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Abstract

This paper conducts an analysis of the water markets in Victoria covered by Watermove. The analysis in this paper examines the weekly trading activity across trading zones. For the majority of trading zones there is little trading activity that occurs. There are three trading zones in which the markets for temporary water rights are reasonably active and liquid on a weekly basis, and for these zones an analysis is conducted of their demand and supply elasticities and consumer and producer surplus. The results of this analysis suggest a stronger relationship on the supply side between prices, volumes, elasticity and producer surplus.

Keywords: Water; Water markets; Elasticities; Consumer and Producer Surplus

JEL Classification: Q25

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1. Introduction

A major issue in the economic analysis of environmental problems relates to the allocation of property rights in the underlying resource. In recent times, a major emphasis of the literature has been on the allocation of such rights to individuals and then allowing the market trading of these rights to determine valuations. One of the major environmental issues in the Australian context is water. The ability to trade water in Victoria was introduced as a result of an overall policy of rationalisation in all areas of the economy during the early 1980s. Historically, water allocation and pricing in Victoria was controlled by government. Rationalisation included deregulation of industries as well as an increase in the accountability of public sector organisations. Prior to the initiation of this reform process water management in Victoria had failed to incorporate sound financial management practices with revenue failing to meet the costs of total cost of water supply including maintenance and management of infrastructure (Harris, 2002; 2004a; 2004b). During the reform process it was well recognised by policy makers that there needed to be a substantive shift toward a management system that incorporated considerations of scarcity within the now, mature water sector. Primarily, it was the recognition of increasing water scarcity that prompted policy debate around the issue of whether traditional regulatory approaches could provide for socially optimal water use that led directly to a re-examination of water rights (Pigram, 1993: 1314/5). As a result of this re-examination, the Victorian Government recognised the need to remove the historical nexus between land ownership and water rights. This was achieved via the passing of the Water Act (1989) to permit temporary and permanent trades of water rights within Victorian irrigation districts.

The trading of water in Victoria and Southern New South Wales is facilitated through Watermove and details are provided on the Watermove website (http://www.watermove.com.au/). Water trading is conducted within trading zones which are detailed on the Watermove website. While there are restrictions on who can trade in the market, the existence of the market does provide information on the valuation placed by individuals on the available water resource.

Recent literature relating to the introduction and evolution of water markets in Australia has focused on a number of relevant, and interrelated issues that must be considered for the full benefits of water markets to be forthcoming. Issues surrounding further clarification of property rights, negative third party effects, interregional trade restrictions, infrastructure cost sharing, and regulatory restrictions increasing transaction costs associated with trading have been the subject of much discussion and analysis (Brennan and Scoccimarro (1999), Campbell (2004), Freebairn (2004), Harris (2002), Crase, O'Rielly and Dollery (2000), and Hentley, Thorpe, Klijn, Beare, and Want (2004)). Nevertheless, most writers recognise a fundamental positive benefit from a shift toward water markets in Australia that will continue to accrue as knowledge and information regarding possible ways of dealing with the above concerns evolves parallel to the growth of markets.

One of the most often cited positive benefits accruing from water markets is the efficiency gains within sectors adding to societal wealth. Efficiency gains can result in considerable structural adjustment within the economy resulting in an industry profile more favourable for long term growth. However, structural change is only one aspect deserving consideration by market proponents. Other important benefits stemming from the creation and liberalisation of markets should also receive attention from analysts such as, the avoidance of government failure and increased innovation and entrepreneurship (Rolfe, 2004). This paper will add weight to the discussion regarding the potential positive affects that accrue from water markets focusing on the positive effects for the environment. Improvements in environmental outcomes can be considered the secondary effects of those benefits mentioned above. However, in light of the challenge environmental degradation has posed for the Australian agricultural sector, the attenuation of the severity of these problems via the use of markets is of considerable significance.

Bell (2002) discusses the role of trading houses in facilitating environmentally sustainable trade. In this stylised model trading houses act as single suppliers of tradable water within a river system attenuating salinity via the maintenance of higher than atomistic market prices. The positive effects limiting salinity will accrue within this model only under the presence of a number of key assumptions. First, characteristics of the upstream and downstream salinity levels where it is assumed that downstream groundwater levels are already high (Bell, 2002: 350). Second, salinity cost and benefit information is assumed to be diffuse within an atomistic market. This leaves little room to consider the effects of price increases associated with an atomistic market that can result in individual farmers internalising the benefits and costs of their water use, this includes the impacts of salinity on their property. If all farmers noted the costs of excessive water usage in relation to salinity individually, they would choose to reduce their usage regardless of what others within the system are doing. The aggregate results would be an overall reduction in salinity at all points along the river system. Third, within Bell's (2002) analysis there is an underlying assumption that while the information on salinity costs and benefits are diffuse in an atomistic market the trading house knows perfectly these costs and benefits. The difficulty with this assumption is that there is little evidence to suggest full information on the part of any actor within an economic system. Moreover, this argument ignores the potential for failure on the part of the trading house, which could be seen as analogous to government failure as there would be a high potential for capture of trading house administrators by interest groups. Why the characteristics of a trading house would be immune to these effects is not addressed.

However, while this highly stylised model cannot provide evidence of the impacts trading houses would have on salinity levels in practice, it does highlight the importance of market design options adopted and notes the impending creation of Watermove arrangements in Victoria and southern New South Wales to facilitate trade. Freebairn (2004) also highlights the possible solutions available from electronic trade arrangement of which Watermove is one type. In line with these studies this paper conducts an analysis of the water markets that are part of Watermove to provide a greater understanding between the potential provided by market based solutions to environmental problems.

The operation of water markets on a weekly basis in Watermove enables an analysis of how an atomistic market structure has worked. Specifically, analysis can be undertaken on prices and quantities traded, associated demand and supply elasticities, as well as the surpluses that flow to buyers and sellers from the operation of the market. The analysis could also allow speculation on the possibility of positive environmental consequences from such trading.

The plan of this paper is as follows. Section two considers the connection between the historical institutional framework and the rise of salinity in Victoria's irrigation areas. Section three provides basic details on the operation of the water markets, and some summary statistics on trading activity. Section four presents an analysis of estimated demand and supply elasticities for the three markets/products in which there is more active trading activity. Section five contains some concluding remarks.

2. Historical institutional inefficiencies and degradation

Within the current institutional framework, an analysis of the impacts of markets on environmental outcomes is limited to consideration of decreases in salinity rather than an increase in amounts of water provided for instream flows that would necessarily improve environmental outcomes. The discussion is limited due to the current regulatory limitations on those who may buy and sell rights within water markets (Harris, 2002). Specifically, environmental groups are unable to enter the market and buy rights for the provision of instream flows. In turn, this had led the government to consider administrative intervention in order to satisfy these stakeholder preferences. While there has been no significant attempts to do this so far, the reality is that unless the government is subject to the same rules of trading as are existing market participants, these efforts will destabilise the market and result in increased uncertainty regarding security of property rights for existing users (Harris, 2002; Moran, 2003). Hence, because there is little capacity for the current market to account for consumer preferences to allocate water to instream flows these potential benefits cannot currently be realised and the discussion must be restricted to the consequences of markets for salination. However, before a discussion of the current state of water markets and the positive results they may yield both economically and environmentally, there must be some consideration of how historical institutional structures contributed to both economic inefficiencies and environmental degradation.

Analysis of historical institutional frameworks used to allocate and price water within Victoria reveals considerable bias toward government intervention. In terms of this institutional history there have been a number of alternative methods used by government to maintain control over the water sector. This preference for control stemmed from two major, interconnected factors: the reliance on the agricultural sector to drive economic development, and the limitations imposed on this sector by the effects of constant, crippling drought. What is most interesting about the history of the water sector within Victoria is the lack of acknowledgement of the considerable negative economic and environmental consequences brought about by government intervention that prevented the evolution of water markets from very early in the states history (Harris, 2002). Evidence of these consequences provides support for the contention that until the introduction of water markets, the water sector was a victim of government failure (Harris, 2002; 2004a).

Phases of water allocation and pricing in Victorian can be broken into 4 distinct periods: domination of the British common law of riparian rights (1800-1882); the introduction of decentralised control under irrigation trusts (1883-1904);

centralisation under the State Rivers and Water Supply Commission (1905-1983); and the move to water markets (1984-present). Each phase had distinct impacts on the economic efficiency of the water sector and environmental degradation, with the most substantive effects accruing in the second and third phases when government control reached its peak. In addition, the premature introduction of government intervention during the second phase in the 1880s resulted in the stifling of innovation and entrepreneurship in water development that prevented the evolution of water markets via the adaptation of property rights (Harris, 2004b). As a result, without user property rights adaptation that may have led to the introduction of water markets much earlier in Victoria's history, the inefficiencies within the water sector and the resultant environmental degradation accelerated over time. These connections are discussed below.

