Closing the factory doors until better times: CGE modelling of drought using a theory of excess capacity

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Abstract

The aim of this paper is to analyse the regional economic impacts of a prolonged period of recurrent droughts. The model used for analysis is TERM-H2O, a dynamic successor to the bottom-up, comparative static TERM (**T**he **E**normous **R**egional **M**odel). We concentrate on the regions of the southern Murray-Darling basin.

Large change simulations are a challenge for modellers. Drought brings substantial inward supply shifts for farm sectors. This paper outlines various theoretical modifications undertaken to improve the modelling of drought in a computable general equilibrium (CGE) framework and then applies them to the period from 2005–06 on. In particular, we apply a theory of sticky capital adjustment to downstream processing sectors, whereby processors temporarily retire capital in response to scarcer farm products, limiting upward price movements in farm outputs and resulting in more realistic modelling of drought.

Results are explained using a back-of-the-envelope approach. This framework allows us to estimate the economic impacts of allowing water trade. In addition, the approach provides some estimate as to the impact of prolonged drought on structural change in predominantly rural regions of south-eastern Australia.

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Introduction

South-eastern Australia has endured recurrent droughts since that of 2002–03. The 2002–03 drought impacted mainly on dry-land farm production, with the notable of the Goulburn Valley and Murrumbidgee irrigation regions. This meant that the negative impacts of drought were extensive in dry-land agriculture but limited in the irrigation sectors of the Murray-Darling basin. Subsequent droughts led to a worsening picture for irrigators. The alpine regions of Victoria and New South Wales, which are the source of the Murray River, suffered record rainfall deficits in the period from 2006–07 to 2008–09 (figure 1). This resulted in recurrent reductions in water allocations throughout the southern Murray-Darling basin. The Goulburn-Murray water authority's allocations illustrate the severity of the first decade of the new millennium: it aims to provide 100 percent allocations in 97 years out of 100 for the Goulburn system, but has failed to do so in five of the past eight irrigation seasons.

The aim of this paper is to analyse the regional economic impacts of this prolonged period of drought. The model used for analysis is TERM-H2O, a dynamic successor to the bottom-up, comparative static TERM (**T**he **E**normous **R**egional **M**odel) (Horridge *et al*., 2005; Wittwer *et al*., 2005; Wittwer 2009). We concentrate on the regions of the southern Murray-Darling basin. This paper outlines various theoretical modifications undertaken to improve the modelling of drought in a computable general equilibrium (CGE) framework and then applies them to the period from 2005–06 on.

The ongoing drought may have accelerated structural change in the regions of the southern Murray-Darling basin. National Accounts data (ABS 2006) indicate that in 2001–02, agriculture accounted for 3.9 percent of Australia's GDP, down from 5.1 percent two decades earlier, 12.6 percent in 1962–63 and closer to 20 percent after World War II (Maddock and McLean, 1987). Therefore, in attempting to assess the impact of drought, we need to be conscious of the baseline change that would have occurred in the absence of drought.

The CGE approach enables us to keep in context the contribution of agriculture to ostensibly rural economies. As agriculture's contribution to the national economy has shrunk, so too has its contribution to regional Australia's economies. For example, our estimates of regional GDP shares indicate that the southern Murray-Darling basin's contribution from agriculture in 2005–06 was 14 percent, little more than the national share in 1962–63 when Australia's population was half of its present total. It follows that although drought still depresses regional economies, the potential impacts are not as large as they might have been had the pattern of drought in the first decade of the new millennium occurred several decades ago. That is, rural economies have also diversified over time, with an increasing share of income being accounted for by services sectors.

Enhancing the representation of irrigation in TERM

The first application of the original TERM was to the Australian drought of 2002–03 (Horridge et al., 2005). As this was the first drought for several years, irrigation water managers were able to maintain reasonable supplies of water to irrigators by drawing down reservoirs with the expectation of better seasons and restorative water yields ahead. From the perspective of CGE modelling, there appeared to be little need at this stage to distinguish between irrigation and dry-land activities, or to account for irrigation water availability. Even so, this meant that modelling of the rice and cotton sectors was restricted, to the extent that some farmers sold their water allocations rather than grow a crop in response to drought.

The biggest single problem in modelling the 2002–03 drought was that the model initially predicted unrealistically large endogenous price changes. For sectors such as dairy, total demand appeared to be too inelastic, resulting in percentage changes in prices far exceeding percentage changes in output. That is, we modelled drought as having a positive impact on the revenue of farmers. The introduction of a small “alchemy” parameter (that is, an intermediate input substitution parameter), alleviated upward price pressures to a moderate extent in response to inward farm supply shifts.

The large price changes could also be attributed to the degree of model aggregation. The original aggregation covered 45 regions, at the statistical division in farm regions, with some composite regions elsewhere. Initially, the sectoral representation was relatively coarse, in order to keep the model database within usable dimensions. This made the demand for some farm products more inelastic than otherwise: if milk is sold almost exclusively to a broad food sector, its cost share in broad food production is smaller than if the sale were instead to a relatively disaggregated milk products sector. The smaller is the cost share, the more inelastic the demand for an input. Further disaggregation enhanced the realism of the modelled price impacts. After overcoming troubling aspects in implementation of the first TERM simulation, the authors predicted with reasonable accuracy agriculture’s changing share of state GDP as revealed by subsequent state accounts data (Horridge *et al*., 2005, table 4).

Incremental enhancements to TERM started with the inclusion of water accounts (Wittwer, 2003). The database of a typical CGE model is based on an input-output structure designated in values. Irrigation water can vary greatly in price between users and years. It is necessary to include volumetric accounts so as to capture differences in water usage per dollar of output between different agricultural outputs. Early applications of this version of TERM did not closely track observed changes in water usage between farm activities in response to changes in water availability. For example, using a version of TERM with water accounts, Young *et al*. (2006) modelled relatively modest declines in rice output in response to worsening water scarcity. This did not tally with available evidence. To place into perspective how responsive water usage in rice production is to changes in water scarcity, water usage in the Murray-Darling basin dropped by 29 percent from 2001–02 to 2002–03, yet usage for rice production in the region dropped by 70 percent (Table 1) (Murrumbidgee general security allocations, perhaps more pertinent to rice, fell from 72 percent to 38 percent over those years). Following the drought of 2002–03, there has only been one year, 2005–06, in which water usage in rice production has reached half of what it was in the years prior to 2002–03. The ability to trade water makes water use in some sectors more responsive to changes in water scarcity than otherwise.

Table 1: Water consumption by crop in the Murray-Darling basin, 2001–02 to 2005–06

	2001–02	2002–03	2003–04	2004–05	2005–06
Water consumption (GL)					
Livestock pasture	2,971	2,343	2,549	2,371	2,571
Rice	1,978	615	814	619	1,252
Cereals (excl. rice)	1,015	1,230	876	844	782
Cotton	2,581	1,428	1,186	1,743	1,574
Grapes & fruit	868	916	871	909	928
Vegetables	152	143	194	152	152
Other agriculture	504	475	596	564	460
Total Agriculture	**10,069**	**7,150**	**7,087**	**7,204**	**7,720**

Source: ABS (2009a), table 4.20.

In order to make demand for water by users such as rice sufficiently elastic to track observed changes in usage, theoretical modifications were made to TERM on the supply side (Dixon, et al. 2007). These modifications made farm land and other farm factors mobile between different outputs. Consequently, in scenarios in which water trading between users was permitted, sectors such as rice decreased output by much larger percentages than modelled water allocation decreases. This was a first step in undertaking large change simulations.

The next step in modelling irrigation sectors and regions in TERM was to move from a representation at the statistical division level to the statistical sub-division (SSD) level. In the context of irrigation, the finer level of representation aligns more closely with catchment regions.

