final report

Project code: B.FLT.9008

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Date published: 2 March 2020

PUBLISHED BY
Meat and Livestock Australia Limited
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Revised Econometric Analysis – Effects of Biofuels Mandates on Wheat and Sorghum Prices

Meat & Livestock Australia acknowledges the matching funds provided by the Australian Government to support the research and development detailed in this publication.

Executive summary

In 2018, ACIL Allen was commissioned by Meat and Livestock Australia (MLA) to conduct an economic assessment of Commonwealth and State biofuels policies. The objectives of the project were to determine the market impact and influences of biofuel mandates on the feedlot sector and the broader Australian community.

As part of that assignment, ACIL Allen conducted an econometric analysis to determine the impact of biofuels mandates on feed grain prices. 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, 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 is a general relationship between the use of ethanol in petrol-based fuel and feed grain prices.

That analysis showed there was 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.

The two main objectives of this project are:

1. to update the econometric analysis conducted in 2018, utilising more than a year of additional grain price data to the end of November 2019, as well as an additional year of data from the ABARES statistical database
2. to explore the effects of additional variables, such as the number of cattle on feed, on wheat and sorghum demand, that were not considered in the original analysis.

A subsidiary objective was to source alternative credible grain price data. Unfortunately there were no suitable, accessible alternative data sources identified. This was discussed with MLA and it was agreed to progress on the other two objectives.

The results of this project show that regardless of updating the data an examining additional variables, there appears to be very little compelling evidence to suggest that the introduction of biofuel mandates in NSW and Queensland have had any significant impact on prices of domestic feed grains.

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1 Background

The biofuels mandate was introduced in Queensland on 1 January 2017. The mandate was initially set at 3% of regular unleaded petrol (RULP) sales, and increased to 4% of RULP sales from July 1 2018. In the lead up to the mandate's commencement, the Queensland Government launched an advertising campaign encouraging motorists to use ethanol blended fuel (E10).

In NSW, a biofuels mandate was introduced at 2% of total petrol sales in October 2007, increasing to 4% on 1 January 2010 and rising to 6% of total petrol sales on 1 January 2011. The NSW Government passed the *Biofuels Amendment Act 2016* which applied more stringent exemptions and required greater compliance from wholesalers and retailers in an attempt to increase the demand for ethanol blended fuel.

In 2018, ACIL Allen was commissioned by Meat and Livestock Australia Limited to conduct an economic assessment of Commonwealth and State biofuels policies with the aim of determining the market impact and influences of biofuel mandates on the feedlot sector and the broader Australian community.

ACIL Allen's analysis included an econometric analysis to determine the impact of biofuels mandates on feed grain prices. 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, 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 is a general relationship between the use of ethanol in petrol-based fuel and feed grain prices.

The 2018 analysis showed there was 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.

In November 2019, MLA commissioned ACIL Allen to update the econometric analysis from the 2018 report and to determine if additional data and variables changed the modelling outcome.

This report presents the updated econometric analysis which sought to explicitly identify and measure a price impact from the introduction of the mandates. This has been done for both sorghum in Queensland and wheat in NSW. Two separate variables were adopted as explanatory variables to capture the impact of the mandates:

- an indicator variable which takes a value of 1 when the mandate is in operation and 0 when it is not
- the share of ethanol blended fuel as a proportion of total automotive fuel sales as an indicator of the take up of ethanol blended fuel over time.

The second variable provides more information than an indicator variable, which shows when a mandate was in force or not. It also gives an indication of the extent to which a mandate has been taken up, and also allows consideration of periods when the demand for ethanol has changed, despite there being no policy shift. ACIL Allen also examined the historical trends of ethanol use in automotive fuel.

2 Project objectives

This project has three objectives:

1. update the econometric analysis conducted in 2018, utilising more than a year of additional grain price data to the end of November 2019, as well as an additional year of date from the ABARES statistical database
2. explore the effects of additional variables such as the number of cattle on feed, on wheat and sorghum demand, which were not considered in the original analysis.
3. source alternative credible grain price data.

Unfortunately, there were no suitable, accessible, alternative data sources identified. This was discussed with MLA and it was agreed to progress on the other two objectives.

3 Methodology

This project uses a combination of regression analysis and econometric modelling, as detailed below.

3.1 Regression analysis

ACIL Allen used regression analysis to identify any valid statistical relationships between domestic wheat and sorghum feed grain prices and the establishment of the NSW 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, and the ethanol blended fuel share of total automotive fuel sales to estimate whether there is a general relationship between the use of ethanol in automotive fuel and feed grain prices.

3.2 Econometric modelling

3.2.1 Key data

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

- monthly Darling Downs sorghum prices (from Profarmer)
- monthly Riverina wheat prices (from Profarmer)
- monthly International No.1 Hard Red Winter wheat prices (from IMF statistical database)
- monthly US Sorghum No. 2, Yellow prices, fob Gulf of Mexico (from IMF statistical database)
- monthly AUD/USD exchange rates (from Reserve Bank of Australia)
- annual Australian wheat closing stocks and production (from ABARES)
- annual Australian sorghum production (from ABARES)

3.2.2 Estimated models

The modelling used a time series of monthly domestic and international wheat and sorghum prices from July 2007 to November 2019.

Two separate approaches were taken to empirically assess the impact of current biofuels mandates on domestic sorghum and wheat prices. The first involved using indicator or dummy variables which took on the value of 1 when the mandate was in operation and 0 otherwise. In the second approach, the variable used in the modelling was the share of ethanol blended fuel as a percentage of total automotive fuel sales. As the share of ethanol blended fuels changes over time, a response might be expected in the domestic price of grain. This approach had the advantage that it allowed consideration of the impact of higher ethanol use on the price of feed grains, irrespective of whether a mandate was in operation. Also, the share of ethanol blended fuel provided additional information on the extent to which the mandate was binding.

