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Grapes, Wine and Water: Modelling water Policy Reforms in Australia

Randy Stringer
Glyn Wittwer

November 2001

Adelaide University
Adelaide 5005 Australia

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Executive Assistant
CIES
School of Economics
Adelaide University
SA 5005 AUSTRALIA
Telephone: (+61 8) 8303 5672
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Randy Stringer and Glyn Wittwer

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School of Economics
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ABSTRACT

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The policies, incentives and management practices shaping the future availability, access, use and quality of water have enormous implications for Australia's wine industry. While grapes are a relatively high value, low volume irrigation activity, growers do depend on reliable supplies of good quality water at specific times throughout the year. This paper explores the key factors motivating change in national, regional and local water institutions and examines how the resulting policy reforms effect water markets, water use, and the profitability of grape growers. FEDSA-WATER, a national level CGE model of Australian is used to examine the removal of implicit subsidies on water usage in irrigation industries in New South Wales and Victoria, and the removal of small implicit taxes on usage in South Australia, for the various irrigation industries. A second scenario taxes producers for salinity. In the water pricing reform scenario, there is a redistribution of irrigation activity to South Australia with pricing reforms. There is an overall decline in agricultural output but this is outweighed by the benefit in terms of reduced salinity damage. Similarly, in the case of taxing producers for the full cost of salinity damage, the benefit of reduced salinity outweighs the reduction in national income.

Keywords: Water markets, CGE, wine, policy reforms.

Contact author :
Randy Stringer
School of Economics and
Centre for International Economic Studies
Adelaide University
Adelaide SA 5005
Phone (+61 8) 8303 4821
Fax (+61 8) 8223 1460
Email: randy.stringer@adelaide.edu.au

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Grapes, Wine and Water: Modelling Water Policy Reforms in Australia

Randy Stringer and Glyn Wittwer[1]

Introduction and Overview

The policies, incentives and management practices shaping the future availability, access, use and quality of water have enormous implications for Australia's wine industry. Water plays a crucial role in a wide range of wine-related activities. Rainfall and irrigation influence grape quality, vine health, vintage variation, grape flavour, and wine complexity. Water prices affect cost competitiveness, risk management, and enterprise returns. Water use is an important marketing trait, with implications for geographical attributes and trade relations. Water management practices and winery waste water control impact on the industry's overall environmental reputation at home and abroad.

While grapes are a relatively high value, low volume irrigation activity, growers do depend on reliable supplies of good quality water at specific times throughout the year. Timely access to high quality water supplies is crucial to grape production and wine quality. To help cope with the implications of the rapidly evolving water reforms, it is essential that the industry remains involved in the ongoing water reform debates.

A number of international, national, and local forces are driving fundamental changes to Australia's water institutions. These rapidly changing water laws, water policies, water markets, licensing regimes, water administrations, and environmental regulations alter the incentives and opportunities facing grape growers and the wine industry. Wine grapes are one of the fastest expanding irrigated crops in Australia. The area of irrigated grapes has increased from around 40 thousand ha in 1990 to 125 thousand in 2000. In South Australia grape production now accounts for some 33 per cent of the state's irrigated area, up from less than 15 per cent just a decade ago (ABS; 2000).

The wine industry has an important stake in how water institutions evolve, how they are influenced and how they are monitored, evaluated and adapted. This paper attempts to contribute to this process by reviewing the key factors motivating change in national, regional and local water institutions and how the resulting policy reforms effect irrigation performance, water markets, water use, and the profitability of grape growers?

What are the key factors motivating change in Australia's water institutions?

Irrigation trends in Australia are diverging from almost all of its OECD counterparts, including its major wine exporting competitors. The proportion of Australia's water

[1] The authors wish to thank the Grape and Wine Research and Development Corporation for funding assistance.

used for agricultural purposes is increasing both in absolute and relative terms. The experience in the European Union, Japan and North America is the opposite -- less water for agriculture and more for cities and industries. In fact, during the past four decades, the area under irrigation in Australia has expanded sixfold, while agricultural area increased by more than one-third, the average farm size doubled in area; and the volume of farm chemicals used per year trebled (ABARE, 1997a, 1997b, 1998, 2000; Chisholm, 1997). Several reasons help explain these trends.

First, Australia is the driest inhabited continent. Most of its soils are shallow and infertile. While 60 per cent of the country's land area is used for agriculture, only 5 per cent of that agricultural land has sown pasture grasses and less than 5 per cent is cropped. The rest is arid leased land used for grazing cattle and sheep on native grasses for meat and wool production. Even so, most sheep and cattle are grazed in the higher-rainfall, mixed-farming zones, with only a small proportion in the arid and semi-arid range lands that cover the majority of the continent.

Second, agriculture is more important to the economic prosperity of Australia than to most other advanced industrial countries. While primary agriculture's contribution to national production is not large, at around 3 per cent of GDP, the entire agricultural and food processing industry contributes 12 per cent of GDP and 7 per cent of employment (DFAT, 1999; ABS, 2000a). It is expected to continue playing a significant role in regional economic development and as a foreign exchange earner.

Third, 80 per cent of Australia's agricultural production is exported, the value of which accounts for one-fifth of all goods and services exports. While that one-fifth share is much smaller than it was in earlier decades, any downturn in agricultural exports still has important macroeconomic implications for Australia. That plus the high dependence of farmers on exports means Australia is unusually sensitive to policies and practices at home and abroad that affect its agricultural competitiveness.

Fourth, Australia has relatively abundant water supplies compared with its major agricultural export competitors (Table 1 and Figure 1). In per capita availability terms, Australia has 16 times more water than South Africa, 9 times more than Italy, 6 times more than France and Spain, and 2 times more than Argentina and the US. Among the major wine producers, Chile has more water per capita with 3 times as much as Australia. In addition, 70 per cent water use in Australia is for agricultural purposes compared with 12 per cent in France, 40 per cent in the US and 53 per cent in Italy.

Fifth, Australia's geographical location, relative isolation, lower population pressure, and a rural sector generally free of polluting industrial activities provide it irrigation-related advantages. The country's 19 million inhabitants are heavily concentrated in urban centres along the south-eastern and south-western coastlines, with most people living and working in cities. More than 80 per cent of the entire population occupy just 1 per cent of Australia's land surface. The country's eight state and territory capital cities account for two-thirds of the population and more than two-thirds of employment (SEAC, 1996). In addition, water use in many Australian cities declined and operational efficiency increased during the 1990s due to water reforms that led to higher prices and reduced subsidies (AATSE, 1999).

In contrast, the population of California, the major grape producing state in the US, is expected to increase from 34 million in 2001 to 47.5 million in 2020 (DWR, 1998). Over this time period, the share of water going to urban users is expected to increase by 4 per cent while agriculture's share declines by 4 per cent (DWR, 1998). At present, agriculture accounts for 43 per cent of total water use in California. Irrigation in South Australia accounts for 80 per cent of total water use and the state faces no foreseeable population pressure. The total area of irrigated vines in California is 218 thousand ha compared to 125 thousand in Australia and 50 thousand in South Australia.