But while at the coarser regional representation, the ‘alchemy’ parameter and a finer sectoral representation were sufficient to limit the impacts of drought on farm output prices, the finer regional representation exacerbates this problem once again. The statistical division level tends to include regions dominated in economic structure by large towns. This makes these regions more service-intensive and less agriculture-intensive than is the case for rural regions at the SSD level.[1] In addition, while at the statistical division level, farm output price rises are moderated by the impact on production costs of downstream processing sectors, at the SSD level, not all regions contain substantial downstream processing sectors. Therefore, the higher concentration of farm activity may result in farm output prices making a larger contribution to terms-of-trade impacts in the smaller regions without being offset significantly by increased costs to downstream users in the same region. Consequently, the model may predict unrealistically large terms-of-trade gains in rural regions.

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[1] For example, farm income in the Murray statistical division in the 2006 TERM database accounted for around 12 percent of total regional income. One town, Albury, accounts for 40 percent of the population of Murray (ABS 2009b). Within the Murray statistical division, the agricultural share of GDP excluding Albury SSD (i.e., the Central Murray and Murray-Darling statistical sub-divisions) exceeds 20 percent.

The consumption function in TERM links nominal consumption to nominal GDP. Terms-of-trade gains affect the price of regional exports (inter-regional plus international) which are included in GDP but not consumption. Regional imports are included in household consumption but not GDP. Therefore, terms-of-trade impacts raise the ratio of real consumption relative to real GDP. There is a danger of modelling real consumption gains in small regions in times of drought. Rectifying this requires a further theoretical modification.

The need to model excess capacity in downstream sectors

To find a way of depicting an extreme drought in a CGE model, we consider the impact of drought on downstream sectors. The ability of the downstream manufacturers to cope with lower supplies of inputs depends on a number of factors.

For example, while drought put dairy processors based in northern Victoria/southern New South Wales under financial pressure that led to cost cutting via such measures as retrenchments, there has been no substantial rationalisation of capacity to date. A number of factors have contributed to this. First, milk is produced Australia-wide and though expensive, processors have the option of transporting milk from non-drought affected regions. For example, recent seasonal conditions have been good in regions of New South Wales and Queensland, and milk has been transported south. As a means of reducing industry-wide transport costs, milk swaps between companies (where milk contracted to a given company is supplied instead to the nearest processor and swapped for milk elsewhere) have become commonplace. In addition, the changing feed-base away from irrigated pastures has lead to a flatter pattern of milk production through the year, favourable to the production of the high-valued cheese relative to milk powder. This flexibility in output mix has also helped maintain processor margins in the region.

Other industries do not have as many options. Whereas milk production out of the southern Murray Darling Basin has fallen in the order of one-third since its peak in 2001-02, rice output has fallen by more like 90 percent, with no potential to prop up capacity utilisation by transporting in raw product from elsewhere. The Deniliquin rice mill, previously the biggest rice mill in the southern hemisphere, closed indefinitely late 2007, along with others through the region.

Other examples include SPC Ardmona (based in the Goulburn Valley) rationalising manufacturing and retrenching staff in 2008, and National Foods’ recent decision to phase out production from the Berri fruit juice factory.

A standard CGE model does not capture this reduction in capacity in response to drought, instead solving for large inward farm supply shifts with implausibly large farm output prices. Far from modelling a drought-induced regional recession, there is a danger that spurious terms-of-trade gains will dominate the scenario. This is not to say that farm output prices do not increase in response to drought. Rather, such price hikes tend to be small relative to output declines. Drought usually is a time of rural hardship, not of regional windfall gains.

The challenge in a dynamic model is to model a temporary reduction in capital utilisation in response to drought. If capital were destroyed in order to mimic reduced capacity utilisation, then to maintain the dynamic link between investment and capital stocks, it would have to be rebuilt. We believe it is more realistic to model a temporary retirement of processing capacity in response to drought, where it is possible to restore capital to full usage without incurring investment costs or lags between investment and operational capital. For that, we require a modelling mechanism that permits a temporary reduction in utilisation in response to deteriorating economic conditions, followed by a return to full capacity with a recovery in seasonal conditions.

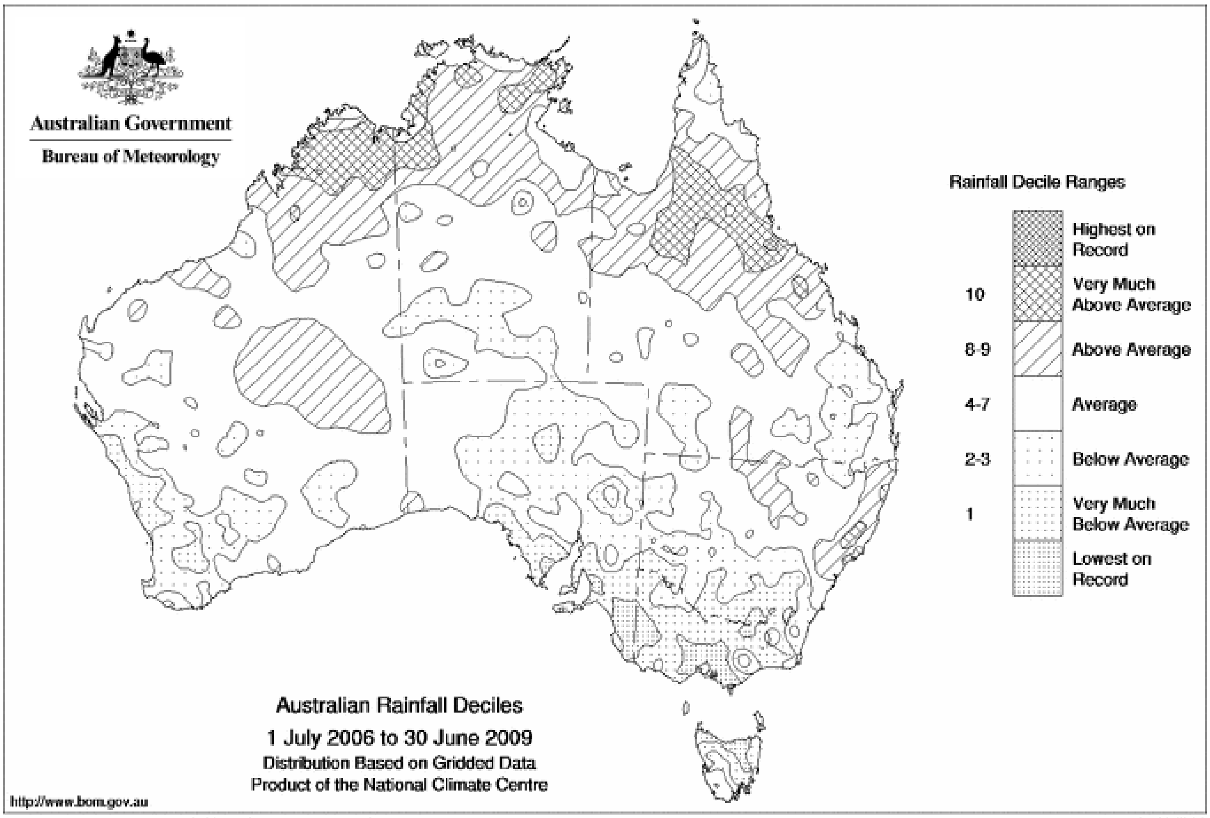
The intuition for the implementation of temporarily idle capital is that industries do not accept sharp decreases in the rate-of-return on capital in response to worsening conditions, whether they arise from a global recession, as in the original application of excess capacity in a CGE model in Dixon and Rimmer (2009), or from drought. In the latter example, instead of responding to reduced farm output by paying much higher input prices, processors reduce capital utilisation. This is equivalent to an inward movement in processing supply curves and an accompanying reduction in demand for farm inputs. While this will have little impact on processing sector output prices, it will reduce the price of farm inputs and consequently moderate the fall in the rate-of-return on capital in the processing sector. In turn, more moderate farm output price hikes will moderate terms-of-trade effects in small regions during drought.

Implementation of idle capital within the model requires the use of a complementarity condition, whereby an industry can be in one or the other of two states. In the context of sticky capital theory, the industry either earns either near normal or above normal rates of return, in which case its capital is fully utilised. Should deteriorating market conditions reduce earnings, the model alters the industry’s state, so that it ceases to operate at full capacity. The usual state entails short-run changes in rates of return (a price adjustment). The altered state entails a quantity adjustment. This complementarity condition is implemented in the model using GEMPACK software, as described by Harrison *et al*. (2004).

