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El Niño and its impact on the New Zealand economy

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NON-TECHNICAL SUMMARY

The National Institute of Water and Atmospheric Research (NIWA) has warned for several months that strong El Niño conditions are present in the tropical Pacific Ocean[1]. El Niño refers to a climatic pattern that negatively affects global food production. During El Niño New Zealand tends to experience drought in east coast areas and more rain in the west in summer. According to NIWA, this El Niño could rank amongst the four strongest El Niño events ever recorded (along with 1972/73, 1982/83 and 1997/98).

El Niño conditions do not, by themselves, condemn New Zealand's agricultural sector to a poor season. Serious east coast drought and excessive rainfall in the west does not occur during every El Niño, and regional impacts can vary from one event to the next. Nonetheless, it is appropriate to closely monitor climatic conditions during El Niño, given the heightened risk.

This *Note* collects together information and empirical insights on El Niño. The introduction draws on material sourced from the NIWA website to clarify what El Niño is and how it affects New Zealand. Section 2 looks at how the 1997/98 El Niño impacted on the New Zealand economy. Section 3 then uses the annual *Agricultural Production Statistics* and the five-yearly *Agricultural Census* to see how farming practices have changed since 1997/98. Section 4 looks at the impact of more recent (non-El Niño) droughts. Section 5 outlines the key indicators that the Bank intends to monitor over the next few months. Section 6 concludes.

The key insights of this *Note* are:

1. The Southern Oscillation Index is currently 1.2 standard deviations below its mean, suggesting that strong El Niño conditions are present. Empirical analysis suggests that an El Niño of this intensity could subtract something in the order of 0.2 to 0.5 percent from New Zealand's GDP.

2. The 1997/98 El Niño, which had a similar Southern Oscillation Index reading to the current situation, significantly affected New Zealand. The contraction seen in the agricultural and primary food manufacturing components of GDP alone subtracted 0.7 percentage points from GDP from the March quarter of 1997 to the September quarter of 1998.

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[1] See NIWA (2015).

3. The actual impact of the current El Niño will depend heavily on where drought occurs. Significant snowfall and greater availability of irrigation mean that farms along the east coast of the South Island are potentially better placed to withstand drought than those in the North. Indeed, the 2012/13 drought – which was concentrated in Northland, Waikato and the Manawatu – had a very large economic impact, subtracting 0.9 percentage points from GDP.

1. INTRODUCTION[2]

El Niño is a natural feature of the global climate cycle. El Niño and La Niña refer to the opposite extremes of the normal cycle in atmospheric and oceanic conditions across the Pacific Ocean.

Outside of these extremes, 'neutral' atmospheric conditions cause trade winds to blow westward across the Pacific (at their 'normal' intensity) piling up warm surface water such that sea levels are higher and temperatures warmer in the western Pacific than in the east. Cooler water is pushed back east under the surface, supporting marine ecosystems and fisheries along the South American coast. Rising air over the warmer water to the west causes relatively more rainfall in that region, whereas the colder east Pacific is relatively dry.

During an El Niño the trade winds weaken, resulting in warmer – and therefore wetter – conditions along the South American coast, and cooler – and therefore drier – conditions along the western Pacific. This can lead to heavy rainfall and flooding in South America and drought in Indonesia and Australia. The upwelling of nutrient rich cool water off the South American coast is also reduced, negatively affecting fisheries. In addition, the pattern of tropical cyclones shifts eastwards, increasing the risk of cyclone damage in the Pacific Islands but reducing this risk in the United States and Central America.

New Zealand tends to experience stronger or more frequent winds from the west in summer, leading to drought in east coast areas and more rain in the west. In winter, southerly winds are more frequent, bringing cooler conditions and more rain and snow than normal[3]. In spring and autumn south-westerly winds tend to be stronger or more frequent, providing a changeable mix of the summer and winter conditions. This all said, weather is variable –

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[2] This introduction draws on the well-written and informative NIWA El Niño and La Niña web page (see http://www.niwa.co.nz/climate/information-and-resources/elnino).

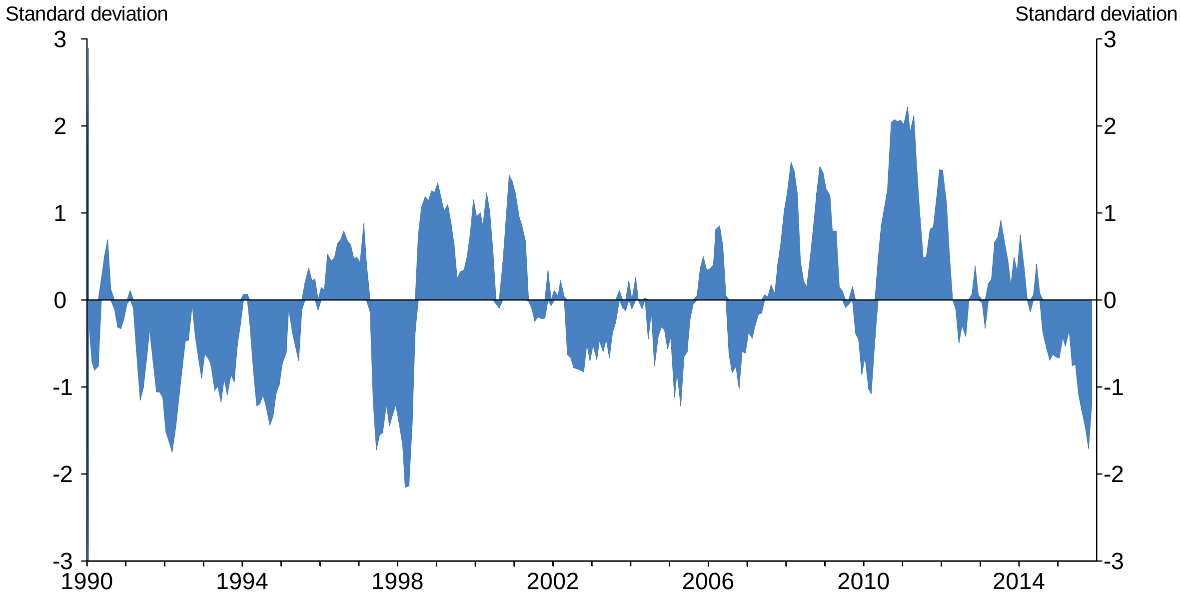
[3] Which is consistent with this winter's prolonged ski season (http://www.stuff.co.nz/the-press/news/72998794/south-island-ski-season-ends-after-record-season).

serious east coast drought and excessive rainfall in the west does not occur during every El Niño, and regional impacts can vary from one event to the next.