Sixth, the depreciating Australian dollar and increased product prices from export demand over the past few years helps explain why producers have been able to expand irrigation while facing increasing expenses imposed by water reforms. For example, the real value of both wine-grape production and wine production has grown at more than 10 per cent per annum over the past 12 years (Anderson 2000). Over the last 9 vintages, grape prices have increased 90 per cent (ABS 1997, 1998, 1999, 2000b). The volume of wine exports has risen from less than 5 per cent to more than 30 per cent of production, and will soon exceed 50 per cent of sales. Australia is now the world's largest wine exporter after the European Union bloc, having been a net importer of wine as recently as the early 1980s.

Seventh, international organisations seek lessons from Australia's experience to guide policies in dozens of other countries throughout the world. Many developing countries face water scarcity issues so severe that health, life and food security are threatened. With some of the highest income and best educated irrigators any where in the world, the OECD, the World Bank, and the United Nations recognise Australia's experience as key to solving water scarcity and water related environmental problems.

In part, international pressures are coming from Australia's wine exporting competitors keen to identify any direct or indirect water related subsidy to grape growers. Information that can be used in trade negotiations to slow the market penetration progress of a country that is making rapid in roads into the market share of their traditional export markets. Additional international obligations influencing water policies include UNCED follow-up requirements, post-Uruguay Round and WTO obligations, environmental treaties on climate change, biodiversity and desertification and adoption of internationally-accepted codes and practices such as CODEX, HACCP and ISO.

Finally, environmental pressures are forcing major changes to Australia's water institutions. Over time, the long-term trends in water use, land clearing, intensification and specialisation have brought about extensive changes to the country's natural resources. While crop productivity growth has been sustained by more intensive water use practices, by-products have included soil structure decline, soil and water erosion, and increased levels of salinity and acidity. The increased demand for water, changing agricultural technologies and management systems are altering soil, landscape, vegetation and water resources, in ways that can result in pollution, contamination, resource degradation and habitat loss.

Water-related environmental issues have become a key factor motivating change in Australia's water institutions. Water has moved to the forefront of national policy debates aimed at meeting expanding social, economic and environmental objectives. The primary agricultural activities causing water-related environmental problems are: (a) allowing runoff from fields to carry sediments, nutrients, organic matter and agricultural chemicals; (b) extracting too much water for irrigation, resulting in severe impacts on aquatic ecosystems, water quality and groundwater supplies; (c) inverting the natural pattern of river flows in southern Australia (high demands for irrigation during summer when river flows are low and low demand for irrigation during winter when river flows are high); and (d) clearing and using land and water in ways that result in rising water tables and salinity (Cullen and Bowmer, 1995).

Water and irrigation-related environmental pressures are greatest in the river system contained in the Murray Darling Basin (MDB). The MDB covers one-seventh of Australia's landmass, and crosses four states (New South Wales, Queensland, South Australia and Victoria). The MDB contains more than 70 per cent of the country's irrigated area and produces 90 per cent of the value of irrigated food crops. In addition, it supports more than 50 per cent of the country's crop land and produces more than 40 per cent of the country's total agricultural output value (ABS, 1996). Some 95 per cent of MDB water diverted for human use goes to agriculture and the flows of all but one of the rivers within the system have been modified to support the growth of agricultural industries. Additional pressures are stemming from the fact that the MDB is rich in Aboriginal cultural heritage sites and includes some 140 conservation areas and numerous internationally-recognised wetlands.

Extensive use of superphosphate fertilizer in the MDB has been singled out as the primary source of phosphorous, which led to the world's largest toxic blue-green algal bloom in the summer of 1991-92. The algae expanded over a 1000-km stretch of the Darling River, resulting in the closure of water supplies and major disruptions to local communities. Local, state and national governments responded by establishing the Murray Darling Initiative. This environmental crisis is credited as the single most important impetus in generating cooperative action and the development of best-practice management activities to address water issues in Australia (ABS, 1996).

To address problems associated with nutrient loads and eutrophication, increasing water salinity, declining wetlands and declining river health, the Murray Darling Basin Ministerial Council imposed a Cap on water diversions in 1997. Establishing a Cap involves the complex task of allocating water for environmental needs as well as for agricultural producers and other users. The Cap on water diversions represents the most significant water resources initiative since the establishment of the MDB Ministerial Council in 1985, and is widely recognised as a landmark decision in Australia's natural resource management (MDBC, 1998). The Council aims to balance economic and social benefits and the environmental uses of water in the rivers. The cap is defined as 'The volume of water that would have been diverted under 1993/94 levels of development. In unregulated rivers this is expressed as an end-of-valley flow regime.

Irrigation in Australia

Agriculture is Australia's largest water user, accounting for some 70 per cent of the country's water consumption (Table 2). The 2.1 to 2.4 million ha of irrigated crops and pastures represent less than 0.5 per cent of the total agricultural land and about 12 per cent of the total area of crops and pastures (Table 3). The value of irrigated production fluctuates between 25 per cent and 30 per cent of Australia's gross value of agricultural output (Cape, 1997; ABS, 2000b). Irrigation supports the production of all rice, most vegetables, milk, fruit, grapes, cotton and significant amounts of soybeans and sugar, while its contribution to meat, cereal, pulse and oilseed production is relatively minor (DPIE, 1998).

Table 4 presents GVP returns per ML of water use for specific crops. Vegetables, fruit and grapes are the high value water users; pasture, rice, sugar and cotton are the low value users. Historically the price of water has been set so low as to not be a critical factor in the choice of crop under irrigation (Smith, 1998). Much of this irrigated water still goes to low value uses. Figure 2 presents data from a 1997 benchmarking study of irrigation performance in NSW. Irrigated grape production out performs cotton, lucerne and rice: grapes averaged 3.4 ML/Ha and returned $6.45 per ML compared with cotton which averaged 7.5 ML/Ha and returned $0.58 per ML; lucerne which required 9.4 ML/Ha and returned $.048 per ML; and rice using 12.8 ML/Ha and retuning $0.27 per ML. These numbers suggest a large potential for high value irrigation activities to draw water away from pasture, rice and sugar.

At the national level, pasture accounts for more than 44 per cent of irrigated area; cereals accounts for 23 per cent, and cotton 17 per cent. During the past decade, cotton and grapes have been two of the fastest growing irrigated crops (Figure 3). The irrigated cotton area expanded from 252 thousand ha in 1993 to 382 thousand in 2000. Irrigated grape production has expanded from around 43 thousand ha to an estimated 125 thousand during the same period. The total area planted to grapes in 2000 is 146.2 thousand ha and an estimated 85 per cent are irrigated.

NSW, Queensland and Victoria account for some 88 per cent of the water consumed in irrigation and 90 per cent of the irrigated area (Table 5). NSW dominates, consuming 46 per cent of the water on 44 per cent of the irrigated land. At the state level, average water use per ha varies from more than 20 ML/Ha in Western Australia to 2.2 ML/Ha in Tasmania.