Drought in south-eastern Australia from 2006–07 to 2008–09

Unlike the drought of 2002–03, which was more widespread, the more recent droughts have had extreme, prolonged impacts concentrated on catchments in the southern Murray-Darling basin. Bureau of Meteorology data indicate that the entire southern Murray-Darling basin had either decile 1 rainfall or the lowest on record for the three-year period between July 2006 and June 2009 (figure 1). Recurrent droughts affected both dry-land and irrigated production. Dry-land production was most adversely affected in 2006–07 and 2007–08, with a partial recovery in some regions in 2008–09. For irrigators, the impacts of catchment shortfalls on water allocations are likely to continue for several years after a seasonal recovery. Figure 2 shows the modelled percentage shortfalls in water availability by region for 2007–08. Our simulation includes the direct impacts on both dry-land productivity and irrigation water allocations for 2006–07 to 2008–09, with an assumed recovery in dry-land productivity in 2009–10 and eventual full recovery in water allocations by 2011–12.

Figure 1: Rainfall deficits for the three years to June 2009



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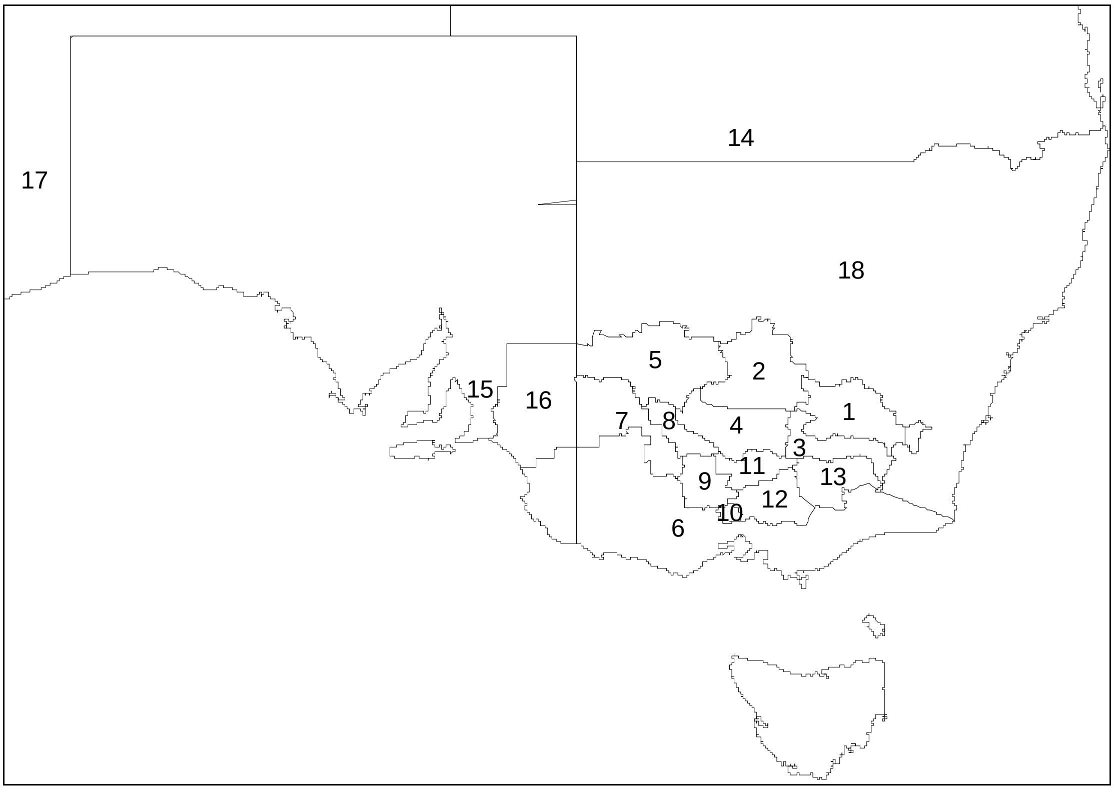
Source: ftp://ftp.bom.gov.au/anon/home/ncc/www/rainfall/decile/36month/blkwht/history/nat/2006070120090630.gif

We use TERM-H20 to simulate the impacts of drought in the basin. TERM-H2O includes water accounts, and has sufficient farm factor mobility so as to replicate observed changes in water usage by crop as water availability changes, such as those shown in table 1. It represents the basin at the catchment level. The model also includes complementarity conditions that allow us to model excess capacity in downstream processing sectors.

Figure 2: **Map of southern Murray-Darling basin regions in TERM-H2O**



Regions: 1 Wagga-Central Murrumbidgee, 2 Lower Murrumbidgee, 3 Albury-Upper Murray, 4 Central Murray, 5 Murray Darling, 7 Far West, 6 Rest of VIC, 7 Mildura-West Mallee, 8 East Mallee, 9 Bendigo-Nth Loddon, 10 Sth Loddon, 11 Shepparton-Nth Goulburn, 12 Sth/SthWest Goulburn, 13 Ovens-Murray14 QLD, 15 Rest of SA, 16 Murray Lands SA, 17 Rest of Australia, 18 Rest of NSW.

Comparing back-of-the-envelope and modelled impacts for 2007–08

We start with an analysis of our results for 2007–08. Lack of rainfall in 2007–08 meant that dry-land productivity in the southern Murray-Darling basin was below average. Crop yields were similar to 2006–07, which also suffered from a rainfall deficit. Irrigation allocations were at a low point after successive droughts, with further cuts relative to the previous year in most irrigation regions.

We can calculate a back-of-the-envelope (BoTE) estimate of the contribution of a subset *k* of industries *j* to a percentage change in GDP in region r (gdp_r) as:

$$gdp_r = \Sigma_k(PRIM_{kr}.q_{kr})/\ \Sigma_j PRIM_{jr} \qquad (1)$$

PRIM is the level of value-added output of each sector and *q* is the percentage change in output. As a starting point for BoTE analysis, we assume that for irrigation sectors *i*, $q_i = xwat_i$ where the latter is the percentage difference in water allocations from normal. Additionally, our BoTE calculation of lost output in dry-land sectors *j* equals the technological deterioration due to drought ($aprim_j$) so that $q_j = aprim_j$. Our initial estimate of the impact of drought, in which *a* refers to all industries in region *r* is:

$$gdp_r = [\Sigma_i PRIM_{ir}.q_{ir} + \Sigma_j PRIM_{jr}.q_{jr}] / \Sigma_a PRIM_{ar} \qquad (2)$$

In table 2, the first two rows show an index of water availability and dry-land productivity relative to a normal year. The succeeding rows provide estimates of the contributions of broad sectors to GDP at the regional level. Then follow rows showing the respective BoTE contributions of irrigation and dry-land sectors to economic activity in the regions of the southern Murray-Darling basin. Finally, the table shows the modelled contributions to regional GDP by broad sector and irrigation water.

Dry-land contributions make a substantial contribution to overall real GDP losses in most regions. Dry-land BoTE losses predict modelled sectoral losses quite closely in some but not all regions, with any variation arising from price changes that alter industry value weights through the simulation – and some resource movements from irrigated towards dry-land production.[2] The first surprise in table 2 is that in some regions, the contribution of irrigation sectors to GDP is positive. This is because the demand for water is inelastic, so that when its scarcity worsens, its contribution to GDP increases. As long as water is mobile between sectors and regions, this is possible. This reflects net water purchases in the region, and is more than offset by the negative contribution of net water in these regions to real GDP. That is, the additional water costs are included in "net water", rather than being subtracted from value-added in the "Irrigation" row (table 2). The "net water" contribution overall is positive: this implies that the percentage increase in the price of water exceeds the percentage decrease in availability. Inelastic demand implies that water's contribution to GDP increases as its scarcity worsens.

