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Water trade in the southern Murray-Darling Basin

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Abstract:

In this paper we use TERM-Water, a bottoms-up regional CGE model of the Australian economy, to examine the regional effects of expanding trade of irrigation water in the southern Murray-Darling Basin.

In the model, trade is induced by reducing water allocations to irrigators. Long run closures are used to consider the effects of 10, 20 and 30 per cent permanent cuts to water allocations. Short run closures are used to model year to year seasonal variability in water allocations for the years 1997-98 to 2001-02.

We find that water trading dampens the impact of water allocation cuts on gross regional product (GRP). The benefits of introducing trading within irrigation districts are greater than the further benefits of expanding trade to between these regions. Permitting trade of seasonal allocations allows irrigators to reallocate water in reaction to climatic conditions and water availability — and it is this flexibility that enables GRP reductions to be minimised.

* The views expressed in this paper are those of the authors, rather than those of the Productivity Commission or the Australian Government.

1 Introduction

Water trade allows water to shift towards uses where it yields higher marginal returns (net of transfer costs). Revenue from water sales can supplement farm income and provide finance for other on-farm or off-farm activities, or facilitate exit from an industry. Water trade can also lessen the impact of reductions in irrigation water availability.

In this paper, a general equilibrium model of the Australian economy (TERM) is used, to examine the effects of expanding trade — in the presence of reductions in the amount of water available to irrigators in the southern Murray-Darling Basin (MDB). The magnitude and distribution of the effects of expanding water trade at the national and state levels are of interest, as well as the impact on industries and regions as irrigation activities adjust. The effect of these reductions in water are compared in three experiments: first, assuming no trade in water; second, assuming only intra-regional trades; and, third, assuming both intra- and interregional trades.

The following water allocation reductions were considered:

- long run reductions of 10, 20 and 30 per cent in water availability in the base year (1996-97)
- short run reductions based on observed allocations for 1997-98 to 2001-02.

Water trade in Australia involves trade in water entitlements and seasonal water allocations. Trade in water entitlements (sometimes referred to as ‘permanent trade’) involves transferring the ongoing right to access water for the term of the right. Trade in seasonal water allocations (sometimes called ‘temporary trade’) involves transferring some or all of the water allocated to the entitlement for the current irrigation season or an agreed number of seasons.

In the three major irrigation districts of the southern MDB (the Murray Irrigation district, the Murrumbidgee Irrigation Area, and the Goulburn-Murray Water district), gross trade in entitlements accounted for less than 2 per cent of total water allocations in 2002-03, while gross trade in seasonal allocations accounted for around 20 per cent.

In addition to seasonal conditions and allocations, a variety of factors affect trade within and between irrigation districts. Some are physical capacity constraints — for example, limitations on the volume of water able to pass through the ‘Barmah Choke’ — others are regulatory in nature.

2 The modelling approach

TERM was developed by the Centre of Policy Studies at Monash University as a more disaggregated tool than the Monash Multi-Regional Forecasting model for regional policy analysis. It can be used to model each of Australia's 57 statistical divisions as a distinct economy with its own input–output and trade relationships. The economy is classified into 144 industry sectors and 57 regions. Each region is modelled as a separate economy with links to the other regions to account for product and factor mobility between regions. TERM draws on national input-output data and disaggregated regional data.

The model database is partly derived from the 1996-97 Australian Bureau of Statistics water accounts (ABS 2000) — hence, 1996-97 is referred to as the 'base year' for this analysis. Accounts for 2000-01 are currently being incorporated.

As part of the model development, TERM has been reconfigured to 48 industry sectors and 20 regions to provide TERM-Water with a detailed representation of irrigated industries in the southern MDB (Wittwer 2003). Irrigated sectors include: sheep, other broad acre, beef cattle, dairy cattle, rice, cotton, four different fruits, three different forms of grape production, irrigated pasture, vegetables and other crops. Regions outside the MDB have been aggregated to the state or 'rest of state' level. The model has retained disaggregation to statistical division level within the MDB (figure 1).

The borders of regions are based on ABS statistical divisions, which have a reasonable concordance with existing boundaries of irrigation districts. One notable exception is the area supplied by Goulburn Murray Water, which lies partly in the Mallee region, as well as providing the vast majority of irrigation water in the Goulburn, Ovens Murray and Loddon Campaspe regions.

In TERM-Water, a variety of products are produced within each region. Each regional farm is specialised, in that it produces only one output and by only one technique. (Irrigated grapes and non-irrigated grapes, for example, are produced by different farms.) In the model there is no threshold for use of a particular input (such as water) below which production ceases. Land, labour and capital are mobile to varying degrees in TERM-Water. When water allocations and prices change, the output mix of a region thus changes in response, and these specialised farms expand or shrink as needed. For this reason, despite the difference between the way in which farms are modelled in TERM-Water and the way in which farming is organised in the real world of the agricultural sector, TERM-Water can model changes in product mixes and inputs.

Figure 1 **Irrigation areas and statistical divisions**

Source: Murray-Darling Basin Commission.

