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An empirical analysis of factors driving outcomes in markets for permanent water – An Australian case study

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Abstract

Prices paid in the market for permanent water within the Goulburn Murray Irrigation District in Australia have increased by 15% p.a. over the last ten years. This is less than half the increase that has taken place in the market for temporary water during the same period. Regression analyses show very few relationships between commodity prices and prices of permanent water, with only wine grape prices having a significant positive influence on price. Correlation analyses show strong negative correlations between commodity prices and the price of permanent water, especially with dairy products, which is the main high value industry within the district. The major factors influencing the price of water in the permanent market are: the price in the market for temporary water, the level of seasonal allocation, vine grape prices and interest rates. There is evidence that high value producers have been willing to pay increasing prices as supply has declined, in order to protect their long-term investments in permanent planting and other capital investments such as dairy equipment and cattle. The negative correlation with dairy prices indicates that dairy farmers have accepted higher prices despite a relative fall in commodity prices; the increase in the price of water has therefore come out of irrigators' profit margins and not out of increased income. Analyses of volumes traded in the market show a positive relationship to the price of dairy commodities. Improved economic conditions in the farm sector have led to increased confidence among irrigators, resulting in a higher willingness to invest in long-term assets. This is despite the fact that the price of this asset has gone up while the relative price of commodities has gone down.

Keywords*:* water markets, water trading, water market prices, Australia, irrigation

1. Introduction

At the conference in 2003 we reported on prices paid for water in the allocation market (Bjornlund and Rossini, 2003) and in 2004 we reported on the relationship between allocation and entitlement prices in order to trace evidence of rational investor behaviour in the entitlement market (Bjornlund and Rossinin, 2004). This paper explores the existence of empirical evidence of factors influencing farmers' willingness to pay for water entitlements and the factors driving the level of activity in the market. The second section briefly discusses the literature regarding similar analyses while the third section places this study within the Australian policy context. The fourth section then discusses the data and methodologies used while sections five to seven discuss the findings.

2. The literature

Very little formal analysis has been carried out on water market prices because active markets have only been in operation in very few countries and prices in most instances are only privy to the buyer and the seller. Two studies have analysed individual water transfers in order to identify the factors influencing water prices during a specific period of time. Colby et al. (1993) applied regression analysis to individual water transactions within the Gila-San Francisco Basin in New Mexico to identify factors influencing the price that individual irrigators paid for permanent water. Bjornlund (2002a) did the same thing within two regions of Australia, the Goulburn Murray Irrigation District in Victoria and the Riverland of South Australia.

In the US the major factors influencing price were the level of urban or industrial activity in the market, the priority of the water right that is traded,[1] and the volume of water traded. In Australia where more than 99% of all transfers are rural-to-rural and where all water entitlements have equal priority, the two most important factors in the US are absent. The research by Bjornlund suggested that the major determinants of price in an agricultural water market are the level of restriction on trade in the area, the water use efficiency of buyers and sellers, the value of commodities produced, and the relative bargaining strength of the buyer and seller.

[1] In the US this determines the reliability of supply under the prior appropriation doctrine.

Likewise only two previous studies were identified that analysed prices over time. Person and Michelsen (1994) used regression analyses to establish what factors influence prices in the market for permanent water over time. They analysed mean annual prices during the 1961 to 1989 period and found that return on water in agricultural production appears to explain part of the price fluctuation until 1975. Since then other factors such as housing starts, population growth and prices of other commodities seem to explain variation in price due to the increased non-agricultural demand for water. These results are supported by the work of Colby et al. discussed above and also the findings by Gardner and Miller (1983).

The second study, by Bjornlund and Rossini (2004), used regression, correlation, and time series techniques to analyse prices paid in the market for temporary water during the period from 1993 to 2003. In the regression function they used mean monthly prices adjusted for inflation as the dependent variables and commodity prices, seasonal allocations, rainfall, evaporation and economic factors such as GDP, interest rates, US$ exchange rates and inflation as independent variables. They concluded that the major drivers of price during the ten-year study period were: (i) water scarcity determined by the seasonal availability of water (the seasonal allocation levels); (ii) level of natural precipitation and evaporation, which drives the short-term demand for water; and (iii) potential long-term losses incurred by irrigators with significant investments in water dependent infrastructure if insufficient water is used. These irrigators were willing to pay prices in excess of the value of water in productive use in order to protect their production and the value of their assets, which allowed them to remain in business for the next season. Commodity prices and macro-economic indicators only had a minor impact on prices. No analyses of what determines the level of market activity were identified.

A similar analysis was carried out by Kerr et al. (2003) within the market for fishing quotas in the New Zealand Fisheries. They found that price dispersion within the fisheries quota market was much the same as within markets for other commodities and that the leasing market was far more active than the market for permanent quotas, with the latter result corresponding with the findings within water markets (Bjornlund, 2003a). They also found that prices paid in the lease market reflected economic fundamentals, such as the price of fish, the cost of fishing, demand for quota and the general performance of the economy. Compared with the lease market for water, the fishing quota market seems to more closely reflect economic fundamentals even though the fishing industry in New Zealand went through a similar rapid policy development and uncertainty during the early to mid 1990s (Major, 1999) to that of the water industry in Australia during the mid to late 1990s.

3. The Australian policy context

Australia has undergone considerable water reforms since the mid 1990s, resulting in significantly increased levels of uncertainty associated with future supply of water. In 1994 the Council of Australian Governments (CoAG) launched a new water policy strategic framework (CoAG, 1994). As a part of this framework water trading was made mandatory in all Australian states, the environment was formally acknowledged as a legitimate user of water and it was decided that specific entitlements should be given to the environment. In 1996, The Murray–Darling Basin Commission (MDBC)[2] introduced a cap on extraction of water for consumptive use set at the 1993/94 level of development (MDBMC, 1996). It was left to the individual states to decide how to stay within this cap. One way of doing this would have been to cancel unused entitlements and reduce partly used entitlements down to actual use following a cap-and-trade philosophy (Colby, 2000). However, it was decided on equity grounds to continue to accept unused and partly used entitlements. As water consumers activated these unused entitlements, seasonal allocations declined as a percentage of entitlements, while the total use for all irrigators was capped.