We might expect modelled GDP losses in each region to be somewhat larger than back-of-the-envelope losses. This is through negative impacts on downstream sectors, and the impact of reduced household consumption on service sectors in each region. Modelled GDP losses are larger than back-of-the-envelope losses for some but not all regions shown in table 2. Water trading between sectors and regions, combined with mobility of farm factors, alleviates some of the losses. For example, Lower Murrumbidgee is a substantial exporter of water to other regions in the scenario. The movement of factors including water partly offsets productivity and allocation losses, so that the modelled GDP loss is smaller than the BoTE GDP loss in this region.

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[2] The solution procedure is Euler 60-steps, used to eliminate solution errors from the linearised model in this large change simulation (Dixon *et al*. 1982, chapter 5). The database is updated at the end of each step, so that if value weights change, dry-land modelled outcomes may vary from our BoTE estimate.

Table 2: Impacts of drought by region, 2007–08 relative to no-drought baseline (%)

	WagCntMrmNSW	LMrmbNSW	AlbUpMrryNSW	CentMrryNSW	MrryDrlngNSW	MldWMaleeVic	EMalleeVic	NthLoddonVic	SthLoddonVic	ShepNGoulVic	SSWGlbrnVic	OvnsMurryVic	MurrayLndsSA	All SthMDB
	Water allocations and productivity levels (100 = average)													
Dry-land productivity [a]	42	42	42	42	42	36	36	69	69	69	69	69	36	51
Water[b]	51	51	14	14	40	42	42	46	40	46	46	45	60	44
	Contributions to GDP in 2005–06 base (%)													
Dry-land	8.3	8.4	6.4	2.3	8.0	13.6	14.4	3.9	1.4	6.9	7.4	3.8	8.0	6.8
Irrigation	1.9	15.3	1.2	19.6	12.1	8.0	14.5	1.5	0.7	9.2	3.2	2.8	14.1	6.1
Total	10.2	23.7	7.6	21.9	20.1	21.6	28.9	5.4	2.1	16.1	10.6	6.6	22.1	12.9
	Back-of-the-envelope estimates of contributions to GDP (%)													
Dry-land	-4.8	-4.9	-3.7	-1.3	-4.6	-8.7	-9.2	-1.2	-0.4	-2.1	-2.3	-1.2	-5.1	-3.3
Irrigation	-0.9	-7.5	-1.0	-16.9	-7.3	-4.6	-8.4	-0.8	-0.4	-5.0	-1.7	-1.5	-5.6	-4.4
Total	-5.7	-12.4	-4.7	-18.2	-11.9	-13.3	-17.6	-2.0	-0.9	-7.1	-4.0	-2.7	-10.8	-6.7
	Modelled contributions by broad sector													
Dry-land	-4.0	-2.0	-2.8	0.1	-2.7	-7.3	-7.9	-0.8	-0.3	-1.0	-1.5	-0.8	-4.5	-3.3
Irrigation	-0.6	-8.8	-0.1	-10.3	-1.2	-0.5	-0.2	-0.4	-0.1	-1.5	-0.8	-0.6	0.1	-2.9
Food	-0.3	-0.5	-0.1	-0.2	0.0	-0.1	-0.2	-0.3	-0.1	-0.6	-0.1	-0.2	-0.6	-0.4
Rest	-1.0	-0.5	-0.7	-1.4	-0.9	-1.2	-1.5	-0.2	-0.4	-0.6	-0.5	-0.8	-1.0	-0.7
Net Water	-0.5	5.0	-1.2	-6.7	-1.9	-2.5	-3.4	-0.2	-0.3	-1.0	-0.3	-0.4	-2.0	1.7
GDP	-6.4	-6.9	-4.9	-18.5	-6.6	-11.6	-13.2	-1.8	-1.2	-4.7	-3.3	-2.9	-8.0	-5.6
Net water sold (GL)	98	442	-37	-213	-14	-25	-92	7	-4	-104	9	-18	-48	0

a Authors' estimates based on rainfall deficiencies.
b Data provided by Murray-Darling Basin Commission.

Changes in output by sector in part reflect ML per dollar of value added (shown in table 3, final column), but are also influenced by different demand elasticities and input-substitution possibilities. For example, the dairy and other livestock sectors can substitute between land and cereal inputs. Recall from table 1 that in the drought of 2002–03, water consumption in irrigated cereal production increased. This was driven by increased demands for feed from Goulburn dairy farmers as water available in that region decreased. In our simulation, there is some movement from dry-land to irrigated production of dairy and other livestock. Had dry-land cereal production fared relatively better than other sectors, cheaper than otherwise cereals might have induced movement in the opposite direction towards dry-land livestock production.

The drought scenario as modelled does not consider externally driven output price movements that may have impacted adversely on some sectors. For example, during 2007 and 2008, some citrus orchards in the basin were taken out of production, a consequence of reduced water allocations combined with unfavourable commodity price movements. By 2009, grape producers were facing similar circumstances due to falling prices. Within the model, the broader fruit sector does relatively well because it is relatively frugal in water requirements per unit of output. With adverse relative price movements for outputs, this would change.

Table 3: Regional contributions to sectoral impacts, 2007–08 relative to no-drought baseline (%), and value of water in production

	WagCntMrmNSW	LMrmbNSW	AlbUpMrryNSW	CentMrryNSW	MrryDrlngNSW	MldWMaleeVic	EMalleeVic	BndNthLodVic	SthLoddonVic	ShepNGoulVic	SSWGlbrnVic	OvnsMurryVic	MurrayLndsSA	Total SthMDB	GL per $m value-added
CerealDryL	-16.1	-5.4	-6.3	0.0	-0.7	-16.4	-7.1	-3.4	-0.1	-1.6	-0.5	-0.2	-3.7	-61.5	..
CerealIrig	-8.8	-2.9	-3.3	-33.8	0.0	-7.0	-3.0	-4.0	0.0	-2.7	-0.6	0.0	-1.7	-67.8	2.8
Rice	-9.3	-41.3	0.0	-22.1	0.0	-2.6	-2.6	0.0	0.0	-3.8	-4.8	-0.5	0.0	-87.0	6.5
DairyCatDryL	0.0	0.0	0.0	1.4	0.0	0.0	-10.3	-1.3	0.0	-9.3	-0.5	-1.8	-4.9	-26.7	..
DairyCatIrig	-0.1	0.0	-0.1	0.1	0.0	0.1	0.3	-0.8	0.0	-8.5	-0.3	-1.6	-0.1	-11.0	0.8
OthLivstoDry	-3.5	-0.4	-2.8	0.0	-0.3	-2.8	-3.0	-1.0	-0.4	-1.9	-4.0	-2.7	-6.4	-29.2	..
OthLivstoIrg	1.7	1.3	1.6	-12.2	0.1	1.7	1.1	0.5	-0.1	-0.7	-1.2	-1.3	2.9	-4.6	1.1
Grapes	-0.1	-1.1	-0.2	-0.1	-1.3	-3.3	-2.1	-0.8	-0.1	-0.6	-1.1	-1.5	-4.6	-16.9	0.9
Vegetables	0.1	2.9	0.0	2.3	0.1	3.4	1.7	-1.9	-0.2	-2.5	-1.9	-0.9	4.3	7.4	0.4
FruitDryL	-4.6	-6.2	0.0	0.0	-3.0	-9.2	-9.3	-2.2	0.0	-15.4	-3.3	-3.1	-22.7	-79.0	..
FruitIrig	0.1	1.0	0.0	0.3	0.0	1.1	0.6	-0.3	0.0	-1.6	-0.4	-0.3	0.6	1.1	0.4
OthAgriDry	-6.1	-3.1	-5.8	1.1	0.0	0.0	-7.9	-1.8	-2.4	-2.7	-3.5	-3.8	0.0	-36.0	..
OthAgriIrig	4.6	3.4	3.2	7.7	-0.1	3.1	5.6	0.7	0.5	2.7	2.5	0.9	0.0	34.8	0.2

The Australian Water Market Report for 2007–08 shows an actual pattern of net downstream trade. Small amounts were transferred out from the upper Murray reaches in both NSW and Victoria, and larger amounts from the Goulburn and lower NSW Murray reaches. The largest net seller was the Murrumbidgee valley, reflecting the influence of rice. Rice is grown in better years; however a moderate worsening of water scarcity is sufficient to make it more profitable for growers to sell their water allocation for a year than to continue growing rice. The buyers of water were the lower Victorian Murray and most notably South Australia. In terms of how the modelling replicated this pattern, the main differences are that trade from the Murrumbidgee is overestimated, while trade to South Australia is underestimated. The modelling predicted that the upstream areas of the Murray, both NSW and Victoria, and the Goulburn region would be net buyers of water rather than sellers. In 2008–09, the Victorian Murray upstream of Barmah and Goulburn Valleys were net importers of water.

