40th Annual Conference of the Australian Agricultural and Resource Economics Society

University of Melbourne, February 11-16 1996

Water Policy Reform in Victoria:

A Spatial Equilibrium Approach

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Abstract

In February 1994, the Council of Australian Governments (COAG) endorsed a strategic framework for water sector reform in Australia to be implemented by the year 2001. In response to the COAG strategy, a project was initiated in association with the NSW Agriculture and the Victorian Water Bureau to assess the economic welfare effects of different water policy reforms. A spatial equilibrium model was developed to facilitate evaluation of policy measures.

The purpose of this paper is to report on the development of a spatial equilibrium model of the Victorian irrigation sector. At this stage, only a basic set of results from the model has been presented. However, three interesting observations emerge. The first is that the relatively abundant supply of water in Victoria limits the ability of markets to discover prices for water. Trade in water is dominated by only a few demand and supply centres which make up over half of all water transactions. Finally, water movement constraints are responsible for a prediction that the traded price of water will vary between two regional trade blocks.

1. Introduction

This paper reports on a significant work program in water economics developed by the Victorian and NSW Departments of Agriculture. The aim of this work program has been to move the irrigation reform process from the broad view of what is desirable in the irrigation sector (the COAG agenda), to specific consideration and comparison of alternative institutional, pricing and tariff structures for water. The key tool which has been developed in this process has been a spatial equilibrium model of the irrigation sectors in both Victoria and NSW. This paper reports on the development and initial results of this work program for the Victorian irrigation industry.

2. Water Policy in Victoria

It is widely recognised that the size and location of irrigation infrastructure has been significantly influenced by social and political objectives. With changes to the Australian economy, particularly the move to improve economic efficiency through microeconomic reform, and broad community concerns about environmental degradation, there has been considerable attention focused on improving the process of resource allocation in the irrigation industry. Where possible, this has involved the substitution of market based mechanisms to replace the highly regulated approaches of the past. Substantial investment has also been made in salinity control and river environment protection. The following discussion provides a brief summary of policy and administration changes which have shaped the irrigation sector in Victoria.

In the development phase of the Victorian irrigation industry, a range of measures were introduced to deal with key resource allocation questions. One of the most significant irrigation management tools which has been used in the Victorian irrigation sector is the notion of a right to water. The water right has its origin is the Water Act, proclaimed in 1905. This Act introduced for the first time the concept of a 'compulsory' water right for each irrigation district (Irrigation Management Study 1986). To guarantee financial security of the system, the Commission rated all properties and introduced a 'compulsory' rate for the water irrespective of whether it was used or not. For the last nine decades, this twin concept of a 'water right' and a 'water rate' has been the basic management tool of the irrigation industry in Victoria.

In addition to a 'compulsory' water right, the Water Act also provided for an 'extra' water right to be apportioned to lands under intense culture, as well as a 'sales' water component in excess of water right (IMS 1986). The consequence of these allocations was a massive expansion of irrigated agriculture, with severe repercussions in the drought years of 1938-39 and 1944-45. Following the drought years, quotas were introduced for sales water to ensure sufficient reserves were available to meet future drought conditions (IMS 1986).

The completion of the Eildon reservoir in 1955, once more raised the issue of how best to allocate additional water. The emphasis again fell on 'equity' issues rather than on economic efficiency. According to Watson, such bureaucratic approaches were initially adopted to facilitate development of resources under conditions of a relatively abundant water supply (Watson 1990 in Pigram 1993). The availability of irrigation was seen as an avenue for the redistribution of land and incomes through soldier settlement schemes, decentralisation of population and the development and promotion of agricultural exports. Furthermore, such an approach may have also been due to a lack of confidence in the ability of markets to make allocation choices (Millington 1991 in Pigram 1993). The end result of these decisions led to 'formula type' allocations, with successive formulae being implemented as additional storage's were completed. Today these allocations form the basis of an irrigation district's water right, a legal entitlement attached to each holding based on a 1964 formula as defined in schedule 3B of the Water Act of 1958.

The decision making forum for water allocations during this stage was an all-party Parliamentary Public Works Committee (PPWC). The Committee operated from 1944 to 1982, and some of its major recommendations included construction/enlargement of storage at Cairn Curran, Tullaroop, Eildon and Eppalock, extension of the Goulburn Murray Irrigation District (GMID), increased water allocations and extension/construction of diversion structures at Goulburn Weir, Torrumbarry and Murray River. Rapid developments of this nature were bound to cause environmental problems as noted by Barr and Cary: "with hindsight we can surmise that irrigating this country was bound to cause salinity problems. The first settlers learnt about the land through experience, but they had no experience of salinity." (Barr and Cary 1992).

By the early 1930's, salinity was a serious problem in much of the irrigation country around Tragowel Plains and Kerang (Barr and Cary 1992). Fifty years later it was estimated that nearly forty five percent of all irrigated land in Victoria were potentially saline (ACIL 1983). The pressure to restrict further expansion in irrigation was evident to ensure the sustainability of the natural resource base.

In November 1982, the Public Bodies Review Committee (PBRC) tabled its report on "Irrigation and Water Resource Management". The recommendations of this Committee placed strong emphasis on the application of economic principles in future water allocation decisions. A significant recommendation of the PBRC was that the existing nexus between land ownership and water right be broken to facilitate the transfer of water right from low value uses to high value uses.