TERM-Water has only one such specialised farm per region — for example, all the fields devoted to wheat in a region are as if they are operated by one farmer — therefore some caution is needed in the interpretation of the results. A reduction in the output of wheat, for example, is not necessarily a good estimate of what would happen to the incomes of real farmers who may have a mix of crops including wheat.

TERM-Water models production and consumption relationships as annual flows of goods and services. Changes in water prices and allocations within a year reflect changes in annual averages.

TERM's water module

TERM-Water includes irrigation water in production as an endowment rather than as an intermediate input and the production of irrigation water is not accounted for in the model. Output is produced using a combination of irrigation water and a bundle of non-water inputs. As represented in figure 2, each regional irrigation industry has a constant elasticity of substitution (CES) production function that allows non-water inputs to be substituted for irrigation water in response to changes in their relative prices. The elasticity parameter is SIGTOP and usually takes the value 0.01, 0.03 or 0.05, depending on the industry. For non-irrigation industries, production is proportional to non-water inputs because these industries do not use irrigation water.

The bundle of non-water inputs consists of intermediate inputs, primary factors and other costs, used in fixed proportions (as shown in figure 2). The use of particular commodities as intermediate inputs varies with changes in their relative prices. The bundle of primary factors consists of capital, labour and land. The composition of the primary factor bundle also varies with changes in relative factor prices.

Water utilities are represented as an industry in TERM-Water. This industry produces sewerage and drainage services, and delivers non-irrigation water. Purchases from water utilities are represented as intermediate inputs in the production process.

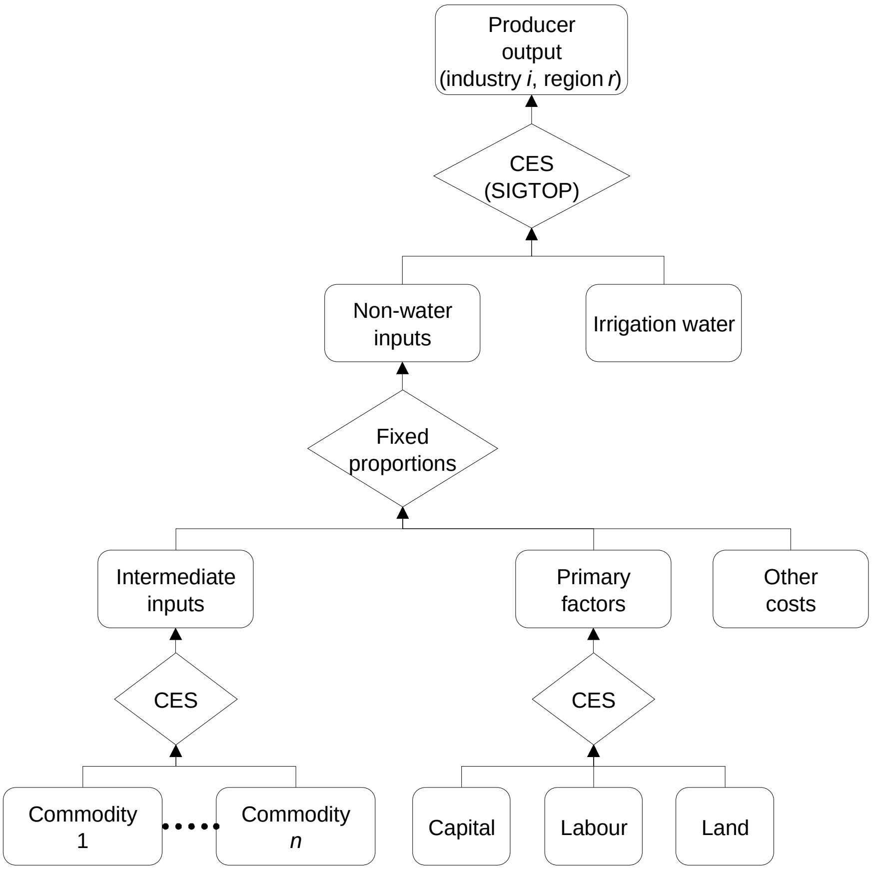
Incorporating water trade

In TERM-Water, the total available water supply is fixed exogenously. A statistical division's endowment of water within TERM-Water is derived from data on the observed use of irrigation water. This means either the initial equilibrium assumes that water entitlements, seasonal allocations and use all coincide (so there is no net trade) or, more realistically, water use may represent some re-allocation but not sufficient to equalise prices across irrigation districts.

Consequently, the data on use includes water trade that did occur in 1996-97 but which is, from the point of view of the model, unobserved. When water availability is reduced, however, the model generates estimates of additional trade, thereby induced.[†]

[†] The Australian Bureau of Statistics has released data for the year 2000-01 on water use — but this has not been incorporated into the TERM database at this time. For some regions of the southern MDB, water availability was lower in 2000-01 than in 1996-97; and the water market had developed this period. Therefore, the 2000-01 data on water use may incorporate more

Figure 2 **TERM-Water production structure**



In the base year (1996-97), water entitlement holders share the total volume of water available according to their priority and entitlement to the resource. Once water has been allocated, the current model does not distinguish between a megalitre of water conferred from a high security entitlement and one conferred from a low security entitlement. Effectively, 'a megalitre is a megalitre' within the present model.

