Moore, Burton, 2015).

Subsequently, the objective of domestic production of 350 million litres of biofuels per year was never formalised, but was often mentioned. In contrast, the re-elected Government announced on 25 July 2003 that it would establish a Biofuels Capital Grants Program in accordance with the promise made in 2001. Grants totalling $37.6 million were awarded in two competitive rounds. A total of $12.4 million was allocated among three ethanol plants, and a total of $25.2 million was allocated among four biodiesel plants (Quirke, Steenbik, Warner, 2008).

Ethanol Tax and Subsidy Scheme, 2002 to 2015

On 12 September 2002, the Prime Minister announced that fuel ethanol would be subject to excise and customs duty at the same rate as unleaded petrol (then 38.143 cents per litre) from 18 September 2002 to 17 September 2003. A production subsidy at the same rate as the duty was to be provided to domestic producers of fuel ethanol. It was described as a "short-term production subsidy" that would "provide a targeted means of maintaining the use of biofuels in transport in Australia, while longer-term arrangements are considered by the Government regarding the future of the emerging renewable industry" (Howard, 2002). Later, the subsidy component of the scheme was labelled the Ethanol Production Grants Scheme.

The new taxation policy for fuel ethanol thwarted plans by an international commodity trading company to import lower-cost Brazilian ethanol. Indeed, a shipment destined for Australia and at sea at the time of the announcement was diverted elsewhere (Quirke, Steenbik, and Warner, 2008; McPhee, Mallett, Preston, Moore, Burton, 2015).

On 13 May 2003, the Government announced that it would extend the tax and subsidy arrangement until 30 June 2008. On 29 March 2004, an extension of the scheme to 30 June 2011 was announced. On 12 May 2011, the scheme was extended again to at least 30 June 2021.

The effect of the tax and subsidy scheme was to provide substantial protection to domestic producers. Imports of ethanol were effectively excluded from the Australian market.

At the time of deciding to provide each extension, the government of the day stated that it planned to reduce the extent of protection to the domestic industry over time to a much lower level. However, on each occasion, the government of the day relented, despite receiving advice from government agencies and a commissioned taskforce that protection of domestic production of biofuels could not be justified on economic grounds, taking into account environmental effects (ABARE, BTRE, CSIRO 2003; O'Connell, Brockway, Keniry, Gillard, 2005; McPhee, Mallett, Preston, Moore, Burton, 2015).

Then, in the 2014-15 Commonwealth budget, a new government announced that the Ethanol Production Grants Scheme would be abolished with effect from 1 July 2015. It was to be replaced by a concessionary fuel taxation regime for locally-produced ethanol that is outlined below. This regime and a similar one for biodiesel (also outlined below) were based on biofuels taxation arrangements announced by the (Howard) Government in December 2003, but subsequently deferred. The deferment occurred because of extensions of the original fuel tax and subsidy arrangements for biofuels to 2008, then to 2011, and then beyond 2011.

From the start of the Ethanol Production Grants Program in September 2002 until its closure at the end of June 2014, the Commonwealth Government outlaid over $774 million in subsidies labelled production grants. When the program commenced, there were two recipients. In 2008-09, the recipients rose to five, and by 2009-2010 the recipients had declined to three. The number of recipients remained at three until the scheme was replaced. One recipient, the entity that owned the Manildra ethanol plant, was paid $543.4 million, which was 70.2 per cent of all ethanol production grants (McPhee, Mallett, Preston, Moore, Burton, 2015).

Biodiesel Tax and Subsidy Scheme

In the 2003-04 Commonwealth budget, the Government announced measures to support production and use of biodiesel in Australia. From 18 September 2003, biodiesel was subjected to excise and customs duty at the same rate as low-sulphur diesel (then 38.143 cents per litre). Under the Cleaner Fuels Grants Scheme, grants were provided to domestic producers and importers of biodiesel at the same rate as the duty applicable to low-sulphur diesel.

While domestic producers of biodiesel received grants that offset excise duty on their production, just as domestic ethanol producers did, domestic biodiesel producers did not benefit from heavy discrimination against imports in the way that ethanol producers did. Domestic biodiesel producers had to compete against untaxed biodiesel imports, but domestic ethanol producers were shielded from competition from imported ethanol by customs duty on ethanol imports at the rate applicable to imports of straight petrol, which had a substantially higher energy content. Consequently, the domestic ethanol industry was much more heavily supported by government policy instruments than the domestic biodiesel industry.

The biodiesel tax and subsidy scheme was extended like its ethanol equivalent, despite internal advice that it was not economically justifiable. Then, it was replaced with effect from 1 July 2015, by concessionary taxation of locally-produced biodiesel. The scheme is outlined below.

Concessionary Fuel Taxation Regime for Locally-Produced Ethanol

The new system of Commonwealth Government support for ethanol and biodiesel was announced in the Commonwealth Government budget for 2014-15, and established by the *Excise Tariff Amendment (Ethanol and Biodiesel) Act 2015*. A rationale for the new regime to support domestic production of biofuels was provided in a second-reading speech by the Assistant Treasurer, Josh Frydenberg (2015) on 4 June 2015. This rationale is discussed in the sub-section after the next one.

From 1 July 2015, the excise duty rate for locally-produced fuel ethanol dropped to zero and then was scheduled to increase by 6.554 per cent of the excise rate for petrol at 1 July each year until it reached 32.77 per cent of the excise duty rate for petrol on 1 July in 2020. In the meantime, the customs duty rate was to remain at the rate applicable to petrol and diesel fuel throughout the transition period. Indexation of the rate of excise duty for petrol and diesel was re-introduced from 1 November 2014.

The final (applicable from 1 July 2020) rate of excise duty for fuel ethanol is to be based on 50 per cent of the rate applicable to petrol after adjusting for the assumed difference between the energy content of ethanol and petrol. Beyond 2020, the rate of excise duty (applicable to domestic production) for fuel ethanol is scheduled to be 32.77 per cent of the customs duty rate (applicable to imports), which is the same as the excise and customs duty rate for straight petrol.

Concessionary Fuel Taxation Regime for Locally-Produced Biodiesel

The fuel taxation regime for biodiesel from 1 July 2015 is similar in concept to the one applying to ethanol from that date. The key difference is that there is a 15-year period of transition (rather than a 5-year transition period) to an excise duty rate that is 50 per cent of the rate applicable to diesel, after adjusting for the energy content difference.

From 1 July 2015, the excise duty rate for locally-produced biodiesel dropped to zero and then was scheduled to increase by 3.333 per cent of the excise duty rate for diesel at 1 July each year until it reached 50 per cent of the excise duty rate for diesel on 1 July in 2030. In the meantime, the customs duty rate was to remain at the rate applicable to diesel and petrol throughout the transition period. Indexation of the rate of excise for diesel, as well as for petrol, was re-introduced from 1 November 2014.

The final (applicable from 1 July 2030) rate of excise duty for biodiesel is to be based on 50 per cent of the rate applicable to diesel after adjusting for the specified difference between the energy content of biodiesel and diesel. The difference has been deemed to be zero. The excise duty rate applicable to domestically-produced biodiesel in 2030 will be only half of the customs duty rate for imported biodiesel, as well as half of the excise and customs duty rates for conventional diesel.

Commonwealth Government's Justification for Protection of Biofuels

In 2001, when the (Howard) Commonwealth nominated a biofuels target of 350 million litres per year and promised a capital subsidy program for new or expanded biofuels capacity, it justified support for biofuels by asserting that it would deliver (Liberal Party, National Party, 2001; Truss, 2001):

- security necessary for new investment to take place
- multiple regional benefits, including more employment, and an additional income stream to provide a buffer against shifting commodity prices
- more efficient use of agricultural and forestry residues
- environmental benefits, such as improved air quality and reductions in greenhouse gas emissions
- replacement of additives, such as MTBE, which has been implicated in groundwater contamination
- reduction of Australia's reliance on imported fossil fuels
- encouragement of ongoing research and development into second generation technologies through development of the ethanol industry.

Prime Minister Howard's 2002 announcement of an ethanol tax and subsidy system said that it was "part of the Government's strategy to encourage the use of biofuels in transport over time" (Howard, 2002). The Prime Minister did not explain why the Government wanted to encourage use of biofuels in transport. Presumably, he considered that it was justified by benefits asserted when a biofuels target was nominated in October 2001.

In a review of the ethanol tax and subsidy scheme, the Bureau of Resources and Energy Economics (2014) stated that the Government was trying to incentivise purchases of ethanol-petrol blends by fuel users through an excise discount.

In 1998, four years before the Prime Minister's announcement of a tax and subsidy scheme for ethanol, the (Howard) Commonwealth Government released a tax reform plan, *Tax reform: Not a New Tax, A New Tax System*. The document claimed that the Government's "central priorities" in taxation policy were (Australian Government, the Treasurer, 1998, p. iii):

- economic efficiency and effectiveness of the national economic policy framework
- equity and fairness that has always been part of the Australian way
- less complexity.

The document's elaboration of the economic efficiency priority included the following statements about "a modern, fair, and transparent taxation system" (Australian Government, the Treasurer, 1998, pp. 4-5):

"It needs to be fair and non-discriminatory between different sectors of the economy."

"As far as practicable, our tax system needs to avoid exemptions and loopholes that distort investment decisions and consumer choice."

It is obvious that the tax and subsidy scheme to protect domestic ethanol production, which was extended in scope to biodiesel, and in time to 2008, and then to 2011, was inconsistent with the taxation policy principles espoused by the (Howard) Government.

Moreover, the (Howard) Commonwealth Government's decision in March 2004 to extend the tax and subsidy schemes protecting domestic biofuels production from 30 June 2004 to 30 June 2008 was taken despite a negative assessment of biofuels policy finalised in December 2003 by the Australian Bureau of Agricultural and Resource Economics, Bureau of Transport and Regional Economics, and Commonwealth Scientific and Industrial Research Organisation (2003).

The (Gillard) Government's decision on 12 May 2011 to extend, without change, the tax and subsidy scheme to protect domestic biofuels production to at least 30 June 2021 was taken in response to negotiations with independent members of parliament to obtain support for a minority government

(Australian Government, Treasurer and Minister for Home Affairs, 2011; McPhee, Mallett, Preston, Moore, Burton, 2015).

An explanatory memorandum in respect of a package of enabling legislative amendments, included a regulation impact statement (RIS) – regulatory assessment – undertaken before the decision was taken. The RIS nominated improving economic efficiency as an assessment criterion, as required by the Commonwealth Government's guidelines for regulatory assessment (Australian Government, Office of Best Practice Regulation, 2007). However, it ignored equity considerations. The RIS acknowledged that economic efficiency would be improved by taxing alternative fuels like conventional liquid petroleum fuels with adjustments for energy content differences. However, it argued that economic efficiency improvements had to be weighed against environmental, energy security, and regional development benefits from production and use of alternative fuels. It did not analyse the nature and magnitude of these perceived benefits. It simply assumed they were large enough to justify ongoing protection of domestic biofuels production, although the level of protection would reduce over the period from 1 December 2011 to 1 July 2012 to 50 per cent of the petrol and diesel excise rate, adjusted to reflect the lower energy content of ethanol relative to petrol (no adjustment for biodiesel as it was deemed to have the same energy content as diesel).

The RIS did not properly follow the Commonwealth Government's own guidelines. It appears that they had to be suppressed in the context of the Government's decision.

The (Gillard) Government's decision to extend protection of domestic biofuels production was taken about 12 months after the release of a major review of the Australian taxation system by Ken Henry and others. Terms of reference from the Government for the review nominated three taxation design and assessment criteria or objectives (Henry, Harmer, Piggott, Ridout, Smith, 2010):

- do least harm to economic efficiency (efficient resource allocation)
- provide equity
- minimise complexity for taxpayers and the community.

The authors of the review argued that to be an efficient user charge, fuel tax would need to be extended to all fuels that were effectively tax free, including domestically produced biofuels and imported biodiesel, and vary between fuels on the basis of energy content (Henry, Harmer, Piggott, Ridout, Smith, 2010). A similar view had been expressed in 2002 by the authors of a fuel tax inquiry commissioned by the Commonwealth Government (Trebeck, Landels, Hughes, 2002).

In December 2011, a few months after the decision to extend the tax and subsidy scheme to protect the domestic biofuels industry, the Government issued a *Strategic Framework for Alternative Transport Fuels*. The document stated (Australian Government, Department of Resources, Energy and Tourism, 2012, pp. 6, 69):

"Measures that support the market development and deployment of alternative transport fuels will ….address market failures … be transparent, accessible and readily understood by investors and consumers ….ensure government outlays have clear rationales and limits."

"For Australia to maintain its energy security position and international competitiveness as we transition to a low carbon future, alternative transport fuels will need to be adopted in a way that is market-driven and ensures economic efficiency."

The *Strategic Framework for Alternative Transport Fuels* pointed out that the appropriate role of government in respect of adoption of alternative transport fuels is to correct market failures to improve the efficiency of resource allocation.[†††] Three potential sources of market failure were mentioned in relation to biofuels:[‡‡‡]

[†††] See Australian Government, Department of Resources, Energy and Tourism, 2011, p. 40
[‡‡‡] Ibid, pp. 40, 46, 54, 69.

- consumers who face conflicting information or lack of information, particularly independent and verifiable information regarding fuel quality, vehicle compatibility, environmental impacts and effects on food prices
- inadequate competition
- too little early-stage research and development activity.

The document also implied that government also had a responsibility to correct policy failures.

The *Strategic Framework for Alternative Transport Fuels* did not suggest that these perceived market failures and any policy failures would be addressed by the extension of the tax and subsidy scheme to protect domestic biofuels production. It did not provide any rationale for this policy decision.

It proposed government funding programs for early-stage research and development activity. It proposed that industry should take on the role of improving information flows to users, and that government should work on fuel quality standards to provide quality assurance to them. Strategy to address any perceived competition issues was not discussed.

It is obvious that the tax and subsidy arrangement for biofuels that was extended from 2011 to 2021 by the Gillard Government did not improve the efficiency of the allocation of resources, as it created an excess burden or deadweight loss by reallocating resources from economic activities to uneconomic activities. It could not reasonably be regarded as fair as most of the gains accrued to owners of a single entity that employed a relatively small number of people.

The Australian National Audit Office/Auditor General observed that specific objectives or intended outcomes were not set out in documentation for the Ethanol Production Grants Program (the subsidy for domestic production in the ethanol tax and subsidy scheme) until 2012. Then, they were presented in the following way (McPhee, Mallett, Preston, Moore, Burton, 2015):

> *Objective*: to support production and deployment of ethanol as a sustainable transport fuel in Australia
>
> *Intended outcome*: to encourage use of "environmentally sustainable" fuel ethanol as an alternative transport, increase the capacity of the ethanol industry to supply the transport fuel market, and improve the long-term viability of the ethanol industry in Australia.

The (Abbott) Government's rationale for replacing the tax and subsidy regimes for ethanol and biodiesel with less generous concessionary fuel taxation regimes for locally-produced biofuels was that it would contribute to a "sustainable trajectory back to (budget) surplus" (Frydenberg, 2015).

The Government offered three reasons for increasing the tax rate on domestically-produced biofuels to only half the energy-content-adjusted rate for petrol and diesel, and for continuing to tax imported ethanol and biodiesel at the full unadjusted rate for petrol and diesel (Frydenberg, 2015):

- it's a long-standing government policy (first proposed by the [Howard] Government in December 2003)
- biodiesel producers play an important role in the Australian economy
- having a range of alternative fuels has a positive effect on Australia's energy security.

No justification was provided for raising rates over five years for ethanol and 15 years for biodiesel.

The Government's decision to switch from a tax and subsidy scheme for protection of domestic biofuels production to concessionary tax arrangements offering less, but still substantial protection (announced in the 2014-15 Commonwealth budget documents), followed completion of a negative assessment of costs and benefits of the Ethanol Production Grants Program (the ethanol version of the tax and subsidy scheme for biofuels) by the Bureau of Resources and Energy Economics (BREE) (2014). BREE's findings included the following.

- An expanded Australian ethanol industry was unlikely to be commercially viable in the absence of the protection provided by the tax and subsidy scheme or other government support, unless oil prices were significantly higher or feedstock costs were sustained at low levels.
- Regional direct employment associated with the ethanol industry was estimated to be 160-200 jobs at a cost of around $545,000 to $680,000 per job.
- There was no evidence to suggest that support for the ethanol industry by the tax and subsidy scheme provided downward pressure on retail prices of petrol.
- The small and concentrated nature of the industry meant it provided no real fuel security benefit. Indeed the effect on energy security might be slightly negative.
- The cost to taxpayers of abatement of greenhouse gas emissions in 2012-13 was estimated to be $274 per tonne of CO2-e.
- Government support for high-cost, first-generation biofuels production could impede development of second-generation biofuels production capacity.
- Health cost reduction benefits were estimated to be $10.6 million in 2012-13, compared to subsidy payments of $108.9 million in that year. However, completion of the phase in of Euro 5 emissions standards by 2018 was expected to reduce particulate emissions – the main source of health benefits attributed to ethanol – by 90 per cent.

It is difficult to reconcile the findings of BREE's report to the Commonwealth Government in 2014 with the Government's decision later in 2014 to continue to provide substantial support to that sector, and its claims of benefits from continuation of support for domestically-produced biofuels. Although this support would reduce slowly, particularly for biodiesel, long-term support would remain substantial.

Also, the concessionary taxation regime for domestically-produced biofuels is not consistent with principles for taxation systems (assessment and design criteria) nominated in a discussion paper on taxation policy reform released by the (Abbott) Commonwealth Government about two months before the Government outlined its rationale for the biofuels regime. The nominated taxation principles were (Australian Government, the Treasury, 2015):

- *equity* – fairness in the distribution of the tax burden
- *economic efficiency* – imposing the lowest possible cost on the economy over and above the revenue raised
- *simplicity* – a tax system that is easy to understand and comply with.

Similar policy assessment principles were specified in the *Australian Government Guide to Regulation* and the original version of the guidelines (Australian Government, Office of Best Regulation, 2014, 2007).

It is difficult to see how concessionary taxation of domestically-produced biofuels could be regarded as fair, when most of the gains accrue to owners of single entity that employs a relatively small number of people. It is clear that such a taxation regime is not economically efficient as it creates an excess burden or deadweight loss by reallocating resources from economic activities to uneconomic activities.

2.4.2 Queensland Biofuels Policy

Ethanol

All petrol (motor spirit) sold to users in Queensland for more than two decades to 1957 contained a proportion of Australian-produced ethanol as required by Queensland Government laws. The Bureau of Transport and Communications Economics (1994) and Roarty and Webb (2003) reported that the prescribed proportion was one tenth.

Although the requirement was rescinded in 1957, the *Motor Spirit Vendors Act*, which had authorised the "power alcohol" (ethanol) mandate since 1934, was not repealed until 1988. However, the *Liquid Fuel Supply Act Amendment Act 1988*, which repealed the *Motor Spirit Vendors Act 1933* and *Motor Spirit Vendors Act Amendment Act 1934*, authorised a similar mandate of Queensland-produced ethanol in petrol. The Queensland Government did not implement a mandate under the *Liquid Fuel Supply Act 1984* before the relevant provisions were revised substantially in 2015.

In 2005, the Queensland Government announced an Ethanol Industry Action Plan with funding of $7.3 million. The Action Plan included $2.28 million for a "customer education" program to increase awareness of attributes of petrol-ethanol blend fuel. The Action Plan also included grants under the Queensland Ethanol Conversion Initiative to upgrade infrastructure to allow sale of petrol-ethanol blend fuel. This included funds to clean tanks, fuel lines, bowsers, and to provide signage in preparation for sale of blended fuel.

On 17 August 2006, during an election campaign, the Queensland Premier announced that a re-elected Labor government would legislate that all petrol produced in Queensland must include 5 per cent ethanol (E5) by 2010. The ethanol blend mandate was to be conditional on tests commissioned by the Commonwealth Government finding that E5 did not adversely affect vehicles. The mandated ethanol percentage was to be increased to 10 per cent as soon as practical after 2010. In January 2007, Department of State Development advised that the E5 mandate would apply to regular unleaded petrol wholesaled and produced in Queensland, but not to premium unleaded petrol (Willett, 2007).

The Queensland Government released a public benefit test review of a 5 per cent ethanol blend mandate in 2009. It explained that the Government planned to legislate application of a mandate that would commence on 31 December 2010. The report claimed that the overall impact of the mandate was likely to be neutral (Queensland Department of Employment, Economic Development and Innovation, 2009). The Queensland Government did proceed with its ethanol mandate proposal at that time.

The concept of an ethanol blend mandate was revived in 2015 after the Labor Party formed a minority government with support from an independent parliamentarian, and two members of Katter's Australia Party (KAP). A condition of KAP support was implementation of an ethanol mandate.

In late 2015, the *Liquid Fuel Supply (Ethanol and Other Biofuels Mandate) Amendment Act 2015* was passed by the Queensland Parliament. It amended the *Liquid Fuel Supply Act* to include biodiesel mandate provisions, as well as to make substantial changes to previously (1933 and 1988) legislated ethanol blend mandate arrangements. The mandate provisions did not include a requirement that biofuels must be produced in Queensland or Australia. The ethanol and biodiesel mandates came into effect from 1 January 2017.

For fuel retailers, the ethanol blend mandate is that a retailer of at least the size prescribed in the Act must sell an amount of ethanol[§§§] that is at least three per cent of its sales of regular petrol plus

[§§§] Or other fuel for petrol engines produced from plant oils, animal oils, biomass or waste. The Act referred to ethanol or this other fuel as "biobased petrol".

ethanol-regular petrol blend in each calendar quarter. After 18 months from commencement of the mandate (after 1 July 2018), the mandated ethanol percentage is to be four percent or any higher percentage prescribed by regulation under the Act. The size threshold for application of the mandate to a retailer is ownership or operation of 10 or more standard service stations or sales of 250,000 litres of petrol (includes all grades) per calendar quarter or a different prescribed amount at any one of the standard service stations owned or operated by the retailer. Subsequently, a sales threshold of 500,000 litres was prescribed.