At about the same time as the PBRC made its recommendations, the Parliamentary Joint Select Committee on Salinity (which replaced the PPWC) reported on its inquiry into water allocations in Northern Victoria. One of its key recommendations was to freeze all district allocations at existing levels. The Salinity Committee also reinforced the recommendation of the PBRC to amend the Water Act to allow for transferability of water entitlements in the GMID. This would give flexibility to irrigators with high water use to meet their demands in the absence of additional allocations.

Following the recommendations of the various Committees, a limited form of temporary transferable water entitlement (TTWE) was introduced in the 1987/88 season in the GMID. However, it was not until the enactment of the Water Act of 1989 that trade in water really commenced[1]. The first transfers occurred in 1989/90 with 430 transfers totalling 21,927 ML. Although the number of transfers reduced between 1989/90 and 1993/94, the volume of transfers increased by about one third to 30,000 ML in the GMID. In 1994/95 there was significant increase in TTWE to 2,268 transfers totalling 192,493 ML. Relaxation of trade conditions and drought are probably responsible for this massive increase (Office of Water Reform 1995). Trade volumes for the period 1991/92 and 1994/95 are shown in table 1

[1] Section 224 of the Water Act of 1989 set out the conditions under which temporary transfer of water entitlement may occur. The Water (amendment) Act of 1995 sets out further conditions including transfers inter-state.

Table 1. Temporary Transfer of Water Entitlements by Water Authority

Season	Goulburn-Murray		Gippsland		Southern		Sunraysia	
	No.	Volume	No.	Volume	No.	Volume	No.	Volume
1989/90	430	21,927						
1990/91	400	31,955						
1991/92	406	32,148						
1992/93	258	22,829	35	1,678				
1993/94	375	29,961	45	2,736				
1994/95	2,268	192,493	54	2,722	2	25	3	720

Source: Office of Water Reform 1995

Permanent transfer of water entitlement (PTWE) came into effect in a restricted form in 1991/92[2]. Although the volume of PTWE increased by more than threefold from 2610 ML to 9800 ML in 1994/95 in the GMID, it is well within a two percent limit placed on such transfers (see table 2). The reasons for the relatively low level of trade in water may be due to a number of factors including: poor definition of water property rights, uncertainty about future water tariff and pricing arrangements, and the impact of other economic reform processes which are currently under way. The most recent phase of water policy development has been aimed at resolving these key issues.

Table 2. Permanent Transfer of Water Entitlements by Water Authority

Season	Goulburn-Murray		Gippsland		Southern		Sunraysia	
	No.	Volume	No.	Volume	No.	Volume	No.	Volume
1991/92	50	2,610						
1992/93	141	8,226	1	50				
1993/94	115	6.399	3	315			17	2310
1994/95	164	9,844	5	265			21	4,260

Source: Office of Water Reform 1995

[2] The Water (Permanent Transfer of Water Rights) Regulations 1991, Amendment Regulations 1994 and the 1995 Water (Amendment) Act set out the conditions under which permanent transfer of water entitlements may take place.

Beginning in 1990, the water industry in Victoria (and nationally) has been subject to scrutiny following a number of reviews and reports. The first of these was the Five Year Business Plan announced by the then Rural Water Commission (RWC). The Plan proposed a reduction in the government's contribution to headwork's maintenance, the application of current cost depreciation principles to value RWC assets, and an increase in water prices, with the objective of full cost recovery within five years. This Plan was rejected by the Victorian Farmer's Federation and following other political pressures, the Government announced a full review of the future management arrangements of the RWC. The resulting report, the McDonald Review (1992) recommended regionalisation of Victoria's irrigation sector and a 2 percent increase in water prices. Water market reforms to achieve the objective of economic efficiency were not addressed by these two reviews.

In September 1992, the Industry Commission's Report on Water Resources and Waste Water Disposal was released. The report's recommendations on irrigation industry reforms emphasised 'user pays' pricing and tradeable water entitlements, management and institutional arrangements. Meanwhile, the Office of State Owned Enterprises in Victoria produced a report on "Reforming Victoria's Water Industry", which according to Watson, did not add anything new to what had already been recommended in the McDonald review (Watson 1995). Watson further adds: "the short separate section on Rural Water Services is strong on describing the steps that have been taken to introduce administrative reforms, but commentary on the theoretical and empirical problems of water pricing is weak, virtually non-existent".

The Hilmer Report on National Competition Policy (Hilmer 1993), on the other hand, addressed utility reform in very generic terms with no specific mention of the water industry. Nevertheless, there were profound implications for the water sector regarding pricing and management reform arising from the Hilmer Review although no specific timetable for the reform process was identified.

At its June 1993 meeting, the Council of Australian Governments (COAG) set up an independent Working Group on water resource policy to prepare a strategic framework for the efficient and sustainable reform of the water industry. COAG, at its meeting in February 1994, endorsed the Working Group's strategic framework and a timetable for implementation by the year 2001. The salient features of the framework relating to rural water supply were:

- that charges and costs for water be progressively reviewed to comply with the principle of full cost recovery by 2001;
- future investments be subject to rigorous economic and environmental appraisal;
- to implement comprehensive systems of water allocations or entitlements backed by the separation of water property rights from land title and the clear specification of entitlement in terms of ownership, volume, reliability, transferability and if appropriate quality;
- by 1998 steps be taken to specify water entitlements so as to facilitate trading; and
- where cross-border trading is feasible, trading arrangements be consistent to facilitate such trade.