It soon became apparent that the existing cap was inadequate to ensure sustainable water use within the Basin and that further reductions were needed (DNRE, 2001). As a result, in 2002 the MDBC started a new Living Murray initiative exploring the options of reducing extractions for

[2] The authority managing Australia's largest river system, which accounts for some 75% of all irrigation in Australia.

consumptive use with 750 GL, 1,500 GL and 3,000 GL respectively (MDBMC, 2002). At the same time all catchments within the Basin have over the past few years gone through a water planning process to establish the environmental needs of the catchment and to share what is left between consumptive users. This process inevitably resulted in further reductions in irrigators' access to water, and in some instances quite substantially so. Finally, in 2003 CoAG launched a new National Water Initiative (NWI) (CoAG, 2003). It was acknowledged that good progress was being made in reform but that three main issues needed to be addressed to speed up the process: (i) uncertainty over the long-term access to water was still hampering investments in higher valued and more efficient production systems; (ii) current water market arrangements are preventing markets from reaching their full potential; and (iii) significant concerns are still prevalent over the pace of securing adequate environmental flows and adaptive management systems to ensure the health of riverine ecosystems. An Intergovernmental Agreement on an NWI was therefore entered into in June 2004 in order to address these issues (CoAG, 2004).

Two other factors have added to this uncertainty during the last six years: 1) large parts of Australia have been in one of the worst droughts on record, which (during 2002/03) has resulted in seasonal allocations reaching record low levels of 56% within the Goulburn Murray Irrigation District in Victoria (GMID), 8% within Murray Irrigation Limited (MIL) in New South Wales, while in South Australia irrigators were for the first time in history faced with water restrictions; and, 2) water authorities have changed their practice when announcing seasonal allocations. Traditionally the water authorities announced the allocation at the beginning of the season based on what was available in the reservoirs and historical inflows during the season. Following this practice the water authority took the risk associated with the level of inflow during the season and irrigators had certainty of supply for the season at the time planting commitments have to be made. This practice was changed around 1997. Now the allocation at the opening of the season is based on what is available in the reservoirs and some very minimum expectations to further inflow during the season. This allocation is then revised on a monthly basis during the season based on actual additional inflows. This has effectively transferred the risk management burden associated with water inflows during the season and as a result farmers do not know what the final allocation for the season will be at the time of planting commitment.

These policy reform processes and the drought have therefore placed increased pressure on irrigators to adjust their access to water in the short and long term in order to manage the increased risk associated with the supply of water. Many irrigators have used the market for temporary water to replace what they used to get via the allocation system, and they have incurred additional cost without seeing an increase in production. They are therefore reluctant market participants (Bjornlund, 2005, Bjornlund 2002b).

4. Data and method

In order to identify empirically the drivers of price variation in the market for permanent water, data have been collected to establish water market prices on a monthly basis from within the GMID over the ten-year period from 1993/94 to 2002/03 yielding a total of 120 data pints. If no trading took place in a given month then the previous months price was used. Prices from 1993/94 to 1995/96 are based on telephone interviews made by the fist named author as part of a previous research project. Prices after 1997 are from Plan Right in Tatura (the largest water broker within the GMID) and Goulburn–Murray Water (the authority managing the GMID). Monthly data on volume traded are only available from 1996/97, which places some limits on the analysis of these data with only 84 data points. During the early years, trade in the market was thin and the number of observations few, while during the latter years the market has matured considerably and irrigators have widely adopted the use of temporary markets (Bjornlund 2003a,b).

Similarly data have been obtained for the same period for: a) water allocation, b) precipitation, c) evaporation, d) commodity prices for: lamb, mutton, wool, cattle, wheat, feeding barley, butter, milk powder, cheese, and Cabernet Sauvignon and Chardonnay grapes; e) interest rates; f) exchange rates (US$); 5) trade weighted index; g) inflation indexes; h) index of rural commodity prices; i) GDP figures for the farm sector, the non-farm sector, as well as in total.

These data have been used for the analyses in the following sections. The water and commodity prices used for the correlation analysis and hedonic functions have been adjusted for inflation using the CPI inflation index. Basic time series analyses were applied to the data set of nominal real time prices to enable the series to be described in terms of trend, seasonality and cycle. Simple time series decomposition is used in a multiplicative form. A regression model in an exponential form using a time index and seasonal dummy variables are used to estimate seasonal indices and a compounding growth rate (trend). The cycle component is then estimated as a ratio of the de-trended and de-seasonalised data to the observed data. The patterns in the cycles can then be examined for relationships with causal factors.

5. Factors driving prices paid in the market for permanent water

Prices paid in the market for permanent water should not reflect immediate fluctuations in supply and demand for water and commodity prices, as was found for prices in the market for temporary water (Bjornlund and Rossini, 2004). The purchase of a long-term water entitlement is a capital investment and should therefore reflect more long-term factors in the economy and long-term trends in commodity prices and supply factors. Macro-economic factors are expected to play a more significant role in setting prices as should lagged commodity prices and supply indicators. It should further be considered that transfers of permanent water often have a fairly long approval process, and that a price agreed on for a transaction approved in December is therefore likely to be negotiated between June and September or even earlier. The price agreed on has therefore been based on the economic signals at that time.