The available ABS data, including the recently published *Water Accounts for Australia* (2000), suggest that average quantity of water used per ha on grapes in 1996-97 are: 15.9 ML/Ha in NSW; 10.5 ML/Ha in Victoria; 5.1 ML/Ha in South Australia; and 4.2 ML/Ha in Western Australia (Table 6). The national average is around 9.3 ML/Ha. Even with the high proportion of furrow irrigation in NSW, the ABS data on water use appears too high and out of line with most other reports on irrigation practices. Grape irrigation specialists suggest that water use ranges from more than 15 ML/Ha in the MDB to less than 0.5 ML/Ha in the groundwater dependent regions of South Australia and Western Australia. Approximately 10 per cent of Australia's vine area receives no irrigation. An additional 3 to 5 per cent receive 'supplementary watering', to control, for example, water stress levels, or to maintain vine health or to manage the risk of an extended drought.

The MDB is the high-water use, high-yield grape production zone in Australia. The MDB contains more than 80 thousand ha of Australia's grape area. The vast majority is irrigated, representing some 55 to 60 per cent of the total area planted to grapes and more than two thirds of the irrigated grape area. The average grape yield (including table grapes) in the MDB is 18.2 t/ha. Average yields in the groundwater-dependent regions of South Australia and Western Australia is 9.5 t/ha, nearly 50 per cent less.

About 90 per cent of Victoria's grape area is in the MDB (34.5 thousand ha); 70 per cent of the area in NSW (24.4 thousand ha); and 40 per cent of South Australia's grape area (24.5 thousand ha). The Barossa and Clare districts in South Australia also have access to Murray River water (Langhorne Creek is included in the 24.5 thousand ha estimate).

The majority of South Australia's grape growers and the majority of the state's vine area are located in groundwater dependent zones, including the Adelaide Hills, Barossa, Coonawarra, Fleurieu Peninsula, Limestone Coast, McLaren Vale, and Padthaway. Water use in these areas is relatively low, averaging less than 2 ML/Ha. These groundwater areas also produce the majority of the country's highest value, premium grapes. The high water use area is South Australia's Murray region, accounting for 31 per cent of the area and averaging 7.5 ML/Ha or 68 per cent of the water used on vines in the state.

The emerging role of markets in water resource management

Research and extension on sustainable irrigation practices and regulatory approaches dominate Australia's policy response to environmental issues and resource mismanagement, full cost resource pricing and overcoming market failure through the creation of property rights are also being encouraged. Over the past several years, the regulatory approach has been complemented by or, in some cases even replaced with, economic incentives, market instruments and property rights systems (Corbyn, 1996; Jones, 1997; Gunasekera, 1997).

Market mechanisms introduced to meet strategic objectives, include implementing the polluter pays, beneficiary pays and user pays principles. This more market-oriented approach also involves assessing total economic values for the costs and benefits attributed to environmental policies and government regulations, as well as the positive and negative externalities generated by agricultural production activities.

One major program drives water policies: the 1994 Council of Australian Government (COAG) water reform agreement. Since the states and territories have prime constitutional responsibility for natural resource management, COAG represents the nation's attempt to integrate and coordinate water policies and avoid further fragmented efforts, policies and activities. The Commonwealth, New South Wales, Victoria, South Australia and Queensland governments established an inter-governmental agreement to provide for a special ministerial council to organise the Murray Darling Basin.

The aim of the COAG principles and guidelines is to reduce the use of government regulations and to encourage 'minimum effective regulation'. An important objective is to sustain and restore ecological processes and biodiversity of water-dependent ecosystems Regulations are supported only where a well-defined social or economic problem exists, where other solutions such as market mechanisms or self-regulation are inappropriate, and where expected benefits exceed likely costs. The guidelines do not prescribe what type of regulation should be used in particular circumstances but set out principles and analytical requirements to be followed in the development of regulation.

Through COAG the state/territory governments agreed to the following water policy reform strategy: water should be priced to reflect social cost and benefits; subsides and cross subsidies should be removed; tradeable property rights would be established; and market mechanisms would be used to encourage more efficient management and use..

In addition to water pricing, entitlements and trading arrangements, COAG set out recommendations covering institutional reforms, environmental considerations, water-related research, taxation issues, consultations and public education. Community participation in the development and implementation of COAG objectives is encouraged either indirectly through Integrated Catchment Management (ICM), which is partially funded by the Commonwealth, or directly through state/territory legislation requiring community consultation before catchment plans are approved.

The COAG water principles have spawned new water legislation in most states and territories. For example, South Australia's Water Resources Act 1997 provides a comprehensive system of transferable water property rights, incorporates principles of ecologically sustainable development, provides holistic water resources management within the context of integrated catchment management, establishes water for the environment, and devolves greater responsibility for water resources to local communities through the establishment of catchment management boards.

The New South Wales government established a framework of water reforms aimed at achieving a better balance in the sharing of water between the environment and water users to ensure long-term sustainability consistent with the COAG requirements. The Water Management Act 2000 came into effect in January 2001. This new legislation allows key aspects of the COAG reforms to be implemented, including: ecologically sustainable development principles applied to all decisions made under water legislation; new opportunities for temporary trading on regulated streams; and new powers for managing and trading in groundwater. Likewise, Victoria passed the Water Resources Act 1997 to amend the Water Act 1989 and to provide for similar COAG-induced reforms.

How are policy reform effecting irrigation practices and land use decisions?

Australia's water policy reforms are leading to higher water costs per unit of water used as the country moves to adopt the COAG water reforms. Volume restrictions in the MDB through the CAP, as well as annual limits on groundwater dependent zones has restricted supply and raised substantially prices for water licenses. Higher unit costs are expected in the future as further reforms are enacted and as market forces influence the price for water. For example, public irrigation system fees are increasing not only to cover operating expenses and capital costs of storage and supply structures, but also to cover refurbishment and replacement of depreciating infrastructure. Many irrigation structures are now at or near the end of their useful lives (Crabb, 1997). In addition, irrigators are forced to present farm management plans, pay environmental levies on water use, establish salinity prevention plans and to pay salinity fees when purchasing water.

As the volume of water used per irrigated crop declines, in many cases, so too does the total expenditure on water-related expenses. This is because producers conserve water by using less as its price rises, including through investing in new water-saving technologies. Other market incentives are also influencing water use. For instance, the trend among grape growers is to produce high-value grapes with concentrated juice through lowering yields. Keeping grape yields down means using less water. This trend implies even lower water requirements and higher returns per unit of water used. High-quality grape production is encouraged by wineries through appropriate incentives in their contracts with growers.

There is little evidence in Australia that these higher short-term unit costs are imposing an enterprise-threatening situation, except for pasture. Even there, pasture producers are taking advantage of the higher water prices and selling some of their unused allocation, or selling their properties which are then put to higher value uses. Moreover, the dairy industry is restructuring due to deregulation and reforms implemented on 1 July 2000.

The evidence suggests that water entitlement transfers between irrigators have been from lower- to higher-valued commodities (Crabb, 1997; ABARE, 1999; Marsden Jacob, 1999; Young et al 2000). Investments in the wine industry, horticulture and the dairy industry in the state of South Australia, for example, are sending strong price signals and banks are insisting that these developments be underpinned by secure water rights. From 1995 to 2000, water prices in South Australia's horticultural areas with access to Murray River water have increased from $500 to $1200 per ML. In some groundwater dependent areas with very thin water markets, water prices have been as high as $10,000 to $30,000 per ML in some cases. Dairy, rice and cotton producers are facing a greater cost-price squeeze than horticultural producers as overall subsidies to their industries are reduced.