Implementing the COAG reforms necessitates significant changes to the legislative and institutional arrangements that currently constrain the reform process. Victoria has made major advances in legislative reforms with the Water Act of 1989 and subsequent amendments to the Act in 1995. The Act and its amendments allow for temporary and permanent transfers of water right within irrigation districts, between irrigation districts, between irrigation districts and river diverters and for temporary transfers inter-state. Although, these legislative reforms have removed some of the barriers that previously constrained the spatial movement of water, to capitalise on the efficiency gains of trade two other elements are vital: clearly defined property rights and a rationalisation of pricing structures. Whilst the currently accepted definition of a property right for rural water is the 'water right' as defined in the Water Act 1989, the status of 'sales water right' is less clearly defined. On the other hand, the conceptual issues related to pricing reform have their own complications (see Watson 1995).

Although the broad direction of change proposed for the irrigation industry under COAG is widely accepted, at least by economists, there are a number of important conceptual, practical and management issues which require careful attention. The success of future changes to the irrigation industry will rely heavily on the skill with which these issues are addressed and the practicality of future changes. An economic model of the Victorian irrigation industry, described in the following section, has been specifically designed to assist in analysing the impact of changes to the price, tariff and property right structures for irrigation water in Victoria.

3. Modelling the Victorian irrigation industry

Watson (1995) identified that maximisation of national payoff from irrigation water should be the overriding motivation for the irrigation industry. Changes being considered to the existing infrastructure should, therefore, aim to improve economic efficiency. Spatial equilibrium models are a particularly useful method of investigating this change process. Bardsley, Daniel and Wilcox (1994) for example, used a spatial equilibrium model to estimate the economic efficiency gains, changes in production and trade which would result from changes to dairy industry policy. There have been relatively few applications of spatial equilibrium analysis to irrigation issues in Australia. Guise and Flinn (1970) developed a model of the Murrumbidgee Irrigation Area of NSW to evaluate pricing and allocation decisions. More recently, Hall, Poulter and Curtotti (1994) developed a model of the southern Murray-Darling Basin to examine issues relating to tradeable water entitlements. Despite its limited application to irrigation reform issues, spatial equilibrium modelling has significant potential to examine issues such as property right options for water, environmental allocation, transferability of entitlements and water price reform.

A graphical illustration of the spatial equilibrium problem is presented in figure 1. This diagram represents a two region economy with supply and demand schedules identified by S1, S2 and D1, D2 respectively. Trade will occur between the two regions where excess supply equates to excess demand. Region 2 has the highest price intercept P2 therefore the excess demand curve will be based on this region's demand curve. Similarly region 1 can supply at a lower price and therefore will determine excess supply. In figure 1, this occurs at a price Pt with the quantity traded equal to Qt. The direction of trade will be from the lower priced region to the higher priced region as long as the price difference between the two regions is greater than transport and transaction costs.

Spatial equilibrium models represent trade problems in a partial equilibrium framework where the impact of change is restricted to a particular sector of the economy, in this example the water industry, with all other factors held constant. The disadvantage of this approach is that it suppresses the interaction between commodities that are linked by substitution and competition. There are, however, a number of advantages of the partial equilibrium approach (Houck 1986). For specific policy schemes and interventions it provides clear results that highlight important differences among policy measures. It is extremely useful for assessing the direct and immediate economic impacts of policy intervention such as quotas, subsidies and other trade regulations and restrictions.

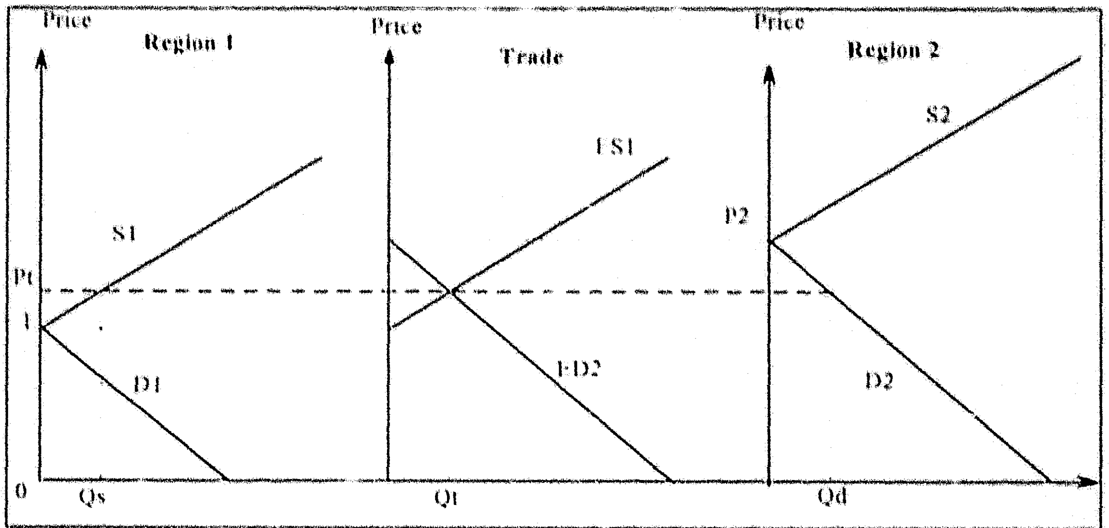

Figure 1. A spatial equilibrium framework

3.1. A Spatial Equilibrium Model of the Irrigation Sector in Victoria

This section of the paper contains a brief description of the structure and specification of the spatial equilibrium model for the Victorian irrigation sector. This model has been developed to represent 14 irrigation regions as illustrated in Figure 2. Two alternative specifications of the spatial equilibrium model, the quantity and price formulations, were presented by Takayama and Judge (1971). The approach adopted in this study is the quantity formulation.