To the extent that our modelling overstates aggregate observed water trading, it might indicate that greater trade could have resulted in allocative efficiency gains. There are several reasons why volumes of water traded might be less than modelled, including physical and institutional barriers to water trading. Notably, the Victorian government’s cap on trade, under which no more than 4 percent of permanent water can leave a water region in a year, may have slowed or even halted permanent trading, to the detriment of allocative efficiency. In addition, perennial irrigation activities, including tree crops and livestock, may slow trading out of a region.

The downstream food sectors lose substantially due to drought. The modifications to TERM-H2O that allow excess capacity to come into effect during drought reinforce such losses while reducing input price pressures on downstream processors.

Dynamic analysis of drought followed by a prolonged recovery

Our simulation consists of widespread drought conditions from 2006–07 to 2008–09, with a dry-land recovery in 2009–10 but some delay before the restoration of full water allocations for irrigation sectors. Full recovery of allocations occurs only in 2012–13.

We first examine the year-by-year regional impacts of the scenario on real GDP. Agriculture's share of GDP averages 12.9 percent across the southern Murray-Darling basin. In addition, downstream processing makes up an additional 6.8 percent of regional GDP (based on ABS 2006 census data). This implies that drought can still depress regional economies markedly, even with structural change over time that has reduced agriculture's share of national income to around 3 percent.

Figures 3 and 4 show that the prolonged drought had a severe effect on real GDP within the southern Murray-Darling basin. The biggest losers in terms of real GDP were Mildura–West Mallee, East Mallee and Rest of Murray–NSW. That a number of regions do worse in 2008–09 than 2007–08 reflects worsening shortfalls in irrigation allocations in 2008–09. Similarly, the stepped recovery for some regions (e.g., Central Murray in figure 4) reflects the gradual restoration of irrigation water allocations after a return to normal rainfall from 2009–10 on.

Most of the real GDP losses shown in figures 3 and 4 arise from lower crop yields for dry-land (rain-fed) crops plus irrigation water shortfalls. Those regions that suffer the largest economy-wide productivity and water allocation losses tend to suffer the largest employment losses (figures 5 and 6). Regional employment (figures 5 and 6) and capital stocks (figures 8 and 9) are depressed by drought, but we expect percentage losses to be smaller than for real GDP. If the total elasticity of demand for farm products were larger, regional factor losses would be larger. The elasticities are constrained by the requirements of domestic downstream processors, imperfect import substitution and finitely elastic export demand curves. Recall that one of the motivations for introducing excess capital to downstream users was to increase demand elasticities so as to avoid excessive terms-of-trade impacts.