Water use is the amount of water that an irrigator uses on a farm. Water may be sourced through the seasonal allocations that irrigators receive from their water entitlements (at the price charged by the water utility), through water trades or on-farm resources (including ground water). In the model, the source of the endowment of water is not identified.

The decision about how much water to use or sell is determined by the price at which trade is occurring, because this price represents the opportunity cost of using

unobserved trade than do the earlier data. If so, (all else being equal) in any model simulations based on later data, reductions in water availability would be expected to produce smaller additional water trades than those reported in this study.

allocated water. TERM-Water re-allocates water according to its marginal value product between trading groups. This reflects the incentive that irrigators have, in the real world, to purchase or sell water until equality is achieved between the water trade price and the value of the marginal product of water. Each irrigator then faces the same opportunity cost of water because each can chose to buy or sell, at the market price, the right to receive water from the water supply company or authority.

The model simulates the long run equilibrium allocation of water use across industries and regions. In the real world, the re-allocation embodied in this final equilibrium can occur through trade in seasonal allocations or trade in water entitlements, or both; in the model, there is no such distinction.

Water and irrigators' substitution choices

A critical parameter of the model is irrigators' choice of input substitution possibilities between water and other inputs. Appels, Douglas and Dwyer (2004) highlight the complex substitution choices that exist and how they differ across major agricultural enterprises such as dairy, rice and perennial horticulture.

A number of possible types of water trade restrictions are not separately identified in the model. In the model, trade restrictions are used to broadly represent these trade constraints in total.

Aside from the prices charged for water by utilities, the determinants of the rents accruing to holders of water entitlements include the productivity and relative scarcity of water in each region. When water trade is unrestricted within a region, the observed water price will be the value of the marginal product of water (which would be common to all water using industries in the region, adjusting for differential delivery costs). Similarly, water price differentials occur across regions if trade is restricted, and would disappear if restrictions were removed.

The issue of congestion is handled outside the model. Results are checked to ensure average annual water trade volumes do not breach the congestion constraints.

Water substitution assumptions

SIGTOP is the input substitutability between water and a bundle of all other inputs. It is represented in the production nest as a constant elasticity of substitution (the top-most CES production function in figure 2). A very low value of SIGTOP means there is little substitutability between water and the non-water aggregate input: even if the price of water rises significantly, the ratio of inputs used remains relatively unchanged.

The assumed value of SIGTOP affects the way in which an industry reacts to the increased scarcity of water and thus to water's increased price. A higher elasticity of substitution means farms can more readily move to those inputs that are relatively cheaper. Consequently, as water quantities used in production fall, the output of a farm can readily be maintained by increasing the intensity of capital, land and/or labour use. This means the effects of water quantity shocks are 'diluted'.

For all irrigated industries in TERM-Water, SIGTOP is assumed to be low, reflecting the importance of water as an input to production (there is little scope for substituting between water and other inputs). In each irrigation region, SIGTOP is assumed to be 0.01 for the rice growing industry and 0.05 for the beef and dairy industries. For all other industries in the irrigation regions, SIGTOP is assumed to be 0.03.

Higher parameter values allocated to particular industries account for the greater opportunities these industries have to substitute other inputs for water. The dairy industry, for example, can substitute purchased feed grains (which may not be derived from irrigated farming) for (irrigated) pasture and thus has been allocated a higher SIGTOP value than that for most other industries.

Model simulation

The economic impacts of expanding water trade in the southern MDB are estimated by comparing the effects of reductions in water availability under various water trade assumptions. In the model, water is permanently removed from use by agricultural industries and is not re-allocated to any other sector. The value of this water is not explicitly valued in the model. The increased opportunities for re-adjustment that exist under expanded trade would mean reductions in water availability would have different effects to reductions in the presence of restricted water trade. Those industries and regions in which water generates relatively low values of marginal product will sell water to those where it has higher marginal value.

In long run simulations using TERM-Water, labour and capital are mobile between industries and regions, and will tend to follow the water trade flows. Land is also assumed to be mobile between industries within a region. Under a reduction in water availability, national gross domestic product would be larger, therefore, than if trade were prevented, but the gross regional product could be larger or smaller.

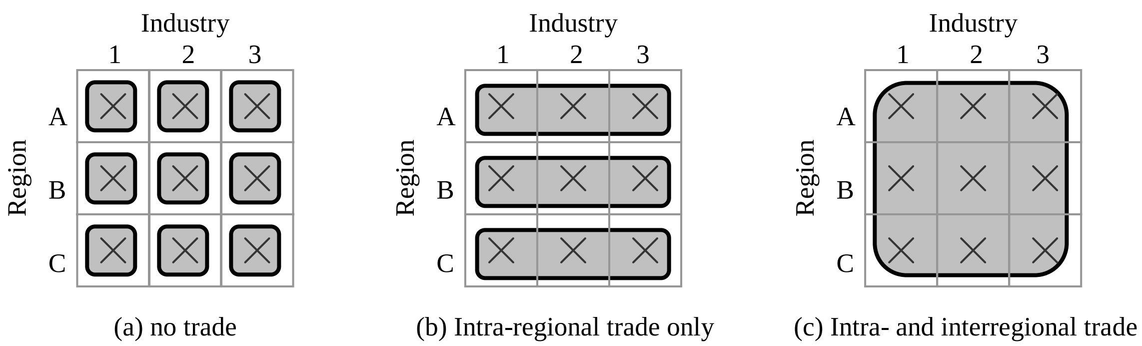
In short run simulations, capital is fixed and the ability for labour to migrate between industries and regions is reduced. This means that for a given water allocation reduction, the southern MDB may not have as significant reduction in