Table 1: Correlations between prices in the market for permanent water and the anticipated market drivers (Pearson's correlation coefficient)

Driver	Correlation real time[1]	most sig. lag	correlation most sig. lag
Allocation	–0.788*	1	–0.797*
Temporary price	0.537*	3	0.614*
Price of cabernet sauvignon grapes	–0.291*	0	–0.291*
Price of chardonnay grapes	–0.476*	0	–0.476*
Price of lamb	–0.311*	5	–0.408*
Price of mutton	0.267*	6	0.268*
Price of cattle	–0.342*	6	–0.416*
Price of wool	–0.386*	0	–0.386*
Price of wheat	–0.759*	0	–0.759*
Price of feeding Barley	–0.444*	6	–0.457*
Price of butter	–0.481*	6	–0.560*
Price of full milk powder	–0.624*	6	–0.682*
Price of cheese	–0.763*	4	–0.766*
Interest rate	–0.470*	6	–0.565*
Exchange rate US$	–0.651*	0	–0.651*
CPI inflation index	0.614*	0	0.614*
GDP farm sector	0.392*	6	0.538*
GDP non-farm sector	0.735*	0	0.735*

* denotes significance at the 0.01 level and ** denotes significance at the 0.05 level

5.1. Correlation analysis

Table 1 shows the correlations between the price of permanent water and the factors hypothesized to influence the willingness of irrigators to pay for permanent water entitlements. The first column shows the correlation at the time the transfer was registered (lag 0), the second column shows at which lag the variable is most significant, and the third column shows the correlation at that lag.

Commodity prices are all negatively correlated with prices paid in the permanent market (with the exemption of the mutton price). Even the price of dairy products and wine grapes is significantly negatively correlated. This is somewhat surprising since analysis of the early market clearly showed that dairy farmers were the predominant water buyers (Bjornlund, 1999) while a review of the first two years of the inter-state permanent water trading pilot program (Young et al., 2000) found that wine grape prices were a major driver of trade downstream into South Australia and also have been a major driver of trade out of the study area since 1998 (Bjornlund, 2003a). However, closer examination of grape prices over the ten-year period shows that the relationship between grape prices and the price of water in the permanent market is non-linear and inconsistent. Across the decade, grape prices moved from $626 per ton for Chardonnay and $657 per ton for Cabernet Sauvignon in 1993/94, to a peak in 1996/97 of $1033 per ton for Chardonnay and $1150 per ton for Cabernet Sauvignon. Since then Chardonnay prices drifted steadily downward to $661 per ton in 1999/00 and then have recovered to a level of $805 per ton in 2002/03, while Cabernet Sauvignon drifted steadily downward to $695 per ton in 2002/03 (Australian Bureau of Agricultural and Resource Economics). Over this period the price of water in the market for permanent water has increased steadily, while grape prices adjusted for inflation have fluctuated and actually decreased (time series analyses show that this fluctuation in wine grape prices has caused the price of permanent water to be above and below the long-term trend line, see Figure 1).

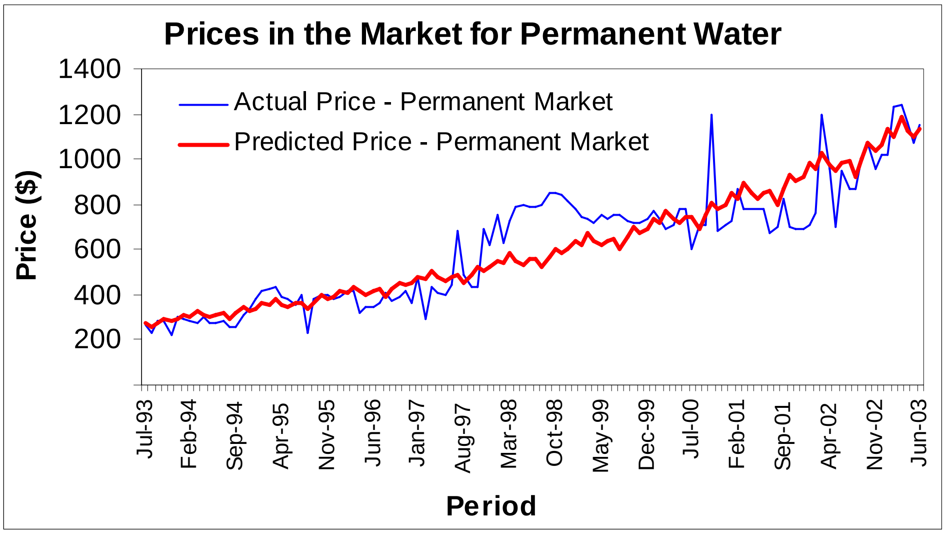

Figure 1: Actual price in the market for permanent water and predicted prices using trend and seasonality

The general index for rural commodities is positive as it was for prices in the temporary market, but with a much lower coefficient. There are no significant correlations with rainfall and evaporation, which proved to be very significant in the market for temporary water (Bjornlund and Rossini, 2004), but there is a strong and negative correlation with the level of seasonal allocation. This suggests that irrigators in the market for permanent water do not react to changes in the immediate weather pattern but tend to consider the long-term nature of the asset. These figures suggest that the level of scarcity, the expansion of the wine industry in Sunraysia and South Australia as well as policy uncertainty have driven the price of water rather than the underlying commodity prices.