There are two reasons why a biofuels mandate may not lead to higher grain prices.

1. The mandate may be operating, 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 NSW mandate up until very recently and appears to be the case in Queensland also.
2. Even though the mandate proves to be effective, the additional demand for feed grain to produce the necessary volumes of ethanol may not be sufficient to impact significantly on the supply and demand balance in the domestic market for grains. This remains a theoretical consideration, as neither the NSW nor Queensland mandates are currently being met.

The regressions for Darling Downs sorghum prices only considered the Queensland mandate, and excluded the NSW mandate, while the Riverina wheat regressions, tested the efficacy of the NSW mandate, but excluded the Queensland mandate. This is because sorghum is 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 NSW ethanol.

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

- Australian dollar international grain price
- annual production
- rainfall (lagged by a quarter)
- the number of cattle on feed
- indicator variables for each of the mandates or the share of ethanol blended fuels
- all the variables except for the indicator variables appearing in the regression as natural logarithms.

4 Results

4.1 Regression analysis results

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

- international grain prices
- exchange rates
- grain stocks and grain production
- rainfall

- the Queensland and NSW biofuels mandates
- the number of cattle on feed.

4.1.1 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 4.1 displays 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, where the domestic price moves away from the international price. This is generally a result of domestic conditions. In those years in which domestic production has been strong and stocks 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. In 2017-18, wheat production in NSW was significantly lower than average as a result of drought conditions. Over this period, the domestic wheat price began to diverge from the international price.

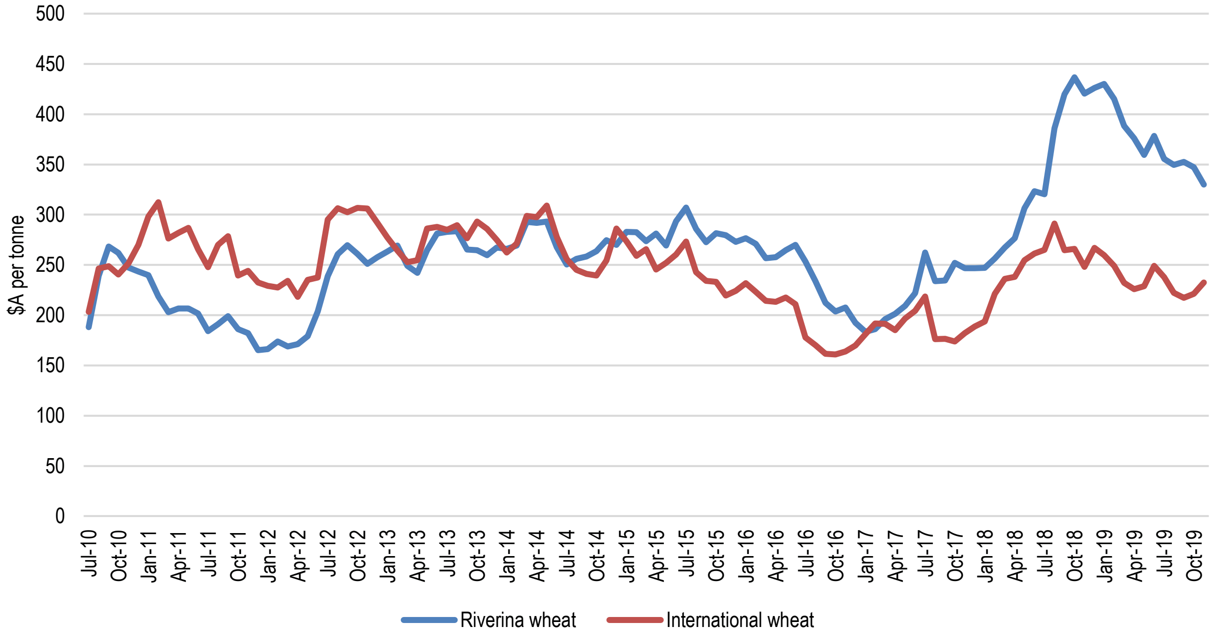


FIGURE 4.1 Riverina Wheat and International Wheat Prices ($A)
Source: Profarmer Australia and IMP

Figure 4.2 shows 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 the international price.

Of interest is the price premium that opened up in 2016-17 and increased further over 2017-18, corresponding with the introduction in the Queensland mandate. This price premium could potentially have been caused by the mandate and an associated increase in E10 sales in Queensland. However, the price premium also corresponded with very poor domestic sorghum crops in 2016-17 and 2017-18 that provided a more plausible explanation for the increase in the domestic price of Darling Downs sorghum.