GRP in the short run as in the long run, because in the short run capital and labour inputs cannot leave the southern MDB to seek higher returns in other parts of Australia.

Each simulation compares three trade experiments that differ by the type of additional water trades allowed to occur. The sensitivity of the results to variations in some parameters of the model and to changes in the level and distribution of reductions in irrigation water allocations is then assessed. Figure 3 illustrates the extent of water trading in each experiment.

- 'No trade': water cannot be re-allocated between industries or regions, so every industry uses only the water that it is allocated (a).
- 'Intra-regional trade only': water re-allocation can occur among industries in the same region, but regions cannot export or import water to/from other regions (b).
- 'Intra- and interregional trade': water can freely flow among all trading regions and all industries within these regions (c).

Figure 3 **The extent of water trading**



3 Long run effects of water trade

The national macroeconomic effects of reduced water availability vary according to the water trade assumptions. Water reductions have the greatest effect if no water trade is allowed to occur within or between regions. If trade can occur between industries within a region, but trade between regions is constrained, the resulting decreases in gross domestic product (GDP) and GRP of the southern MDB are lessened. GDP and GRP effects are further reduced if both intra- and interregional water trade can occur. Moving from no trade to intra- and interregional trade together more than halves the impact of the reductions in water on the GRP of the southern MDB.

Without trade in water, a 10 per cent reduction in water availability, for example, reduces GRP of the southern MDB by 1.04 per cent ($356 million in 2003) (table 1). That is, relatively small reductions in GRP occur despite the assumption that other productive inputs are not readily substitutable for water. With trade permitted in each region, the reduction in GRP is less, at 0.67 per cent; it is less again, at 0.52 per cent, when trade in water is also allowed between regions.

Table 1 **GRP and GDP effects under different trade experiments[a]**

After a 10 per cent reduction in water availability

	No water trade [b]	*Intra-regional trade only* [c]	*Intra- and inter-regional trade* [d]	*Relative effects of moving from no trade to allowing intra-regional trade only* [e]	*Relative effects of moving from intra-regional trade only to allowing interregional trade* [f]
	%	%	%	%	%
New South Wales					
Murrumbidgee	–1.29	–0.66	–0.87	49	–32
Murray	–1.52	–0.90	–1.21	41	–35
Victoria					
Mallee	–1.39	–0.71	–0.41	49	42
Goulburn	–1.07	–0.90	–0.39	16	56
Loddon Campaspe	–0.30	–0.22	–0.13	25	42
Ovens Murray	–0.24	–0.19	–0.06	22	70
South Australia					
Murray Lands	–1.50	–1.18	–0.30	21	75
Southern MDB	–1.04	–0.67	–0.52	35	23
Australia	–0.008	–0.006	–0.004	31	22

[a] GDP includes market sales of water. Purchases of water are treated as an input cost. [b] No water trade permitted between industries within the same region or between regions. [c] Trade permitted between industries in the same region, but not between regions. [d] Trade permitted between industries in the same region as well as with other regions in the southern MDB. [e] Proportional difference between the first and second columns. [f] Proportional difference between the second and third columns.

Source: TERM-Water simulations.

Larger cuts in water availability have disproportionately larger effects on GRP and GDP. Doubling the cut in allocation more than doubles the effect on GRP for each region in the southern MDB and on national GDP (table 2). When intra- and interregional trade are both permitted, for example, a 10 per cent cut in water allocations reduces GRP for the southern MDB by 0.52 per cent, a 20 per cent cut reduces it by 1.17 per cent, and a 30 per cent cut decreases it by 2.02 per cent — almost four times the loss from the 10 per cent cut.