The price of water in the permanent market has a significant and negative correlation with interest rates and also the exchange rates between the Australian and the US dollar. As interest rates increase, the willingness of farmers to pay for water decreases, and this is consistent with economic theory. The correlation with the US dollars is also negative suggesting that a lower exchange rate results in higher prices. This also makes economic sense since a low exchange rate improves the terms of trade for the agricultural sector, which is predominantly export driven and paid in US dollars. This is consistent with the findings in the market for temporary water (Bjornlund and Rossini, 2004), but the correlation with the US$ exchange rate is significantly higher than for temporary prices, which could be because the permanent market is dominated by export oriented industries more dependent on the US$ exchange rate. Contrary to temporary prices, permanent prices are significantly positively correlated to GDP within the farm sector. This could be because permanent water is a long-term capital asset which irrigators are more likely to invest in during more prosperous times within the industry, whereas the purchase of temporary water during this period of water scarcity is a short-term action to minimize risk and losses.

5.2. Regression analysis

Regression was used to examine which factors drive the inflation-adjusted price of water in the permanent market. The best model using this approach had an adjusted R^2 of 0.719 suggesting that the model can explain 71.9% of variation in the price of permanent water, and, combined with an F value of 54.337, and variables that all are significant at the 0.01 level, the model must be considered to be significant. The Durbin–Watson statistics of 1.603, which is just in the indeterminate range, indicates that the model is free from serious serial correlation. Multicollinearity tests suggest that the model is free from serious multicollinearity. The maximum VIF figure is 2.548, which indicates no sign of multicollinearity. The maximum condition index of 21.759, while below the critical limit of 30, indicates that there might be some multicollinearity in the model (Belsley, 1991). However, none of the variables have a variance proportion figure above 0.5, which confirms the findings of the analysis of the VIF figures (this model is shown in Table 2).

Table 2: Hedonic function for prices in the market for permanent water, 1993 to 2003[1]

	Monthly mean prices		
Variable	Coefficient	t	VIF
Interest rate (lagged 3 months)	–24.609	3.693*	1.332
Allocation (lagged 3 months)	–1.261	6.847*	2.548
Prices of lamb (lagged 3 months)	–0.732	3.426*	1.386
Prices of cabernet sauvignon grapes (lagged 3 months)	0.223	4.726*	1.554
Deseasonalised temporary price (lag 3 months)	0.864	4.018*	2.058
Constant	652.09	12.857*	
R^2	0.719		
F statistics	54.337*		

*denotes significance at the 0.01 level,
[1] Prices are adjusted for inflation back to June 1993 prices.
Max condition index 21.759, only the constant has a variance proportion bigger than 0.5

The following conclusions can be reached from an examination of this model. The price of water in the permanent market is significantly affected by (i) interest rates; (ii) the price of temporary water; (iii) allocation levels; (iv) grape prices; and (v) lamb prices. The model suggests that on average the price of permanent water:

- decreases by about $25 each time the interest rate increases by one percent (e.g. from 5% to 6%), holding the other variables constant. This impact is stronger than for the price of water in the temporary market, where price decreases by about $18 for a one percent change in interest rates; the stronger impact is sensible given the short-term consumptive nature of temporary water against the long-term capital nature of permanent water;

- decreases when the seasonal allocation increases as was the case in the market for temporary water; the model suggests that the price of permanent water decreases by $1.26 each time the allocation increases by one percent (e.g. from 75% to 76%), holding other variables constant;
- increases when the price of temporary water increases; the model suggests that the price of permanent water increases by 86 cents each time the deseasonalised price of temporary water increases by one dollar, holding other variables constant;
- increases by 22 cents each time the price of cabernet sauvignon grapes increases by one dollar per ton, holding other variables constant; and,
- decreases by 73 cents, when the price of lamb increases by one dollar, holding other variables constant.
-

5.3 Time series analysis

Time series analysis was conducted to establish the presence of seasonality in price and to establish the growth rate in water prices. It was not expected that seasonality would be a significant issue in the market for permanent water, which was confirmed by regressing prices against a time index and quarterly variables. This analysis showed that all the quarterly variables are insignificant; that is, there is no significant seasonality in the price of permanent water. The results of the analysis are shown in table 3. The model has a very high explanatory power with the trend and seasonal components explaining 83% of variation in the price of water in the permanent market, with an associated F statistics of 145 confirming the significance of the model. Both the constant and the time index are significant at the 0.01 level. The time index indicates a monthly growth of 1.2% which implies an annual growth of 15.41%. This is almost exactly half the growth rate of temporary prices over the same period (Bjornlund and Rossini, 2004); however, the high growth rate in the price of water in the temporary market is significantly influenced by the prices paid during the last two seasons of exceptional drought and associated resource constraints, and therefore cannot be expected to reflect long-term growth.

Table 3: Simple exponential regression for time index and twelve period CMA of prices paid in the market for permanent water, 1997 to 2003

R Square	0.8348			
F	145.2597		Significance level	0.0000
Variable	Coefficients	T	Significance level	Exp (bn)
Intercept	5.6081	124.6737	0.0000	272.6159
Time Index	0.0119	23.9634	0.0000	1.0120
Summer	0.0206	0.4224	0.6735	1.0208
Autumn	0.0197	0.4042	0.6868	1.0199
Winter	-0.0340	-0.6967	0.4874	0.9666

The chart in Figure 1 shows the actual permanent price and the predicted price using trend and seasonality only. The most interesting observation from the graph is the period from late 1997 when actual price is consistently above the trend and season line. The two lines converge again in late 1999. This period corresponds with the time when Cabernet Sauvignon grape prices peaked at between $1,100 and $1,200. Grape prices actually started to rise in 1994/95, suggesting that it has taken approximately two years for the market to respond to this increase by forcing water prices up above the long-term trend line. Since then grape prices have returned to pre-1994 levels and permanent water prices fell below the long-term trend and season line for about two years.

