

Implicit values and explicit prices of water – Do they converge?

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Abstract

This paper reviews the historic relationship between the explicit market price of water entitlements and the implicit value of water when attached to land. Hedonic functions are applied to 246 farm sales during 2001–02 in the Greater Shepparton, Campaspe and Moira areas of northern Victoria in order to establish the implicit value of water. These implicit values are then compared to explicit prices paid for water entitlements during the same period. A longitudinal analysis of this relationship is then conducted based on a similar analysis from the same region during the 1991–93 and 1994–96 periods

It was found that during the early to mid 1990's the explicit price of water entitlements lagged implicit values as farmers sold unused water, which would not compromise the productive capacity of their farms. In 1997, events occurred to push the explicit price above the implicit value during the 1994–96 periods. Due to a prolonged and increasingly intense drought the explicit price of water entitlements significantly exceeded the implicit value of water from mid 2002. This has caused an increase in land transactions, with the intention of subsequently selling the attached water entitlements in order to profit from this emerging price gap.

Keywords: Water values, water prices, water markets,

Introduction

Trading in water entitlements has emerged in all four eastern states of Australia in response to resource demands, resulting in a more efficient allocation of water resources. The traditional connection between land and water entitlements has essentially disappeared, and valuers responsible for farmland valuation, for the purpose of rating and taxes, are now charged with the responsibility of allocating a part of the previous farmland value to the water entitlement. This is largely un-chartered territory for valuation authorities (Bjornlund and O'Callaghan, 2004).

In order to redistribute these values in an equitable manner, methods of separation or deconstruction of value should be developed and applied. In this way, the real value impact of water when part of an irrigated property can be assigned to the water component. At the same time, the value derived from the fact that the property can be supplied with water for irrigation can be assigned to the land (commandable land).

This study applies the hedonic pricing approach to data collected from an irrigation area in northern Victoria, Australia to establish the implicit value of water and thereby establish a methodology to assist rating and taxing valuers to effect this separation of land and water values. The first part of the paper discusses the literature, the second part

briefly describes the data used and its sources, and the third part outlines the model specification, while the fourth part briefly discusses the results of the hedonic function. The fifth part then provides a longitudinal analysis of the relationship between the explicit market price of water entitlements and the implicit value of water.

The literature

In earlier years, Renshaw (1958) and Milliman (1959) struggled with the concept of water and land values. Renshaw used regression to support the hypothesis that land and water value is, in effect, some weighted function of the proportion of total acreage devoted to various crops. He found that for the crop value index to be a successful predictor of land value, the cropping pattern must be directly related to the economic, technological and physical factors that govern the marginal product of the land. He also found that changes in land value could be used as indirect measures of irrigation benefits. Milliman disagreed, suggesting that attempts to measure the value of water are constrained by incomplete data on the demand side, and differing water allocation mechanisms, and that the method proposed by Renshaw, rather than simplifying an existing process, may be just as cumbersome.

In a hedonic pricing study designed to estimate the value of irrigation water in a study area in Colorado, Hartmann and Anderson (1962, 1963) found that the value of irrigated farmland was dependent on geographic location, soil type and use. They also found that water attached to larger farms became less valuable in line with the per acre allocation, and that the value of irrigated land was higher for farms of fifty acres or less, which reflects a consumptive rather than productive use value. In terms of comparison, water market prices generally were higher than the value of water when sold together with land; they also found that the value difference varied depending on the type of water product. It was argued that the reason for this difference was that part of the value of water when attached to land had been capitalised into other water-dependent farm improvements, and that the value of water, land and improvements therefore could not be easily separated. In classic demand and supply form, the value of additional water was highest where supply was least certain.

Coelli et al. (1991) found the hedonic pricing model a useful method of establishing the value of water when they carried out a study in Western Australia to assess the importance local farmers placed on the availability of water. Hedonic models were constructed for two areas within a wheat belt farming area, including whether or not a farm is connected to a proposed irrigation scheme. The hedonic model directly measures the value that farmers attribute to the scheme water. Cost-benefit ratios suggested that expansion of the scheme could not be justified.