Table 2 **GDP and GRP effects under different trade and water availability experiments[a]**

	10 per cent reduction in water availability			*20 per cent reduction in water availability*			*30 per cent reduction in water availability*		
	No trade[b]	Intra- trade[c]	Inter- trade[d]	No trade[b]	Intra- trade[c]	Inter- trade[d]	No trade[b]	Intra- trade[c]	Inter- trade[d]
	%	%	%	%	%	%	%	%	%
New South Wales									
Murrumbidgee	–1.29	–0.66	–0.87	–3.02	–1.45	–1.92	–5.11	–2.45	–3.23
Murray	–1.52	–0.90	–1.21	–3.48	–1.98	–2.65	–5.78	–3.30	–4.42
Victoria									
Mallee	–1.39	–0.71	–0.41	–3.67	–1.57	–0.98	–6.64	–2.59	–1.78
Goulburn	–1.07	–0.90	–0.39	–2.63	–2.09	–0.94	–4.57	–3.54	–1.72
Loddon Campaspe	–0.30	–0.22	–0.13	–0.70	–0.49	–0.31	–1.18	–0.78	–0.58
Ovens Murray	–0.24	–0.19	–0.06	–0.66	–0.46	–0.13	–1.26	–0.81	–0.24
South Australia									
Murray Lands	–1.50	–1.18	–0.30	–4.08	–2.89	–0.70	–7.48	–4.99	–1.27
Southern MDB	–1.04	–0.67	–0.52	–2.55	–1.53	–1.17	–4.43	–2.58	–2.02
Australia	–0.008	–0.006	–0.004	–0.027	–0.017	–0.012	–0.059	–0.036	–0.024

[a] GDP includes market sales of water. Purchases of water are treated as an input cost. [b] No water trade permitted between industries within the same region or between regions. [c] Trade permitted between industries in the same region, but not between regions. [d] Trade permitted between industries in the same region as well as with other regions in the southern MDB.

Source: TERM-Water simulations.

The *relative* gains from allowing intra-regional trade, and intra- and interregional trade are remarkably similar between the different allocation reductions (see table 3). For example, the effects of moving from intra-regional trade only to allowing both intra- and interregional trade on southern MDB GRP are reduced by 23, 24 and 22 per cent, when water allocations are cut by 10, 20 and 30 per cent respectively. There is a 98 per cent correlation between the trade effects on GRP resulting from the various per cent reductions in water availability.

Table 3 **GDP and GRP effects of trade after water availability reductions**

	Relative effects of moving from no trade to allowing intra-regional trade only [a]			*Relative effects of moving from intra-regional trade only to allowing interregional trade* [b]		
	10% reduction	20% reduction	30% reduction	10% reduction	20% reduction	30% reduction
	%	%	%	%	%	%
New South Wales						
Murrumbidgee	49	52	52	–32	–32	–32
Murray	41	43	43	–35	–34	–34
Victoria						
Mallee	49	57	61	42	38	31
Goulburn	16	21	22	56	55	52
Loddon Campaspe	25	30	34	42	36	26
Ovens Murray	22	30	36	70	72	71
South Australia						
Murray Lands	21	29	33	75	76	75
Southern MDB	35	40	42	23	24	22
Australia	31	36	39	22	30	32

a Proportional difference between GRP/GDP changes in the no trade and intra-regional trade only experiments. **b** Proportional difference between GRP/GDP changes in the intra-regional trade only and intra- and interregional trade experiments.

Source: TERM-Water simulations.

Detailed analysis of a 10 per cent water reduction

As water becomes scarcer, its relative value (opportunity cost) increases. With intra- and interregional trade, irrigators can respond by moving water between industries and regions. Irrigators with higher water intensities (water use per unit of output) in production, those with water expenditures representing a higher proportion of total costs, and those for whom other inputs can be substituted more easily for water (that is, with higher SIGTOP values) are more likely to use less water and to sell unused water to generate income. As water moves to different industries and regions, labour and capital tend to move with it, increasing the growth effects in importing regions and increasing the falls in output in exporting regions. Within a region, land can also be re-allocated between industries to some degree.

The top panel of table 4 summarises the patterns of net water trade (exports minus imports) under intra-regional trade. When trade is allowed within a region, the rice and dairy industries in most regions reduce water use and become net sellers of water to the remaining (net purchasing) industries.

With only intra-regional trade permitted, the opportunity cost of water differs across regions. When trade is allowed between regions as well as within regions, prices equalise and industries that were net sellers of water under intra-regional trade tend to become net exporters to water purchasing industries in other regions (see the lower panel of table 4). Similarly, interregional trade allows industries purchasing water under intra-regional trade to become net importers of water.

The Murrumbidgee and Murray regions are estimated to be net exporters (each exporting in excess of 46 gigalitres of water) and the Murray Lands and northern Victorian regions are likely to be net importers of the water — reflecting the distribution of industries across regions. Water is primarily exported from the rice industry in the Murrumbidgee and Murray regions, with almost all industries in the importing regions being purchasers of water.

Total *net* water trade within the southern MDB is a relatively small share of total water allocations, with only 2.3 per cent of total allocations traded among regions. Similarly, net water exports or imports from a region are a small percentage of total water allocations in that region. Imports to the Murray Lands region, for example, represent approximately 8 per cent of total allocations in that region, while exports from the Murrumbidgee region represent around 4 per cent of total allocations for that region.