The Southern Oscillation Index (figure 1) is used to measure the stage and intensity of the atmospheric cycle. It is calculated using pressure differences between the east and west Pacific (specifically between Tahiti and Darwin), with anomalously low values corresponding to El Niño conditions. The index is currently 1.2 standard deviations below its mean, suggesting that strong El Niño conditions are present.

Figure 1: Southern Oscillation Index

(3-month moving average, deviation from seasonal norm)

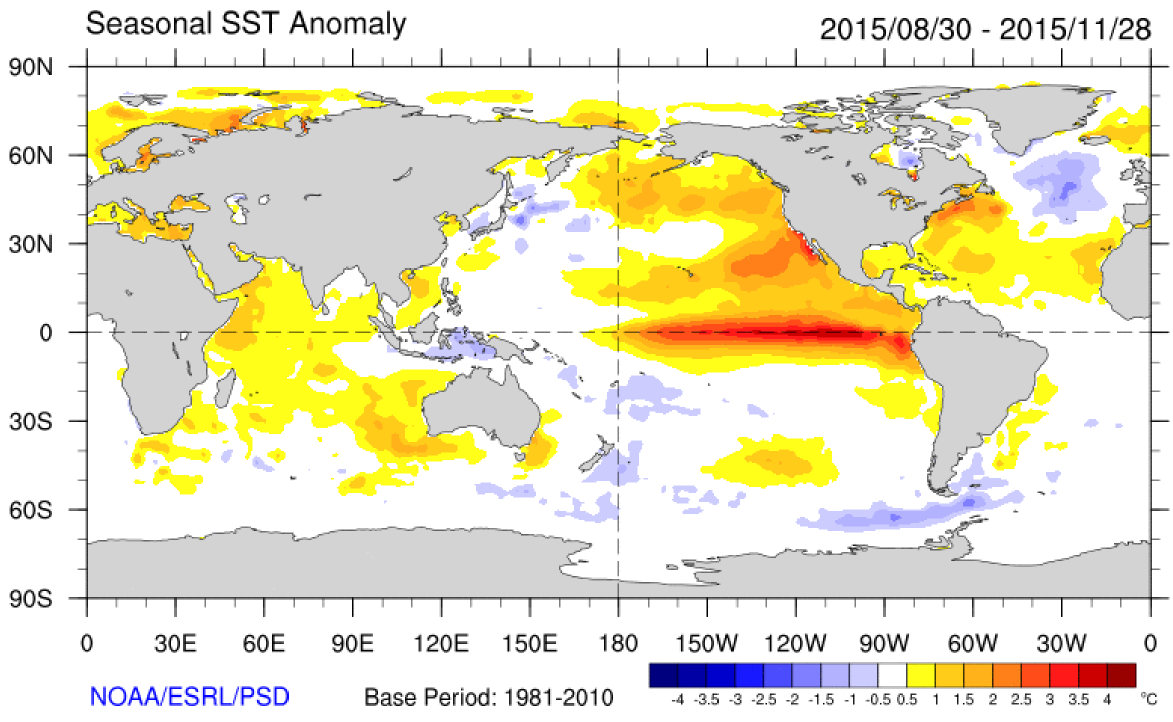


Source: Australian Bureau of Meteorology.

The Southern Oscillation Index is actually quite volatile, with pressure differences rising and falling from month to month. Such short-lived swings do not necessarily imply that El Niño- or La Niña-like conditions will arise. For the trade winds to weaken or strengthen sufficiently pressure anomalies must persist for several months. Sea surface temperature readings provide a cross check for identifying El Niño or La Niña conditions – anomalies will only develop once pressure differences have persisted for long enough to cause a weakening in the trade winds. Current sea surface temperature readings are also strongly suggestive of El Niño conditions, with temperatures well above normal for this time of year in the eastern equatorial Pacific (figure 2).

Figure 2: Sea surface temperature anomaly as at 28 November 2015

(3-month average)



Source: United States' National Oceanic & Atmospheric Administration.

Cashin, Mohaddes and Raissi (2015) investigated the impact of El Niño on the economies of a selection of countries from around the world. They found that countries such as Australia, New Zealand, Chile and Indonesia faced a short-lived fall in economic activity during past El Niños (table 1). For New Zealand, a one-standard-deviation El Niño is estimated to subtract 0.4 percent from GDP after four quarters – suggesting the current event could subtract 0.5 percent from GDP.

Cashin *et al* (2015) find that some countries do benefit from the changed weather pattern, however, with economic activity in Canada, the United States, Mexico and Argentina boosted by El Niño. These countries benefited from warmer weather, more rain and fewer tornados.

Table 1: The effects of a one standard deviation El Niño shock on real GDP growth *(percent)*

	Initial impact	Cumulated response after			
		1 quarter	2 quarters	3 quarters	4 quarters
Argentina	-0.08	0.03	0.29*	0.64*	1.08*
Australia	-0.03	-0.18*	-0.30**	-0.37*	-0.41
Brazil	-0.06	0.04	0.20	0.42*	0.68*
Canada	0.00	0.13**	0.33*	0.58**	0.85**
Indonesia	-0.35**	-0.61*	-0.91*	-1.02	-1.01
Mexico	0.03	0.37**	0.71*	1.12*	1.57**
New Zealand	-0.16**	-0.29*	-0.37	-0.42	-0.43
Peru	-0.07	-0.28	-0.35	-0.34	-0.33
South Africa	-0.11**	-0.24*	-0.47**	-0.63*	-0.72
United States	0.05*	0.10	0.23*	0.39*	0.55*

Source: Cashin *et al* (2015). ** and * denote significance at the 90 and 68 percent confidence levels.

In net though, El Niño adversely affects global food production, causing food prices to increase (table 2). Other commodity prices also rise. Increased irrigation usage boosts electricity demand and this, combined with reduced capacity for hydroelectric generation, sees coal and crude oil prices rise.