The first phase of water development dominated by the British common law of riparian rights did not result in substantive increases in salinity over the period primarily due to the limited development of water supplies by settlers. During this period, squatters' dominated settlement expansion and much of their activities were limited to pastoral pursuits, that is, sheep grazing. While squatters' faced considerable risk and uncertainty associated with rainfall variation rather than adapting water rights to suit environmental conditions vastly different from those of their homeland, like that which occurred in the western United States with the prior appropriation doctrine, squatters' instead made limited improvements to sure up water supplies via the construction of dams and the sinking of wells and bores (Harris, 2004b). These activities were complimented by the inherent mobility sheep grazing provided and the scattering of run ownership that allowed squatters to protect themselves against the effects of regional drought. Conflicts over water rights were not common in Victoria during this period, with little evidence of either violence or defence via the legal system. This was most likely the result of low demand for water due to the limited number of settlers' in the more remote areas of the colony compared with supply (Harris, 2002, 2004b). However, institutional equilibrium was shattered by the discovery of gold at Bendigo in 1851.

Gold mining brought a substantive increase in population during the 1850s as migrants came to make their fortune on the lucrative Victorian gold fields. Once the technologically available supplies of gold were exhausted for the capital poor, smaller miner, the government was faced with a significant challenge of employment for the vastly increased population. As a result, land reform was almost inevitable with the establishment of a viable agricultural sector being considered the most effective way to utilise this increased population in an under developed economy. To these ends the colonial government enacted legislation to unlock the lands, attempting to remove the squatter monopoly and replace it with a class of small, yeoman settlers. This period is referred to as the selection era and, while considered a failure by contemporary analysts (Fitzpatrick (1969), Powell (1970), Dingle (1984)) it did focus legislators' attention on the limitations rainfall variability caused for the small settler. Prior to these developments, policy makers' water supply development attempts were limited to the provision of supply on the gold fields. These efforts had no impact on settlers located outside populous mining districts (Harris, 2002). Nonetheless, the relative increase in population in the more arid parts of the colony, and the possible impact of an electoral backlash should government inaction on the water supply question continue, shook the government out its complacency (Powell, 1989; Harris, 2004b).

Initially, water supply development efforts were concentrated on the provision of domestic and stock supply to small regional centres with the Water Conservation and Distribution Act (1881) providing the organisational framework and finance for development of local schemes to be managed by settlers themselves. However, this had little impact on the riparian doctrine with local bodies referred to as waterworks trusts being given the right to access a certain quantity of water from a specific source(s) via legislation. Nonetheless, this period did signal a shift in philosophy regarding water supply development that led to more significant changes in the decades that followed with a shift in focus toward the possibilities irrigation provided to drought-proof settlers. Alfred Deakin was the primary supporter of irrigation development in the colony. Deakin aroused the public and parliamentary interest in the advantages irrigation provided to protect the embryonic agricultural industry from the devastating effects of drought. By the mid-1880s Deakin had chaired a Royal Commission the findings of which became the basis for the Irrigation Act (1886) that radically altered the water rights framework in Victoria. This new framework ushered in a period of government intervention and control that was to dominate water rights development in the state for the next one hundred years. In turn, these developments would forever alter the Victorian landscape and lead to devastating environmental effects with the rise of salinity that would come to threaten the continued productivity of the agricultural sector.

The causal links between irrigation and salinity are well known. However, analysis of the links between the institutional framework and environmental effects has had little attention. Findings in Harris (2002) indicate a direct causal relationship between the institutional setting and the rise of salinity within Victoria over the periods being discussed here. Primarily, the institutional framework was characterised by the lack of ability to trade water rights and prices being set by government at levels that could not cover the cost of supply, maintenance, and management of irrigation systems. In turn, individual farmers did not internalise the cost and benefits of their resource use leading to distorted incentives that promoted over use and lack of innovation. In addition, the inability of farmers to sell their water rights separately from the land to which it was attached reinforced this incentive structure, as farmers were unable to be flexible in their production decisions. This resulted in the rise of inefficiencies that have come to dominate the irrigation sector with production of low value crops on marginal lands. It is these effects that led to the rise of salination that may have been avoided if the evolution of institutions and property rights framework had been permitted to take place from the bottom-up.

The Irrigation Act (1886) provided for management of irrigation schemes by local districts under bodies referred to as irrigation trusts. The state treasury provided finance with water rates revenue being used to pay back government loans and the 4% interest charged. However, it was not long before this system began to show signs of financial strain as farmers refused to pay their water rates resulting in trusts being unable to pay back even the interest on government loans (Harris, 2002; 2004b). Financial problems were combined with poor local management and high levels of uncertainty regarding water rights. Water rights uncertainty stemmed from the fact that farmers were only guaranteed their rights for a maximum of 14 years (Martin, 1955). As a result, farmers had no incentive to invest the considerable sums required for successful irrigation. Combined with lack of access to markets for produce and lack of knowledge regarding irrigation methods, these factors all led to the quick demise of the trust system culminating in its financial collapse at the turn of the twentieth century.

During this initial phase of irrigation development, salination began to be identified on a small number of farms. However, there was a lack of understanding between the excess watering taking place with irrigation and salinity. Farmers who identified salt intrusion on their land were unsure whether it was a direct consequence of irrigation, and due to the small number of settlers that were affected, these early signs of the problems to come did not lead to any substantial scientific investigation to assess the impacts of irrigation on salinity (Harris, 2002).

While the failure of the trust system indicated irrigation was introduced prematurely in Victoria's history, the faith of policy makers in the possibilities irrigation provided for decreasing the risks associated with drought in the agricultural sector remained unwavering. Further, it was considered that the system of decentralised management was the real cause of the failure therefore, if the institutional framework was altered the creation of a large-scale irrigation sector that would become the backbone of the agricultural sector would become a reality. Hence, in 1905 another legislative enactment, the Water Act, ushered in a move to fully centralised control of water allocation and pricing under the auspices of a newly created body known as the State Rivers and Water Supply Commission (SWRSC). The SRWSC would come to dominate the institutional landscape for water development within the state for the next eighty years. It was during this period that environmental consequences of irrigation induced salinity on both the land and in river systems accelerated with devastating consequences for regional areas.

The SRWSC was the first statutory body of its type in the world, imbued with the power of government combined with the initiative of the private sector (East, 1962). Under SRWSC control, the irrigation sector grew at a phenomenal pace with storage capacity increasing from 701, 700 in 1918/19 to 10,390,740 megalitres in 1983/84 and the land under irrigation agriculture growing from 108,059 acres in 1906/07 to 1,416,355 acres in 1983/84 (SRWSC, 1906/07 to 1983/84). While growth of the irrigation sector under the SRWSC was remarkable, the underlying institutional structure promoted substantial inefficiencies within this sector that resulted in considerable negative environmental effects. However, before the discussion considers the environmental costs of irrigation salinity an outline of the institutional framework of the SRWSC is required.

The institutional framework to develop the irrigation sector under the 1905 Act had two main features: a compulsory charge and the inability to sell water rights separately from the land to which they were attached. First, the compulsory charge required farmers to pay for a minimum amount of water regardless of whether they used it or not. In addition, this charge was set at a level that could not recoup the costs associated with supply, management, and maintenance of the irrigation sector (Harris, 2002; 2004a; 2004b). As a result, a significant proportion of the cost of irrigation was transferred to urban areas while the benefits were concentrated on regional areas. In turn, farmers were unable to internalise the full costs and benefits of their water use leading inefficiencies to dominate the sector with the expansion of irrigated farming on marginal lands with soils unsuited to intensive agriculture and the focus of production on low valued crops the prices for which fluctuated widely on the world market. Excessive watering also mobilised salinity naturally occurring in the landscape leading to an increase in the incidence of shallow water tables as additional moisture added to groundwater levels bringing them closer to the surface. Additional water also mobilised salt within the soil bringing it to the surface and adding to stream salinity levels via return flows. These effects, while natural occurrences during the irrigation process were exacerbated by the fact that farmers had no incentive to minimise their water usage nor innovate to create more efficient irrigation technologies that could limit the damage being caused. Second, the inability of farmers to sell water separately from the land to which it was attached reinforced a lack of flexibility inherent in the system with farmers being locked into irrigated production. As a result, distorted incentives came to dominate the system and promote inefficiencies.

The political system simply supported the inherent problems of the water sector under the SRWSC, with the electoral system concentrating power in rural areas (Harris, 2002; 2004a). Specifically, while the majority of population was located in urban areas, 36 out of 75 seats in the Legislative Assembly were decided in rural areas. In addition, the ratio of vote values indicates consistently higher values associated with rural votes compared with urban (Hay, Hallinger, Warhurst, and Coster, 1985: 15) reinforcing the political systems bias and the continuation of favourable water pricing policies that underpinned growth in the irrigation sector (Harris, 2002: 142).

Together the political and institutional framework that dominated water exploitation for the bulk of the twentieth century led to the creation of a system that encouraged inefficient and wasteful water usage practices. In turn, the institutional framework provided users with an incentive structure that promoted degradation rather than preservation. Only recent reforms aimed at the creation of water markets and complimented by a restriction on diversions (the Cap), and the Salinity Debit and Credit scheme have gone part way to redressing this imbalance and limiting further salination of Victoria's irrigation districts and river systems. Water markets will be the key to driving the reduction in salinity as they will result in higher prices that will lead to a reallocation of water away from less efficient producers and ensure farmers internalise the full environmental costs and benefits of their water use. An analysis of the current state of the market using the data from Watermove will provide a more complete picture of the extent of potential environmental benefits.