Figure 3: Impact of drought on real GDP in Victorian regions

% change relative to no-drought baseline

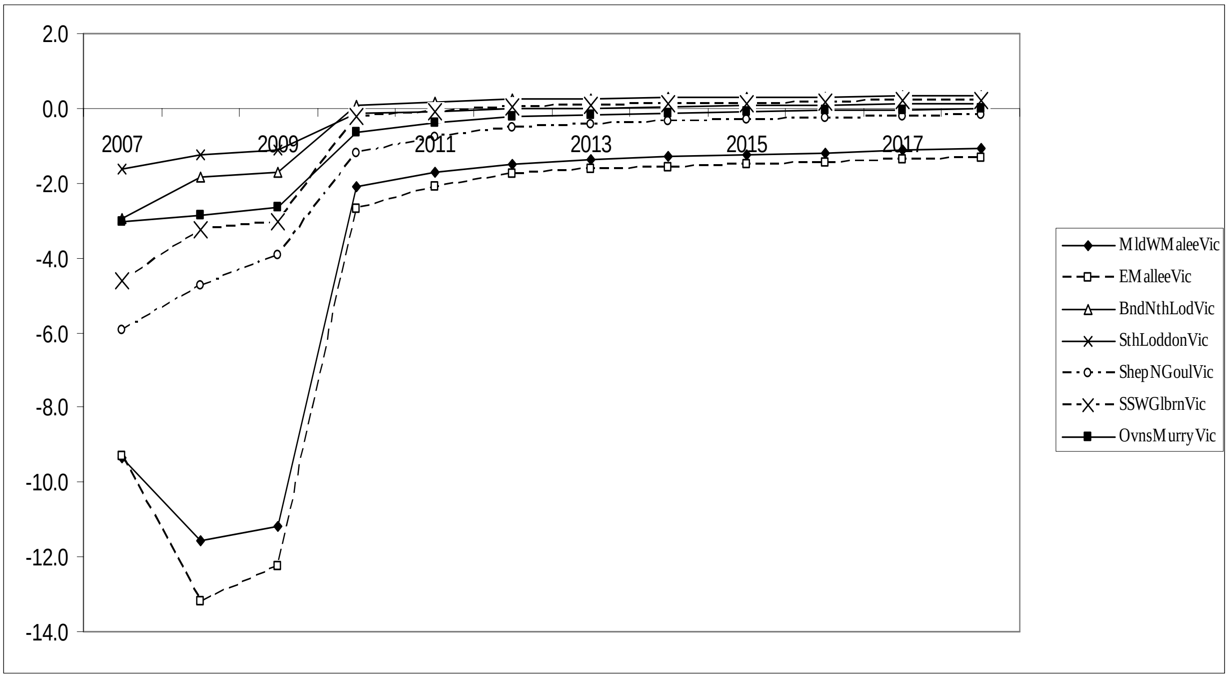


Figure 4: Impact of drought on real GDP in remaining Sth MDB regions

% change relative to no-drought baseline

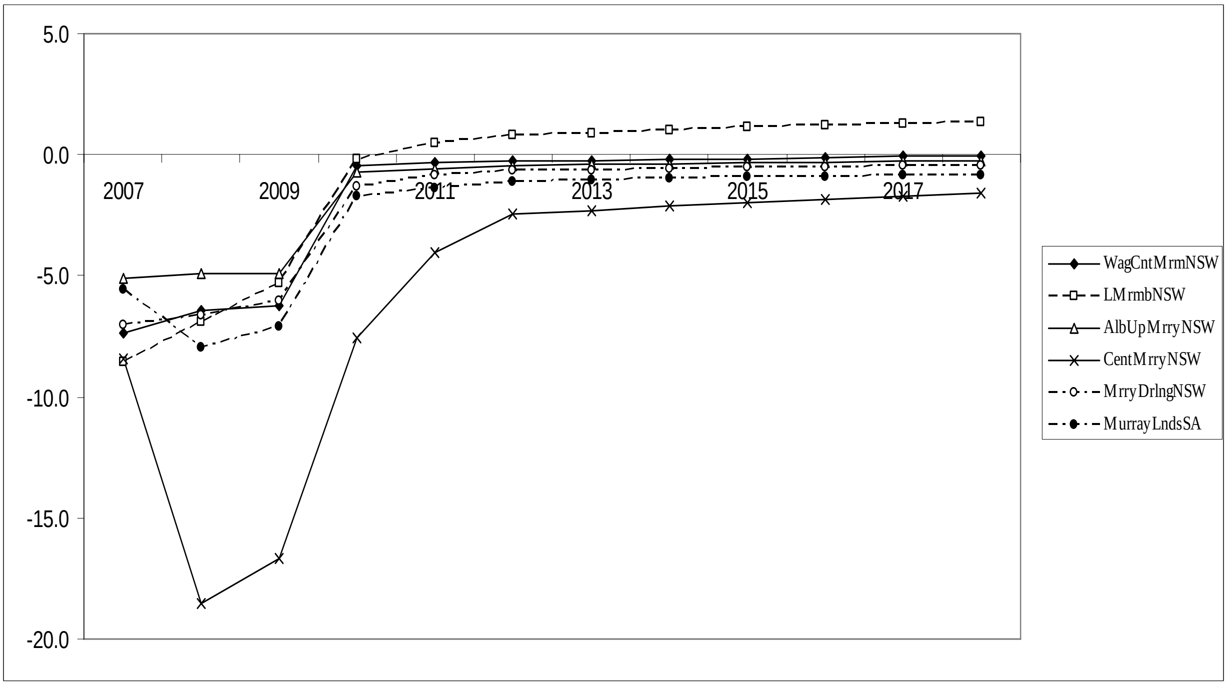


Figure 5: Impact of drought on employment in Victorian regions

% change relative to no-drought baseline

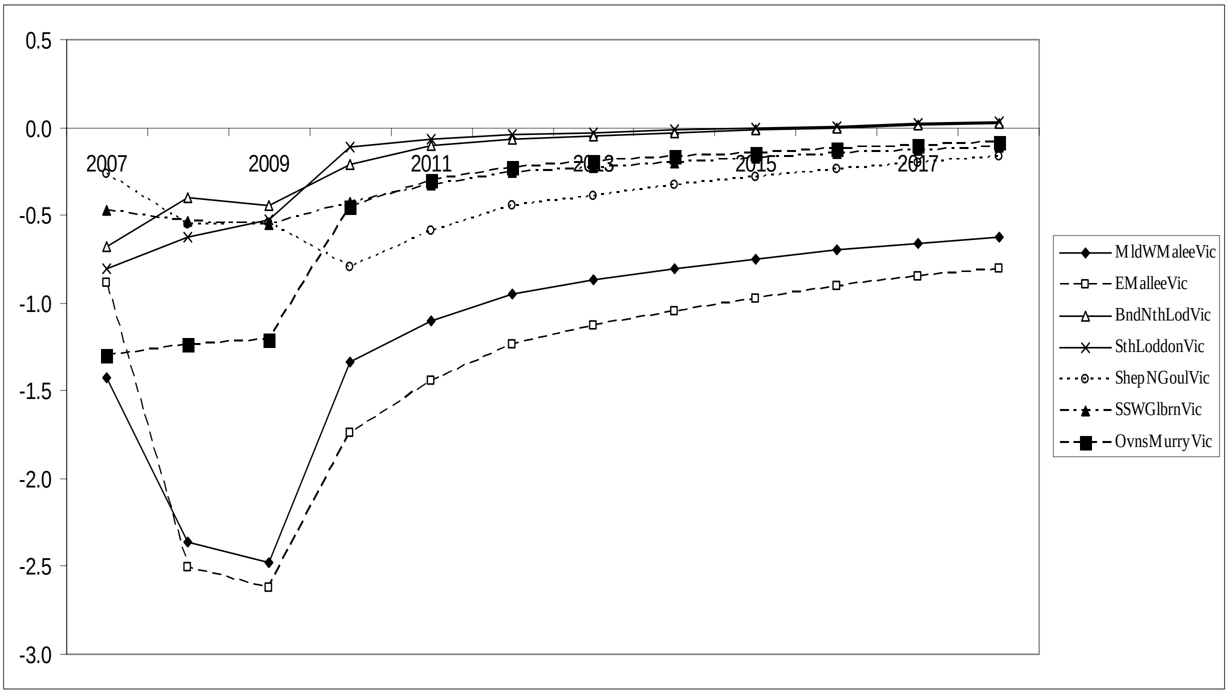
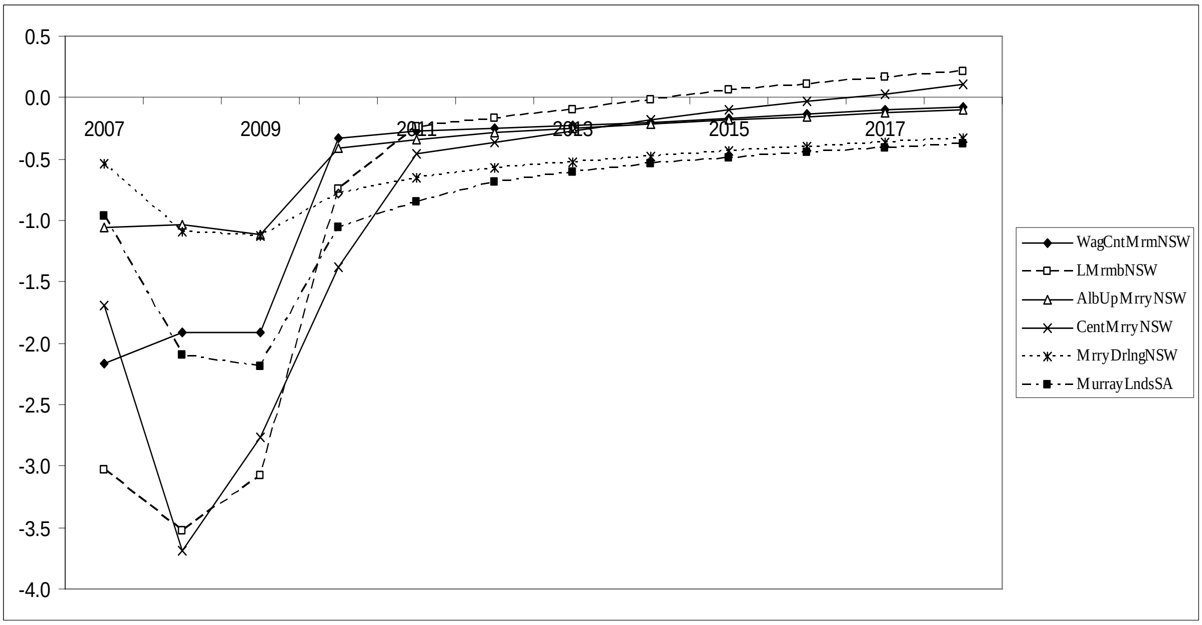


Figure 6: Impact of drought on employment in remaining Sth MDB regions

% change relative to no-drought baseline



One of the features of figures 3 and 4 is that although some regions return to baseline real GDP after normal seasons return, others appear to have shifted to a permanently lower income level. This is because years of depressed investment due to drought impact negatively on capital stocks. The magnitude and duration of the drought has consequences for investment and employment that may be irreversible. In East Mallee, for example, capital stocks drop to almost 2.5 percent below forecast in 2009–10 (figure 8) and do not recover to baseline levels. In other regions with smaller downward deviations from forecast during the drought, capital stocks recover, with accompanying recoveries in employment and real GDP. Bendigo-North Loddon is an example (figures 3, 5 and 8).

This version of TERM-H2O includes specific capital for tree crops and livestock herds, to reflect perennial production. Depressed rates-of-return on specific capital might explain why regions including East Mallee fail to recover completely after drought. Were we to link accelerated depreciation rates of fixed capital to water application shortfalls (to represent plantation damage and herd culls), the modelled permanent falls in income relative to forecast due to drought potentially would be even larger. Moreover, this may introduce an irreversible feature to the model, so that a temporary drought results in lasting cut in regional income relative to forecast due to destruction of capital.

Figure 7 shows the difference between available and used capital in Shepparton-North Goulburn for meat products, dairy products and flour-cereals. These three industries include sticky capital, so that quantity adjustments occur in the form of changing capital utilisation as capital earnings decrease. That is, once there is a substantial recovery in seasons, which in turn lowers the price of farm inputs, the deviations in used and available capital merge. Note that in regions without sticky capital sectors, capital usage remains unchanged relative to forecast in the first year of the simulation, reflecting the lagged impact of changes in investment. Given this, we can deduce from figures 8 and 9 that in addition to Shepparton-North Goulburn, Murray Lands includes sectors with sticky capital, which allows deviations from forecast in the first year of the simulation.