Increased product prices from export demand are the main reason why these increasing expenses imposed by water reforms and cost-increasing environmental policies are not reducing horticultural production in Australia (Stringer and Anderson, 2001). The real value of both wine-grape production and wine production has grown at more than 10 per cent per annum over the past 12 years (Anderson 2000). Over the last 9 vintages, grape prices have increased 90 per cent (ABS 1997, 1998, 1999, 2000b). The volume of wine exports has risen from less than 5 per cent to more than 30 per cent of production, and will soon exceed 50 per cent of sales. Australia is now the world's largest wine exporter after the European Union bloc, having been a net importer of wine as recently as the early 1980s.

Since 1995, grape growers in South Australia with access to River Murray water expanded their vine area by 67 per cent. Grapes, especially premium grapes, are a relatively high value, low volume water user compared with other irrigation activities. Irrigation costs (including fuel for pumping costs and all related fees and levies) can range from 5 per cent to 15 per cent for grape growers. Grape growers can out-bid most other irrigation activities due to higher profit margins compared with other competing agricultural water uses.

A recent study of how irrigation reforms are impacting horticulture farms in the Murray Darling basin concludes that the rate of expansion is likely to slow but production is unlikely to fall as water becomes scarcer (ABARE, 1999). The study suggests that producers will purchase more water, invest in improved irrigation equipment, adopt new irrigation management practices, and change their enterprise mix. The ABARE study also concludes that increases in water charges are unlikely to lead to a fall in water use by horticulture in the Murray Darling Basin since water charges are only a small proportion of total costs, while the returns to water in horticulture are high. Water expenses ranged from 2 to 7 per cent of total cash costs. As water expenses increased from $40 to $100 per Ml (with other prices held constant), gross margins fell from around $6500 per ha to $5900 per ha for grapes and from $3500 per ha to $2800 per ha for citrus.

A number of reasons help explain why higher unit water costs and increasing water delivery costs are not imposing problems for non-pasture irrigators (Stringer and Anderson, 2001). These include:

- water costs are only a small proportion of total costs. For those cases where input costs are small yet critical, producers have flexibility to reduce costs in other areas (taxation options, corporate structure);

- alternatives are available to offset higher unit water costs and provide opportunities for cost-saving improvements (as the cost of leasing water rights is tax deductible);

- much more water is used in production processes than necessary, so many irrigators are able to make management changes to greatly reduce their water consumption;

- all current on-farm irrigation investments are much more efficient in water saving technologies than previous investments, and they utilise management systems such as under-canopy sprinklers, mini-sprinklers, drip systems, centre-pivot systems that produce ‘soft rain’, laser land forming, soil moisture measuring equipment, and efficient drainage;

- in South Australia, the use of furrow irrigation declined from 50 per cent of the total area in 1976 to 20 per cent by the mid 1990s (while in Victoria’s Sunraysia district 70 per cent is irrigated by furrow and flood methods and in New South Wales it is 84 per cent -- Crabb, 1997);

- changes to improve water use efficiency are also taking place in the livestock sectors (such as replacing dams with piped reticulation systems for stock watering);

- over the past decade, higher water charges have encouraged water transfers out of low-value uses and locations (as with water entitlements used on pasture in South Australia’s Lower Murray being transferred to vegetable production in the Riverland (WRMS, 1994; Crabb, 1997); and

- higher water prices have allowed irrigators to sell off part of their entitlement, invest the money in new water-saving technologies and then sell more of their entitlement (Young et al., 2000).

Modelling water pricing reforms

Water policy, like other resource management and environmental policy making are not the province of any one sphere of government in Australia. Although the federal government has powers to enact laws affecting the environment and sustainable development, the Australian Constitution does not specifically deal with environmental powers. Water legislative responsibilities rest with state/territory governments. When international treaty obligations are at stake, , the Commonwealth takes precedence over state/territory and local powers.

The divergence in state approaches to water management has greatly complicated water management in the MDB. The basin's hydrological, ecological, economic and social systems do not stop at state borders. The rules, institutions and incentive structures governing the use of water do differ in each state. For example, until 1998, when a pilot interstate water trade project was trailed, permanent trades in water entitlements were not allowed between irrigators in the different states. The Murray Darling Basin Ministerial Council agreed to the pilot permanent interstate water trade in the Mallee regions of New South Wales, South Australia and Victoria for a two-year period.

The first trade occurred in September 1998 and 9.8 GL of water, valued at more than $10 million were traded in 53 transaction over the next two years. These interstate trades provide insights into how a market across the MDB might operate. In the majority of the trades (99 per cent of cases), the water traded was not being used at its origin and in virtually all cases it has moved to a very profitable use (Young et al, 2000). A survey of the buyers, indicated that three quarters of all purchases caused an expansion of irrigation with some 60 per cent going into viticulture and 18% into horticulture.

Introducing market pricing of water to irrigation industries is one possible application of FEDSA-WATER. This CGE model can explore the economic implications of a MDB wide market on four of the major irrigated crops -- pasture, cotton, rice and grapes. Prices for permanent water entitlements vary from around $400/ML in the pasture, cotton and rice producing zones of NSW, to $700/ML in the pasture and grape zones of Victoria, to more than $1000/ML in South Australia. Allowing trades across all state would reduce prices paid by South Australian irrigators and increase NSW prices. In the following scenarios, a price of $700 across the basin is used.

In the FEDSA-WATER model, agents respond to the changes in relative prices of inputs. In practice, there may be, at least in the short- to medium-term, a degree of inertia at least in some regions. Rice growers, for example, may perceive that their crop-specific capital, infrastructure and managerial expertise prevents them from cultivating other crops. To the extent that such inertia exists, particular regions may lose considerably from pricing reforms, and to a greater extent than we model on the assumption of full adjustment.

Our scenario depicts the removal of implicit subsidies on water usage in irrigation industries in New South Wales and Victoria, and the removal of small implicit taxes on usage in South Australia, for the various irrigation industries. These subsidies are measured in terms of relative prices to irrigation users, rather than as social subsidies or taxes. We include the latter (in the form of salinity damage) in the transformation function of each agricultural industry in the model (see appendix A.3).[2]

The major focus is on the redistribution of activity between industries and regions with the pricing reforms, and with the impact of the pricing reforms on salinity damage. As we would expect, the irrigation industries in NSW (cotton, rice and irrigation pasture NSW) lose from the reforms. The costs of production for cotton rise by 2 per cent, for rice by 7 per cent and for irrigation pasture NSW by almost 13 per cent. Outputs in these sectors decline by 0.4 per cent, 1.1 per cent and 1.0 per cent respectively.

A surprising result is that grapes in Victoria lose. The main reason for this appears to be intra-domestic substitution: although the costs of production change little with the slight change to the price of water used in Victorian grape production, the costs of production of irrigated grapes in South Australia drop by almost one per cent. We assume a high degree of interstate substitutability of grapes between South Australia and the rest of Australia as inputs into wine. Consequently, some of the output growth of 1.2 per cent in South Australian grapes is at the expense of Victorian grapes, through a change in relative regional prices.[3]

In addition to a redistribution of activity from the rest of Australia to South Australia, there is also a small reduction in the overall output of irrigated industries with the price reforms. As measured in national accounts terms, there is a small increase in national welfare arising from the pricing reforms of $29 million.[4] The social benefit arising through reduced salinity damage is $24 million. The latter figure is sensitive to two sets of assumptions. The first is the proportional value of salinity damage arising from each type of agricultural activity. The second is transformation parameter choice.