For fuel wholesalers, the ethanol blend mandate is that in each calendar quarter a wholesaler must sell an amount of ethanol that is least the percentage of its sales of regular petrol plus ethanol-regular petrol blend prescribed by regulation under the Act.

The ethanol mandate requirements for fuel retailers and wholesalers may be met by sales of ethanol in blends with regular or premium unleaded petrol.

Biodiesel

The biodiesel blend mandate requires that at least 0.5 per cent of the amount of diesel and biodiesel blend sold by a wholesale fuel seller be biodiesel in each calendar quarter.[****] The Act provides that a higher biodiesel percentage may be prescribed by regulation.

Exemptions from and Suspensions of Current Mandates

The relevant Government Minister, on receipt of an application from a fuel seller, may exempt or partially exempt the fuel seller from complying with a biofuel mandate for a stated period. An exemption is subject to the Minister being satisfied that the seller is unable to get enough biofuel or biofuel blend to comply with the mandate because of a supply shortage, or compliance would threaten the viability of the fuel seller’s business, or extraordinary circumstances justify an exemption.

The relevant Government Minister may, by declaration, suspend an ethanol or biodiesel mandate for all fuel sellers or a stated class of fuel sellers for a specified period of not more than one year. Such a suspension is subject to the Minister being satisfied that there is an industry-wide shortage of supply or insufficient demand for biofuels or biofuel blends, or supply of biofuel or biofuel blend poses a risk to public health or safety, or continuation of a mandate would adversely impact Queensland’s economy.

Queensland Government’s Justification of Biofuels Mandates

A paper accompanying the Queensland Premier’s 2006 (5 per cent) ethanol mandate announcement asserted that the mandate would “combat rising petrol prices”, provide “a secure source of fuel which does not rely on dwindling and uncertain oil supplies”, “open new markets for Queensland farmers”, “protect them from fluctuating world prices for sugar and grains”, “strengthen our regional economy and provide more secure jobs for the future”. The paper did not repeat the Queensland Government’s previous frequent assertion that ethanol-petrol blend fuels are better for the environment and health. For example, such an assertion was made in a press release by the Deputy Premier on 1 September 2005 (Willett, 2007).

[****] In the context of this discussion of the Queensland mandate, the term “biodiesel” also includes other fuel for diesel engines produced from plant oils, animal oils, biomass or waste. The Act referred to biodiesel or this other fuel as bio-based diesel.

In 2009, in a document outlining a "public benefit test" on a 5 per cent ethanol mandate, various objectives were nominated (Queensland Department of Employment, Economic Development and Innovation, 2009):

- provide certainty to decision makers to invest in the ethanol supply chain
- establish a market for the ethanol industry
- provide benefits to rural and regional Queensland
- greenhouse gas abatement
- contribute toward energy security
- facilitate ongoing research and development into second generation technologies through development of the ethanol industry.

More recently, the Queensland Government offered similar justifications for the current biofuels mandates. In a discussion paper released in June 2015, the Queensland Government stated that the aims of the biofuels mandates were to (Department of Energy and Water Supply, 2015, pp. 2, 4, 10):

- provide certainty and confidence to decision makers to invest, innovate, and create jobs in a sustainable biofuels industry and to grow that industry
- contribute to regional growth and jobs creation
- lower the wholesale price of ethanol and ensure consumers see cheaper ethanol (biodiesel not mentioned)
- reduce greenhouse gas emissions from motor vehicles
- take advantage of advanced biofuel production technologies that can use a range of feedstocks, including waste
- create a foundation for a new high-value, knowledge-based bio-manufacturing industry for Queensland.

On the day the mandates took effect (1 January 2017), the Minister for Energy, Biofuels and Water Supply, Mark Bailey (Bailey, 2017) claimed they would, "in a sustainable way":

- drive jobs growth in regional Queensland
- add value to the state's abundant agricultural resources
- diversify the economy
- encourage innovation
- support knowledge-based jobs for the future.

It appears that the decision-making process regarding the biofuels mandates that commenced on 1 January 2017 bypassed the Queensland Government's regulatory impact analysis system.

Guidance notes for the system explained that a *prima facie* case for government intervention could be made if there is market failure or policy failure, indicating misallocation of resources, or there are poor equity outcomes. The guidelines required assessment of policy options in a social benefit-cost analysis framework (Queensland Productivity Commission, 2018). Such a framework, like the concepts of market failure and policy failure, is focussed on assessing whether or not the efficiency of resource allocation would be improved by a policy change. Normally, a social benefit-cost analysis is accompanied by analysis of distributional (equity) impacts. The regulatory impact analysis system indicates that the Queensland Government has endorsed improving the efficiency of resource allocation and equity as principal policy design and assessment criteria.

It is difficult to reconcile the Queensland Government's justifications for its biofuels mandate with Government-endorsed assessment criteria for designing and assessing regulatory actions by government. On the basis of these criteria, there does not appear to be a case for government intervention in the form of a biofuels mandate. A regulatory impact analysis establishing the existence or otherwise of such a case has not been published. It is not obvious how the Queensland biofuels mandate could be regarded as a means of improving equity and the efficiency of allocation of resources in the Queensland economy.

2.4.3 New South Wales Biofuels Policy

Ethanol

The *Biofuel (Ethanol Contact) Act 2007* imposed an ethanol blend mandate in New South Wales. The Mandate commenced on 1 October 2007.

Initially, the ethanol blend mandate applied only to primary fuel wholesalers, such as Caltex, BP, Shell (later Viva) and Mobil. The minimum amount of ethanol they were required to sell was 2 per cent of the volume of petrol (including ethanol-petrol blend) sold in New South Wales.

The *Biofuel (Ethanol Content) Amendment Act 2009* increased the required ethanol percentage to 4 per cent of the volume of petrol sold in New South Wales from 1 January 2010, and to 6 per cent from 1 January 2011 (subsequently deferred to 30 September 2011). The amended Act became the *Biofuels Act 2007*.

The *Biofuel (Ethanol Content) Amendment Act 2009* also extended the ethanol blend mandate to "major fuel retailers", such as Woolworths, Coles Express and 7-Eleven, as well as to previous mandate targets, the primary fuel wholesalers (collectively referred to as "volume fuel sellers"). The ethanol mandate did not apply to sales of petrol by primary fuel wholesalers to major retailers.

Under the amended legislation, only ethanol that complied with a standard prescribed by the Biofuels Regulation for the sustainable production of ethanol would satisfy the ethanol blend mandate.

The Act provided that from July 2011, regular unleaded petrol (research octane number less than 95) could be sold by a primary fuel wholesaler only if it was blended with ethanol and the ethanol content was between 9 per cent and 10 per cent by volume. However, in 2011, this requirement was delayed to 2012. In May 2012, it was removed by the *Biofuels Amendment Act 2012*.

Because the mandates had been ineffective in achieving biofuels uptake targets (ethanol's share of the petrol market had been declining and was only 2.5 per cent in 2015-16) [††††], the New South Wales Government passed the *Biofuels Amendment Act 2016* to address the issue. The legislative amendments refocussed responsibility for meeting the blend mandates, restricted exemptions from the mandates for fuel retailers, required better accessibility of ethanol-petrol blend fuel, and targeted greater compliance with the mandates (Dominello, 2016; New South Wales Fair Trading, 2018). In addition, because E10 was overpriced on an energy content basis relative to straight petrol, the Independent Pricing and Regulatory Tribunal in New South Wales was assigned the task of regulating the wholesale price of ethanol. It was also asked to maintain a watching brief on retail prices of E10 to ensure that any regulated reductions in the wholesale price of ethanol are passed on at retail outlets (Dominello, 2016).

Responsibility for meeting the mandate was shifted from primary fuel wholesalers and major retailers to an expanded retail category, "volume fuel retailers". This label was applied to entities that operate or control:

†††† IPART (2015a, b); Australian Government, Department of Environment and Energy (2018b).

- one or more “volume fuel service stations”, such an outlet being one that sells three or more types of petrol or diesel totalling more than 900,000 litres per quarter in two consecutive quarters, or
- 20 or more service stations, none of which are volume fuel service stations.

Eligibility for exemptions was restricted by removing some grounds for exemption. Those grounds included increases in fuel prices, and reduced availability of grain or stock feed availability or substantially higher prices of those commodities.

As well as meeting the ethanol and biodiesel mandates, “volume fuel retailers” were required to ensure that ethanol-petrol blend fuel was made as accessible as any form of straight petrol (interpreted by New South Wales Fair Trading to be the most popular form). The accessibility requirement applied whether or not a volume fuel retailer meets the biofuel volume mandates.

New legislative provisions came into effect on 1 January 2017 for retailers that were subject to the previous biofuel laws, and on 1 April 2017 for retailers not subject to the previous laws, but covered by the new regime (New South Wales Fair Trading, 2018).

The New South Wales Government also initiated an information campaign. The Minister for Innovation and Better Regulation, Victor Dominello (2016) said it was focussed on education regarding the benefits of ethanol, and compatibility and performance of vehicles. In addition, he stated that the information campaign would explain the energy disparity between fuels, and that E10 would be the most cost-effective option if priced at a large enough discount to straight regular unleaded petrol.

By December 2017, ethanol’s share of petrol sales in New South Wales had moved up to 2.93 per cent. However, in the first quarter of 2018, ethanol’s share stagnated around 2.35 per cent (Australian Government, Department of Environment and Energy, 2018b).

Biodiesel

In 2009, a biodiesel blend mandate was introduced in New South Wales by the *Biofuel (Ethanol Content) Amendment Act 2009*. The amended legislation became the *Biofuels Act 2007*.

The minimum percentage of biodiesel in diesel sold by a “volume fuel seller” in New South Wales was set at 2 per cent. This mandate applied from 1 October 2009. It was scheduled to be increased to 5 per cent from the beginning of 2012. In December 2011, because of insufficient local production, the scheduled increase was suspended. The suspension was to continue until local production could meet an increase in the mandate.

The biodiesel blend mandate did not apply to sales of diesel fuel by primary fuel wholesalers to major retailers.

Only biodiesel that complied with a sustainability standard qualified as biodiesel in satisfaction of the biodiesel requirement. The standard is prescribed by the *Biofuels Regulation*.

The *Biofuels Amendment Act 2016* amended elements of the biofuels mandate regime. The changes affected the biodiesel regime, as outlined in the preceding sub-section.

New South Wales Government’s Justification of Biofuel Mandates

When the biofuel mandate was initiated, the relevant New South Wales Government Minister, Tony Kelly, suggested that it was aimed at reducing fuel costs and land transport emissions (Kelly, 2007).

Subsequently, the relevant Minister, Tony Kelly (2009), explained that the intended policy outcomes of the mandate included:

- regional development and job creation
- cheaper fuel for consumers
- reduction of greenhouse gas and toxic emissions
- substitution of renewables for imported petroleum-based products, improving Australia's balance of payments and fuel security
- provision of a base for development of second generation renewable fuel industry.

The Minister for Innovation and Better Regulation provided the following reasons for a revised government biofuels mandate in his second reading speech in respect of the *Biofuels Amendment Bill 2016* (Dominello, 2016).

- Ethanol could be as cheap as straight petrol if priced competitively on the basis of energy content (a discount of at least 3 per cent). E10 typically was overpriced relative to straight petrol on the basis of energy content prior to the 2016 changes to the mandate regime, but it was claimed that this would be rectified by IPART's regulation of the wholesale price of ethanol and its watching brief on retail E10 prices.
- Biofuels reduce dependence on foreign oil.
- Ethanol makes productive economic use of an agricultural waste product (a by-product of starch produced from wheat in New South Wales).
- Biofuels production supports regional jobs.

New South Wales Fair Trading (2018) stated that the ethanol blend mandate was conceived as a step towards reducing New South Wales dependence on fossil fuels and reducing the State's reliance on imported petroleum products.

The New South Wales Government's changes to the biofuels mandate regime in 2016 followed receipt of advice sought from IPART (2015a, b) on a range of options to increase the uptake of ethanol-petrol blend fuel. IPART's analysis of 13 categories of options (with one to four options in each category) indicated:

- without changes to the mandate regime, the ethanol uptake was likely to continue to decline to about 2 per cent by 2024-25 (from 2.5 per cent in 2015-16)
- all options except one would fail to lift the share of ethanol in total petrol sales to the mandated amount of 6 per cent, and would not get close to that target
- the exception would be a mandate of up to 10 per cent ethanol in all petrol sold in New South Wales, without any exemptions, but this would have a <u>negative</u> nett present value (NPV) of about $1.2 billion
- most options would increase the nett cost to the New South Wales community of an already expensive policy
- most of the benefits of measures to increase ethanol uptake would accrue to producers of ethanol
- most of the costs would ultimately be borne by consumers through higher fuel prices
- measures to increase ethanol uptake by reducing consumer choice would strengthen Manildra Groups already substantial market power in the context of the mandate
- only two options would increase the ethanol's market share and have a positive nett present value
  - regulation of the price of ethanol based on energy content (positive NPV of $2 million)
  - evidence-based educational campaigns conveying factual information, not just promotional activities (positive NPV of $56 million).

IPART (2015b, p. 6) also pointed out:

"The current price of E10 often does not represent value for money on an energy efficiency basis. Ethanol contains 31.6 per cent less energy per litre than petrol, and on average, using E10 increases fuel

consumption by about 3 per cent. The loss of energy content in the ethanol blend is not compensated by the price discount offered on E10 in the market. To be price competitive, E10 needs to be about 3 per cent cheaper than regular unleaded petrol. However, at the time of our assessment for the Final Report, the market average discount was only about 1.5 per cent."

In revising the ethanol mandate in New South Wales, the Government apparently took note of IPART's advice about E10 being overpriced, Manildra's market power being substantial because of the mandate, and benefits of an evidence-based education campaign. However, the Government chose not to act on the message that strengthening the mandate would add to the already substantial nett social costs of the New South Wales ethanol mandate. It continued to claim that the mandate was beneficial to the people of New South Wales.

IPART's (2015a, b) analysis was based on two criteria: efficiency of resource allocation (applied within a social-benefit cost analysis framework), and equity or fairness (in respect of the distribution of benefits and costs). The New South Wales Government's own guidelines on design and assessment of regulatory intervention refer to the same criteria. The most recent version of the relevant guidelines (New South Wales Government, Department of Finance, Services and Innovation, 2016) explained that government intervention may be justified to improve the efficiency of resource allocation, when markets fail to allocate them efficiently, and to promote equitable outcomes. The guidelines emphasised that government intervention should occur only if the benefits outweigh the costs (indicating an improvement in the efficiency of resource allocation).

The New South Wales Government chose not to assess the revised ethanol mandate by reference to these principles in a Better Regulation Statement or Regulatory Impact Statement – an assessment in accordance with the guidelines on design and assessment of regulations. Instead, after changes had been made to the *Biofuels Act* by the *Biofuels Amendment Act 2016,* the Government commissioned a Regulatory Impact Statement (RIS) focussed only on whether or not the Biofuels Regulation should be changed given that the governing Act had changed, on fine-tuning of administrative arrangements. The document reached the inevitable conclusion that the Regulation should be changed to support and be consistent with the revised Act. The RIS noted that changes to the mandate regime had been "informed and guided" by IPART's (2015a, b) assessment and advice (New South Wales Government, New South Wales Fair Trading, 2016).

It is difficult to reconcile the New South Wales Government's justifications for its biofuels mandate with assessment criteria that IPART has applied and that government guidelines indicate agencies should apply in designing and assessing regulatory interventions.

3 Project Objectives

The objectives of this project were to determine the market impact and influences of biofuel mandates on the feedlot sector and the broader Australian community.

Due to data availability and limitations, it was not possible to quantify these impacts in the way that the study team expected to be able to do. Attempts at quantification are provided in section 4.1 below. As a result, considerable attention was focused on a qualitative economic assessment of biofuels policies, informed by a large body of literature (section 4.2).

4 Methodology

This section set outs a two-pronged approach to assessing the impacts of biofuels policy on the Australian feedlot industry and the broader Australian society. First, econometric modelling was undertaken to determine the effects of biofuels on the feedlot industry. Second, qualitative economic analysis of biofuels was undertaken by reference to widely accepted economic assessment principles.

4.1 Econometric Analysis of Domestic Biofuels Mandates on Feed Grain Prices

This section reports on use of regression analysis to identify any valid statistical relationships between domestic wheat and sorghum feed grain prices and the establishment of the New South Wales and Queensland mandates. Separate models were estimated for Riverina wheat prices and Darling Downs sorghum prices, using both indicator variables to denote the time when the mandates were deemed to be in operation, as well as the ethanol-blended fuel share of total automotive fuel sales, to estimate whether there has been a general relationship between the use of ethanol in petrol-based fuel and feed grain prices.

The results are presented in the following sub-sections.

4.1.1 Possible Drivers of Domestic Feed Grain Prices

A number of possible drivers of domestic sorghum and wheat feed grain prices are considered as part of the regression analysis.

- international grain prices
- exchange rates
- grain stocks and grain production
- rainfall
- the Queensland and New South Wales biofuels mandates.

International Grain Prices

A simple plot of domestic grain prices against their $A international equivalents shows that there is a significant degree of co-movement between the series. Figure 8 shows the Riverina wheat feed stock price plotted against the Wheat, No.1 Hard Red Winter price converted to an Australian dollar price. The figure shows that domestic and international wheat markets are linked, and that Australian wheat prices are driven to a significant degree by global factors. There are periods, however, in which the domestic price moves away from the international price. This is generally a result of domestic conditions. In years in which domestic production has been strong and stocks are high, domestic wheat has tended to sell at a significant discount relative to international prices. This happened in 2010-11 and again in 2016-17 when domestic wheat production was quite strong.

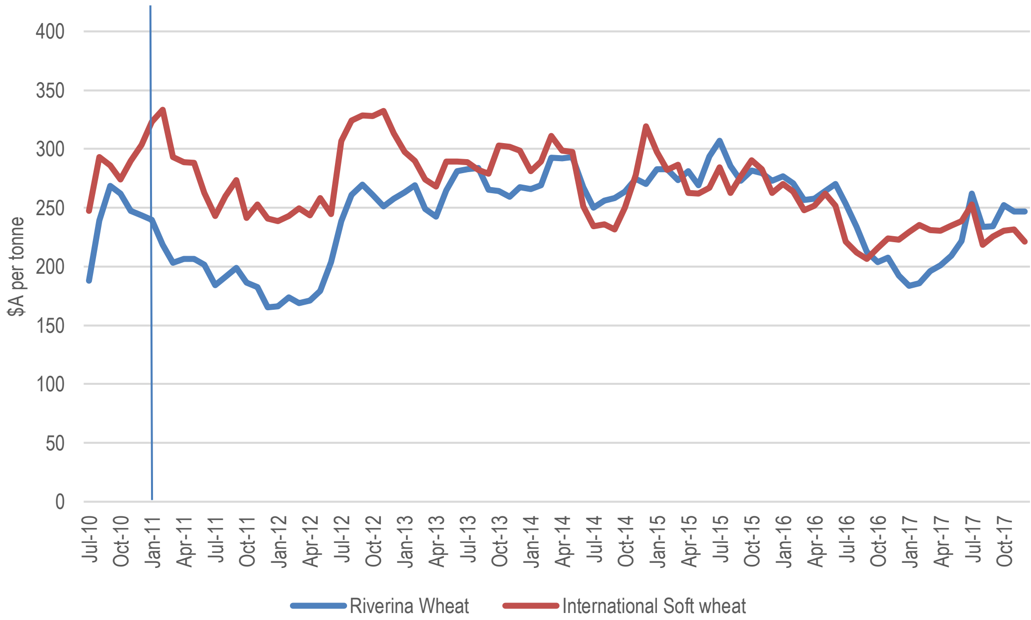

Figure 8 Riverina Wheat and International Wheat Prices, $A

Source: ProFarmer Australia and IMF

Figure 9 plots the domestic Darling Downs sorghum price against its Australian dollar international equivalent. Just like wheat, there is considerable co-movement between the two series, although not to the same degree as in wheat markets. The figure also shows that there are periods when the domestic sorghum price will deviate considerably from the international price as a result of domestic conditions. For example, in 2011-12 and 2012-13, domestic sorghum production was very strong, leading to a significant discount in the domestic price relative to the international price. In 2013-14, a steep decline in production led to a premium in domestic sorghum prices over international prices.

Of great interest is the price premium that emerged in 2016-17, corresponding with the introduction in the Queensland mandate. This price premium could potentially be caused by the mandate and the recent increase in E10 sales in Queensland. Unfortunately, the price premium also corresponded with a very poor domestic sorghum crop in 2016-17, which is a more plausible explanation for the increase in the price of Darling Downs sorghum.

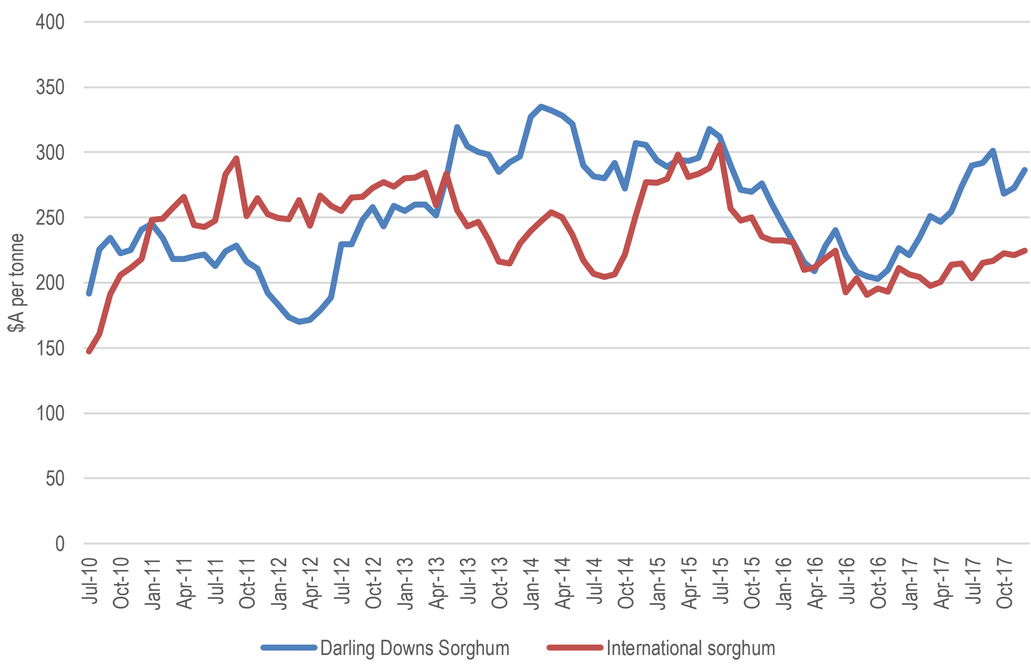

Figure 9 Darling Downs Sorghum and International Wheat Prices, $A

Source: ProFarmer Australia and IMF

4.1.2 Closing Stocks and Production

Figure 10 shows Australian closing stocks of wheat on an annual basis. Stocks rise and fall in line with domestic production. In those years where production and stocks are high, domestic wheat feed grain prices tend to be lower while during periods of weak production, stocks fall and prices tend to rise. Stock movements tend to dampen price movements in the underlying commodity, by adding to supply precisely when it's needed most, and removing supply when demand is insufficient to take all of the season's production.