3. Water Markets

The water exchanges conducted in Watermove are divided into six regions as follows:

Northern Victoria Groundwater; Northern Victoria Regulated; Northern Victoria Unregulated; Southern New South Wales; Southern Victoria Regulated; and Wimmera Mallee.

Within each of the six regions there is a further division into trading zones. The number of trading zones in each region are detailed in table 1. The products traded include Temporary Water Rights/Diversion Licence (TWRDL), Temporary Sales

(TS), Temporary High Security (THS), Temporary General Security (TGS), Permanent Used Water Right/Diversion Licence (PWRDL), and Permanent Unused Water Right/Diversion Licence (PUWRDL). Details on the regions, trading zones and products traded are obtained from the Watermove website (http://www.watermove.com.au/).

Trading is restricted to those individuals who are supplied water from certain water authorities and there are restrictions on who can trade with whom in particular zones. Details are provided in the trading zone profiles available on the website at: http://www.watermove.com.au/selectregion.asp?next=selecttradingzone.asp&jump=tradingzoneprofile

For each trading zone traders are able to submit their offers by mail, fax or online. According to the trading rules, pool prices and water exchanges are conducted on the following basis. Sellers will be considered on an ascending price basis. The lowest price seller within a trading zone shall be the first seller eligible to trade. The highest price seller within a trading zone will be the last seller eligible to trade. Buyers will be considered on a descending price basis. The highest price buyer within a trading zone shall be the first buyer eligible to trade. The lowest price buyer within a trading zone will be the last buyer eligible to trade.

The pool price for a trading zone is then calculated to maximise the volume of water traded (subject to any limit for that particular zone) and is calculated to clear the market. In a number of trading weeks the market clears with sell and buy offers at the pool price. However in some trading weeks, the market clears by establishing a pool price by averaging sell and buy offers and in these cases the pool price is calculated by averaging the sale and buy prices of the last successful traders respectively so as to apportion any price benefits equally these sellers and buyers. Trading is conducted on a weekly basis and typically takes place at 10am on a Thursday, with results notified by noon, unless impacted by a public holiday. Offers need to be lodged by noon on Monday (although they can be cancelled up to noon on Wednesday). These details are available on the website at:
http://www.watermove.com.au/aboutwatertrading.asp#how_water_move_works

For each trading zone data was collected on the price history for that trading zone from the relevant section of the Watermove website (http://www.watermove.com.au/selectregion.asp?next=results/pricehistoryforzone.asp) for the period from August 22 2002 to March 17 2005. For the majority of trading zones there is little (or no) trading activity. In Northern Victoria Groundwater there are only 4 weeks in February/March 2003 in which offers are lodged for TWRDL for Spring Hill Groundwater and in only one of these weeks (13/3/03) does trading occur with 25 ML traded at a price of $20. In Northern Victoria Unregulated there is slightly more trading activity. For 11 of the trading zones no offers are recorded. For the Lower Campaspe River there are 2 weeks in April 2004 that produce offers for TWRDL. For the Lower Loddon Unregulated there are 4 weeks in February/March 2005 that produce offers for PUWRDL. However in these two zones no trades ever occur. For Goulburn Unregulated there are 8 weeks that produce offers from August to October 2004 for PUWRDL, and in one of these weeks (16/9/04) trading occurs with 32 ML traded at a price of $1150. For Kiewa Main Stem there are 6 weeks in September/October 2002 and 14 weeks from January to April 2004 that produce offers for TWRDL. For three of these weeks trading occurs. On September 19 2002 - 40 ML are traded for $46, on October 3 2002 – 10 ML traded for $46, and on April 8 2004 – 25 ML traded for $21. In Southern New South Wales there is no trading that occurs, although there is one week for Hume to Barmah (10A) in April 2003 and 4 weeks for Murray Irrigation Limited (10B) from December 2003 to February 2004 that offers occur. In Wimmera Mallee there are no offers in any weeks. In Southern Victoria Regulated there is no trading in 7 of the 9 trading zones, although two of these zones show limited offers for the TWRDL. There are two trading zones in Southern Victoria Regulated for which trading activity takes place. These are for 4 weeks for the Werribee System (31) for TWRDL, and for 5 weeks for Lower LaTrobe (43) for TWRDL. For the Werribee System prices range from $195 (23/12/04) to $1050 (22/1/04) while the amounts traded range from 5.1ML (19/2/04) to 46.6 ML (27/2/03). For Lower LaTrobe prices range from $13 (29/5/03, 12/6/03) to $20 (11/3/04), while the amounts traded range from 50ML (11/3/04) to 300ML (24/7/03).

The only region where there is significant trading activity is Northern Victoria Regulated. For 13 of the 23 trading zones there are no trades that occur, although in many of these zones there are a number of weeks in which offers are made. There are a further 10 zones where there are 11 particular products that trade for 9 weeks or less in the sample period. The details for these trading zones are presented in table 2. These zones trade both temporary and permanent water rights. Consistent with expectations the prices for trading permanent water rights are significantly higher. In fact for the 23 weeks of trading activity in these products summarised in table 3 there is only a single week where the price is less than $1000. The trade of temporary water rights is done at lower prices, although there is considerable variation in these prices from a low of $15 to a high of $450. In these zones and products with a limited number of trading weeks there are only small quantities of ML traded from a low of 2ML to a high of 200ML.

There are however three zones in which there is reasonably consistent trading activity in the Northern Victoria Regulated region. These zones are Greater Goulburn, Hume-Barmah and Barmah-Nyah. In all three of these zones TWRDL have been traded for most weeks across the three financial years that Watermove has been operational. For Hume-Barmah and Barmah-Nyah there is also a reasonable number of trading weeks in TS in 2002/03, and for Greater Goulburn there is a scattering of weeks across the three financial years for PUWRDL. For these three zones and six products the results in table 3 report the number of weeks in which trading activity occurs, the number of weeks in which offers are made but no trades occur, the number of weeks in which no offers are made, the minimum and maximum values for prices and ML traded across the trading weeks, the average ML traded in a trading week, the simple average price for trading weeks and the weighted average price for trading weeks where the weights are calculated as a function of the ML traded. For the sake of completeness table 3 also includes the averages and ranges for prices and ML traded for all other zones combined into two groups trading of temporary and permanent water rights.

An analysis of the results in table 3 reveals the following patterns. For the Greater Goulburn trading zone there are 108 trading weeks, for the Hume-Barmah trading zone there are 85 trading weeks and for the Barmah-Nyah trading zone there are 118 trading weeks. The number of weeks in which no offers are received is very small, in fact, only a single figure number for all zones. The Hume-Barmah zone has a higher number of non-trading weeks than the other zones. The minimum prices across all trading weeks are similar across the three zones, while the maximum price for Greater Goulburn is higher than the other two zones. In terms of simple average prices Greater Goulburn is higher than the other two zones. However when prices are weighted by volumes traded average prices in Greater Goulburn and Barmah-Nyah are very similar, with weighted average prices in Hume-Barmah a bit lower. Figure 1 presents a graph of prices in the three zones across the sample period which illustrates the price variability that occurs. In terms of ML traded Greater Goulburn is by far the most liquid market with an average ML traded almost five times as large as that in the other two zones. While these zones are less liquid than Greater Goulburn their average trading volumes are much higher than those in the zones where trading activity is sporadic. Figure 2 presents a graph of the ML traded across the three zones, which illustrates the variability in the ML traded.

4. Demand and Supply Analysis

For the three zones which have spans of data for three financial years for TWRDL the data is subjected to further analysis. For each week of trading it is possible to obtain data on the sell and buy orders lodged in that week. For the analysis in this paper it is assumed that each lodged order represents the true value assigned to that quantity of water by the individual lodging that order. If that assumption holds then all of the offers trace out points which lie on the respective demand and supply curves for that week. The elasticity of demand (supply) can then be estimated via an OLS regression involving the logarithms of quantity of ML traded and the prices. This analysis is done for every week for which trading takes place and multiple offers exist to be able to estimate the demand and supply elasticities. For these three zones the results in table 4 report the minimum and maximum elasticity estimates, along with the simple average and a weighted average where the weights are calculated as a function of the ML traded. In addition table 4 also reports consumer and producer surplus for each of the zones, both the weekly average and the sum for all weeks. The consumer and producer surplus is calculated based on the assumption that lodged offer prices represent the true values of individuals. The difference between these and the established pool prices for that week are then multiplied by the relevant quantity to obtain the calculated surpluses. For the sake of completeness table 4 also includes the averages and ranges for prices and ML traded for the other three products traded in these zones as well as all other zones combined into two groups trading of temporary and permanent water rights. In calculating these surpluses no adjustments are made for the costs of transacting on the market. Details on the transaction costs are available on the website at:
http://www.watermove.com.au/aboutwatertrading.asp#terms_and_conditions

