



AgEcon SEARCH
RESEARCH IN AGRICULTURAL & APPLIED ECONOMICS

The World's Largest Open Access Agricultural & Applied Economics Digital Library

This document is discoverable and free to researchers across the globe due to the work of AgEcon Search.

Help ensure our sustainability.

Give to AgEcon Search

AgEcon Search

<http://ageconsearch.umn.edu>

aesearch@umn.edu

*Papers downloaded from **AgEcon Search** may be used for non-commercial purposes and personal study only. No other use, including posting to another Internet site, is permitted without permission from the copyright owner (not AgEcon Search), or as allowed under the provisions of Fair Use, U.S. Copyright Act, Title 17 U.S.C.*

No endorsement of AgEcon Search or its fundraising activities by the author(s) of the following work or their employer(s) is intended or implied.

Estimating the regional economic impacts of the present drought on NSW

Report prepared by Glyn Wittwer,
Centre of Policy Studies,
Victoria University

26 October 2018

Paper prepared for the 2019 AARES conference, Melbourne



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 \$30 per NSW resident.

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

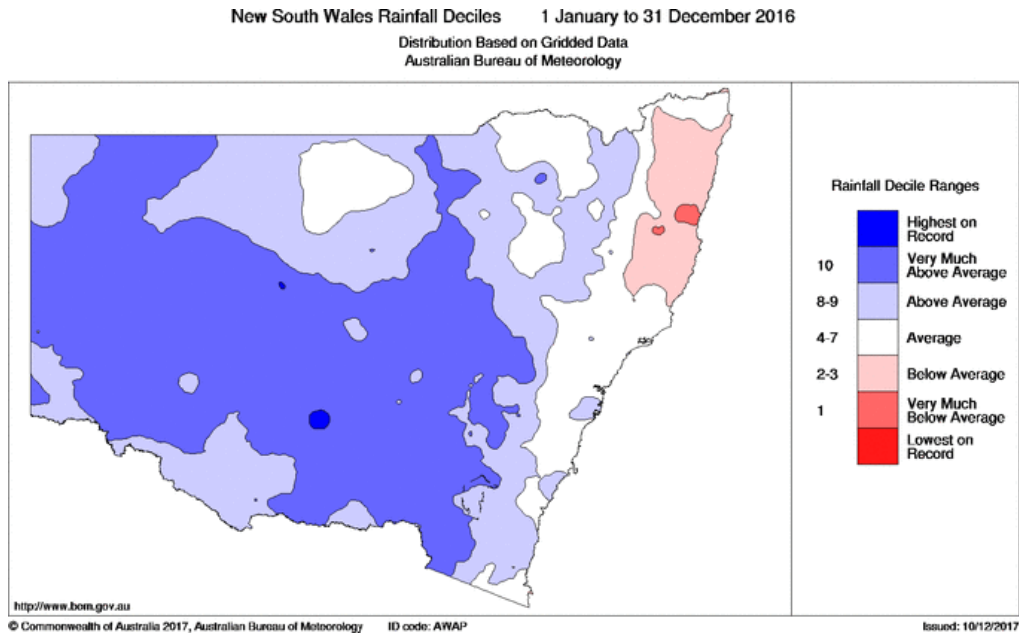
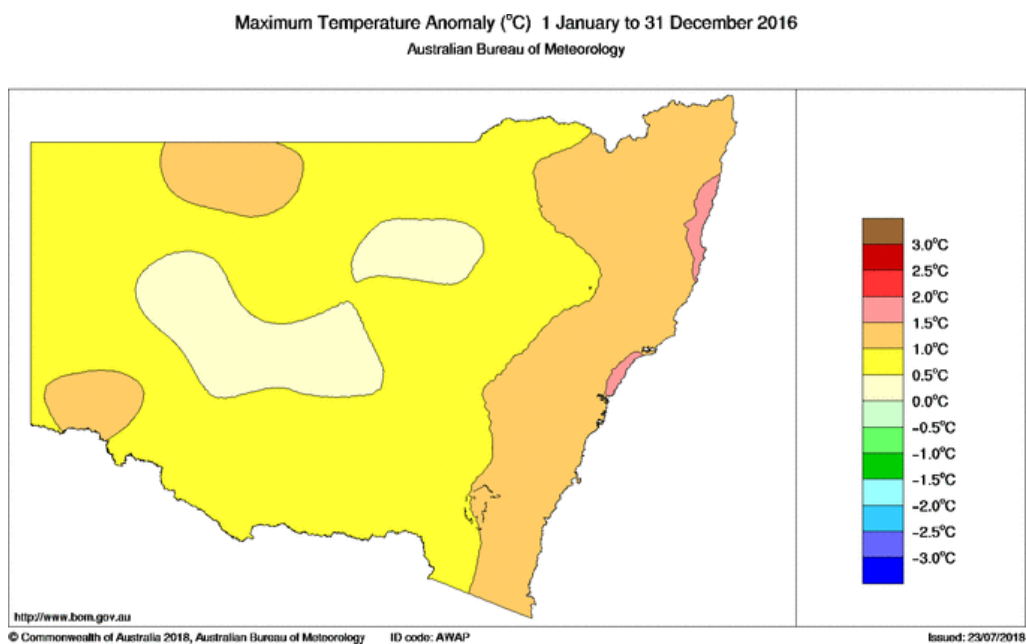


Figure 2



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

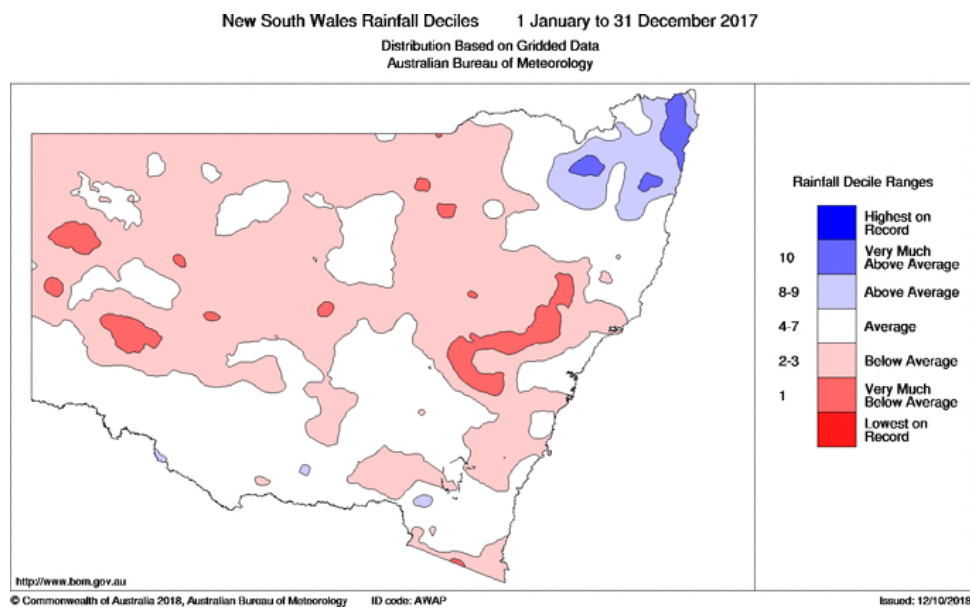


Figure 4a

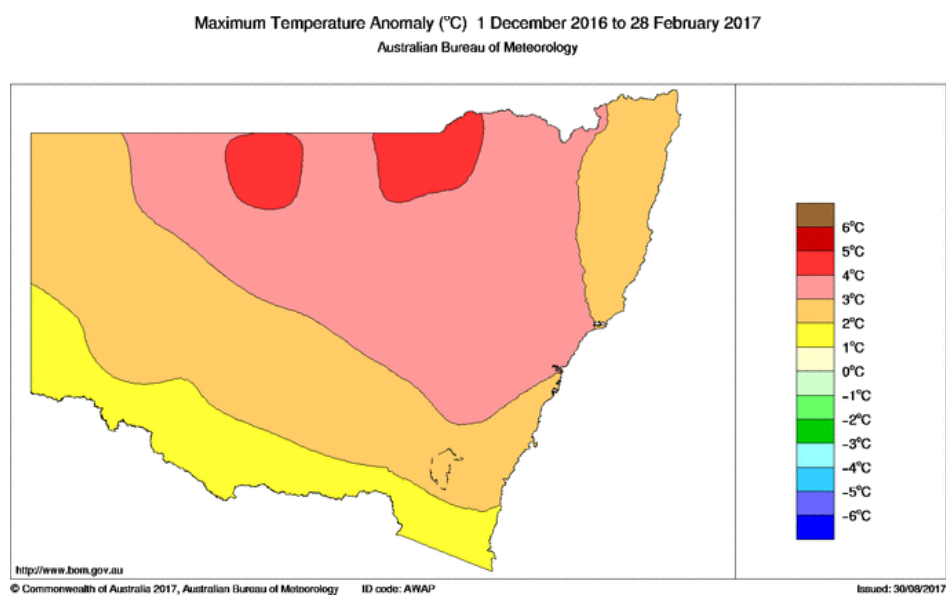
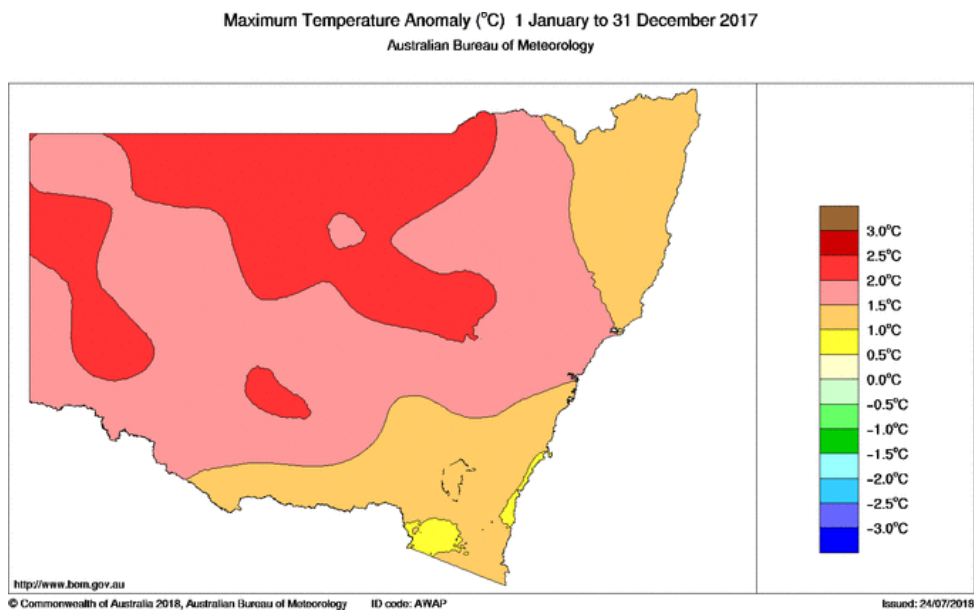


Figure 4b

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/>).

