

The regional economic impacts of the 2017 to 2018 drought on NSW

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Executive summary

The economy of New South Wales has suffered from a drought which started in the northern part of the state in 2017 and has spread over much of the state in 2018. Prolonged droughts impose greater hardship on regional communities than a drought lasting one year.

Given the prolonged nature of the present drought, this study uses a dynamic, multi-regional computable general equilibrium model of the Australian economy, VU-TERM, to estimate the impacts on regions within New South Wales.

Modelling results indicate that state-wide real GDP falls relative to forecast by 0.4% or \$2.2 billion in 2017-18 and prospectively by 0.9% or \$5.3 billion in 2018-19. These impacts reflect a severe diminution of farm output, given that agriculture accounts for around 1.6% and downstream processing for around 3.5% of NSW's income.

State-wide modelled job arises due to drought are around 0.24% or 7,700 FTE jobs in 2017-18 and 0.54% or 17,300 jobs in 2018-19.

At the regional level, relatively farm-intensive parts of the state suffer proportionally greater drought-induced losses. The worst affected region is New England–North West, in which real GDP in 2018-19 falls more than 12% below forecast, with an accompanying drop in employment of 3.9%. Other hard-hit regions include Far West-Orana, in which 2018-19 real GDP falls 9.5% and employment falls 2.8% below forecast. The real GDP fall in Murray in the same period is 6.1%, with employment depressed by 2.4%. We assume that although irrigation water allocations fall in the Murray region due to drought, perennial producers are able to satisfy water requirements through purchases of water from annual producers. Another irrigation region, Riverina, suffers a loss in real GDP in 2018-19 of 7.1% relative to base, accompanied by an employment decline of 2.0%.

The economic losses spread into regions not directly affected by drought. In the composite coastal region spanning Wollongong, Sydney and Newcastle, real GDP falls 0.2% below forecast and employment around 0.3% below forecast. Jobs in the coastal region which accounts for 78% of baseline state-wide employment fall by around 8,900 FTE, with jobs in other regions falling by around 8,400 FTE in 2018-19 relative to base.

In this scenario, we assume that there is a full recovery in seasonal conditions in 2019 which impacts on 2019-20 economic outcomes. However, prolonged drought depletes farm capital through two mechanisms. First, reduced farm income depresses investment during drought years. Second, prolonged drought leads to a depletion of herd numbers. This extends beyond additional slaughtering to culling. Consequently, drought depletes the income earning capacity of farms in recovery relative to no drought. At the sectoral level, there are some output losses in crop and livestock outputs in the recovery phase relative to forecast due to the need for catch-up investment following drought.

The drought diminishes national welfare. Lost productivity depresses income in drought. Depleted capital in recovery implies that even with NSW and national employment rising above forecast in recovery, real GDP rises only slightly relative to forecast in recovery and does not compensate for drought-induced losses. The net present value of national welfare losses in annualised terms is \$380 million. The NSW welfare loss is around \$230 million annualised, equivalent to permanent annual welfare loss of \$29 per NSW resident.

Two compensation packages are also modelled. First, of a freight subsidy on fodder purchases results in a small improvement in state welfare relative to no subsidy. However, this is at the expense of fodder users who are not recipients of the subsidy. The problem with

this subsidy is that the scarcity of fodder has worsened due to drought: the freight subsidy raises fodder prices, which already elevated due to scarcity. It provides a slight improvement in welfare because it provides additional jobs during the drought-induced downturn.

Another compensation package consists of direct transfers to households in drought-affected regions. This results in a slight increase in welfare (and slightly better than the freight subsidy) in NSW. This is because compensation stimulates consumption, which in turn stimulates employment slightly in 2018-19, thereby reducing drought-induced job losses relative to no compensation.

Model outline

Unlike Wittwer and Griffith (2011), the model used in this study, dynamic VU-TERM, does not include water accounts. Although cutbacks in water allocations were a consequence of the 2018-2019 drought, dry-land productivity losses due to rainfall deficiencies dominate overall farm losses.

The main theoretical modification for this study was to allow input substitution between land and fodder input in livestock production. A consequence of this is that drought-induced land productivity collapses result in a switch to fodder inputs.

Introduction

2016 was a year of above average rainfall over much of New South Wales (figure 1). Maximum temperatures over the entire year were close to historical averages (figure 2).

Figure 1

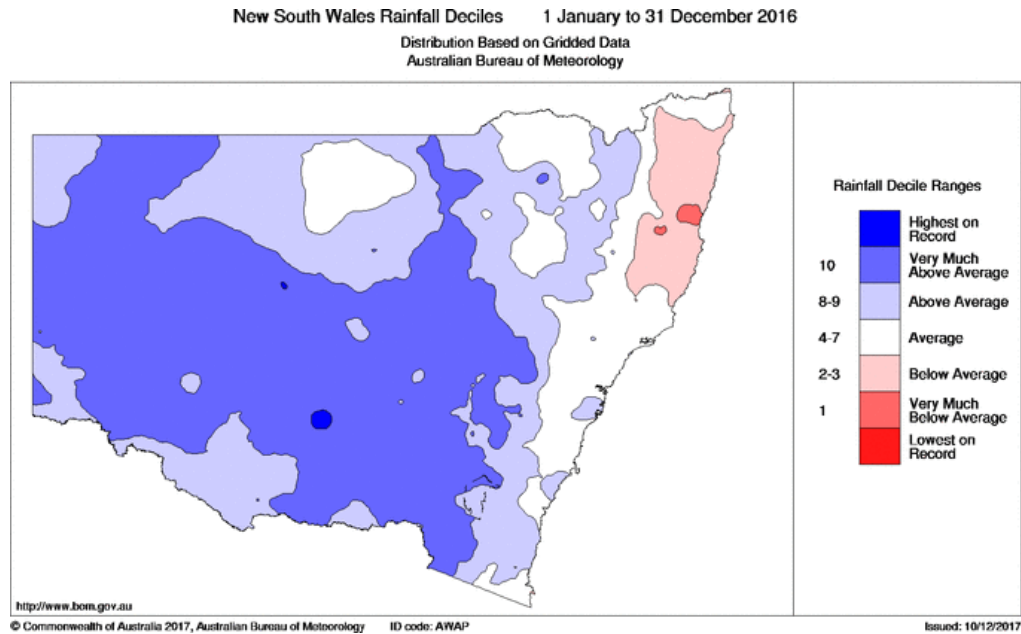
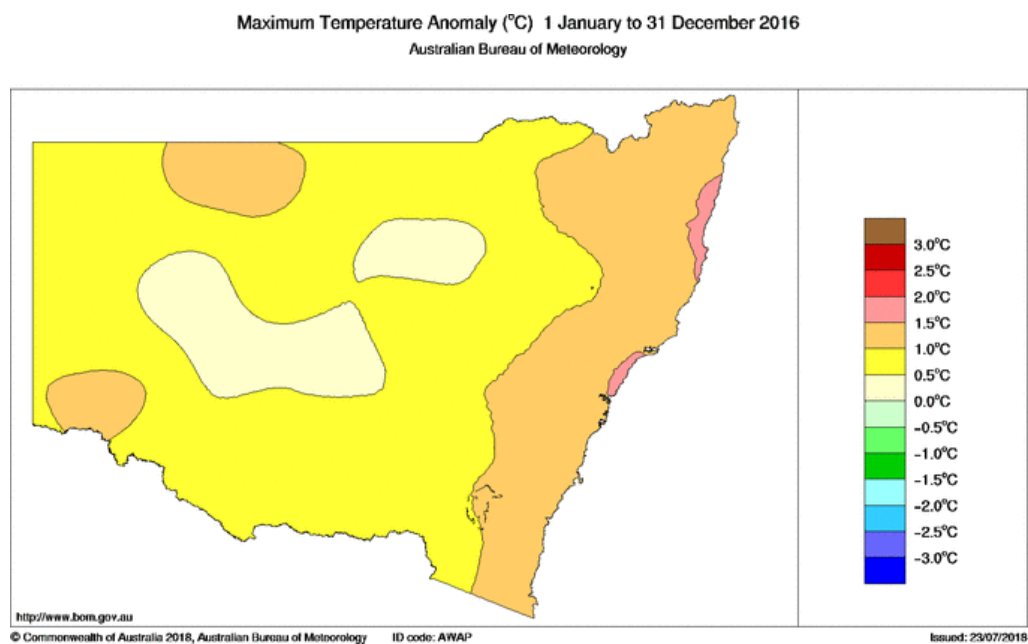


Figure 2



But in the summer of December 2016 to February 2017, the northern part of New South Wales suffered an extraordinary temperature anomaly. Figure 4a shows that over virtually all of the northern part of the state, summer maxima were more than 3 degrees above normal, with a patch near the Queensland border suffering temperatures more than 4 degrees over normal.

For the northern part of the state, even with near normal rainfall, conditions would have been drier than normal due to above-average temperatures and evaporation. Maxima were more than 2 degrees above normal for 2017 over most of the north (figure 4b). In the event, most of the north experienced rainfall in the 2nd and 3rd decile rainfall, with some patches receiving bottom decile rainfall. These conditions indicate that the northern part of the state suffered moderate to severe drought in 2017.

In southern part of the state, rainfall and temperatures were closer to normal. ABARES crop reports indicate a fall in crop output between 2016-17 and 2017-18. A substantial part of the decline in crop output arose in the north of the state.

Figure 3

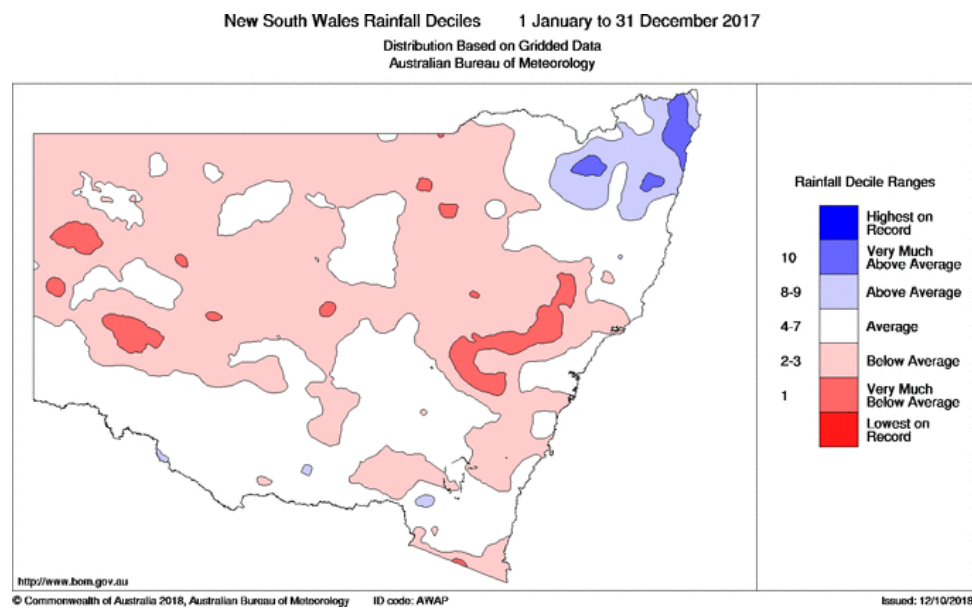


Figure 4a

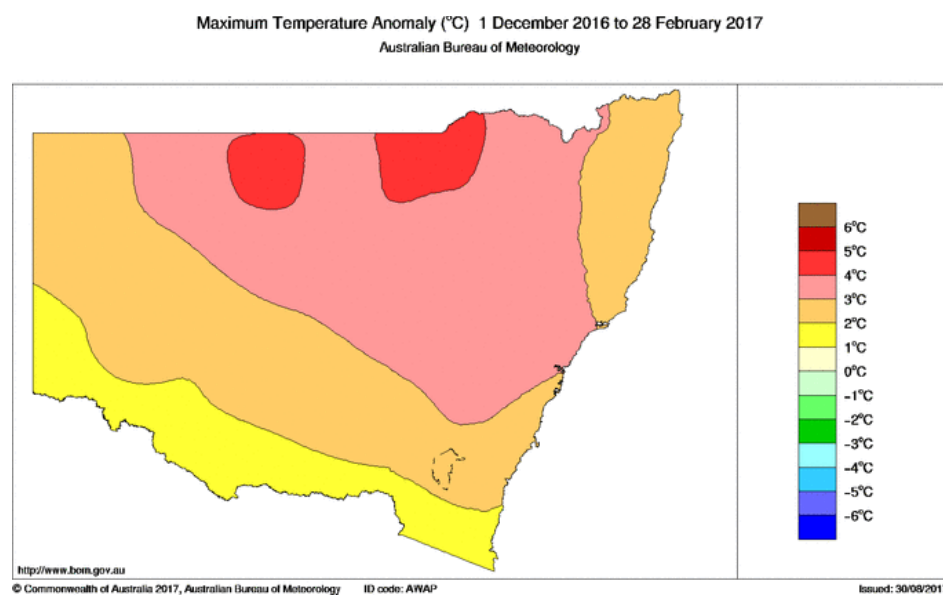
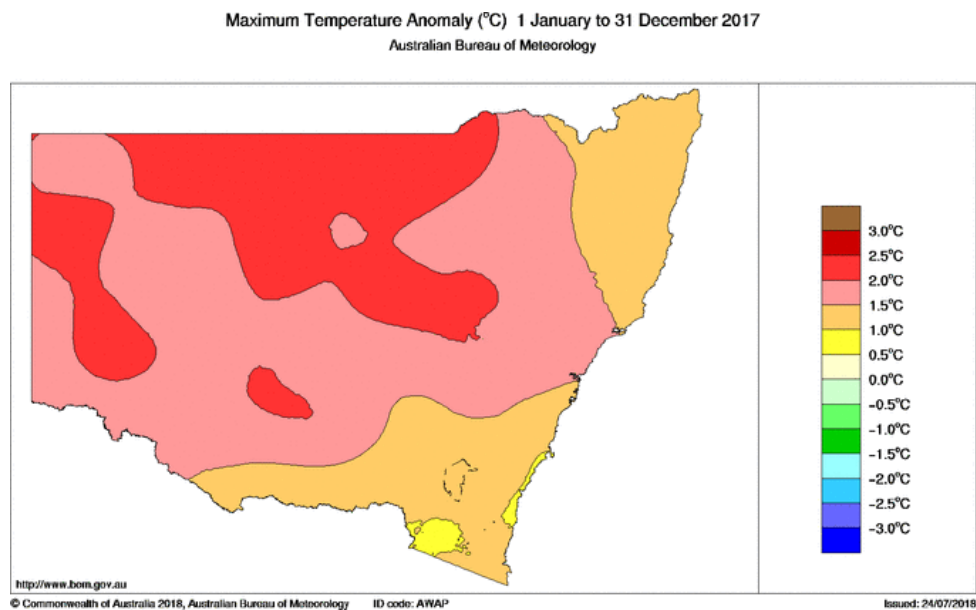


Figure 4b

In 2018, the drought has spread to virtually the entire state. Significant areas of the state suffered the driest October-September period on record (figure 5). Virtually all of the remainder of the state suffered rainfall in bottom decile. Maximum temperature anomalies for a substantial part of the state are more than 2 degrees above (figure 6).