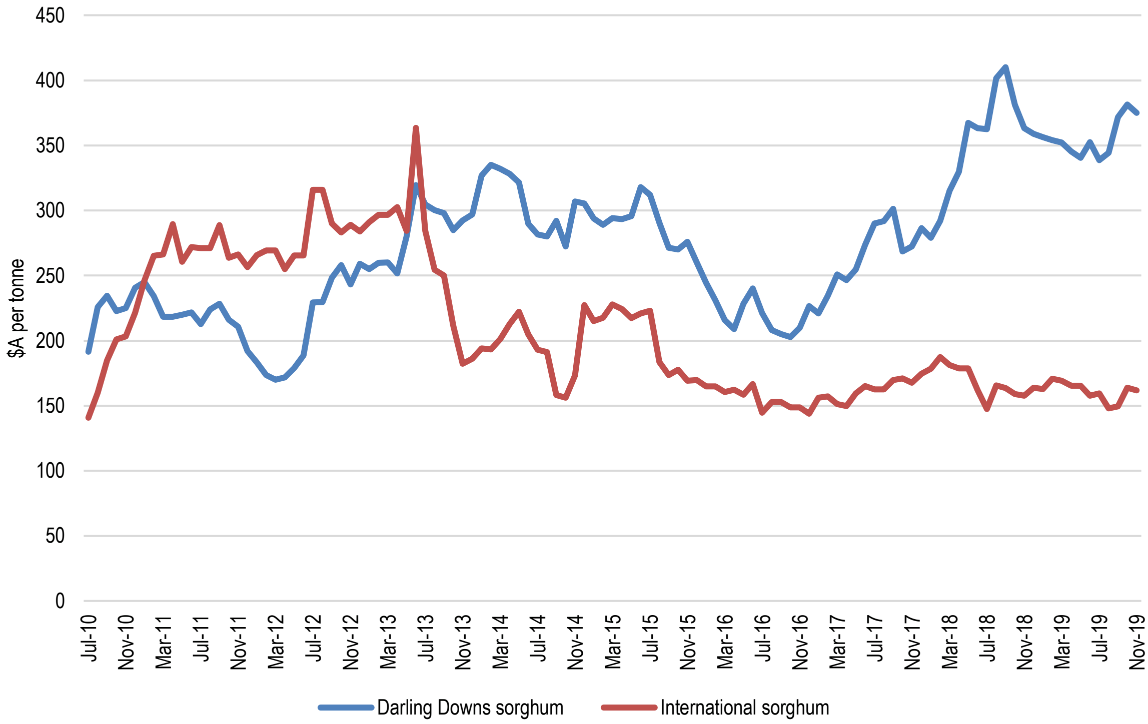


FIGURE 4.2 Darling Downs Sorghum and International Sorghum Prices ($A)
Source: Profarmer Australia and IMP

4.1.2 Closing stocks and production

Figure 4.3 shows Australian closing stocks of wheat on an annual basis. Stocks rose and fell in line with domestic production. In those years in which production and stocks were high, domestic wheat feed grain prices tended to be lower, while during periods of weak production, stocks fell and prices tended 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.

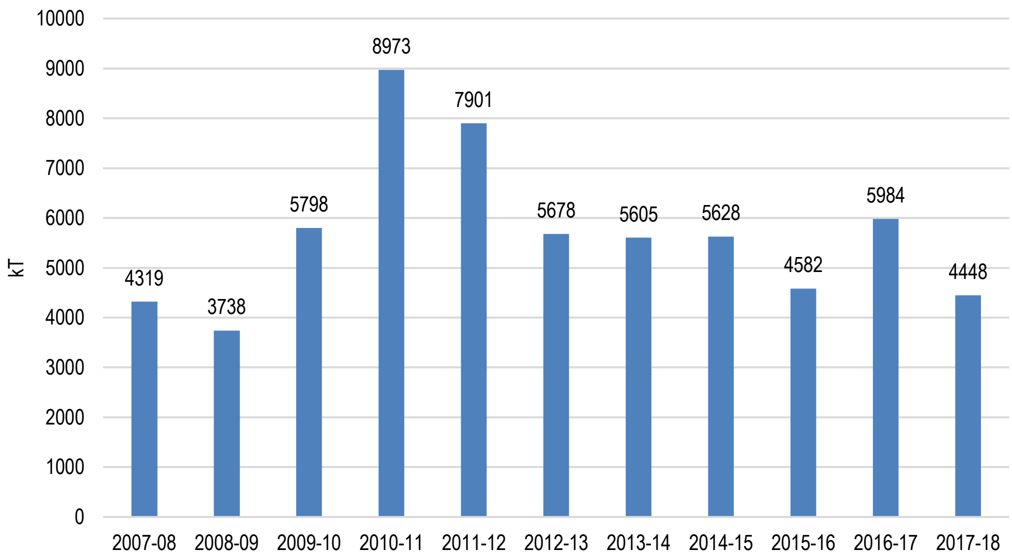


FIGURE 4.3 Australian Wheat Closing Stocks, 2007-08 to 2017-18
Source: ABARES

Figure 4.4 shows annual NSW wheat production over the last 11 years. Wheat production slumped to 4,703 kilotonnes in 2017-18, a decline of over 50% on the previous year, as a result of severe drought conditions.

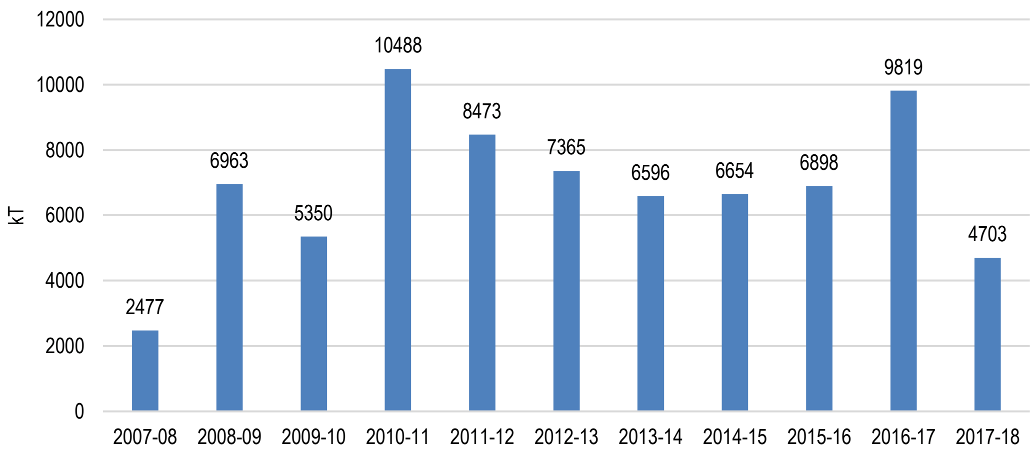


FIGURE 4.3 NSW Wheat Production, 2007-08 to 2017-18
Source: ABARES

Figure 4.5 presents Australia's annual sorghum production from 2007-08 to 2017-18. Low production years, such as 2017-18, 2016-17 and 2013-14, tended to be associated with periods in which domestic sorghum traded at a price premium over the international price.