Table 4 **Net water trades among industries in the southern MDB[a]**

After a 10 per cent reduction in water availability

	Murrumbidgee	*Murray*	*Mallee*	*Goulburn*	*Loddon Campaspe*	*Ovens Murray*	*Murray Lands*
	ML	ML	ML	ML	ML	ML	ML
Intra-regional trade only							
Sheep	10 601	7 735	1 857	1 614	2 324	0	303
	(8.0%)	(8.2%)	(3.2%)	(6.7%)	(6.5%)	–	(5.2%)
Other broadacre	14 347	13 651	209	473	–528	5	66
	(7.6%)	(7.9%)	(7.7%)	(4.8%)	(–3.4%)	(7.4%)	(5.2%)
Beef cattle	4 796	3 967	45	783	320	299	–6
	(6.4%)	(6.9%)	(0.2%)	(0.7%)	(1.7%)	(3.7%)	(–0.1%)
Dairy cattle	736	6 613	–17 518	–8 072	–352	–531	–5 309
	(6.9%)	(6.6%)	(–8.3%)	(–1.6%)	(–0.9%)	(–1.3%)	(–9.9%)
Rice	–52 730	–43 926	–64	–709	0	0	0
	(–8.2%)	(–5.6%)	(–9.1%)	(–12.9%)	–	–	–
Perennial horticulture	11 962	5 757	13 964	3 604	97	60	4 150
	(10.2%)	(9.9%)	(7.3%)	(5.2%)	(1.7%)	(0.5%)	(2.3%)
Irrigated pasture	672	1 094	–631	503	267	82	–200
	(7.7%)	(7.6%)	(–4.1%)	(1.4%)	(2.2%)	(2.3%)	(–5.4%)
Vegetables	2 690	1 774	1 148	859	275	0	793
	(8.2%)	(8.5%)	(7.0%)	(5.8%)	(7.2%)	–	(4.1%)
Other crops	6 928	3 334	989	945	–2 402	85	203
	(6.6%)	(6.9%)	(7.2%)	(3.8%)	(–5.8%)	(7.0%)	(4.6%)
Total	**0**	**0**	**0**	**0**	**0**	**0**	**0**
	(0%)	(0%)	(0%)	(0%)	(0%)	(0%)	(0%)
Intra- and interregional trade							
Sheep	9 208	6 673	3 811	2 142	2 959	0	530
	(7.0%)	(7.1%)	(6.5%)	(8.9%)	(8.2%)	–	(9.0%)
Other broadacre	11 996	11 343	256	833	484	7	120
	(6.4%)	(6.5%)	(9.4%)	(8.4%)	(3.1%)	(10.0%)	(9.5%)
Beef cattle	3 457	2 905	1 271	6 452	995	668	349
	(4.6%)	(5.0%)	(4.7%)	(6.0%)	(5.3%)	(8.2%)	(7.3%)
Dairy cattle	420	3 294	–121	24 748	1 420	2 809	2 623
	(3.9%)	(3.3%)	(–0.1%)	(4.9%)	(3.6%)	(6.7%)	(4.9%)
Rice	–89 692	–91 627	64	658	0	0	0
	(–14.0%)	(–11.6%)	(9.1%)	(12.0%)	–	–	–
Perennial horticulture	9 887	4 907	16 528	5 666	322	939	15 107
	(8.5%)	(8.5%)	(8.7%)	(8.2%)	(5.5%)	(7.6%)	(8.5%)
Irrigated pasture	494	755	393	2 392	689	294	241
	(5.7%)	(5.2%)	(2.5%)	(6.5%)	(5.6%)	(8.1%)	(6.5%)
Vegetables	2 329	1 533	1 414	1 256	330	0	1 706
	(7.1%)	(7.3%)	(8.6%)	(8.4%)	(8.6%)	–	(8.7%)
Other crops	5 161	2 484	1 208	1 903	497	115	394
	(4.9%)	(5.2%)	(8.8%)	(7.6%)	(1.2%)	(9.6%)	(9.0%)
Total	**–46 741**	**–57 734**	**24 824**	**46 051**	**7 696**	**4 832**	**21 071**
	(–3.6%)	(–4.3%)	(4.6%)	(5.7%)	(4.5%)	(7.1%)	(7.8%)

a Percentages in parentheses are net trades as a proportion of water allocations.

Source: TERM-Water simulations.

Regional impacts

All regions' GRP losses are reduced by allowing intra-regional trade. Under a 10 per cent reduction in water availability, the loss in GRP is 16–49 per cent less than in the no trade experiment (table 1). Allowing interregional trade as well as intra-regional trade further reduces the GRP losses in most regions. The Murray Lands region in South Australia and northern Victorian regions become net water importing regions and experience reduced losses in GRP, moving from intra-regional trade only to allowing trade between as well as within regions. The Murrumbidgee and Murray regions in New South Wales experience larger declines in GRP (by 32 per cent and 35 per cent respectively) with expanded trade as the two regions export water.

The differences in the effects of trade on individual regions depend on differences in the price of water and value of marginal product of water between regions. The regional distribution of the water purchasing and water selling industries will reflect these differences. The effects of trade on GRP are larger for regions with a higher proportion of water sales to allocations than for regions where the proportion is low. Water selling industries (such as rice) are concentrated in the Murrumbidgee and Murray regions, while water purchasers (such as dairy and horticulture) are located in the northern Victorian regions (except for dairy in the Murray Lands region). As water is exported from a region, capital and labour also move to the regions that import the water (table 5).