Royer (1995) applied a hedonic model to estimate the value of water when attached to irrigated land. In a study analysing 230 farm sales in south eastern Alberta, data were collected in two stages: firstly in the form of generic data from Land Information Alberta on each sold property, and secondly as property characteristics from county land assessors. From the information provided, 23 variables were specified; however, in the final model only five of these variables were significant: water, building improvements, farm area, and the distance to a 'very large city' and a 'large city'. The study found that farms that had access to irrigation increased in value by \$190 per acre, adding approximately 35% to the value of non-irrigated land.

Crouter (1985, 1987) studied the implicit water market and analysed transactions of irrigated farmland in Weld County, Colorado. The hypothesis of the study was that in areas where water entitlements are easily transferred separately from land, then the hedonic price function for irrigated farm parcels should be separable in land and water, and linear in water. The empirical model developed in the study did not support this hypothesis. Crouter seems to have overlooked the findings of Hartman and Anderson (1962, 1963) that water entitlements are tied to significant capital investments in water-dependent farm improvements. Water and land can therefore not easily be separated in its totality except in areas where local conditions such as soil degradation make these improvements useless and of no value.

Bjornlund (1999, 2001) applied hedonic function to data collected from the eastern part of Goulburn-Murray Irrigation District in Victoria and Riverland of South Australia, to see whether the value of water when attached to land was equated the explicit price of water. At the time of the study, data from 1992–1994 and 1994–96 were used in two different models. A subsequent paper by Bjornlund and Shanahan (2004) used the 1994–1996 data, and the hedonic model for the GMID was slightly altered by changing two variables: firstly, the variable representing dry land was eliminated due to a high standard error, and secondly the construction of the variable ‘unused water’ was changed to reflect water used in excess of allocation, and denoted as ‘sales water’¹.

The adjusted model explained approximately the same variation in land price (R^2 0.85) as the first model. The change made to the variable ‘unused water’ to ‘sales water’ provided for a more logical interpretation as the variable measuring the volume of water used in excess of water entitlement; that is, the property had the infrastructure in place to utilize the ‘sales water’ allocation. This suggested that the estimated value of water when attached to land increased from \$432 to \$584 per megalitre if the ‘sales water’ component was used. During the 1994–96 period entitlements were selling for between \$200 and \$400 per ML, which is in the lower half of the estimated confidence interval estimated by the hedonic function, and below the mean value of \$432, which does not incorporate the ‘sales water component (see figure 1). Bjornlund and Shanahan therefore concluded that water entitlements when traded in the water market was undervalued when compared to water attached to land, and that water market prices therefore had a long way to go. However, the gap between the two was decreasing.

With regard to the ability to separate the value of water from the value of land and water dependent infrastructure, the research by Bjornlund (1999, 2001) and continued in Bjornlund and Shanahan (2004), partly supports the findings of Milleman, and Hartman and Anderson. However, when comparing the hedonic models for three Australian states, with different levels of capital intensive production, it was highlighted that the problems associated with separating the value of water from the value of land and water-dependent farm improvements, depended on the nature of the agricultural production in the area under investigation. In areas such as the rice-growing district in the Murray Region of

¹ Irrigators within the GMID in Victoria has two different water entitlements: 1) a water entitlement with a very high level of security of supply (96 years out of 100), and 2) a ‘sales water’ entitlement. The size of this entitlement varies from year to year and is dependent on the availability of water in the reservoirs. The high level of certainty of water entitlements is ensured by not announcing any ‘sales water’ for a given season until the next season’s water entitlements are secure in the reservoirs. Sales water is announced as a percentage of water entitlement and the long-term average is expected to be 60%, that is, irrigators can use 160% of their entitlement in an average year.