An analysis of the results in table 4 reveals the following patterns. There is a considerable range in the demand elasticities across all three trading zones, although the simple average estimated demand elasticity is fairly comparable across the three zones. In fact, when the volume weighted average elasticity is calculated across all the three zones it is remarkably similar. In terms of supply elasticities the ranges for Greater Goulburn and Barmah-Nyah are similar, while the range for Hume-Barmah is more extreme. The extreme elasticities for Hume-Barmah are in weeks where trading and offers are thin, illustrating the concern of Crase, O'Reilly and Dollery (2000) about the thin markets. The estimated average (both simple and weighted) supply elasticity is lower in Greater Goulburn, even after the extreme observations are removed from the Hume-Barmah time series (three observations of estimated supply elasticities are removed). For the TWRDL trading in the three most active zones, figure 3 presents a time series plot of the estimated weekly demand and supply elastcities (with the three extreme Hume-Barmah observations removed). The figure shows the variable nature of the estimated weekly elasticities, in part induced by the thin trading effects mentioned in Crase, O'Reilly and Dollery (2000). Rolfe (2004) discusses that calculations of consumer and producer surplus are a means of measuring the economic gains from water trading. Heaney et. al. also discuss the economic gains from allowing inter-regional trade, and suggest that significant gains are likely to be present. Heaney et. al. (2004) assume that all gainful intra-regional trades have already occurred. This analysis provides some measure of these gains. In terms of consumer and producer surplus the results show significant economic gains on the basis of the assumptions made in the analysis. For Greater Goulburn the average weekly consumer and producer surplus exceed \$20,000 respectively, and cumulate to amounts in excess of \$2.5 million, respectively for the whole sample period. While the results for Barmah-Nyah are less spectacular they are still quite sizable at average weekly surpluses of around \$4000 respectively, and cumulative sums for the whole sample period of around \$500,000 each. For Hume-Barmah the results are a little less around \$2000 on average per week, and cumulative sums of around \$170,000. Figure 4 presents a time series plot of the calculated consumer and producer surpluses on a weekly basis for the whole sample period.

For the TWRDL trading in the most active three trading zones further analysis is then conducted on the elasticities and surpluses. Specifically, for each zone the following four regression models are estimated:

$$DdElas = \alpha1\ SsElas + \alpha2\ ConsSurp + \alpha3\ ProdSurp + \alpha4\ Price + \alpha5\ ML\ Traded + \alpha6\ DdElas(-1) + \alpha7\ Trweek + \varepsilon$$

$$SsElas = \alpha1\ DdElas + \alpha2\ ConsSurp + \alpha3\ ProdSurp + \alpha4\ Price + \alpha5\ ML\ Traded + \alpha6\ SsElas(-1) + \alpha7\ Trweek + \varepsilon$$

$$ConsSurp = \alpha1\ SsElas + \alpha2\ DdElas + \alpha3\ ProdSurp + \alpha4\ Price + \alpha5\ ML\ Traded + \alpha6\ ConsSurp(-1) + \alpha7\ Trweek + \varepsilon$$

$$ProdSurp = \alpha1\ SsElas + \alpha2\ ConsSurp + \alpha3\ DdElas + \alpha4\ Price + \alpha5\ ML\ Traded + \alpha6\ ProdSurp(-1) + \alpha7\ Trweek + \varepsilon$$

where DdElas is the estimated demand elasticity, SsElas is the estimated supply elasticity, ConsSurp is the calculated consumer surplus, ProdSurp is the calculated producer surplus, Price is the weekly pool price, ML traded is the quantity of ML traded for that week and Trweek is the number of trading weeks that the exchange has been in operation. Each of the models is also augmented with a set of dummy variables for the financial years, and for the months of the year

The results of estimating each of these models for each of the trading zones are reported in tables 5, 6 and 7, respectively. Two specifications are reported, both with and without the year and month dummy variables. The tables report OLS parameter estimates, OLS p-values in parantheses, White (1980) p-values in brackets, as well as the adjusted R-squared, Durbin-Watson test and White (1980) test. The Durbin-Watson test is used with a lagged dependent variable following the findings of Inder (1984, 1986) which support the use of the test provided that the correct critical value is used. The results reveal the following patterns. For the models of demand elasticities across the three trading zones there are no variables which are consistently significant across all specifications. In Greater Goulburn and Barmah-Nyah the trading week is significant in the specification without dummies, but this result disappears when the dummy variables are added. A similar pattern is found for the lagged dependent variable for Greater Goulburn and Hume-Barmah. In contrast, the results for the models of supply elasticities are much stronger. In all three trading zones, producer surplus is found to be significantly negative, while price and volume are found to be significantly positive. These results hold true for specifications with and without dummy variables, and for either conventional or White (1980) standard errors. Higher prices and volumes, but lower producer surplus is found to be associated with higher supply elasticities. For the models of consumer surplus, a significantly positive volume effect is found across all trading zones and all specifications. For Greater Goulburn there is a positive price effect in the model without dummies, and for Hume-Barmah there is a negative trading week effect in the model without dummies, however neither of these results are robust to the inclusion of the dummy variables. For the producer surplus models there are a number of variables which are significant. In general supply elasticity is significantly negative, while price and volume are significantly positive. This is consistent with the broad result found in the models of supply elasticity.

The estimated models are now augmented to analyse whether there are spillover effects across the three trading zones. Specifically, if we are estimating the model for the demand elasticity for one zone, the demand elasticities for the other two trading zones are then added as explanatory variables. A similar approach is taken for each of the other variables of interest. The results of this estimation are reported in tables 8, 9 and 10, respectively. The first issue that arises in the analysis is whether any spillover effects are present. For Greater Goulburn which is the most liquid of the trading zones there is no evidence of spillover from Hume-Barmah or Barmah-Nyah. For the Barmah-Nyah trading zone there is no evidence of spillovers on the consumer and producer surplus measures. However, for the elasticity model there is evidence of spillover effects. For the demand elasticity this is only from Greater Goulburn, while for the supply elasticity spillover effects are found from both the Greater Goulburn and Hume-Barmah trading zones. For Hume-Barmah the results are even more mixed. For both the consumer and producer surplus analysis there is spillover from Barmah-Nyah in the models without the dummy variables. For the demand elasticity there is spillover from Greater Goulburn for all model specifications, while for the supply elasticity there is spillover from Barmah-Nyah for all model specifications. In summary the results show some relationships between the three trading zones. The second issue that arises in the analysis is whether the impacts found to be significant in the models without spillover effects are still present once such effects are allowed in the modelling. In general, this is found to be the case.

5. Conclusion

This paper has conducted an analysis of the water markets in Victoria covered by Watermove. The analysis in this paper has examined the weekly trading activity. For the majority of trading zones there is little trading activity that occurs. There are three trading zones in which the markets for temporary water rights are reasonably active and liquid on a weekly basis, and for these zones an analysis was conducted of their demand and supply elasticities and consumer and producer surplus. The results of this analysis suggest a stronger relationship on the supply side between prices, volumes, elasticity and producer surplus. While trade is relatively limited, the stronger relationship on the supply side indicates that sellers are taking into account the marginal benefits of water usage on farm compared with trading via the market. Specifically, given the three more active trading zones that formed the basis of this analysis are located in areas where irrigation was established under the trust system during the 1880s. The extent of environmental degradation in these zones is considerable with shallow water tables being the dominant problem. In addition, much of the irrigated production in these areas is concentrated on pastures and fodder crops, and cereals that generally have a low return per acre. As a result, because shallow water tables decrease the lands productivity, the returns from which are relatively low compared with grapes or citrus it would be logical to conclude that farmers in these areas would incorporate the marginal benefits of water used in farming compared with that traded thereby increasing their responsiveness to price and volume changes on the supply side. Put simply, as wealth maximising individuals farmers would be aware that return on water is higher in trading compared with putting the water to use in irrigation thereby encouraging sellers to increase volumes traded as prices increased. Given trade between zones is restricted, there is not a similar level of responsiveness on the demand side because the cost of water is relatively high compared with returns from production. As a result, trading is being driven by supply side considerations. In light of this argument, it could be argued that farmers consider the wealth limiting effects of degradation in their decisions engage in water trading. In turn, the move of water out of areas dominated by shallow water tables and low valued crops would indicate that there will be significant environmental benefits forthcoming from increased water trade as demonstrated by the statistical analysis of Watermove.

References

Bell, R. (2002), Capturing benefits from water entitlement trade in salinity affected areas: A role for trading houses, *Australian Journal of Agricultural and Resource Economics* 46, 347-366.

Brennan, D. and Scoccimarro, M. (1999), Issues in defining property rights to improve Australian water markets, *Australian Journal of Agricultural and Resource Economics* 43, 69-89.

Campbell, D. (2004), Water trading instruments in Australia, paper presented to the IPA conference on Establishing Australian Water Markets

Crase, L., O'Reilly, L. and Dollery, B. (2000), Water markets as a vehicle for water reform: The case of New South Wales, *Australian Journal of Agricultural and Resource Economics* 44, 299-321.