Moreover, the forecast for coming months from the Bureau of Meteorology indicates that there is a low probability of respite over coming months. An El Nino pattern, associated with drought, has emerged in the Pacific Ocean (see <http://www.bom.gov.au/climate/enso/>).

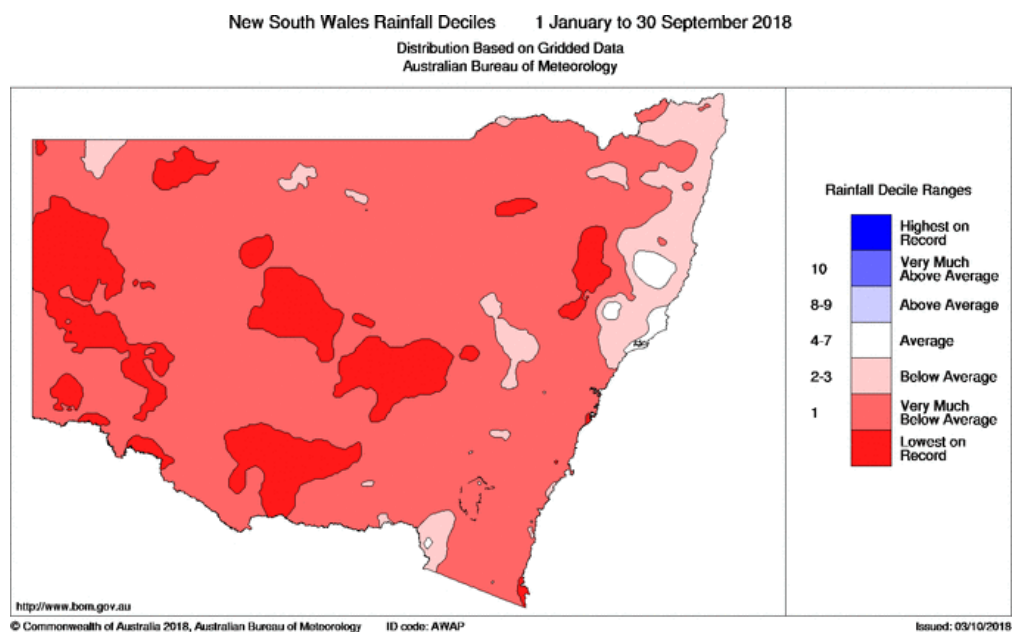
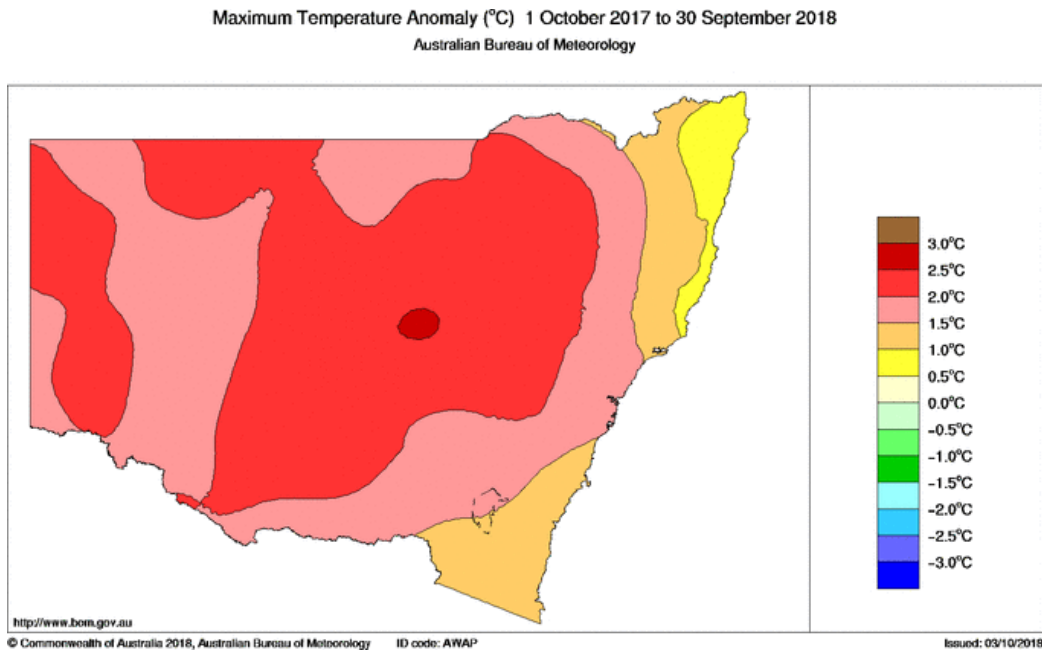
Figure 5

Figure 6

Within the modelling reported in this study, we assume that there is a full seasonal recovery reflected in the state-wide 2019-20 economy.

Statewide results

Ascribing shocks to VU-TERM

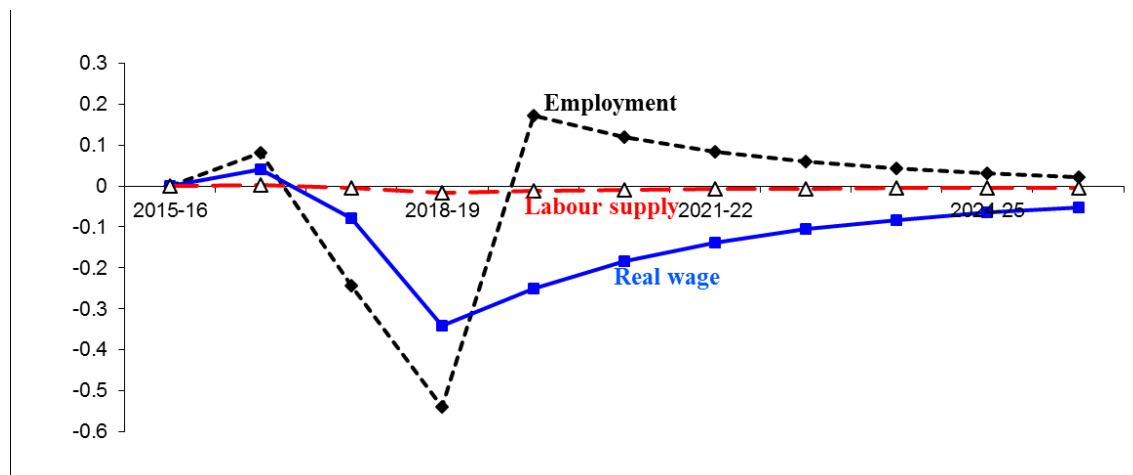
There are two types of shocks in this simulation. Crop outputs for 2016-17 and 2017-18 are based on observations. The corresponding outputs for 2018-19 are based on projections (ABARES Crop Reports).

Livestock output within the model is depicted via land productivity shocks. The reason for choosing land productivity instead of total factor productivity is that within the modified theory of VU-TERM, land is substitutable with hay & fodder within the production function of the livestock sectors. Once pastures fail due to drought, farmers turn to hay & fodder to feed their livestock.

To put the present drought into context, the simulation starts at 2015-16. The following year 2016-17 is depicted as a better than average year for agriculture. The following year 2017-18 is depicted as a moderate drought in northern NSW, with crop data indicating a poorer season elsewhere. In 2018-19, modelling depicts a worsening drought that has spread state-wide except in the northern coastal region.

The state-wide macro results reflect the shocks to the model. We explain GDP as a function of primary factors and underlying technology: $GDP=f(\text{Land, Labour, Capital, Technology})$. The impact of changes in income-side factors and technology is shown in figure 7.

Figure 7: NSW GDP, income side
(% deviations from base)



During drought, we observe that on-farm and contractor machinery may be idle due to reduced plantings. This effect is captured mostly by exogenously assuming a reduction in utilized capital. With a return to normal seasons in 2019-20, capital returns to full utilization. However, capital remains below base in 2019-20 due to a drought-induced decline in investment (figures 7 and 9).

Drought reduces the output that farms can produce from given inputs, implying a technological deterioration. This is evident in figure 7. Real GDP is a macro measure of output, and in both 2017-18 and 2018-19, the percentage fall in real GDP is larger than the percentage fall in labour or utilized capital, with technological deterioration explaining most of the loss.

Drought weakens the labour market in NSW, with both employment and real wages falling below forecast (figure 8). Employment falls more than 0.25% or 7,800 FTE jobs below forecast in 2017-18 and 0.54% or 17,300 FTE jobs below base in 2018-19. By assumption, real wages adjust sluggishly at the regional level. In 2017-18 in conditions of moderate drought, real wages remain near base despite employment falling below forecast. But with labour supply exceeding labour demand (employment), there is downward pressure on real wages leading into 2018-19, exacerbated by the worsening drought.

In the recovery year (2019-20), employment rises to 0.17% or around 5,500 jobs above forecast in NSW. With a strengthening of the labour market due to a return to normal seasonal conditions, real wages persist below forecast due to sluggish adjustment. As long as labour demand exceeds labour supply, there is upward pressure on wages. By 2025-26, labour supply, employment and real wages have all returned to near base.

Figure 8: NSW labour market
(% deviations from base)

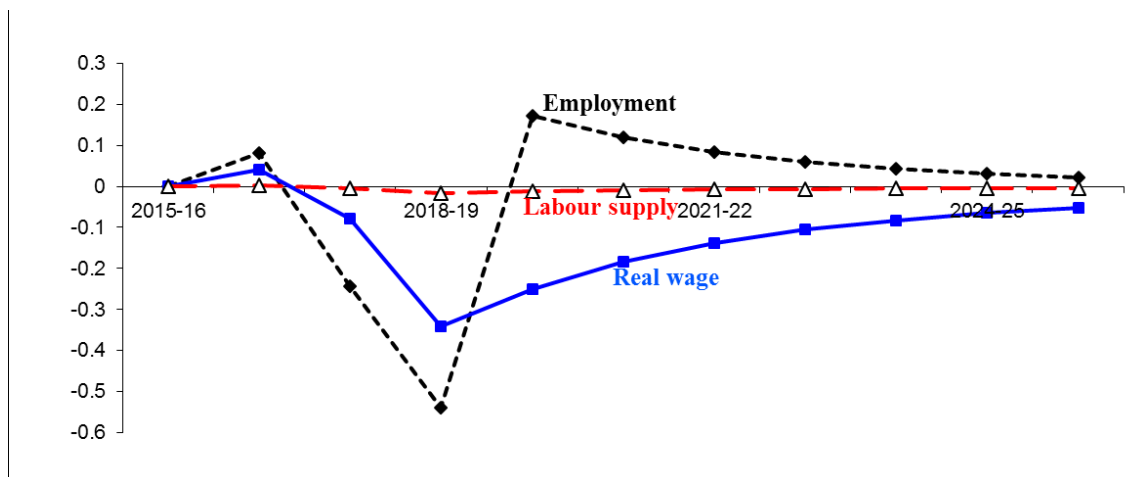
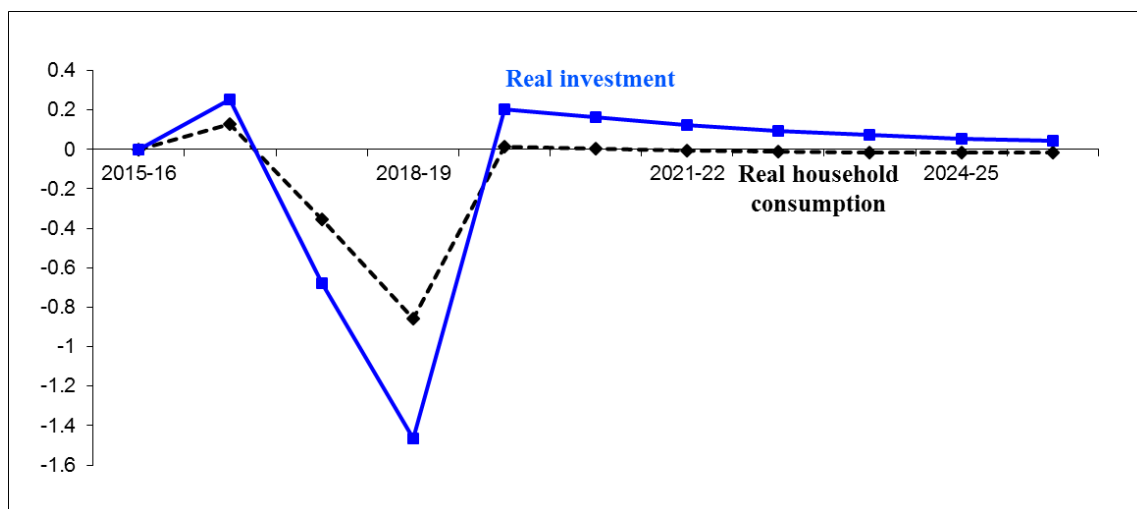


Figure 9: NSW expenditure side
(% deviations from base)



Fluctuations in farm investment in response to changing seasonal conditions drive fluctuations in NSW macro investment relative to forecast (figure 9). In the relatively good season of 2016-17 and in recovery in 2019-20, state-wide investment rises above forecast. In the dry year of 2017-18 and drier year of 2018-19, investment falls below forecast.