Linear programming (LP) techniques were used to solve this model using the *What's Best!©* software package. The model is solved as a quadratic programming problem (Takayama and Judge 1964) with an objective function which maximises net social welfare. Net social welfare is measured as the area under the excess supply or demand curve. Takayama and Judge (1971) termed this objective as quasi welfare. The objective function can be represented as:

$$\text{Max. } Z = \lambda' y - v' x - y' \Omega y - x' H x - T'$$

where,

x,y are levels of supply and demand respectively,

Ω,H are coefficients of supply and demand respectively and

T is a matrix of transport costs.

The objective function of a mathematical programming model of the spatial equilibrium model problem is quadratic in form. Two alternative specifications of the objective function are the quasi-welfare function Takayama and Judge (1971) and the net social revenue objective function (MacAulay, Batterham and Fisher 1988). The latter has been adopted in this study.

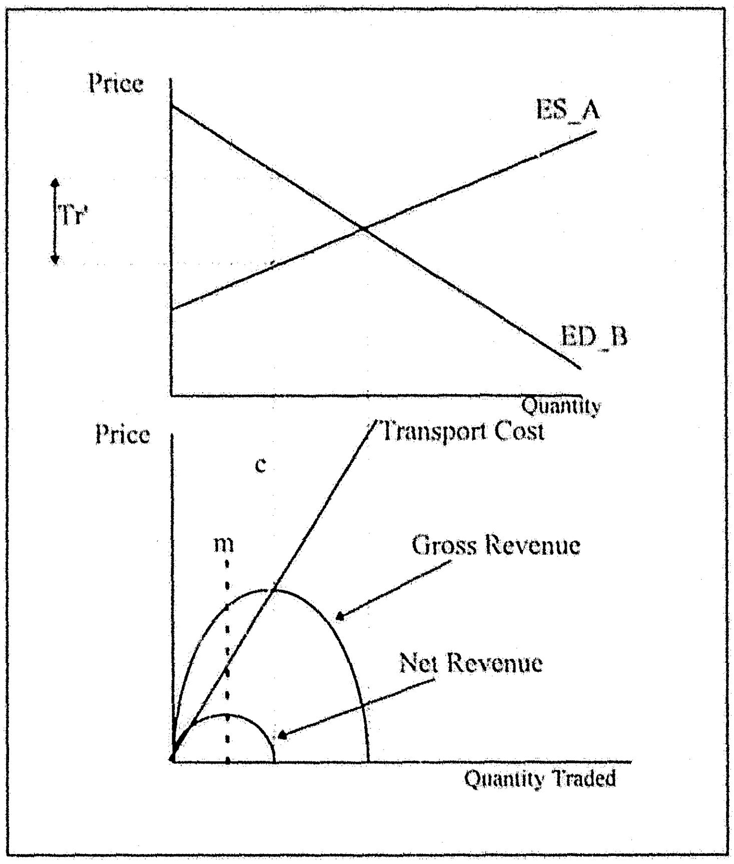

Figure 2. Net Revenue Maximisation

Using the MacAulay, Batterham and Fisher approach, the vertical difference between the excess supply and demand curves is plotted against quantity traded, as shown in the middle part of Figure 2. The resulting relationship represents the demand for transfer services. This curve is downward sloping since it relates the quantity of goods that would be shipped at any level of difference in prices between the two regions up to the point where no trade would take place or the direction of trade would be reversed. The gross revenue to be gained by arbitrage at every level of trade (bottom part of Figure 2) is derived by multiplying the price difference by the level of trade and is quadratic in form. Net social revenue is derived by subtracting the total transportation costs. An important feature of this model is the assumption that arbitrage bids away any profits to be made in transferring the goods so that at equilibrium the net social revenue is zero.

Generally a primal-dual form is used for the spatial equilibrium model. This simply means that to form the primal-dual objective function, the dual objective function is subtracted from the primal and the constraints from both the primal and dual are used. Properly specified, this ensures that the value of the objective function will be zero at the optimum. Specification of the spatial equilibrium model is as follows:

Let i,j denote the regions which compose the discrete but divisible production and consumption locations. Transport costs per unit are expressed as:

$t_{ij} \geq 0$, for all i and j.

The typical linear demand function will be represented is:

(1) $p_i = \lambda_i - \omega_i y_i$, for all i,

where p_i is the demand price in the ith region, y_i is the quantity demanded in the ith region and $\lambda_i > 0$ and $\omega_i > 0$.

The typical linear supply function is:

(2) $p_i = \nu_i + \eta_i x_i$, for all i,

where p_i is the supply price in the ith region, x_i is the quantity supplied in the ith region and

$\eta_i > 0$.