Dingle, T., (1984), *The Victorians Settling*, Fairfax, Syme, and Weldon Associates, Melbourne, Australia

Fitzpatrick, B., (1969), *The British Empire in Australia: An Economic History 1834-1939*, Macmillan of Australia, Australia

Freebairn, J. (2003), Economic policy for rural and regional Australia, *Australian Journal of Agricultural and Resource Economics* 47, 389-414.

Freebairn, J. (2004), The definition of water rights, paper presented to the IPA conference on Establishing Australian Water Markets

Harris, E. (2002), *Treading Water: An Analysis of Institutions and Natural Resource Sustainability, The Case of the Murray River*, Unpublished Ph.D. Thesis, The University of Melbourne

Harris, E., (2004a), What price the Murray? Management options for a sustainable future, *Enviro 04 Conference Proceedings*

Harris, E. (2004b), State administration versus private innovation: The evolution of property rights to water in Victoria, Australia, paper presented to the IPA conference on Establishing Australian Water Markets

Hay, P.R., Hqallinger, J., Warhurst, J., and Coster, B., (1985), *Essays on Victorian Politics*, Warnambool Institute Press, Australia

Heaney, A. Thorpe, S. Klijn, N. Bearne, S. Want, S. (2004), Water charges and interregional trade in the southern Murray Darling Basin, paper presented to the IPA conference on Establishing Australian Water Markets

Inder, B. (1984), Finite sample power of tests for autocorrelation in models containing lagged dependent variables, *Economics Letters* 14, 179-185.

Inder, B. (1986), An approximation to the null distribution of the Durbin-Watson statistic in models containing lagged dependent variables, *Econometric Theory* 2, 413-428.

Marin, C. S., (1955), *Irrigation and closer settlement in the Shepparton district 1836-1906*, Melbourne University Press, Australia

Moran, A., (2003), 'Property Rights to Water: Effects on Agricultural Productivity and the Environment', *IPA Backgrounder*, 15(3)

Pigram, J. J., (1993), 'Property Rights and Water Markets in Australia: an evolutionary process toward institutional reform, *Water Resources Research*, 29(4), 1313-1319

Powell, J. M., (1970), *The Public Lands of Australia Felix: settlement and land appraisal in Victoria 1834-1891 with special reference to the western plains,* Oxford University Press, Melbourne, Australia

Powell, J. M., (1989), *Water the Garden State: water, land, and community in Victoria, 1834-1988*, Allen and Unwin, Sydney, Australia

Rolfe, J. (2004), Potential efficiency gains from water trading in Queensland, paper presented to the IPA conference on Establishing Australian Water Markets

State Rivers and Water Supply Commission, (1906/07-1983/84), *Annual Reports*, Victorian Government Printer, Melbourne, Australia

White, H. (1980), A Heteroskedasticity-Consistent Covariance Matrix Estimator and a Direct Test for Heteroskedasticity, *Econometrica* 48, 817-838.

Table 1: Water Regions and Trading Zones

This table presents details on the number of trading zones and products traded for each of the six regions in Watermove.

Region	No. of trading zones	Products traded
Northern Victoria Groundwater	14	TWRDL, TS
Northern Victoria Regulated	23	TWRDL, TS, PWRDL, PUWRDL
Northern Victoria Unregulated	15	TWRDL, TS, PWRDL, PUWRDL
Southern New South Wales	2	TWRDL, TS, THS, TGS
Southern Victoria Regulated	9	TWRDL, TS, PWRDL, PUWRDL
Wimmera Mallee	1	TWRDL, TS, PWRDL, PUWRDL

Table 2: Northern Victoria Regulated Zones with Limited Trading Activity

This table presents details on the number of trading weeks, and ranges for prices and ML traded for the zones and products with limited trading activity (9 weeks or less) in Northern Victoria Regulated.

Trading Zone	Product	Trading Weeks	Price (Min.)	Price (Max.)	ML (Min.)	ML (Max.)
Greater Goulburn	PWRDL	2	1100.50	1250	20	23
Pyramid Boort	PUWRDL	2	1149.50	1150	5	5
Central Goulburn	PUWRDL	1	1238	1238	19	19
Broken NCW	TWRDL	1	78.5	78.5	100	100
Broken CWGR	TWRDL	9	48	201.75	4	59.4
Lower Goulburn	TWRDL	9	15	435	9	185
Campaspe	TWRDL	9	65	403.25	10	200
Loddon	TWRDL	3	50	450	10	15
Hume Barmah	PUWRDL	9	930	1200	4	124
Hume Barmah	PWRDL	2	1000	1000	2	40
Barmah Nyah	PUWRDL	7	1150	1220	4	15

Table 3: Summary Statistics on Water Trading

This table reports summary statistics on the number of trading weeks, prices and ML traded for the three trading zones and six products in the Northern Victoria Regulated region for which trading is reasonably consistent. For completeness the summary statistics for the other zones are reported in two aggregated categories.

Trading Zone	Product	Weeks Traded	Weeks No Trade	Weeks No Offer	Price Min.	Price Max.	Price Ave	Price Ave wght	ML Min	ML Max	ML Ave
Greater Goulburn	TWRDL	108	8	3	12	500	174.27	148.09	100	4111.8	1447.77
Greater Goulburn	PUWRDL	17	48	17	1100	1250	1176.56	1188.96	2	60	13.59
Hume Barmah	TWRDL	85	36	9	22.50	310.55	131.72	101.20	9	1015	226.92
Hume Barmah	TS	21	12	11	57.50	305	213.35	189.33	5	155.2	50.69
Barmah Nyah	TWRDL	118	11	1	11	306.50	132.91	144.02	5	1135.1	311.69
Barmah Nyah	TS	35	2	7	37.50	276.27	199.23	220.02	2.3	413	121.61
Other	Temporary				13	1050	177.10	116.47	4	300	48.40
Other	Permanent				930	1250	1132.73	1090.41	2	124	27.29

Table 4: Elasticities and Surpluses for Trading Zones

This table reports summary statistics on the estimated elasticities and calculated surpluses for the three trading zones and six products in the Northern Victoria Regulated region for which trading is reasonably consistent. For completeness the summary statistics on surpluses for the other zones are also reported. For Hume-Barmah the figures in parantheses are for supply elasticities with those observations where the calculated elasticity is above 20 removed.

Trading Zone	Product	DdElas Min.	DdElas Max	DdElas Ave	DdElas Ave wght	SsElas Min.	SsElas Max.	SsElas Ave	SsElas Ave wght	CS Ave	CS Sum	PS Ave	PS Sum
Greater Goulburn	TWRDL	0.80	7.56	3.20	3.53	0.18	13.26	3.50	3.71	24575	2654191	28708	3100513
Greater Goulburn	PUWRDL									200.88	3415	195.88	3330
Hume Barmah	TWRDL	0.76	16.06	3.46	3.56	0.56	43.90	6.13 (5.09)	5.90 (4.67)	2081.93	176494	1960.54	166646
Hume Barmah	TS									851.52	17882	1629.91	34228
Barmah Nyah	TWRDL	0.68	12.29	3.49	3.51	0.36	16.36	4.21	4.96	3579.54	422386	4303.44	507805
Barmah Nyah	TS									2057.4	72009	3012.63	105442
Other	Temporary									209.14	9202	256.32	11278
Other	Permanent									375.42	9010	150.63	3615

Table 5: Models for Elasticities and Surpluses for the Greater Goulburn Region

The table reports OLS parameter estimates. OLS p-values are reported in parantheses, while White corrected p-values are reported in brackets.

	DdElas	SsElas	ConsSurp	ProdSurp	Price	ML	LDep	Trweek	Adj. R2	DW	White
DdElas		0.042 (0.606) [0.546]	-0.003 (0.681) [0.736]	0.002 (0.654) [0.584]	0.001 (0.659) [0.581]	0.049 (0.786) [0.828]	0.261 (0.012) [0.022]	0.027 (0.000) [0.000]	0.477	1.846	22.974 (0.061)
DdElas (d)		0.024 (0.781) [0.755]	-0.001 (0.484) [0.525]	0.001 (0.201) [0.134]	-0.003 (0.197) [0.100]	-0.160 (0.442) [0.500]	0.140 (0.183) [0.224]	0.054 (0.302) [0.191]	0.523	1.928	31.640 (0.169)
SsElas	0.101 (0.425) [0.343]		-0.001 (0.501) [0.551]	-0.020 (0.001) [0.024]	0.012 (0.000) [0.003]	0.813 (0.000) [0.003]	0.181 (0.089) [0.107]	0.012 (0.219) [0.140]	0.440	1.805	24.632 (0.038)
SsElas (d)	0.064 (0.657) [0.619]		0.001 (0.463) [0.340]	-0.019 (0.005) [0.023]	0.009 (0.004) [0.054]	0.934 (0.000) [0.004]	0.075 (0.518) [0.498]	-0.033 (0.630) [0.530]	0.467	1.926	34.211 (0.103)
ConsSurp	-0.879 (0.516) [0.620]	-0.393 (0.730) [0.736]		-0.001 (0.985) [0.982]	0.046 (0.082) [0.046]	8.386 (0.000) [0.000]	0.143 (0.131) [0.350]	-0.129 (0.202) [0.174]	0.415	1.827	26.305 (0.024)
ConsSurp (d)	-1.088 (0.449) [0.546]	0.853 (0.460) [0.447]		0.005 (0.949) [0.937]	0.018 (0.585) [0.615]	6.497 (0.016) [0.004]	0.015 (0.881) [0.918]	0.475 (0.489) [0.502]	0.495	1.733	38.612 (0.040)
ProdSurp	1.678 (0.352) [0.251]	-3.883 (0.007) [0.015]	-0.023 (0.865) [0.818]		0.091 (0.007) [0.015]	12.265 (0.000) [0.000]	0.471 (0.000) [0.000]	-0.205 (0.128) [0.045]	0.678	1.585	30.618 (0.006)
ProdSurp (d)	2.497 (0.215) [0.161]	-3.859 (0.013) [0.040]	0.001 (0.997) [0.996]		0.004 (0.353) [0.384]	16.009 (0.000) [0.000]	0.359 (0.000) [0.005]	-0.528 (0.586) [0.601]	0.688	1.620	38.150 (0.045)

Table 6: Models for Elasticities and Surpluses for the Barmah-Nyah region

The table reports OLS parameter estimates. OLS p-values are reported in parantheses, while White corrected p-values are reported in brackets.