Table 2: The effects of a one standard deviation El Niño shock on real commodity prices *(percent)*

	Initial impact	Cumulated response after			
		1 quarter	2 quarters	3 quarters	4 quarters
Non-fuel commodity prices	0.42	0.77	1.97**	3.75**	5.31**
Crude oil prices	1.20*	4.23*	7.80**	11.09**	13.87**

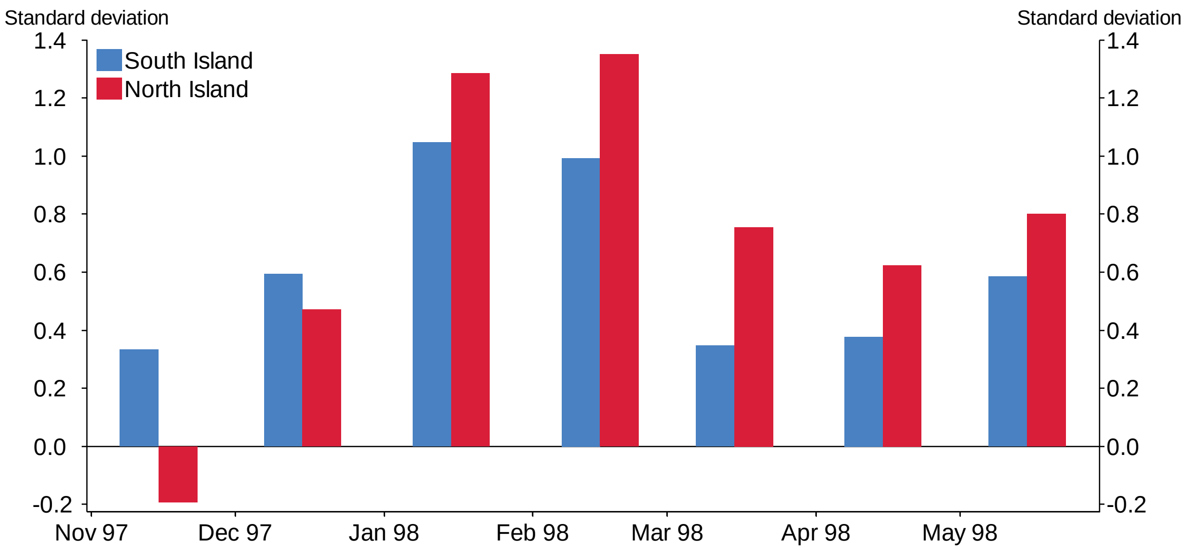
Source: Cashin *et al* (2015). ** and * denote significance at the 90 and 68 percent confidence levels.

Reserve Bank research has also shown that El Niño has a significant negative impact on the New Zealand economy, albeit of a lesser magnitude than does Cashin *et al* (2015). Bloor and Matheson (2008) found that an El Niño of the current intensity reduces GDP by 0.2 percent. This impact was identified as being concentrated in the agricultural and manufacturing components of GDP.

2. THE 1997/98 EL NIÑO

A major El Niño developed rapidly over the second quarter of 1997, and has been cited as the cause of many climatic disasters around the world. Drought occurred in Australia, Papua New Guinea and Indonesia, in Venezuela, French Guyana and northern Brazil, and severe flooding occurred in Ecuador, Peru and central Chile. In New Zealand, the 1997/98 El Niño led to much drier conditions, particularly along the east coast of the North Island (figure 3).

Figure 3: Cumulative soil moisture deficit index 1997/98
(deviation from seasonal norm)



Source: Kamber *et al* (2013) using NIWA data.

The macroeconomic impact of drought can be estimated by examining the agricultural and primary food manufacturing components of quarterly production GDP. Agriculture is negatively affected by drought through reduced milk production and reduced animal growth. Primary food manufacturing is initially positively affected by increased slaughtering, but subsequently falls due to fewer and lighter animals being slaughtered thereafter.

While these two GDP components are those most obviously affected by drought in New Zealand, it should be noted that other parts of the economy are also adversely affected. Transport, finance and business services are all tied to the health of the agricultural sector.

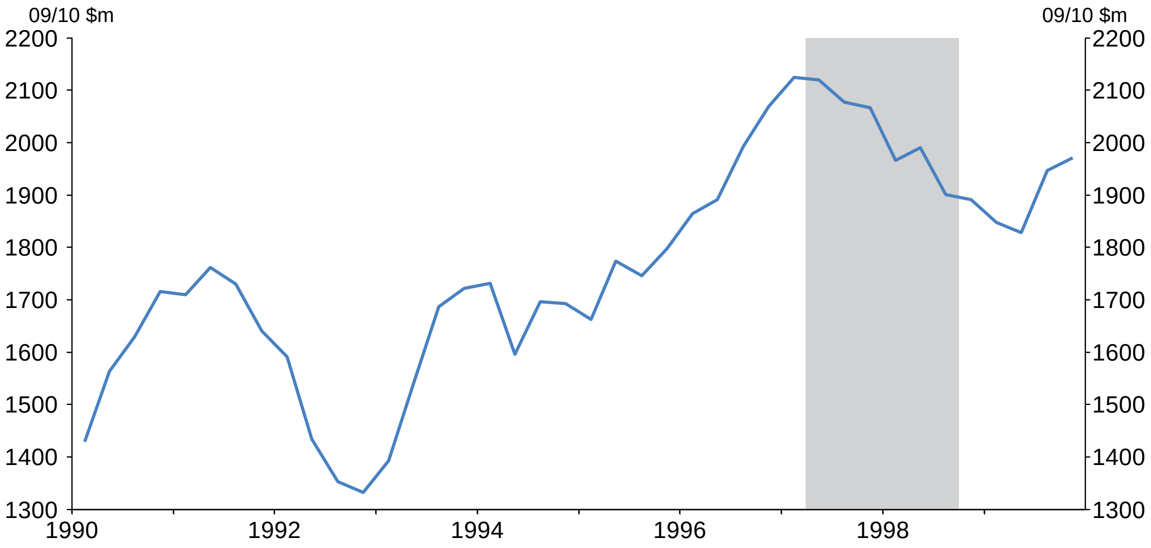
Furthermore, the electricity, gas, waste and water services component of GDP can also be negatively affected by drought. During droughts – as hydro lake levels and river flows fall – there tends to be a switch in electricity generation from hydroelectric to thermal and gas fired generation. Hydroelectric generation has lower input costs than other types of generation, meaning that this switch negatively affects electricity GDP value-add for a given quantity of electricity generated. The largest impacts tend to occur during winter droughts. This is because high power demand and low lake inflow occur simultaneously.