NSW it is generally possible to separate the value of land and water. This is because the production does not involve a lot of water-dependent farm improvements, and the improvements that are there can also be used for dry land production. Further anecdotal evidence in the study area suggests that most rice farms sold during the study period had very inefficient improvements, and the irrigation and drainage infrastructure therefore was totally reworked after purchase. The hedonic model, however, suggested that the value of water was more than twice as high if it was applied to permanent pastures for dairy production. This is because dairy production is associated with a high level of investment in water-dependent farm improvements such as permanent pastures, fencing and watering, milking herd, and milking equipment. The latter finding in NSW was clearly reflected within the dairy producing region of northern Victoria. Here the hedonic function could not be easily separated into land, water and improvements. The most complicated relationship between land, water and improvements was found in South Australia where almost 100% of irrigation water is used for horticulture and viticulture and where the level of natural precipitation is very low, which means that the productive capacity of these improvements is zero without the presence of irrigation water. Here it was found that the hedonic function could not be separated into water, land and improvements. The value of water was dependent on whether the water was used for vine grape production, citrus production or other horticultural productions, the quality of the plantings on which the water was used, and the quality of the irrigation system used to apply the water.

Data, data sources and data collection

Data for analysis were collected from four sources. The office of the Valuer General (VG) in Victoria provided data related to 246 land transfers during the years 2001 and 2002 for the Moira, Campaspe and Greater Shepparton areas (similar to the area used by Bjornlund (1999, 2001)). These data included sales price, site value, capital value, transfer and settlement date, purchaser and vendor details, land area, CT reference, and plan reference. Based on these data it was possible to extract information on farm type, arable land area and quality, crop and pasture type and condition rating and value, fencing type and value, irrigation improvements, residential improvements and value from the records of the rating and taxing valuer in Shepparton. Based on the VG's data it was also possible to extract information about the water entitlements attached to the properties traded and the actual water use prior to the sale from the records of Goulburn–Murray Water (GMW) in Tatura. Water market prices of water entitlements traded during the same period were provided by Plan Right (the largest water broker in the study region) and from GMW.

Methodology

In this study, hedonic functions have been applied to transactions of irrigated farmland, in order to identify the value placed on water when traded with irrigated farmland. In this context water is only one of a number of characteristics making up the bundle of goods purchased as a farm. The hedonic theory sets itself apart from property appraisal, by shifting the focus of interest from determining the value of the commodity to determining the partial value of its underlying characteristics. Griliches (1971) did some of the early

work on hedonic price functions when analyzing car prices. He did so in order to improve the way price indexes are adjusted to distinguish the proportion of price increases caused by quality changes from those caused by inflationary price increases.

The theoretical framework is developed around the fact that many commodities are heterogeneous goods, consisting of a bundle of characteristics in different quantities. These goods cannot be un-bundled, and the characteristics sold separately; neither can they be re-packaged. Buyers in the market are therefore shopping around, finding the bundle of characteristics which best suits their purposes. If enough of such packages including different quantities of each characteristic, are sold in the market, a hedonic price function can be identified:

$$P(Z) = f(Z_1, \dots, Z_n),$$

where $P(Z)$ is observed product prices and Z_1 to Z_n is the bundle of product characteristics. Solving this function for a large number of transactions will establish the value of each of the Z characteristics.

In the process of building the final model, a number of issues have to be considered. One key assumption is that the independent variables, the Z s, in the equation, are truly independent, that is, no multicollinearity exists. This is especially important in a study like this, where the emphasis is on the relative magnitude of the estimated coefficients, rather than the predicted value of the dependent variable. To ensure this, scaled condition indexes, and their associated variance-decomposition proportions, have been used (Belsley, 1991). The advantage of this approach is that it identifies the variables involved in interdependency, and provides measures of their severity. This enables the analyst to better identify the potential impact of such interdependencies on the outcome. If the involved variables are not of key concern for the analysis, the remaining coefficients can still be used. Belsley suggests that a condition index above 30 shows conclusive presence of multicollinearity, and that variables with a variance-decomposition proportion of more than 0.5 are involved in such multicollinearity. Belsley also suggests that if condition indexes exceed 10, then researchers should consider the potential implications of multicollinearity. Other researchers have used VIF figures; the literature suggests different cut-off points as critical VIF values. A cut-off point of 4 would normally be considered conservative.