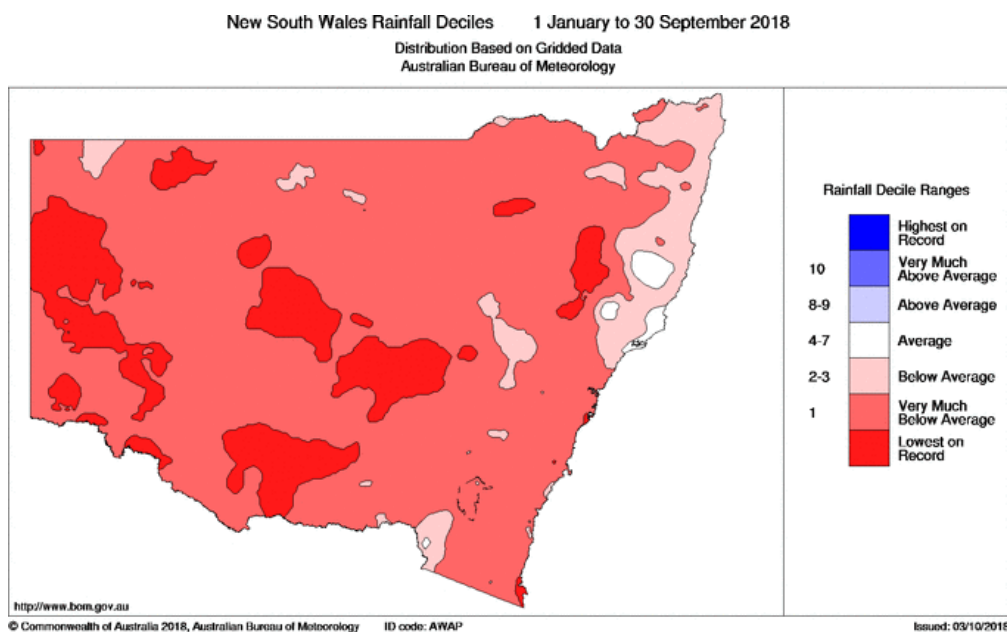
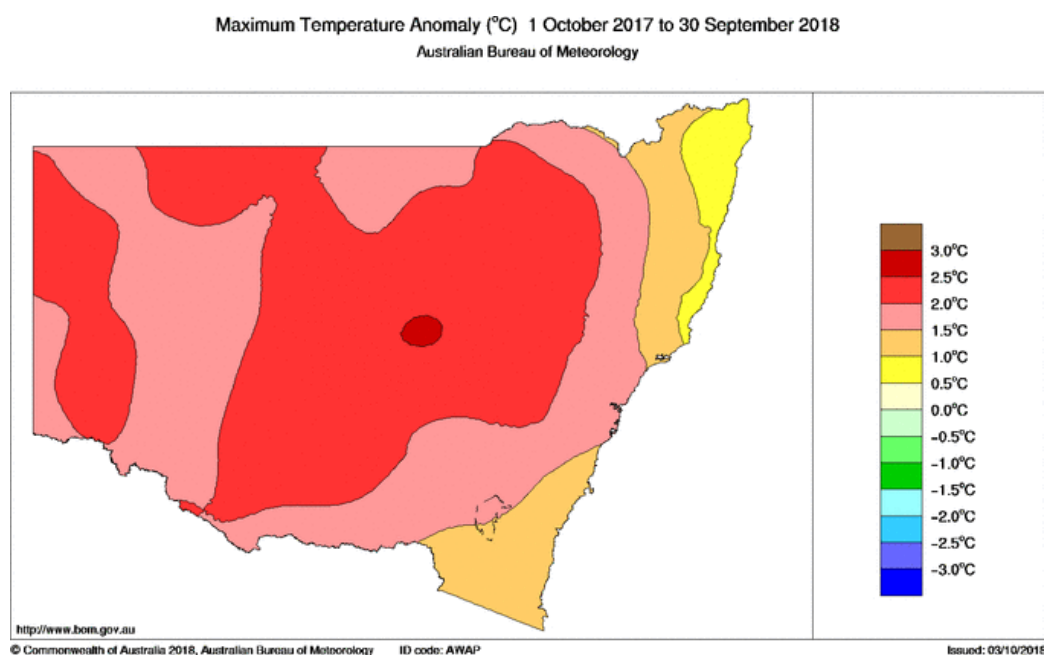
Figure 5

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

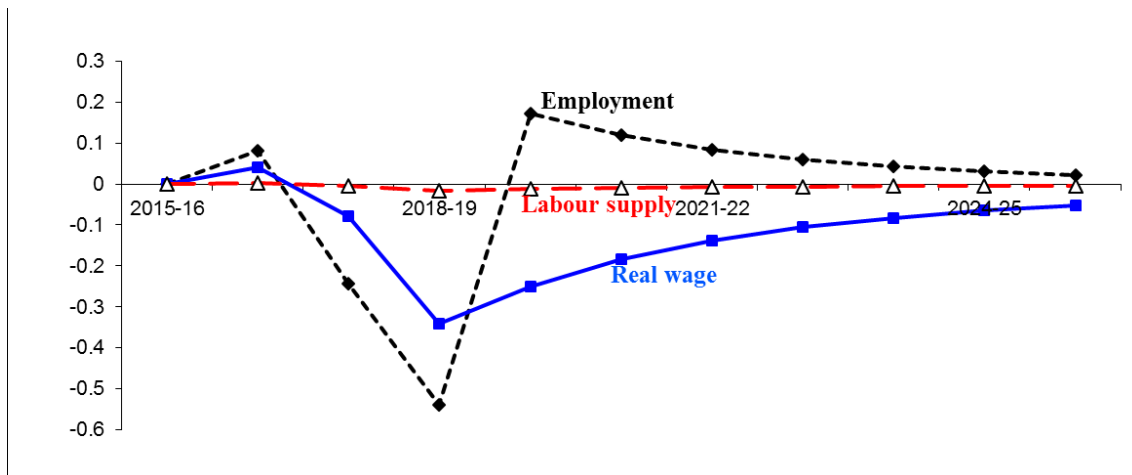
There are two types of shocks in this simulation. Crop outputs for 2016-17 and 2017-18 are based on observations. The corresponding outputs for 2018-19 are based on projections (ABARES Crop Reports).

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 0.24% or 7,700 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)

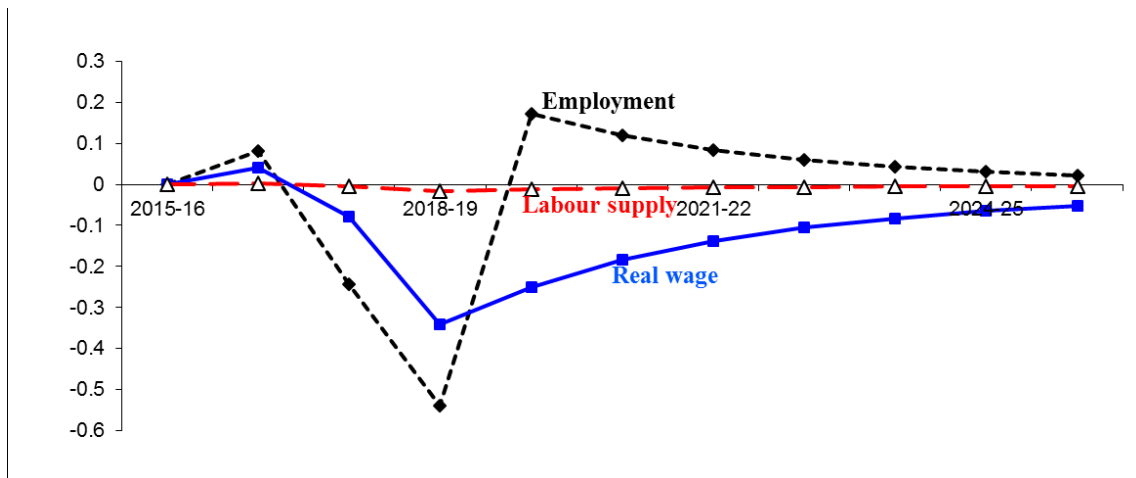
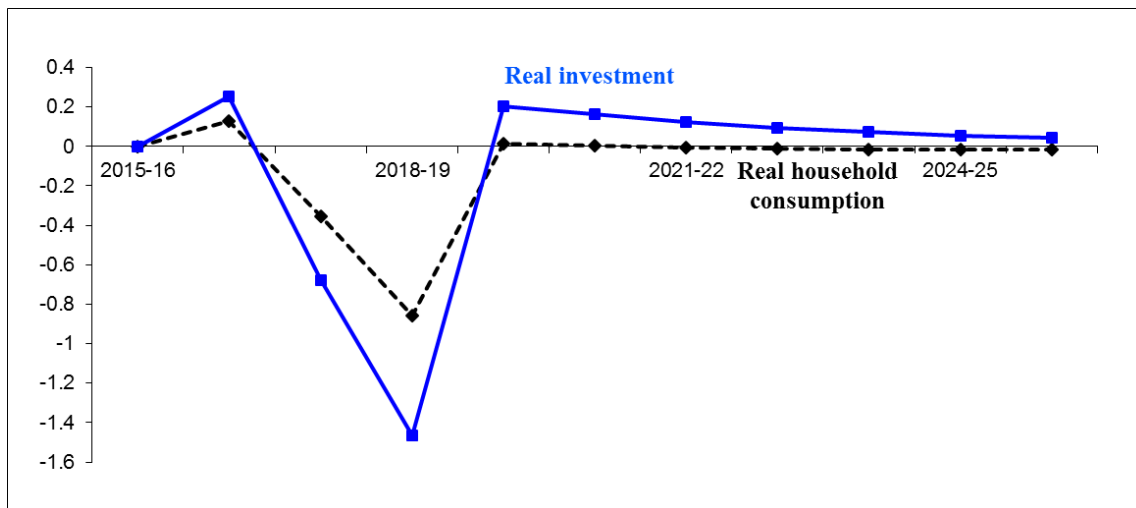


Figure 9: NSW expenditure side
(% deviations from base)



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	-2176	-5286	164	88	2	-58	-101	-131	-153
Household consumption (\$m)	412	-1217	-3036	44	6	-31	-53	-66	-72	-75
Real investment (\$m)	316	-882	-1946	278	224	173	134	104	81	64
Employment (FTE)	2587	-7731	-17274	5520	3927	2761	1956	1396	1005	730