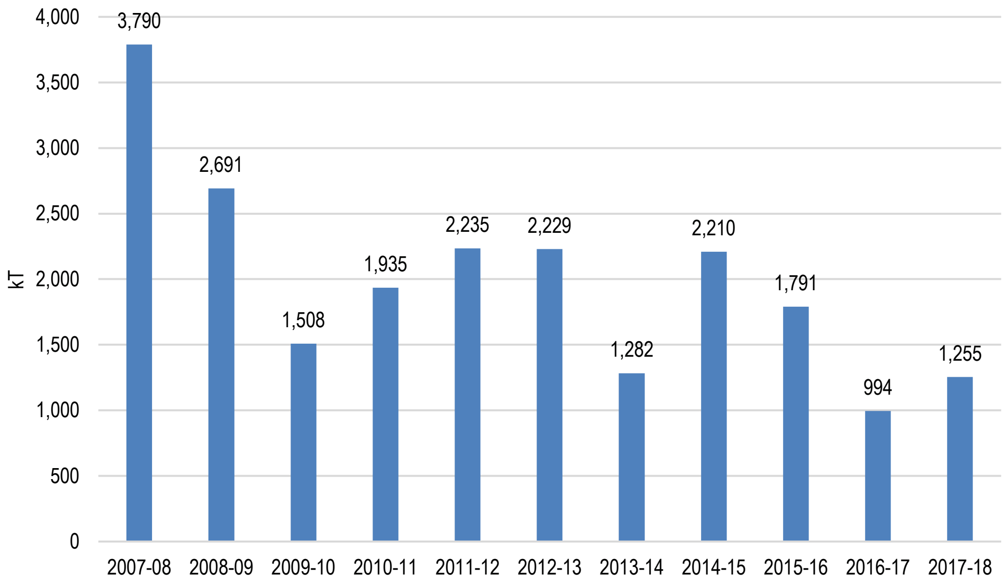


FIGURE 4.5 Australian Sorghum Production, 2007-08 to 2017-18
Source: ABARES

4.1.3 Rainfall

Another variable considered as a potential explanatory variable was 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 growing period. It is important to note that rainfall will be closely correlated with output and stocks, and so it may or may not add significant explanatory power to the estimated regressions.

Figure 4.6 shows the monthly rainfall at Darling Downs in Queensland, while Figure 4.7 presents a chart of monthly rainfall in the Riverina region of NSW.

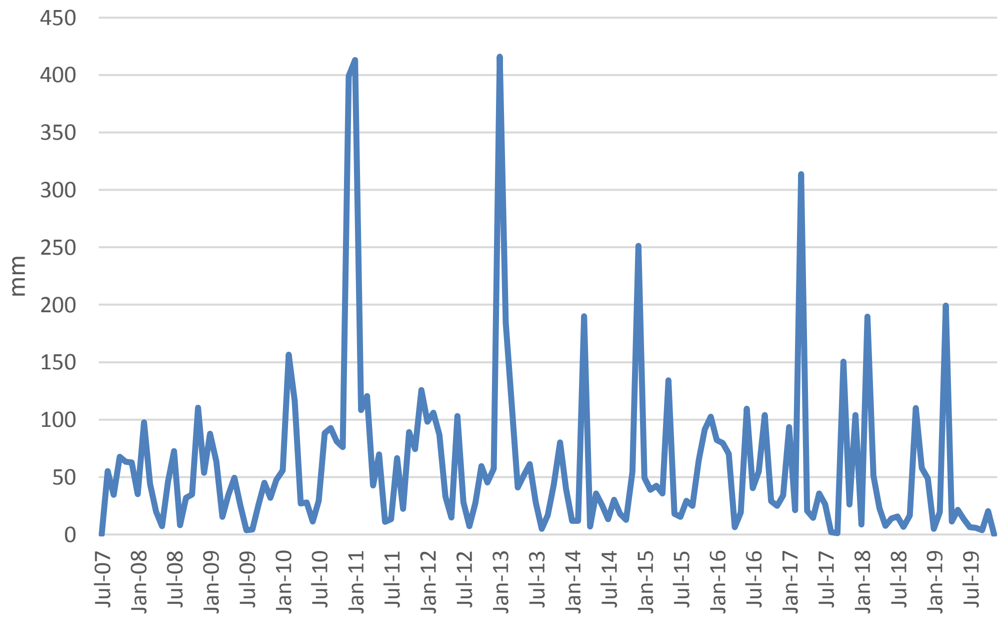


FIGURE 4.6 Monthly Rainfall at Darling Downs, Queensland

Source: Bureau of Meteorology, Toowoomba Airport (41529)