Table 5 **Changes in regional primary factor use**

After a 10 per cent reduction in water availability

	Intra-regional trade only [a]			*Intra- and interregional trade* [b]			*Difference* [c]		
	Water	*Capital*	*Labour*	*Water*	*Capital*	*Labour*	*Water*	*Capital*	*Labour*
	%	%	%	%	%	%	%	%	%
New South Wales									
Murrumbidgee	–10	–1.3	–0.4	–13.2	–1.8	–0.6	–3.2	–0.5	–0.2
Murray	–10	–1.8	–0.6	–13.8	–2.5	–0.9	–3.8	–0.7	–0.3
Victoria									
Mallee	–10	–1.0	–0.7	–5.8	–0.5	–0.4	4.2	0.4	0.3
Goulburn	–10	–1.3	–0.8	–4.8	–0.6	–0.4	5.2	0.7	0.4
Loddon Campaspe	–10	–0.3	–0.2	–6.0	–0.2	–0.1	4.0	0.1	0.1
Ovens Murray	–10	–0.3	–0.2	–3.6	–0.1	0.0	6.4	0.2	0.1
South Australia									
Murray Lands	–10	–1.6	–1.2	–3.0	–0.4	–0.3	7.0	1.2	0.9

a Trade permitted between industries in the same region, but not between regions. **b** Trade permitted between industries in the same region as well as with other regions in the southern MDB. **c** The percentage point difference between the corresponding columns for the two experiments.

Source: TERM-Water simulations.

Unlike water, under ‘no trade’ capital and labour can move between regions. With larger intra-regional effects on industry under no trade, capital and labour also respond by larger movements from the regions. For example, capital and labour in the Murrumbidgee region decline 1.9 per cent and 1.0 per cent respectively under ‘no trade’, both more than with water trade.

Within Victoria, under a 10 per cent reduction in water availability, the Goulburn and Mallee regions (which have a higher share of dairy output) experience a larger decline in output than that experienced by those regions with a larger share of perennial horticulture industries.

Also dampening the impacts of the reduction in water availability are the second and third round impacts on other agricultural industries that are not major water users. The effects on GRP of contracting irrigated industries, for example, are partly offset by growth in non-irrigated agricultural industries (such as wheat, barley and other crops) as labour and capital are freed to move to those industries.

Sectoral impacts

The primary sector accounts for most of the fall in industry value added after a reduction in water availability. Under a 10 per cent reduction, and allowing only intra-regional trade, the primary sector accounts for 65 per cent of the relatively small decline in GRP in the southern MDB. Growth in the (non-food processing) manufacturing sector and income from water sales lessen this impact. With interregional trade, the primary sector contributes 72 per cent to the overall decline in GRP. This is because expanding water trade allows primary industries in some regions to substitute water sales for output sales as a source of income. As income sources change, output, employment and capital used in these industries declines as water trade expands and, as local primary industries contract, other industries (in, say, the food processing sector) switch the source of their inputs to other regions or overseas.

Local labour and capital become cheaper as wages and returns to capital decline when these factors are released from declining primary industries. Cheaper labour and capital reduce production costs for food processing, so food processing output in the southern MDB declines less under expanded trade. However, the smaller decline in the region’s food processing is not sufficient to absorb all of the capital and labour released from primary industries as water trade expands. As a result, with national employment unchanged, remaining unused labour is absorbed by industries in other regions and output there expands.

In Victoria, primary industries contract less because they import water from New South Wales. The Victorian food processing sector contracts further as demand for its products is increasingly satisfied by food processing industries in New South Wales regions. As a result, manufacturing declines, although small, are more pronounced in the northern Victorian regions, which have larger food processing industries (such as dairy products). The transport industry is an important component of the regional services sector and, in most regions, is more affected than other service industries by moving from intra-regional trade only to intra- and interregional trade.

As a result of interregional trade, value added in the primary sector and, to lesser extent, the service and (non-food processing) manufacturing sectors in some regions decline as water trade expands. However, this is less than reductions in value added in other regions. Thus, value added for each of these sectors declines less for the entire southern MDB, as trade expands (table 6). The 10 per cent reduction in water availability leads to a 2.29 per cent and 1.91 per cent reduction in primary sector production in the southern MDB under intra-regional trade only and intra- and interregional trade respectively. This means that expanding water trade lessens the impacts of the water reduction by 16.4 per cent.

Table 6 **Sectoral differences in value added from expanded water trade[a]**
After a 10 per cent reduction in water availability

	Primary	*Food processing*	*Other manufacturing*	*Services*
	%	%	%	%
New South Wales				
Murrumbidgee	–40.9	47.7	7.9	–38.1
Murray	–44.7	22.3	42.0	–40.9
Victoria				
Mallee	41.9	47.8	–60.8	43.8
Goulburn	55.7	54.9	–13.7	56.3
Loddon Campaspe	41.5	41.4	–9.5	43.2
Ovens Murray	74.1	45.8	25.2	68.5
South Australia				
Murray Lands	77.8	63.6	156.6	73.3
Southern MDB	**16.4**	**53.8**	**3.7**	**15.4**

[a] Differences are calculated as the percentage difference between the intra-regional trade only experiments and the intra- and interregional trade experiment. Changes in sectoral output are presented in appendix D, table D.4.