Therefore, a negative relationship between stocks (and production) levels and domestic grain prices could be expected.

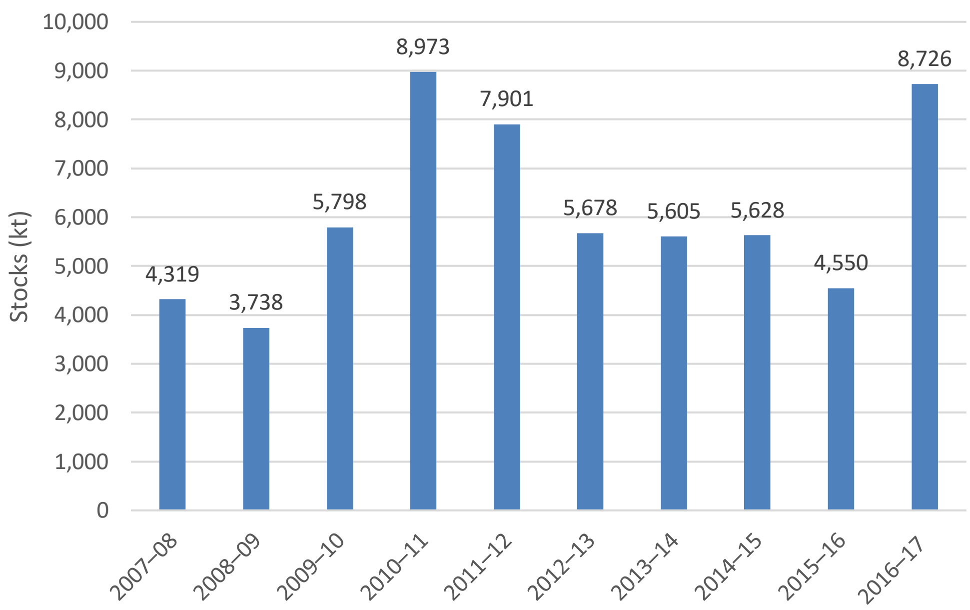

Figure 10 Australian Wheat Closing Stocks, 2007-8 to 2016-17

Source: ABARES

Figure 11 presents Australia's annual sorghum production from 2007-08 to 2016-17. Low production years, such as in 2016-17 and 2013-14, tended to be associated with periods where domestic sorghum trades at a price premium over the international price.

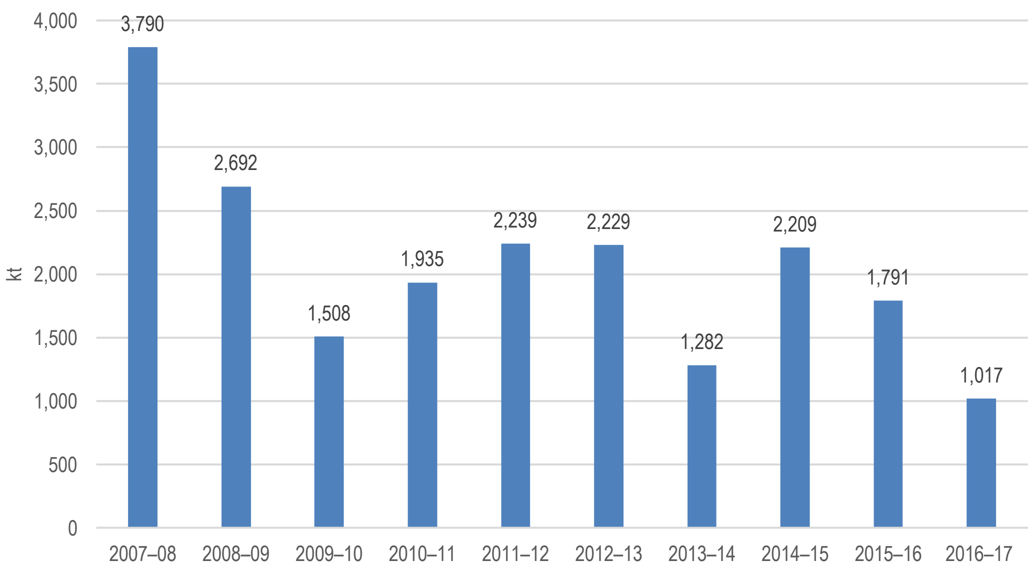

Figure 11 Australian Sorghum Production, 2007-08 to 2016-17

Source: ABARES

4.1.3 Rainfall

Another variable considered as a potential explanatory variable is rainfall in the Riverina region (for wheat) and Darling Downs region (for sorghum). Clearly, the success of grain crops will depend on adequate rainfall in the period prior to harvesting. It is important to note that rainfall will be closely correlated with output and stocks, so may or may not add significant explanatory power to the estimated regressions. Figure 12 shows the monthly rainfall at Darling Downs in Queensland, while Figure 13 presents a chart of monthly rainfall in the Riverina region of New South Wales.

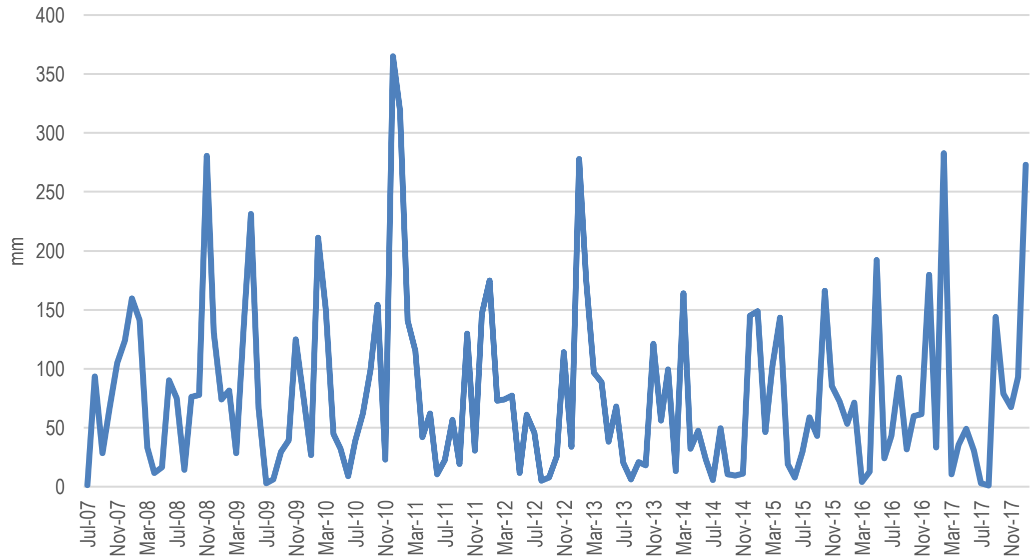

Figure 12 Monthly Rainfall at Darling Downs, Queensland

Source: Bureau of Meteorology

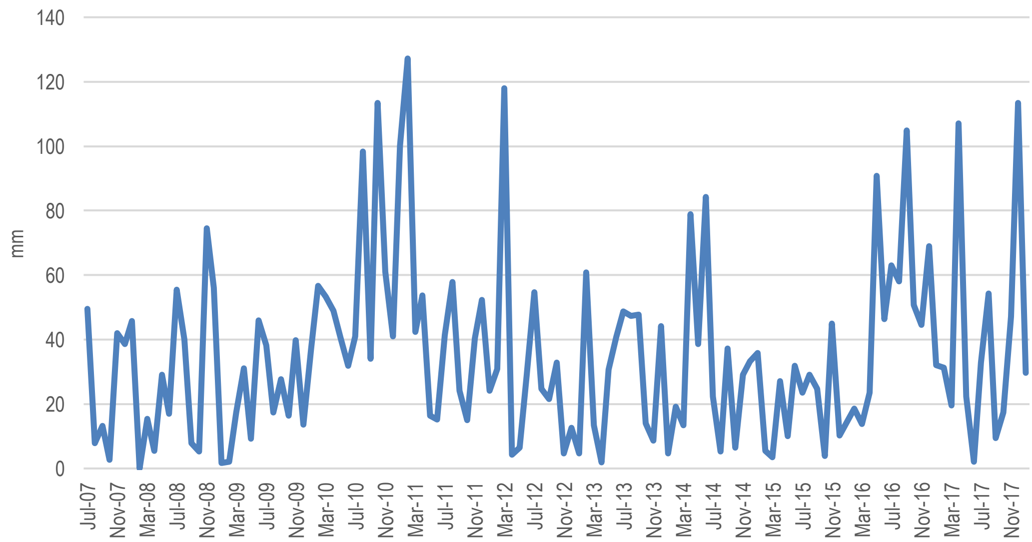

Figure 13 Monthly Rainfall at Riverina, New South Wales

Source: Bureau of Meteorology

4.2 Policy Assessment Principles

4.2.1 Core Principles

In this investigation, Commonwealth, New South Wales and Queensland biofuels policies and changes thereto have been analysed by reference to three core principles:

- economic efficiency: improving the efficiency of allocation of resources in the economy or at least not adversely affecting it (avoiding deadweight loss or economic waste)
- administrative efficiency or simplicity: keeping monitoring, compliance and enforcement costs borne by private and government entities to reasonably low levels, an achievement facilitated by avoiding complexity
- equity or fairness: treatment of individuals fairly relative to others.

These core principles have become widely accepted by economists as criteria for design and assessment of policy proposals and instruments. They have also been adopted and applied by governments around the world.

In the economics literature, the three core principles can be traced back at least 242 years to the pioneering economic insights of Adam Smith (1776). They have been nominated as policy design and assessment criteria in prominent public economics/finance texts over the past 95 years.[‡‡‡‡]

In Australia, equity, economic efficiency and simplicity criteria have been applied in several reviews of the tax system over the past 50 years.[§§§§] In addition, they have underpinned regulatory design and assessment guidelines issued by Commonwealth, New South Wales, and Queensland Governments and the Council of Australian Governments.[*****] The Commonwealth Government's Productivity Commission typically applies the three core principles in its inquiries and research papers regarding policy issues.[†††††] The same criteria have also been applied in various other government-commissioned policy reviews and statements in Australia.[‡‡‡‡‡] The energy policy principles set out in the Commonwealth Government's *Energy White Paper 2012* clearly were based on overarching objectives of efficient resource allocation and equity.[§§§§§]

Government intervention in the economy may be justified if markets have failed to allocate resources efficiently (market failure), if previous interventions have misallocated resources unnecessarily (policy failure), or if there are inequities that are judged to be undesirable. However, for a policy initiative to be worthy of selection, not only should it yield benefits in excess of costs, but also it should be the policy option that provides the largest surplus of benefits over costs (Coase, 1960).

These important considerations have been emphasised in regulatory design and assessment guidelines issued by Commonwealth, New South Wales, and Queensland Governments, and by the Council of Australian Governments.[******] However, in formulating and offering justifications for biofuels policies, relevant governments chose to ignore their own guidelines.

[‡‡‡‡] See Dalton (1923), Pigou (1929), Musgrave (1959), Musgrave and Musgrave (1973), Atkinson and Stiglitz (1980), Stiglitz (2000), Rosen and Gayer (2008).

[§§§§] For example, Downing, others (1964), Asprey, others (1975), Australian Government, Treasurer (1985), Ralph, others (1998), Australian Government, Treasurer (1998), Henry, others (2010), Australian Government, Treasury (2015).

[*****] See Australian Government, Office of Best Practice Regulation (2007, 2014a), Council of Australian Governments (2007), New South Wales Government, Department of Finance, Services and Innovation (2016), and Queensland Productivity Commission (2018).

[†††††] For example, see Productivity Commission (2009, 2015, 2016).

[‡‡‡‡‡] For example, see Parkinson, others (2010), and Harper, others (2015).

[§§§§§] See Australian Government, Department of Resources, Energy and Tourism (2012, pp. 5-6, 52). The *Energy White Paper 2012* focussed on efficient resource allocation, although consideration of equity is implied

[******] See Australian Government, Office of Best Practice Regulation (2007, 2014), New South Wales Government, Department of Finance, Services and Innovation (2016), Queensland Productivity Commission (2018), and Council of Australian Governments (2007).

4.2.2 Economic Efficiency

Economic efficiency is concerned with how well all resources – human resources, capital, land, mineable resources, and other natural resources, including the natural environment – are used in or allocated between competing ends. It means providing people with as much as possible of what they want with available resources.

Resources may be misallocated – not used efficiently – because of various sources of market failure or policy failure. These concepts are discussed briefly below.

Market Failure

There are several sources of market failure, which include:

- external costs
- external benefits
- under-provision of goods and services with public good characteristics (a high proportion of benefits are external)
- information deficiencies – inadequate and asymmetrically available information
- incomplete markets
- excessive market power.

Governments have established legal and protective frameworks to establish and enforce property rights, facilitate and enforce contracts, and protect people from criminal behaviour. This is a pre-condition of efficient operation of markets. Such action by governments is not usually categorised as a response to market failure. However, the absence of such frameworks could reasonably be categorised as a form of market failure involving under-provision of public goods, in this case, legal and protective arrangements.

Policy Failure

Costs of government intervention are not confined to costs of enforcing and complying with the policy. To the extent that policy instruments distort otherwise preferred economic decisions, they cause departures from an efficient allocation of resources, known as "deadweight loss". This economic waste caused by government intervention depends on the nature of the intervention and the design of the policy instruments applied. Well-designed policy instruments would minimise the extent of any deadweight loss. Poorly-designed measures could cause substantial deadweight loss.

Government intervention in economic affairs is pervasive. Market failure is just one of several reasons why governments intervene. Sometimes, they act to address circumstances wrongly perceived to be market failure. In addition, a common reason for government intervention is to modify the distribution of income and wealth for equity reasons. Governments also take action to stabilise the economy. At times, governments have intervened for protectionist or other political reasons.

The terms "government failure" and "policy failure" have often been used in reference to interventions by government that cause larger deadweight losses than necessary, because of:

- misdiagnosis of a problem or misguided action
- poor selection or flawed design of policy instruments
- unintended consequences.

Justification for Intervention on Economic Efficiency Grounds

Market failure and policy failure may warrant corrective action by governments in the interests of improving the efficiency of resource allocation. An improvement or reduction of efficiency of resource allocation in response to a policy initiative is indicated by the aggregate of changes in all benefits and costs or changes in benefits relative to costs accruing to people within the jurisdiction in which the policy change was made.

The conditions for intervention to correct market failure and policy failure are the same. The benefits of reform or intervention should exceed costs, and the chosen approach to reform should be the one that yields the largest increase in benefits relative to costs.

Benefits are interpreted broadly to include external benefits or things of value conferred on relevant people outside market mechanisms and without compensation. An example of an external benefit is useful information that spills over to other parties, such as information about suitability of new technologies or techniques. Another example would be lower noxious or greenhouse gas emissions that help improve air quality or mitigate adverse effects of climate change, respectively.

Costs, like benefits, are interpreted broadly. They include opportunity costs, which are values of human, financial, built, and natural capital (or resources) in their best alternative uses. Costs also include adverse effects imposed on others outside of market mechanisms and without compensation. An example of such an external cost is damage to environmental attributes of importance to some or all people for health, aesthetic, or income reasons.

4.2.3 Administrative Efficiency

Administrative efficiency can be regarded as an aspect of economic efficiency. This is the case, because administrative efficiency is about keeping down opportunity costs of resources involved in compliance, monitoring, and enforcement activity. Unnecessarily high policy administration costs can be regarded as a form of deadweight loss or economic waste.

4.2.4 Equity

Fairness or equity is focussed on the distribution of benefits and costs, rather than their aggregate, which is of interest from an economic efficiency perspective. Fairness is an important policy consideration for governments. However, it involves highly subjective issues that have to be resolved by value judgements.

Two concepts of equity have been discussed extensively in the economics literature: the ability to pay principle and the benefit principle. These principles pre-date the foundational economic work of Adam Smith (1776), in which they were conflated (Musgrave, 1959).

Over the past 30 years, a third principle has received much attention: the concept of intergenerational equity. It has been particularly prominent in public discussion of irreversible environmental damage.

Ability to Pay Principle

The ability to pay principle is that costs of government interventions should be borne differently by people in accordance with differences in financial circumstances, with more being borne by better-off people (vertical equity), and similar burdens borne by people in similar financial circumstances (horizontal equity). The ability to pay principle has often been a dominant consideration in political discussion of policy issues.

Ability-to-pay issues have been discussed in respect of health and environmental risks associated with activities and products. Key considerations are the distribution of the burden of hazards and the distribution of costs and benefits of policy measures designed to address them. A common concern is that low-income households often bear a disproportionate share of health and other environmental risks, and that policies to address these risks may not be progressive in distributing benefits and costs (Parry, others, 2005; Bento, 2013).

Benefit Principle

The benefit principle of equity states that entities should contribute to government in accordance with benefits received from governments or from society more generally.

The benefit principle is underpinned by the concept of allocation of supply through prices, rather than reliance on inefficient mechanisms, such as administrative allocation or rationing by queuing. Therefore, it tends to be consistent with economic efficiency. This is an important advantage of the benefit principle over the ability to pay approach.

It is widely recognised that specific benefit taxes are potentially applicable in practice in cases in which benefits of goods and services can be imputed to, and internalised by specific users, and there is rivalry for those benefits. In those circumstances, the benefit principle can be applied through a system of user-charges. Typical examples include charges for services and commodities provided by government owned entities, such as electricity, water, and transport.

In addition, the benefit principle is particularly relevant to consideration of fairness issues in respect of extraction of natural resources and use of the environment. The benefit principle indicates that enterprises that are allowed to extract natural resources owned by a government should be required to pay according to the nett *in situ* value of the natural resource. Also, it implies that enterprises should be required to pay compensation if, through their use (or abuse) of the natural environment, they impose non-market costs, such as health and environmental costs (external costs), on others. This implication is consistent and closely associated with the *polluter-pays* principle, which states that those who impose environmental and health costs on others should be required to pay.

In contrast, general benefit taxation has typically been perceived to be of interest mainly from a theoretical perspective. Moreover, the benefit principle typically has not been regarded as a useful guide for the re-distributive role of government. This function generally has been perceived to be the strength of the ability to pay principle (Musgrave, Musgrave, 1973). However, a counter to these perceptions is that benefits provided by the activities of governments and society as a whole tend to be capitalised in land values, and ownership of land tends to be associated with wealth, and therefore, taxation of land value would tend to operate like a general benefit tax and to have a redistributive role (Stiglitz, 2016).

Inter-Generational Equity

The concept on inter-generational equity is concerned with fairness of treatment of individuals across generations. Because of obvious data deficiencies regarding future income and wealth and their distribution, inter-generational equity is even more difficult to deal with than the concept of intra-generational equity. Until about 30 years ago, intra-generational equity was the primary focus of ability to pay and benefit principles of equity.

The rise to prominence of the concept of inter-generational equity over the past 30 years was originally associated with the concept of sustainable development or sustainability. As concern about climate change increased, interest in inter-generational equity issues came to the fore alongside intra-generational equity.

4.2.5 Other Criteria

Sustainability

The concept of sustainability or sustainable development, which was popularised by the World Commission on Sustainable Development (Brundtland, 1987) has sometimes been proposed as a standalone policy design and assessment criterion. However, it is really a composite criterion, which incorporates economic efficiency and equity principles.

Like efficient allocation of resources at a particular time and over time, sustainability or sustainable development is concerned with using natural resources efficiently – extracting them efficiently, or using or not using them as a repository for emissions and other waste materials, taking into account (risk of) damage (particularly irreparable damage) to the natural environment.

Like the concept of intergenerational equity, sustainable development is concerned with ensuring that exploitation of extractable resources and the natural environment in the short to medium term does not leave future generations worse off.

Flexibility

The Commonwealth Government added "flexibility" as a criterion for assessing regulatory policy instruments in its *Best Practice Regulation Handbook* (Office of Best Practice Regulation, 2007) *The Report of the Prime Minister's Task Group on Energy Efficiency* commented that policies should be "flexible enough to allow new technologies and solutions to develop" (Parkinson, others, 2010, p. 22). Nobel Laureate in economics, Joseph Stiglitz (2000) added "flexibility" as a criterion for assessing tax systems, because it helps with the task of stabilising the economy – keeping unemployment and inflation low – which is an important function of the central government. The Henry Tax Review added "fiscal sustainability", comprising "revenue adequacy", "durability", and "flexibility", as a multi-faceted principle for tax reform (Henry, others, 2010).

Generally, however, criteria such as flexibility, revenue adequacy and durability are perceived to be aspects of other criteria. For example, by facilitating economic stabilisation, policy flexibility helps avoids economic waste (inefficiencies) and inequities associated with high unemployment or high inflation. Also, policy flexibility to facilitate innovation acknowledges the existence of market failures and policy failures that impede efficient allocation of resources to such activity.