The smoothed long-term price cycle was used to examine the relationship between rainfall and the cycles in the permanent price. Rainfall is calculated as a twelve period moving average, which shows the cycles in the rainfall, and is then lagged 12 months. This gives a good indication of the average over the previous year. Figure 2 shows the price cycle and rainfall cycles, which indicates a clear relationship between the two cycles. This suggests that the willingness of irrigators to pay for permanent water is influenced by the rainfall pattern during the previous season. This is logical and is in accordance with anecdotal evidence, namely that increased scarcity and difficulties in reliably obtaining water in the market for temporary water has driven some irrigators toward the market for permanent water and resulted in increased prices.

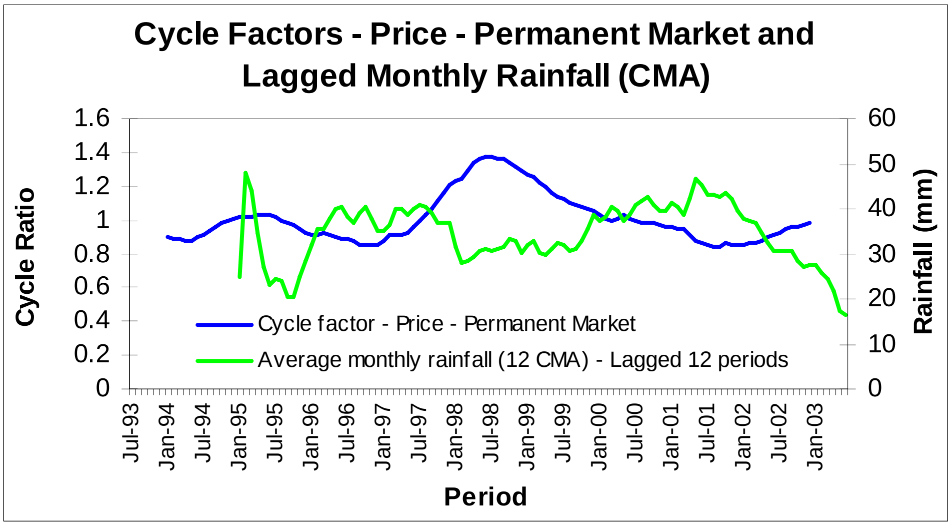

Figure 2: Cycle factors for price in the permanent price and rainfall lagged twelve months

6. The relationship between prices in the temporary and permanent market

The hedonic functions for prices in both the market for temporary and permanent water suggest that there is a strong relationship between permanent and temporary prices, as economic theory would suggest (Bjornlund and Rossini, 2004). Figure 3 illustrates the cycle factors for the price series in the markets for permanent and temporary water. The figure shows a very strong relationship between the two cycle factors, suggesting that irrigators make rather astute business decisions when dealing in temporary and permanent water. The market for permanent water seems to lead the market for temporary water in the cyclical movements until January 1997. Since then the market for temporary water has been leading the market for permanent water, as rational economic behaviour would dictate.

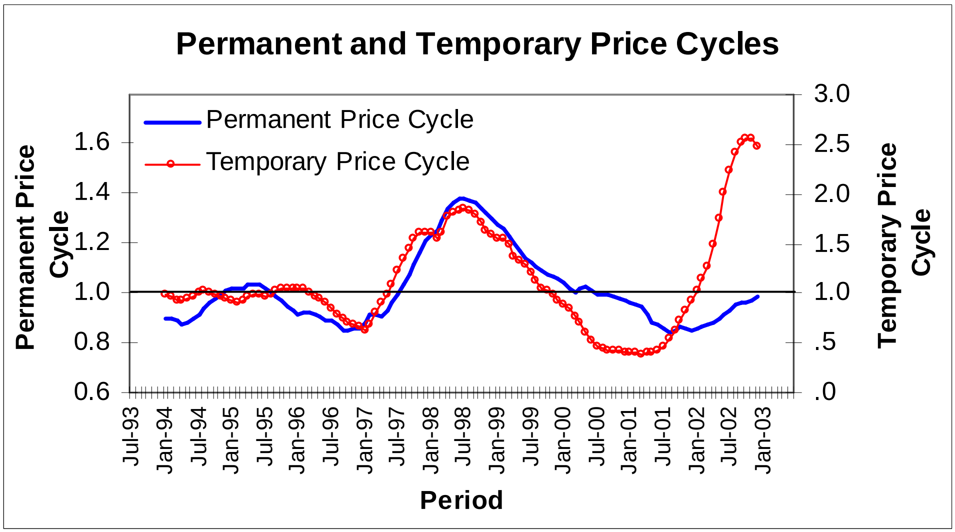

Figure 3: Cycle factors for permanent and temporary prices

Also note that: (i) the scales of the two vertical axes are not the same, which suggests that the magnitude of the cyclical fluctuations in the market for temporary water is much higher than it is in the market for permanent water. This is consistent with the arguments that the price of temporary water fluctuates far more rapidly in response to short-term variations in supply and demand; nevertheless, the market for permanent water does not capitalize these extreme fluctuations into the price of permanent water. This is most clearly illustrated during 2000/01 and 2002/03; the first of these two seasons saw a very wet spring resulting in low demand, the price of temporary water was therefore at record low levels and resulted in the price cycle for temporary water dipping sharply while the cycle for permanent water remained flat. During the season of 2002/03 the difference is more dramatic. Here the cycle for permanent water does not follow the cycle for temporary water by more than a fraction; irrigators are aware that the abnormal prices for temporary water during that year were due to historically low allocations. In both instances irrigators seem to be aware that the fluctuation in the price of temporary water is due to extraordinary circumstances and therefore do not capitalize these fluctuations into the price of permanent water.