Table 1 summarises the deviations in macro variables and employment for forecast from a base with business-as-usual or average seasonal conditions.

Table 1: NSW macro outcomes
(\$m real or jobs FTE relative to base)

	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22	2022-23	2023-24	2024-25	2025-26
Real GDP (\$m)	825	-2221	-5335	191	119	32	-28	-71	-101	-122
Household consumption (\$m)	412	-1227	-3060	55	20	-18	-42	-56	-63	-67
Real investment (\$m)	315	-900	-1966	289	237	184	144	113	89	71
Employment (FTE)	2588	-7893	-17285	5592	4004	2817	1995	1423	1022	740

Table 2: NSW industry outputs
(% change in outputs relative to base)

	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22	2022-23	2023-24	2024-25	2025-26
Sheep	-0.1	-1.5	-12.5	-0.1	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2
BeefCattle	-0.1	-1.2	-9.5	0.0	0.0	-0.1	-0.1	-0.1	-0.1	-0.1
DairyCattle	0.1	-2.1	-10.2	-0.4	-0.4	-0.3	-0.3	-0.3	-0.3	-0.3
OthLivstock	-0.2	-0.5	-6.2	-0.1	-0.1	-0.2	-0.2	-0.2	-0.1	-0.1
Wheat	42.3	-43.4	-67.5	-4.8	-4.7	-4.5	-4.4	-4.3	-4.2	-4.1
OthBrdAcrCrp	18.6	-45.0	-63.9	-4.2	-4.1	-4.0	-3.9	-3.8	-3.6	-3.5
Horticulture	-0.1	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1
Rice	-0.1	-29.9	-64.8	-19.6	0.2	0.3	0.3	0.4	0.4	0.4
Cotton	0.0	-20.0	-48.1	-1.4	-1.5	-1.6	-1.6	-1.6	-1.7	-1.7
HayCerealFod	12.8	-18.5	-56.1	-4.4	-4.4	-4.5	-4.4	-4.4	-4.4	-4.3
ForestFish	-0.1	-0.1	-0.2	0.0	0.1	0.1	0.1	0.1	0.1	0.1
GinnedCotton	0.2	-14.2	-34.6	1.4	1.0	0.7	0.6	0.4	0.3	0.3
AgriSrvces	2.8	-6.4	-16.0	-0.2	-0.2	-0.3	-0.3	-0.3	-0.3	-0.3
Mining	-0.2	0.5	1.3	0.2	0.2	0.2	0.2	0.1	0.1	0.1
MeatProds	-0.2	0.6	-0.1	0.3	0.2	0.1	0.1	0.1	0.1	0.1
Seafood	-0.1	0.2	0.4	0.1	0.0	0.0	0.0	0.0	0.0	0.0
DairyProds	0.5	-0.6	-1.6	-0.2	-0.2	-0.2	-0.2	-0.1	-0.1	-0.1
OtherFood	0.4	-0.4	-1.0	-0.2	-0.2	-0.2	-0.2	-0.1	-0.1	-0.1
TCFs	-0.2	0.4	1.0	0.3	0.3	0.2	0.2	0.2	0.2	0.2
OthManuf	-0.1	0.3	0.7	0.2	0.2	0.1	0.1	0.1	0.1	0.1
Utilities	0.1	-0.1	-0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Constructn	0.1	-0.4	-0.9	0.1	0.1	0.1	0.1	0.1	0.0	0.0
Trade	0.2	-0.4	-0.9	0.1	0.0	0.0	0.0	0.0	0.0	0.0
HotelsCafes	0.1	-0.2	-0.5	0.1	0.1	0.0	0.0	0.0	0.0	0.0
RoadFreight	0.5	-0.7	-1.5	0.0	0.0	0.0	0.0	0.0	-0.1	-0.1
OthTransport	0.1	-0.2	-0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0
OthService	0.0	-0.1	-0.2	0.1	0.0	0.0	0.0	0.0	0.0	0.0
OwnerDwellng	0.0	0.0	0.0	-0.1	-0.1	-0.1	-0.1	-0.1	0.0	0.0
GovAdmDefOrd	0.1	-0.2	-0.6	0.1	0.1	0.0	0.0	0.0	0.0	0.0
EduHealth	0.0	0.0	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0

Table 3: NSW industry outputs
(\$m change in outputs relative to base, 2018 dollars)

	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22	2022-23	2023-24	2024-25	2025-26
Sheep	-1	-10	-77	-1	-1	-1	-1	-1	-1	-1
BeefCattle	-1	-11	-80	0	0	0	0	0	0	0
DairyCattle	0	-2	-11	0	0	0	0	0	0	0
OthLivstock	-1	-3	-32	-1	-1	-1	-1	-1	-1	-1
Wheat	375	-379	-575	-40	-39	-37	-36	-35	-34	-33
OthBrdAcrCrp	195	-469	-651	-43	-41	-40	-38	-37	-36	-35
Horticulture	-1	0	-1	0	0	0	1	1	1	1
Rice	0	-34	-85	-29	1	1	1	1	2	2
Cotton	0	-184	-443	-9	-9	-8	-8	-8	-7	-7
HayCerealFod	30	-42	-125	-9	-9	-9	-9	-9	-9	-9
ForestFish	0	-1	-2	0	1	1	1	1	1	1
GinnedCotton	2	-139	-331	15	11	8	6	5	4	3
AgriSrvces	12	-30	-73	-1	-1	-1	-1	-2	-2	-2
Mining	-12	35	91	17	13	11	10	9	8	7
MeatProds	-5	14	0	6	4	3	2	2	1	1
Seafood	0	0	0	0	0	0	0	0	0	0
DairyProds	3	-3	-9	-1	-1	-1	-1	-1	-1	-1
OtherFood	25	-25	-59	-14	-13	-11	-10	-9	-8	-8
TCFs	-1	4	8	3	2	2	2	2	1	1
OthManuf	-25	66	170	45	32	25	20	16	12	11
Utilities	4	-13	-32	3	2	1	0	0	0	0
Constructn	40	-120	-294	41	38	32	27	23	19	16
Trade	69	-163	-384	25	18	11	6	3	0	-1
HotelsCafes	7	-31	-83	13	11	8	7	6	5	5
RoadFreight	29	-47	-96	-3	-2	-2	-3	-3	-3	-3
OthTransport	8	-31	-76	6	7	6	6	6	6	6
OthService	55	-151	-351	146	103	73	53	38	28	21
OwnerDwellng	0	6	-10	-48	-45	-41	-37	-34	-31	-28
GovAdmDefOrd	16	-62	-163	25	19	13	9	7	5	4
EduHealth	-5	11	47	70	49	35	25	18	13	9

Note: the sum of real value-added does not exactly equal real GDP, as the latter includes indirect taxes.

The welfare of drought calculated from a national perspective, based on the net present value of the deviation in real private plus public consumption from base, minus the change in net foreign liabilities in the final year of the simulation. The welfare impact of the drought is an annualised loss of \$380 million. If we apply the same calculation to NSW deviations, the annualised loss is \$190 million or \$30 per person.

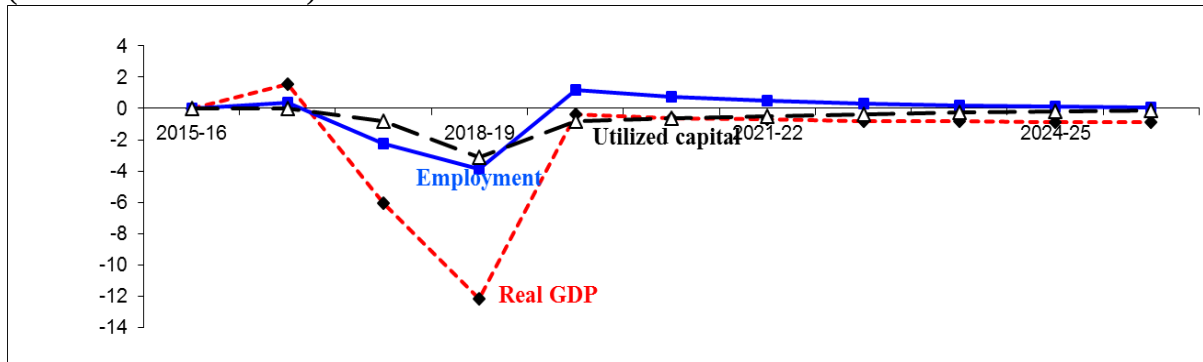
Sub-state

New England-North West

New England-North West (an SA4 region) has the largest drought-induced productivity losses of any region in the scenario. Real GDP and employment rose relative to forecast in 2016-17 due to a seasonal recovery, then slumped in 2017-18 due to drought. Worsening drought in 2018-19 drives employment to almost 4% below base. Idle farm capital due to

drought is largely responsible for a fall in utilized capital to near 4% below forecast in this year. Real GDP in 2018-19 is more than 12% below base, reflecting reduced employment, capital utilization and drought-induced productivity losses (figure 10). In the base year, farming and downstream processing accounts for around 24% of regional income.

Figure 10: New England-North West GDP income side
(% deviation from base)



Drought weakens the labour market in New England-North West, with the fall of employment of almost 4% or around 2600 jobs in 2018-19 being accompanied by a fall in real wages of 2.6% relative to forecast (figure 11).

Figure 11: New England-North West labour market
(% deviation from base)

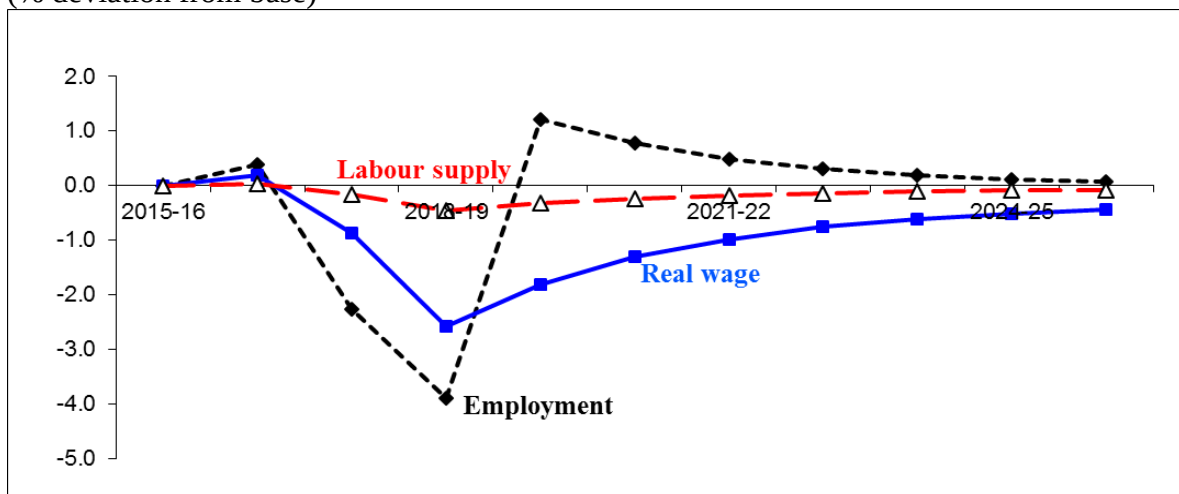
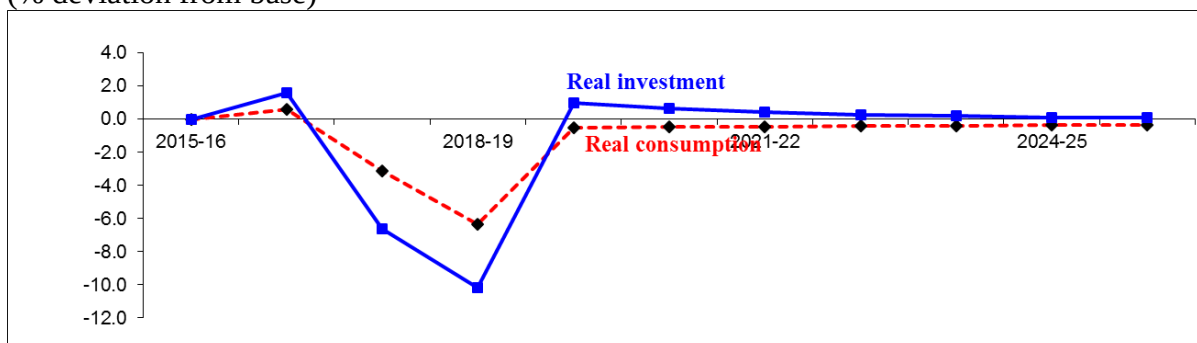


Figure 12: New England-North West real consumption and investment
(% deviation from base)



The recovery that follows assumes that 2019-20 is a year of normal rainfall. Without seasonal recovery, the livestock base of the region, which together with meat processing accounts for around 6% of income in a normal year, will continue to suffer a downturn. Any prolongation of drought will lengthen the recovery time of herd numbers.