These functions can be more compactly expressed in matrix form as

(3) $P_y = \lambda - \Omega y$

(4) $P_x = \nu + Hx$

For each region it is assumed that the quantity actually consumed, y_i, is less than or equal to the quantity shipped into the region from all supply regions,

(5) $$y_i \leq \sum_{j=1}^{n} x_{ji}$$

where $x_{ji} \geq 0$ is the quantity shipped from the jth to the ith region.

The actual supply quantity, x_i, is assumed to be greater than or equal to the effective supply from region i to all regions

(6) $$x_i \geq \sum_{j=1}^{n} x_{ij}$$

where $x_{ij} \geq 0$. The objective is to develop a mathematical programming model which will yield a competitive spatial equilibrium and allocation solution. The resulting model is to maximise

(7) $Z = \lambda' y - \nu' x - y' \Omega y - x' H x - T' X$

subject to

(8) $$\begin{bmatrix} \lambda \\ -\nu \\ -T \\ 0 \\ 0 \end{bmatrix} - \begin{bmatrix} -I & & -\Omega & & \\ & I & & -H & \\ G_y' & G_x' & & & \\ & & I & & -G_y \\ & & & -I & -G_x \end{bmatrix} \begin{bmatrix} \rho_y \\ \rho_x \\ y \\ x \\ X \end{bmatrix} \leq 0$$

and

$(y' x' X' \rho_y' \rho_x') \geq 0$,

where

$$\lambda = \begin{bmatrix} \lambda_1 \\ \lambda_2 \\ \vdots \\ \lambda_n \end{bmatrix}, \qquad v = \begin{bmatrix} v_1 \\ v_2 \\ \vdots \\ v_n \end{bmatrix}, \qquad T = \begin{bmatrix} t_{11} \\ t_{12} \\ \vdots \\ t_{nn} \end{bmatrix},$$

$$\Omega = \begin{bmatrix} \omega_1 & & & \\ & \omega_2 & & \\ & & \ddots & \\ & & & \omega_n \end{bmatrix}, \qquad H = \begin{bmatrix} \eta_1 & & & \\ & \eta_2 & & \\ & & \ddots & \\ & & & \eta_n \end{bmatrix},$$

$$G_s = \begin{bmatrix} 1 & & & 1 & & & & 1 & & \\ & 1 & & & 1 & & & & 1 & \\ & & \ddots & & & \ddots & \cdots & & & \ddots \\ & & 1 & & & 1 & & & & 1 \end{bmatrix},$$

$$G_t = \begin{bmatrix} -1 & -1 & \cdots & -1 & & & & & & & \\ & & & & -1 & -1 \cdots & -1 & & & & \\ & & & & & & & \ddots & & & \\ & & & & & & & & -1 & -1 & \cdots & -1 \end{bmatrix},$$

$$y = \begin{bmatrix} y_1 \\ y_2 \\ \vdots \\ y_n \end{bmatrix}, \qquad x = \begin{bmatrix} x_1 \\ x_2 \\ \vdots \\ x_n \end{bmatrix}, \qquad X = \begin{bmatrix} x_{11} \\ x_{12} \\ \vdots \\ x_{nn} \end{bmatrix}.$$

3.1.1. Estimates of supply and demand for water

One key data requirement for spatial models is information on supply and demand schedules. Because the irrigation industry in Victoria has for many years operated in a regulated, rather than a free market environment, price and quantity data for water are not available to estimate supply and demand functions. To overcome this problem, excess demand and excess supply relationships have been estimated using regional LP models of irrigation farms. LP models were developed for each of the 14 irrigation regions: Boort, Calivil, Campaspe, Cohuna, Dingee, Kerang, Murray Valley, Pumped District, Rochester, Rodney, Shepparton, Swan Hill, Tongala, Tragowel Plains identified (see Figure 3 below).