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	-10	-79	0	0	0	-1	-1	-1	-1
DairyCattle	0	-2	-11	0	0	0	0	0	0	0
OthLivstock	-1	-3	-33	-1	-1	-1	-1	-1	-1	-1
Wheat	375	-379	-575	-40	-38	-37	-36	-34	-33	-32
OthBrdAcrCrp	195	-469	-651	-42	-41	-39	-38	-37	-36	-34
Horticulture	-1	0	0	0	0	0	0	0	0	0
Rice	0	-34	-85	-29	0	1	1	1	1	1
Cotton	0	-187	-454	-14	-15	-15	-16	-17	-17	-16
HayCerealFod	30	-42	-125	-10	-10	-10	-10	-9	-9	-9
ForestFish	0	0	-1	0	1	1	1	1	1	1
GinnedCotton	2	-133	-331	14	10	8	6	5	4	3
AgriSrvces	12	-29	-73	-1	-1	-1	-2	-2	-2	-2
Mining	-12	35	89	17	14	12	11	10	9	9
MeatProds	-5	14	-2	6	4	3	3	2	2	2
Seafood	0	0	0	0	0	0	0	0	0	0
DairyProds	3	-4	-9	-1	-1	-1	-1	-1	-1	-1
OtherFood	25	-25	-61	-13	-12	-11	-10	-9	-8	-7
TCFs	-1	3	8	3	2	2	2	2	2	2
OthManuf	-23	60	163	46	34	27	22	18	15	14
Utilities	4	-12	-31	2	1	1	0	0	0	-1
Constructn	40	-117	-289	39	35	29	24	20	17	14
Trade	69	-158	-379	23	16	9	4	1	-2	-4
HotelsCafes	7	-28	-77	11	9	6	5	4	3	2
RoadFreight	29	-46	-95	-3	-2	-3	-3	-4	-4	-4
OthTransport	8	-26	-66	4	5	4	3	3	2	2
OthService	55	-147	-362	147	103	74	54	40	30	23
OwnerDwellng	0	6	-10	-48	-44	-40	-37	-34	-31	-28
GovAdmDefOrd	16	-61	-160	24	17	11	7	5	3	2
EduHealth	-4	11	41	72	51	37	28	21	16	13

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

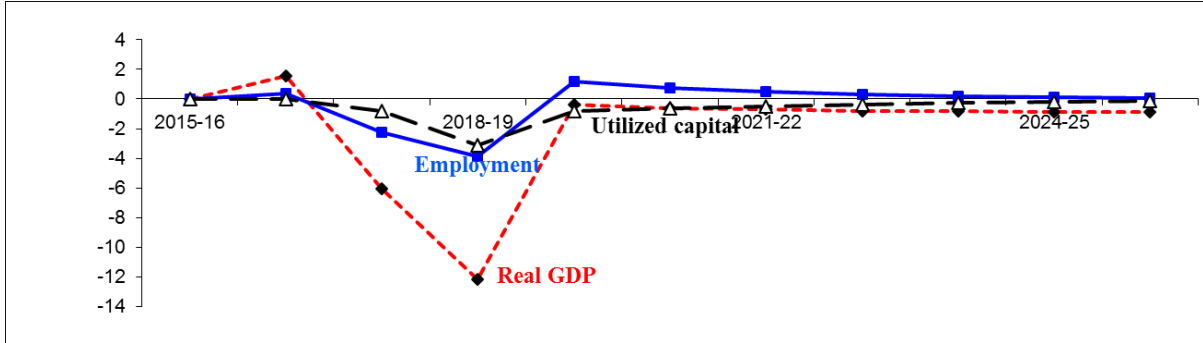
New England-North West

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)

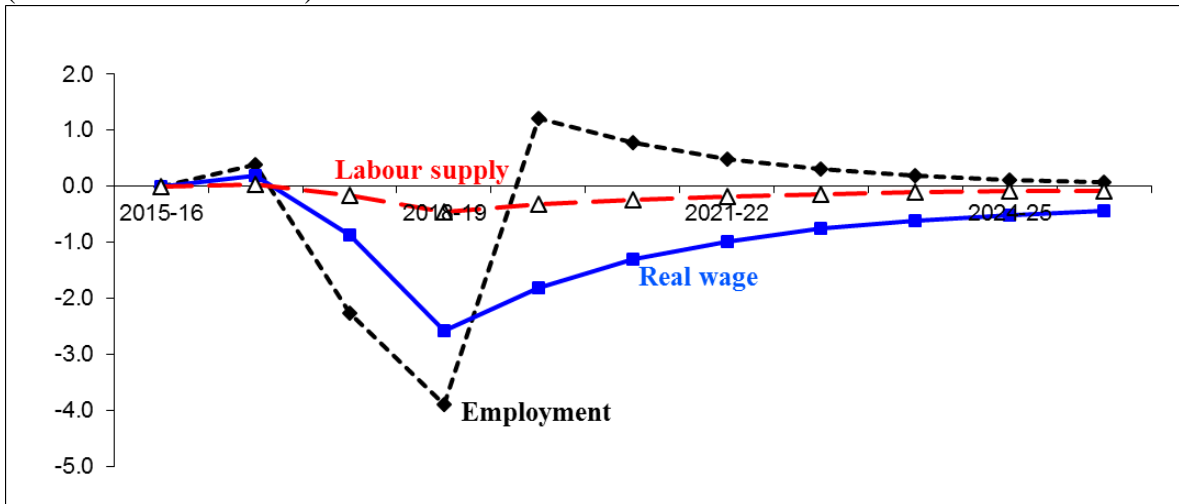
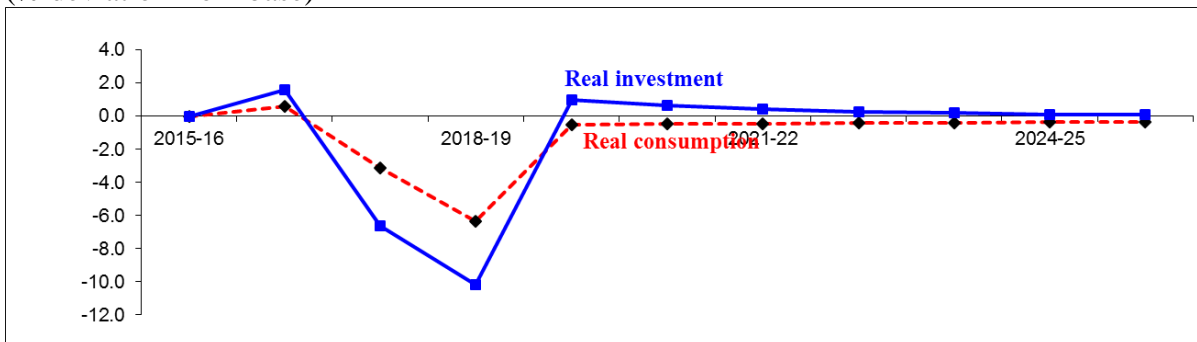


Figure 12: New England-North West real consumption and investment

(% 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	-0.3	-1.9	0.2	0.1	0.0	-0.1	-0.1	-0.1	-0.1
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	-1.1	-3.5	0.1	-0.1	-0.2	-0.2	-0.2	-0.3	-0.3
Glen Innes	0.5	-1.1	-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	0.2	0.1	0.1	0.0
Inverell Region - East	1.1	-4.1	-9.6	-0.6	-0.8	-0.9	-0.9	-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	-1.1	-2.0	0.2	0.0	-0.1	-0.1	-0.2	-0.2	-0.2
Moree	1.6	-9.4	-20.0	-0.6	-0.8	-1.0	-1.1	-1.2	-1.2	-1.2
Moree Region	10.2	-31.7	-50.9	-4.4	-4.5	-4.5	-4.5	-4.5	-4.5	-4.5
Narrabri	1.0	-6.7	-17.5	-0.8	-1.0	-1.1	-1.2	-1.3	-1.3	-1.3
Narrabri Region	4.3	-20.2	-40.6	-2.5	-2.8	-2.9	-3.0	-3.0	-3.1	-3.1
Gunnedah	0.3	-1.7	-4.1	0.4	0.1	0.0	-0.1	-0.1	-0.2	-0.2
Gunnedah Region	2.9	-14.1	-29.5	-2.2	-2.3	-2.4	-2.5	-2.5	-2.5	-2.5
Quirindi	2.9	-9.2	-15.1	-1.0	-1.1	-1.2	-1.3	-1.3	-1.3	-1.3
Tamworth - East	0.3	-0.4	-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	0.1	0.0	0.4	0.2	0.1	0.0	0.0	0.0	0.0
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	-1.4	-2.8	1.3	0.9	0.6	0.4	0.2	0.2	0.1
Glen Innes	0.4	-1.1	-1.3	1.3	0.8	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	-0.7	-0.6	1.2	0.7	0.5	0.3	0.2	0.1	0.1
Inverell Region - West	0.5	-3.0	-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	-5.7	-12.5	1.3	0.8	0.5	0.3	0.2	0.1	0.1
Moree Region	1.0	-9.9	-16.0	0.3	0.0	-0.2	-0.3	-0.4	-0.4	-0.4
Narrabri	0.4	-3.6	-7.5	1.1	0.7	0.4	0.2	0.1	0.0	0.0
Narrabri Region	0.4	-8.8	-19.0	1.0	0.5	0.2	0.0	-0.1	-0.1	-0.2
Gunnedah	0.1	-0.7	-0.8	1.4	0.9	0.6	0.5	0.3	0.3	0.2
Gunnedah Region	0.4	-4.0	-6.9	0.8	0.4	0.1	0.0	-0.1	-0.2	-0.2
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	-0.6	-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	-0.4	-0.5	1.3	0.9	0.6	0.4	0.3	0.2	0.1
Tamworth Region	0.4	-0.9	-0.9	1.3	0.8	0.6	0.4	0.3	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)

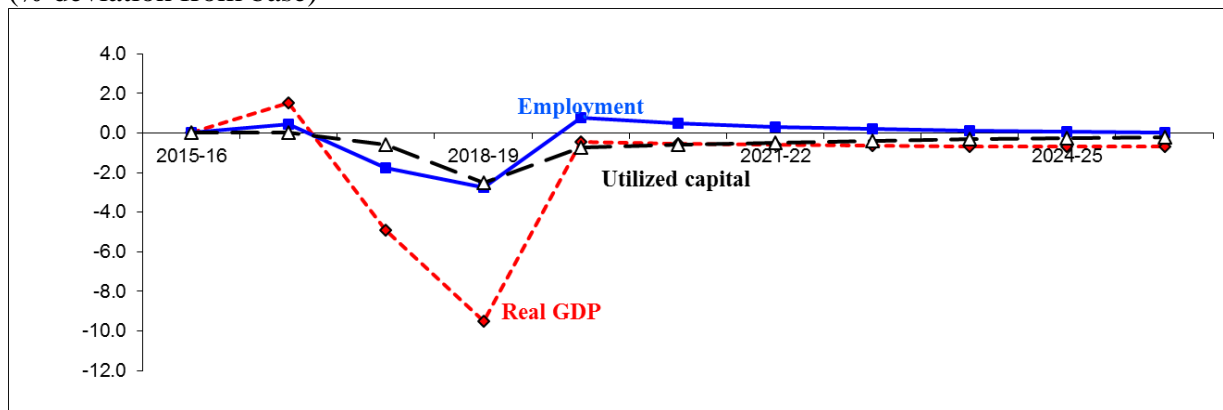


Figure 14: Far West-Orana labour market
(% deviation from base)