Drought induces a sharp fall in investment in New England-North West, as shown for 2017-18 and 2018-19. Recovery induces a rise relative to base in investment in 2019-20 (figure 12).

New England-North West includes economic activities that are not directly affected by drought, including education, health and other essential service. At the SA2 level, in which some regions are far more reliant on farming, losses are more substantial.

Table 4: SA2 level macro outcomes within New England-North West
(% change from base)

	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22	2022-23	2023-24	2024-25	2025-26
Real GDP										
Armidale	0.3	-0.5	-0.2	0.7	0.4	0.3	0.2	0.1	0.0	0.0
Armidale Region - North	0.2	-0.4	-1.9	0.2	0.1	0.0	-0.1	-0.1	-0.1	-0.2
Armidale Region - South	0.2	-0.1	-0.7	0.4	0.2	0.1	0.0	0.0	-0.1	-0.1
Walcha	0.6	-1.2	-3.5	0.1	-0.1	-0.2	-0.2	-0.2	-0.3	-0.3
Glen Innes	0.5	-1.2	-2.2	0.3	0.1	0.0	-0.1	-0.1	-0.1	-0.2
Inverell	0.3	-0.4	-0.5	0.6	0.4	0.2	0.1	0.1	0.0	0.0
Inverell Region - East	1.1	-4.2	-9.8	-0.6	-0.7	-0.8	-0.8	-0.9	-0.9	-0.9
Inverell Region - West	3.1	-9.9	-13.6	-0.7	-0.9	-0.9	-1.0	-1.0	-1.0	-1.0
Tenterfield	0.5	-1.2	-2.0	0.2	0.0	-0.1	-0.1	-0.2	-0.2	-0.2
Moree	1.6	-9.6	-20.2	-0.5	-0.7	-0.9	-1.0	-1.0	-1.1	-1.1
Moree Region	10.2	-31.3	-50.8	-3.7	-3.8	-3.8	-3.8	-3.8	-3.8	-3.7
Narrabri	1.0	-6.9	-17.9	-0.6	-0.8	-0.9	-1.0	-1.1	-1.1	-1.1
Narrabri Region	4.3	-20.2	-40.8	-2.0	-2.3	-2.4	-2.5	-2.5	-2.6	-2.6
Gunnedah	0.3	-1.7	-4.3	0.4	0.2	0.1	0.0	-0.1	-0.1	-0.2
Gunnedah Region	2.9	-14.1	-30.0	-1.8	-2.0	-2.1	-2.1	-2.1	-2.1	-2.1
Quirindi	2.9	-9.2	-15.4	-0.9	-1.0	-1.1	-1.2	-1.2	-1.2	-1.2
Tamworth - East	0.3	-0.5	-0.5	0.6	0.4	0.3	0.2	0.1	0.1	0.0
Tamworth - North	0.3	-0.5	-0.4	0.6	0.4	0.2	0.1	0.1	0.0	0.0
Tamworth - West	0.2	0.0	0.0	0.4	0.2	0.1	0.0	0.0	0.0	-0.1
Tamworth Region	0.7	-1.6	-2.4	0.5	0.2	0.1	0.0	-0.1	-0.1	-0.1
Employment										
Armidale	0.2	-0.3	0.3	1.3	0.9	0.6	0.4	0.3	0.2	0.2
Armidale Region - North	0.4	-0.9	-1.6	1.3	0.9	0.6	0.4	0.3	0.2	0.1
Armidale Region - South	0.4	-0.7	-0.8	1.3	0.9	0.6	0.4	0.3	0.2	0.1
Walcha	0.5	-1.5	-2.8	1.3	0.9	0.6	0.4	0.2	0.2	0.1
Glen Innes	0.4	-1.1	-1.4	1.3	0.9	0.6	0.4	0.3	0.2	0.1
Inverell	0.2	-0.2	-0.2	1.4	0.9	0.6	0.4	0.3	0.2	0.2
Inverell Region - East	0.3	-0.6	-0.6	1.2	0.7	0.5	0.3	0.2	0.1	0.1
Inverell Region - West	0.5	-3.1	-4.2	1.2	0.8	0.5	0.3	0.2	0.2	0.1
Tenterfield	0.4	-1.0	-1.0	1.3	0.8	0.6	0.4	0.2	0.2	0.1
Moree	0.5	-5.8	-12.5	1.3	0.9	0.6	0.4	0.2	0.1	0.1
Moree Region	1.0	-9.4	-16.1	0.3	0.0	-0.2	-0.3	-0.3	-0.3	-0.3
Narrabri	0.4	-3.6	-7.5	1.1	0.7	0.4	0.2	0.1	0.1	0.0
Narrabri Region	0.4	-8.6	-19.1	1.0	0.5	0.3	0.1	0.0	-0.1	-0.1
Gunnedah	0.1	-0.7	-0.8	1.4	0.9	0.6	0.4	0.3	0.2	0.2
Gunnedah Region	0.4	-3.7	-7.0	0.8	0.4	0.1	0.0	-0.1	-0.1	-0.1
Quirindi	0.6	-2.3	-2.5	1.1	0.7	0.4	0.2	0.1	0.1	0.0
Tamworth - East	0.4	-0.7	-0.5	1.3	0.9	0.6	0.4	0.3	0.2	0.1
Tamworth - North	0.3	-0.5	-0.1	1.3	0.9	0.6	0.4	0.3	0.2	0.1
Tamworth - West	0.4	-0.5	-0.4	1.3	0.9	0.6	0.4	0.3	0.2	0.1
Tamworth Region	0.4	-0.9	-0.8	1.3	0.8	0.6	0.4	0.2	0.2	0.1

For example, the Moree Region suffers a loss in real GDP of more than half relative to base in 2018-19, with an accompanying fall in employment of 16%. In general, SA2 regions that cover towns tend to suffer losses that are smaller than SA2s that are cover out-of-town regions. This reflects the industry composition of the SA2 economy, with services accounting for a larger share of within-town income.

Some local regions suffer modelled losses that may be substantially smaller than apparent observed losses. Quirindi, for example, suffers relatively modest losses. This arises for the aforesaid reason that the town itself is not as reliant on agriculture in its income base as the out-of-town area. In addition, the shocks are ascribed to VU-TERM at the SA4 level so that for each industry, the same shocks apply throughout the SA4 region. If Quirindi and surrounds have suffered more severe drought impacts relative to base than the rest of the New England-North West region, the top-down methodology does not capture these SA2 impacts.

Far West-Orana

Far West-Orana is another SA4 region severely affected by two years of drought. Figures 13 to 15 show the macro outcomes.

Figure 13: Far West-Orana real GDP income side
(% deviation from base)

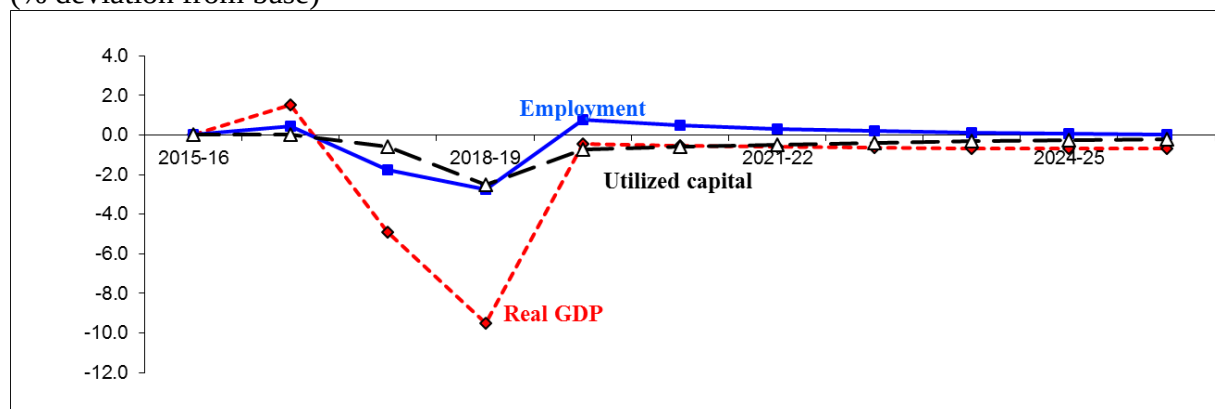


Figure 14: Far West-Orana labour market
(% deviation from base)

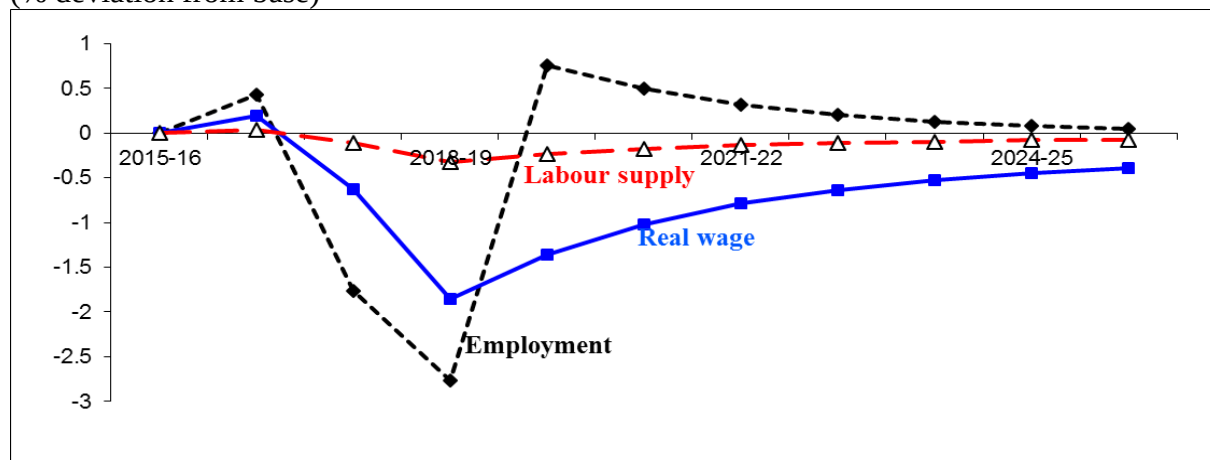


Figure 15: Far West-Orana real consumption and investment
(% deviation from base)

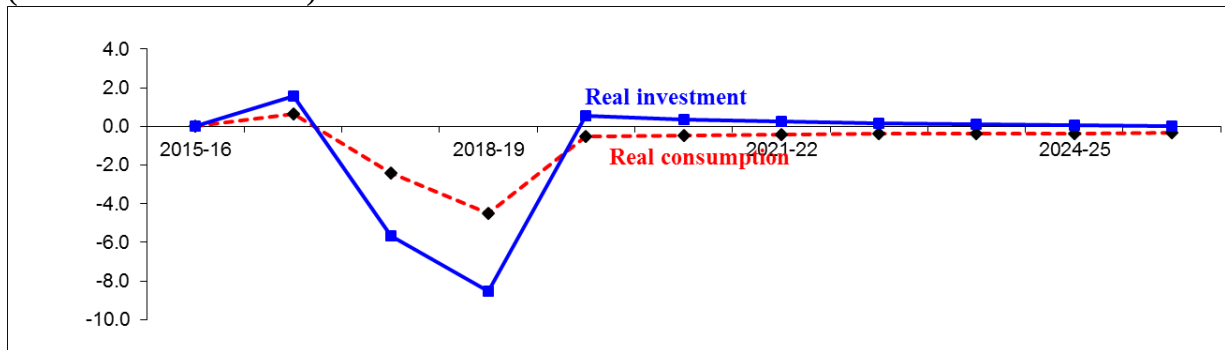


Table 5: SA2 level macro outcomes within Far West-Orana
(% change from base)