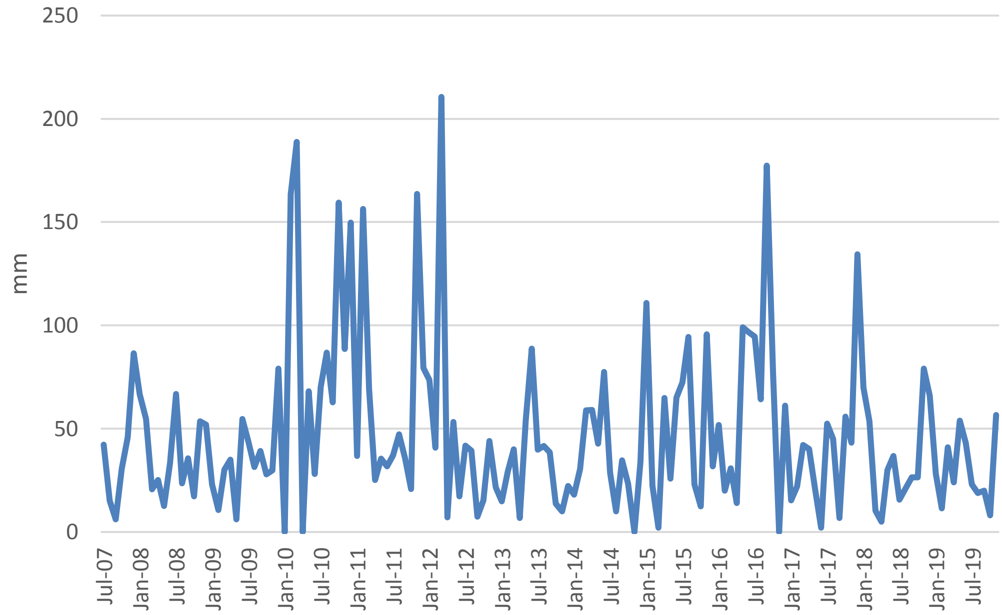


FIGURE 4.7 Monthly Rainfall in the Riverina, NSW
Source: Bureau of Meteorology, Wagga Wagga (Gurwood St) (74127)

4.1.4 Cattle on feed

Another possible driver of domestic grain prices is the number of cattle on grain in NSW and Queensland. Figure 4.8 shows the number of cattle on feed in NSW and Queensland from July 2007 to September 2019. Both series display an upward trend over time, with the number of cattle on feed in Queensland increasing from 518,700 in December 2017 to 660,300 in September 2019. In NSW there were 322,000 cattle on feed in September 2019.

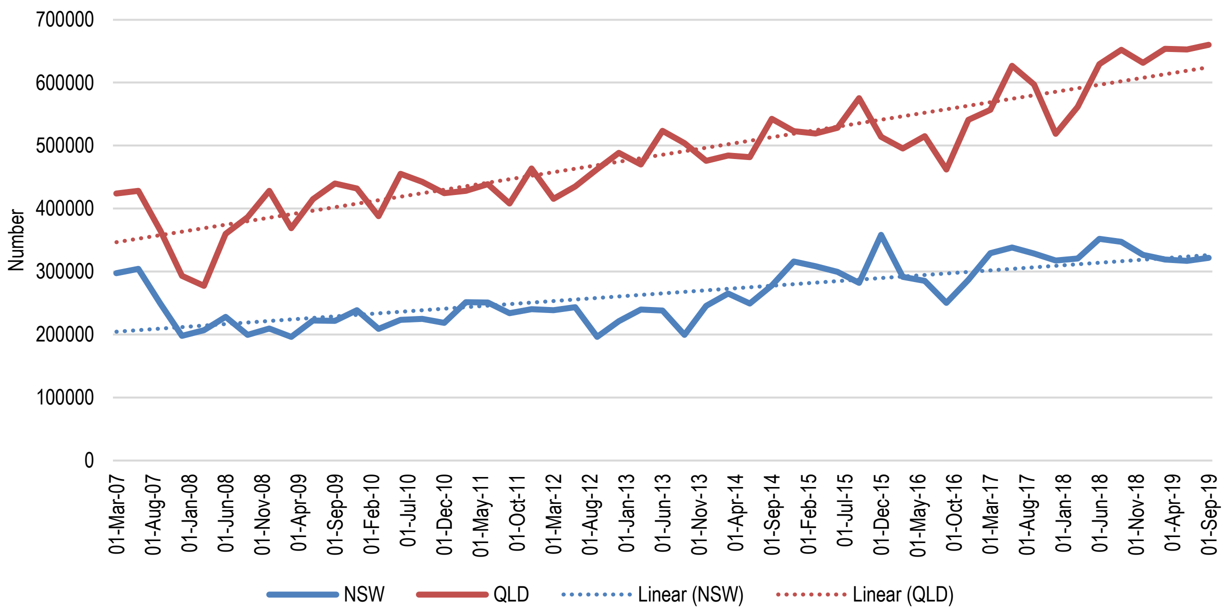


FIGURE 4.8 Number of Cattle on Feed, NSW and Queensland
Source: MLA

4.2 Econometric modelling results

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

4.2.1 Riverina Wheat

Table 4.1 presents the estimated model coefficients for Riverina wheat prices (using dummy variables to test the impact of the NSW mandate).

TABLE 4.1 Riverina Wheat Regression with Mandate Indicator

Variable	Coefficient	Std. Err.	T	P>t
International price	0.6377	0.1012	6.3000	0.0000
NSW mandate (4%)	0.0340	0.0659	0.5200	0.6070
NSW mandate (6%)	-0.0029	0.0600	-0.0500	0.9610
Annual wheat production	-0.6988	0.0835	-8.3700	0.0000
NSW Cattle on feed	0.5616	0.1001	5.6100	0.0000
Constant	2.0482	1.9895	1.0300	0.3050
R^2	0.6736			

Source: ACIL Allen

The coefficients can be interpreted as follows.

- A 1% increase in the Australian dollar international wheat price flows through into a 0.64% increase in the domestic feed grain price.
- A 1% rise in annual wheat production leads to a 0.70% reduction in the domestic feed grain price.
- A 1% rise in the number of cattle on feeds leads to a 0.56% increase in the domestic feed grain price.
- The coefficient on rainfall was statistically insignificant.
- The coefficients on the indicator variable for the 4% and 6% mandates in NSW were found to be statistically insignificant at both the 1% and 5% level of statistical significance.

The last result is not a surprising result given that the mandates in NSW have not been binding, and the use of ethanol blended fuels in NSW has continued to decline over time.

Table 4.2 presents the estimated model coefficients for Riverina wheat prices (using ethanol share as an explanatory variable).