The impact of drought is therefore likely to be larger than the direct impact on the agriculture and primary food manufacturing components of GDP. That said, focusing solely on these two components helps isolate the impact of drought from whatever other macroeconomic events are also affecting the economy at that time. This is particularly important for the 1997/98 El Niño given that the Asian Financial Crisis was also affecting New Zealand at the time.

During the 1997/98, El Niño agricultural (figure 4) and primary food manufacturing GDP (figure 5) both moved sharply lower. This impact was particularly severe given that dry conditions persisted through the summers of both 1997 and 1998. Indeed, the decline in these two components of GDP subtracted 0.7 percentage points from GDP from the March quarter of 1997 to the September quarter of 1998

Figure 4: Agricultural GDP – 1990 to 2000

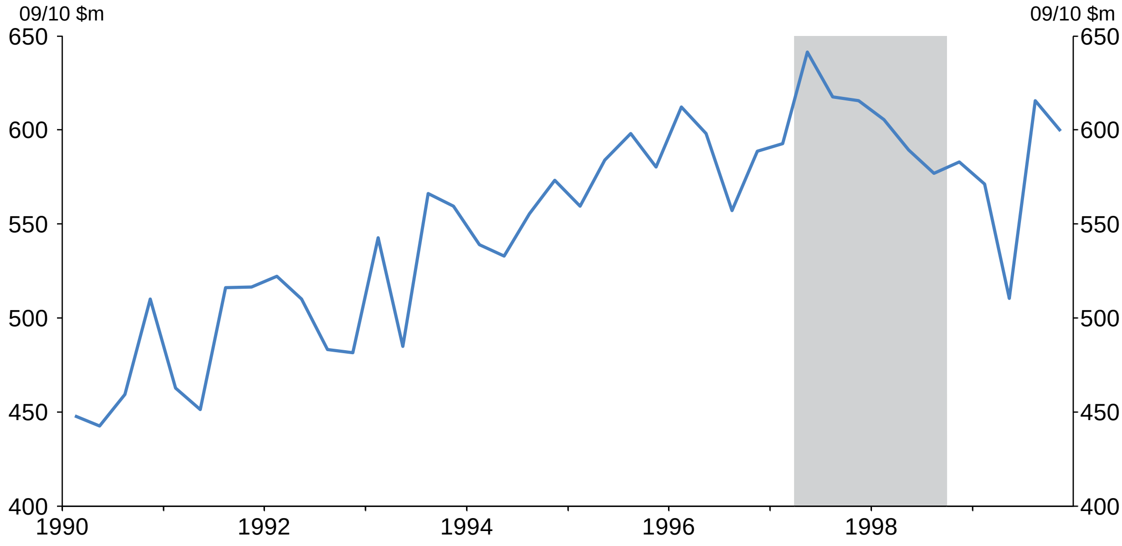
(quarterly, seasonally adjusted)



Source: Statistics New Zealand.

Figure 5: Primary food manufacturing GDP – 1990 to 2000

(quarterly, seasonally adjusted)



Source: Statistics New Zealand.

There was no noticeable change in global dairy prices during the 1997/98 El Niño. While New Zealand production fell, milk production increased in the United States, China and South America over that period (figure 11).

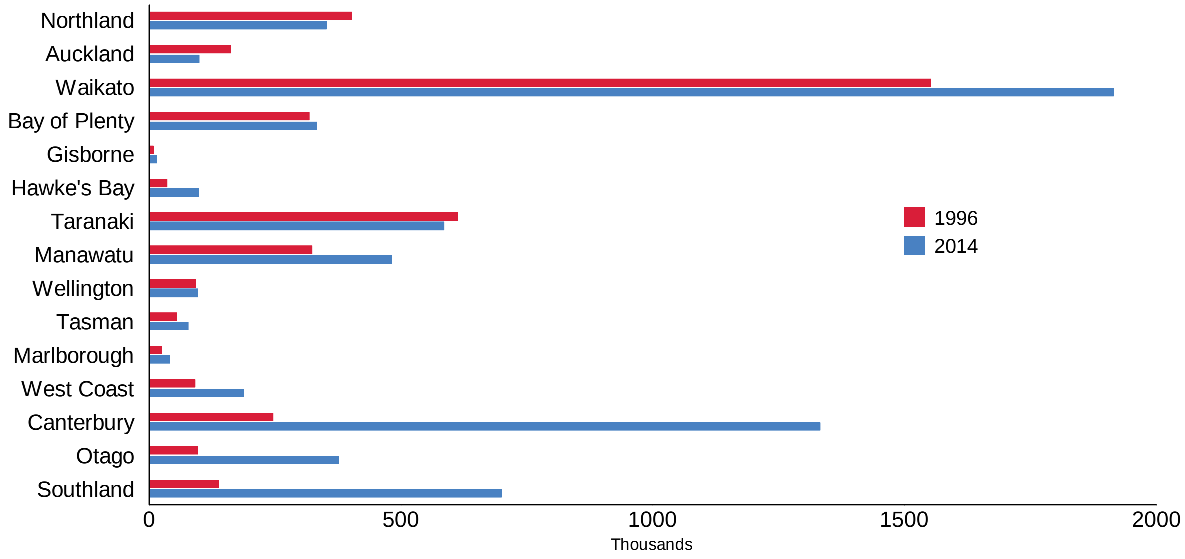
3. How New Zealand's agricultural sector has evolved since 1997/98

New Zealand's agricultural sector has evolved substantially over the past two decades, with dairy farming expanding and the use of irrigation increasing. It is unclear whether these changes make New Zealand more or less susceptible to drought.

Since 1996 the number of dairy cattle has increased by 61 percent, while sheep and beef numbers have decreased 37 percent and 24 percent respectively. The growth in dairy cattle has been concentrated in the South Island, particularly in the Canterbury region (figure 6).