If market participants behave rationally then the price of permanent water should reflect the price paid for temporary water discounted by some kind of market discount rate. The above discussion supports this expectation. To pursue this further a yield figure was computed for each month. This expresses the percentage return that an investor would achieve by investing in permanent water and then selling it on the market for temporary water. It is computed by dividing the price paid for temporary water lagged 3 months and adjusted for the allocation level at that time by the price paid for permanent water and then multiplying by 100. The logic behind this adjustment is that when an irrigator buys one ML of permanent water the volume of temporary water, which can be sold that month, will depend on the allocation level. In an average season an irrigator should be able to sell 1.3 ML of temporary water for each ML of permanent water purchased[3]. However this figure fluctuates from season to season and from month to month within a season. During 2001/02 the allocation was 100% while during 2002/03 it was only 57%; that is, if an irrigator bought one ML of permanent water, only 0.57 ML of temporary water could be sold that season. Therefore, when computing the yield, the price for temporary water has first been adjusted for the seasonal allocation by multiplying the price of temporary water with the allocation level.

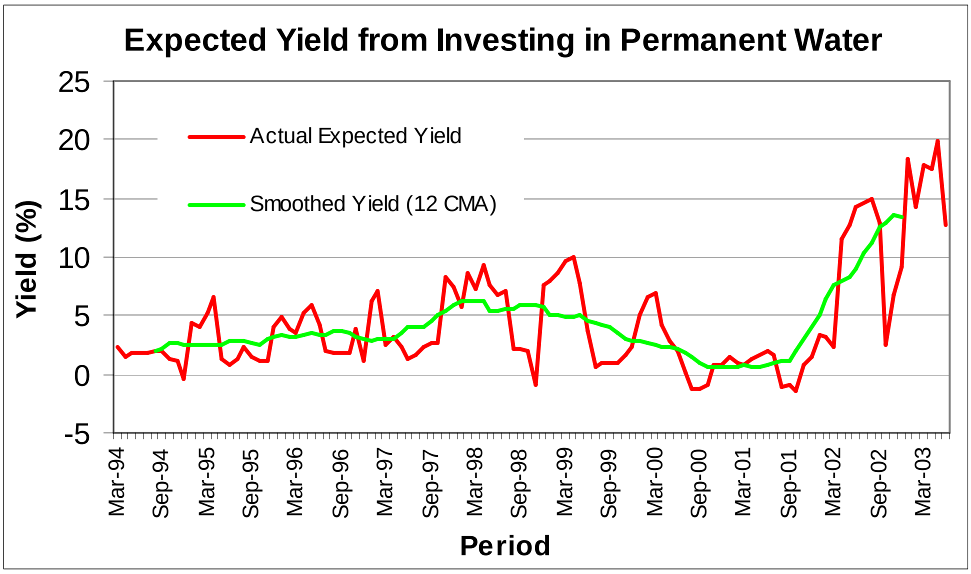

Figure 4: Yields based on temporary prices adjusted for allocation levels

[3] Irrigators have a water right which is delivered in full 96 years out of 100. In additional irrigators receives sales water allocations during most seasons. The long-term mean sales water allocation is expected to be 60%. I.e. for each ML water right the irrigator can use 1.6 ML. However, if an irrigators decides to sell any water the maximum sales water allocation will be reduced to 30%, i.e. 1.3 ML per ML of water right.

Figure 4 shows the monthly yields figures together with the twelve-month moving average. Yields fluctuate widely, which reflects the high level of variability in the price of temporary water. The twelve-month moving average indicates that yields were quite constant between 3% and 4% until early 1997 and then increased to around 6% during 1998/99, before falling to around 1% during the wet season of 2000/01. During the very dry seasons of 2001/02 and 2002/03 yields have increased sharply as the price of temporary water rose significantly relative to the price of permanent water, even when reduced for allocation. This suggests that irrigators have not capitalized the very low prices of temporary water during 2000/01and the very high prices during 2001/03 into the price of permanent water, as the cycle factor analysis also suggest. Irrigators obviously do not see these price levels as representative of the long-term trend. Figure 4 also shows that irrigators during periods of high supply, or toward the end of the season where prices traditionally are low have been willing to sell temporary water at prices around the cost of supply, which they have to pay whether they use it or not. At a few periods irrigators have sold at negative yield, which shows that they only covered part of their unavoidable supply cost.

7. Factors driving volumes traded in the market for permanent water

The factors that should influence the volume of water traded in the market for permanent water are less obvious than those that drive the volume purchased in the market for temporary water, which react to the immediate supply and demand factors (rain, evaporation and allocation), and the price of water (Bjornlund and Rossini, 2004). The volume of permanent water traded should also react to allocation and prices, but not immediately. It is expected that as temporary prices increase and constraints in this market make it more difficult to secure adequate water, more water would be traded in the market for permanent water. There is anecdotal evidence to suggest that this is the case. It could also be expected that an increase in the price of permanent water would reduce demand. Further, economic theory suggests that when the economy is better in the farming sector there should be a greater confidence among irrigators and therefore a greater willingness to invest in long-term entitlements.

7.1 Correlation analysis

Table 4 shows the correlations and significance levels for variables having a significant correlation with volume traded in the market for permanent water. Only the price of temporary water and the evaporation level proved to have a significant relationship with volume traded in the market when considered in isolation. The correlations suggest that the volume of water traded in the market for permanent water increases with the price paid for water in the market for temporary water, as hypothesized. The correlation with evaporation suggests that the volume traded decreases as evaporation increases. This could indicate that when evaporations are high irrigators are struggling to get enough water for the season from the market for temporary water and have little time to think further ahead, and they therefore make deals that will affect their access to water in future seasons by purchasing water from the permanent market.