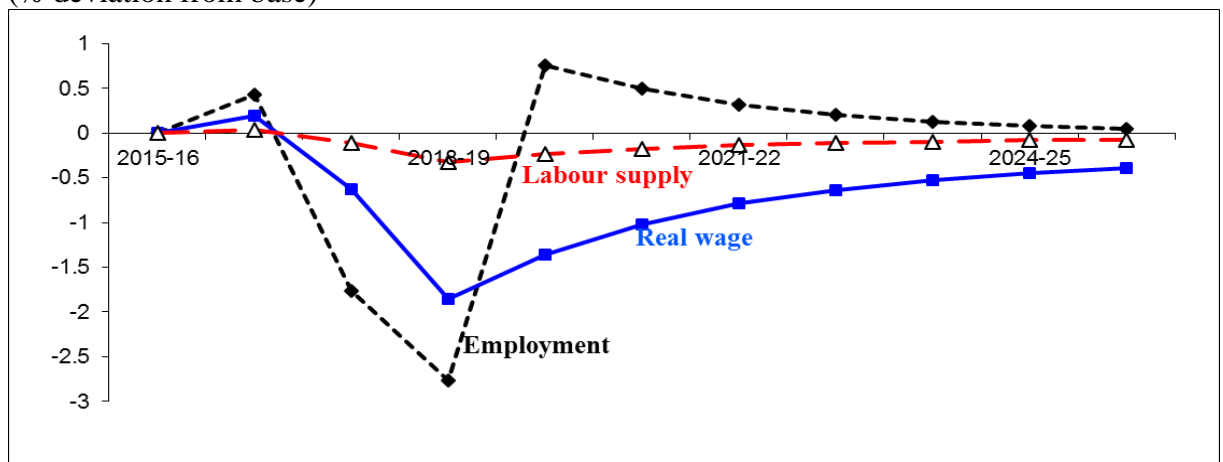


Figure 15: Far West-Orana real consumption and investment
(% deviation from base)

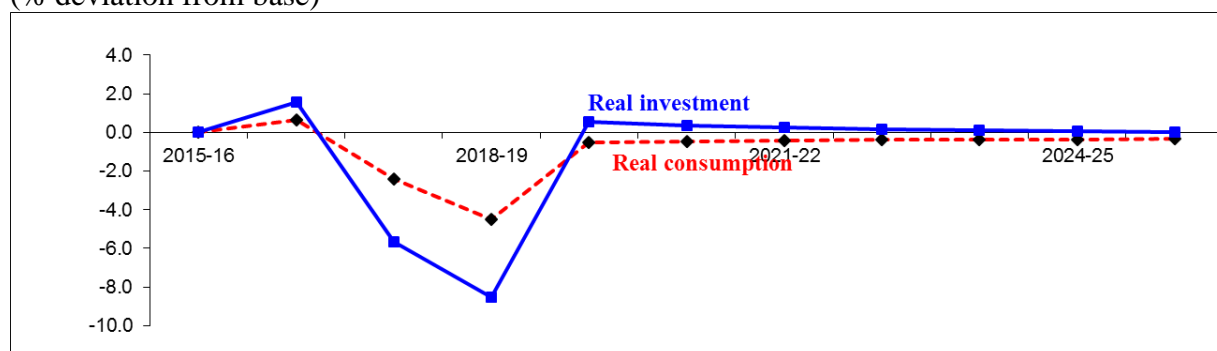


Table 5: SA2 level macro outcomes within Far West-Orana
(% change from base)

	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	-4.5	-14.4	-1.1	-1.2	-1.2	-1.3	-1.3	-1.3	-1.3
Cobar	0.7	-1.4	-1.8	0.3	0.2	0.1	0.0	0.0	0.0	0.0
Coonamble	7.1	-17.6	-27.4	-2.2	-2.2	-2.2	-2.2	-2.2	-2.2	-2.2
Nyngan - Warren	2.7	-13.8	-33.4	-2.8	-2.9	-2.9	-2.9	-3.0	-3.0	-3.0
Walgett - Lightning Ridge	5.1	-15.9	-26.9	-1.9	-2.0	-2.1	-2.1	-2.1	-2.1	-2.1
Broken Hill	0.1	0.0	0.1	0.5	0.3	0.2	0.2	0.1	0.1	0.1
Far West	0.0	-0.1	-3.9	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	-13.0	-17.8	-1.1	-1.2	-1.2	-1.2	-1.2	-1.2	-1.2
Narromine	3.6	-14.3	-27.1	-1.8	-1.9	-2.0	-2.0	-2.0	-2.0	-2.0
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	-2.1	-4.1	0.6	0.3	0.1	0.0	0.0	-0.1	-0.1
Cobar	-0.1	0.3	1.1	1.0	0.8	0.6	0.4	0.4	0.3	0.3
Coonamble	0.9	-5.2	-7.6	0.4	0.2	0.1	0.0	-0.1	-0.1	-0.1
Nyngan - Warren	0.7	-2.2	-2.2	-0.2	-0.4	-0.6	-0.6	-0.7	-0.7	-0.7
Walgett - Lightning Ridge	0.7	-5.2	-8.9	0.5	0.3	0.1	0.0	0.0	-0.1	-0.1
Broken Hill	0.2	-0.2	0.1	1.0	0.7	0.5	0.4	0.3	0.2	0.2
Far West	0.0	-0.1	-1.7	0.9	0.7	0.5	0.4	0.3	0.2	0.2
Coonabarabran	0.5	-1.9	-3.1	0.8	0.5	0.4	0.3	0.2	0.1	0.1
Dubbo - East	0.4	-0.9	-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	0.2	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	-1.8	-2.8	0.8	0.5	0.4	0.2	0.2	0.1	0.1
Gilgandra	0.9	-4.4	-6.8	0.7	0.4	0.3	0.2	0.1	0.1	0.0
Narromine	0.8	-6.4	-12.1	0.5	0.3	0.1	0.0	-0.1	-0.1	-0.1
Wellington	0.5	-1.6	-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)

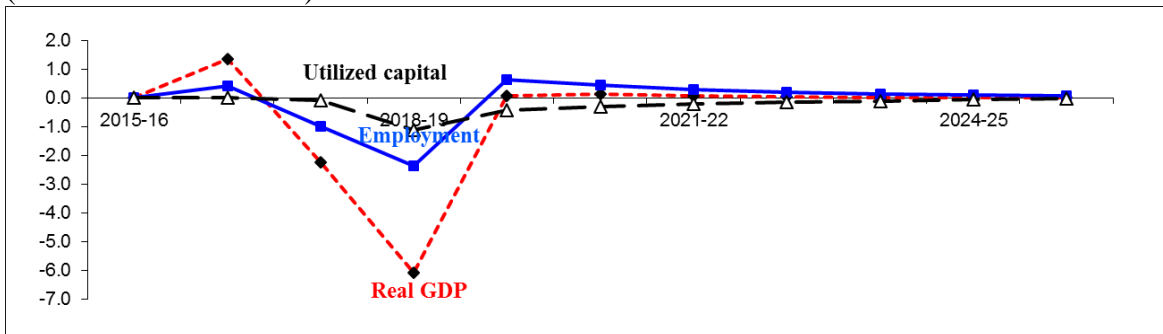


Figure 14: Murray labour market
(% deviation from base)

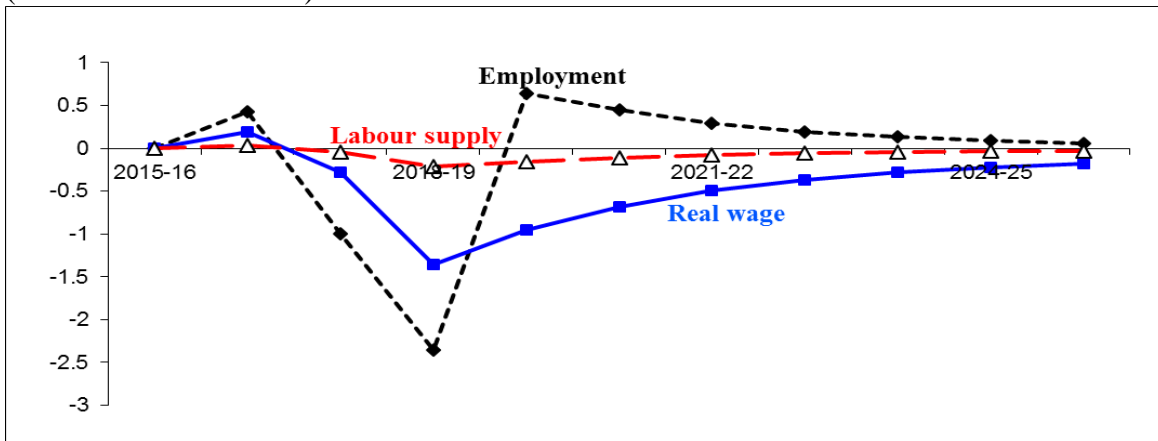


Figure 15: Murray real consumption and investment
(% deviation from base)

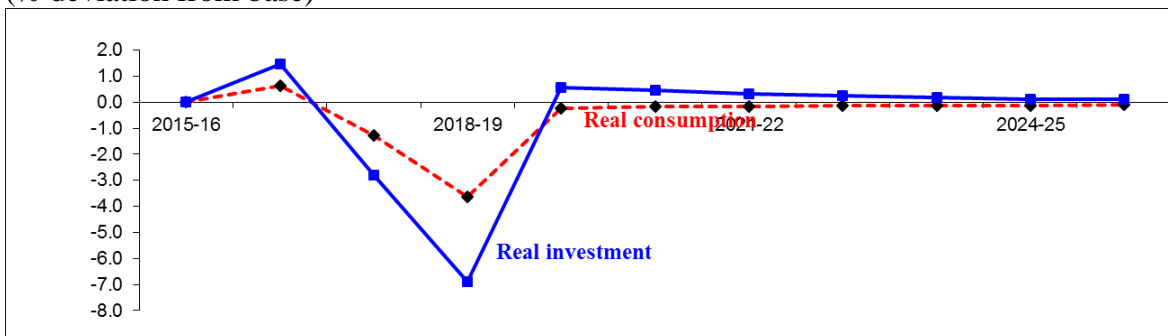


Table 6: SA2 level macro outcomes within Murray
(% change from base)