	DdElas	SsElas	ConsSurp	ProdSurp	Price	ML	LDep	Trweek	Adj. R2	DW	White
DdElas		0.040 (0.606) [0.534]	-0.063 (0.263) [0.025]	-0.048 (0.365) [0.131]	-0.002 (0.506) [0.320]	1.416 (0.180) [0.135]	0.057 (0.572) [0.683]	0.020 (0.018) [0.011]	0.252	2.058	18.818 (0.172)
DdElas (d)		-0.054 (0.594) [0.582]	-0.032 (0.611) [0.432]	-0.019 (0.770) [0.722]	-0.010 (0.054) [0.029]	0.851 (0.473) [0.491]	-0.119 (0.249) [0.412]	0.138 (0.416) [0.403]	0.336	2.203	38.106 (0.076)
SsElas	-0.053 (0.651) [0.655]		0.011 (0.862) [0.867]	-0.165 (0.006) [0.003]	0.015 (0.001) [0.011]	2.782 (0.017) [0.014]	0.543 (0.000) [0.000]	-0.001 (0.967) [0.969]	0.586	2.304	27.087 (0.019)
SsElas (d)	-0.076 (0.526) [0.543]		-0.026 (0.687) [0.693]	-0.258 (0.000) [0.001]	0.024 (0.000) [0.000]	3.533 (0.005) [0.007]	0.256 (0.009) [0.039]	-0.004 (0.984) [0.982]	0.662	2.181	33.362 (0.185)
ConsSurp	-0.152 (0.389) [0.158]	-0.009 (0.947) [0.943]		0.205 (0.026) [0.123]	0.861 (0.896) [0.893]	3.913 (0.027) [0.027]	0.335 (0.001) [0.061]	-0.014 (0.334) [0.338]	0.509	1.928	23.891 (0.047)
ConsSurp (d)	-0.037 (0.850) [0.766]	-0.078 (0.662) [0.673]		0.146 (0.196) [0.318]	0.004 (0.647) [0.638]	5.687 (0.006) [0.003]	0.245 (0.022) [0.160]	0.104 (0.723) [0.730]	0.515	2.010	41.791 (0.035)
ProdSurp	-0.146 (0.449) [0.349]	-0.385 (0.006) [0.041]	0.235 (0.031) [0.034]		0.022 (0.002) [0.017]	10.172 (0.000) [0.000]	0.212 (0.008) [0.015]	-0.018 (0.265) [0.148]	0.646	1.677	19.304 (0.154)
ProdSurp (d)	-0.029 (0.883) [0.858]	-0.702 (0.000) [0.001]	0.146 (0.180) [0.226]		0.038 (0.000) [0.000]	9.552 (0.000) [0.000]	0.021 (0.806) [0.861]	-0.090 (0.760) [0.740]	0.712	1.754	34.259 (0.158)

Table 7: Models for Elasticities and Surpluses for the Hume-Barmah region

The table reports OLS parameter estimates. OLS p-values are reported in parantheses, while White corrected p-values are reported in brackets.

	DdElas	SsElas	ConsSurp	ProdSurp	Price	ML	LDep	Trweek	Adj. R2	DW	White
DdElas		0.002 (0.962) [0.936]	-0.210 (0.263) [0.126]	-0.099 (0.590) [0.316]	-0.006 (0.367) [0.265]	2.544 (0.261) [0.230]	0.324 (0.010) [0.005]	-0.005 (0.807) [0.762]	0.192	1.579	7.390 (0.919)
DdElas (d)		0.016 (0.778) [0.637]	-0.276 (0.210) [0.056]	-0.051 (0.827) [0.772]	0.008 (0.480) [0.376]	3.989 (0.174) [0.092]	0.203 (0.158) [0.091]	-0.287 (0.278) [0.350]	0.156	1.563	13.029 (0.966)
SsElas	-0.106 (0.627) [0.452]		0.332 (0.316) [0.390]	-1.382 (0.000) [0.000]	0.061 (0.000) [0.000]	10.348 (0.010) [0.018]	0.022 (0.797) [0.851]	0.048 (0.193) [0.124]	0.549	1.529	30.594 (0.006)
SsElas (d)	-0.004 (0.988) [0.981]		0.420 (0.296) [0.423]	-1.524 (0.001) [0.002]	0.062 (0.004) [0.004]	10.851 (0.041) [0.095]	-0.021 (0.837) [0.878]	0.115 (0.822) [0.789]	0.511	1.744	34.588 (0.075)
ConsSurp	-0.134 (0.106) [0.167]	0.036 (0.309) [0.207]		0.123 (0.337) [0.381]	-0.007 (0.107) [0.103]	7.952 (0.000) [0.000]	0.003 (0.973) [0.974]	-0.030 (0.024) [0.036]	0.604	1.659	26.648 (0.021)
ConsSurp (d)	-0.132 (0.123) [0.179]	0.024 (0.492) [0.422]		-0.057 (0.699) [0.672]	-0.005 (0.477) [0.361]	9.094 (0.000) [0.000]	-0.136 (0.165) [0.226]	-0.048 (0.776) [0.731]	0.659	1.914	34.668 (0.073)
ProdSurp	-0.051 (0.540) [0.363]	-0.121 (0.000) [0.026]	0.137 (0.275) [0.300]		0.012 (0.003) [0.040]	4.237 (0.005) [0.025]	0.166 (0.077) [0.177]	-0.018 (0.895) [0.879]	0.445	2.264	31.889 (0.004)
ProdSurp (d)	-0.018 (0.826) [0.788]	-0.100 (0.001) [0.026]	-0.079 (0.573) [0.552]		0.011 (0.105) [0.105]	6.766 (0.000) [0.000]	-0.083 (0.472) [0.437]	0.130 (0.411) [0.471]	0.551	2.560	40.139 (0.021)

Table 8: Models for Elasticities and Surpluses for the Greater Goulburn region with spillovers

The table reports OLS parameter estimates. OLS p-values are reported in parantheses, while White corrected p-values are reported in brackets.

	DdElas	SsElas	ConsSurp	ProdSurp	Price	ML	LDep	Trweek	HB	BN	Adj.R2	DW	White
DdElas		-0.007 (0.942) [0.931]	-0.003 (0.681) [0.732]	0.002 (0.771) [0.737]	0.002 (0.479) [0.380]	0.034 (0.869) [0.901]	0.287 (0.017) [0.025]	0.026 (0.012) [0.009]	-0.038 (0.528) [0.389]	0.102 (0.123) [0.138]	0.542	2.264	20.696 (0.295)
DdElas (d)		-0.024 (0.814) [0.803]	-0.003 (0.795) [0.805]	0.005 (0.535) [0.517]	-0.002 (0.493) [0.353]	-0.180 (0.521) [0.583]	0.135 (0.286) [0.369]	-0.089 (0.497) [0.517]	-0.080 (0.227) [0.129]	0.079 (0.284) [0.241]	0.502	2.124	33.339 (0.223)
SsElas	0.092 (0.534) [0.415]		-0.006 (0.588) [0.632]	-0.024 (0.003) [0.025]	0.015 (0.000) [0.004]	0.663 (0.009) [0.029]	0.109 (0.368) [0.414]	0.025 (0.069) [0.047]	0.004 (0.908) [0.901]	-0.037 (0.690) [0.653]	0.418	1.844	21.693 (0.234)
SsElas (d)	-0.007 (0.967) [0.960]		0.006 (0.631) [0.537]	-0.024 (0.015) [0.038]	0.010 (0.059) [0.127]	0.903 (0.008) [0.046]	0.003 (0.983) [0.982]	0.043 (0.785) [0.790]	0.004 (0.906) [0.910]	0.002 (0.987) [0.986]	0.442	1.876	29.286 (0.398)
ConsSurp	-0.710 (0.664) [0.749]	0.242 (0.867) [0.858]		-0.012 (0.879) [0.867]	0.030 (0.380) [0.297]	8.207 (0.005) [0.000]	0.111 (0.301) [0.511]	-0.185 (0.171) [0.130]	-0.219 (0.808) [0.807]	0.658 (0.149) [0.153]	0.363	1.941	29.649 (0.041)
ConsSurp (d)	-0.592 (0.722) [0.771]	0.303 (0.832) [0.819]		-0.027 (0.782) [0.781]	0.003 (0.943) [0.955]	7.525 (0.041) [0.027]	0.009 (0.934) [0.953]	3.761 (0.017) [0.030]	-0.413 (0.670) [0.610]	-0.357 (0.498) [0.502]	0.491	1.876	38.258 (0.094)
ProdSurp	1.819 (0.415) [0.333]	-4.056 (0.022) [0.036]	-0.033 (0.847) [0.815]		0.091 (0.035) [0.032]	13.259 (0.000) [0.001]	0.459 (0.000) [0.001]	-0.264 (0.161) [0.110]	-0.932 (0.522) [0.551]	0.092 (0.881) [0.936]	0.659	1.570	46.627 (0.001)
ProdSurp (d)	1.355 (0.532) [0.446]	-3.201 (0.068) [0.080]	0.023 (0.900) [0.891]		-0.037 (0.512) [0.563]	21.394 (0.000) [0.000]	0.268 (0.013) [0.052]	-4.131 (0.049) [0.083]	-1.588 (0.310) [0.220]	-0.451 (0.485) [0.687]	0.738	1.921	46.093 (0.017)