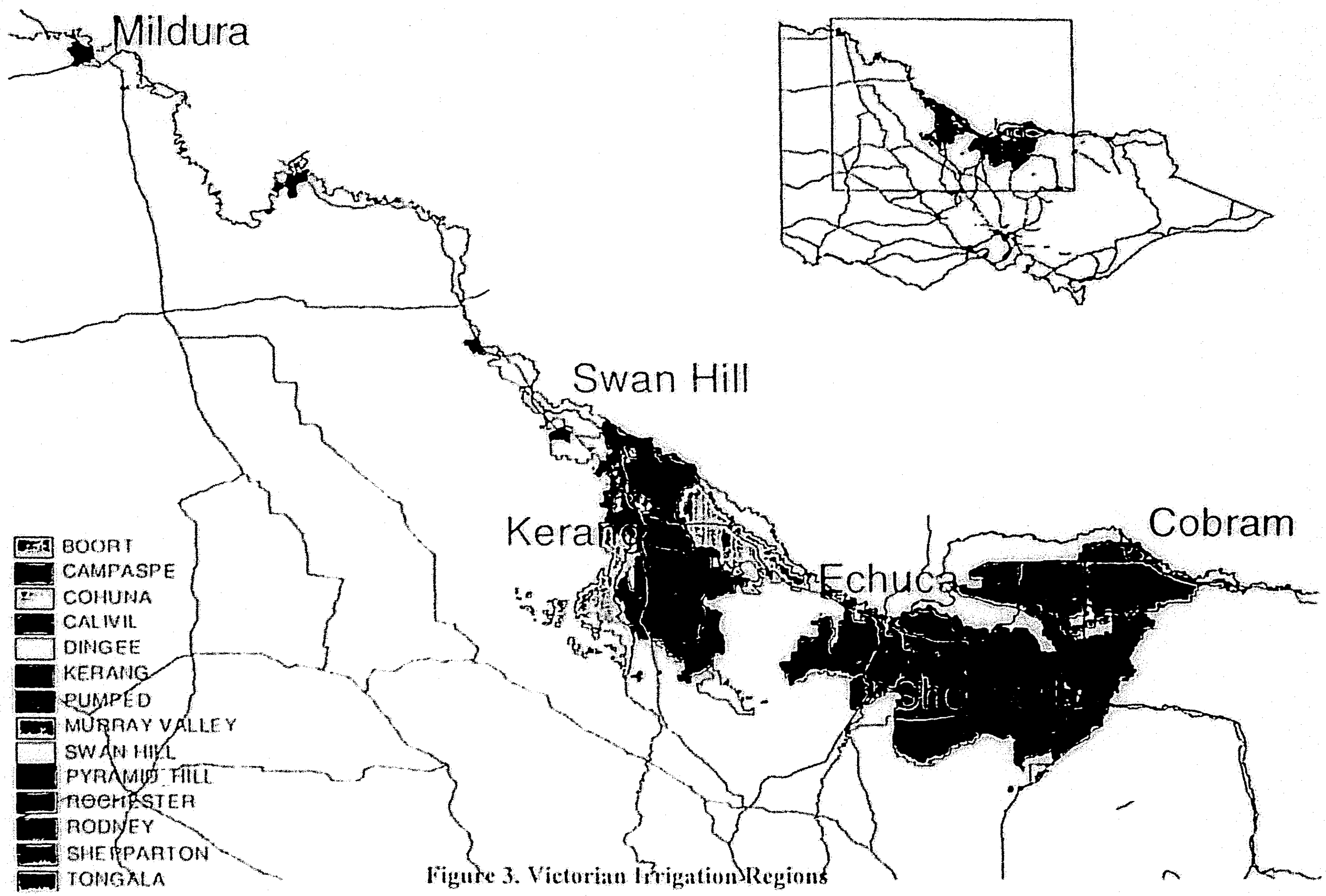

Figure 3. Victorian Irrigation Regions

There are a range of deficiencies associated with using linear programming methods (see Hardaker 1971, and Dent, Harrison and Woodford 1986). These include the assumption of linearity, perfect divisibility, and an objective function which maximises profit (in this case) where other objectives such as the minimisation of risk and accumulation of wealth could be equally appropriate. The regional models are short-run and deterministic in nature and assume risk neutrality. Kingwell (1994) argues that these assumptions can be expected to lead to some overestimation of supply.

An advantage of using a programming model approach to estimate water supply and demand is that possible curve shifters, such as changes in capital infrastructure (channel capacity) and alternative water policies (specifically water prices, allocation and transferable water entitlements) can be taken into account and modified to examine their pact of change.

A number of studies have used linear programming methods to estimate demand relationships for water including: Moore and Hedges (1963), Gisser (1970), and Gisser and Mercado (1972). In Australia, Flinn (1969) estimated the regional demand function for water by aggregating the demand function determined from five individual farm linear programming models of the Yanco Irrigation Area. More recent studies have been conducted by Briggs, Clark, Menz and Frith (1986), Chewings and Pascoe (1988), and Reed and Sturgess and Associates (1991). Essentially these studies use parametric linear programming to determine demand functions for irrigation water.

Estimating excess demand - Excess demand for water has been estimated as the amount of water which can be profitably used by farmers but which is in excess of the water currently available. Diagrammatically, excess demand for water can be represented on Figure 4 as the section *ab* of the demand curve *D*. This represents the demand for water in excess of the total quantity of water available (*Qo*) bounded by the point where the demand schedule equates to the cost of water *Pf*. *Qf* is the maximum amount of water which will be demanded because the marginal cost of water exceeds the marginal revenue earned beyond this point. The volume of water *Qo* represents the sum of water right (*Qs*) and sales water (*Qo-Qs*).

The first step in estimating excess demand for water was to estimate the demand for water. Linear programming (LP) models for each of these regions were specified to include the differences in soil types, irrigation technologies, enterprise differences, environmental restrictions, water allocation limits, supply system constraints, labour availability etc. Each regional LP model includes a range of activities including dairy, mixed farming and horticultural enterprises. Other activities included lucerne, hay making, livestock, labour hire, crop selling and various season feed pool transfers. More details of the specification and technical coefficients contained in the models can be found in Branson and Eigenraam (1996). A parametric technique was then used to estimate the relationship between the price of water and quantity consumed by irrigation farms in each of the 14 regions. OLS regression analysis was then applied to the resulting stepped functions to estimate a linear demand function. The function estimated through this normative process is an unconstrained demand function in an unregulated market. Excess demand was then estimated using the above method. It should be noted that the current configuration of regional irrigation models generate short-run estimates.