Certainty

Adam Smith (1776) and subsequently, others nominated "certainty" as a policy design and assessment criterion. The principle is that policies should be implemented and administered consistently without arbitrariness in application across entities and over time. This principle is really an element policy design to achieve economic efficiency.

4.2.6 Additional Policy Design and Assessment Principles

Importance of Considering Relevant Policy Instruments Together

A recurring theme in the literature on the economics of policy design and assessment is that criteria such as the core principles identified above are meant to apply to relevant policy regimes as a whole (comprising policy instruments at all three levels of government), rather than to each policy instrument in isolation.[††††††] A perceived inequity associated with one policy instrument may be offset by a feature of another instrument. An inefficiency created in one part of the package of pertinent policy actions may be reduced by the settings of another policy measure. An inequity or inefficiency caused by one policy instrument may be exacerbated by another policy action.

It is unrealistic to expect that every policy instrument will perform perfectly with respect to all criteria. It is the performance of the whole policy package that matters, not each policy instrument by itself. Nevertheless, it is useful to assess how each policy initiative performs with respect to the criteria to ascertain how it might contribute to or detract from a package of instruments comprising a good policy regime.

In the light of these considerations, it is important to analyse biofuels mandates in New South Wales and Queensland in the context of substantial Commonwealth Government excise tax concessions

[††††††] This principle was highlighted several decades ago by Tinbergen (1952).

applicable to domestically-produced biofuels. It is also useful to consider the implications of mandates and tax concessions as stand-alone policy initiatives.

Matching Policy Instruments to Targets

An important aspect of the policy task of improving the efficiency of allocation/use of resources is careful matching of policy instruments to objectives, and to specific elements of objectives, which could be referred to as targets. The process of matching means to ends is also important for effective policy.

Seminal work on principles for matching policy instruments to targets was undertaken by Nobel Laureate in economics, Jan Tinbergen (1952), and independently by Bent Hansen (1955). They formulated several important, pertinent principles, which have been discussed briefly below.

The critical initial step is to ensure that targets, which are stepping stones to objectives, are logically linked to and contribute to basic objectives like equity and economic efficiency. Sensibly determining the hierarchy of objectives and targets will facilitate the task of selecting and designing policy instruments to achieve objectives. If particular targets are not logically linked to objectives, instruments designed to pursue those targets could be incorrectly specified and achievement of some or all objectives impeded.

No published evidence was found that would indicate any attempts were made Commonwealth, New South Wales, and Queensland Governments over the past 18 years to link stated targets of biofuels policies with overarching objectives they have frequently nominated, particularly improving the efficiency of resource allocation and equity. Similarly, in the three governments' published material on biofuels policies, justifications of those policies in terms of economic efficiency and equity principles could not be found. Contrary to the governments' own regulatory assessment guidelines, no market or policy failures were discussed that might justify government intervention to promote biofuels production, and no inequities were identified to rationalise such intervention.

The targets or justifications for biofuels policies nominated by the three governments were similar, terse, and devoid of explanations of why they were considered to be justifications or appropriate targets of heavy protection of domestic biofuels production. A merged list of targets or justifications offered by the three governments for their biofuels policies is:

- development and jobs growth in regional areas
- diversification of the economy
- provision of certainty to encourage investment in sustainable biofuels
- encouragement of innovation and knowledge-based bio-manufacturing industry, including research into and production of second generation biofuels
- productive use of agricultural and forestry waste materials
- reduction of noxious and greenhouse gas emissions
- greater energy security and less dependence on imported petroleum
- cheaper fuel.

A critical second step in formulation of policy to achieve targets and objectives is to select and design each policy instrument carefully to achieve its primary target. It is not clear what the primary target(s) is (are) for Commonwealth tax concessions for biofuels, and Queensland and New South Wales biofuels mandates. Moreover, no published analysis by relevant governments could be found that assessed the suitability of any chosen policy instrument for pursuit of the grab-bag of targets listed above. Similarly, no published information could be found that provided an assessment of any selected policy instrument or target by reference to a government's own stated overriding objectives or assessment: improving equity and the efficiency of resource allocation. Also, it is not clear what came first: the listed justifications and targets, or the decisions to provide assistance to the biofuels sector.

A policy instrument may influence outcomes in respect of multiple targets or objectives, not just the primary one pursued. Therefore, it would be sensible to engage in simultaneous consideration of the implications of multiple targets for instrument choice and vice versa, rather than focus on the relationship between a single target and single instrument. Tinbergen (1952, p. 68) observed:

"It has taken a considerably long time before even economists looked at economic policy as a coherent entity. In most textbooks on economics or economic policy, separate components are .... considered without much attention to their interdependence, and the targets and instruments of each of these components are often considered in isolation, this general coherence being neglected. Yet this interdependence is a reality and therefore the (economic policy) unit to be considered is the totality of all measures in execution at a given moment or proposed to be taken simultaneously."

While the three governments have nominated multiple targets or justifications for their biofuels policies, it does not appear that consideration was given to important considerations that were not listed. These considerations include the opportunity cost of resources diverted to biofuels activities from other uses in the private and public sectors, resulting costs imposed on others, and the equity implications of heavily protecting a highly concentrated sector.

If an instrument is an effective and efficient means of achieving one target, but has a detrimental effect on achievement of another target, rejection of that instrument or modification of it to trade-off between degrees of achievement of targets would not be the only options. It may be preferable to address the undesirable aspect of an instrument by changing the setting of another instrument or by adding a new instrument to the policy package. Tinbergen (1952, pp. 40-41) explained:

"Incompatibility may of course be avoided by an increase in the number of instruments. In particular, it will often be useful to analyse carefully why certain targets are, at first sight at least, contradictory, and this analysis will lead us sometimes to detect new instruments that enable us to fulfil all targets or at least more than is first believed."

Achievement of multiple targets often requires availability and application of at least as many policy instruments. If the number of available efficient and effective instruments is less than the number of targets, trade-offs between targets (compromises) are inevitable. A corollary of this is that trying to modify a single instrument to achieve multiple targets typically would result in trade-offs or compromises between targets. Trade-offs between targets may be avoided by the addition of policy instruments to the policy package.

In some circumstances, trade-offs between targets may be avoided by replacement of some instruments by others to compile a package of instruments better suited to achievement of specific targets. Sometimes, targets may require multiple policy instruments.

No evidence could be found that indicated the three governments had made or considered any adjustments to the range of policy instruments at their disposal to deal with adverse effects of biofuels policies. Similarly, evidence could not be found in relation to consideration of how biofuels policies and other policies relating to some of the listed targets could be made complementary.

Economics of the "Second-Best"

In a perfect world, all inefficiencies in the economy that arise from market failure would be corrected, and there would be no policy failures. Then, everyone could be made better-off.

In reality, constraints on the form and extent of government intervention are common, with distributional and political considerations being prominent determinants of such constraints. In addition, imperfect knowledge and deficient analyses often lead to poor selection and design of policy instruments. Consequently, elimination of all inefficiencies or achievement of economic efficiency is not a practical objective.

Therefore, a more realistic objective or policy design and assessment principle than an efficient allocation of resources is improvement of the efficiency of resource allocation. The latter principle was nominated at the beginning of this section. Another way stating this objective is minimisation of aggregate inefficiencies or deadweight losses, subject to various extant constraints. Economic analysis of policy issues with this focus has become known as the economics of the "second-best" or theory of the "second-best".[‡‡‡‡‡‡] The branch of the economics of the "second-best" focused on taxation policy has been called the "theory of optimal taxation".[§§§§§§] However, the theory of "second-best" taxation is a more appropriate label.

The body of economic literature focusing on the economics of "second-best" is complex and highly technical. Some pertinent, key insights relevant to biofuels policy have been summarised briefly below.

It is important to recognise that, in the context of numerous inefficiencies in the economy, as in Australia, government intervention to deal with a single problem or to undertake other piecemeal reform may result in an overall reduction in economic welfare rather than an increase. One source of inefficiency may partly offset the adverse consequences of another, and therefore, removing the first would exacerbate the nett adverse effects of the second. There may also be circumstances in which a reform to address one inefficiency may fall short of its potential, because its effect is undermined by another inefficiency left uncorrected.

Obviously, any decision to undertake piecemeal policy action should be based on a thorough, broadly-based assessment of the benefits and costs of that action to ensure that policy changes do not do more harm than good in the context of remaining inefficiencies. This would include design or modification of policy instruments involved in a partial reform initiative to take account of interactions with continuing inefficiencies.

The ideal approach to correction of multiple inefficiencies is comprehensive reform. This does not require that all inefficiencies in the economy be addressed simultaneously. That would be impractical. It does mean simultaneous targeting of major sources of related, interacting inefficiencies that are not inevitable or not untouchable, and it does require thorough broadly-based analysis of the package of policy measures.

It is clear that the three governments did not cite any market or policy failures that warranted intervention to protect domestic biofuels production as part of either piecemeal or comprehensive reform. In addition, there is no published evidence that any consideration was given to identification and amelioration of adverse consequences of biofuels policies on the efficiency of resource allocation and the distribution of income and wealth, either when the policies were first implemented or subsequently revised.

5 Analysis and Results

5.1 Introduction

This section reports the findings of the two-pronged approach described in Section 4, involving assessing the impacts of biofuels policy on the Australian feedlot industry and the broader Australian society. First, results of the econometric modelling are presented to determine the effects of biofuels on the feedlot industry. Second, the findings of a qualitative economic analysis using accepted assessment principles are presented in relation to the effects of biofuels tax concessions and mandates in Australia and on the targets and justifications for protecting the Australian biofuels industry.

[‡‡‡‡‡‡] Seminal work was undertaken by Ramsay (1927), Corlett and Hague (1953-54), Meade (1955) and Lipsey and Lancaster (1956-57).
[§§§§§§] Seminal work in this branch of the economics of the second best was undertaken by Ramsay (1927), Baumol and Bradford (1970), and Diamond and Mirrlees (1971a,b).

5.2 Econometric Modelling

5.2.1 The Data

The key time series used to construct the regression models of domestic wheat and sorghum feed grain prices are:

- monthly Darling Downs sorghum prices obtained from Profarmer Australia (prices were obtained on a weekly basis and converted to monthly for input into the regression models).[*******]
- monthly Riverina wheat prices obtained from Profarmer Australia
- monthly International No.1 Hard Red Winter from the IMF Primary Commodity Prices webpage[†††††††]
- monthly A/US (AUD/USD) exchange rates from the Reserve Bank of Australia[‡‡‡‡‡‡‡]
- annual Australian wheat closing stocks and production from ABARES Agricultural commodities and trade data webpage[§§§§§§§]
- annual Australian sorghum production from ABARES Agricultural commodities and trade data webpage.

5.2.2 Estimated Econometric Models

The modelling uses a time series of monthly domestic and international wheat and sorghum prices from July 2007 to December 2017.

There are two separate approaches taken to empirically assess the impact of current biofuels mandates on domestic sorghum and wheat prices.

The first involves the use of indicator or dummy variables which take on the value of 1 when the mandate is in operation and 0 otherwise. In the second approach, we use the share of ethanol blended fuel as a percentage of total petrol-based fuel sales. As the share of ethanol blended fuels changes, it might be expected there would be a response in the domestic price of grain. This approach has the advantage in that it allows scrutiny of the impact of higher ethanol use on the price of feed grains, irrespective of whether there is a mandate in operation. Also, the share of ethanol-blended fuel provides additional information on the extent to which the mandate is binding. There are two reasons why a biofuels mandate may not lead to higher grain prices.

First, the mandate may in operation, but may not be binding in any meaningful sense, so that there is no increase in the use of ethanol as a result of the mandate. This has been true of the New South Wales mandate up until now, and may turn out to be the case in Queensland also.

Second, even though the mandate proves to be effective, the additional demand for feed grain to produce the necessary volumes of ethanol are not sufficient to impact significantly on the supply and demand balance in the domestic market for grains. This remains a theoretical consideration, as neither the New South Wales nor Queensland mandates are currently being met.

The regressions for Darling Downs sorghum prices only consider the Queensland mandate, and exclude the New South Wales mandate, while the Riverina wheat regressions, test the efficacy of the

******* Please see https://www.profarmergrain.com.au/
††††††† Please see https://www.imf.org/external/np/res/commod/index.aspx
‡‡‡‡‡‡‡ Please see https://www.rba.gov.au/statistics/frequency/exchange-rates.html
§§§§§§§ http://www.agriculture.gov.au/abares/research-topics/agricultural-commodities/agricultural-commodities-trade-data#australian-crop-report-data

New South Wales mandate, but exclude the Queensland mandate. This is because sorghum is assumed to be the main feed stock for the production of ethanol to serve the Queensland market, and wheat starch is the main input into the production of New South Wales ethanol.

The domestic price of wheat (and sorghum) is modelled as a function of:

- USD international price
- AUD/USD exchange rate
- closing stocks (for wheat) and production (for sorghum)
- rainfall (lagged by a quarter)
- indicator variables for each of the mandates or the share of ethanol blended fuels

All the variables except for the indicator variables appear in the regression as natural logarithms.

5.2.3 Model Results

The results of the main regression models estimated are presented below.

Riverina Wheat

Table 7 presents the estimated model coefficients for Riverina wheat prices (using dummy variables to test the impact of the New South Wales mandate).

Table 7 Riverina Wheat Regression with Mandate Indicator Variables

Variable	Coefficient	Std. Err.	T	P>t
International price	0.634	0.138	4.600	0.000
Exchange rate	-0.616	0.271	-2.270	0.025
New South Wales mandate (4per cent)	-0.148	0.066	-2.240	0.027
New South Wales mandate (6per cent)	0.073	0.048	1.520	0.131
Closing stocks	-0.271	0.073	-3.700	0.000
Rainfall (1 quarter lag)	-0.011	0.015	-0.750	0.456
Constant	4.443	1.246	3.570	0.001
R^2	0.5446			
SOURCE: ACIL ALLEN				

The coefficients can be interpreted as follows.

- A one per cent increase in the international wheat price flows through into a 0.6 per cent increase in the domestic feed grain price.
- A one per cent rise in the exchange rate reduces the domestic price by 0.62 per cent.
- A one per cent rise in closing wheat stocks leads to a 0.28 per cent reduction in the domestic feed grain price.

- The coefficient on rainfall was statistically insignificant.
- The coefficient on the indicator variable for the 6 per cent mandate in New South Wales were found to be statistically insignificant at the 1% and 5% levels of statistical significance.
- While the coefficient on the indicator variable for the 4 per cent mandate was found to be statistically significant at the 5% level of significance, the coefficient has a theoretically incorrect sign, suggesting that the introduction of the mandate has resulted in lower domestic feed grain prices rather than higher prices.

This is not a surprising result given that the mandates in New South Wales have not been binding, and the use of ethanol blended fuels in New South Wales has continued to decline over time.

Table 8 presents the estimated model coefficients for Riverina wheat prices (using ethanol's share of the petrol-based fuel market as an explanatory variable).

Table 8 Riverina Wheat Regression with Share of Ethanol Blended Fuel

Variable	Coefficient	Std. Err.	T	P>t
International price	0.736	0.109	6.770	0.000
Exchange rate	-1.607	0.209	-7.690	0.000
Ethanol share in New South Wales	0.011	0.116	0.100	0.923
Closing stocks	-0.150	0.056	-2.690	0.009
Rainfall (1 quarter lag)	-0.008	0.011	-0.710	0.482
Constant	2.523	0.967	2.610	0.011
R^2	0.703			

SOURCE: ACIL ALLEN

In this specification:

- a one per cent increase in the international wheat price flows through into a 0.7 per cent increase in the domestic feed grain price
- a one per cent rise in the exchange rate reduces the domestic price by 1.6 per cent
- a one per cent rise in closing wheat stocks leads to a 0.15 per cent reduction in the domestic feed grain price
- the coefficient on rainfall was statistically insignificant
- the coefficient on the share of ethanol blended fuel in New South Wales was found to be statistically insignificant, meaning that a statistical link cannot be established between the use of ethanol in New South Wales and domestic wheat prices.

Darling Downs Sorghum

Table 9 presents the estimated model coefficients for Darling Downs sorghum prices (using a dummy variable to test the impact of the Queensland mandate).

Table 9 Darling Downs Sorghum Regression with Mandate Indicator Variables

Variable	Coefficient	Std. Err.	T	P>t
International price	0.402	0.122	3.280	0.001
Exchange rate	-0.259	0.192	-1.350	0.180
QLD mandate	0.104	0.045	2.300	0.023
Sorghum production	-0.072	0.066	-1.090	0.277
Rainfall (1 quarter lag)	-0.031	0.014	-2.170	0.032
Constant	3.973	0.566	7.010	0.000
R^2	0.196			
SOURCE: ACIL ALLEN				

The coefficients can be interpreted as follows:

- a one per cent increase in the international sorghum price flows through into a 0.4 per cent increase in the domestic sorghum price
- a one per cent rise in the exchange rate reduces the domestic price by 0.26 per cent
- a one per cent rise in production leads to a 0.07 per cent reduction in the domestic price
- a one per cent rise in rainfall leads to a 0.03 per cent reduction in the domestic price
- the introduction of the Queensland mandate has led to a 0.1 per cent increase in the domestic price.

Although the coefficient on the Queensland mandate was statistically significant at the 5 per cent level, the estimated coefficient is extremely small (economically insignificant). There are several reasons to question this result. The first is that the introduction of the mandate corresponds almost exactly with a period of very poor production in the domestic sorghum market. This means it is very difficult to disentangle the potential causes of a recent increase in the price of domestic sorghum. Most likely, it is the drop in production that has driven the price rise (just as it has done on other occasions historically), rather than the introduction of the mandate in Queensland. Also, the estimated R^2 of the model is quite low, meaning that only 20 per cent of the variation in the domestic sorghum price is in fact explained by the regression model. The likelihood of a mis-specified model in this instance is therefore quite high.

Table 10 presents the estimated model coefficients for Darling Downs sorghum prices (using ethanol's market share as an explanatory variable).

Table10 Darling Downs Sorghum Regression with Share of Ethanol Blended Fuel

Variable	Coefficient	Std. Err.	T	P>t
International price	0.5214305	0.1502143	3.47	0.001
Exchange rate	-0.7861173	0.2182948	-3.6	0.001
QLD ethanol share	-0.0707352	0.0649137	-1.09	0.279

Variable	Coefficient	Std. Err.	T	P>t
Sorghum production	-0.1716355	0.0678943	-2.53	0.013
Rainfall (1 quarter lag)	-0.020623	0.0137961	-1.49	0.139
Constant	4.26037	0.8856121	4.81	0
R^2	0.233			
SOURCE: ACIL ALLEN				

The coefficients of this regression can be interpreted as follows:

- a one per cent increase in the international sorghum price flows through into a 0.5 per cent increase in the domestic sorghum price
- a one per cent rise in the exchange rate reduces the domestic price by 0.79 per cent
- a one per cent rise in sorghum production leads to a 0.17 per cent reduction in the domestic price
- a one per cent rise in rainfall leads to a 0.02 per cent reduction in the domestic price (not statistically significant)
- the share of ethanol blended fuel was not found to be a statistically different from zero at the one per cent and five per cent levels of significance.

Based on this result, the increased uptake in the share of ethanol blended fuel in Queensland from late 2016 has not translated into higher domestic sorghum prices.

There appears to be very little compelling evidence to suggest that the introduction of biofuel mandates in New South Wales and Queensland have had any significant impact on the price of domestic feed grains.

The situation in New South Wales is quite clear cut. The New South Wales mandates have had no effect on wheat prices at all. The situation for sorghum prices is a little less clear. This is because the data display an increase in the uptake of ethanol in the lead up to the introduction of the mandate and a significant fall in domestic sorghum production, at the same time as there was an increase in the domestic sorghum price relative to the international price. It is clear that additional data is required to determine if the price premium for domestic sorghum persists even after domestic production returns to normal. Moreover, it is possible that the recent increase in ethanol sales in Queensland will prove to be temporary, driven by a Queensland marketing campaign, the effects of which will soon wear off, rather than the mandate itself. In this case, the mandate may prove to be ineffective, as is the case in New South Wales.

5.3 Qualitative Analysis of Effects of Biofuels Tax Concessions and Mandates in Australia

Price and quantity effects of tax concessions for domestically-produced biofuels have been analysed qualitatively from an economic perspective in this section. Tax concessions and mandates have been analysed separately and together. This was done so that policy interactions could be highlighted. Understanding of relationships between policy instruments is relevant for consideration of policy reform.

5.3.1 Concessional Fuel Taxation Regime for Locally-Produced Biofuels

Elements of the Regime

Ethanol

As of 1 July 2015, the Commonwealth Government changed its scheme for protection of locally-produced biofuels from a tax and subsidy scheme to a scheme based on differential taxation of fuels. The revised structure of the scheme is as follows.

The customs duty rate for imported fuel ethanol was to remain at the rate applicable to imported petrol and diesel fuel. The rate of customs duty on imported petrol is to be indexed to retain the real value of the duty. Indexation also applies to the identical rate of excise duty on domestically-produced petrol.

The excise duty rate for locally-produced fuel ethanol dropped to zero from 1 July 2015, and was scheduled to increase by 6.554 per cent of the excise rate for petrol at 1 July each year until it reached 32.77 per cent of the excise duty rate for petrol on 1 July in 2020. This final rate of excise duty for fuel ethanol is 50 per cent of the rate of excise and customs duty applicable to petrol after adjusting for the specified difference between the energy content of ethanol and petrol. The energy content of ethanol was deemed to be 65.54 per cent of the energy content of petrol.

Biodiesel

The revised regime for biodiesel from 1 July 2015 is similar in concept to the one applying to ethanol from that date. The key difference is that there is a 15-year transition (rather than a 5-year transition) to an excise duty rate that is 50 per cent of the rate applicable to diesel, after adjusting for the energy content difference.

From 1 July 2015, the excise duty rate for locally-produced biodiesel dropped to zero and then was scheduled to increase by 3.333 per cent of the excise duty rate for diesel at 1 July each year until it reached 50 per cent of the excise duty rate for diesel on 1 July in 2030. The final rate of excise duty for biodiesel is meant to be based on 50 per cent of the rate applicable to diesel after adjusting for the specified difference between the energy content of biodiesel and diesel. The difference has been deemed to be zero.