Table 9: Models for Elasticities and Surpluses for the Barmah-Nyah region with spillovers

The table reports OLS parameter estimates. OLS p-values are reported in parantheses, while White corrected p-values are reported in brackets.

	DdElas	SsElas	ConsSurp	ProdSurp	Price	ML	LDep	Trweek	GG	HB	Adj.R2	DW	White
DdElas		-0.045 (0.706) [0.695]	-0.078 (0.235) [0.018]	-0.065 (0.433) [0.308]	0.003 (0.732) [0.710]	1.287 (0.308) [0.255]	-0.017 (0.885) [0.911]	0.018 (0.236) [0.199]	0.373 (0.095) [0.046]	0.088 (0.436) [0.517]	0.278	1.911	19.320 (0.372)
DdElas (d)		-0.118 (0.351) [0.363]	-0.048 (0.519) [0.340]	-0.015 (0.868) [0.852]	-0.005 (0.598) [0.574]	1.114 (0.457) [0.501]	-0.151 (0.204) [0.318]	0.222 (0.327) [0.266]	0.339 (0.159) [0.109]	0.154 (0.199) [0.207]	0.357	2.154	31.640 (0.289)
SsElas	-0.090 (0.418) [0.444]		0.073 (0.299) [0.194]	-0.233 (0.003) [0.012]	0.031 (0.000) [0.000]	2.468 (0.029) [0.040]	0.161 (0.134) [0.267]	0.027 (0.023) [0.004]	0.325 (0.054) [0.038]	0.094 (0.029) [0.034]	0.707	2.046	25.883 (0.104)
SsElas (d)	-0.078 (0.522) [0.546]		0.023 (0.785) [0.707]	-0.313 (0.001) [0.004]	0.035 (0.000) [0.000]	3.824 (0.004) [0.011]	0.010 (0.930) [0.945]	0.093 (0.657) [0.537]	0.424 (0.032) [0.034]	0.127 (0.004) [0.007]	0.718	2.037	29.510 (0.387)
ConsSurp	-0.227 (0.256) [0.048]	0.108 (0.592) [0.646]		0.287 (0.040) [0.162]	-0.007 (0.557) [0.644]	1.139 (0.602) [0.590]	0.415 (0.001) [0.063]	-0.012 (0.577) [0.612]	0.030 (0.245) [0.168]	0.020 (0.916) [0.875]	0.514	2.084	21.549 (0.253)
ConsSurp (d)	-0.076 (0.727) [0.589]	-0.051 (0.812) [0.806]		0.115 (0.455) [0.568]	-0.001 (0.956) [0.960]	4.175 (0.090) [0.065]	0.261 (0.049) [0.222]	0.621 (0.107) [0.106]	-0.016 (0.587) [0.562]	0.042 (0.850) [0.754]	0.553	2.084	34.869 (0.174)
ProdSurp	-0.136 (0.418) [0.302]	-0.537 (0.001) [0.006]	0.173 (0.060) [0.146]		0.039 (0.000) [0.000]	8.230 (0.000) [0.000]	0.180 (0.014) [0.051]	0.015 (0.429) [0.422]	0.015 (0.174) [0.268]	0.121 (0.525) [0.572]	0.734	1.473	17.498 (0.489)
ProdSurp (d)	-0.014 (0.938) [0.933]	-0.573 (0.001) [0.001]	0.111 (0.311) [0.450]		0.045 (0.000) [0.000]	9.599 (0.000) [0.000]	0.149 (0.076) [0.116]	0.092 (0.776) [0.769]	0.009 (0.573) [0.643]	-0.009 (0.970) [0.967]	0.741	1.591	28.041 (0.462)

Table 10: Models for Elasticities and Surpluses for the Hume-Barmah region with spillovers

The table reports OLS parameter estimates. OLS p-values are reported in parantheses, while White corrected p-values are reported in brackets.

	DdElas	SsElas	ConsSurp	ProdSurp	Price	ML	LDep	Trweek	GG	BN	Adj.R2	DW	White
DdElas		0.001 (0.993) [0.988]	-0.286 (0.140) [0.048]	-0.186 (0.323) [0.078]	-0.001 (0.971) [0.959]	3.869 (0.098) [0.085]	0.355 (0.003) [0.001]	0.027 (0.247) [0.114]	-0.462 (0.062) [0.021]	-0.041 (0.769) [0.749]	0.238	1.556	8.207 (0.975)
DdElas (d)		0.003 (0.958) [0.923]	-0.386 (0.086) [0.013]	-0.151 (0.514) [0.384]	0.001 (0.943) [0.884]	4.527 (0.120) [0.082]	0.277 (0.054) [0.020]	-0.290 (0.269) [0.398]	-0.584 (0.039) [0.029]	0.045 (0.779) [0.767]	0.194	1.689	15.775 (0.969)
SsElas	0.030 (0.887) [0.829]		0.419 (0.173) [0.269]	-1.291 (0.000) [0.000]	0.037 (0.003) [0.003]	6.756 (0.077) [0.069]	-0.032 (0.693) [0.726]	0.019 (0.582) [0.554]	0.280 (0.298) [0.262]	0.606 (0.004) [0.060]	0.624	1.528	39.966 (0.002)
SsElas (d)	0.067 (0.774) [0.639]		0.435 (0.239) [0.372]	-1.478 (0.000) [0.000]	0.051 (0.027) [0.083]	6.802 (0.168) [0.244]	-0.076 (0.423) [0.464]	-0.055 (0.907) [0.885]	0.321 (0.351) [0.329]	0.687 (0.003) [0.052]	0.601	1.756	39.822 (0.068)
ConsSurp	-0.144 (0.091) [0.191]	0.032 (0.362) [0.285]		0.087 (0.512) [0.523]	-0.006 (0.113) [0.130]	8.423 (0.000) [0.000]	-0.019 (0.835) [0.841]	-0.027 (0.050) [0.047]	-0.010 (0.383) [0.332]	0.091 (0.062) [0.031]	0.613	1.716	26.601 (0.087)
ConsSurp (d)	-0.151 (0.091) [0.186]	0.019 (0.594) [0.545]		-0.071 (0.665) [0.656]	-0.009 (0.280) [0.117]	9.357 (0.000) [0.000]	-0.157 (0.120) [0.199]	-0.109 (0.956) [0.951]	-0.003 (0.846) [0.811]	0.033 (0.601) [0.539]	0.654	1.928	36.127 (0.139)
ProdSurp	-0.051 (0.557) [0.387]	-0.114 (0.001) [0.047]	0.087 (0.507) [0.539]		0.101 (0.016) [0.117]	4.311 (0.005) [0.037]	0.148 (0.116) [0.184]	-0.031 (0.841) [0.810]	-0.008 (0.251) [0.154]	-0.088 (0.084) [0.114]	0.453	2.323	30.789 (0.030)
ProdSurp (d)	-0.013 (0.880) [0.856]	-0.100 (0.002) [0.033]	-0.066 (0.662) [0.629]		0.010 (0.220) [0.192]	6.641 (0.000) [0.001]	-0.078 (0.520) [0.484]	0.157 (0.338) [0.403]	0.003 (0.752) [0.680]	0.045 (0.380) [0.388]	0.537	2.628	41.177 (0.052)