Source: TERM-Water simulations.

Industry impacts

When water availability is reduced by 10 per cent, with or without trade, output declines in most industries. However, in most industries, declines in output are lower when intra- and interregional trade is allowed. The extent of the effects of trade differs across industries and regions, depending on whether trade is confined within regions or allowed across regions. Given the large number of industries considered in the model, the focus here is on selected irrigated industries that dominate agricultural output in the southern MDB.

- Dairy industry output falls by around 8 per cent under intra-regional trade, and by around 4 per cent under intra- and interregional trade.
- Perennial horticulture industry output (citrus, apples and pears, stone fruits, other fruits and nuts, dryland premium grapes, irrigated premium grapes and other grapes) decreases by around 1.4 per cent under intra-regional trade and by around 0.7 per cent under intra- and interregional trade.
- The output of the rice industry falls by around 15 per cent under intra-regional trade and by around 20 per cent under intra- and interregional trade.

For each industry, there can be significant differences in effects across regions.

4 Short run effects of water trade

Year to year variations in seasonal allocations can be represented within TERM-Water as reductions in water availability relative to the base year 1996-97.

Table 7 **Reductions in water availability compared to 1996-97**
Based on observed seasonal allocations

	1997-98	*1998-99*	*1999-00*	*2000-01*	*2001-02*
	%	%	%	%	%
Murrumbidgee	–8.3	–12.4	–18.0	–10.0	–23.7
Murray	–28.9	–20.7	–54.1	–12.0	–15.8
Mallee	–14.1	–15.2	–33.8	–16.4	–13.0
Goulburn	–22.8	–27.0	–34.3	–25.8	–19.1
Loddon Campaspe	–14.1	–15.2	–33.8	–16.4	–13.0
Ovens Murray	–5.0	–5.0	–5.0	–5.0	–5.0
Murray Lands	–5.0	–5.0	–5.0	–5.0	–5.0
Southern MDB	–17.7	–17.4	–33.2	–14.0	–17.4

Source: PC estimates.

Each year is modelled separately under short run assumptions with the corresponding cuts in allocations assumed to occur only in that year. Tables are not reproduced, due to space limitations. Consequently, within an individual year some regions face larger cuts in allocations than others. Those that face larger cuts are likely to be net importers of water.

In each year, moving from no trade to intra- and interregional trade approximately halves the effect (between 47 and 55 per cent) of the reductions in water on the gross regional product (GRP) of the southern MDB.

The potential increases in GRP of the southern MDB from water trade are greater in drier years such as 1999-2000 ($555 million in 1999-2000 dollars), compared with years when water is more abundant, as in 2000-2001 ($201 million in 2000-01 dollars).

These estimates are the change in GRP of moving from no trade to both intra- and interregional trade when water availability is reduced from 1996-97 levels to 1999-2000 or 2000-01 levels. It is assumed that the structure of the economy is relatively constant between years. The dollar value of altering the trading regime is estimated by comparing the results of the different trade experiments.

If variations in seasonal allocations are random (and do not exhibit long term patterns) irrigators are more likely to manage this short term risk through trade in seasonal allocations rather than trade in entitlements. Nevertheless, freeing up either or both kinds of trade will enable irrigators to better manage the variability associated with seasonal allocations.

Although TERM-Water is not a dynamic model and therefore does not consider the flow on effects of changing levels of production, the year to year effects of expanding trade can be totalled to provide a rough indication of the longer term implications of expanding trade to manage seasonal variability in allocations. For example, in the five years between 1997-98 and 2001-02, the GRP of the southern MDB would have been around $1.4 billion (in undiscounted 2001-02 dollars) or about one per cent higher if intra- and interregional trade had been allowed to re-allocate water in response to variability in seasonal allocations (compared to no water trade). Given that variability in seasonal allocations is a common phenomena across the southern MDB, the long term benefits of expanding trade are likely to be larger than these estimates.

5 Model design considerations

A number of aspects o the design of the model mean that the results should be carefully interpreted. Design constraints include the following:

- In the database, each industry in each region has water consumption that is assumed to be its initial allocation.
- Production decisions of industries are based on annualised data and do not reflect how choices may change within an irrigation season.
- Transmission losses of water (evaporation and accession to groundwater) associated with the intra- and interregional trade of water are not included.
- Only the irrigation industries use water; it is not possible to re-allocate the water to (or have it purchased by) other users, such as other industries or the environment.
- There is no distinction between trade in seasonal allocations and trade in water entitlements.
- The model is comparative static and cannot assess progressive reductions in water availability or trade liberalisation over time.
- Care is needed in extrapolating because the results of the model are specific to the experiments undertaken. The effect on GRP in the southern MDB of a 20 per cent reduction in water availability are more than double those of a 10 per cent reduction — that is, the effects are not linear.
- This analysis does not take into account the impact of changes in water trade on environmental conditions such as salinity.

6 References

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