	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	-0.4	-0.9	0.4	0.3	0.2	0.2	0.1	0.1	0.1
Albury - North	0.2	-0.5	-1.4	0.3	0.4	0.3	0.2	0.2	0.2	0.2
Albury - South	0.1	-0.4	-1.2	0.3	0.3	0.3	0.2	0.2	0.1	0.1
Albury Region	1.7	-2.0	-6.1	0.0	0.1	0.0	0.0	-0.1	-0.1	-0.1
Lavington	0.2	-0.4	-1.2	0.3	0.4	0.3	0.2	0.2	0.2	0.1
Hay	0.4	-9.4	-20.9	0.3	0.4	0.3	0.3	0.3	0.2	0.2
Wentworth - Buronga	0.5	-0.9	-2.7	0.1	0.3	0.3	0.2	0.2	0.2	0.2
Wentworth-Balranald Reg.	3.6	-3.9	-11.2	-0.2	0.1	0.0	0.0	0.0	0.1	0.1
Corowa	0.4	-1.0	-4.6	0.0	0.2	0.1	0.1	0.1	0.1	0.1
Corowa Region	5.0	-5.8	-14.8	-0.4	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3
Deniliquin	0.9	-1.3	-4.1	0.1	0.2	0.2	0.1	0.1	0.1	0.1
Deniliquin Region	5.9	-6.7	-18.7	-0.8	-0.6	-0.6	-0.7	-0.6	-0.6	-0.6
Moama	0.9	-1.3	-4.2	0.1	0.3	0.2	0.2	0.2	0.2	0.2
Tocumwal - Finley - Jerilderie	3.5	-4.5	-12.1	-0.4	-0.3	-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	-15.7	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)

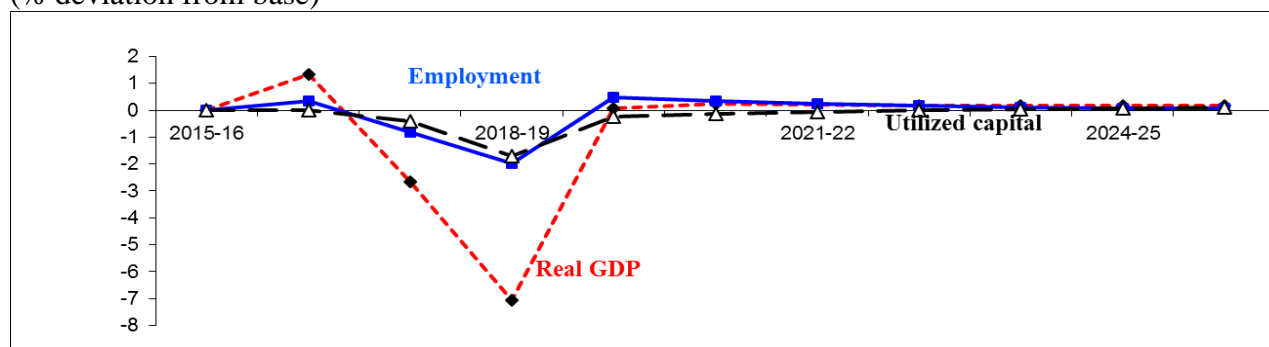


Figure 17: Riverina labour market

(% deviation from base)

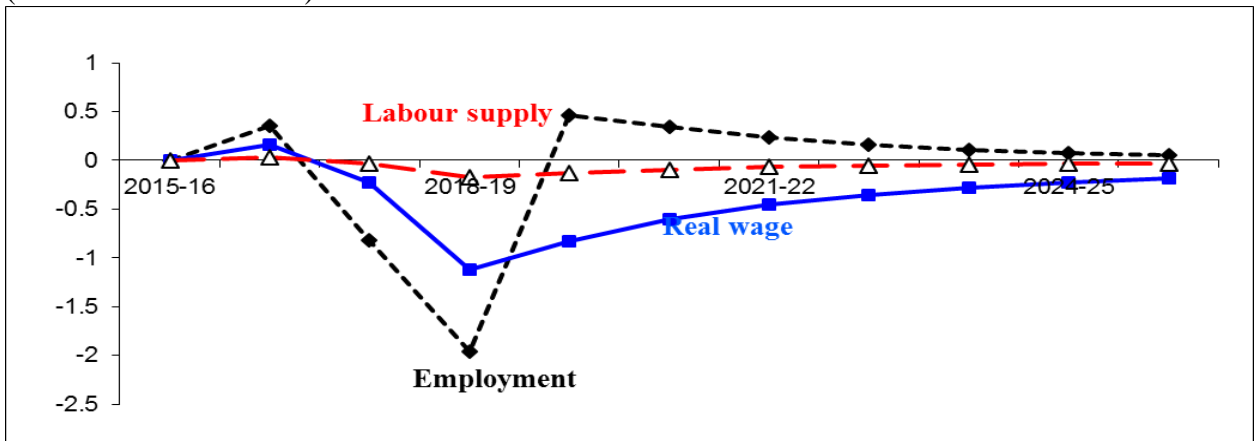


Figure 18: Riverina real consumption and investment

(% deviation from base)

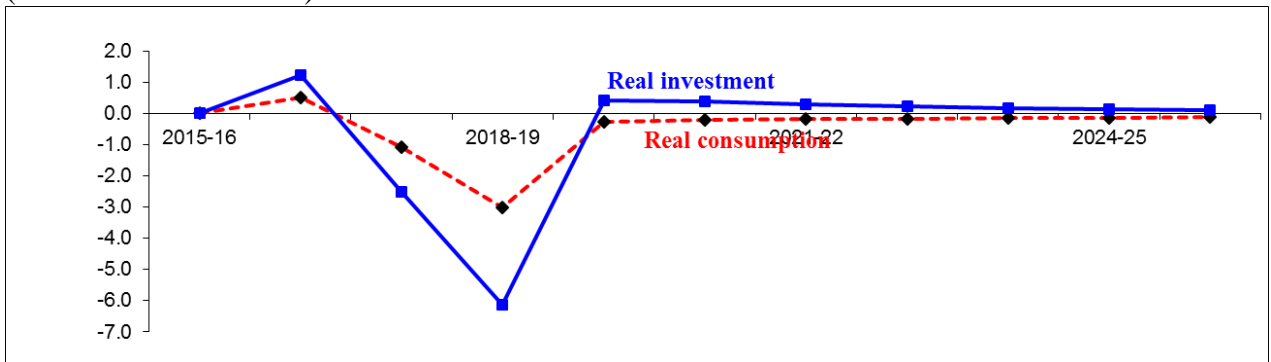


Table 7: SA2 level macro outcomes within Riverina
(% change from base)

	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	-8.3	-18.9	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	-14.7	-0.4	0.1	0.1	0.1	0.1	0.1	0.1
Tumbarumba	0.1	-1.1	-4.8	0.0	0.5	0.5	0.5	0.5	0.5	0.5
Tumut	0.1	-0.8	-2.8	0.2	0.6	0.5	0.5	0.5	0.5	0.4
Tumut Region	0.1	-1.0	-3.9	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	-7.3	-0.1	0.6	0.6	0.6	0.6	0.6	0.6
Junee	2.3	-3.1	-8.9	-0.1	0.3	0.2	0.2	0.2	0.2	0.2
Temora	5.5	-7.2	-17.7	-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	-3.5	-6.4	0.0	-0.1	-0.2	-0.2	-0.3	-0.3	-0.3
Leeton	0.4	-0.3	-0.8	0.4	0.3	0.2	0.1	0.1	0.1	0.0
Narrandera	0.5	-0.9	-3.7	0.5	0.4	0.3	0.2	0.2	0.2	0.2
Tumbarumba	0.2	0.2	-0.4	0.6	0.5	0.4	0.3	0.2	0.2	0.2
Tumut	0.2	0.0	-0.2	0.6	0.5	0.4	0.3	0.2	0.2	0.2
Tumut Region	0.2	0.1	-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	0.3	-1.1	0.5	0.5	0.4	0.3	0.2	0.2	0.2
Junee	0.3	-0.4	-1.8	0.5	0.4	0.3	0.2	0.2	0.2	0.1
Temora	0.7	-1.5	-4.9	0.5	0.4	0.3	0.2	0.2	0.1	0.1
Wagga Wagga - East	0.3	-0.4	-0.9	0.6	0.4	0.3	0.2	0.1	0.1	0.1
Wagga Wagga - North	0.3	-0.1	-0.8	0.5	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)

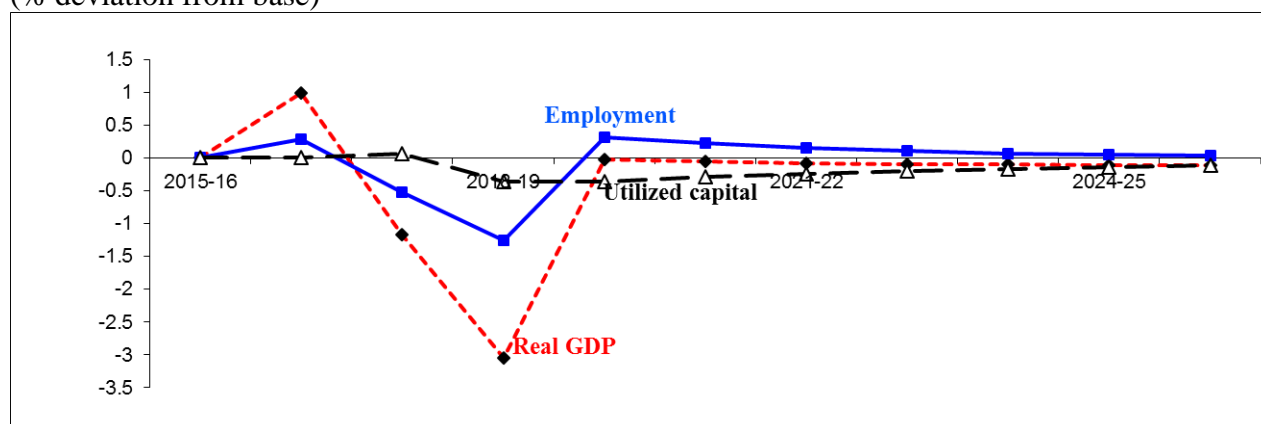


Figure 20: Central West labour market
(% deviation from base)