Figure 7: Available and used capital in Shepparton-North Goulburn

% change relative to no-drought baseline

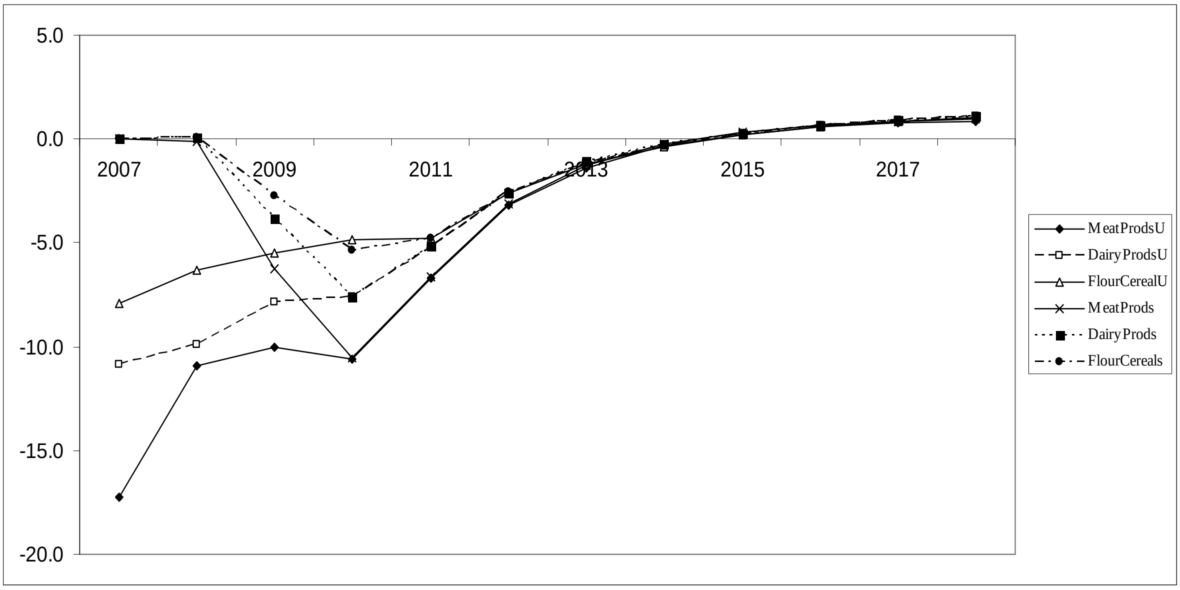


Figure 8: Impact of drought on capital stocks in Victorian regions

% change relative to no-drought baseline

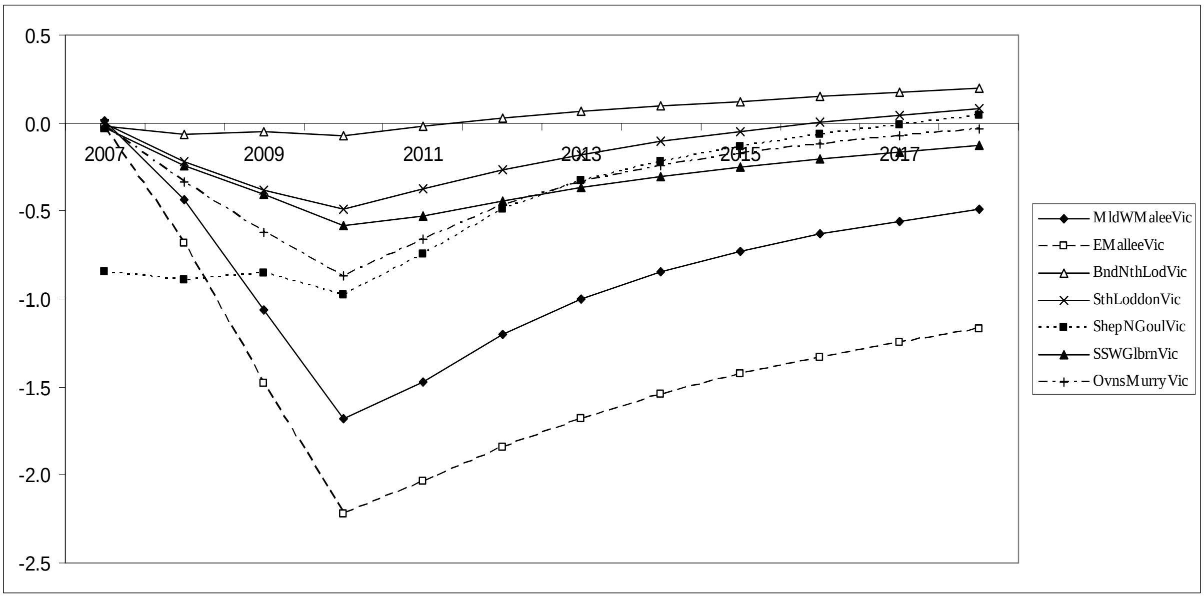


Figure 9: Impact of drought on capital stocks in remaining Sth MDB regions

% change relative to no-drought baseline

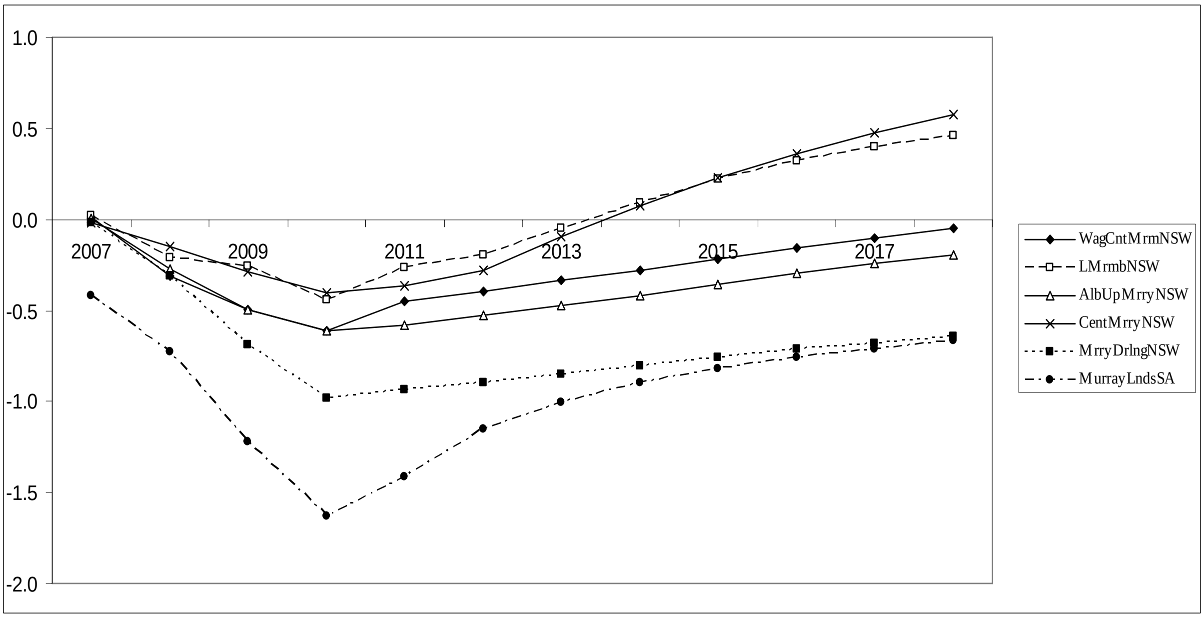


Figure 10: Impact of drought on aggregate consumption in Victorian regions

% change relative to no-drought baseline

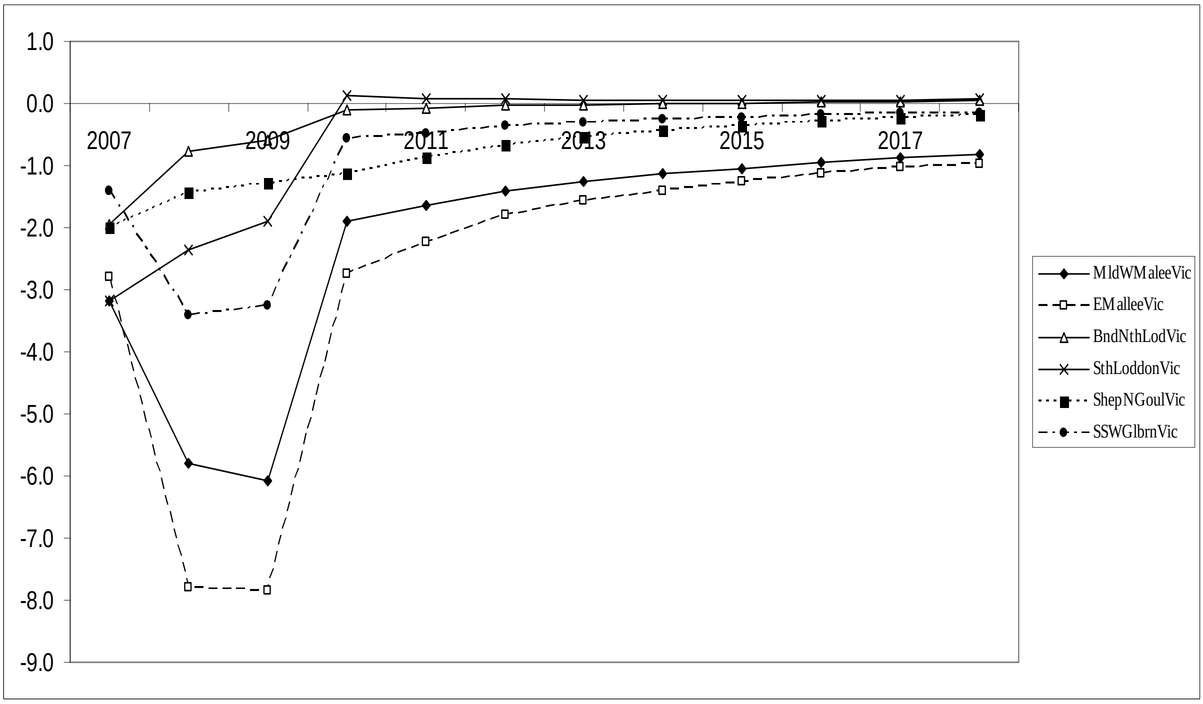
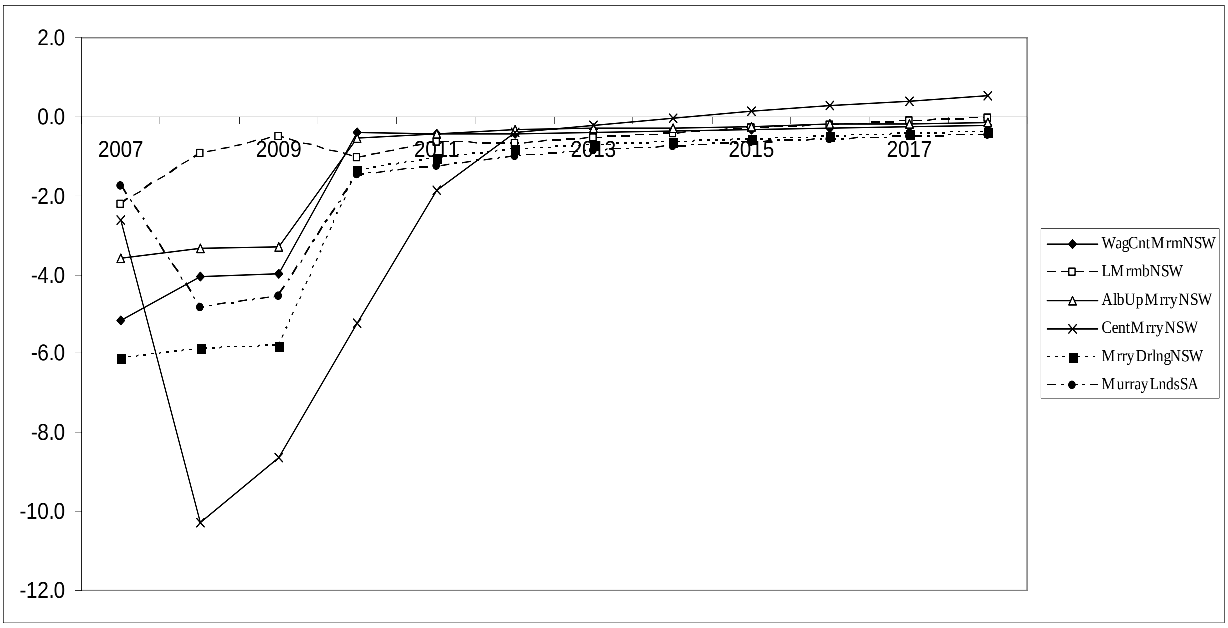


Figure 11: Impact of drought on aggregate consumption in remaining Sth MDB regions

% change relative to no-drought baseline



Long-term implications

It is possible that some regions will not recover to no-drought forecast levels, even with a return to average seasons. Prolonged disinvestment may lead to a permanent reduction in farm output. We have yet to model accelerated depreciation or destruction of capital (orchards, vineyards and herds) due to drought which would worsen the lasting impacts of drought. In addition, recurring droughts may eventually result in the factory doors of regional processing plants closing permanently rather than temporarily.

The usual practice for dry-land farmers may have been to make allowance for some drought years. Mixed enterprise farmers, for example, may stock up on livestock fodder and grains during better years, in anticipation of increased hand-feeding during dry years. Such farmers may be prepared for one or two years of drought in a row, but may be severely tested by below-average rainfall that continues for longer. In the past, fluctuating commodity prices, high interest rates and rising input prices may also have contributed to rural hardship.

The profitability of dry-land farms may depend on improved medium-term forecasts from the Bureau of Meteorology. At present, the bureau uses the Southern Oscillation Index to help forecast El Nino events. More recently, low Indian Ocean temperatures have contributed to dry springs in south-eastern Australia. If forecasting of droughts were improved to the extent where farmers knew the probable rainfall pattern over the season ahead, this would contribute to better investment decisions. Hertzler (2006) has also explored the possibility of farmers insuring against drought.