Figure 6: Dairy cattle numbers by region

(June years)

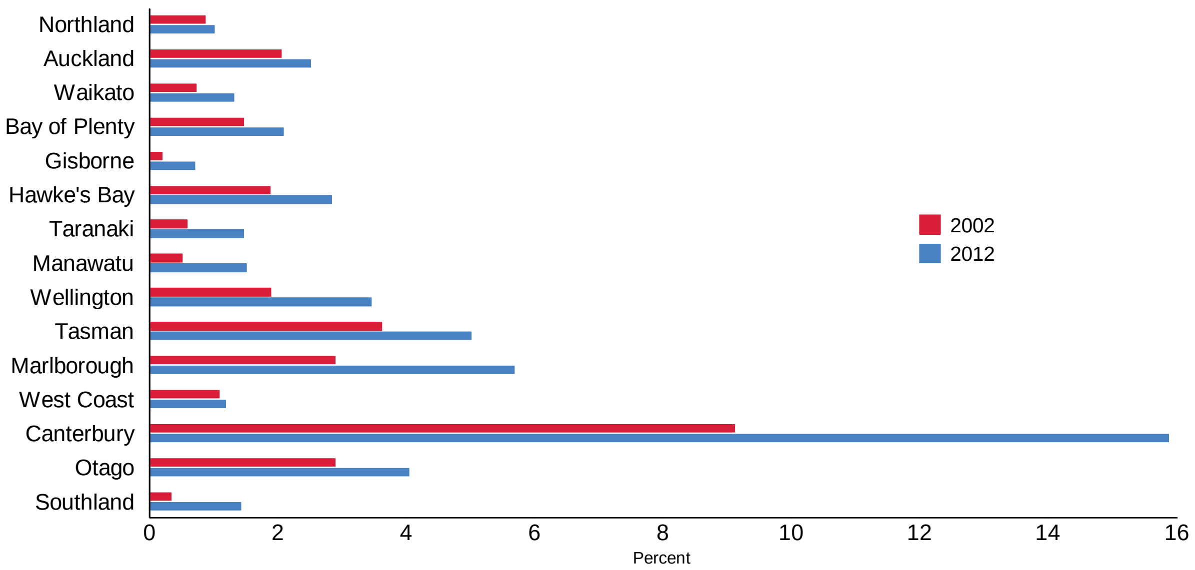


Source: Statistics New Zealand.

Growth in Canterbury dairy cattle numbers has been facilitated by increased use of irrigation. Since 2002, the five-yearly *Agricultural* Census has collected significant detail on land use and treatments. It shows that the hectares of farm land irrigated increased by 54 percent between 2002 and 2012, with growth in irrigation in Canterbury contributing 34 percentage points to this increase. Almost 16 percent of Canterbury farm land is irrigated (figure 7).

Figure 7: Irrigation by region

(share of total hectares farmed)



Source: Statistics New Zealand.

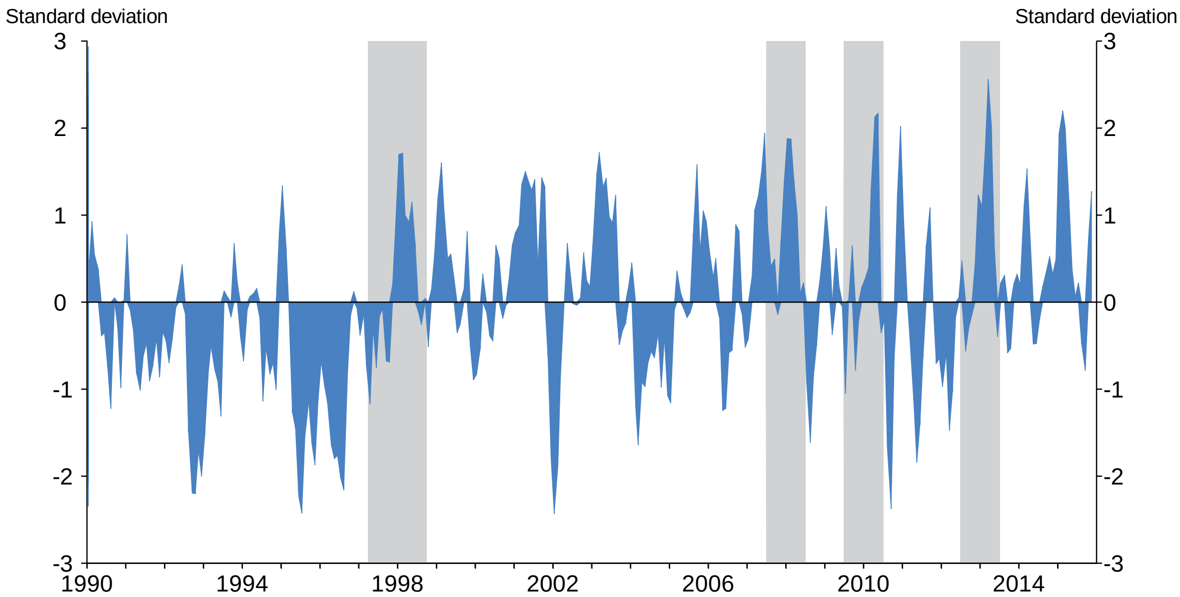
Since 2007, much of the growth in land irrigated has been due to more efficient use of water allocations. Centre pivot and other sprinkler based systems allow more prolonged irrigation for a given amount of water than the flood systems traditionally used in Mid Canterbury.

4. Impact of Recent Droughts on New Zealand

To assess whether New Zealand's susceptibility to drought has changed since 1997/98, this section looks at the impact of more recent droughts. The droughts of 2007/08, 2009/10 and 2012/13 were not El Niño driven, but the resultant soil moisture readings were comparable to that of 1997/98 (figure 8).