The customs duty rate for biodiesel was to remain at the indexed rate applicable to conventional diesel and straight petrol throughout the transition period. Therefore, the excise duty rate applicable to domestically-produced biodiesel in 2030 will be only half of the customs duty rate for imported biodiesel, as well as half of the excise and customs duty rates for conventional diesel.

Concessional Taxation of Biofuels without a Blend Mandate

The effects of current concessional taxation of domestic biofuels production in the absence of a blend mandate are discussed in this sub-section. This is the situation in states and territories other than New South Wales and Queensland.[********]

[********] It is also similar to circumstances that applied in New South Wales and Queensland before blend mandates were implemented in those states. The main difference is that, before 1 July 2016, there was full exemption of Australian production from excise duty, while now the biofuels excise duty

On the assumption that rational fuel users will pay no more for biofuels than they pay for straight petrol or diesel after adjusting for differences in energy content (affecting kilometres per litre), a wholesaler of fuel will pay no more for biofuel on which excise duty has been paid than the duty-inclusive wholesale price of straight fuel multiplied by the assumed energy content of biofuel relative to the corresponding conventional fuel. Indeed, the wholesaler would expect to pay less, because it would have to bear extra supply chain costs associated with blending of biofuels with conventional fuels, and sale of blended products.

The amount paid to the biofuels producer by the wholesaler/blender includes an implicit excise duty component representing the excise rate for the relevant refined petroleum product multiplied by the energy content of the substitute biofuel as a proportion of energy in the relevant petroleum-based fuel. To the extent that the biofuels producer pays a concessional rate of duty, the price received for the producer's product includes a premium deriving from the tax concession.

The biofuels tax concession regime acts as a subsidy for domestic biofuels production and effectively excludes biofuels imports. It induces additional domestic biofuels production that is made commercially viable by the subsidy, meaning it can be produced and sold profitably at a price that makes it attractive relative to straight petroleum-based fuel. The price at which biofuel is offered to wholesalers/blenders of fuel needs to be low enough to compensate for the lower energy content of biofuel, blending costs, and market resistance to petroleum-biofuel fuel blends. This allows it to be blended with conventional refined petroleum fuel and to displace some conventional fuel.

Biofuels production and use as a result of the tax concession does not affect prices of conventional refined petroleum products as Australian activity is too small to affect the price of refined products in international markets. International activity and international transport costs determine import parity prices of refined petroleum products in Australia. Australian taxes and local distribution and marketing costs sit on top of internationally determined prices.

In these circumstances, most of the benefit of the tax concession can be expected to accrue to domestic biofuels producers. However, some will be diverted to fuel wholesalers/blenders to cover extra costs supply chain costs associated with blended products, and to induce them to substitute some biofuel for conventional petroleum-based fuel.

Currently, the hypothetical non-concessional energy-content-adjusted rate of excise duty for ethanol is $0.268 per litre, based on an energy content of 0.6554 of that of petrol, as assumed by the Commonwealth Government. The current concessional excise rate for ethanol is $0.054 per litre. Therefore, the current excise duty concession for ethanol is $0.214 per litre (rates to change on 1 July 2018). The last figure is the current ethanol price premium for producers resulting from the concessionary taxation of ethanol ($0.054) relative to the energy-content-adjusted rate ($0.268).

The tax concession and price premium for ethanol may be understated, as the energy content of ethanol has been estimated by various sources to be around 0.67 to 0.69 of the energy content of straight petrol. Assumption of such a higher energy content of ethanol, would increase the non-concessional energy-content-adjusted rate of excise duty for ethanol by about one cent per litre.

concession is being phased down, but it is not the intention to eliminate it. Another difference is that before 1 July 2015, imports of biofuels were effectively exempt from customs duty, but subsequently have been subject to customs duty at the same rate as conventional diesel.

For biodiesel, the hypothetical non-concessional energy-content-adjusted rate of excise duty is $0.409 per litre, based on an energy content that is the same as that assumed by the Commonwealth Government for conventional diesel. The current concessional excise rate for biodiesel is $0.027 per litre. Therefore, the current excise duty concession for ethanol is $0.382 per litre (rates to change on 1 July 2018). This represents the current biodiesel price premium for producers resulting from the concessionary taxation of biodiesel ($0.027) relative to the energy-content-adjusted rate ($0.409).

The tax concession and price premium for biodiesel may be overstated, as the energy content of biodiesel ethanol has been estimated by various sources to be around 0.91 to 0.93 of the energy content of straight petroleum-based diesel. The Government's assumption that biodiesel has the same energy content as conventional diesel would lower the non-concessional energy-content-adjusted rate of excise duty for biodiesel and the size of the tax concession by 2.9 to 3.7 cents per litre.

5.3.2 Biofuels Blend Mandates

Current biofuels blend mandates in New South Wales and Queensland were applied in the context of Commonwealth fiscal arrangements that heavily protected domestic production of biofuels. These arrangements effectively excluded imports of biofuels by applying customs duty at the rate applicable to straight petrol and diesel having significantly higher energy content, while applying excise duty at low rates to domestically-produced biofuels.

The state blend mandates did not include a requirement that biofuels must be produced in the state or Australia. However, the structure of the Commonwealth fiscal regime for biofuels ensured that domestically-produced biofuels would be the only practical option for blending with conventional fuels.

New South Wales Regime

The biofuels blend mandates in New South Wales currently apply to "volume fuel retailers", categorised as entities operating or controlling:

- one or more "volume fuel service stations", such an outlet being one that sells three or more types of petrol or diesel totalling more than 900,000 litres per quarter in two consecutive quarters, or
- 20 or more service stations, none of which are volume fuel service stations.

The current ethanol blend mandate is a minimum of 6 per cent ethanol in petrol-based fuel sold by a volume fuel retailer in New South Wales. The biodiesel blend mandate currently applying to a volume fuel retailer is a minimum of 2 per cent biodiesel in diesel-based fuel.

Queensland Regime

The ethanol blend mandate in Queensland applies to any retailer owning or operating 10 or more standard service stations or selling 500,000 litres of petrol (all grades) per calendar quarter at any one of the standard service stations it owns or operates. It also applies to wholesalers. The minimum percentage of ethanol in regular petrol plus ethanol-regular petrol blend sold by a retailer of defined size or a wholesaler rose from 3 per cent to 4 per cent on 1 July 2018.

The biodiesel blend mandate in Queensland applies to wholesalers in respect of sales to retailers and bulk end users. The mandate requires that at least 0.5 per cent of sales of diesel and biodiesel to retailers and bulk end users be biodiesel.

5.3.3 Biofuels Blend Mandates without Concessional Taxation of Biofuels

Implementation of biofuels blend mandates in New South Wales in October 2007 and in Queensland in January 2017 occurred in the context of a fiscal regime that heavily favoured domestic biofuels production. However, analysis of the hypothetical case of blend mandates in the absence of concessional taxation of domestically-produced biofuels provides insights that are helpful in analysing a combination of blend mandates and concessional taxation.

Blend mandates requiring that fuel sales include a minimum percentage of domestically-produced biofuels would raise demand for biofuels, and consequently, lift prices of biofuels. As a result, prices of blended fuels would rise. However, with prices of conventional fuels being linked to internationally-determined prices, marketers of high-priced blended fuels would not be able to attract customers from conventional fuels. To meet the blend mandate, fuel wholesalers would have to raise the price of unblended refined-petroleum fuels (and perhaps lower the price of petroleum fuels in blended fuels) sufficiently to make purchase of blended fuels attractive to fuel users.

A standalone blend mandate is conceptually equivalent to a tax on fuel and a production subsidy for biofuels. It transfers resources from fuel users to biofuels producers. This would affect disposable incomes, resulting in an income effect that lowers demand for a range of goods and services, including fuel. This could moderate the fuel price increase slightly.

Higher absolute fuel prices would reduce aggregate consumption of fuel. The accompanying change in relative prices of blended and straight fuels, would increase the proportion of biofuels in the fuel total to help achieve the blend mandate in the context of reduced fuel sales.

It might be thought that higher fuel prices would attract more imports and domestic production of conventional fuels sourced at internationally determined prices. However, marketers of those fuels in Australia would have to comply with the mandate, keeping fuel prices high.

Imports of lower-cost biofuels from overseas could not bring down fuel prices. They would not be eligible to meet blend requirements.[††††††††]

5.3.4 Concessional Taxation of Domestic Biofuels Production Combined with Biofuels Blend Mandates

When biofuels blend mandates are combined with concessional taxation of domestic biofuels production, it is important to understand if the policies reinforce each other, or one policy modifies the effects of another, or one dominates the other. Understanding of these matters could be useful in consideration of policy reform.

[††††††††] The analysis in this sub-section built upon insights gained from analysis of the United States biofuels mandate and tax concessions by Harry de Gorter, Dusan Drabik and David Just (de Gorter, Just, 2008, 2010; de Gorter, Drabik, Just, 2013, 2015). However, the analytical approach differed because the Australian and United States regimes are structured very differently, and because Australia is a price taker in international fuel markets, while activities in the United States can influence international prices greatly.

The policy combination of blend mandates and concessional taxation of domestically-produced biofuels is relevant to New South Wales and Queensland. Commonwealth and state policies in Australia are not independent.

The state blend mandates did not include a requirement that biofuels must be produced in the relevant state or Australia. However, the Commonwealth concessional tax scheme for domestic biofuels effectively excluded imports of biofuels by applying customs duty at the rate applicable to straight petrol and diesel that have significantly higher energy content, while applying excise duty at low rates to biofuels produced domestically. Together, the policies ensured that only domestically-produced biofuels would be blended with conventional fuels.

If the concessional tax regime raised the sum of the biofuel price and the tax concession above the biofuel price determined by the mandate, the concessional tax regime would be binding and the mandate would be redundant. The effects would be as set out above for the concessional tax regime alone.

If the mandate caused a higher biofuel price than the sum of the pre-mandate biofuel price and the tax concession, the mandate would be binding. However, in that case, the tax concession could be applied to moderate the price and fuel consumption impacts of a mandate operating alone (described in the previous sub-section).

A binding mandate would provide domestic biofuels producers with a sufficiently high price to induce domestic supply of biofuels that satisfied the mandate. However, this would require adjustments to prices of conventional fuels to induce greater purchases of blended fuels to ensure the mandate is met. The resulting increase in the proportion of biofuels in the fuel mix, would occur at the expense of total fuel sales (discussed in the previous sub-section).

If biofuels producers could sell more of their product, they would capture more of the production subsidy per litre provided by the tax concession applicable to domestically-produced biofuels. They could sell more by discounting the price of their products. Such discounting would be enabled by the tax concession. One result of discounting biofuels prices is a direct reduction in the price of blended products. Another result is an indirect reduction of prices of biofuels through reduction of prices of conventional fuels from the high levels required to improve the relative price of blended fuels sufficiently to ensure compliance with a standalone mandate. Higher sales of conventional fuels in response to lower prices would require purchase of more biofuel to meet the mandate.

As explained above, a standalone mandate acts like a tax on fuel and a production subsidy for biofuels, and standalone tax concessions for domestic production of biofuels act like a production subsidy for biofuels. However, when the schemes are combined and the mandate is binding, the tax concessions act like a consumption subsidy that offsets to some extent the mandate's effective tax on fuel.[‡‡‡‡‡‡‡‡]

‡‡‡‡‡‡‡ The statement in the previous footnote is also applies to this sub-section.

5.3.5 Which Policy Dominates in Australia?

New South Wales ethanol consumption as a percentage of total petrol-based fuel sales peaked in 2010-11 at 3.63 per cent, and had declined to 2.72 per cent in 2015-16.[§§§§§§§§] This occurred despite an increase in the mandate from 4 per cent to 6 per cent on 1 January 2011.

Following a government advertising campaign implemented in mid-2016, ethanol's share recovered to 2.82 per cent in December 2016. The mandate scheme was tightened from 1 January 2017, but ethanol's share of the petrol-based fuel market had moved up only slightly to 2.93 per cent by December 2017. In the first quarter of 2018, ethanol's share was around 2.35 per cent.

In Queensland, ethanol's peak market share was attained in 2009-10. In 2010-11, ethanol's share of petrol-based fuel sales was 1.95 per cent. It was down to 1.06 per cent in 2015-16. In December 2016, ethanol's share of the petrol-based fuel market was up to 1.28 per cent, following a government advertising campaign during 2016 in advance of commencement of an ethanol blend mandate on 1 January 2017. In December 2017, at the end of the first year of the mandate, which was supported by further Government advertising, ethanol's market share was 1.92 per cent. Subsequently, ethanol's share of petrol-based fuel sales has fallen. In the first quarter of 2018, it was fairly static around 1.68 per cent.

The evidence in respect of ethanol's market share in Queensland and New South Wales over the past few years indicates that government promotional advertising has lifted ethanol's sales and market share only temporarily. It appears likely that publicity relating to commencement of tighter mandate arrangements in New South Wales and commencement of the Queensland mandate also helped boost ethanol's market share for a time. The outcomes of mandates in New South Wales and Queensland have not matched the stated intentions of those schemes. The mandates have not been effective in sustaining a significantly higher market share for ethanol or even stopping a downward trend in ethanol's market share. After the advertising effort has declined and the publicity has faded, ethanol's market share has tended to slide, despite the continuation of mandates with tightening requirements.

These circumstances suggest that the mandates may not have been binding. However, even if they were binding, the circumstances seem to be such that there may be little difference between the existing mandates being binding or not binding.

It appears that New South Wales and Queensland mandates have resulted in only marginal increases, at most, in consumption and production of ethanol. The associated increases in ethanol prices would have been only minimal as substantial excess capacity in existing ethanol plants indicates relatively high price elasticity of supply. Therefore, only a minimal increase in the price of straight petrol would have been required to change relative prices to ensure uptake of enough ethanol to comply with the mandate. The tax concession would have provided more than adequate subsidy to offset an increase in fuel prices from the fuel-tax aspect of the mandate.

[§§§§§§§§] Market share calculations in this sub-section were derived from *Australian Petroleum Statistics* (Australian Government, Department of Environment and Energy, 2018).

This outcome would be similar to one in which in which the mandate is redundant. Then, fuel prices paid by users would not rise, but ethanol output would increase in response to the production subsidy in the form of the tax concession for domestic biofuels production.

It is notable that ethanol's market share has followed a downward trend in New South Wales and Queensland, notwithstanding mandates in those states. This suggests that not only have the mandates been too weak to be binding, but also producers have not been prepared to discount prices of their products sufficiently to compensate for its lower energy content, blending costs, and market resistance to petroleum-biofuel-blend fuel. An alternative explanation is that wholesalers/ blenders of fuel have attempted to absorb discounts provided by producers, rather than pass them on to fuel users. Regardless of the reason, E10 has been overpriced relative to straight regular unleaded petrol at the retail stage of the supply chain. Assuming that the ethanol's energy content is 65.54 per cent (or 68 per cent) of that of straight petrol, E10 should be discounted relative to straight petrol by 3.6 per cent (3.3 per cent), respectively, just to allow for the energy-content and consequent fuel consumption disparity. Further discounting would be required to give E10 a competitive edge. But, the current discount is typically only about 1.45 per cent in Brisbane and 1.5 per cent in Sydney.

The structure of fuel prices would change if the mandates were strengthened substantially, ensuring that they were clearly binding. For example, the ethanol mandate might be lifted to 10 per cent ethanol in all petrol-based fuel, without current exemptions. Then, prices of petrol-based fuel would rise significantly, even though the tax-concession regime would be transformed into a consumption subsidy that moderates the increase.

5.4 Qualitative Economic Analysis of Targets and Justifications for Australian Biofuels Protection

In Australia, Governments, biofuels producers, and associations formed to promote the interests of biofuels producers have put forward similar justifications for protection of domestic biofuels production through highly concessionary excise taxation and biofuels mandates. They have claimed that these policies will deliver multiple benefits. The benefits nominated most often are:[*********]

- expansion of rural/regional economic activity
- encouragement of innovation and knowledge-based bio-manufacturing industry, including research into and production of second generation biofuels
- reduction of greenhouse gas emissions
- reduction of noxious emissions and resulting adverse effects on human health
- greater energy security and less dependence on imported petroleum
- cheaper fuel.

Each government has claimed that such benefits are the intended targets of its biofuels policy. But, judging policy instruments and packages on the basis of intentions, rather than by results, is a great mistake (Friedman, 1975). Another big mistake is to neglect to take considerable care to match policy instruments to targets and to take account of the interdependence of policy measures and the interdependence of the various targets and objectives of government (Tinbergen, 1952; Hansen, 1955). A third big mistake is to select a policy instrument or package of instruments without ascertaining whether or not the benefits exceed the costs, the chosen policy regime provides a

[*********] See the previous section, and material produced by biofuels lobby groups: Queensland Renewable Fuels Association (2018); Hughes and Mulvay (2015) of Biofuels Association of Australia; and O'Hara, Robins, and Melssen (2018) of Bioenergy Australia.

larger surplus of benefits over costs than all other feasible regimes, and the distribution of benefits and costs is acceptable (Coase, 1960). In other words, it is a big mistake to select a policy regime without assessing whether or not it satisfies economic efficiency (including its administrative efficiency aspects) and equity criteria.

In this section, economic efficiency and equity criteria, and complementary policy design and assessment principles discussed in section 4 have been applied to analyse typical justifications or stated targets for state and federal government biofuels policies in Australia. This analysis draws on insights gained from investigation of price and quantity effects of relevant, existing government policy instruments in Section 5.3.

In section 4, reasons for adopting economic efficiency and equity criteria were explained. Recapping briefly, the criteria are widely accepted in the economics literature, have been nominated as regulatory assessment criteria by Commonwealth, New South Wales and Queensland Governments for more than a decade, and have been applied as assessment criteria in numerous reviews of taxation and other policies in Australia over the past 50 years.

5.4.1 Expansion of Rural/Regional Economic Activity

Commonwealth, Queensland, and New South Wales Governments, and biofuels industry associations have attempted to justify government protection of domestic biofuels production by asserting that it generates jobs and economic development/activity and jobs in rural and regional areas. Typically, this perceived benefit has been portrayed as a particularly important justification of protection of the local biofuels industry by proponents of such government action.

Two reports have been cited by proponents of protection of Australian biofuels production as providers of economic support for their position. Both were produced in 2014 – one by Deloitte Access Economics (2014), and the other by Deloitte Access Economics and Corelli Bio-Industry Consulting (2014).

The former report was tabled in the New South Wales Parliament on 3 May 2016 by the Minister for Innovation and Better Regulation, a few weeks after his second reading speech in respect of the *Biofuels Amendment Bill 2016*, which strengthened the Government's biofuels mandate (Dominello, 2016). The same report was cited in a submission by the Biofuels Association of Australia (now Bioenergy Australia) to the Queensland Government (Hughes, Mulvay, 2015) in response to a Queensland Government discussion paper on the then proposed biofuels mandates (Queensland Government, Department of Energy and Water Supply, 2015). The second report was cited in the same Queensland Government discussion paper, and in a Queensland University of Technology discussion paper promoting the Australian biofuels industry and protection of it, and promoting bio-manufacturing in Australia more generally (O'Hara, Robins, Melssen, 2018).

The report produced by Deloitte Access Economics (2014) calculated the "direct economic contribution" (value added = labour income plus gross operating surplus) and direct employment of Australian biofuels production using incomplete data for 2012-13 collected from producers. Direct economic contribution was estimated to be $51 million for ethanol and $13 million for biodiesel. Direct employment was estimated to be 281 and 66 full time equivalent employees, respectively. "Indirect economic contribution" was estimated too, using input-output tables. Indirect economic contribution (value added) was estimated to be $351 million for ethanol and $50 million for biodiesel. Indirect employment was estimated to be 2,668 and 372 full time equivalent employees, respectively.

The estimated indirect effects appear to be extraordinarily high. They indicated value added multipliers and employment multipliers that are not plausible. Bureau of Resources and Energy

Economics (2014) suggested an employment multiplier of about one for ethanol production, in contrast to a multiplier in excess of 9.5 (one direct job leads to 9.5 indirect jobs) implicit in the estimate provided by Deloitte Access Economics (2014). Deloitte Access Economics (2014) said that its indirect contribution estimates were “upper bound”, because input-output analysis did not capture crowding out effects and other dynamic interactions in the economy. However, even as upper bounds, the estimates appear to be implausibly high.

Deloitte Access Economics explained that direct economic contribution in each case was calculated excluding subsidies received and excise duty paid. This might be construed as meaning that they had removed any distortion of estimated gross operating surplus (earnings before interest, tax, depreciation and amortisation) caused by inclusion of transfers resulting from protection of domestic ethanol and biodiesel production. Deloitte Access Economics did not make it clear that such an interpretation would be incorrect.

Under the scheme applying to ethanol until 30 June 2015, subsidies (grants) simply cancelled out the excise tax on domestic production, and under the current scheme, excise is applied at a highly concessional rate compared to petrol. Meanwhile, imports have attracted the full rate of customs duty applying to imports of petrol. In addition, New South Wales mandate arrangements were in place from 1 October 2007. The New South Wales scheme, in conjunction with the Commonwealth excise and customs duty regime, protects domestic ethanol production from competition from imports and from petrol, adding substantially to the estimate of gross operating surplus. Netting out subsidies and excise duty to calculate economic contribution did not remove the monopoly profits accruing to producers because of fiscal and mandate schemes. Monopoly profits created by previous and current Commonwealth Government policy and by state mandates are transfers to ethanol producers from the community. They should not be construed as being part of economic contribution.

In the case of biodiesel, subsidies cancelled out both the excise tax on domestic production, and the customs duty on imported biodiesel under the scheme applying until 30 June 2015. Consequently, biodiesel was protected from conventional diesel, but not from imported biodiesel. In addition, New South Wales mandate arrangements were in place from 1 October 2009. These protection schemes added to gross operating surplus calculated for local biodiesel production, but to a lesser extent than in the case of ethanol. Under the Commonwealth Government scheme currently applying to biodiesel, domestic production attracts highly concessionary rates of excise duty, but imports attract the full rate of customs duty applicable to conventional diesel. The revised scheme protects biodiesel from competition from conventional diesel, and biodiesel imports. Monopoly profits created by the previous and current biodiesel schemes should not be included in economic contribution.