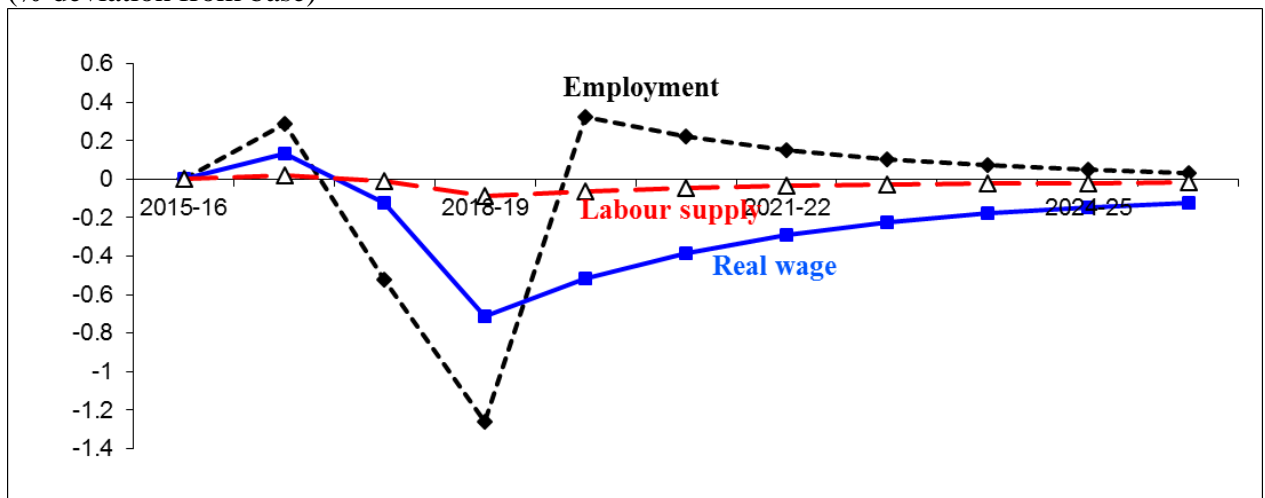


Figure 21: Central West real consumption and investment
(% deviation from base)

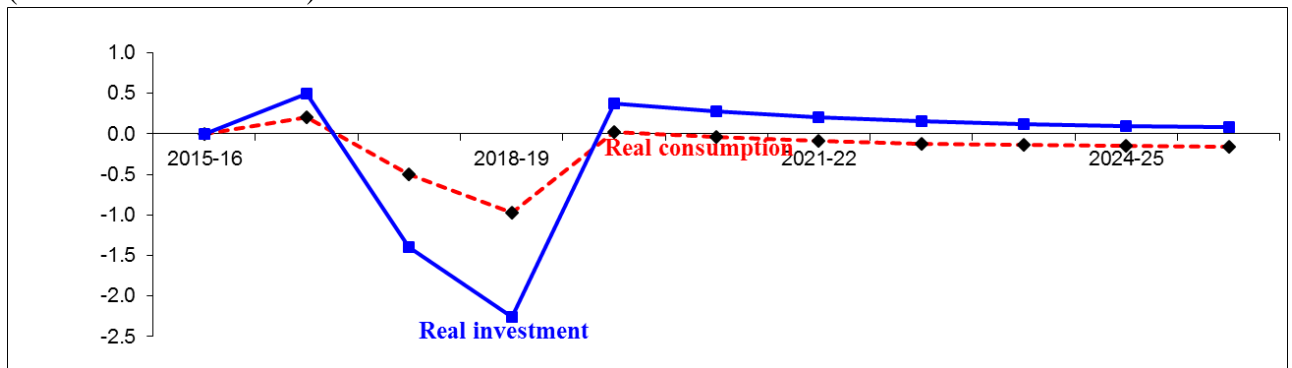


Table 8: SA2 level macro outcomes within Central West
(% change from base)

	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	-18.8	-0.6	-0.6	-0.6	-0.6	-0.6	-0.6	-0.5
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	-0.4	-0.4	-0.4	-0.4
Grenfell	7.5	-7.9	-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
Wollangambe - Wollemi	0.2	-0.3	-1.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0
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	-5.2	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	0.0	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	-2.6	-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	-5.8	0.2	0.2	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	0.3	0.2	0.1	0.1	0.1	0.1
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	0.1	0.0
Wollangambe - Wollemi	0.2	-0.4	-0.8	0.3	0.2	0.2	0.1	0.1	0.1	0.0

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

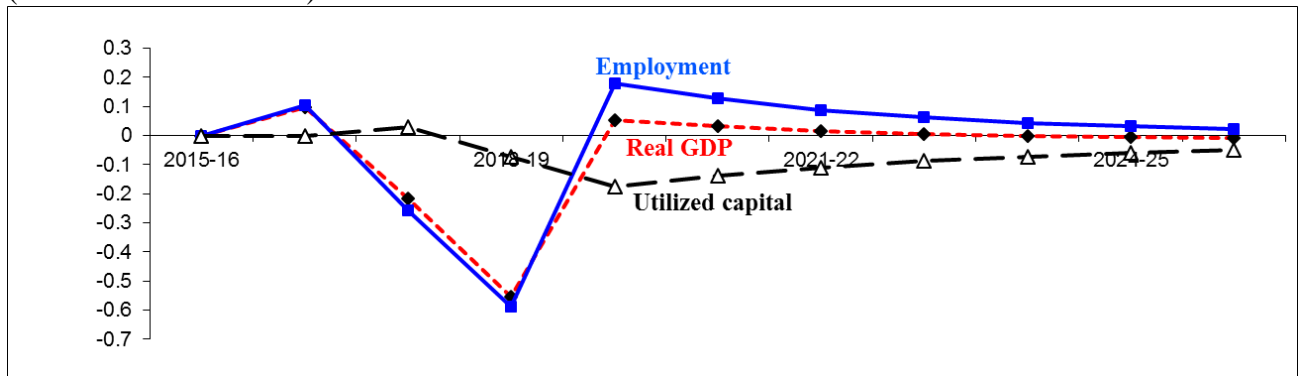


Figure 20: Southern Highlands-Shoalhaven labour market
(% deviation from base)

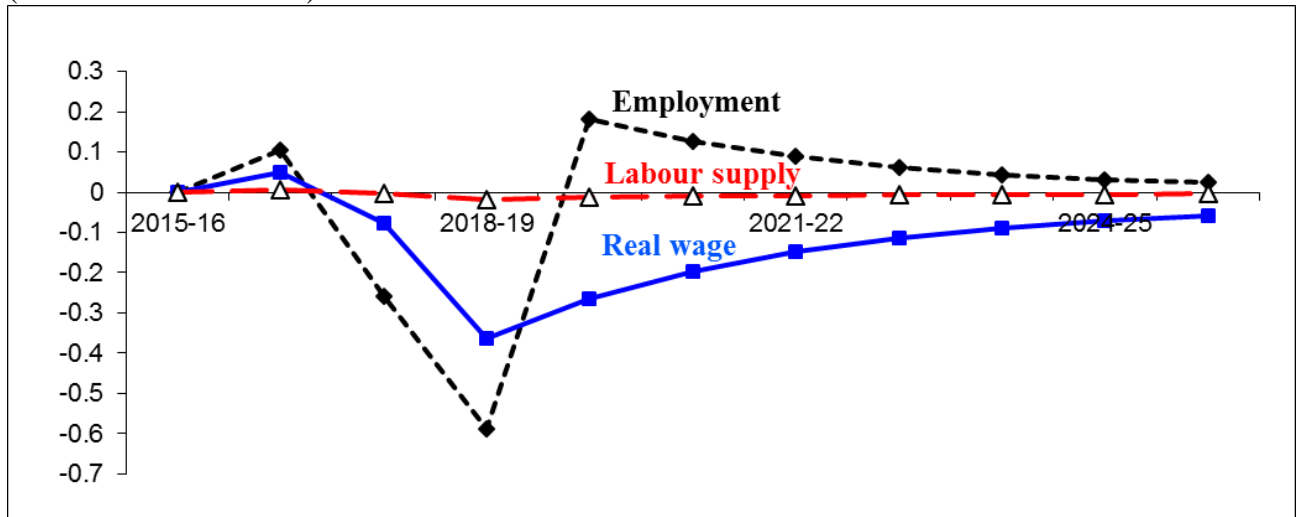


Figure 21: Southern Highlands-Shoalhaven real consumption and investment
(% deviation from base)

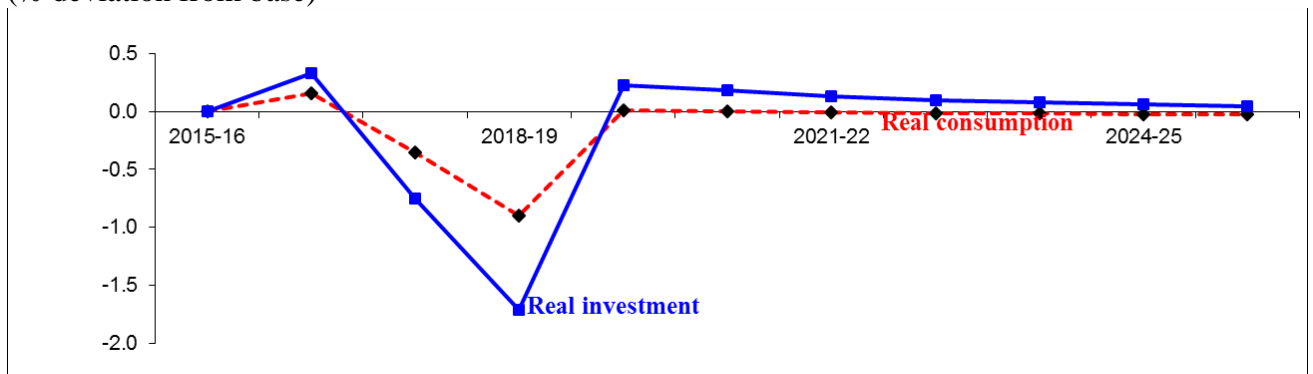


Figure 22: Hunter exc. Newcastle real GDP income side
(% deviation from base)

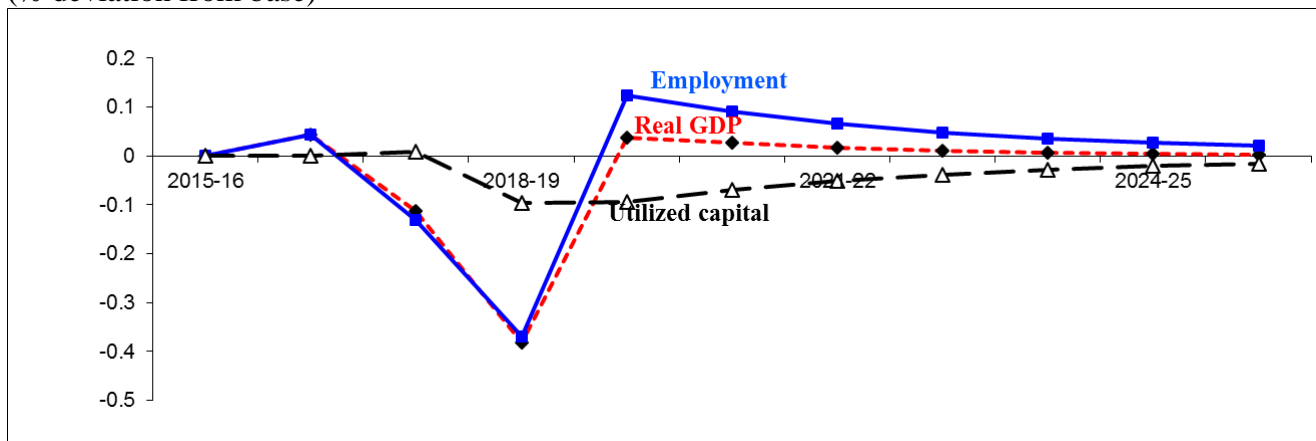


Figure 23: Hunter exc. Newcastle labour market
(% deviation from base)