Figure 8: Cumulative soil moisture deficit index

(monthly, deviation from seasonal norm, shaded areas represent past four major droughts)

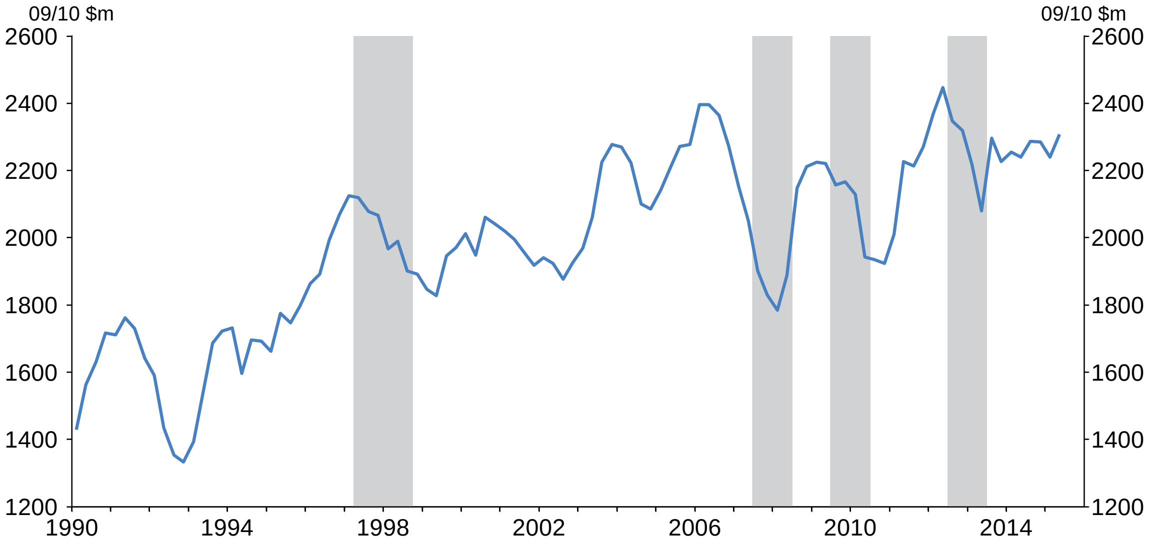


Source: Kamber *et al* (2013) using NIWA data.

Time series for agriculture and primary food manufacturing GDP from 1990 are shown in figures 9 and 10. Unsurprisingly, agricultural GDP drops noticeably during droughts and primary food manufacturing declines in their aftermath. These declines subtracted 0.1, 0.2 and 0.9 percentage points from GDP in the year to the June quarters of 2008, 2010 and 2013 respectively. This compares to the 0.5 percentage point detraction from GDP in the year to the June quarter of 1998 from agriculture and primary food manufacturing during the 1997/98 El Niño. The more severe impact from the 2012/13 drought reflects its concentration in Northland, Waikato and the Manawatu – areas with large numbers of dairy cattle but only limited irrigation.

Figure 9: Agricultural GDP

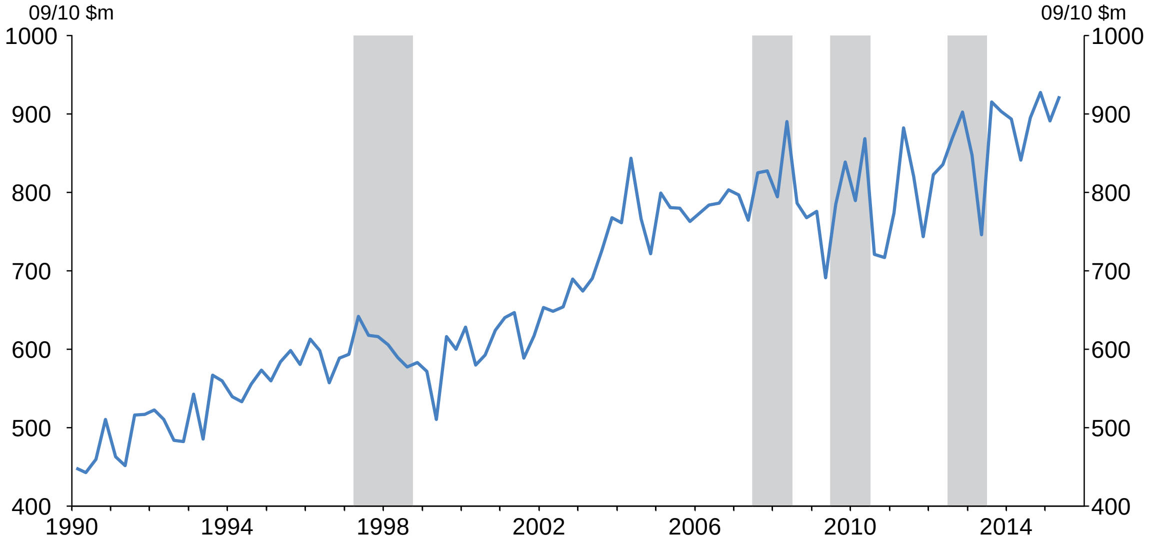
(quarterly, seasonally adjusted, shaded areas represent past four major droughts)



Source: Statistics New Zealand.

Figure 10: Primary food manufacturing GDP[4]

(quarterly, seasonally adjusted, shaded areas represent past four major droughts)



Source: Statistics New Zealand.

It is difficult to determine whether these droughts in New Zealand had an influence on global dairy prices. New Zealand's share of global dairy production is small and does not tend to be a large driver of swings in global milk production growth (figure 11). At the same time, New Zealand is one of the largest suppliers to the global dairy export market, particularly for whole milk powder.

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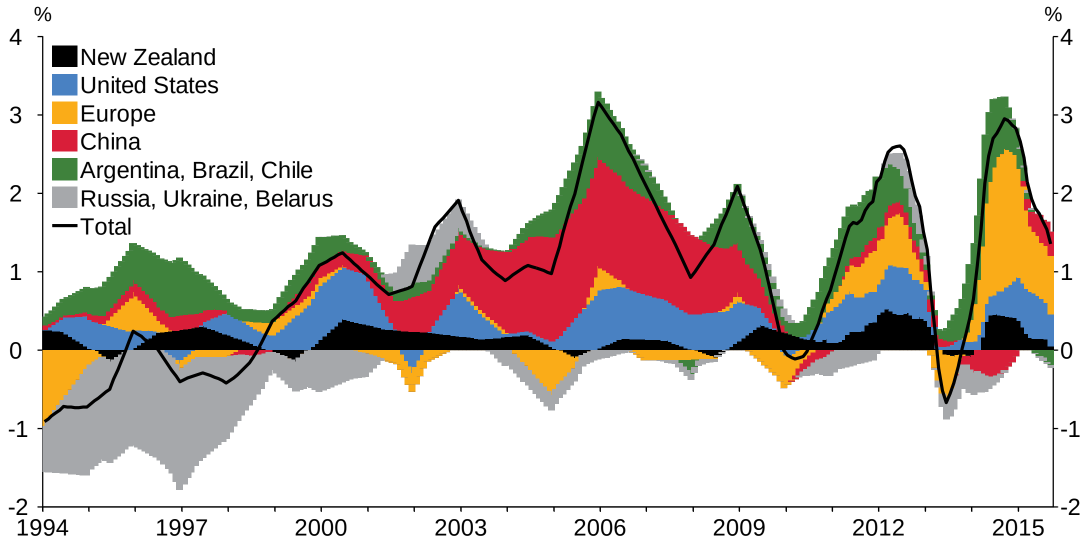
[4] Primary food manufacturing prior to 2002Q3 scaled to reflect reclassification of dairy food production from wholesale trade to primary food manufacturing.