TABLE 4.2 Riverina Wheat Regression with Share of Ethanol Blended Fuel

Variable	Coefficient	Std. Err.	t	P>t
International price	0.6908	0.0726	9.5100	0.0000
Ethanol share in NSW	-0.9346	0.1052	-8.8900	0.0000
Annual wheat production	-0.6326	0.0794	-7.9700	0.0000
Constant	7.0636	0.9994	7.0700	0.0000
R^2	0.7838			

Source: ACIL Allen

In this specification, the coefficients can be interpreted as follows.

- A 1% increase in the Australian dollar international wheat price flows through into a 0.69% increase in the domestic feed grain price.
- A 1% rise in annual wheat production leads to a 0.63% reduction in the domestic feed grain price.
- The coefficients on rainfall and cattle on feed were found to be statistically insignificant.
- The coefficient on the share of ethanol blended fuel in NSW was found to be statistically significant, but had a theoretically incorrect sign. This means that we cannot establish any meaningful link between the use of ethanol in NSW and domestic wheat prices.

4.2.2 Darling Downs Sorghum

Table 4.3 presents the estimated model coefficients for Darling Downs sorghum prices (using a dummy variable to test the impact of the Queensland mandate).

TABLE 4.3 Darling Downs Sorghum Regression with Mandate Indicator Variables

Variable	Coefficient	Std. Err.	t	P>t
International price	0.1816	0.0970	1.8700	0.0630
QLD mandate	0.1727	0.0499	3.4600	0.0010
Cattle on feed	0.3527	0.1421	2.4800	0.0140
Rainfall (1 quarter lag)	-0.0248	0.0123	-2.0100	0.0460
Constant	0.5527	1.8460	0.3000	0.7650
R^2	0.41142			

Source: ACIL Allen

The coefficients can be interpreted as follows.

- A 1% increase in the international sorghum price flows through into a 0.4% increase in the domestic sorghum price.
- A 1% rise in cattle on feed leads to a 0.35% increase in the domestic sorghum price.

- A 1% rise in monthly rainfall leads to a 0.02% reduction in the domestic price.
- The introduction of the Queensland mandate has led to a 0.18% increase in the domestic sorghum price.

Although the coefficient on the Queensland mandate was statistically significant at the 5% level, it only just passes the threshold, remaining statistically insignificant at the 1% level. This means that the estimated coefficient lacks a high degree of accuracy. The estimated coefficient is also very small, meaning that it lacks economic significance so that the introduction of the mandate does not materially impact the domestic sorghum price based on the coefficient size.

The estimated R^2 of the model is quite low, meaning that only 40% 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 4.4 presents the estimated model coefficients for Darling Downs sorghum prices (using ethanol share as an explanatory variable).

TABLE 4.4 Darling Downs Sorghum Regression with Share of Ethanol Blended Fuel

Variable	Coefficient	Std. Err.	t	P>t
International price	0.275	0.090	3.040	0.003
QLD ethanol share	-0.012	0.041	-0.300	0.762
QLD cattle on feed	1.116	0.077	14.550	0.000
Monthly rainfall	-0.032	0.010	-3.310	0.001
Constant	-9.651	1.010	-9.560	0.000
R^2	0.6376			

Source: ACIL Allen

The coefficients of this regression can be interpreted as follows.

- A 1% increase in the Australian dollar international sorghum price flows through into a 0.28% increase in the domestic sorghum price.
- A 1% rise in the number of cattle on feed leads to a 1.1% increase in the domestic sorghum price.
- The share of ethanol blended fuel was not found to be a statistically different from zero at the 1% and 5% 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.

Given the above analysis, there appears to be very little compelling evidence to suggest that the introduction of biofuel mandates in NSW and Queensland have had any significant impact on the price of domestic feed grains.

5 Discussion

As part of this analysis, changes in the use of ethanol in automotive fuel in Queensland since the 2018 project were examined.

5.1 Trends in the use of ethanol in automotive fuel

Figure 5.1 shows the monthly volumes of demand for ethanol in Queensland from July 2010 to December 2019. The figure shows that ethanol demand in Queensland declined significantly from July 2010 to January 2012, dropping from 8.5 ML to 2.5 ML per month. Ethanol sales thereafter remained reasonably stable at about 3 ML per month through to the middle of 2015, before shifting up to about 3.5 ML per month. Ethanol sales then commenced an upward trajectory in the lead up to the introduction of the biofuel mandate in January 2017, and continued increasing until December 2017, when they reached 7.1 ML. They subsequently fell back to 5.6 ML in March 2018. In the period following March 2018, the demand for ethanol for automotive fuel has been relatively stable. By December 2019, ethanol demand stood at 5.8 ML.

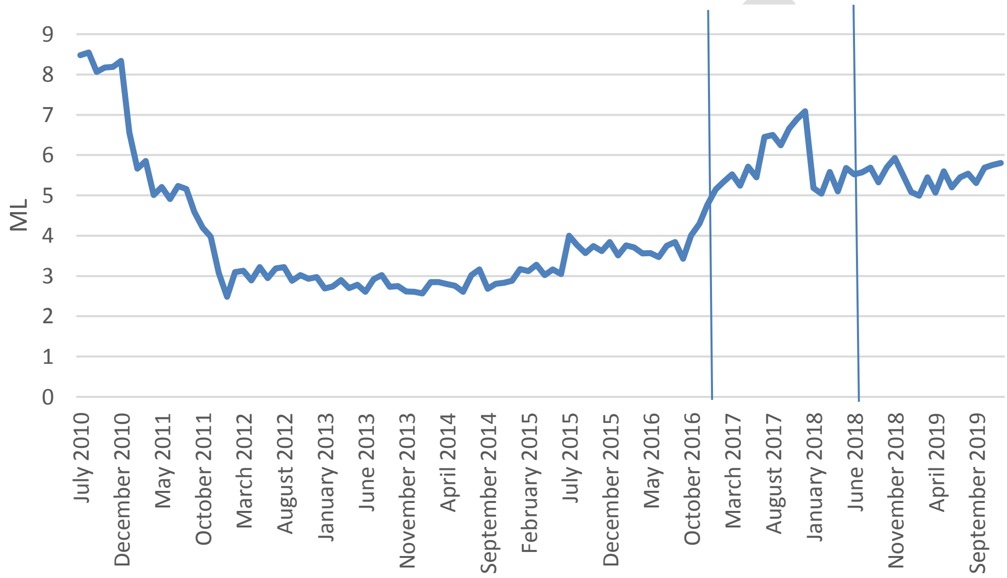


FIGURE 5.1 Demand for Ethanol, Queensland
Source: Australian Petroleum Statistics