Irrigators may have felt in the past that they were insulated from drought, if not from the other fluctuations that have impacted on farm profitability. Repeated shortfalls in water allocations have presented a new crisis for irrigators in the first decade of the new millennium. Various options to deal with the new crisis, including water trading, have been insufficient in the face of the severity of drought in the past few years. Dairy deregulation resulted in a greater concentration of dairy production in Victoria, with investment decisions driven by reliability of water supply. Unfortunately, below average rainfall has prevailed in each year from 1996 in much of south-eastern Australia.

Policies to improve long-term management of the southern Murray-Darling basin have evolved slowly. The benefit of water trading increases as the scarcity of water worsens. This has some resonance for farmers who may perceive of the Commonwealth’s buyback scheme as an opportunity to restructure. The Victorian government’s annual cap on permanent water trading outside of catchment regions has acted as a significant constraint on trading. Some farmers may have sought to sell permanent water as part of enterprise restructuring or retirement plans. Their plans may have been confounded by the cap.

The behaviour of state governments is not the only area of policy concern. How the Commonwealth uses buyback water will also matter. Young and McColl (2008) suggest that when water is scarce during years of drought, buyback water should be sold to farmers. Then, in wet years, additional water should be purchased from farmers for environmental flows. At present, there are no Commonwealth plans for flexible environmental flows. Such plans would have the advantage of reducing the water allocation risk faced by farmers, particularly for perennials, while providing environmental flows at times when water is abundant.

An important contribution that the CGE approach makes to drought analysis is to provide an awareness of the shrinking contribution of farm and downstream sectors to regional GDP over time. To put this in context, when AARES was formed in 1957, agriculture's share of GDP for all of Australia was around 16 percent (Maddock and McLean, 1987). Now, the contribution of farming in the southern Murray-Darling basin to GDP is less than 13 percent (table 2). This indicates that policy efforts in the basin must increasingly concentrate on service sectors. Regional communities are aware of the importance of keeping schools and hospitals open both to service their communities and to provide employment. Moreover, to the extent that regional communities are aging, the need for health and aged care services will grow. It may be tempting during a regional economic crisis brought on by drought to consider only the impact on farming and associated sectors such as farm implement dealers. Communities may suffer much more if publicly funded services are allowed to deteriorate in such a crisis.

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