What seems to matter more is the extent to which climatic conditions in New Zealand are correlated with those in other dairy producing regions. If widespread drought causes global animal feed prices to increase, dairy production will suffer just as much elsewhere as it does in New Zealand. Indeed, during the most recent drought global dairy prices increased noticeably. New Zealand dairy production fell sharply over the first half of 2013, as did production in Europe and Russia.

Figure 11: Contribution to global milk production growth

(annual average, countries for which timely data is available)



Source: FAO, CLAL, Haver analytics, RBNZ estimates.

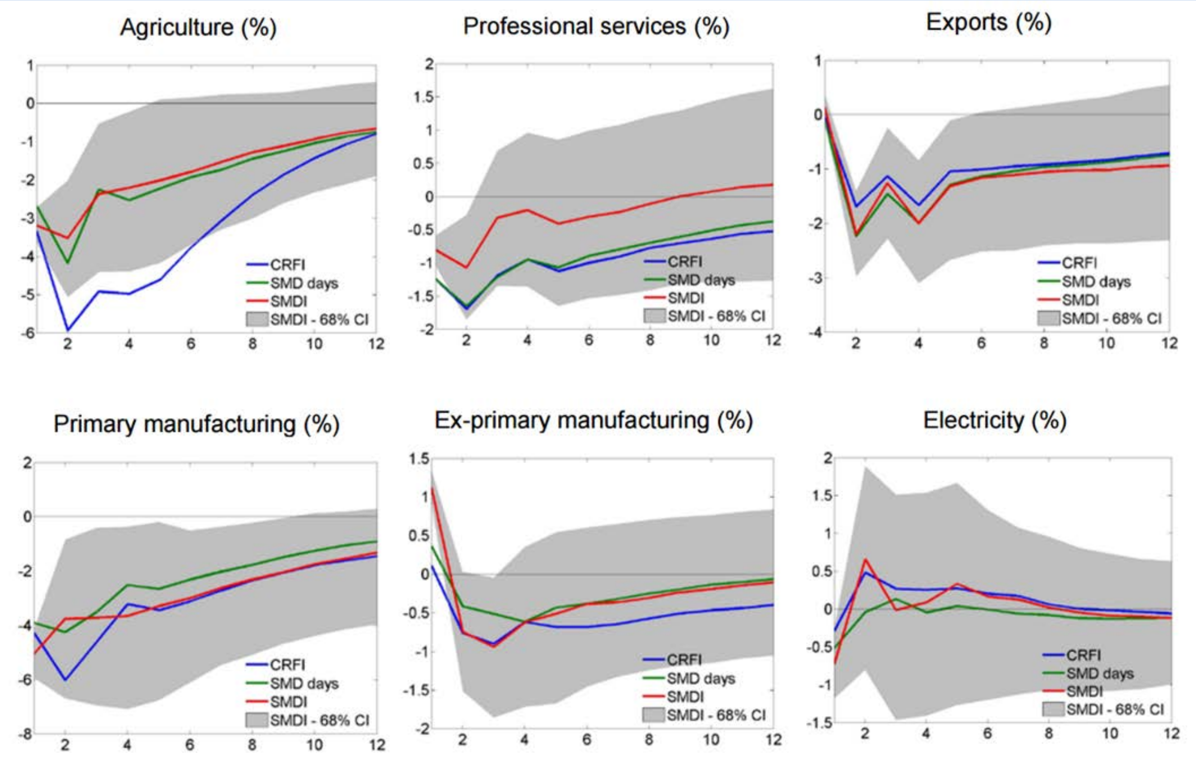
Box A: Kamber *et al*, Investigating the economic effects of drought in New Zealand

Kamber, McDonald and Price (2013) use a vector autoregressive model to estimate the macroeconomic impact of the 2012/13 drought. These estimates were calculated using soil moisture and rainfall data, so provide a useful cross-check to studies that use the Southern Oscillation Index to identify climatic conditions. Furthermore, rather than relying on the Southern Oscillation Index to predict a soil moisture event, it can estimate the economic impact of a given drought as it is happening.

The paper found that the 2012/13 drought would reduce GDP by 0.3 percent over the first two quarters of the year, with the greatest impact occurring in the June quarter. Most industry components of GDP were expected to be negatively affected (figure A1). The paper also found that when the impacts of North Island and South Island droughts were estimated separately, droughts in the North Island had the biggest impacts on GDP. In this case, a drought like in 2013 would normally reduce GDP in the first two quarters of the year by 0.6

percent. As it turned out, the 2012/13 drought was concentrated in the North Island and did have a relatively severe impact.

Figure A1: Estimated impact of the 2012/13 drought on selected GDP components



Source: Kamber *et al* (2013). CRFI = cumulative rainfall index; SMDI = soil moisture deficit index.

The paper also found that the 2012/13 drought could increase global dairy prices by around 10 percent. Such a response may indicate New Zealand's relatively large share of global dairy *export* markets, particularly for whole milk powder, outweighs its small share of global milk *production*. An alternative hypothesis is that New Zealand droughts are correlated with poor agricultural production elsewhere in the world.

Another result relevant to the current context is that while international dairy prices tended to increase during droughts, the New Zealand dollar tended to depreciate. This suggests droughts, especially those correlated with poor climatic conditions elsewhere, can cause the usually pro-cyclical relationship between international dairy prices and the New Zealand dollar to break down.