Although Deloitte Access Economics did not recognise that protection of biofuels created monopoly profits that should not be included in the calculation of economic contribution, it observed that the biofuels industry would be smaller, employing fewer people, if it was not protected. The economic contribution analysis did not take into account the consequences of policies that draw labour and capital and resources from other sectors. In other words, it did not account for the opportunity cost of those resources – the value of resources in their best alternative use. Deloitte Access Economics (2014, p. 18) recognised this “limitation” of economic contribution studies in the following words:

“Unless there is significant unused capacity in the economy (such as unemployed labour) there is only a weak relationship between an industry’s economic contribution as measured by value added (or some other static aggregates) and the welfare or living standard of the community. Indeed, the use of labour

and capital by demand created from the industry comes at an opportunity cost as it may reduce the amount of resources available to spend on other economic activities."

A high proportion of resources tied up in biofuels production could be deployed elsewhere.[†††††††††] This includes resources allocated to biofuels production either through grants or tax concessions or mandates. Those resources could be used to generate more economic or social value elsewhere, in industries that do not require government support to be commercially viable, or in public provision of infrastructure or other services with benefits/cost ratios comfortably above one.

The Productivity Commission (2016) pointed out that the opportunity cost of resources allocated to supporting the biofuels industry is "high". The Bureau of Resources and Energy Economics (BREE) (2014) provided quantitative evidence for this observation, by comparing the magnitude of financial assistance from the Commonwealth Government with the number of jobs supported in the fuel ethanol industry.

BREE (2014) estimated that the cost to the community of the tax and subsidy scheme protecting domestic ethanol production was between $545,000 and $681,000 per year for each direct job supported (160 to 210). Allowing for the possibility of as many indirect jobs (jobs created outside ethanol production) as direct jobs, the cost per job supported was between $272,500 and $340,500 per year.

The estimated cost per job supported per year is likely to be an underestimate of the cost per year of each additional job resulting from the tax and subsidy scheme, as two of the three Australian plants currently producing fuel ethanol were already in operation when the scheme was introduced in September 2002. Additional jobs would be those associated with expansion of pre-existing plants and establishment of a new one at Dalby.

The funds allocated annually by the Commonwealth Government to support the biofuels industry could have been allocated to other programs, such as those that increase the productivity of the economy or assist disadvantaged people or both. These alternative uses of resources potentially could have high benefit/cost ratios. Reallocation of funds currently directed to biofuels subsidies would have created jobs in other sectors, and if allocated astutely, could have created more jobs. More generally, reallocation of funds could have provided a high economic payoff.

Biofuels mandates in New South Wales and Queensland also may have tended to reallocate additional resources to activities that would not be economic without federal and state government support, and away from activities that did not require government assistance to be commercially viable. So, the opportunity cost of these resources exceeds their value in protected biofuels industries.

The report prepared by Deloitte Access Economics and Corelli Bio-Industry Consulting (2014) discussed the potential for various bio-manufacturing industries in Queensland and estimated the economic impacts of seven hypothetical bio-refinery projects, including two ethanol projects. The two ethanol projects were:

- a plant in the Wide Bay region producing ethanol and xylitol (sugar alcohol used as a sugar substitute and as a basis for manufacture of other rare sugars), using sweet sorghum (grain and stalks) as feedstock
- a plant in the Darling Downs region producing ethanol, using sorghum as feedstock.

It was asserted that six of the seven projects would be commercially viable, and the seventh (polyethylene from sugar cane) would be viable at higher oil prices. Supporting analysis was not

[†††††††††] Exceptions might include some sunk capital and some inputs in the form of waste from other activities.

provided in respect of commercial viability claims. Nevertheless, Deloitte Access Economics and Corelli Bio-Industry Consulting (2014, p. 6) claimed:

"This report provides sufficient proof of concept to proceed with further due diligence and a full feasibility study of the future potential and viability of these bio-refineries. Combined with government policy settings that are conducive to investment and 'open for business', a tropical bio-refinery industry could be an important future source of economic growth in Queensland."

Queensland University of Technology scientists provided information about the seven projects, including inputs, outputs, revenues and costs, to Deloitte Access Economics, which used a computable general equilibrium economic model to estimate economic impacts. The report advised (p. 32):

"Deloitte Access Economics undertook a sense-check of the model inputs, but has not independently verified the costings."

Deloitte Access Economics and Corelli Bio-Industry Consulting (2014) concluded that a bio-refining industry in Queensland could have a significant impact on the Queensland economy. They claimed that the seven projects analysed by them could add around $1.8 billion to gross state product and 6,640 full time equivalent jobs over the next two decades.

However, the report explained critical assumptions of the economic impact assessment as follows (Deloitte Access Economics and Corelli Bio-Industry Consulting, 2014, p. 32):

"The economic impact analysis employs the assumption that these (seven projects) are commercial projects, operating without government subsidies, but also that government provides a stable operating environment that does not place unreasonable limitations on the technologies used.

The report also warned against governments subsidising biorefinery industries, of which the biofuels (ethanol and biodiesel) industry is the most familiar. Deloitte Access Economics and Corelli Bio-Industry Consulting (2014, p. 32) explained:

Foreign governments (and therefore taxpayers) have in some cases contributed significant funds to the biorefinery sector. While this does undoubtedly provide the sector with a boost, it distorts the allocation of resources in the economy, and means scarce public funds are captured mostly by owners of the subsidised businesses. Sound public policy principles would recommend against this type of intervention."

In other words, subsidising domestic production of biofuels violates principles of improving the efficiency of resource allocation and equity. That is precisely what Commonwealth, New South Wales, and Queensland Governments have done. They have subsidised domestic production of ethanol and biodiesel, even though their policy initiatives do not comply with economic efficiency and equity principles that they have espoused in their own policy assessment guidelines.

Regional development and jobs that require discriminatory policies in the form of tax concessions for, and mandated use of domestically-produced substances do not represent genuine economic development and job growth. The regional development and jobs resulting from governments' favourable treatment of particular activities occur at the expense of entities not involved in the favoured activities. These other parties may be affected by higher costs of inputs to economic activities as resources are drawn from higher value uses, and higher taxes and/or less government services. Therefore, development, jobs and welfare, both elsewhere and overall, are adversely affected. In economic terms, resources are allocated inefficiently or misallocated.

Moreover, the discriminatory policies redistribute income towards participants in favoured entities and away from the rest of the community. This raises questions regarding the fairness of such policy regimes.

5.4.2 Encouragement of Innovation and Bio-Manufacturing

Proponents of government protection of domestic biofuels production have argued that this support encourages research and development activity in respect of new technologies for bio-manufacturing and take-up of such technologies. These bio-manufacturing technologies include, but are not confined to second generation technologies for production of biofuels.[‡‡‡‡‡‡‡‡‡]

Some proponents of protection of the domestic biofuels industry have argued that support would not be required in the long-term, because new technologies will make production economically viable in the short- to medium-term future. Other proponents of government support for the industry have remained silent on this matter.

There are major flaws in these arguments. They have been discussed below.

First, government support for research and development or innovation activity in respect of bio-manufacturing is economically justifiable to correct market or policy failures that impede such activity. The proviso is that the selected form of government intervention not only yields benefits in excess of costs, but also the highest surplus of benefits over costs among the available policy instruments. Proponents of protection of domestic production of biofuels have not identified market or policy failures justifying government intervention to correct perceived deficiencies in bio-manufacturing research and development, and have not explained why tax concessions and mandates in relation to domestic biofuels production are the best available policy instruments for that role.

The conventional market failure argument for government intervention in relation to research and development and later-stage innovation activity is based on the economic characteristics of information. It is a form of public good because the benefits each entity can gain from it do not detract from the benefits others can derive. As the marginal cost of making it available to other parties is close to zero, while marginal benefits of doing so are positive, exclusion of parties from access is economically inefficient. Entities generating information may seek to exclude others from access, but may be only partly successful. So, as those generating information try to exploit it, some valuable elements may spill over to other parties (learning by seeing others doing), but no payment is received by the innovator. These spill-over benefits are known as external benefits. Public good and external benefits concepts are closely related. A public good provides services that would be of value to all potential users, so that benefits are mainly external in nature.

The public good nature of information and external benefits of information are sources of market failure. If private entities that generate information cannot capture all of the benefits themselves, they will under-produce it from a social perspective. If the information is priced (allowing generators to capture benefits) or potential users are otherwise excluded, it will be underused from a social perspective.[§§§§§§§§§]

Market failure also results from asymmetric (uneven availability of) information or pursuit of it. Researchers or innovators might rush to generate information to beat others to a discovery, and

[‡‡‡‡‡‡‡‡‡] For example, see Queensland Government, Department of Energy and Water Supply (2015), Hughes and Mulvay (2015), and O'Hara, Robins and Melssen (2018).
[§§§§§§§§§] See Arrow (1962,a, b), and Bikhchandani, Hirshleifer and Riley (2013).

then attempt to keep it private through patent rights and other means. This could result in generation of too much information, too soon from an economic perspective. This problem is more likely to arise after very early or basic research and development activity (in later stages of innovation), when resulting information is more specific to circumstances such as an entity and location, and easier to keep private.**********

Consequently, there is a prima facie case for government intervention to increase public availability of innovation information, at least in early stages of research and development, when information would be applicable to a wider range of circumstances and entities (providing more benefits that are public or external in nature). More publicly available information would tend to address both problems: too little information from an economic perspective, and asymmetric availability of information.

A policy initiative to increase publicly available information on early-stage innovation is very different to subsidising production based on established technologies through arbitrary tax concessions and mandates. The latter does nothing to induce innovation activity, and may discourage it.

A second flaw is that it does not make sense to prop up an industry based on a technology that is considered likely to be rendered redundant within a few years. That would misallocate (waste) society's resources in various ways. If breakthrough technology is coming, it would be better to wait and avoid economic waste.

Third, protection of first-generation biofuels production may impede development and take-up of second- and third-generation technologies (Bureau of Resources and Energy Economics, 2014). Substantial, prolonged protection blunts incentives or pressures to innovate to survive and prosper.

Fourth, economically viable new biofuels-producing technologies could be a long way off. In the case of ethanol, research into technologies that process cellulosic material has already been underway overseas for more than four decades. Cellulosic ethanol research plants, based on perennial biomass sources like grasses, wheat, oat and barley straw, sugar cane bagasse, and wood waste, are currently operating. However, no process has yet been commercialised, even in countries where ethanol production is heavily protected by policy instruments such as subsidies, tax concessions, trade barriers, and mandated use. It appears that further substantial technological breakthroughs will be required for cellulosic ethanol to be commercially viable, and more substantial technological progress will be required for it to economically viable (without protection).

Cellulosic ethanol's proponents in the scientific community have expressed optimism that processes under investigation have the potential to produce ethanol at significantly lower cost than plants based on existing technologies, with lower energy requirements per unit of energy output, lower emissions of greenhouse gases and pollutants on a "life cycle" basis, reduced land and water degradation problems, and less flow-on impacts on prices of vegetable and animal foods. They are also optimistic that cellulosic ethanol will constrain fuel prices. Other researchers are pessimistic

********** See Barzel (1968), Hirshleifer (1971), Dasgupta and Stiglitz (1980), Dasgupta, Gilbert and Stiglitz (1982), and Bikhchandani, Hirshleifer and Riley (2013).

about this potential being realised sufficiently in the foreseeable future to make cellulosic ethanol economically and environmentally sustainable on a large scale.

It would be much more sensible to support investigations of the potential for advances in conventional and cellulosic ethanol technologies and their application in Australian conditions, than to impose substantial costs on the public to prop up an intrinsically uneconomic ethanol industry based on technologies currently in use that are not economic anywhere without government support.

5.4.3 Fuel Costs

Some proponents of protection of domestic biofuels production have argued that it provides cheaper fuel. For example, Queensland and New South Wales Government Ministers claimed in 2006 and 2007, respectively, that ethanol mandates in those states would result in lower fuel prices. In 2009, this assertion was repeated by the relevant New South Wales Government Minister, when legislation to increase the mandated percentage of ethanol was introduced to parliament (Kelly, 2009), and by the Queensland Department of Employment, Economic Development and Innovation (2009) in a public benefit test report on a proposed ethanol mandate in Queensland. The latter suggested that the widespread availability of E10 in Sydney following implementation of the New South Wales mandate had placed downward pressure on unleaded petrol prices in Sydney. In 2015, the Queensland Government argued in a discussion paper on its then proposed ethanol and biodiesel mandates that the ethanol mandate would induce new entrants to the industry, driving down wholesale prices over time, and that the Government wanted to ensure that consumers see cheaper ethanol (Queensland Government, Department of Energy and Water Supply, 2015).

Energy Content and Octane Differences

An assessment of the fuel price effects of the effective exemption of domestically-produced biofuels from excise duty from 20002 to 2015, highly concessionary excise duty treatment thereafter, and the New South Wales and Queensland mandates that commenced in 2007 and 2017, respectively, must take into account the energy content of biofuels relative to petrol and diesel fuel derived from oil.

Ethanol as a fuel has about 68 per cent of the energy content of straight petrol. Biodiesel's energy content is comparable to that of conventional diesel.

It follows that E10 containing 10 per cent ethanol and 90 per cent unleaded petrol (ULP) has 96.8 per cent of straight ULP's energy. So, fuel consumption, in theory, is 3.3 per cent higher if E10 is used instead of straight ULP. Scientific tests have revealed that the fuel consumption increase is in the range 2.6 to 5 per cent, depending on the vehicle and driving conditions.

The Commonwealth Government assumed that the energy content of ethanol is 65.54 per cent of the energy content of straight petrol when it revised its tax concession policy for domestic production of biofuels in 2015 (see section 5). That assumption implied that fuel consumption, in theory, would be approximately 3.6 per cent higher if E10 was substituted for straight petrol.

Scientific tests have revealed that the fuel consumption increase is in the range 2.6 to 5 per cent. The increase depends on the vehicle and driving conditions.

Proponents of government support for ethanol production have also argued that blending of ethanol with petrol benefits motorists, because it lifts petrol's octane rating. So, the octane effect needs to be taken into account when considering relative fuel prices.

Ethanol has a higher octane rating than petrol. An ethanol content of 10 per cent adds about 3-4 numbers to the Research Octane Number (RON) of ULP, lifting the RON of E10 to a range of 94 to 95 compared to 91 for straight ULP. The Motor Octane Number (MON) is boosted less, by about 1-2 numbers, from 81 to a range of 82 to 83.

E10 (based on ULP) is not equivalent to premium unleaded petrol (PULP). It definitely does not meet the MON standard of 85 and it may or may not reach the RON specification of 95 for PULP 95 petrol. In New South Wales, E10 (based on ULP) must be labelled as 94 RON fuel. New South Wales Fair Trading has stressed that E10 based on ULP is 94 RON fuel, and should not be used in engines for which the manufacturer has recommended PULP with a RON of 95 or 98. For E10 to satisfy PULP specifications, ethanol would have to be blended with PULP. Therefore, E10 (based on ULP) prices should be compared ULP prices, not with PULP 95 prices.

The theoretical discussion in section 5 indicated that a rational, informed purchaser of ethanol or E10 would not be prepared to pay more than a price derived by adjusting the petrol price to allow for the lower energy content of ethanol. This suggests that E10 should be priced about 3.3 per cent below the price of straight 91 RON petrol to be of interest to informed, rational fuel users.

Following the introduction of the Commonwealth Government's tax and subsidy scheme to protect domestically-produced fuel ethanol, subsequent government pressure on oil companies to stock E10 fuel, and state grants to facilitate installation of E10 facilities, E10 prices typically were discounted by about 4 cents per litre relative to ULP. Over time, the typical discount shrank to 2 cents per litre (occasionally lower or higher) in both Sydney and Brisbane, and has been around that level for at least five years. In addition, retail petrol prices are much higher in 2018 than in 2003-04. In 2003-04, they averaged around 91 to 92 cents per litre in Sydney and Brisbane (after adjusting for the effect of the Queensland Fuel Subsidy of 8.354 cents per litre). In March 2018, ULP prices in Sydney and Brisbane averaged around 131.4 and 137.6 cents per litre, respectively (no adjustment required for the Queensland Fuel Subsidy, as it was abolished about a decade ago).

In 2003-04, the E10 discount of around 4.4 per cent in Sydney and Brisbane (after adjusting the Brisbane price for the Queensland Fuel Subsidy) was greater than the 3.3 per cent higher theoretical fuel consumption when E10 is used instead of ULP, but within the range of 2.6 per cent to 5 per cent higher fuel consumption associated with E10 in tests. In March 2018, the E10 discount relative to the average ULP price in Sydney (1.5 per cent) and Brisbane (1.45 per cent) was much less than the range of higher fuel consumption (2.6 to 5 per cent) that results if E10 is used instead of ULP.

In March 2016, the New South Wales Government Minister for Innovation and Better Regulation addressed the matter of the E10 discount in his second reading speech on a bill to strengthen the ethanol mandate in the state. He pointed out that ethanol could be as cheap as straight petrol if priced competitively on the basis of energy content. He suggested that this would involve a discount of around 3 per cent relative to the price of ULP. But, he observed that E10 typically had been overpriced relative to ULP on the basis of energy content, as it was typically discounted by 2 cents per litre, and sometimes the discount was as low as 1.6 cents per litre. Those discounts as a percentage of the average Sydney retail price in March 2016 were about 1.8 per cent and 1.5 per cent, respectively. The Minister claimed that this uncompetitive pricing of E10 would be rectified by the Government's decision that, in conjunction with a tighter ethanol mandate, IPART would regulate the wholesale price of ethanol and have a watching brief on retail E10 prices (Dominello, 2016).

The Minister's speech indicated that the New South Wales Government perceived that market power was being exercised (a market failure) in the supply of ethanol. However, the Government seemed to be unsure whether market power was being exercised by domestic ethanol producers or by other participants in the E10 supply chain.

The domestic ethanol industry is highly concentrated, protected from competition from ethanol producers overseas, and insulated from interfuel competition by the ethanol mandate. All of these circumstances can contribute to market power. On the other hand, there have been many accusations made by public commentators over the past 20 years about market power being exercised by oil refining and product distribution companies. It is pertinent that Gavin Hughes and Garry Mulvay (2015) of the Biofuels Association of Australia (now Bioenergy Australia following a merger between two entities) claimed that ethanol producers were providing discounts to petrol wholesalers that exceeded the rate of excise duty – that is, greater than 38.143 cents per litre of ethanol, which translates into 3.8143 cents per litre of E10. They said that as the discount to the wholesaler had increased, the discount at the pump had fallen from 4 to 2 cents per litre.

In March 2018, the typical discount for E10 in Sydney was still around 2 cents per litre, as it had been in March 2016, when the New South Wales Government acted to address market power in the supply of ethanol. However, the typical discount was 1.5 per cent of the price of PULP, down from 1.8 per cent in March 2016. In late-April 2018, the typical discount for E10 was still 2 cents per litre (although a few independent service stations offered a 3 cents per litre discount), according to the New South Wales' Government's *Fuel Check* service. So, in the period since IPART was assigned responsibility for regulating the wholesale price of ethanol and monitoring retail prices of E10, the typical absolute discount for E10 has not changed, by in percentage terms it has declined.

In 2015, the Queensland Government argued that its ethanol mandate would drive down wholesale ethanol prices over time by attracting new suppliers. The Government said it wanted to ensure consumers saw the benefits of lower ethanol prices. At that time, E10 was typically overpriced in terms of energy content at a discount of 2 cents per litre to 91 RON petrol. Three years later, E10 is still typically discounted at only 2 cents per litre, but some service stations offer a discount of only 1.5 cents per litre. Consumers have not seen any benefits from lower ethanol prices in the 18 months since the mandate was introduced.

The occurrence of E10 sales, in the context of overpricing of the product on the basis of energy content, indicated that some consumers lacked information, were not able to access ULP easily, or were not rational. Lack of information is a market failure. It should have been corrected by the *Fuel for Thought* and *E10 OK* "educational" campaigns conducted by the New South Wales and Queensland Government, respectively, over the past two years. However, the websites supporting those campaigns have not been straight with motorists regarding the extent of the mismatch between the discount for E10 fuel and the higher fuel consumption associated with its use. The information market failure has been perpetuated by policy failure.

Excise Discount

The Bureau of Resources and Energy Economics (BREE) (2014) explained that an objective of the tax and subsidy scheme protecting domestic ethanol production was to incentivise purchases of ethanol-petrol blends by fuel users through an excise discount. BREE pointed out that E10 was subject to an excise tax discount of 3.8143 cents per litre in February 2014, as the 10 per cent ethanol component was effectively tax free, while the ULP component was subject to excise and customs duty at a rate of 38.143 cents per litre. The typical discount offered at the pump for E10 at the time of BREE's analysis was 2 cents per litre. Therefore, 1.8143 cents per litre was not passed on to retail purchasers of E10.petrol. After allowing for the effect of GST on the excise component of the price of E10, the amount not passed on to E10 users was 1.996 cents per litre.

BREE observed that the excise discount was being absorbed by ethanol producers or other participants in the E10 supply chain. BREE was not able to determine where this was occurring in the supply chain, but thought it might be in the ethanol production stage.

In contrast, Gavin Hughes and Garry Mulvay (2015) of Bioenergy Australia said that ethanol producers were providing discounts to petrol wholesalers that exceeded the rate of excise duty. They said that these wholesale ethanol discounts had risen as retail discounts for E10 had fallen over time.