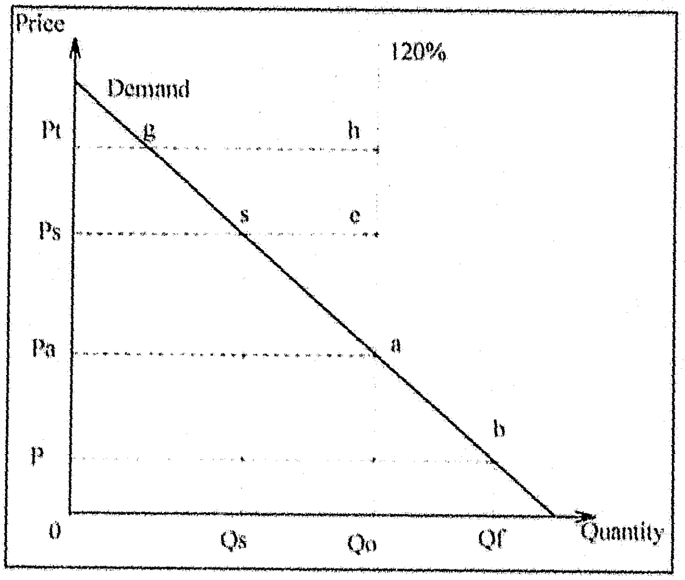

Figure 4. Determination of the Excess Supply and Demand

Estimating excess supply - Excess supply of water is defined at all prices as the residual amount of total water not demanded by the region. For example, if sales water is announced at 120%, excess supply at price *Ps* will be the quantity *se*, and at *Pt* excess supply will equal *gh*. Using the estimates of irrigation water demand, as noted above, excess supply quantities have been defined for each price of water. Again these estimates of excess supply are short term since they represent only the quantities which will be released above the quantity demanded. Longer term estimates of supply would involve consideration of the costs associated with increasing the supply of total water available for irrigation rather than simply the scope to release water from each region.

Physical Constraints - A range of constraints limit the direction and quantity of trade in the irrigation system. Some of these constraints are modelled in the regional LPs and others in the spatial model.

The regional models explicitly include all intra-regional channel capacities and constraints on a seasonal basis. Therefore, the derived demand curve estimates have channel capacities implicitly imposed through the regional models. Neither demand nor supply can exceed the constraints for any of the equilibrium prices determined with the spatial model.

The trade model is solved for water movements given the current inter-regional hydrological constraints and capacities of the system. The major consideration in this respect are losses which occur when water is transported between regions. These losses have been included in the spatial model as a matrix of translation factors. Appendix 1 lists the translation factors between all regions. This information is derived from the REALM model of the irrigation system in Victoria. The translation factors are determined by the losses of water from the source to the region. For example, if water availability in Boort were reduced by 1 ML this could be translated to 1.072 ML of water available in Calivil or 1.143 in Swan Hill. These transmission factors indicate that water losses are lower to Swan Hill than to both Calivil and Boort (see Appendix 1).

4. Preliminary Results

Solving the 14 region spatial equilibrium model generates a range of information about the distribution of water, the price at which water is traded and the economic value of any restrictions on the use of water in the irrigation system. At this stage of the project, initial validation of the model has occurred, but the model has not been used to evaluate the impact of changes to key policy instruments. In this paper, a basic set of results are presented along with some preliminary interpretation of the results generated. It should be noted that further validation will be carried out before policy experiments are commenced.

A number of observations can be made from the preliminary results generated by the model. The first concerns the price at which water is traded under a range of assumptions regarding the availability of water (Qo in figure 2). The total quantity of water (water right plus sales water) available for irrigation varies from year to year. This variability in water trapped in the irrigation system is accommodated by varying the amount of sales water available as a percentage of water right. In some years, when there is abundant water, sales water could represent over 200% of water right, while in drought years, only 110% might be available. Figure 4 records the relationship between the availability of water and the traded price of water for two regions as estimated by the model.

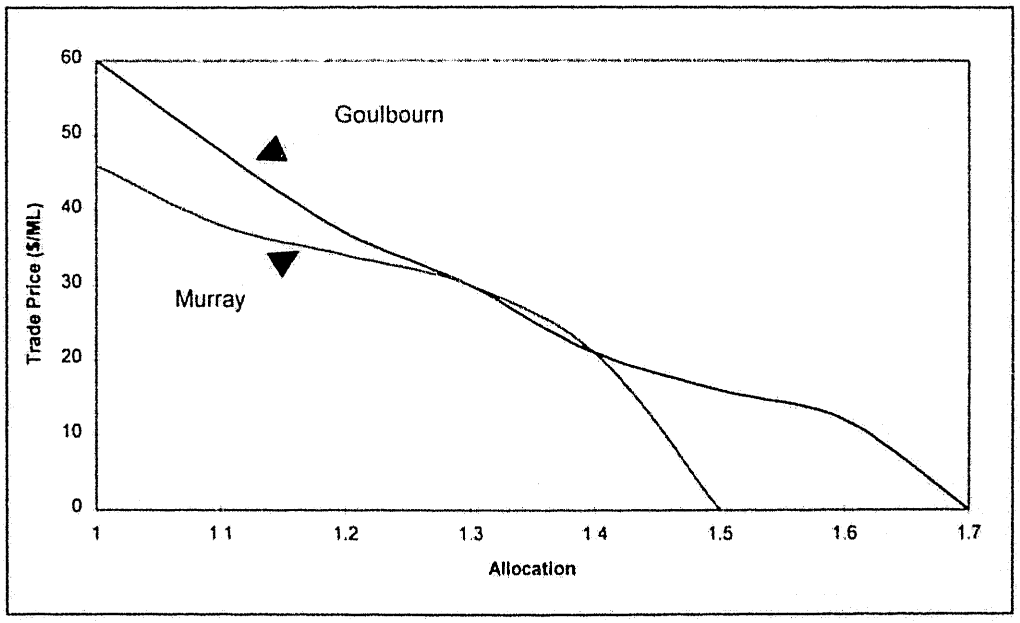

Figure 5. Trade price for water.