5. WHAT TO WATCH

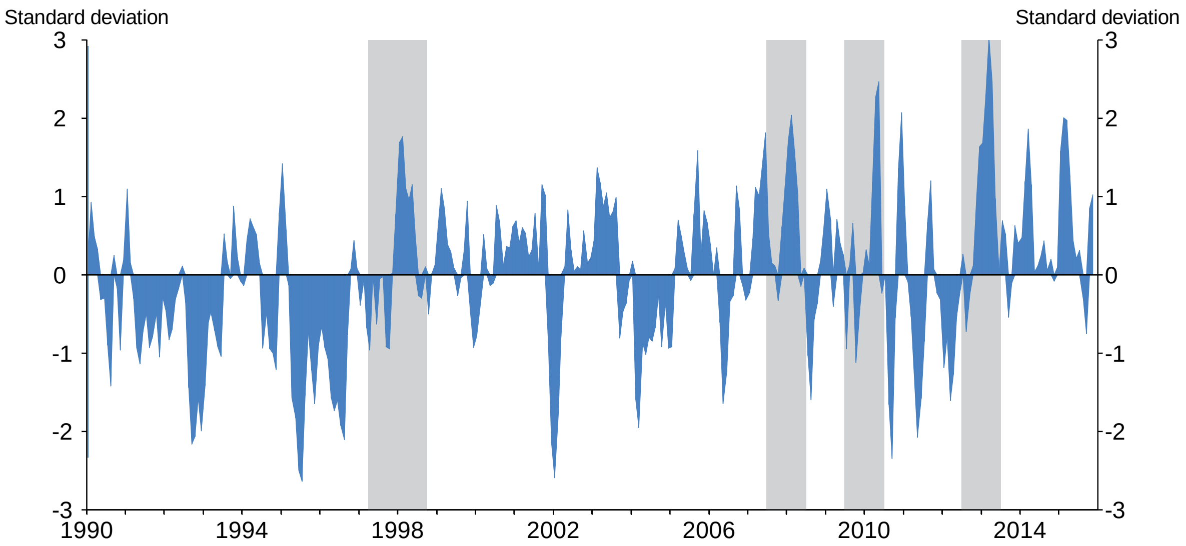
Current information suggests strong El Niño conditions are in place and that these will almost certainly continue through the New Zealand summer. However, the severity and regional distribution of any drought or excessive rainfall that occurs will only become clear as the summer progresses. This section details the key indicators the Bank intends to monitor over the next few months.

Soil moisture

In Kamber *et al* (2013), Reserve Bank staff developed a cumulative soil moisture deficit index that correlates well with the macroeconomic impacts of drought. This index cumulates deviations in soil moisture readings from the historic average for each month. Cumulating deficits means persistent episodes of dryness receive more weight than more transitory droughts. This index is constructed using NIWA data from weather stations around New Zealand, with the data weighted by the number of dairy cattle, beef cattle and sheep in each region. These weather stations are typically not on farmland so should be thought of as giving an indication of pre-irrigation soil moisture.

Consistent with Kamber *et al* and the experience of 2012/13, it is useful to consider regional soil moisture readings. The North Island index, for instance, is more closely correlated with recent droughts than the national index shown in figure 8 (figure 12).

Figure 12: North Island cumulative soil moisture deficit index
(monthly, deviation from seasonal norm, shaded areas represent past four major droughts)



Source: Kamber *et al* (2013) using NIWA data.

Milk production

High frequency milk production data, both in New Zealand and overseas, can give a useful indication of an El Niño's impact on agricultural production.

In New Zealand, milk production tends to be most adversely affected by drought in the second half of the season. Prior to this, particularly during the spring flush, production is relatively invariant to climatic conditions. Pasture growth tends to be greater than cows demand for feed and so milk production is more reflective of cow numbers. As such, any drought that persisted into March and beyond would be likely to have a more noticeable impact on dairy production than one that was concentrated through spring and early summer.

Fonterra expects milk production to be down by at least 5 percent over the 2015/16 season[5], mainly due to farmers reducing cow numbers and using less supplementary feed in the face of lower cash flows. If a drought were to occur this estimate is likely to be revised lower.

Meat slaughter

Meat slaughter tends to increase in the quarter of the drought and then decrease as livestock numbers are diminished. Cattle slaughter is most affected from around July until September, whereas lamb slaughter tends to occur earlier in the year. NZ Beef and Lamb currently forecast (in absence of a drought) lamb slaughter will be 7.4 percent lower in the 2015/16 season compared to the previous season, while total cattle slaughter is expected to be 8.5 percent lower[6].

Hydro lake storage levels and inflows

High frequency data is available on storage levels and inflows to the various hydroelectric schemes around the country[7]. Hydro lake levels and inflows give some indication of river flows more broadly and therefore the volume of water available for irrigation, as well as the price of electricity and therefore the cost of using irrigation pumps.

As at 7 December, lake storage levels were 112 percent of average, while lake inflows were 102 percent of average. Over the coming month or so, inflows are likely to be boosted by snow melt from heavy snowfall through the 2015 winter. Beyond this, inflows will drop rapidly – especially if drought occurs.

6. Concluding comments

This *Note* collects together information and empirical insights on El Niño. During El Niño New Zealand tends to experience stronger or more frequent winds from the west in summer,

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[5] See Fonterra (2015).
[6] Beef + Lamb New Zealand (2015).
[7] See http://www.electricityinfo.co.nz/comitFta/ftaPage.hydrology.

leading to drought in east coast areas and more rain in the west. El Niño can have a significant negative impact on the New Zealand economy, particularly those industries affected by the agricultural and primary food manufacturing components of GDP.

The Southern Oscillation Index is currently 1.2 standard deviations below its mean, suggesting that strong El Niño conditions are present. Empirical analysis suggests that an El Niño of this intensity could subtract as much 0.2 to 0.5 percentage points from New Zealand's GDP.

But El Niño conditions do not by themselves condemn New Zealand's agricultural sector to a poor season. Serious east coast drought and excessive rainfall in the west does not occur during every El Niño, and regional impacts can vary from one event to the next. Nonetheless, it is appropriate to closely monitor climatic conditions during El Niño, given the heightened risk.

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