	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22	2022-23	2023-24	2024-25	2025-26
Real GDP										
Bourke - Brewarrina	0.5	-4.7	-14.9	-0.9	-1.0	-1.1	-1.1	-1.1	-1.1	-1.2
Cobar	0.7	-1.4	-1.7	0.3	0.2	0.1	0.0	0.0	0.0	-0.1
Coonamble	7.1	-17.5	-27.6	-2.0	-2.1	-2.1	-2.1	-2.1	-2.0	-2.0
Nyngan - Warren	2.7	-13.8	-33.9	-2.3	-2.3	-2.4	-2.4	-2.4	-2.4	-2.4
Walgett - Lightning Ridge	5.1	-15.9	-27.1	-1.8	-1.8	-1.9	-1.9	-1.9	-1.9	-1.9
Broken Hill	0.1	-0.1	0.1	0.5	0.3	0.2	0.2	0.1	0.1	0.1
Far West	0.0	-0.1	-3.8	0.0	-0.1	-0.2	-0.2	-0.2	-0.2	-0.2
Coonabarabran	2.2	-5.4	-8.3	-0.2	-0.3	-0.4	-0.4	-0.5	-0.5	-0.5
Dubbo - East	0.4	-0.7	-1.0	0.3	0.2	0.1	0.1	0.0	0.0	0.0
Dubbo - South	0.4	-0.9	-1.3	0.4	0.2	0.1	0.1	0.0	0.0	0.0
Dubbo - West	0.4	-0.8	-1.2	0.3	0.2	0.1	0.0	0.0	0.0	0.0
Dubbo Region	1.5	-3.8	-5.7	-0.1	-0.2	-0.3	-0.3	-0.3	-0.3	-0.4
Gilgandra	5.0	-13.1	-17.8	-1.1	-1.2	-1.2	-1.2	-1.2	-1.2	-1.2
Narromine	3.6	-14.4	-27.4	-1.6	-1.7	-1.7	-1.8	-1.8	-1.8	-1.8
Wellington	1.6	-3.8	-5.9	0.0	-0.2	-0.2	-0.3	-0.3	-0.3	-0.3
Employment										
Bourke - Brewarrina	0.4	-1.9	-4.2	0.6	0.3	0.2	0.1	0.0	0.0	-0.1
Cobar	-0.1	0.3	1.1	1.0	0.7	0.5	0.4	0.3	0.3	0.2
Coonamble	0.9	-5.0	-7.7	0.4	0.2	0.1	0.0	0.0	-0.1	-0.1
Nyngan - Warren	0.7	-1.3	-2.5	-0.3	-0.4	-0.5	-0.5	-0.5	-0.5	-0.5
Walgett - Lightning Ridge	0.7	-5.1	-9.0	0.5	0.3	0.1	0.1	0.0	0.0	0.0
Broken Hill	0.2	-0.3	0.1	1.0	0.7	0.5	0.3	0.3	0.2	0.2
Far West	0.0	-0.1	-1.6	0.9	0.7	0.5	0.4	0.3	0.2	0.2
Coonabarabran	0.5	-2.0	-3.1	0.8	0.6	0.4	0.3	0.2	0.1	0.1
Dubbo - East	0.4	-1.0	-1.3	0.9	0.6	0.4	0.3	0.2	0.1	0.1
Dubbo - South	0.4	-0.9	-1.3	0.9	0.6	0.4	0.3	0.2	0.1	0.1
Dubbo - West	0.4	-1.0	-1.3	0.9	0.6	0.4	0.3	0.2	0.1	0.1
Dubbo Region	0.6	-1.9	-2.8	0.8	0.5	0.4	0.2	0.2	0.1	0.1
Gilgandra	0.9	-4.5	-6.9	0.7	0.4	0.3	0.2	0.1	0.1	0.0
Narromine	0.8	-6.3	-12.1	0.5	0.3	0.1	0.0	0.0	-0.1	-0.1
Wellington	0.5	-1.7	-2.6	0.8	0.6	0.4	0.3	0.2	0.1	0.1

Other SA4 regions

Drought-induced income losses in Murray SA4 are moderated by irrigation activity. Perennial producers purchase water off annual irrigators, particularly rice and cotton, in this scenario. Although low security water allocations have been cut severely, higher security water cuts have not been severe in most regions. This is unlike the millennial drought, in which irrigation allocations were cut so severely as to reduce the supply of water available to perennial producers, even after water trading (around 2007 to 2009). In VU-TERM modelling, Horticulture output changes little in 2018-19 relative to a normal year (tables 2 and 3).

Figure 13: Murray real GDP income side
(% deviation from base)

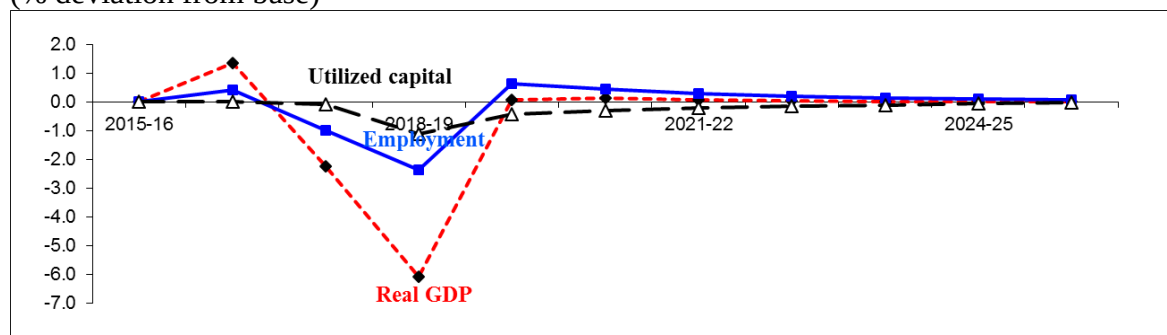


Figure 14: Murray labour market
(% deviation from base)

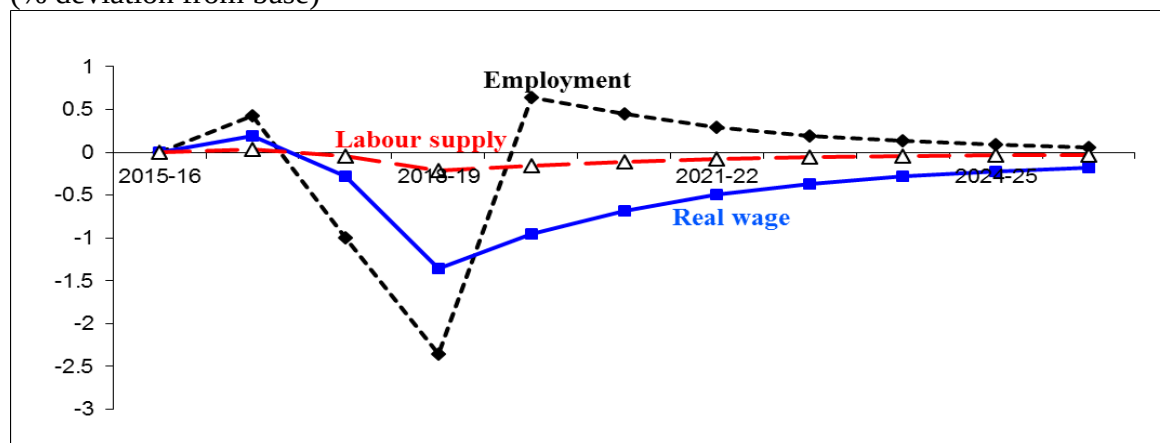


Figure 15: Murray real consumption and investment
(% deviation from base)

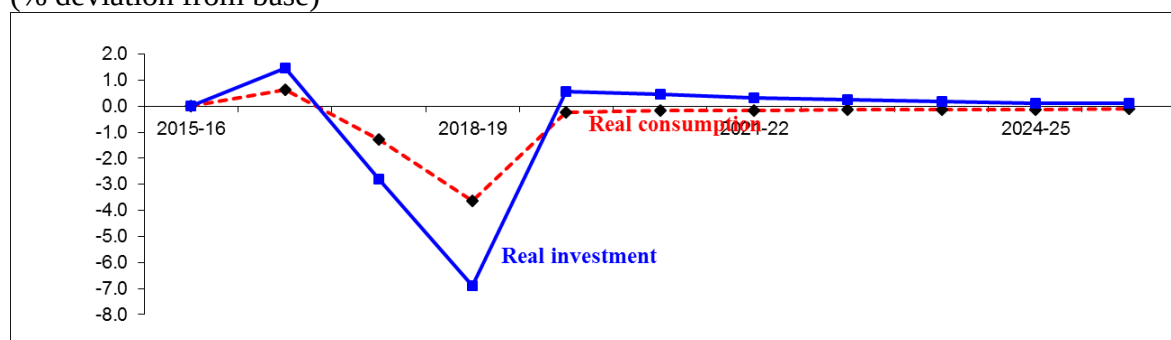


Table 6: SA2 level macro outcomes within Murray
(% change from base)

	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22	2022-23	2023-24	2024-25	2025-26
Real GDP										
Albury - East	0.2	-0.3	-0.9	0.4	0.3	0.3	0.2	0.2	0.1	0.1
Albury - North	0.2	-0.5	-1.3	0.3	0.4	0.3	0.2	0.2	0.2	0.2
Albury - South	0.1	-0.4	-1.1	0.3	0.4	0.3	0.2	0.2	0.2	0.2
Albury Region	1.7	-2.0	-6.1	0.1	0.1	0.0	0.0	-0.1	-0.1	-0.1
Lavington	0.2	-0.4	-1.1	0.4	0.4	0.3	0.2	0.2	0.2	0.2
Hay	0.4	-9.6	-21.1	0.6	0.7	0.6	0.6	0.5	0.5	0.5
Wentworth - Buronga	0.5	-0.9	-2.6	0.2	0.3	0.3	0.3	0.2	0.2	0.2
Wentworth-Balranald Reg.	3.6	-3.9	-11.1	-0.2	0.1	0.1	0.1	0.1	0.1	0.1
Corowa	0.4	-1.0	-4.5	0.0	0.2	0.2	0.1	0.1	0.1	0.1
Corowa Region	5.0	-5.8	-14.7	-0.4	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3
Deniliquin	0.9	-1.3	-4.0	0.1	0.2	0.2	0.1	0.1	0.1	0.1
Deniliquin Region	5.9	-6.7	-18.6	-0.8	-0.6	-0.6	-0.6	-0.6	-0.6	-0.6
Moama	0.9	-1.3	-4.1	0.1	0.3	0.3	0.2	0.2	0.2	0.2
Tocumwal - Finley - Jerilderie	3.5	-4.5	-12.1	-0.4	-0.2	-0.3	-0.3	-0.3	-0.3	-0.3
Employment										
Albury - East	0.2	-0.3	-0.4	0.7	0.5	0.3	0.2	0.1	0.1	0.1
Albury - North	0.3	-0.3	-0.6	0.7	0.5	0.3	0.2	0.2	0.1	0.1
Albury - South	0.2	-0.2	-0.3	0.7	0.5	0.3	0.2	0.1	0.1	0.1
Albury Region	0.4	-0.7	-1.8	0.6	0.5	0.3	0.2	0.1	0.1	0.1
Lavington	0.3	-0.4	-0.6	0.7	0.5	0.3	0.2	0.2	0.1	0.1
Hay	0.3	-7.8	-15.8	0.4	0.2	0.1	0.0	-0.1	-0.1	-0.2
Wentworth - Buronga	0.5	-0.5	-1.2	0.7	0.5	0.3	0.2	0.2	0.1	0.1
Wentworth-Balranald Reg.	0.6	-1.1	-4.0	0.6	0.5	0.3	0.2	0.2	0.2	0.1
Corowa	0.4	-0.3	-1.4	0.6	0.4	0.3	0.2	0.1	0.1	0.1
Corowa Region	0.7	-1.4	-4.2	0.6	0.4	0.3	0.2	0.1	0.1	0.1
Deniliquin	0.5	-0.7	-1.9	0.6	0.5	0.3	0.2	0.1	0.1	0.1
Deniliquin Region	0.8	-1.8	-5.7	0.5	0.4	0.2	0.2	0.1	0.1	0.1
Moama	0.5	-0.6	-1.6	0.6	0.5	0.3	0.2	0.1	0.1	0.1
Tocumwal - Finley - Jerilderie	0.8	-1.4	-4.1	0.6	0.4	0.3	0.2	0.1	0.1	0.0

Riverina's Horticulture sector similarly copes with drought via water trading. Macro losses at the regional level are slightly larger in Riverina than Murray.

Figure 16: Riverina real GDP income side
(% deviation from base)

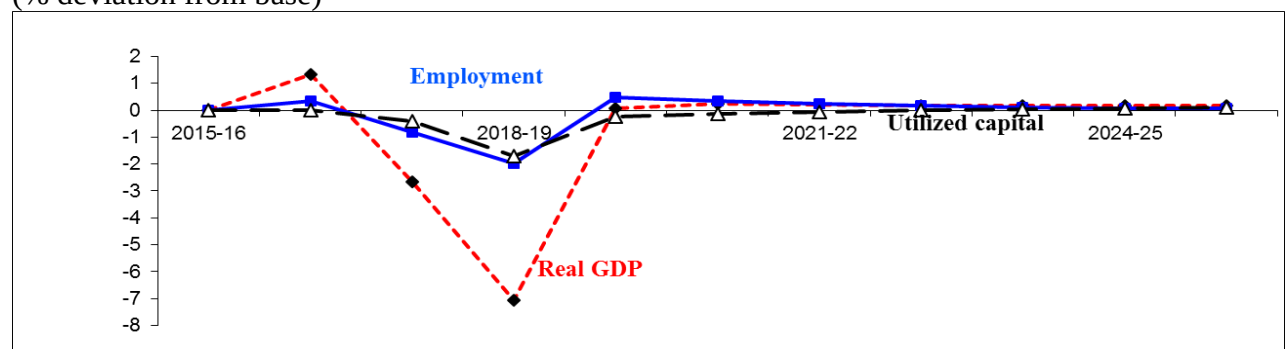


Figure 17: Riverina labour market
(% deviation from base)

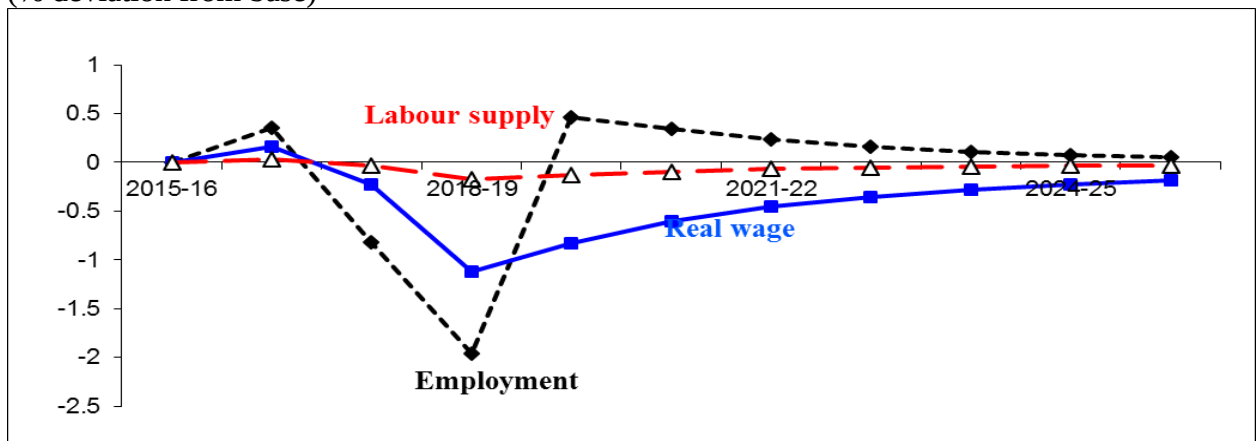


Figure 18: Riverina real consumption and investment
(% deviation from base)