The average Brisbane ULP price in the first quarter of 2014 was $1.57 per litre. If fuel consumption had been 3.3 per cent (or 3.6 per cent) higher using E10 rather than ULP, a rational consumer would prefer ULP unless E10 was at least 5.2 cents (or 5.6 cents) per litre cheaper. The required discount is much bigger than the typical E10 price discount of 2 cents per litre, and significantly larger the excise duty discount of 3.8143 cents per litre (nearly 4.2 cents after allowing for the GST effect) at the time. Even if the excise duty reduction had been passed on to motorists in full, the resulting price discount it may not have been enough to induce rational, informed consumers to purchase E10 instead of straight ULP.

Fuel System Issues

Motorists considering the E10 value proposition appear to have taken into account warnings from various sources regarding potential fuel system damage from fuel containing ethanol. The bases for these warnings is that ethanol is more corrosive than petrol, and that it absorbs water.

As a result of the former property, ethanol-petrol blends are incompatible with fuel system components of some cars. In particular, it is not advisable to use ethanol-petrol blends in pre-1986 vehicles. Governments that have promoted fuel ethanol have acknowledged this issue and have advised motorists not to use E10 in older vehicles. In some cases, governments have advised motorists not to use ethanol-petrol blends in pre-1986 vehicles or other vehicles fitted with a carburettor, but have claimed that it is suitable for most other vehicles. In other cases, governments (such as the Queensland Government on its *E10 OK* website) have advised that E10 is suitable for most vehicles built since 2000.

While most vehicle manufacturers have advised that E10 (ethanol blended with 91 RON ULP) is a suitable fuel for modern vehicles tuned for 91 RON petrol, invariably they have stressed that E10 is not suitable for vehicles tuned for PULP (95 or 95 RON fuel). Again, pro-ethanol governments have passed on this advice.

Despite advice from governments and manufacturers that E10 is a suitable fuel for modern vehicles tuned for 91 RON petrol, there has been substantial consumer resistance to use of the fuel. One reason is that many motorists have learned that the increase in fuel consumption associated with E10 use outweighs the lower price of E10 than of petrol. However, doubts also persist about suitability of E10 for modern cars tuned for 91 RON petrol.

These doubts about suitability of E10 appear to have three sources. First, governments have not been precise about which vehicles are fully compatible with E10. References to “most” vehicles and different dates of manufacture of compatible vehicles have not removed doubts. Second, there is a degree of mistrust of advice from governments and private sector entities that promote biofuels for reasons perceived to be politically motivated or based on vested interests. Third, some authorities have raised issues about use of ethanol-petrol blend in vehicles deemed to be compatible with E10 in some circumstances.

One issue contributing to the third source of doubts about suitability of E10 is that ethanol's corrosive property means it strips out sediment that builds up in the bottom of petrol tanks over time, and this material is carried into the fuel system, resulting in filter blockages. After the fuel system has been scoured and filter blockages rectified, the problem should not recur.[††††††††††] Advice from governments that the problem is attributable to poor maintenance, not ethanol has not removed consumers' doubts about ethanol-petrol blends.

A second issue is that ethanol absorbs small amounts of water and if the ethanol content rises above 0.5 per cent, the ethanol and water mixed with it to drop out of suspension to the bottom of a fuel tank. The result could be a failure of an engine to start or poor running if it does start.[‡‡‡‡‡‡‡‡‡‡]

Uncertainties about fuel system issues outlined above translate into costs of E10 use from the perspective of owners of vehicles with petrol engines. The E10 discount relative to straight petrol is not enough to compensate for this cost and the higher fuel consumption associated with E10. As pointed out above, it does not get close to covering just the fuel consumption penalty.

It is noted that proposed changes in fuel quality standards in Australia, which are discussed in the next sub-section, include reduction of inorganic chloride content limit of ethanol in petrol from 32 mg/L to 1 mg/kg to reduce the scouring effect, and reduction of the maximum water content of ethanol in petrol from one per cent to 0.3 per cent to address engine start and running problems (Australian Government, Department of Environment and Energy, 2016, 2018).

Fuel Quality Standards

In December 2016, the Commonwealth Government issued a discussion paper regarding potential changes to fuel quality standards, and then, in January 2018, released a draft regulation impact statement (RIS), which reported on comparative assessment of alternatives (Australian Government, Department of Environment and Energy, 2016, 2018). The preferred option according to a benefit-cost analysis and multi-criteria analysis undertaken as part of the draft RIS, was alignment with European standards, with a notable exception. The difference was that 91 RON ULP fuel would be retained, albeit with sulphur and aromatics substantially reduced to European PULP limits of 10 ppm and 35 per cent, respectively.

Under the preferred option, the sulphur limit for ethanol also was to be reduced to the European standard of 10 mg/kg, and other specifications were to follow the European standard or be more stringent. The limit for inorganic chloride content was to be lower than under the European standard, at 1 mg/kg, rather than 1.5 mg/kg.

An issue touched on, but not resolved in the two documents on fuel quality standards was the possible use of ethanol as an octane enhancer for ULP and PULP after loss of octane through reduction of the aromatics limit from 45 per cent to 35 per cent, and substantial desulphurisation. However, fuel consumption rises by around 3.3 per cent if E10 is used instead of straight petrol. This would mean extra cost, unless E10 prices are discounted by at least 3.3 per cent relative to straight petrol prices. An obstacle is that for several years E10 (based on ULP) has been overpriced after taking into account its lower energy content and consequent more frequent refuelling than for ULP. No plausible reasons have been advanced to indicate that this would change after adoption of more stringent fuel quality standards. The extra cost would be additional to higher prices estimated to be of the order of 2 cents per litre for 91 RON petrol and 2.3 cents per litre for 95 and 98 RON petrol (Australian Government, Department of Environment and Energy, 2018).

[††††††††††] See the New South Wales Government's *Fuel for Thought* website on ethanol and fuel lines, the RACQ website on ethanol facts, and a public benefit test report by Queensland Government, Department of Employment, Economic Development and Innovation (2009).

[‡‡‡‡‡‡‡‡‡‡] This issue was outlined in the RACQ website on ethanol facts, to which the Queensland Government's *E1O OK* website referred parties interested in facts on ethanol fuels.

Effects of Biofuels Policies on Prices of Straight Petroleum Fuels

The discussion of fuel costs above has been focussed on the price of blended fuels relative to the relevant straight petroleum fuel substitute. An equally important issue is the effect of biofuels policy instruments on prices of straight petroleum fuels. The latter issue was investigated from a theoretical economic perspective in section 5.3. There, four different policy cases were discussed.

If the tax concession regime applied without mandates or if the former was binding, it was shown that straight fuel prices would not change, because Australia is a price taker in international oil and refined products markets. If tax-induced displacement of straight petrol and diesel occurred, the reduce demand for refined petroleum products would not mean lower conventional fuel prices, as they would be linked to internationally determined prices. Biofuels prices, in turn, should be linked to straight fuel prices on an energy-content basis.

However, mandates without tax concessions would push up prices of straight petroleum fuels, as well as biofuels, disrupting the link between local prices and internationally determined prices of straight petroleum fuels. A standalone blend mandate is conceptually equivalent to a tax on fuel and a production subsidy for biofuels. How it works is explained in section 5.3. This situation would apply if the Commonwealth Government abandoned its tax concession system protecting domestic production of biofuels.

With the tax concession regime operating in conjunction with mandates, and if the mandate is binding, the tax concession arrangements act like a consumption subsidy that tends to offset the fuel tax characteristic of the mandates. This is explained in section 5.3.

The available evidence regarding the operation of Australian biofuels tax concessions and Queensland and New South Wales mandates suggests that even if the existing mandates are binding, any fuel price increase resulting from current biofuels policies is likely to be small. Reasons for this are outlined in section 5.3.

Fuel Costs-Summing Up

The promise of lower fuel costs as a result of protection of domestic biofuels has not been delivered. Fuel costs have risen to the extent that vehicle owners have purchased biofuel that is overpriced relative to straight petroleum products on the basis of energy content. Meanwhile, straight petroleum product prices have not been suppressed by policies that have induced substitution of biofuels for a portion of petroleum product use, because Australia is a price taker in international oil and refined products markets. In addition, the available evidence indicates that any increase in prices of straight petroleum products would be small if the mandates are binding and disrupt the link with internationally determined prices. If the mandates are not binding, prices of straight petroleum products should not be moved up by biofuels policies.

Purchases of overpriced E10 have been facilitated in recent years by “education” campaigns by the New South Wales and Queensland Governments that have not called out the overpricing of E10, because that would have reduced E10 sales, conflicting with the primary aim of the campaigns that is to increase E10 sales. A New South Wales Government initiative two years ago to address the problem of overpriced E10 through regulation of the wholesale price of ethanol, and monitoring of retail E10 prices has not been successful so far.

5.4.4 Increased Energy Security

Proponents of policy measures to protect domestic biofuels production often have listed energy security as a justification for such government intervention. Typically, however, they have not defined the term, and have not provided adequate justification for deployment of protective policies to target the vague concept.

Definitions of energy security have proliferated in the relevant international literature. This has been documented by Benjamin Sovacool (2011), who identified 45 distinct definitions and Christian Winzer (2012), who listed 35. There was little overlap between the lists.

Many contributors to the literature on energy security have noted the vagueness of the concept and the definitions offered.[§§§§§§§§§§] This issue has been discussed in depth by Lynne Chester (2010), Scott Valentine (2011) and Aleh Cherp and Jessica Jewell (2011).

The scope of the concept of energy security has expanded over time, as definitions have proliferated. This has exacerbated the vagueness issue.

The proliferation of definitions has been confined largely to the non-economic literature. There, definitions have typically been framed by reference to various perceived dimensions of energy security, such as availability, accessibility, affordability, acceptability, reliability, resilience and risk. In the non-economic literature, there has been little reference to objectives/criteria of efficiency of resource allocation and equity/fairness, and related concepts of social costs, and welfare effects, all of which have been widely discussed in the economic literature.

The *economic approach* to energy (in)security analysis and measurement is not closely linked to a definition or definitions of energy security. Therefore, there has been little focus on definitions in the economics literature. Definitions that have been provided typically have remained close to one suggested by Resources for the Future economists Douglas Bohi and Michael Toman (1996, p. 1), who believed energy insecurity should be narrowly defined to refer to "…… the loss of economic welfare that may occur as a result of a change in the price or availability of energy." However, definitions along these lines only partly reflect the economic approach.

The economic approach to analysis of energy (in)security focuses on issues relating to the efficiency of resource allocation and equity:

- welfare losses arising from market and policy failures within the control of the relevant government(s) (not to be confused with costs associated with translation of supply shocks into price spikes by the efficient operation of markets)
- correctly diagnosing and understanding causes of those welfare losses
- targeting intervention at causes of social costs or welfare losses, not at symptoms of assumed problems
- social benefits and costs of government intervention to provide perceived increases in energy security.

This approach is exemplified by comprehensive analysis of the economics of energy (in)security by Bohi Michael and Toman (1993, 1996). A more recent example is provided in a detailed economic assessment of United States energy policy by Peter Grossman (2013).

The relevant economic literature is critical of the typical approach in the non-economic literature that presumes (rather than demonstrates through careful analysis) that the prevailing degree of energy insecurity is a social problem warranting government action.[***********] Dieter Helm (2002), Paul Joskow (2009), Löschel, Moslener, Rübbelke (2010), Andy Sterling (2010, 2011), Christian

[§§§§§§§§§§] For example, see Winzer (2012), NZ Institute of Economic Research (2012), Sovacool, Mukherjee, others (2011), Vivoda (2010), Löschel, Moslener, Rübbelke (2010a), Hedenus, Azar, Johansson (2010); Kruyt, van Vuuren, de Vries, Groenenberg (2009, 2011), Joskow (2009).

[***********] For example, see Grossman (2013) for such criticism.

Winzer (2012) and Peter Grossman (2013) have observed that, in various countries, a presumption that energy (in)security is a problem of social or economic importance has been exploited in various ways by different interest groups. In particular, it has been cited to provide cover for the pursuit of, and provision of government assistance that could not be justified on grounds of overarching policy objectives of improving the allocation of resources or equity. Joskow (2009, p. 11) stated bluntly:

"Energy security policy rationales remain a refuge for rogues who have difficulty making more respectable and coherent cases for the policies they favour."

This inappropriate approach has been followed by proponents of protection of domestic production of biofuels. They have asserted that there is an energy (in)security problem of economic or social importance, and then claim that protection of domestic biofuels production is the solution.[†††††††††††] They have not shown that there are market or policy failures associated with the alleged problem that justify intervention by governments in Australia on economic efficiency grounds, or that it involves inequities that warrant corrective government action.

Calls for government support for biofuels typically increase at times of demand or supply shocks in international oil markets. If global oil supplies failed to keep up with demand growth, because of a demand or supply shock, oil prices would rise. This would induce:

- less driving
- more research and investments to increase fuel efficiency
- more oil exploration
- development of better exploration techniques
- additional research and investments to recover more oil from known resources and difficult locations
- extra research and investment in alternative energy sources, including ethanol and biodiesel from existing feed stocks, and from alternative technologies and feedstocks that are under investigation.

Prolonged rises in oil prices would increase the viability of measures that reduced oil usage and increased supply of oil and a range of alternatives. Therefore, they would undermine the case for government support for biofuels, not improve it.

The argument that protecting domestic production of biofuels improves the security of supply of fuel has been severely criticised by economists and other policy specialists involved in analyses of biofuels policies commissioned by the Commonwealth Government.

The Prime Minister's Biofuels Task Force provided a comprehensive rebuttal of the energy security argument for protecting domestic biofuels production. It summed up its case as follows (O'Connell, C., Brockway, D., Keniry, J., Gillard, M., 2005, p. 124):

"Biofuels are not cost-competitive compared with conventional fuel alternatives and are expected to continue to require substantial and ongoing support to maintain their production and use. Therefore, achieving a level of biofuels production and use high enough to make a meaningful contribution to energy security (whether through excise subsidies or higher costs to consumers imposed through a mandate arrangement) would impose significant economic costs, which would not be justified, given the (Commonwealth) government's assessment of energy security.

Were the government to consider there is a need to purchase a higher level of fuel energy security, the cost effectiveness of developing biofuels as a strategy to increase fuel security would need to be considered against other options, such as developing other alternative fuel sources/technologies (such as coal to liquids; shale oil or gas to liquids), oil stockpiles and measures to encourage greater fuel-efficiency."

A review of the Ethanol Production Grants Program for the Commonwealth Government in 2014 argued that that energy security benefits from domestic biofuels production are negligible. The

[†††††††††††] For an example, see O'Hara, Robins, and Melssen (2018), pp. 24-25.

entity responsible for the review, the Bureau of Resources and Energy Economics (2014, p. 20), provided the following explanation.

"The Energy White Paper 2012 noted that there were no tangible energy security benefits provided by the small Australian alternative fuel industry given the proven and robust and reliable supply chains provided by the international petroleum market. In fact, it noted that a shift to domestically produced alternative fuels could actually increase supply risks (i.e. reduce energy security) where this is based on a small number of producers with poor supply resilience. This was borne out by the industry's inability to supply demand during the 2012 Queensland floods due to loss of crops and transport difficulties. This concern would be removed if the excise discrimination against imports was addressed allowing ethanol fuel distributors access to a broader set of suppliers (Australian Government, Department of Resources, Energy and Tourism, 2012).

Given the small size of the ethanol supply within the transport fuel market, that the international petroleum market functions well in balancing supply and demand, and also the availability of other alternative fuels such as liquid petroleum gas (LPG) and compressed natural gas (CNG), we consider that the suggested benefits for energy security from producing ethanol (or similar biofuels - as an alternative to petrol), are negligible."

The Bureau of Resources and Energy Economics (2014) pointed out liquid fuel security benefits from access to ethanol could be improved by removing tax discrimination against imported ethanol. This discrimination has been applied by making imported ethanol subject to the full rate of customs duty applicable to petrol, and then subjecting domestically-produced ethanol to a highly concessionary excise duty regime that was effectively zero rated for 14 years, before rising in five annual steps to a rate that is only half of the petrol rate of duty after adjusting it for the specified difference between the energy content of ethanol and petrol. From 1 July 2020, the rate of excise duty for domestically-produced fuel ethanol is scheduled to be 32.77 per cent of the customs duty rate for imported ethanol (which is the same as the excise and customs and customs duty rates for straight petrol).

The Independent Pricing and Regulatory Tribunal (IPART) (2015a) was commissioned by the New South Wales Government to identify and assess options to increase the uptake of ethanol-petrol blend fuel. In doing so, it considered various effects, including impacts on energy security. IPART judged that energy security effects were likely to be negligible.

5.4.5 Reduction of Noxious Emissions and Consequent Adverse Health Effects

Proponents of protection of domestic production of biofuels have argued that one of the justifications of this special treatment is that it leads to lower noxious emissions, and this means reductions of adverse health effects of noxious emissions. In Australia, non-government proponents have been more forthright in promoting this argument than governments.[‡‡‡‡‡‡‡‡‡‡‡]

Ethanol's Health Effects

Proponents of protection of domestic biofuels production have cited a study by CSIRO and Orbital Corporation (2008) on the health effects of petrol-ethanol blend fuel, and a paper based on that work by Tom Beer and others (2011) to support their claim that use of ethanol instead of straight petrol reduces noxious emissions and consequent health costs. A report for ethanol producer Manildra comparing tailpipe emissions from laboratory tests of straight (91 RON) petrol and E10 in the same vehicle (Brear, 2016) has also been cited as evidence of the alleged desirability of protecting domestic production of biofuels.

The CSIRO and Orbital Corporation (2008) researchers estimated changes in various noxious emissions resulting from fuelling vehicles with E10 or E5, rather than straight petrol. Then, they estimated nett health cost savings (nett value of health benefits) that would result from 50 per cent

[‡‡‡‡‡‡‡‡‡‡‡] See O'Hara, Robins and Melssen (2018), Hughes and Mulvay (2015), T take-up of E10 and 100 per cent take up of E5 in 2006, 50 per cent or 100 per cent take up of E10 in 2011, or 100 per cent take up of E5 in 2011.

Tail-pipe emissions of fine particulate emissions were found to decrease when E10 was used instead of straight petrol. Carbon monoxide, volatile organic compounds, and total hydrocarbon emissions typically declined. Emissions of air toxics BTEX, 1,3-butadiene, and styrene tended to decline. Formaldehyde increased or stayed much the same.[§§§§§§§§§§§] Acetaldehyde and nitrogen dioxide were found to increase.

Evaporative emissions of volatile organic compounds, BTEX, and total hydrocarbons increase when E10 is used instead of straight petrol. The increase in volatile organic compounds from evaporation more than offsets the reduction of tailpipe emissions of those substances, and carbon monoxide, resulting in an increase in peak ozone concentrations.

A nett increase in volatile organic compounds from evaporative (up) and tailpipe (down) emissions from use of E10, rather than straight petrol, produces additional fine particulates through formation of secondary organic aerosols. Despite this, there is a nett reduction in emissions of fine particulate matter if E10 replaces straight petrol.

The nett health benefits estimated by CSIRO and Orbital Corporation (2008) were overwhelmingly dominated by reductions in particulate matter. Mortality and morbidity reductions from lowering emissions of fine particulate matter accounted for over 98 per cent of the estimated nett value of health benefits, with the morbidity component being less than 0.1 per cent.[************] The cost of mortality, which has been referred to as the value of a statistical life (VOSL), in the economics literature, was assumed to be $7 million in 2008 (around $8.95 million in 2018 price terms).

Estimates of VOSL can vary widely, but the estimate used in the study by CSIRO and Orbital Corporation is within a credible range. The Australian Government's Office of Best Practice Regulation (2014b) recommended a VOSL of $4.2 million in 2014 (around $4.6 million in 2018 prices) be used in benefit-cost analyses in regulation impact statements. This figure was based on analysis by Peter Abelson (2008). Kip Viscusi, who is a recognised international expert on VOSL, estimated a VOSL for Australia of $10.1 million in 2017 (around $10.3 million in 2018 prices).

CSIRO and Orbital Corporation (2008) estimated that for a 50 per cent take up of E10 in Sydney, Melbourne, Brisbane and Perth the nett health benefit would have been $39 million in 2006 and $20 million in 2011. The estimate for 100 per cent adoption of E10 in the same metropolitan areas in 2011 (when most of the fleet was considered likely to be E10 compatible) was $42 million.

Beer and others (2011) and CSIRO and Orbital Corporation (2008) pointed out that the nett health benefit from use of E10 instead of straight petrol reduces as newer vehicles enter and represent an increasing proportion of the vehicle fleet. They observed that newer vehicles are subject to increasingly stringent emissions standards, progressively reducing the significance of reductions in fine particulate matter from use of E10.

Bureau of Resources and Energy Economics (2014) commented that the process of phasing in Euro 5 vehicle emissions standards commenced on 1 November 2013 and was to be fully implemented in 2018. Euro 5 standards in conjunction with tighter fuel quality standards, were expected to reduce maximum allowable emissions of particulate matter from new petrol-engine vehicles by up to 90 per cent.

Implementation of Euro 6 vehicle emissions standards and new fuel quality standards based on the regime in the European Union are currently under consideration by government. In December 2016, the Commonwealth Government released a draft regulation impact statement regarding adoption of Euro 6 vehicle (noxious) emissions standards for light vehicles and Euro VI standards for heavy

[§§§§§§§§§§§] BTEX refers to a group of volatile organic compounds: benzene, toluene, ethylbenzene, and xylene.

[************] Fine particulate matter has a diameter less than 2.5 microns measured gravimetrically.

vehicles (Australian Government, Department of Infrastructure and Regional Development, 2016). It also released a discussion paper regarding tighter fuel quality standards based on the regime in the European Union (Australian Government, Department of Environment and Energy, 2016). In January 2018, a draft regulation impact statement on fuel quality standards was released (Australian Government, Department of Environment and Energy, 2018). The draft regulation impact statements included benefit-cost analyses, which indicated that tighter vehicle (noxious) emissions standards and more stringent fuel quality standards were economically justified.

The proposed tighter standards for vehicle (noxious) emissions and fuel quality standards would further reduce emissions of fine particulate matter (mass and number of particles) and other noxious substances. Consequently, these regimes would undermine further the claims made by proponents of protection of domestically-produced biofuels that such protection is desirable for air quality and health reasons.