The proportional value of salinity damage requires a closer examination of available estimates than we have managed to this point. The choice of parameter choice has been dealt with to some extent, through the use of systematic sensitivity analysis (Arndt and Pearson 1996). In this analysis, we vary the transformation parameter from its base value of 2 by plus or minus 1.75 (with a uniform distribution) in order to obtain the estimated standard deviations shown in parentheses in Table 1. This scenario shows us that pricing reform has a positive effect on salinity externalities,

[2] The results at the macroeconomic level are of academic interest only. If we treat pre-reform water pricing as a combination of input taxes and subsidies on water usage in the specific industries we focus on, then removing these taxes and subsidies provides direct tax reductions to maintain revenue-neutrality. The result for real GDP is positive. But if we do not maintain budget neutrality, by excluding the value of the implied net subsidy to irrigators, without allowing for direct tax reductions, real GDP decreases slightly when we introduce pricing reforms.

[3] At present, the model does not include the same substitutability between NSW grapes and those from elsewhere. To do so would reinforce the substitution effect, with larger gains for South Australia.

[4] Aggregate real consumption is used as the measure of welfare, with aggregate real investment, real government expenditure and the trade balance all exogenous.

mainly because we assume that the most environmentally damaging industries are those with the largest implicit subsidies for water usage.

Next, we go a step further and introduce taxes on each of the industries to reflect the environmental damage inflicted by them. In each case, the additional taxes equal approximately the value of salinity damage within the database. In each irrigated sector, the price of water moves from its present price inclusive of an implicit tax or subsidy to a price determined purely by the salinity damage. In the model closure, we assume that the additional revenue raised is used specifically to repair salinity damage, so that there is no direct tax reduction to offset the revenue from taxing salinity damage.

In all irrigated industries, outputs decline as the costs of production rise. The magnitude of these declines is small, given the very large cost hikes particularly for cotton and rice. It is possible that the aggregation of downstream industries in the database masks the extent of possible declines: more aggregated downstream industries will suffer smaller cost hikes if a primary product rises than in the case of more disaggregated industries, such as ginned cotton. With the decline in agricultural output, aggregate consumption decreases by $95million, but the reduction in the salinity damage is $222 million, with a standard deviation of $72 million arising from varying the transformation parameters in agriculture by ±1.75.

Summary of modelling outcomes

In the water pricing reform scenario, there is a redistribution of irrigation activity from upstream to South Australia with pricing reforms. There is an overall decline in agricultural output but this is outweighed by the benefit in terms of reduced salinity damage. Similarly, in the case of taxing producers for the full cost of salinity damage, the benefit of reduced salinity outweighs the reduction in national income.

These are a preliminary set of results, which will change as better estimates of salinity damage become available. The direction of results did not change as the transformation parameter varied within the range discussed. Some of the most serious concerns with reforms to water pricing originate at a district level. The model is based on much larger regions so that potential losses in some regions could be understated. In addition, the aggregation of downstream processing industries in the model's database may also mask some of the potential losses to primary activities whose costs rising with pricing reforms or taxes on salinity. Both district and downstream industry disaggregation would help estimate the potential effects of pricing reforms and taxes in further modelling.

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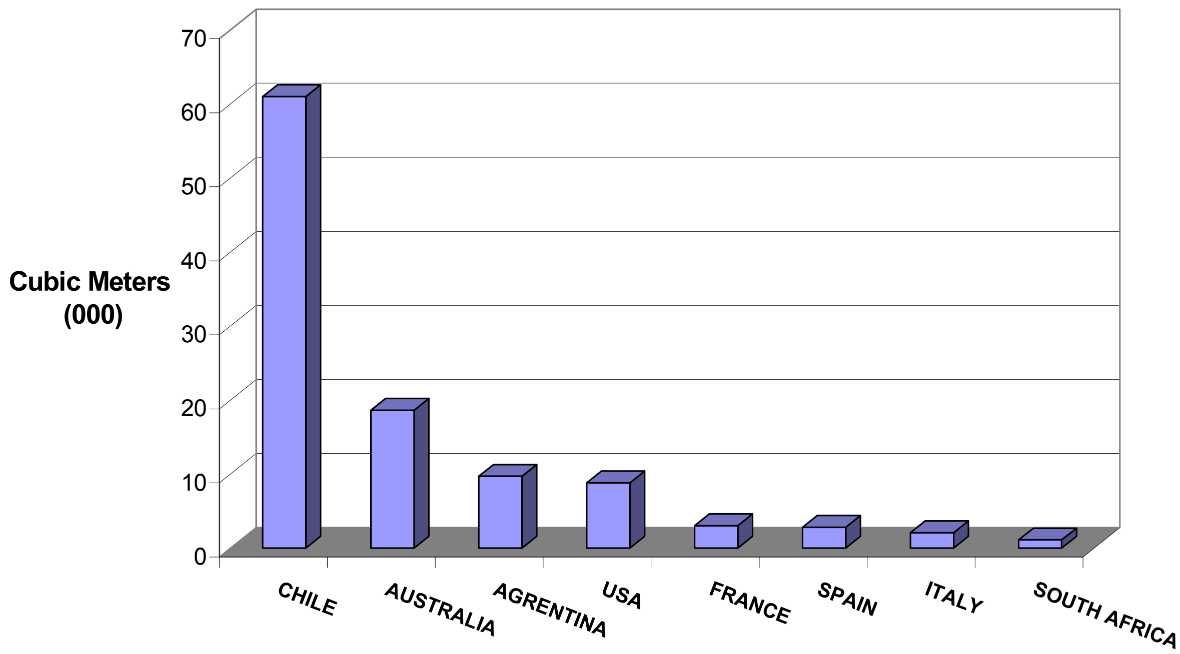
Table 1 Water use in Australia and its wine export competitors

	Per Capita Availability	Per Capita Use	Agriculture's Share	Irrigated Area
	m^3	m^3	%	(000) Ha
Chile	61,007	1629	84%	1,800
Australia	18,638	839	70%	2,057
Argentina	9,721	822	75%	1,561
US	8,838	1844	40%	21,400
France	3,047	704	12%	2,000
Spain	2,821	897	68%	3,640
Italy	2,080	840	53%	2,698
South Africa	1,110	391	72%	1,350

Source: World Resources Institute 2000 and FAOSTAT, 2001.

Figure 1
Per Capita Water Availability
Australia's Main Competitors



Source: WRI, 2000.