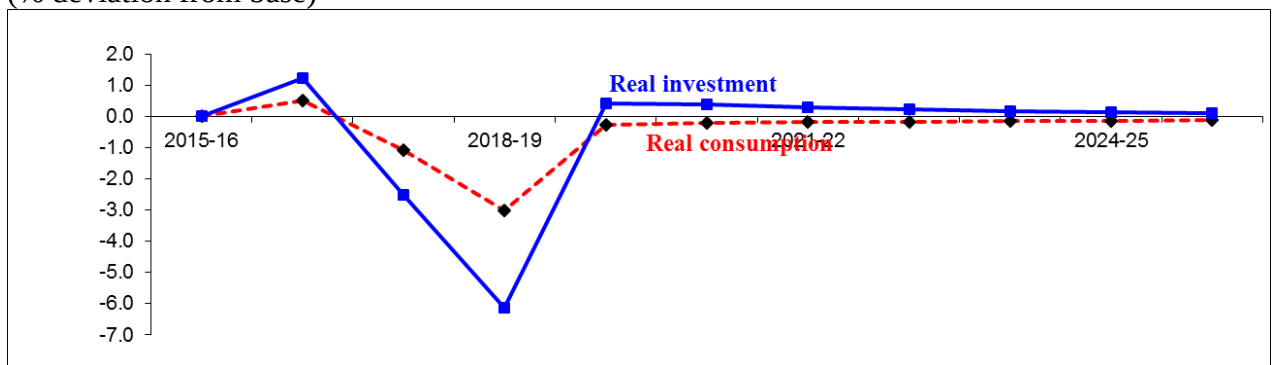


Table 7: SA2 level macro outcomes within Riverina
(% change from base)

	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22	2022-23	2023-24	2024-25	2025-26
Real GDP										
Griffith (NSW)	0.6	-1.6	-4.3	0.1	0.2	0.2	0.2	0.1	0.1	0.1
Griffith Region	2.8	-8.5	-19.1	0.3	0.4	0.4	0.4	0.4	0.4	0.4
Leeton	0.7	-1.7	-5.0	0.1	0.3	0.3	0.3	0.3	0.3	0.3
Narrandera	5.3	-5.4	-14.5	-0.4	0.1	0.1	0.1	0.1	0.1	0.1
Tumbarumba	0.1	-1.1	-4.6	0.0	0.5	0.5	0.5	0.5	0.5	0.5
Tumut	0.1	-0.8	-2.7	0.2	0.6	0.5	0.5	0.5	0.5	0.4
Tumut Region	0.1	-1.0	-3.7	0.1	0.6	0.5	0.5	0.5	0.5	0.5
Cootamundra	1.4	-2.2	-6.6	0.0	0.3	0.3	0.3	0.2	0.2	0.2
Gundagai	0.4	-1.7	-7.1	-0.1	0.6	0.6	0.6	0.6	0.6	0.6
Junee	2.3	-3.1	-8.8	-0.1	0.3	0.2	0.2	0.2	0.2	0.2
Temora	5.5	-7.2	-17.6	-0.7	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2
Wagga Wagga - East	0.3	-0.7	-2.1	0.2	0.3	0.3	0.2	0.2	0.2	0.2
Wagga Wagga - North	0.5	-1.4	-5.0	0.0	0.5	0.5	0.4	0.4	0.4	0.4
Wagga Wagga - South	0.3	-0.6	-1.8	0.2	0.3	0.2	0.2	0.2	0.1	0.1
Wagga Wagga - West	0.3	-0.7	-2.1	0.2	0.4	0.3	0.3	0.2	0.2	0.2
Wagga Wagga Region	3.6	-4.6	-11.8	-0.3	-0.2	-0.2	-0.2	-0.3	-0.3	-0.3
Employment										
Griffith (NSW)	0.4	-0.6	-1.5	0.5	0.3	0.2	0.1	0.1	0.1	0.0
Griffith Region	0.6	-3.3	-6.5	0.0	-0.1	-0.2	-0.2	-0.2	-0.2	-0.2
Leeton	0.4	-0.2	-0.8	0.4	0.3	0.2	0.1	0.1	0.1	0.0
Narrandera	0.5	-1.0	-3.7	0.5	0.4	0.3	0.2	0.2	0.2	0.2
Tumbarumba	0.2	0.1	-0.4	0.6	0.5	0.4	0.3	0.3	0.2	0.2
Tumut	0.2	-0.1	-0.2	0.6	0.5	0.4	0.3	0.2	0.2	0.1
Tumut Region	0.2	0.0	-0.4	0.6	0.5	0.4	0.3	0.2	0.2	0.2
Cootamundra	0.4	-0.5	-1.7	0.5	0.4	0.3	0.2	0.2	0.1	0.1
Gundagai	0.2	0.1	-1.1	0.6	0.5	0.4	0.3	0.2	0.2	0.2
Junee	0.3	-0.4	-1.8	0.6	0.4	0.3	0.2	0.2	0.2	0.1
Temora	0.7	-1.6	-4.9	0.5	0.4	0.3	0.2	0.2	0.2	0.1
Wagga Wagga - East	0.3	-0.5	-0.9	0.6	0.4	0.3	0.2	0.1	0.1	0.1
Wagga Wagga - North	0.3	-0.2	-0.8	0.6	0.4	0.3	0.2	0.2	0.2	0.1
Wagga Wagga - South	0.3	-0.4	-0.8	0.6	0.4	0.3	0.2	0.1	0.1	0.1
Wagga Wagga - West	0.2	-0.2	-0.4	0.6	0.4	0.3	0.2	0.2	0.1	0.1
Wagga Wagga Region	0.4	-1.3	-3.3	0.5	0.4	0.3	0.2	0.1	0.1	0.1

Figure 19: Central West real GDP income side
(% deviation from base)

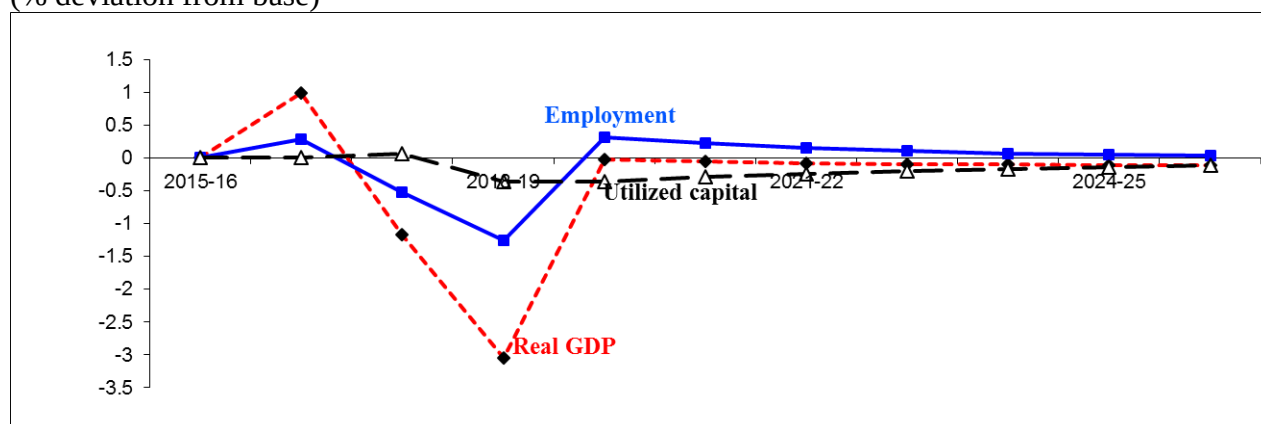


Figure 20: Central West labour market
(% deviation from base)

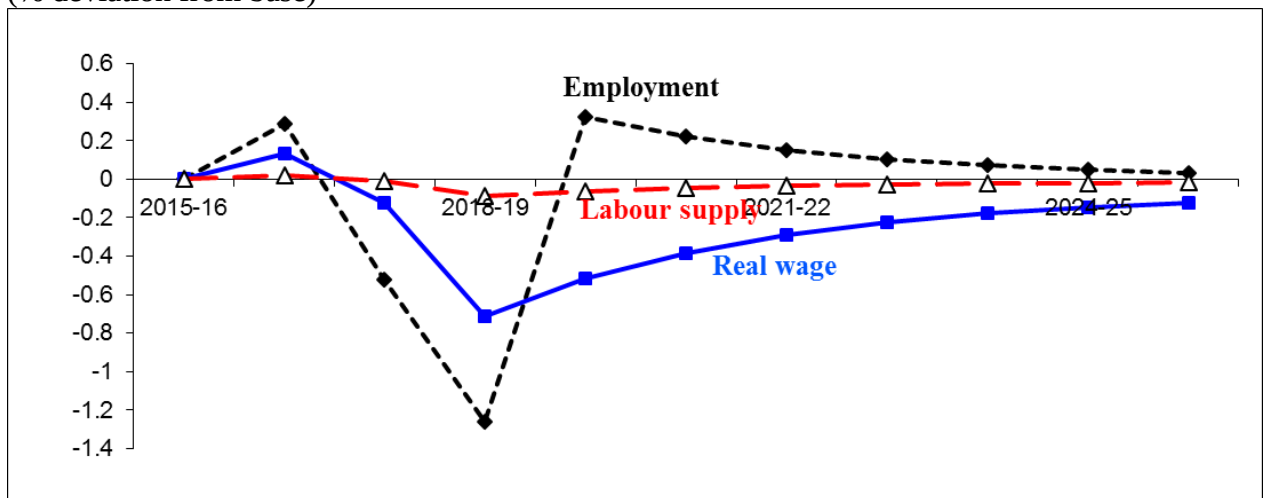


Figure 21: Central West real consumption and investment
(% deviation from base)

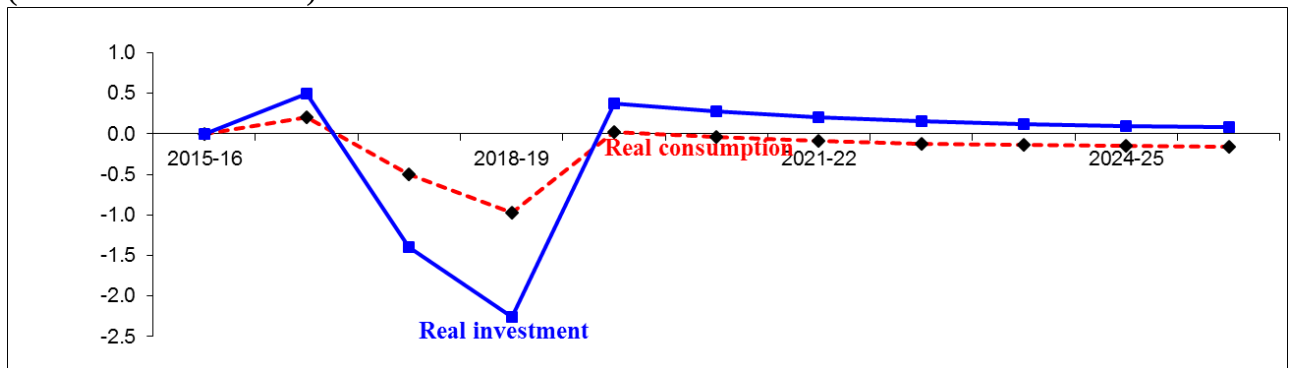


Table 8: SA2 level macro outcomes within Central West
(% change from base)