Table 4: Correlations with volumes traded in the market for permanent water

Driver	real time (lag 0)	lag	most sign lag
Temporary price	0.226***	1	0.231***
Evaporation	not sign.	3	–0.299*

* denotes significance at the 0.01 level ; *** at the 0.10 level

7.2. Hedonic functions

The hedonic function for volumes traded in the permanent market can be seen in Table 5. The explanatory power of this model is weaker than the price model with an adjusted R^2 of 0.19, indicating that 19% of the variation in the volume traded can be explained by variations in the independent variables. However with an F value of 2.934 the model is still significant at a 99% level of confidence and the variables reflect the expected factors with many of them being significant at the 0.05 level. The Durbin–Watson statistics of 2.445 is in the indeterminate range suggesting there is no major problem with serial correlation. The maximum condition index of 27.644 while below the critical limit of 30 indicates that there might be some multicollinearity present. However, the fact that no variable has a variance proportion in excess of 0.5 and that the maximum VIF figure is 2.117 suggests that there is no significant problem with multicollinearity.

Table 5: Hedonic function for volumes traded in the market for permanent water, 1997 to 2003

	Monthly mean prices		
Variable	Coefficient	t	VIF
Evaporation in Kyabram (lag 3)	–9.928	2.932*	3.554
Permanent price (lag 2)	–3.011	1.666***	1.163
Deseasonalised Temporary price (lag 1)	8.821	2.145**	2.021
Price full milk powder (lag 0)	2.198	2.067**	1.857
Winter	924.17	2.174**	1.543
Autumn	931.41	1.519	3.510
Summer	686.33	1.584	1.680
Constant	890.66	0.634	
R^2	0.187		
F statistics	2.934*		

* denotes significance at the 0.01 level, ** denotes significance and the 0.05 level, and *** at the 0.10 level. Max condition index 27.248, variables with variance proportions in excess of 0.5: price full milk powder and the constant

The effects of the price of water in the temporary market and the evaporation level are consistent with the findings from the correlation analyses. As evaporation increases volume traded decreases, and as the deseasonalised temporary price increases by one dollar the volume traded in the permanent market increases by nine megalitres for the month. Increased prices for water in the market for temporary water drives irrigators to buy more water in the market for permanent water. However, as the price of water in the permanent market increases, less water is sold. It is noteworthy that the price of dairy products (full milk powder prices) is significant in this model and has the anticipated sign. Recall that in the pricing models (both in the market for temporary and permanent water) dairy products were insignificant and consistently had a significant and negative correlation with water prices. Diary farmers' willingness to pay has not been in response to good commodity prices but to water scarcity. However, this model proves that dairy farmers are increasing their purchases of permanent water when dairy prices are good, which reflects an increased level of confidence in the future. Due to the low overall R^2 these findings though statistically significant the impact of the overall market outcomes is limited.

Seasonality is a significant factor in the model, although the effect is not as strong as in other models. Only winter is significant, showing a high volume traded over this period for reasons that will be discussed in 7.3. The coefficient for autumn is insignificant and is very high relative to winter. This is possibly due to the presence of the variable evaporation lagged three months.

7.3. Time series analysis

Similar time series techniques were applied to volume traded, as was discussed for water prices in the market for permanent water. The only variation is that the regression model does not use a log form due to the weak trend in volume traded. It could properly be expected that there is some seasonal pattern in the trade for permanent water since there has been a practice of closing transfers for permanent water in July at the end of the allocation cycle, which has eliminated the issue of ownership of the seasonal allocation.

Table 6: Time index regression using seasonal dummies for volume traded in the market for permanent water, 1997 to 2003

R Square	0.3091		
F	7.3826	Significance level	0.000

Variable	Coefficients	T	Significance level
Constant	1505.4840	3.5636	0.0007
Time Index	3.9449	0.4925	0.6240
Summer	-262.1681	-0.5732	0.5685
Autumn	-1168.2234	-2.5436	0.0133
Winter	1341.1476	2.8933	0.0052

Dependent variable is in linear form. No dummy variable is recorded for Spring, which becomes the base quarter for comparison.

With an R^2 of 0.31 and an F value of 7.3826 the model in Table 6 is significant at better than a 99% level of confidence. The model indicates that 31% of the variation in volume traded on a quarterly basis can be explained by trend and seasonal variation. The time index variable is statistically insignificant, and shows that there has not been any significant change in the volume traded in the market for permanent water. The coefficients for autumn and winter are significant and have the anticipated signs. For reasons discussed above most transfers take place as of July 1, the coefficient for winter is therefore significant and positive, and as a result trading is low during the period leading up to July 1, which results in a significant and negative coefficient for autumn.

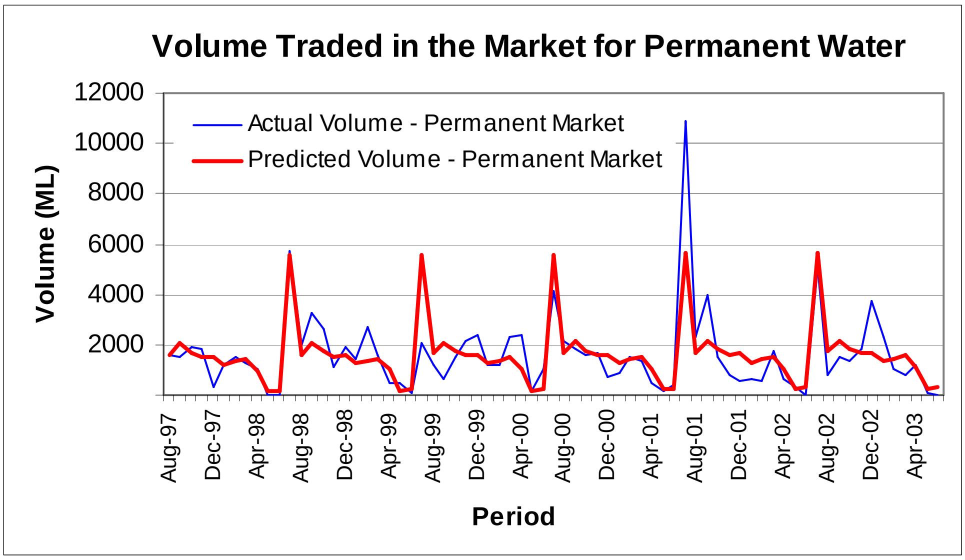

Figure 5: Actual volume traded in the market for permanent water and predicted volume based on trend and seasonal factors

Actual volume traded and those predicted using trend and seasonality are displayed in Figure 5. The pattern is supported by the results of the hedonic regression (Table 5) and shows the significant random portion of the volume not explained by trend and seasonality resulting in the relatively low adjusted R^2. The lack of trend is also evident.