In the case of NSW, monthly ethanol sales have trended downwards consistently since July 2010, peaking at 22.1 ML in December 2010, just before the increase in the NSW mandate from 4% to 6%, and reaching 12.2 ML in December 2019. This is shown in Figure 5.2.

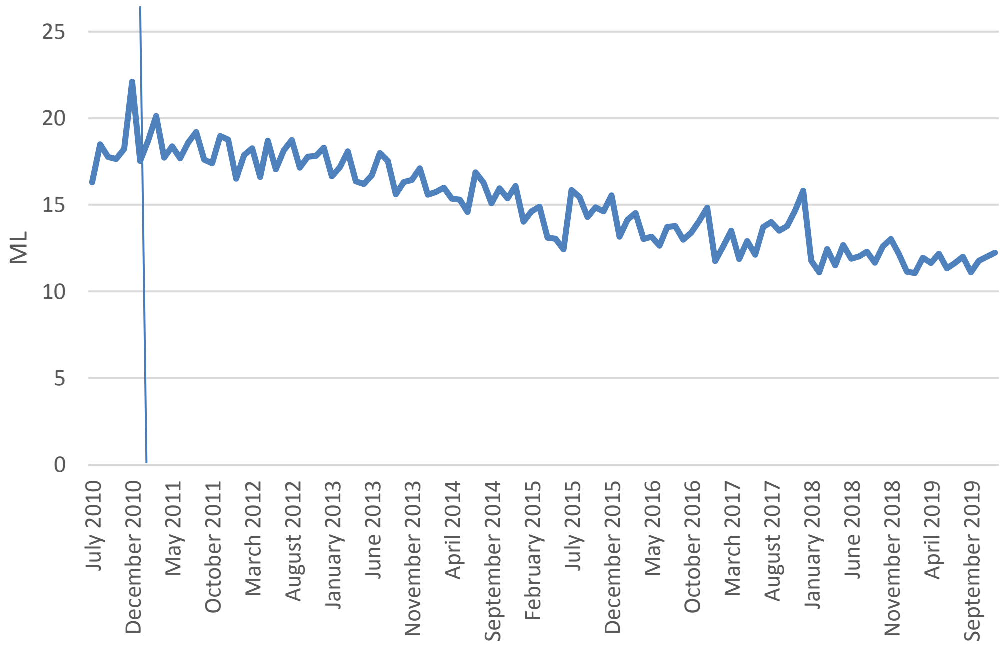
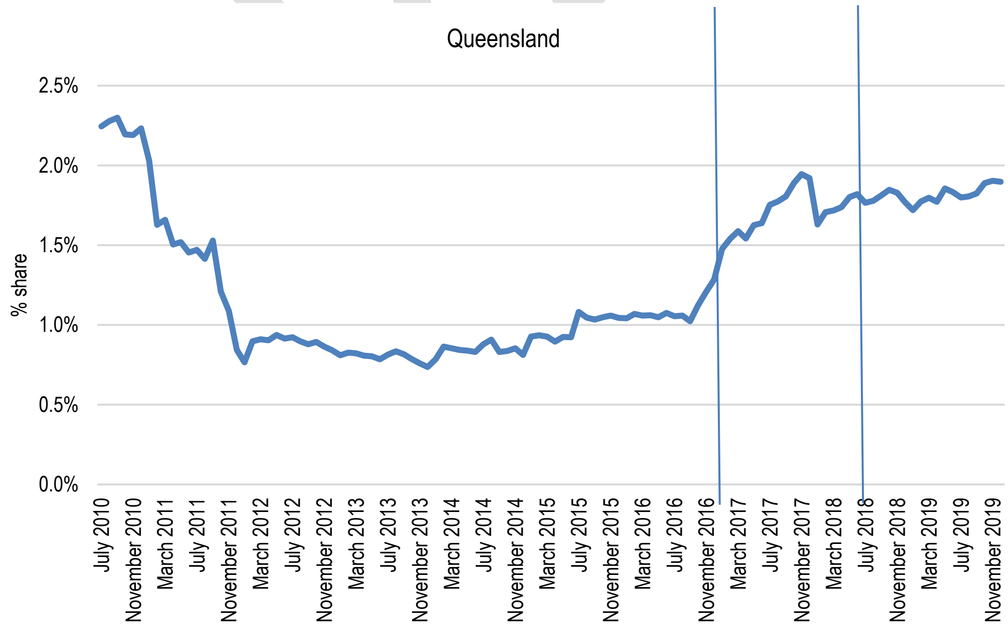


FIGURE 5.2 Demand for Ethanol, NSW
Source: Australian Petroleum Statistics

Figure 5.3 shows the share of ethanol in total automotive gasoline demand for NSW and Queensland. In Queensland, the share of ethanol in monthly automotive gasoline demand declined from a peak of 2.3% in September 2010 to 0.7% in December 2013. The share of ethanol in automotive fuel demand has increased, from 1.0% in September 2016, just prior to the commencement of the Queensland mandate and reached 1.9% in November 2017. In December 2019, the share of ethanol in total automotive gasoline demand in Queensland stood at 1.9%.