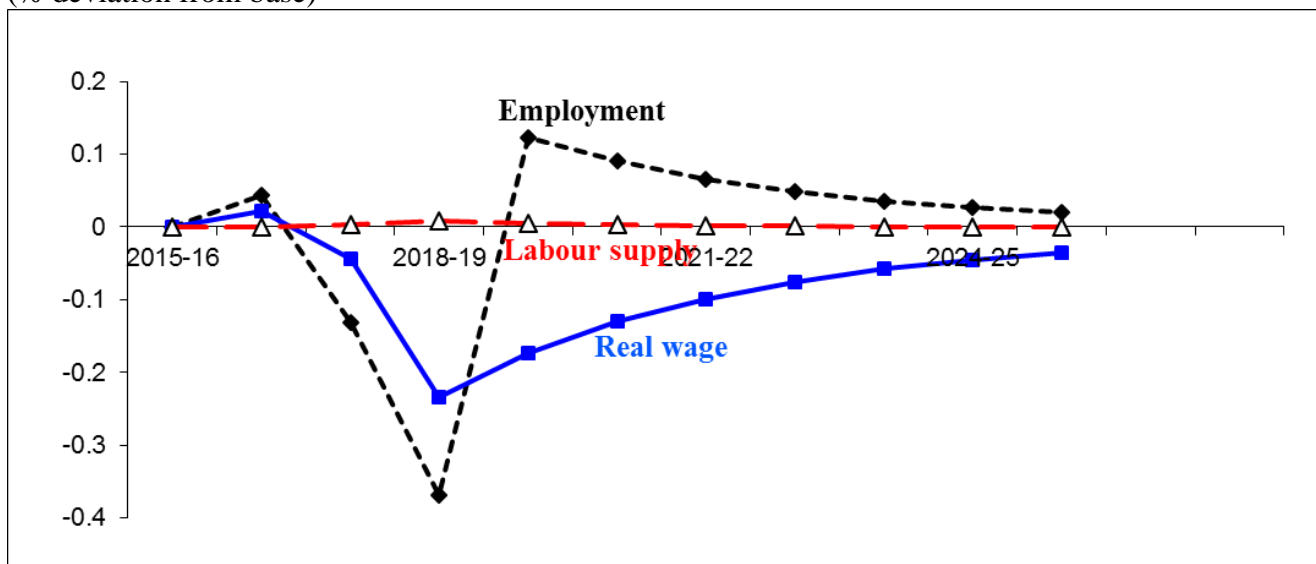
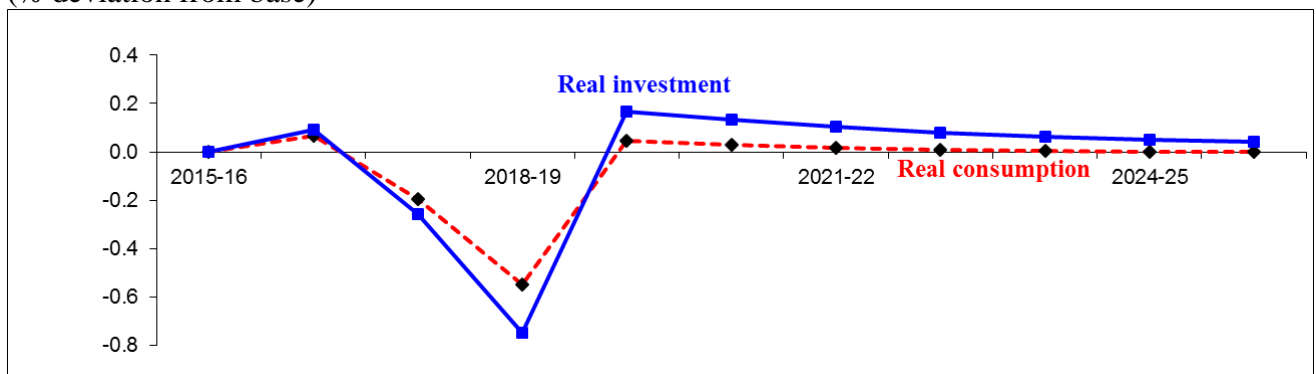


Figure 24: Hunter exc. Newcastle real consumption and investment
(% deviation from base)



Appendix A

VU-TERM version for NSW

Part 1

What is a computable general equilibrium (CGE) model?

A CGE model can be an economy-wide model. In the context of VU-TERM, it is an economy-wide model that also includes small-region representation. Unlike an input-output model which solves either for quantities or for prices, but not both at once, a CGE model solves for both prices and quantities together.

CGE models can be either comparative static or dynamic. Comparative static models are easier to run than dynamic models. However, comparative static results are in some respects harder to explain. Results are reported as changes from a base case – at some point in the future. The only base case defined in a comparative static model is the initial database.

In dynamic models, we prepare a forecast baseline. This may include forecast increases in macroeconomic variables, technological change and taste changes. For example, agricultural productivity historically has grown by 1 to 2% per annum, so productivity growth of this magnitude is imposed on the forecast baseline.

In this study, we use dynamics to take the timeline of the NSW drought. The relatively good year of 2016 was followed by a drought which started in the northern part of the state in 2017 and spread state-wide in 2018. Results are presented relatively to a business-as-usual baseline which includes “average” seasonal conditions.

Dynamic CGE modelling

Dynamic models trace the effects of ascribed direct impacts across time periods. The theoretical basis of dynamics is in linkages between investment and capital across time, and the balance of trade and net foreign liabilities. Investment and balance of trade outcomes are flows that a comparative static model includes. Capital and net foreign liabilities are stocks that require a dynamic model.

The importance of these dynamic linkages is evident in project analysis. For example, drought recovery may include a phase of elevated investment and regional aggregate consumption. Investment may be funded by additional borrowing from foreigners, thereby adding to net foreign debt. We need to account for changes in interest payments to foreigners when calculating the spending power of Australian residents arising from a given level of income.

Dynamic VU-TERM combines much of the theory of dynamic national models (see Dixon and Rimmer, 2002) with bottom-up, regional representation. That is, each region in VU-TERM has its own production functions, household demands, input-output database and inter-regional trade matrices. This enables us to model relatively local issues.

Dynamic VU-TERM

TERM was originally developed by Mark Horridge at the Centre of Policy Studies (see <http://www.monash.edu.au/policy/term.htm>). Since then, Glyn Wittwer has developed a dynamic version of the model, an application of which Wittwer *et al.* (2005) is an example.

In dynamic VU-TERM, we use an underlying forecast. This may be based on the macro forecasts of other agencies. The underlying forecast or baseline gives us a year-by-year “business as usual” case.

Typical variables to be reported in the policy scenario relative to a baseline forecast are regional real GDP, employment and aggregate consumption. Industry level results are also available.

Part 2

Figure A1: Regions in this application of VU-TERM

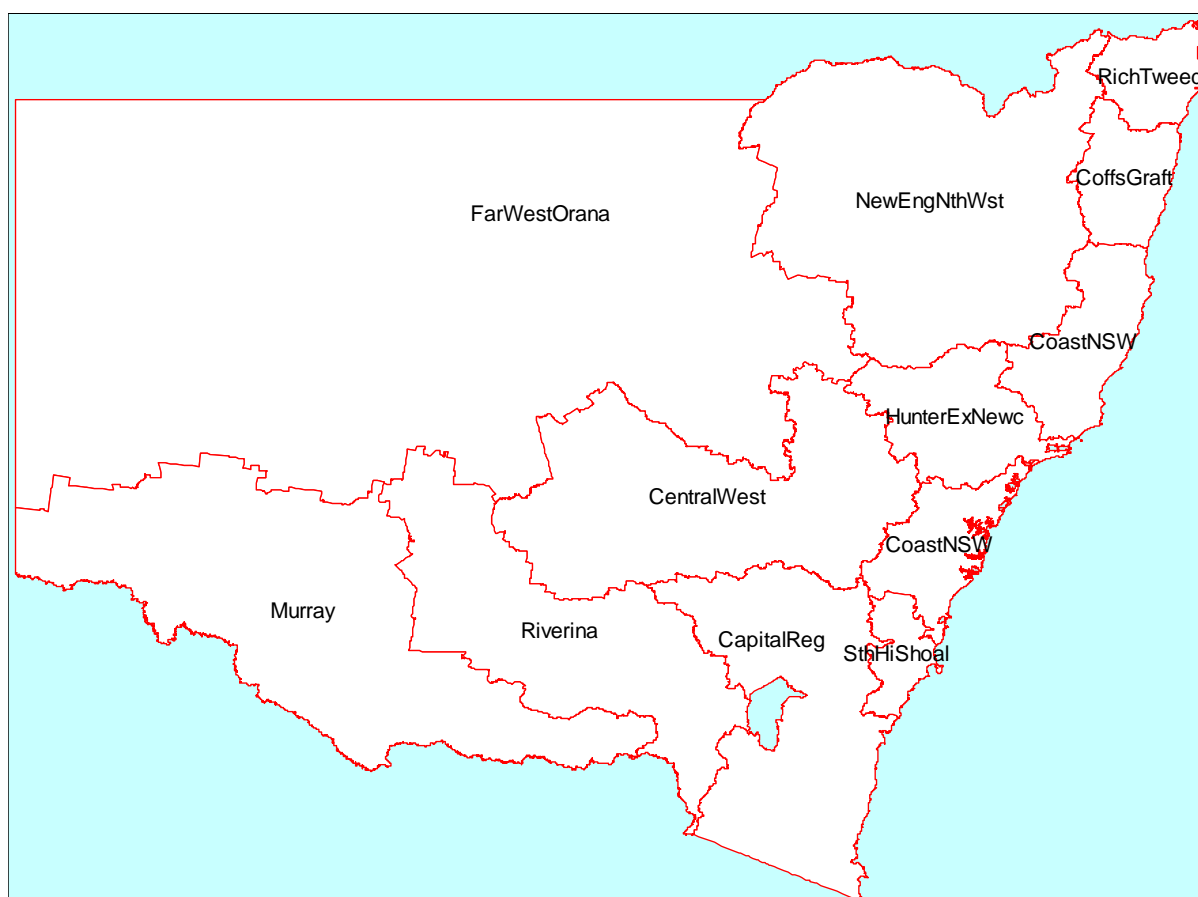


Figure A1 shows the bottom-up regions in this study. Essentially, away from a coastal composite that includes Sydney, Wollongong and Newcastle, the bottom-up regions are SA4 regions.

Industry/commodity sectors in master database of VU-TERM

In practice, both the regional and industry/commodity dimensions of the master database of VU-TERM are aggregated so as to reflect the emphasis of a particular project.

The following table contains the full list of 182 sectors in the master database.