	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22	2022-23	2023-24	2024-25	2025-26
Real GDP										
Bathurst	0.2	-0.3	-0.6	0.1	0.1	0.1	0.0	0.0	0.0	0.0
Bathurst - East	0.2	-0.2	-0.7	0.1	0.1	0.0	0.0	0.0	0.0	0.0
Bathurst Region	0.2	-0.4	-1.2	0.0	0.0	0.0	0.0	-0.1	-0.1	-0.1
Oberon	0.0	-0.1	-0.4	0.1	0.1	0.0	0.0	0.0	0.0	0.0
Condobolin	6.6	-7.7	-18.9	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5	-0.4
Cowra	0.8	-0.9	-2.7	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1
Cowra Region	2.9	-2.8	-9.6	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5
Forbes	2.5	-2.6	-7.5	-0.3	-0.3	-0.3	-0.3	-0.4	-0.4	-0.3
Grenfell	7.5	-8.0	-19.8	-1.0	-1.0	-1.0	-0.9	-0.9	-0.9	-0.9
Parkes (NSW)	0.6	-0.7	-1.7	0.1	0.0	0.0	0.0	0.0	-0.1	-0.1
Parkes Region	6.8	-7.5	-18.0	-0.9	-0.9	-0.9	-0.8	-0.8	-0.8	-0.8
West Wyalong	6.3	-7.1	-16.7	-0.7	-0.7	-0.7	-0.7	-0.7	-0.7	-0.7
Lithgow	0.1	-0.1	0.0	0.2	0.1	0.1	0.1	0.0	0.0	0.0
Lithgow Region	0.1	-0.1	-0.2	0.1	0.1	0.0	0.0	0.0	0.0	0.0
Mudgee	0.1	0.0	-0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0
Mudgee Region - East	0.0	0.0	-0.2	0.0	0.0	0.0	0.0	-0.1	-0.1	-0.1
Mudgee Region - West	0.3	-0.4	-1.6	0.0	0.0	0.0	-0.1	-0.1	-0.1	-0.1
Blayney	0.2	-0.3	-1.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0
Orange	0.1	-0.2	-0.3	0.1	0.1	0.1	0.0	0.0	0.0	0.0
Orange North	0.1	-0.1	-0.3	0.2	0.1	0.1	0.0	0.0	0.0	0.0
Orange Region	0.5	-0.7	-1.9	0.0	0.0	-0.1	-0.1	-0.1	-0.1	-0.1
Employment										
Bathurst	0.2	-0.4	-0.8	0.3	0.2	0.2	0.1	0.1	0.1	0.0
Bathurst - East	0.3	-0.4	-0.9	0.3	0.2	0.2	0.1	0.1	0.0	0.0
Bathurst Region	0.3	-0.5	-1.1	0.3	0.2	0.2	0.1	0.1	0.0	0.0
Oberon	0.2	-0.3	-0.6	0.3	0.2	0.2	0.1	0.1	0.1	0.0
Condobolin	0.8	-1.8	-5.3	0.1	0.0	0.0	0.0	-0.1	-0.1	-0.1
Cowra	0.4	-0.6	-1.7	0.3	0.2	0.1	0.1	0.1	0.0	0.0
Cowra Region	0.6	-1.1	-3.6	0.2	0.1	0.1	0.1	0.0	0.0	0.0
Forbes	0.5	-1.0	-2.8	0.3	0.2	0.1	0.1	0.1	0.0	0.0
Grenfell	1.1	-2.7	-8.0	0.2	0.1	0.1	0.0	0.0	0.0	0.0
Parkes (NSW)	0.3	-0.5	-1.0	0.3	0.2	0.2	0.1	0.1	0.1	0.0
Parkes Region	0.8	-2.3	-6.7	0.2	0.1	0.1	0.1	0.0	0.0	0.0
West Wyalong	0.8	-2.0	-5.7	0.2	0.1	0.1	0.1	0.0	0.0	0.0
Lithgow	0.1	-0.2	-0.3	0.4	0.3	0.2	0.1	0.1	0.1	0.1
Lithgow Region	0.2	-0.3	-0.4	0.4	0.3	0.2	0.1	0.1	0.1	0.1
Mudgee	0.1	-0.1	0.0	0.4	0.2	0.2	0.1	0.1	0.1	0.0
Mudgee Region - East	0.2	-0.3	-0.6	0.3	0.2	0.2	0.1	0.1	0.1	0.0
Mudgee Region - West	0.2	-0.3	-0.8	0.3	0.2	0.2	0.1	0.1	0.0	0.0
Blayney	0.2	-0.4	-0.8	0.3	0.2	0.2	0.1	0.1	0.1	0.0
Orange	0.2	-0.3	-0.5	0.3	0.2	0.2	0.1	0.1	0.1	0.0
Orange North	0.2	-0.2	-0.4	0.3	0.2	0.2	0.1	0.1	0.1	0.0
Orange Region	0.3	-0.5	-1.2	0.3	0.2	0.1	0.1	0.1	0.0	0.0

Figure 19: Southern Highlands-Shoalhaven real GDP income side
(% deviation from base)

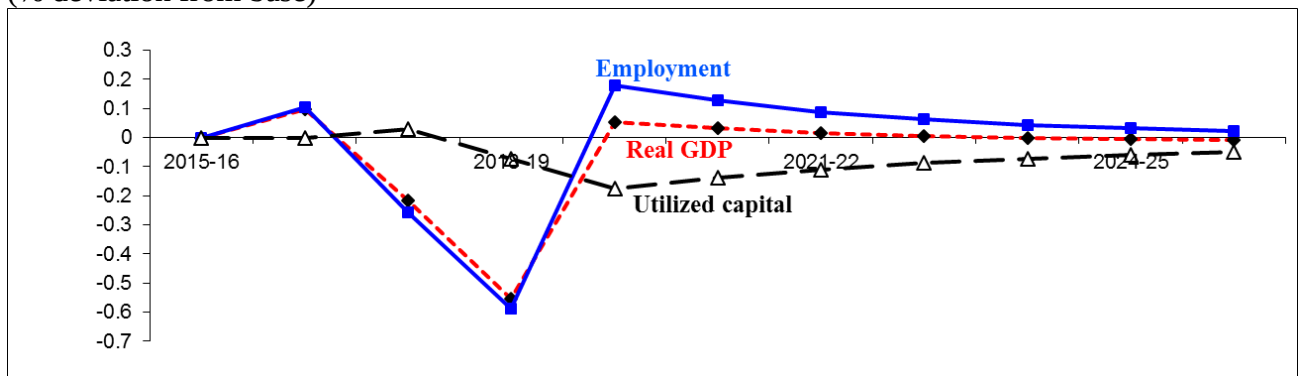


Figure 20: Southern Highlands-Shoalhaven labour market
(% deviation from base)

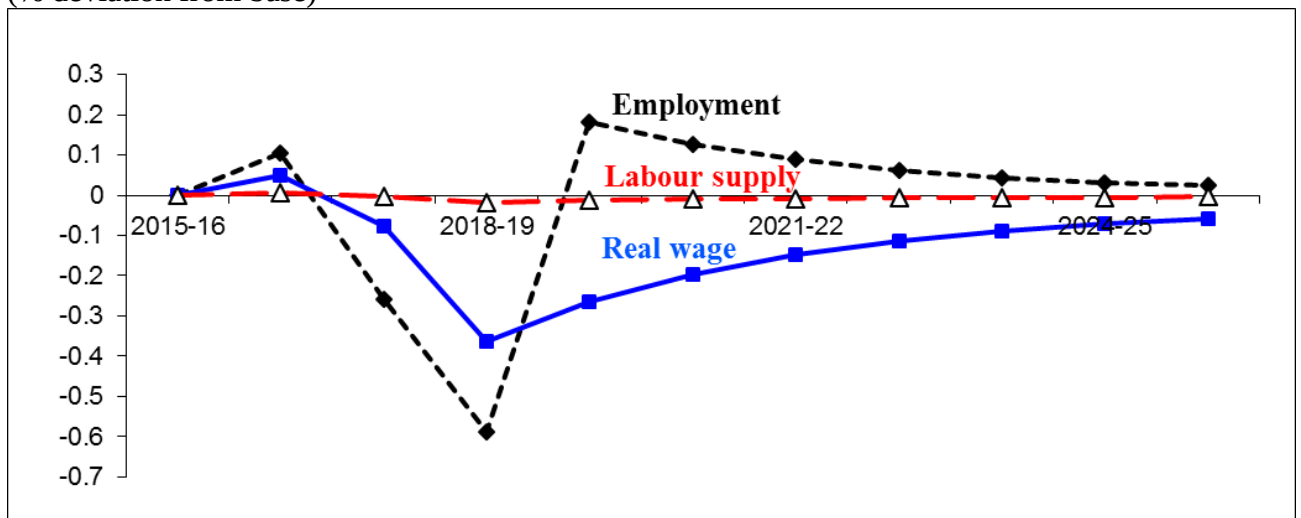


Figure 21: Southern Highlands-Shoalhaven real consumption and investment
(% deviation from base)

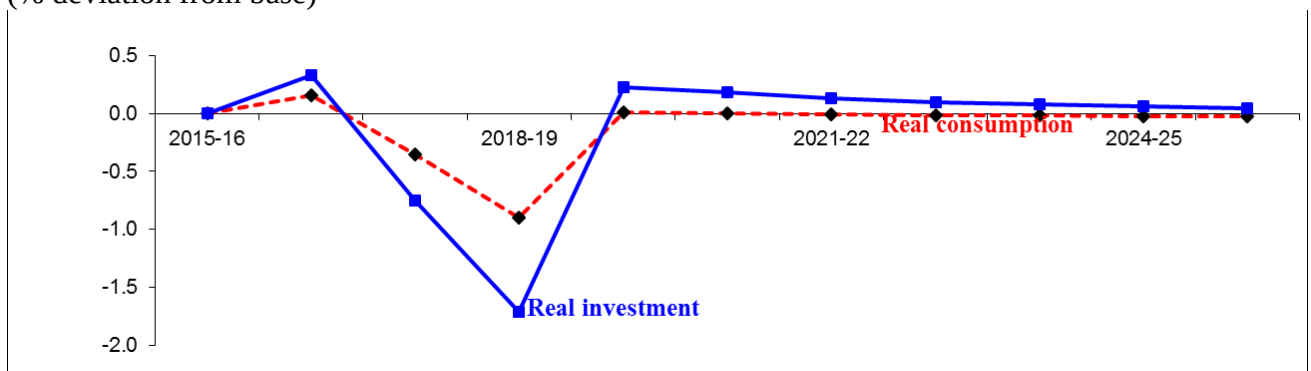


Figure 22: Hunter exc. Newcastle real GDP income side
(% deviation from base)

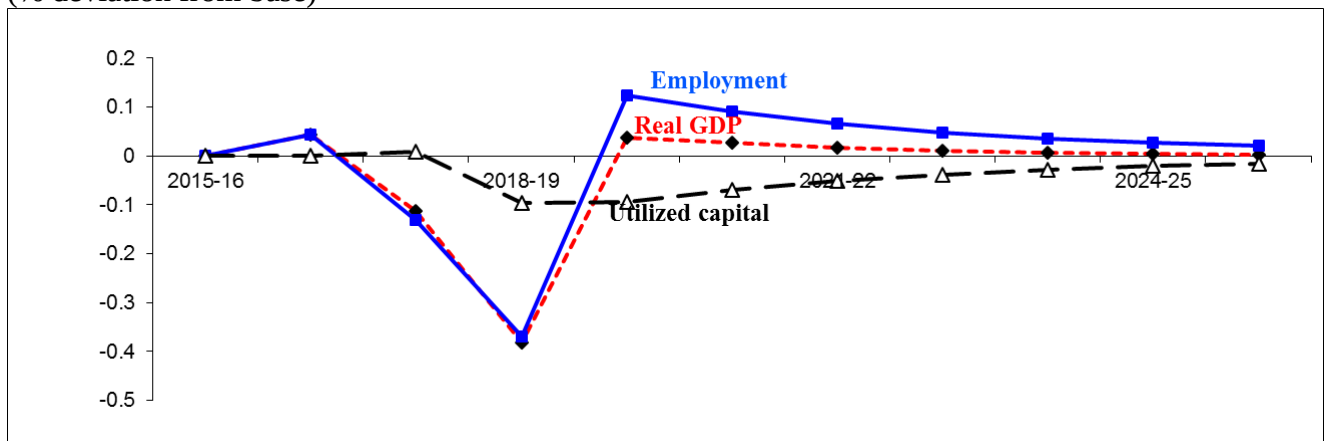


Figure 23: Hunter exc. Newcastle labour market
(% deviation from base)

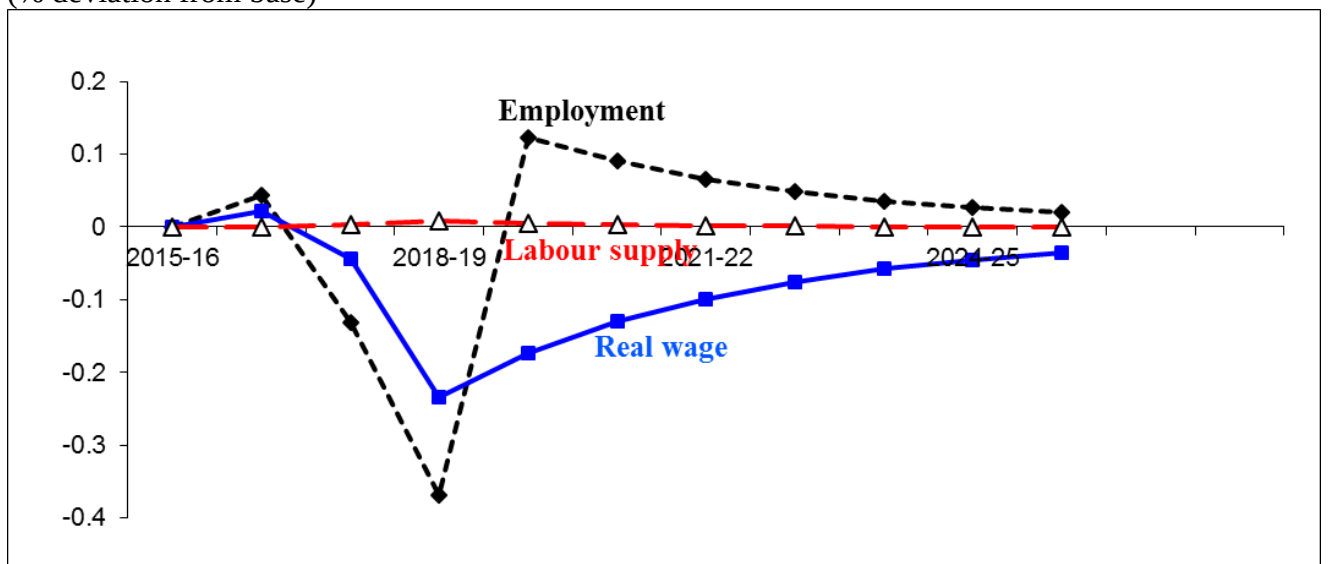
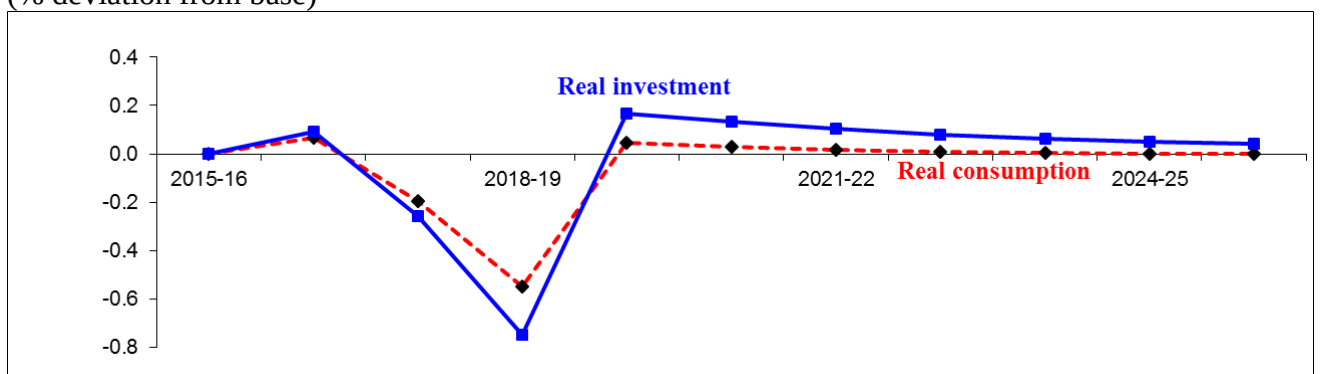