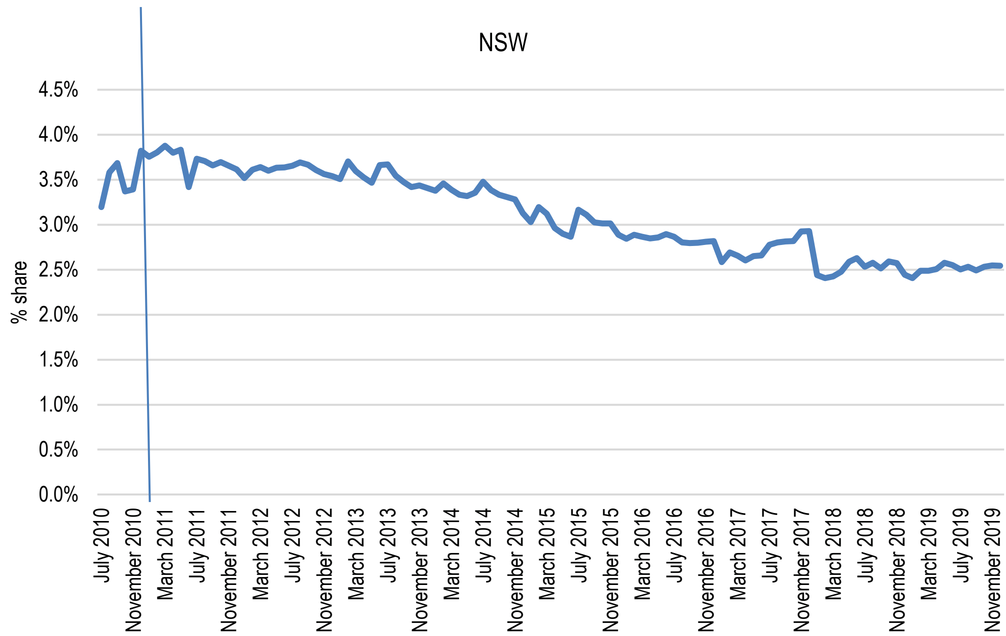


FIGURE 5.3 Ethanol Share of Total Automotive Gasoline Demand, Queensland and NSW
Source: Australian Petroleum Statistics

In NSW, the share of ethanol in total automotive fuel sales peaked at 3.9% in March 2011, two months after the increase in the NSW mandate, before commencing a long downward trend, reaching a low of 2.4% in February 2018. The share has remained relatively stable after February 2018, and was 2.5% in December 2019.

In the case of NSW, the mandate to have 6% of total automotive fuel sales comprise of ethanol has clearly failed. 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 of regular unleaded petrol and E10 sales rather than total automotive sales, as is the case in NSW.

Figure 4.4 presents the percentage for Queensland on this basis. After the introduction of the mandate, the share of ethanol peaked at 2.6% in November 2017, before falling back to 2.2% in February 2018. The increasing share of ethanol commenced prior to the mandate's introduction, starting off a low of 1.4% 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 appears that the trend increase starting in late 2016 has been sustained over the last 12 months. In December 2019, the ethanol share of total RULP and E10 sales was 2.6%. This is still significantly below the mandate of 4% which commenced on 1 July 2018.

FIGURE 4.4 Ethanol Share of RULP and E10, Queensland
Source: Australian Petroleum Statistics

5.2 Meeting the objectives

The objectives of the analysis were:

1. to update the econometric analysis conducted in 2018, utilising more than a year of additional grain price data to the end of November 2019, as well as an additional year of date from the ABARES statistical database
2. to explore the effects of additional variables such as the number of cattle on feed, on wheat and sorghum demand, which were not considered in the original analysis.
3. source alternative credible grain price data.

5.2.1 Objective 1 – update the econometric analysis

The econometric analysis (Section 4) has been updated to use an additional year of ABARES data and additional grains data as well as reporting on the trends in the use of ethanol in automotive fuel (Section 5.1).

5.2.2 Objective 2 – explore the effects of additional variables

Two separate variables are adopted as explanatory variables to capture the impact of the mandates:

- an indicator variable which takes a value of 1 when the mandate is in operation and 0 when it is not
- the share of ethanol blended fuel as a proportion of total automotive fuel sales as an indicator of the take up of ethanol blended fuel over time.

The second variable provided more information than just an indicator variable which depicts whether a mandate was in force or not. It also gives an indication of the extent to which a mandate has been taken, and allows consideration of periods when the demand for ethanol has changed, despite there being no policy shift.

5.2.3 Objective 3 – source alternative grain price data

Unfortunately there were no suitable, accessible, alternative data sources identified. This was discussed with MLA and it was agreed to progress on the other two objectives.

6 Conclusions/recommendations

This project has shown that regardless of updating the data an examining additional variables there appears to be very little compelling evidence to suggest that the introduction of biofuel mandates in NSW and Queensland have had any significant impact on the price of domestic feed grains.

6.1.1 Recommendations

Future Analysis

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

7 Key messages

The key findings of this project are that additional data and analysis have not changed the outcome of the original analysis. There still appears to be very little compelling evidence to suggest that the introduction of biofuel mandates in NSW and Queensland have had any significant impact on the prices of domestic feed grains.

This would suggest that, in line with the conclusions of ACIL Allen's previous report, 'Economic Assessment of Commonwealth and State Biofuel Policies' (October 2018), the implications of this latest 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.

8 Bibliography

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Australian Bureau of Statistics (ABS) (2017-2018), *Value of Agricultural Commodities Produced, Australia*, 7503.0.

9 Appendix

9.1 Excel spreadsheets data and model

Excel files are available on request from MLA.