Table 2 Area of crops and pastures irrigated in Australia, 1999

	New South Wales	Victoria	Queensland	South Australia	Western Australia	Tasmania	Northern Territory	Australia
	000 ha.							
Annual pasture	199	267	28	18	12	10	0	534
Perennial pasture	115	251	21	41	5	19	0	452
Rice	148	0	0	0	0	0	0	148
Other cereals	163	17	30	5	1	2	0	219
Cotton	256	0	117	0	1	0	0	375
Sugar cane	0	0	153	0	3	0	0	156
Vegetables	16	21	26	11	8	15	0	97
Fruit (incl. nuts)	23	22	23	15	6	3	2	94
Grapevines	25	32	1	45	5	0	0	108
All other crops	29	9	20	7	2	9	0	77
Total	974	619	417.4	138	42	58	2	2,251

Source: ABS Agriculture, Australia, 1998-99 (Cat. 7113.0).

Table 3 Australia Net Water Use by Sector 1997

	ML	SHARE
Agriculture	15,502,973	69.9%
Services To Agriculture	18,815	0.1%
Mining	570,217	2.6%
Manufacturing	727,737	3.3%
Electricity/Gas	1,307,834	5.9%
Sewerage/Drainiage Services	1,706,645	7.7%
Other	522,513	2.4%
Household	1,828,999	8.2%
Total	22,185,733	100.0%

Source: ABS: Water Account for Australia 4610.0.

Table 4 Australia Irrigated Water Use 1997

	Gross Value	Net Water Use	Share of Water Use	Area	Share of Area	Water Applied
	$M	ML		Ha		ML/Ha
Livestock, Pasture, Other	2540	8,795,428	56.7%	1174687	57.1%	7.49
Pasture				934000	45.4%	
Cereals				184000	8.9%	
Others				56687	2.8%	
Vegetables	1119	634,913	4.1%	88782	4.3%	7.15
Sugar	517	1,236,250	8.0%	173224	8.4%	7.14
Fruit	1027	703,878	4.5%	82316	4.0%	8.55
Grapes	613	648,574	4.2%	70248	3.4%	9.23
Cotton	1128	1,840,624	11.9%	314957	15.3%	5.84
Rice	310	1,643,306	10.6%	152367	7.4%	10.79
Total	7254	15,502,973	100.0%	2056581	100.0%	7.54

Source: ABS, 2000b

Table 5

STATE	Water use ML	Proportion of total water use %	Area Ha	Proportion of area %	Average water use ML/Ha	TONNES	T/ML (97)
NSW	242,288	37.4%	15,194	22%	15.95	209,901	0.87
VIC	217,888	33.6%	20,800	30%	10.48	329,687	1.51
QLD	4,062	0.6%	800	1%	5.08	4,530	1.12
SA	171,836	26.5%	30,432	44%	5.65	374,589	2.18
WA	11,113	1.7%	2,654	4%	4.19	21,796	1.96
TOTAL	647,187	100%	70,364	100%	9.19	943,113	1.45

Source: Water Account for Australia 4610.0 and ABS 7113,

Figure 3:
Water Performance: NSW Benchmarking Study
1997

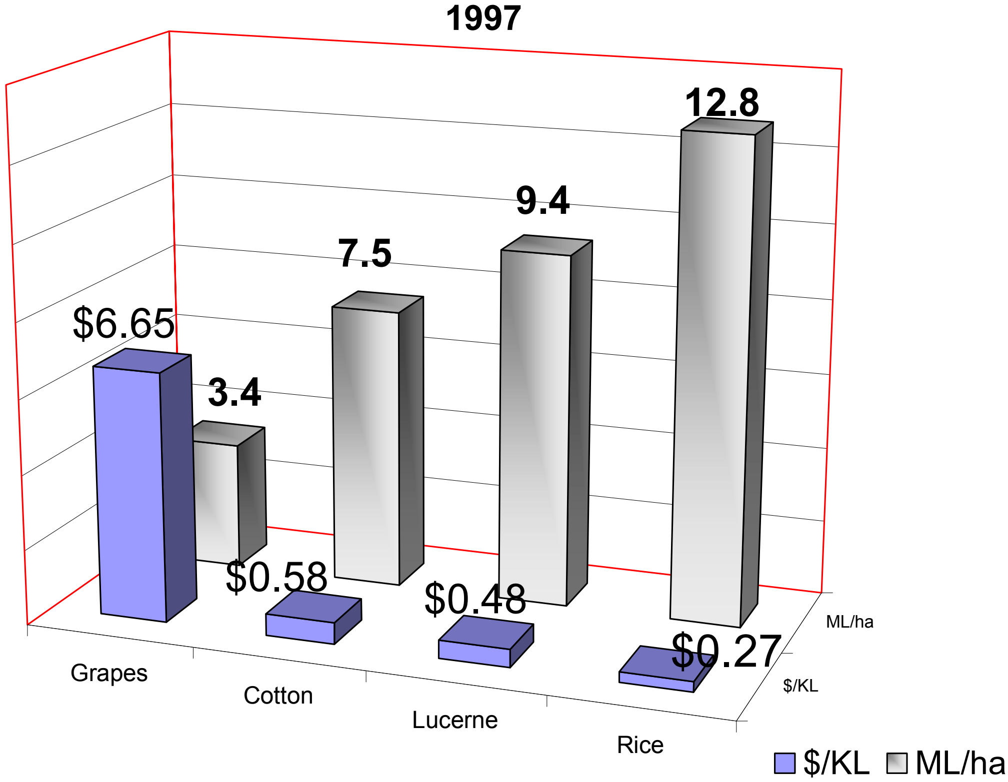


Table 6: Vine Irrigation at by state

STATE	ML	Ha	Share of water used on vines	ML/Ha	TONNES	T/ML (97)
NSW	242288	15194	37.4%	15.95	209901	0.87
VIC	217888	20800	33.6%	10.48	329687	1.51
QLD	4062	800	0.6%	5.08	4530	1.12
SA	171836	30432	26.5%	5.65	374589	2.18
WA	11113	2654	1.7%	4.19	21796	1.96
TOTAL	647187	69880	100%	9.26	943113	1.46

Source: Water Account for Australia 4610.0 and ABS 7113

Table 7: Water pricing reforms

Percentage change from base case unless indicated otherwise

	National	SA	ROA	
Aggregate consumption[a]	$29m	$39m	-$10m	
Salinity externality[b]	-$24m	$4m	-$28m	
		($3m)	($11m)	
<u>Industry outcomes</u>	**Output SA**	**Producer price SA**	**Output ROA**	**Producer price ROA**
Dryland	0.09	0.00	-0.16	-0.03
IrrigPasture	0.99	-0.52	-0.66	-0.14
IrrPastVIC	..	..	-0.65	-0.14
IrrPastNSW	..	..	-0.99	12.65
Cotton	..	..	-0.37	2.09
Rice	..	..	-1.13	7.08
Othagri	0.19	0.00	-0.03	-0.02
Grape	1.21	-0.67	-0.62	-0.12
GrapeNSW	..	..	-0.39	0.63

a The Commonwealth budget balance is exogenous.
b The standard deviation arising from varying the transformation parameter between outputs and salinity from 2.0±1.75 is in parentheses.