From Figure 5 it can be seen that the trade price of water falls rapidly as the availability of water increases. This means that, from a short term perspective, there will really only be a vigorous market for water in relatively dry years. This result represents a significant contrast to the NSW spatial model (Jones and Fagan 1996) because of the relatively abundant supply of high security water in the Victorian irrigation system.

The second observation which can be made from the results so far concerns the direction of trade predicted by the model. Assuming an historical average water use, where sales represents 20% of water right, table 3 summarises the trade patterns predicted by the model. As shown in the model, total trade in water has been estimated at 104,047 ML of which

Rodney is the largest demand region making up 57% of total trade in water. Murray Valley is the next largest demander of water making up 31% followed by Campaspe, Rochester and Shepparton making up the remaining 12%. Boort and Tragowel plains are the largest supply regions making up 61% of total water sold followed by Cohuna and Kerang with 31%.

Table 3. Water Trade Volumes.

ML *Demand* *Supply*	Campaspe	Rochester	Rodney	Shepparton	Murray Valley	Total
Boort	1,886	-	21,854	-	-	**23,740**
Calivil		446		173		**619**
Dingee			1,714	177		**1,891**
Tongala			5,485			**5,485**
Tragowel Plains		8,115	31,196	177		**39,487**
Cohuna					17,284	**17,284**
Kerang					15,050	**15,050**
Swan Hill					489	**489**
Total	**1,886**	**8,561**	**60,248**	**527**	**32,823**	**104,047**

The third observation from the model thus far is that the fourteen irrigation regions cluster into two regions with respect to the trade price of water, these are the Murray Irrigation System and the Goulbourn Campaspe Loddon system. In the Murray irrigation block, the trade price of water is estimated at $34.93/ML while in the Goulbourn Campaspe Loddon system, the trade price was $37.12/ML. Several factors may be responsible for this result. The first is that there are physical constraints to trade between these two blocks. This can be observed from the translation matrix contained in Appendix 1. Secondly, it is apparent that some regions have very generous initial endowments of water which combined with restrictions on the flow of trade create regional price differences. The model suggests that the trade price of water in the Murray Valley systems will be lower than in the Goulbourn.

5. Conclusion

The purpose of this paper has been to report on the development of a spatial equilibrium model of the Victorian irrigation sector. At this stage, only a preliminary set of results from the model has been presented. However, three interesting observations emerge. The first is that the relatively abundant supply of water in Victoria limits the ability of markets to discover prices for water. Trade in water is dominated by only a few demand and supply centres which make up over half of all water transactions. Finally, water movement constraints are responsible for a prediction that the traded price of water will vary between two regional trade blocks.

Following further validation of the model, it is intended, and where necessary develop, the model to examine a range of water reforms issues. These include the impact of changes to water pricing and tariff arrangements, property right arrangements and a range of adjustment issues including the standard asset problem.

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5. Appendix I: Translation Factors

From	REGION	1	2	3	4	5	6	7	8	9	10	11	12	13	14
BOORT	1	X	1.072	1.116	1.044	1.072	1.044	1.117	1.143	1.118	1.053	1.075	1.044	1.07	1.072
CALIVIL	2	0.933	X	1.08	0.973	1	0.973	1.042	1.065	1.043	0.982	0.993	0.973	0.998	1
CAMPASPE	3	0.864	0.926	X	X	0.926	X	X	X	0.956	X	X	X	X	0.926
COHUNA	4	X	X	X	X	X	1	1.115	1.096	X	X	X	1	X	X
DINGEE	5	0.933	1	1.08	0.973	X	0.973	1.042	1.065	1.043	0.982	0.993	0.973	0.998	1
KERANG	6	X	X	X	1	X	X	1.115	1.096	X	X	X	1	X	X
MURRAY VALLEY	7	X	X	X	0.897	X	0.897	X	0.992	X	X	X	0.897	X	X
SWAN HILL	8	X	X	X	1	X	1	1.115	X	X	X	X	0.913	X	0.973
ROCHESTER	9	0.894	0.959	1.046	0.933	0.959	0.933	0.998	1.021	X	0.941	0.961	0.933	0.957	0.959
RODNEY	10	0.95	1.018	X	0.991	1.018	0.991	1.061	1.085	1.063	X	1.021	0.991	1.027	1.018
SHEPPARTON	11	0.93	1.007	X	0.971	1.007	0.971	1.039	1.083	1.04	0.979	X	0.971	0.901	1.007
SWAN HILL	12	X	X	X	1	X	1	1.115	1.096	X	X	X	X	X	0.973
TONGALA	13	0.935	1.002	X	0.965	1.002	0.965	1.033	1.057	1.045	0.974	1.11	0.965	X	1.002
TRAGOWEL PLAINS	14	0.933	1	1.08	0.973	1	0.973	1.042	1.065	1.043	0.982	0.993	0.973	0.998	X

NB: "X" denotes that a transfer/trade is not possible.