Another flaw in the case for protecting domestically-produced biofuels on health grounds is that the reports cited by promoters of such policy action did not take into account the full range of life-cycle emissions. Brear (2016) considered only tailpipe emissions. The much more comprehensive analysis undertaken by CSIRO and Orbital Corporation (2008) covered evaporative emissions, and the secondary organic aerosol formation process, as well as exhaust emissions. A critically important omission was upstream emissions resulting from domestic production/supply of biofuels and their inputs. Inclusion of estimates of upstream emissions of noxious substances is necessary to compile "life-cycle" estimates.

Clara Cuevas-Cubria (2009) of the Australian Bureau of Agricultural and Resource Economics provided estimates of differences between life-cycle (tail pipe and upstream[††††††††††††]) emissions of various noxious substances in production and use of liquid petroleum fuels and life-cycle emissions of blends of those fuels and biofuels. She also provided estimates of consequent health cost differences. Estimates of emissions and health costs were drawn from work by various Commonwealth Government agencies.

In the case of ethanol, taking account of upstream emissions meant particulate emissions and carbon monoxide emissions from substituting E10 for straight petrol went from significant reductions to a significant increases when the ethanol component was derived from processing of wheat starch waste, wheat, grain sorghum, and molasses. However, if production of ethanol from molasses involved cogeneration of electricity, upstream emissions of particulate matter did not decline sufficiently to reduce life-cycle particulate emissions as a result of substitution of E10 for straight petrol.

The adjustment to the estimate of emissions was particularly important because of the dominant contribution of fine particulates to health costs of emissions. Cuevas-Cubria (2009) reported that estimates of health cost <u>increases</u> from substituting E10 for straight petrol were $0.382 per litre of E10 for grain sorghum, $0.372 per litre of E10 for wheat starch waste, and $0.332 per litre of E10 for of E10, respectively. If co-generation of electricity was combined with production of ethanol from molasses, the estimated health cost <u>reduction</u> was $0.188 per litre of E10 or $0.235 in real 2018 terms.

The analysis undertaken by Cuevas-Cubria (2009) indicated that replacement of straight petrol by E10, in which all of the ethanol is domestically produced, would impose health costs on others without payment of compensation. Such an external cost may warrant government action to tax E10 based on domestically-produced ethanol at a rate sufficiently higher than for straight petrol to require users to take into account (internalise) the magnitude of the differential external cost per litre of E10. Since external costs affecting the Australian population would be lower if ethanol was

[††††††††††††] Cuevas-Cubria (2009) apparently did not include evaporative emissions and consequences of secondary organic aerosol processes.

imported, it could be argued that the fuel taxation system and mandates, which together discriminate against imported ethanol and all straight petrol under current ethanol policy, should be redesigned to discriminate against domestically-produced ethanol instead. These policy changes would tend to correct a market failure (caused by the external cost) and a policy failure (poorly designed previous policy). However, policy changes should be designed in the context of other relevant policy settings, as discussed in section 4 and in the sub-section following the next one.

Biodiesel's Health Effects

Cuevas-Cubria (2009) reported that in the case of biodiesel, combined tailpipe and upstream emissions of carbon monoxide and volatile organic compounds were estimated to be substantially lower for BD5 (5 per cent biodiesel and 95 per cent ultra-low-sulphur diesel)[‡‡‡‡‡‡‡‡‡‡‡‡] than for straight ultra-low-sulphur (50 ppm) diesel. Combined particulate emissions were also estimated to be lower for BD5 than for straight diesel, but the reduction was not as great in relative terms as the reduction for carbon monoxide and volatile organic compounds. Aggregated emissions of NOx (nitrogen oxides, mainly nitric oxide [NO] and nitrogen dioxide [NO_2]) from vehicle exhausts and upstream activities were estimated to be significantly higher than for straight diesel.

The <u>avoided</u> health costs from substitution of BD5 for straight ultra-low-sulphur (50 ppm) diesel were estimated to be $0.331 per litre of BD5 if the biodiesel was made from waste cooking oil, $0.298 per litre of BD5 if it was produced from tallow and $0.273 per litre of BD5 if the feedstock was canola. In 2018 prices or real terms, those health benefits would be $0.413, $0.363, and $0.341 per litre of BD5, respectively. In practice, biodiesel producers typically use a combination of feedstocks.

However, the emissions estimates presented by Cuevas-Cubria (2009) were based on 50 ppm sulphur in straight diesel (ultra-low-sulphur diesel). Since 1 January 2009, diesel must contain no more 10 ppm sulphur (extra-low-sulphur diesel).

In 2005, the *Report of the Biofuels Task Force to Prime Minister* pointed out that after the mandated use of extra-low-sulphur diesel commenced, substitution of BD5 for straight diesel would result in slightly higher particulate emissions than for straight diesel (not lower as with ultra-low-sulphur diesel).[§§§§§§§§§§§§] This applied to BD5 incorporating biodiesel made from canola and tallow, but particulate emissions from BD5 incorporating biodiesel made from waste cooking oil were marginally lower than for straight diesel. Volatile organic compounds and carbon monoxide would still be lower for all BD5 than for diesel, but the gap would be less than with straight diesel containing 50 ppm sulphur. NOx emissions would still be higher for all BD5 than for extra-low-sulphur diesel and the gap would widen (O'Connell, Brockway, Keniry, Gillard, 2005). CSIRO reported similar findings (Beer, Grant, Campbell, 2007).

So, the health benefits from substituting BD5 for straight diesel estimated by Cuevas-Cubria would have disappeared after the extra-low-sulphur diesel mandate commenced. The increase in NOx emissions was the decisive factor in this result (O'Connell, Brockway, Keniry, Gillard, 2005).

‡‡‡‡‡‡‡‡‡‡‡‡ The maximum biodiesel content of diesel fuel has been 5 per cent since 1 March 2009. That limit remains in place in the proposed new fuel quality standard.

§§§§§§§§§§§§ Substitution of BD20 for extra-low-sulphur (10 ppm sulphur) diesel would lower emissions of particulate matter relative to 10 ppm sulphur diesel. However, the current and proposed fuel quality standards limit the biodiesel content of blended diesel fuel to 5 per cent biodiesel.

Australia adopted Euro V noxious emissions standards for heavy vehicles from 1 January 2011. From 1 November 2013 it began to phase in Euro 5 noxious emissions standards for light vehicles. At present, the Commonwealth Government is considering adoption of Euro VI noxious emissions standards for heavy vehicles and Euro 6 noxious emissions standards for light vehicles, in conjunction with more stringent fuel quality standards. The assessment process is at an advanced stage.

In December 2016, a draft regulation impact statement on adoption of tougher vehicle noxious emissions standards than those currently in place presented estimates of a progressive decline in emissions of particulate matter, carbon monoxide, NOx, and hydrocarbons from heavy vehicles using diesel and BD5. Estimates of a progressive increase in health benefits were also presented (Australian Government, Department of Infrastructure and Regional Development, 2016).

Policy Reforms

Design of any biofuels policy reform should take into account life-cycle emissions, not just tailpipe emissions. Focussing only on tailpipe emissions could lead to undesirable policies and outcomes. This is obvious from the discussion above.

Design of biofuels policy should also be considered in the context of analysis of the effects of other relevant policy instruments that are in place and planned. These include vehicle emissions standards, fuel quality standards, and measures proposed to address greenhouse gas emissions from motor vehicles. The importance of taking into account the interactions of policy instruments is obvious from the discussion above, and was stressed in section 4. In that section, it was also explained that comprehensive reform is preferable to piecemeal reform, as the latter might inadvertently lead to undesirable outcomes.

5.4.6 Reduction of Greenhouse Gas Emissions

Common Justification for Biofuels Support

Governments that have promoted domestic biofuels production, biofuels producers, and biofuels industry lobby groups have invariably cited greenhouse gas reductions and consequent climate change benefits as justifications for fiscal schemes and mandates to support domestic biofuels production.

However, they have invariably failed to point out the high cost of greenhouse gas reductions resulting from these policy measures. Estimates of these costs are high, even without allowing for emissions resulting from indirect land use change induced by higher demand for feedstocks for biofuels plants, and possible underestimation of climate change effects of application of nitrogen-based fertilisers to produce crops for biofuels plants.

In addition, proponents of government support for domestic production of biofuels have chosen to ignore or not to undertake comparative analyses of alternative policies for addressing greenhouse gas emissions associated with production and use of energy in the transport sector.

Cost Estimates

In 2005, the Australian Prime Minister's Biofuels Taskforce reported that the cost to government (ultimately taxpayers and beneficiaries of other government programmes) in 2010 of fiscal support for domestic biofuels production was estimated to be $267 per tonne CO_2-e in 2004-05 prices. In 2018 price terms, the cost to government would be $368 per tonne CO_2-e. The estimated economic cost per tonne CO_2-e in 2010 was $204 in 2004-05 price terms, which translates into $281 in 2018 prices (O'Connell, Brockway, Keniry, Gillard, 2005).

Quirke, Steenblik and Warner (2008) estimated that the cost of avoiding greenhouse gas emissions through fiscal support for the domestic biofuels industry in 2006-07. Estimated costs in 2018 price terms are shown in parentheses. For ethanol derived from wheat starch or C-molasses, the estimated cost was $400 ($512) per tonne CO_2-e. If ethanol was derived from wheat, the cost per tonne CO_2-e avoided was at least $690 ($883). For biodiesel made from virgin plant oils, the estimated cost was $300 ($384) per tonne CO_2-e. For biodiesel derived from waste cooking oil or tallow, the estimated cost per tonne CO_2-e avoided was under $200 ($256).

The Bureau of Resources and Energy Economics (2014) estimated the cost to government in 2012-13 of greenhouse gas emissions reductions associated with fiscal support for domestic ethanol output under the Commonwealth Government's Ethanol Production Grants programme. The estimated cost was $274 per tonne CO_2-e. In 2018 price terms, the estimate would be $ 310 per tonne CO_2-e.

These estimates attribute all of the cost of fiscal support for biofuels to greenhouse gas abatement. It could be argued that the cost should be shared by the multiple benefits nominated by those who have advocated protection of domestic biofuels production. However, as discussed in this section, the other perceived benefits are basically illusory.

The estimates of the fiscal and economic cost of avoiding emission of each tonne CO_2-e through Commonwealth Government protection of domestic production of biofuels indicate that such support is a very expensive way of mitigating climate change. There are other much more efficient ways of reducing greenhouse gas emissions in general, and of cutting them in the land transport sector, as discussed below.

Incompleteness of Estimates

The cost estimates above are incomplete. There are three reasons for this.

First, most of the estimates did not take into account costs of reallocating resources from higher to lower value uses – from uses that don't require government assistance to be profitable to uses that are not commercially attractive without government support.

Second, the estimates did not take into account any changes to emissions that mandates might cause when they are implemented in the context of pre-existing fiscal support for domestically-produced biofuels. The analysis in section 5.3 investigated how prices and quantities of biofuels and conventional petroleum fuels might change as a result of mandates being implemented in the context of pre-existing fiscal support. Under existing mandates, changes in fuel use were considered likely to be minimal, and therefore the effect of implementing mandates on greenhouse gas emissions would be similarly small. This could be altered substantially if mandates were strengthened substantially, for example, by raising the mandate to 10 per cent ethanol in petrol-based fuel and elimination of current exemptions. Then higher fuel prices would reduce consumption of fuel and consequent emissions.

Third, while the estimates of the cost per tonne of CO_2-e avoided by use of biofuels take into account life-cycle emissions, there were potentially important gaps or oversights in the estimation of emissions, as highlighted by scientific work about a decade ago.

Crutzen, Mosier, Smith, and Winiwarter (2008) explained that release of nitrous oxide (N_2O) associated with application of nitrogen-based fertilisers to grow feedstocks for biofuels plants could more than offset reductions in CO_2 emissions in other parts of the life cycle. Nitrous oxide is a greenhouse gas having 100-year climate change potential that is 296 times that of carbon dioxide with the same mass. They argued that nitrous oxide emissions from nitrogen-based fertiliser application in agro-biofuel production was 3 to 5 times the amount assumed in previous analyses of life-cycle emissions of greenhouse gases from biofuels production and use that were based on the method proposed by the International Panel on Climate Change. As a result, past studies appeared to have underestimated release rates of nitrous oxide to the atmosphere and consequent climate change effects of production and use of biofuels.

Searchinger and others (2008) and Fargione and others (2008) highlighted previous neglect of greenhouse gas emissions from land-use change in life-cycle calculations of greenhouse gas emissions associated with production and use of biofuels. The issue is that if demand for feedstock for biofuels grows sufficiently to move up the price of feedstock in the short term, supply of additional quantities would be induced. This could result from expenditure to increase yields on land already producing the relevant crop (such as by use of nitrogen-based fertiliser) or from diversion of land from other uses. In the latter case, bush or forest may be cleared somewhere (possibly in another country) to provide more farmland to grow biofuel feedstock or for another crop it has displaced, or to replace grazing land converted to farmland. Substantial emissions of greenhouse gases could result from burning or decomposition of material on cleared land. Very long periods of time could elapse before emissions from clearing are offset by subsequent avoidance of downstream emissions. The make-up time could be decades or centuries, depending on the biofuel, the feedstock, and vegetation cleared.

Searchinger and others (2008) and Fargione and others (2008) commented that the problem would be ameliorated to the extent that biofuels can be produced from biomass that is either waste or derived from perennials grown on degraded and abandoned agricultural land.

These scientific insights regarding land-use-change effects on greenhouse gas emissions attracted considerable subsequent attention in the scientific and economics literature. Examples of such interest include: Hertel, Tyner and Birur (2010), Khanna and Crago (2012); Greaker, Hoel and Rosendahl (2014); and several contributions to a multi-article volume edited by Khanna and Zilberman (2017).

The problem of emissions arising from land clearing ultimately triggered by demand for feedstock for biofuels production typically has been referred to in the relevant literature as indirect land use change (ILUC). In the literature responding to the work of Searchinger and others (2008) and Fargione and others (2008), there is agreement that greenhouse gas emissions from ILUC should be taken into account in estimation of life-cycle emissions associated with biofuels. In addition, there is agreement that ILUC emissions would reduce earlier life-cycle estimates of emissions from biofuels production and use.

However, there has been considerable controversy regarding the magnitude of ILUC emissions and estimation methods. Much of the literature has concluded that ILUC emissions typically will be less than suggested by Searchinger and others (2008) and Fargione and others (2008). The question, "how much lower?", remains unsettled.

Another issue yet to be settled is how to compare climate change implications of ILUC emissions which occur earlier than greenhouse gas reductions from biofuels production and use over time. However, there appears to be agreement that simply summing emissions over time is unsatisfactory. Therefore, economists typically have suggested discounting.

A detailed review of the literature on ILUC emissions and those resulting from use of nitrogen-based fertilisers to grow feedstock for biofuels plants use, and how they compare with emissions in other parts of the production and consumption life cycle is beyond the scope of this report. Nevertheless, it is important to note that greenhouse emissions savings associated with biofuels will be less than those estimated in early life-cycle analyses and used to calculate emissions savings costs reported above. Therefore, the estimated costs are likely to be lower bound estimates.

Fuel Tax Concessions and Greenhouse Gas Emissions

Historically, the Commonwealth Government has justified the fuel tax regime (excise and customs duty on domestic production and imports of fuels) as a mechanism for funding roads and as a source of government revenue. In the former role, it is roughly supported by the benefit principle of equity (see section 4) – payment in accordance with benefits received. However, it is only a crude benefit tax as it does not adequately address external costs of congestion and road damage, even though it helps address greenhouse gas emissions that are proportional to fuel use. In addition, its role as a road funding mechanism and as a source of general revenue has been eroded inexorably by improving fuel economy of vehicles. It could be further eroded by penetration of the light vehicle market by electric cars.

The Commonwealth Government has directly or indirectly nominated economic efficiency reasons for adjustments to the fuel tax regime. It has justified fuel tax exemptions for off-road diesel use on grounds that it avoids taxation of intermediate inputs to economic activity and therefore removes an impediment to the production efficiency aspect of economic efficiency. The same justification has been used to support the road-charging regime for heavy vehicles that consists of approximately 63 per cent of the standard rate of fuel tax, plus registration fees that vary according to type of heavy vehicle. Full fuel tax is not payable because the amount in excess of that required to represent the variable component of the heavy vehicle road-use charge has been deemed to be a tax on the intermediate input, road transport services. This regime does not adequately address road damage by heavy vehicles, which is widely considered to be a function of the fourth power of axle weight.

In addition, improving the efficiency of resource allocation has implicitly been suggested as a justification for fuel tax concessions for domestic biofuels production. The notion was that encouraging additional use of biofuels to displace refined petroleum products would, *inter alia*, lower greenhouse gas emissions and contribute to Australian and global efforts to mitigate climate change.

However, as explained in section 4, it is important for economic reasons to design policy instruments carefully to pursue targets and to select a policy instrument that not only yields benefits in excess of costs, but also provides the highest surplus of benefits over costs among the available policy options. Current policy settings for biofuels do not that. They are highly inefficient. There are better policy instruments available. Moreover, there are better policy instruments available for road funding and charging for road damage than the current fuel taxation regime.

Tinkering with the fuel taxation regime to try to achieve multiple targets, as has occurred in the past, has not been a sound approach. In section 4, it was pointed out that comprehensive reform involving designing and matching of a package of policy instruments to achieve various targets is desirable. A comprehensive reform package that would be consistent with principles/criteria of improving the efficiency of resource allocation and the benefit principle of equity, and could contribute positively to achievement the ability to pay principle of equity would comprise:

- abolition of fuel taxation
- application of road damage pricing based on vehicle mass, vehicle configuration, distance travelled and location, with recycling of revenue to the relevant road authority for road repairs and upgrades
- application of network-wide, variable congestion pricing with recycling of revenue to address bottlenecks, provide by-pass road capacity, and increase public transport capacity (in metropolitan areas, congestion pricing and road damage pricing together would recover the cost of providing and maintaining the arterial road network)
- application of greenhouse gas emissions tax-price regime or an emissions permit pricing regime that covers transport as well as other sectors
- alternatively, road transport could be excluded from emissions pricing and fuel tax could be retained, but focussed solely on reducing greenhouse gas emissions from evaporation and engine exhausts identification of market and policy failures that impede offerings and take up of vehicles that use less fuel to perform selected tasks.

6 Conclusions / Recommendations

6.1.1 Conclusions

Biofuels mandates, in conjunction with Commonwealth protection of domestic biofuels production, have raised the cost structure of the economy. However, qualitative economic analysis and regression analysis of Riverina wheat and Dalby sorghum prices demonstrated that the non-binding biofuel mandates have had negligible effects on domestic stockfeed prices. For a small price-taking country like Australia, external drivers such as international prices, the exchange rate and weather conditions have a greater influence on feed-grain prices than biofuels mandates. This is significantly different to the impacts of similar policies in North America and Europe.

Biofuel mandates and fuel tax concessions have been ineffective policy instruments for achieving the objectives nominated by governments. In addition, they have imposed significant costs on Australian society though misallocation of resources.

The overstated value of protecting the local biofuel production industry that has been claimed by governments and the biofuels industry is evident in the high cost per direct and indirect job associated with the industry. The cost of each new job is even higher because two of three ethanol plants were operational prior to implementation of current protection policies.

Furthermore, protection of established industries using first-generation technologies creates perverse incentives for biofuel producers to maintain the status quo, with no obvious incentive to innovate. Commonwealth and State Governments could better use the funding used to protect local biofuels production to fund alternative programs with greater nett social benefits.

Finally, the commonly-mentioned benefits of increased energy security, reduction in noxious emissions and greenhouse gas emissions from biofuels uptake have been greatly overstated. Indeed, they may have been negative.

6.1.2 Recommendations

Future Analysis

The feedlot industry and the red meat industry should consider further reviewing the effect the Queensland mandate on sorghum prices when more data is available.

7 Key Messages

7.1.1 Feed Grain Prices

- There appears to be very little compelling evidence to suggest that the introduction of biofuel mandates in New South Wales and Queensland have had any significant impact on the price of domestic feed grains.
- The introduction of the Queensland mandate has led to a 0.1 per cent increase in the domestic price of sorghum.
- The international wheat price, exchange rate and weather are the main drivers of local grain prices.

7.1.2 Expansion of Rural/Regional Economic Activity

- Protection of the domestic biofuel production industry has a high cost per direct job (estimated that the cost to the community of the tax and subsidy scheme protecting domestic ethanol production is between $545,000 and $681,000 per year for each direct job supported (160 to 210) (BREE 2014)). Allowing for the possibility of as many indirect jobs (jobs created outside ethanol production) as direct jobs, the cost per job supported was between $272,500 and $340,500 per year.
- The funds allocated annually by the Commonwealth Government to support the biofuels industry could have been allocated to other programs with greater nett social benefits.

7.1.3 Encourage Innovation and Bio-Manufacturing

- It would be more sensible to support investigations of the potential for advances in conventional and cellulosic ethanol technologies and their application in Australian conditions, than to impose substantial costs on the public to prop up an intrinsically uneconomic ethanol industry based on technologies currently in use that are not economic without government support.

7.1.4 Fuel Costs

- E10 has been overpriced relative to straight regular unleaded petrol on an energy-content basis at the retail stage of the supply chain.

7.1.5 Increased Energy Security

- Energy security effects are negligible.

7.1.6 Reduction of Noxious Emissions and Consequent Adverse Health Effects

- Health benefits from biofuels policies are minimal.

7.1.7 Reduction of Greenhouse Gas Emissions

- Governments that have promoted domestic biofuels production, biofuels producers and biofuels industry lobby groups have invariably cited greenhouse gas reductions and consequent climate change benefits as justifications for fiscal schemes and mandates to support domestic biofuels production.
- Governments have failed to point out the high cost of greenhouse reductions resulting from these policy measures. Estimates of these costs are high, even without allowing for emissions resulting from indirect land use change induced by higher demand for feedstocks for biofuels plants, and possible underestimation of climate change effects of application of nitrogen-based fertilisers to produce crops for biofuels plants.

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