Table 8: Taxing the salinity damage of each irrigation activity

Percentage change from base case unless indicated otherwise

	National	SA	ROA	
Aggregate consumption[a]	-$95m	$30m	-$125m	
Salinity externality[b]	-$222m	$0m	-$222m	
		($10m)	($72m)	
<u>Industry outcomes</u>	**Output SA**	**Producer price SA**	**Output ROA**	**Producer price ROA**
Dryland	0.18	-0.04	-1.27	-0.14
IrrigPasture	-3.27	6.95	-4.43	6.55
IrrPastVIC	..	..	-5.07	12.05
IrrPastNSW	..	..	-5.57	34.91
Cotton	..	..	-5.68	39.91
Rice	..	..	-5.69	40.04
Othagri	-0.80	0.03	-0.25	-0.15
Grape	-3.04	7.53	-2.36	6.63
GrapeNSW	..	..	-3.27	6.95

a The Commonwealth budget surplus increases by $755m, with these funds used for salinity repair.
b The standard deviation arising from varying the transformation parameter between outputs and salinity from 2.0±1.75 is in parentheses.

Appendix A

The theoretical structure of FEDSA-WATER

A.1. Introduction

FEDSA-WATER, the CGE model used in this study, is in the ORANI family of general equilibrium models described in Dixon et al. (1982).

A.2. Configuration of FEDSA-WATER's database

Figure A.1 illustrates the absorption matrix or flows database of FEDSA-WATER. The column headings identify the agents who buy 'C' commodities. The source 'S' of these commodities may be either domestic industries, located in two regions, South Australia or the rest of Australia, or foreign suppliers. The agents for sales are producers, investors, households, overseas exports, Commonwealth and state governments and changes in inventories.

Examining the row headings, in addition to the basic sale flow, each transaction includes four different sorts of margins 'M'. These include wholesale and retail markups, restaurant and hotel markups imposed on on-premise sales of beverages, transport costs and insurance. An important part of margins usage in a CGE model is to distinguish between different prices by type of transaction. In addition, there are two types of commodity taxes: both the Commonwealth and state governments may impose a tax on each transaction. To complete the production column, there are primary inputs of labour, capital and agricultural land, and associated income taxes.

Figure A.1: The FEDSA-WATER database

		Absorption matrix					
		1	2	3	4	5	6
		Production	**Investment**	**Household**	**Export**	**C'wealth govt.**	**State govts.**
	Size	← **I** →	← **I** →	← **I** →	← **I** →	← **I** →	← **I** →
Basic flows	↑ **CxSxR** ↓	BAS1	BAS2	BAS3	BAS4	BAS5	BAS6
Margins	↑ **CxSxRxM** ↓	MAR1	MAR2	MAR3	MAR4	MAR5	MAR6
Taxes: CG	↑ **CxSxR** ↓	TAX1CG	TAX2CG	TAX3CG	TAX4CG	n.a.	n.a.
Taxes: St.	↑ **CxSxR** ↓	TAX1ST	TAX2ST	TAX3ST	TAX4ST	n.a.	n.a.
Labour	↑ OxR ↓	WAGE					
	↑ OxR ↓	INCTAX					
	↑ OxR ↓	PAYROLL					
Capital	↑ R ↓	KAPRENT					
	↑ R ↓	KAPTAX					
	↑ R ↓	LNDTAX					
Land	↑ R ↓	AGLND					
	↑ R ↓	AGRITAX					
Other	↑ R ↓	OTHCOST					
	↑ R ↓	CO1TAX					
	↑ R ↓	ST1TAX					

I = number of industries

C = number of commodities

S = number of sources

R= number of regional destinations

M = number of commodities used as margins

O = number of occupations

CG = Commonwealth government

ST = state governments

	Joint production matrix
Size	← **I** →
↑ CxR ↓	SHOIRJ

	Import duty
Size	← **1** →
↑ C ↓	VIMPORT

Each cell in figure A.1 contains the name of a data matrix. *MAR1* is a 5-dimensional matrix containing the costs of margin services ‘M’ on sales of commodities C from sources S to industries I for intermediate usage in region ‘R’. Each industry within the structure of the model may produce any of ‘C’ commodities.

A.3. The transformation function of FEDSA-WATER

The MAKE matrix shows the value of output of each commodity by each industry. The database has been modified so that each agricultural output also entails salinity damage. For most agricultural industries, the initial value of salinity damage is set at 5 per cent of the total value of output. For rice, the damage is set equal to 20 per cent of the output value and for cotton, the corresponding figure is 30 per cent. The transformation parameter between agricultural outputs and salinity damage is set at 2.0 (since salinity is recorded as a negative value, outputs and salinity are complements in production).