Table A1: Industries/commodities in VU-TERM

Sheep	MeatProds	OthManuf (cont.)	Trade	OthService (cont.)
BeefCattle	Seafood	<i>IronSteel</i>	<i>WholesaleTrd</i>	<i>CommntyHlth</i>
DairyCattle	DairyProds	<i>Alumina</i>	<i>RetailTrade</i>	<i>ChildCareSrv</i>
OthLivestock	OtherFood	<i>Aluminium</i>	HotelsCafes	<i>LbryMuseumArt</i>
<i>Poultry</i>	<i>FruitVeg</i>	<i>OthNonFeMtl</i>	<i>Accommodation</i>	<i>SportRecreat</i>
<i>OthLivestock</i>	<i>OilsFats</i>	<i>ForgedFeStl</i>	<i>Restaurant</i>	<i>Gambling</i>
Wheat	<i>FlourCereals</i>	<i>StrucMetlPrd</i>	RoadFreight	<i>AutoRepairs</i>
Rice	<i>Bakery</i>	<i>SheetMetlPrd</i>	OthTransport	<i>OtherRepairs</i>
Cotton	<i>SugarConfect</i>	<i>FabrcMetlPrd</i>	<i>RoadPassngr</i>	<i>HrDresBeauty</i>
HayCerealFod	<i>OtherFood</i>	<i>MVPOthTrnEq</i>	<i>RailFreight</i>	<i>OthPrsSrv</i>
OthCrops	<i>SoftDrinks</i>	<i>ShipsBoats</i>	<i>UrbanRailway</i>	<i>ReligiousOrg</i>
<i>Barley</i>	<i>BeerMalt</i>	<i>RailwayEquip</i>	<i>InterUrbRail</i>	<i>IntrstGrpNEC</i>
<i>Oats</i>	<i>WineSpirTob</i>	<i>Aircraft</i>	<i>WaterTrnsprt</i>	<i>DomHHServce</i>
<i>OthGrainLegu</i>	TCFs	<i>PhotSciIEEq</i>	<i>AirTransport</i>	<i>OthService</i>
<i>SugarCane</i>	<i>TextileManu</i>	<i>ElectricEqp</i>	<i>Pipeline</i>	OwnerDwelling
<i>OtherAgriclt</i>	<i>LeatherProds</i>	<i>HouseholdApp</i>	<i>TransprtSrv</i>	GovAdmDefOrd
<i>OthVegetble</i>	<i>TextileProds</i>	<i>OthMachEquip</i>	<i>PostCourier</i>	<i>FedGovAdmSrv</i>
<i>Potatoes</i>	<i>KnittingMill</i>	<i>Furniture</i>	OthTransport	<i>StaGovAdmSrv</i>
<i>Grapes</i>	<i>Clothing</i>	<i>OtherManufac</i>	<i>CommunicSrvc</i>	<i>LocGovAdmSrv</i>
<i>BerriesAll</i>	<i>Footwear</i>	Utilities	<i>FilmSndRcrd</i>	<i>Defence</i>
<i>ApplesPears</i>	OthManuf	<i>ElecCoalBlac</i>	<i>Broadcasting</i>	<i>PoliceCrctnl</i>
<i>Stonefruit</i>	<i>SawmillProds</i>	<i>ElecCoalBrow</i>	<i>Internet</i>	<i>OthPublicOrd</i>
<i>Citrusfruit</i>	<i>OthWoodProds</i>	<i>ElecGas</i>	<i>Telecomms</i>	<i>Firebrigades</i>
<i>Olives</i>	<i>PulpPaper</i>	<i>ElecOil</i>	<i>LibraryInfo</i>	Education
<i>Bananas</i>	<i>PaperProds</i>	<i>ElecNuclear</i>	<i>Finance</i>	<i>Preschool</i>
<i>Orchardfruit</i>	<i>Printing</i>	<i>ElecHydro</i>	<i>Insurance</i>	<i>PrimSchool</i>
<i>AlmondMacad</i>	<i>Petrol</i>	<i>ElecBiomass</i>	<i>Superannuatn</i>	<i>SecdrySchool</i>
ForestFish	<i>OthPetrlPrd</i>	<i>ElecBiogas</i>	<i>FinanceSrvce</i>	<i>ArtSptOthEdu</i>
<i>Aquaculture</i>	<i>Diesel</i>	<i>ElecWind</i>	OthService	<i>TechVocEduc</i>
<i>ForestryLogs</i>	<i>AviationFuel</i>	<i>ElecTranDist</i>	<i>RentHire</i>	<i>TertiaryEdu</i>
<i>FishingHunt</i>	<i>RefinedLPG</i>	<i>GasSupply</i>	<i>OthPrprtySvc</i>	Health
GinnedCotton	<i>BasicChemicl</i>	<i>WaterDrains</i>	<i>ArchEngScSvc</i>	<i>HospitalNurs</i>
AgriSrvces	<i>HumPharmac</i>	<i>WasteTmtDsp</i>	<i>LegalSrv</i>	<i>GPs</i>
Mining	<i>OthPharmac</i>	Constructn	<i>AccountngSrv</i>	<i>SpecialistSv</i>
<i>CoalBlack</i>	<i>SoapsCosmtc</i>	<i>ResidBuildng</i>	<i>PrfSrvNEC</i>	<i>PathologySvc</i>
<i>CoalBrown</i>	<i>PlasticProds</i>	<i>NonResBldCns</i>	<i>ComputerSrv</i>	<i>DentalSrv</i>
<i>Oil</i>	<i>RubberProds</i>	<i>CvlEngCnstct</i>	<i>EmpTrvOthAdm</i>	<i>OpmetryOptic</i>
<i>LNG</i>	<i>GlassProds</i>	<i>ConstrucSrvc</i>	<i>SupportSrv</i>	<i>OtherHealth</i>
<i>Gas</i>	<i>CeramicProds</i>			<i>AmbulanceSrv</i>
<i>IronOres</i>	<i>CementLime</i>			
<i>Bauxite</i>	<i>PlasterEtc</i>			
<i>NonFeOres</i>	<i>ONmtlMinProd</i>			
<i>OtherMining</i>				
<i>MiningSrvces</i>				

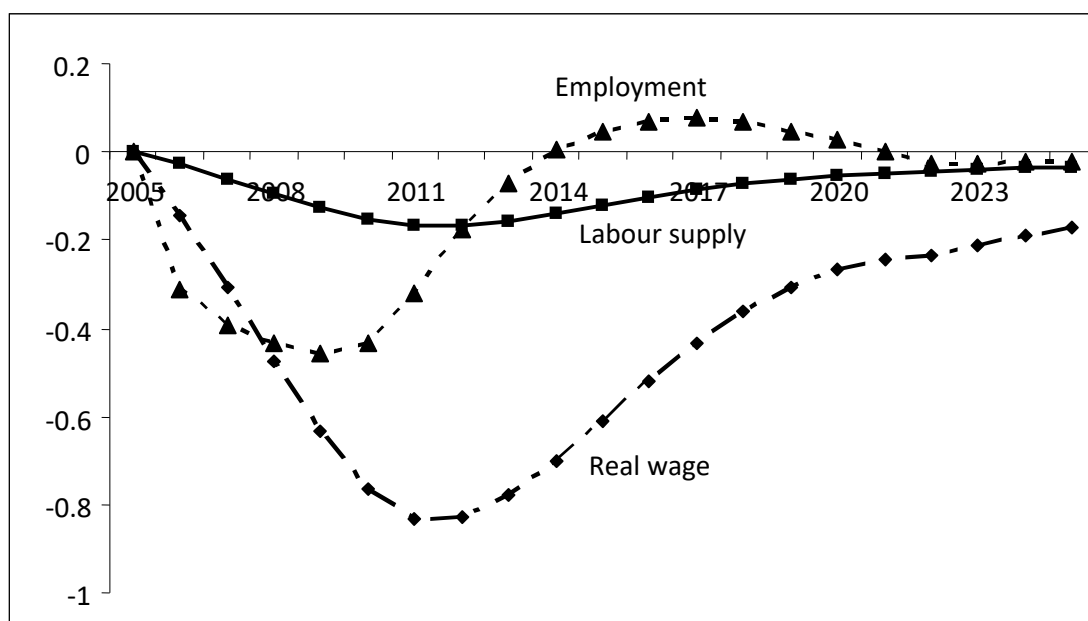
* **Bold red** denotes sectors with a one-to-one mapping from the master database, **bold black** the aggregated sectors and *italicised* sectors the master database sectors that are aggregated.

Labour market – forecast v. policy scenario

In the theory of regional labour market adjustment, if regional labour market conditions improve or deteriorate relative to forecast, adjustment occurs in the short term mainly via changes in employment. Regional wages adjust sluggishly, with gradual adjustment in regional labour market supply (i.e., through migration between regions). Real wages will fall or rise to close the gap between employment and slowly adjusting labour supply. Once the deviation in employment is equal to the deviation in labour supply, real wages reach a turning

point (either they bottom out, in the case of a weakening labour market, or peak, in the case of strengthened labour market conditions). Within this theory, adjustment in the longer term occurs via a combination of altered regional labour supply and real wages that deviate relative to those in other regions. Figure A2 shows an example, in which weakened labour market conditions in a region lead to unemployment in the short run and a lower real wage in the region in the long run.

Figure A2: An example of a weakened regional labour market with eventual recovery (% change from forecast)



Production technologies

VU-TERM contains variables describing: primary-factor and intermediate-input-saving technical change in current production; input-saving technical change in capital creation; and input-saving technical change in the provision of margin services (e.g. transport and retail trade).

VU-TERM's unique treatment of transport to assess the regional benefits of the project

The supply of margins originating in one region can lower the costs of moving goods between regions further afield. Previous multi-regional models (for example, Naqvi and Peter, 1996) assign the margins supply of a sale either to the origin or destination of the sale.

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.
- Naqvi, F. & Peter, M. (1996). A multiregional, multisectoral model of the Australian economy with an illustrative application. *Australian Economic Papers*, 35, 94-113.
- 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. (2009), "The economic impacts of a new dam in South-east Queensland", *Australian Economic Review*, 42(1):12-23, March.
- Wittwer, G. and Griffith, M. (2011), "Modelling drought and recovery in the southern Murray-Darling basin", *Australian Journal of Agricultural and Resource Economics*, 55(3): 342-359.
- Wittwer, G., McKirdy, S. and Wilson, R. (2005), "The regional economic impacts of a plant disease incursion using a general equilibrium approach", *Australian Journal of Agricultural and Resource Economics* 49(1): 75-89, March.
- Wittwer, G. (2012) (editor), *Economic Modeling of Water: The Australian CGE Experience*, Springer, Dordrecht, Netherlands (186 pages).
- Wittwer, G. (2014), "Modelling the economic impacts of changing SA Water's pricing. Report prepared for the Essential Services Commission of South Australia." Downloadable at <http://www.escosa.sa.gov.au/library/140711-WaterInquiry-ModellingEconomicImpactsChangingPricing-VicUni-ConsultantReport.pdf>.