Finally the cycle factors for volumes trade in the temporary and permanent markets were compared. Figure 6 shows that there is some relationship between the two cycle factors, but it is not as apparent as was the case for prices in Figure 3. During the first two cycles in 1998 to 2001 the cycle for temporary water was leading the cycle for permanent water, while during the last two cycles since January 2001 the cycle for permanent water was leading the cycle for temporary water. This is likely to reflect the shift of emphasis towards the market for permanent water following strongly escalating prices and the increase in uncertainty of obtaining temporary water when needed, as discussed elsewhere. Note also that in Figure 6 the scales on the two vertical axes are identical, showing that the cycle in volume traded within the two markets is of similar magnitude.

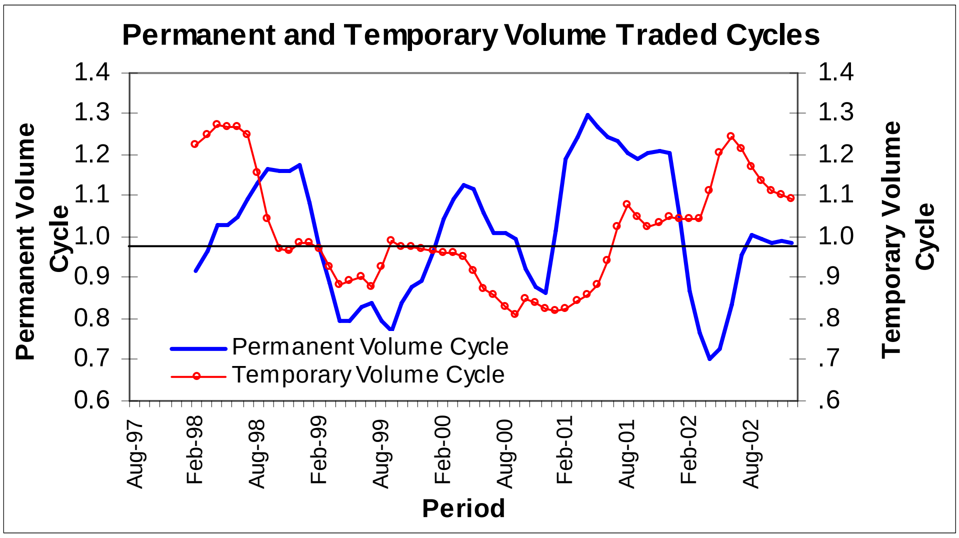

Figure 6: Cycle factors for permanent and temporary volumes traded

8. Conclusions

This paper provides new insight into how irrigators behave in the market for permanent water and draws some interesting parallels to what has been found in the market for temporary water based on analyses of ten years of market data using hedonic functions, correlation analysis and time series analysis. It was found that commodity prices have had very little influence on the price of water in the permanent market (as was found with the prices in the temporary market) during the ten-year period. Only wine grape prices seem to have some influence on the price of permanent water, and this reflects the fact that the wine industry has been one of the main buyers of water during most of this period and is also the industry with the highest gross margin per ML of water used. The wine industry is located outside the region under study, and has therefore caused an export of water out of the study region. The other main factors influencing price is interest rate, the level of seasonal allocation, and the price of temporary water. All other commodities show a negative correlation between commodity prices and the price of permanent water; of particular interest is the fact that dairy prices have a strong negative correlation with permanent water prices. Given that the dairy industry is the main buyer within the region under study, it suggests that dairy farmers have been buying permanent water to replace a steady decline in seasonal allocation caused by policy changes and drought.

Over the ten-year period the price of permanent water has increased at an average rate of 1.2% per month or an implied annual growth of 15.41%. This is approximately half the annual growth experienced in the market for temporary water during the same period. However, comparing the cycle ratios of the prices in the two markets suggests that prices of temporary water fluctuate much more widely than prices of permanent water. While it seems that generally increases in the price level of temporary water is capitalized into the price of permanent water, this is not the case during seasons where the price of temporary water is unusually low due to high levels of supply, or when it is unusually high due to extremely low supply. During such periods irrigators seem to be aware that such prices do not represent long-term trends and therefore they do not capitalize such price fluctuations into the price of permanent water.

Analysis of the volume of water traded in the market for permanent water shows that the volume of water traded has been steady over the seven-year period studied. It was found that demand in the market for permanent water seems to stagnate when supply is very low and irrigators therefore struggle to cover their short term needs. Volume traded reduces when prices of permanent water increases, while it increases when the price of temporary water goes up. As temporary water reached very high levels during 2001/2003 more and more irrigators turned to the market for permanent water not only to avoid the high cost, but also because during these periods of extreme scarcity water was not only expensive it was hard to get hold of. The volume of water traded in the market for permanent water increases when the dairy sector is more prosperous, which is the major buyer within the study region. While farm prosperity did not seem to have any impact on prices paid in the markets for permanent and temporary water, it did have a significant impact on the volume traded. When times look better farmers are more willing to commit funds to long-term assets, even though the price of this asset has gone up relative to the price of the commodities produced by that asset.

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