Figure 24: Hunter exc. Newcastle real consumption and investment
(% deviation from base)



Modelling of drought relief measures

Subsidy of road freight for fodder transport

The NSW government has provided \$190 million of transport subsidies to facilitate the movement of fodder. The rationale is that if livestock can be kept alive until the season breaks, livestock farmers will maintain their capital base (i.e., herd) as a source of future income. From economic analysis without using a model, we expect that any subsidies on either fodder transport or fodder will push up the producer price of fodder. This will disadvantage buyers of fodder who are not beneficiaries of the subsidy. Fodder supplies have also been reduced due to drought, so that in effect a subsidy used to purchase a drought-diminished quantity of fodder will push fodder prices up even more than drought alone. The subsidy will also push up the price of road transport. The hope of government in implementing a subsidy is that the upward pressure on producer prices for fodder and road transport will be more than offset by reductions in user prices. This is only so for direct beneficiaries.

Table 9: Marginal impact of fodder freight subsidy on producer prices
(% change from base)

	Road freight	HayCerealFod
CapitalReg	-2.6	2.6
CoastNSW	0.0	1.8
CentralWest	-2.7	2.5
CoffsGraft	0.0	2.0
FarWestOrana	-2.5	2.8
HunterExnWC	-2.8	2.3
Murray	-2.6	2.7
NewEngNthWst	-2.6	2.6
RichTweed	0.0	2.0
Riverina	-2.7	2.6
SthHiShoal	-2.7	2.2
RoA	0.0	2.0

Table 9 shows the marginal impact of \$190 million of subsidies on the producer prices of road freight services and hay, cereal & fodder in the drought year 2018-19. Beneficiaries are those farmers for whom the subsidy more than offsets the hike in producer prices. Losers are users of hay, cereal & fodder who are not beneficiaries of the subsidy.

Table 10: NSW livestock output, 2018-19
(% change from base)

	Drought	Drought + subsidy
Sheep	-12.5	-9.7
BeefCattle	-9.5	-7.4
DairyCattle	-10.2	-8.4

Within the model, the subsidy does help a little to compensate livestock production for the collapse in land productivity within NSW. Table 10 shows that state-wide livestock output losses are smaller with the subsidy. But these ostensible gains come at the expense of producers who are not direct beneficiaries, including those in NSW in drought-affected areas who are not recipients of the subsidy.

The subsidy provides a very slight improvement welfare. The annualised welfare loss per head in NSW is 10 cents lower than without the subsidy.

A direct transfer to households in drought-affected regions

Table 11: SA2 level aggregate consumption losses in 2018-19, with and without transfers to household

(% change from base)

	Drought only	Drought + Transfer		Drought only	Drought + Transfer
Armidale	-2.2	-1.5	Gundagai	-2.2	-1.9
Armidale Region - North	-4.1	-3.4	Junee	-2.9	-2.6
Armidale Region - South	-3.3	-2.6	Temora	-5.9	-5.6
Walcha	-5.3	-4.7	Wagga Wagga - East	-1.9	-1.6
Glen Innes	-3.9	-3.2	Wagga Wagga - North	-1.9	-1.6
Inverell	-2.7	-2.0	Wagga Wagga - South	-1.8	-1.5
Inverell Region - East	-3.1	-2.5	Wagga Wagga - West	-1.5	-1.2
Inverell Region - West	-6.7	-6.0	Wagga Wagga Region	-4.4	-4.1
Tenterfield	-3.5	-2.8	Albury – East	-1.9	-1.5
Moree	-14.7	-14.1	Albury – North	-1.6	-1.2
Moree Region	-18.2	-17.7	Albury – South	-3.1	-2.7
Narrabri	-9.8	-9.2	Albury Region	-1.9	-1.5
Narrabri Region	-21.1	-20.6	Lavington	-16.9	-16.6
Gunnedah	-3.3	-2.7	Hay	-2.5	-2.1
Gunnedah Region	-9.4	-8.8	Wentworth - Buronga	-5.3	-4.9
Quirindi	-5.0	-4.4	Wentworth-Balranald Reg.	-2.7	-2.3
Tamworth - East	-3.0	-2.3	Corowa	-5.5	-5.1
Tamworth - North	-2.6	-1.9	Corowa Region	-3.1	-2.8
Tamworth - West	-3.0	-2.3	Deniliquin	-6.9	-6.6
Tamworth Region	-3.4	-2.7	Deniliquin Region	-2.9	-2.5
Bourke - Brewarrina	-5.9	-5.4	Moama	-5.4	-5.0
Cobar	-0.7	-0.3	Tocumwal - Finley - Jerilderie	-2.2	-1.5
Coonamble	-9.3	-8.9	Bathurst	-1.5	-1.3
Nyngan - Warren	-4.2	-3.8	Bathurst – East	-1.5	-1.3
Walgett - Lightning Ridge	-10.6	-10.2	Bathurst Region	-1.7	-1.5
Broken Hill	-1.7	-1.2	Oberon	-1.2	-1.0
Far West	-3.4	-3.0	Condobolin	-5.9	-5.7
Coonabarabran	-4.9	-4.4	Cowra	-2.3	-2.1
Dubbo - East	-3.1	-2.6	Cowra Region	-4.2	-4.0
Dubbo - South	-3.1	-2.5	Forbes	-3.4	-3.3
Dubbo - West	-3.1	-2.6	Grenfell	-8.6	-8.4
Dubbo Region	-4.5	-4.0	Parkes (NSW)	-1.6	-1.4
Gilgandra	-8.5	-8.1	Parkes Region	-7.3	-7.2
Narromine	-13.7	-13.3	West Wyalong	-6.4	-6.2
Wellington	-4.4	-3.9	Lithgow	-0.9	-0.7
Griffith (NSW)	-2.6	-2.3	Lithgow Region	-1.1	-0.9
Griffith Region	-7.5	-7.2	Mudgee	-0.7	-0.5
Leeton	-1.8	-1.5	Mudgee Region - East	-1.3	-1.1
Narrandera	-4.7	-4.4	Mudgee Region - West	-1.4	-1.3
Tumbarumba	-1.5	-1.2	Blayney	-1.5	-1.3
Tumut	-1.3	-1.0	Orange	-1.2	-1.0
Tumut Region	-1.5	-1.2	Orange North	-1.0	-0.8
Cootamundra	-2.8	-2.5	Orange Region	-1.9	-1.7

Another scenario variant was to give \$190 million to households in drought-affected regions. This results in a slight improvement in both national and state welfare relative to drought with no transfer to households. The reason for this is that drought weakens the labour market, resulting in job losses. Compensation to households which results in increased household spending relative to no compensation results in a small increase in employment relative to no compensation in 2018-19.

The welfare impact is small, equal to an annualised improvement per capita in NSW of 20 cents relative to no compensation.

Table 11 shows SA2 aggregate household spending impacts in 2018-19 relative to base, with drought alone and drought plus a transfer to households. The transfer to households varies by

region according to drought-induced losses. It is imposed at the SA4 level. This means that the uneven losses between different SA2 regions within an SA4 are not reflected in the modelling. However, the differences shown in table 11 are indicative of how \$190 million might dampen consumption losses in 2018-19.

Assessing drought conditions earlier

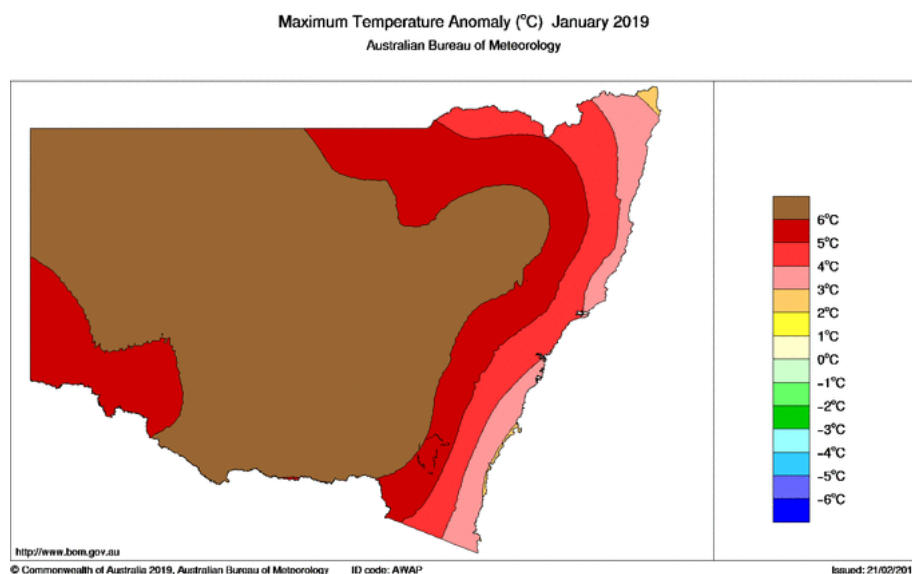
The lesson for the future from the present predicament faced by farmers in NSW is that the early signs of drought require a farm management response. Figure 4a shows that farmers in northern NSW suffered drier than usual conditions at the beginning of 2017 entirely due to abnormally high temperatures throughout the 2016-17 summer. Even average rainfall for the remainder of the year may have resulted in depleted productivity or herd carrying capacity on farmland in the north of the state. In the event, below average rainfall resulted in moderate to severe drought conditions that worsened in 2018. With climate change, temperature events far above average may become more common. Effective rainfall will diminish due to hot weather events. A drought event such as that of 2017 to 2018 will require more careful management based on all relevant meteorological data, not rainfall alone. Access of such data to farmers has improved over the past decade or so.

One example of how such data might be used concerns observations for Moree. Average January evaporation at the town's weather station is around 260 mm but in January 2017 it was 300 mm. Average January rainfall is 80 mm, compared with 17 mm in that month. Given the combination of high evaporation and low rainfall, about 100 mm more than average rainfall for the remainder of the year would have been required for an "average" year in terms of effective rainfall. Livestock farmers may have responded earlier in terms of herd management with this interpretation of the beginning of 2017.

Gloom ahead

As of early April 2019, the probability of an El Nino event with continuing drought remained. Any hopes of a recovery over summer in NSW received a setback in another extraordinary heat event in January 2019. Much of inland NSW suffered average maximum temperatures that were more than 6C above average in the hottest month of the year.

Figure 25: NSW extraordinary heat event, January 2019



Appendix A

Figure A1: Regions in this application of VU-TERM



Figure A1 shows the bottom-up regions in this study. Essentially, away from a coastal composite that includes Sydney, Wollongong and Newcastle, the bottom-up regions are SA4 regions.

GEMPACK software

Dynamic VU-TERM uses GEMPACK software for implementation (Harrison, *et al.* 2013; Harrison and Pearson, 1996).

References and published applications

Dixon, P.B. and Rimmer, M.T. (2002). Dynamic General Equilibrium Modelling for Forecasting and Policy: a Practical Guide and Documentation of MONASH, Contributions to Economic Analysis 256, North-Holland, Amsterdam.

Dixon, P., Rimmer, M. and Wittwer, G. (2011), "Saving the Southern Murray-Darling Basin: the Economic Effects of a Buyback of Irrigation Water", *Economic Record*, 87(276): 153-168.

Horridge, M, Madden, J. & Wittwer, G. (2005). Using a highly disaggregated multi-regional single-country model to analyse the impacts of the 2002-03 drought on Australia. *Journal of Policy Modelling*, 27, 285-308.

Horridge, M. and Pearson, K. (2011) "Solution software for CGE modelling", Centre of Policy Studies working paper. <http://www.monash.edu.au/policy/ftp/workpapr/g-214.pdf>

Harrison, J. and Pearson, K. (1996) "Computing Solutions for Large General Equilibrium Models Using GEMPACK", *Computational Economics*, 9: 83-127.

Harrison, J., Horridge, M., Jerie, M. & Pearson (2013), *GEMPACK manual*, GEMPACK Software, ISBN 978-1-921654-34-3

Wittwer, G. and Horridge, M. (2010), "Bringing Regional Detail to a CGE Model using Census Data", *Spatial Economic Analysis*, 5(2):229-255.

Wittwer, G., Vere, D., Jones, R. and Griffith, G. (2005), "Dynamic general equilibrium analysis of improved weed management in Australia's winter cropping systems", *Australian Journal of Agricultural and Resource Economics*, 49(4): 363-377, December.

Wittwer, G. (2012) (editor), *Economic Modeling of Water: The Australian CGE Experience*, Springer, Dordrecht, Netherlands (186 pages).