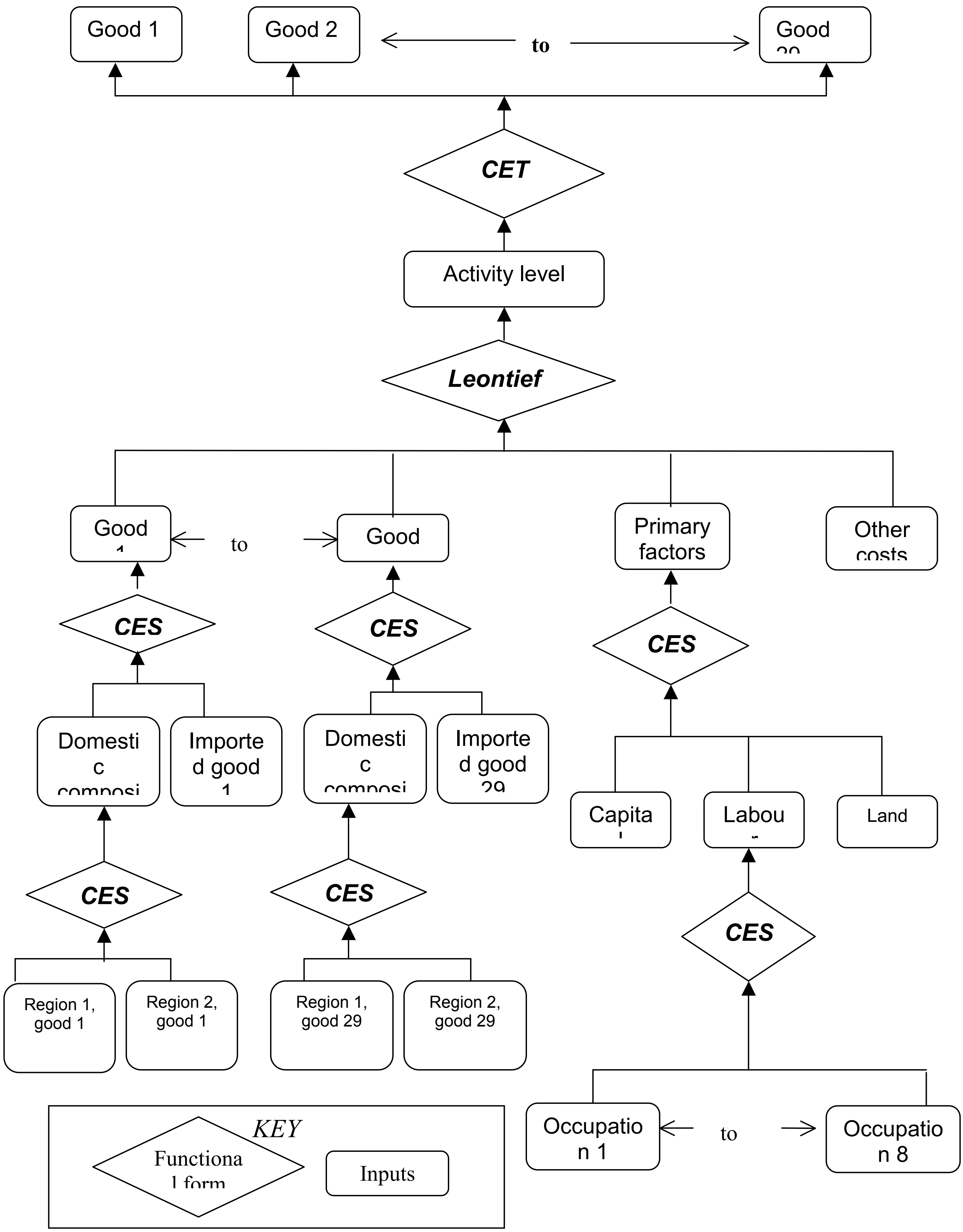
A.4. Overview of the model’s equations

Blocks of equations deal with production, investment, household consumption, exports, Commonwealth expenditure and state government expenditure. Subsequent parts cover margins, prices, primary factor prices, market clearing equations and regional and national aggregates.

A.5. Structure of production

Figure A.2 summarises the structure of production within the model. Separability assumptions keep the production specification of the model manageable.

Figure A.2: Structure of production in FEDSA-WATER



At the top of figure A.2, we assume input-output separability. Consider the production function of an industry, given as:

$$F(\text{inputs, outputs}) = 0 \qquad (A.1)$$

We write this as:

$$G(\text{inputs}) = X\_TOT = H(\text{outputs}) \qquad (A.2)$$

where X_TOT is an index of industry activity.

A.6. Demands for intermediate inputs

Further separability assumptions apply in a series of nests in the G function. Demands for intermediate inputs into production are based on the assumption that producers' purchases from each source are imperfectly substitutable. This occurs in two CES (constant elasticity of substitution) 'nests'. In the first, changes in the domestic nest occur through substitution as a result of differences between the regional and domestic nested prices (at the bottom of figure A.2). In the second, changes in the domestic-international nest result from Armington substitution (Armington 1969).

A.7. Demands for primary factors

The first problem is to choose a combination of labour types to minimise the total labour cost. Different types of labour are substitutable according to a CES function linking occupation-specific labour costs to the composite labour cost.
At the next level the primary factor costs are minimised for a given primary input requirement. Labour (a composite of occupations), capital and land have CES substitution possibilities. Agricultural land is usually fixed in supply in each industry. We could make the supply response of each agricultural industry larger by moving some of the production costs from land to capital, which is variable in the long run within the model.
The effective (i.e. nested) intermediate input and primary factor demands, plus other costs (including production taxes) are Leontief. This means that as the composite price of each input varies, the proportions of each composite input demanded remain unchanged, for a given technology.

A.8. Demands for investment inputs

Unlike production, there are no direct primary inputs into investment. Rather, primary inputs are indirectly involved in capital creation through the intermediate inputs. For example, one of the important inputs into investment, construction, is relatively intensive in its use of labour. In determining the mix of intermediate inputs by source, investment demands follow the two stage nesting process (domestic-domestic and domestic composite-import) with CES substitution, as applies to production.

A.9. Household demands

As is the case for demand for intermediate inputs into production and investment, the nested household commodities are determined by two CES functions. The allocation of household expenditure between commodity composites is derived from the Klein-Rubin utility function (Klein and Rubin 1948-49).

The expenditure on each composite commodity is a linear combination of prices and total nominal expenditure, hence the term 'linear expenditure system'. The form of the demand equations implies that household expenditure includes a 'subsistence' component, purchased independently of price. The remaining expenditure is the 'luxury' component.

A.10. Export demands

Separate export demands exist for traditional and non-traditional exports. 'Traditional' exports include primary products, some downstream manufactures from primary products, the three wine industries and, for GST simulations, tourism-related exports. Non-traditional exports generally only account for a small proportion of the output of the commodity so classified.
Traditional exports face downward sloping demand curves with a constant commodity-specific export demand elasticity. Non-traditional exports have an exogenous commodity composition due to a Leontief aggregation. The total quantity of non-traditional exports is related to the average non-traditional export price by a constant elasticity demand.

A.11. Demands for margins

The percentage change in margins associated with each transaction is set equal to the percentage change in the volume of each type of sale.

A.12. Prices for each type of purchase

The percentage change in output prices are equal to the cost-share weighted sum of percentage changes in the components of production. This imposes the zero pure profits condition on production. The same conditions applies to capital creators. The prices faced by importers depend on shifts in commodity import prices, tariff rates and the nominal exchange rate.

A.13. Primary factor prices

The price of labour is calculated as the value-weighted sum of the percentage changes in the unit value of take-home wages, the income tax rate on labour and payroll tax rates.

A.14. The model's database and parameters

The ABS 1996-97 input-output table was initially split into two regions, South Australia and the rest of Australia. A 75 sector version of this database was then projected to 1999-00, using FEDSA, the CGE model on which FEDSA-WATER is based, using available state accounts, production, trade and consumption data. FEDSA-WATER has been modified by disaggregating "other agriculture", as appears in the national input-output tables, into various irrigation industries. There are three irrigation pasture industries in the model, with region-specific entities for NSW and Victoria (to distinguish them from pasture elsewhere in Australia). Cotton and rice, grown entirely in NSW, appear as separate industries. There are grape industries in South Australia and the rest of Australia, with a separate NSW grape industry (to distinguish it from the Victorian industry in the rest of Australia region).

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Table A.1: FEDSA-WATER parameters

	Intra-domestic elasticities of substitution	International elasticities of substitution	Export demand elasticities	Expenditure elasticitires
Dryland agriculture	4.5	1.5	10.0	0.9
Irrigated Pasture	4.5	1.5	20.0	0.9
Irrigated Pasture VIC	4.5	1.5	20.0	0.9
Irrigated Pasture NSW	4.5	1.5	20.0	0.9
Cotton	4.5	1.5	10.0	0.9
Rice	4.5	1.5	10.0	0.9
Other agriculture	4.5	1.5	10.0	0.9
Grape	9.0	0.0	10.0	0.9
Grape NSW	9.0	0.0	10.0	0.9
Other Primary Sectors	5.0	1.5	10.0	0.9
Non-ferrous ores	5.0	1.7	10.0	0.9
Meat & Dairy	5.0	3.0	10.0	0.5
Fruit & vegetables	5.0	3.0	10.0	0.5
Other Agri Processing	5.0	3.0	10.0	0.5
Premium wine	8.0	4.5	6.5	1.7
Non-premium wine	8.0	4.5	6.5	0.6
TCFs	8.0	4.5	20.0	0.5
Other Manufacturing	6.0	3.0	20.0	0.6
Basic non-ferrous metals	6.0	3.0	20.0	0.6
Trade	0.0	0.0	20.0	1.3
Transport	1.5	0.2	20.0	1.3
Electricity, Gas	0.0	0.0	20.0	1.1
Water	6.0	0.0	20.0	1.1
Other services	0.0	0.0	20.0	1.3

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