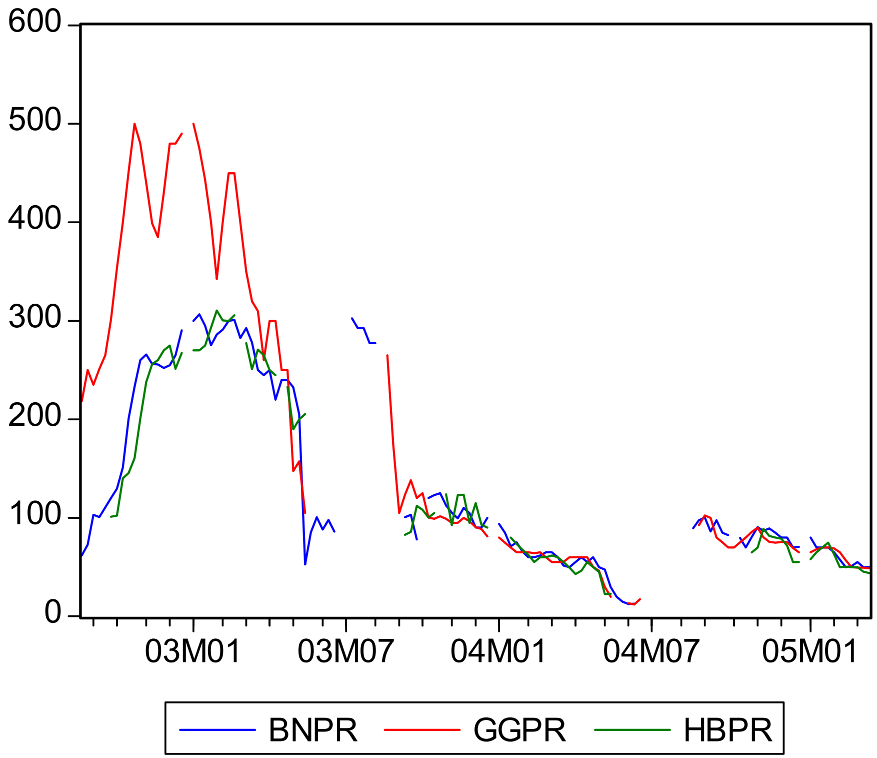

Figure 1: Graph of prices across the trading zones

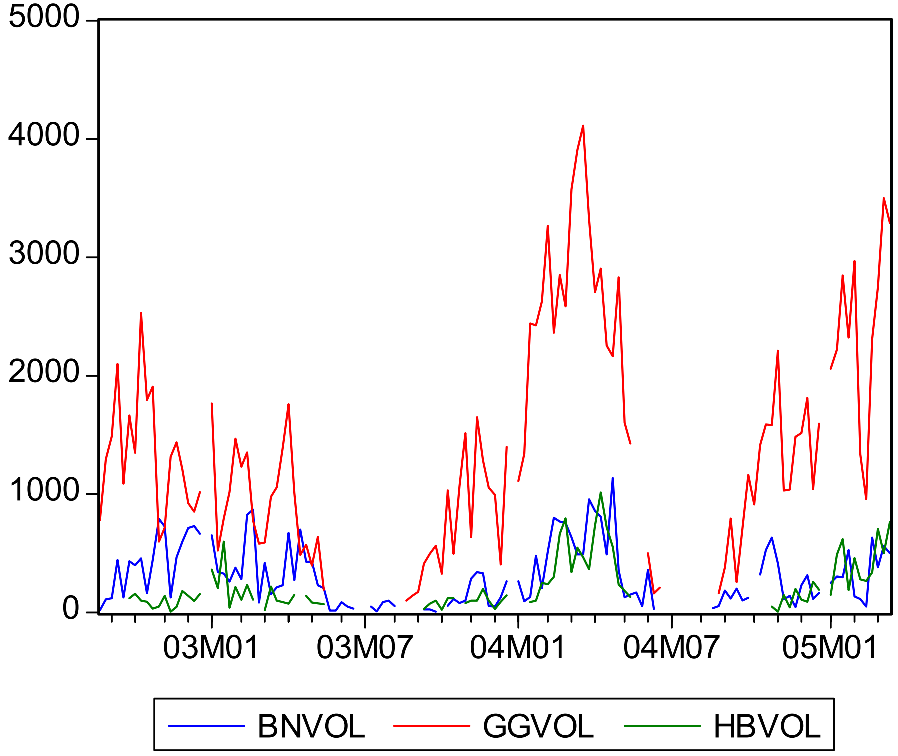

Figure 2: Graph of volumes across the trading zones

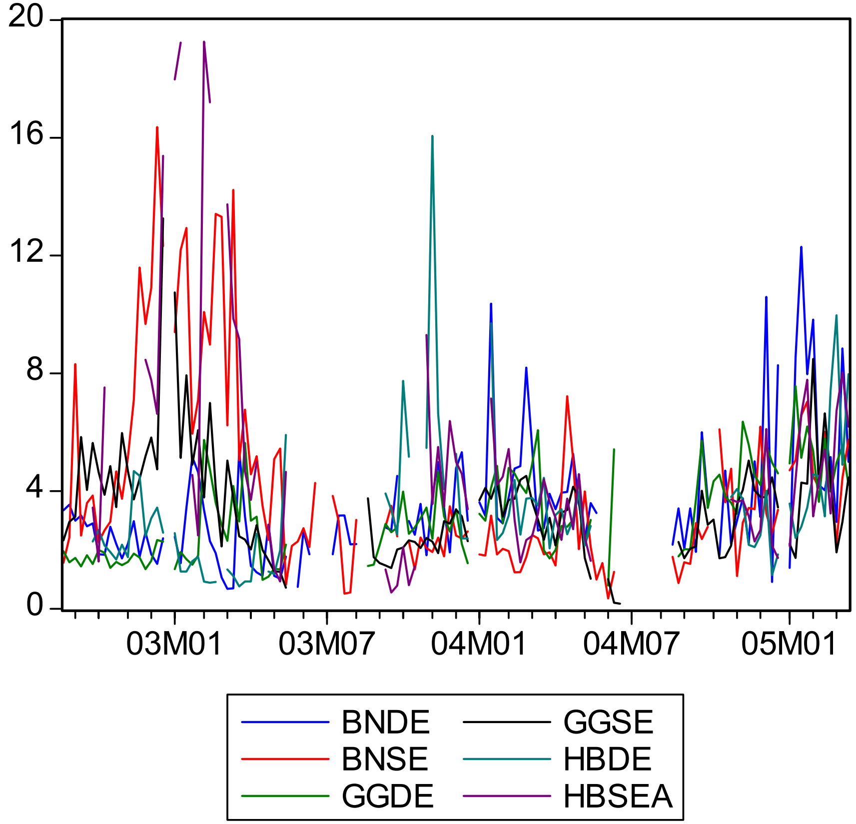

Figure 3: Graph of demand and supply elasticities across the trading zones

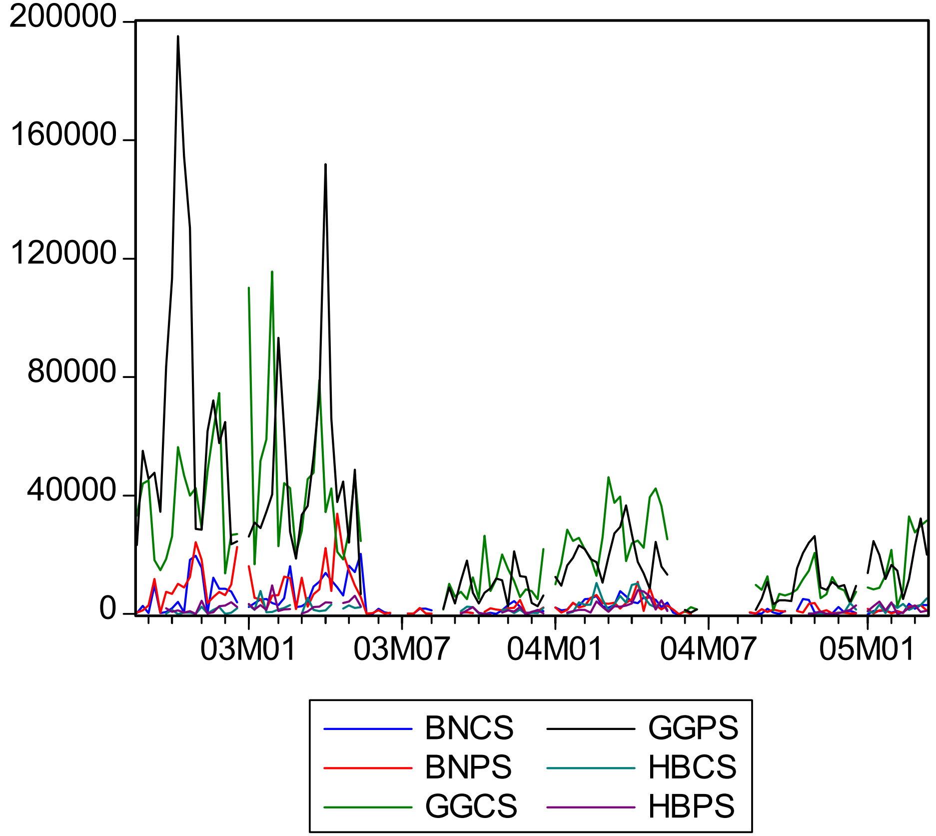

Figure 4: Graph of consumer and producer surplus across the trading zones