Model Specification

The selection of variables to be used in the model is guided by two parameters; firstly, existing literature, and secondly, data availability. The literature review identified several variables as significant value determinants in the valuation of irrigated farmland. Hartman and Anderson (1962, 1963) reported that location, soil type and farm use were significant variables. Dunford et al. (1985) identified soil quality, arable areas, buildings and other improvements, topography, climate and location (distance to town, road access) and availability of water, as important factors. Coelli et al. (1991) suggested that purchasers include the value of irrigation improvements when assessing the value of a farm. Royer (1995) found that water entitlements, building improvements, farm area and distance were significant variables in estimating the value of irrigated farmland. Xu et al. (1993) identified permanent improvements, regional characteristics, land size, soil quality and water rate per hectare as significant. King and Sinden (1995) recognized land quality

as a significant value determinant. Bjornlund (1999) and Bjornlund & Shanahan (2004) found that water entitlement, quality of dwelling, location and water used for permanent pastures were significant at the 0.01 level.

Based on the literature and the data available from the sources described above the following independent variables were employed in the model-building process.

- Total water entitlement included in the sales price.
- Water use during 2001/02.
- Water use during 2002/03
- Entitlement per Irrigated Hectare.
- Farm type: Dummy variables for each of the recorded farm activities – dairy, mixed, livestock/horses, fodder production, beef cattle, orchard, and hobby farm.
- Topography: Dummy variables representing categorical rankings associated with topography.
- Shape: Dummy variables representing categorical rankings associated with shape.
- Pasture: A dummy variable representing pasture condition codes.
- Area Irrigated Land, number of hectares of irrigated farmland.
- Area Dry Arable land, number of hectares suitable for dry land cropping.
- Area Low Value, number of hectares not able to be farmed.
- Arable Area Hectares, number of hectares of cropping and irrigated land.
- Area Permanent Pasture, number of hectares in permanent plantings.
- Fencing Value, the dollar value placed on fencing by the valuer.
- Irrigation Improvements Value: the dollar value placed on irrigation improvements by the valuer.
- Farm Building Improvements Value, the dollar value placed on farm buildings by the valuer.
- House Value, the dollar value placed on residential improvements by the valuer.

The sales were preliminarily screened and sales between related parties were removed, as were sales without water entitlement attached. Furthermore the sales were analyzed for outliers and as a consequence some transactions at very low prices were removed.

Results

Initially the full transaction cost was used as the dependent variable and the house value as an independent variable. However, it was found that the coefficient of 'House Value' was not significantly different from one. The dependent variable was therefore recomputed by deducting the value of the house from the transaction price, and thus the new dependent variable reflects the price paid for the agricultural component of the property. This follows the approach taken by Crouter (1987). Two different and significant models were produced using hedonic functions, which are shown in Table 1.

In both models the condition index, as well as the VIF figures, falls well below the critical values, which indicates that multicollinearity is not a significant problem. Notwithstanding this, the VIF and variance-decomposition proportions of irrigated land and water entitlement in model 2 indicate that some weak multicollinearity may be present.

Table 1: Two Models Summary

Variable	Model 1				Model 2			
	β	Se β	VIF	VDP ¹	β	Se β	VIF	VDP ¹
Water entitlement	719.06	137.76**	1.881	0.84	510.68	165.98**	2.891	0.92
Moira Area	-56439.42	19177.70*	1.180	0.05	-46491.49	19219.01*	1.254	0.11
Farm Bldg Value	1.844	0.377**	1.390	0.09	1.925	0.369**	1.405	0.08
Arable Area Hectares	1294.13	312.82**	1.488	0.65				
Irrigated Area Hectares					1882.88	411.40**	2.368	0.77
Dry Arable Land					787.61	386.39*	1.084	0.00
CONSTANT	64357.77	18553.09**			64969.50	18034.96**		
SEE	67360.77				65471.39			
Adjusted R ²	0.743				0.757			
F Value	47.32				40.98			
Condition Index	6.412				8.319			

Notes: Significance Levels: ** = 0.01; * = 0.05. ¹Variance-decomposition Proportion

Both models explain approximately 75% of the variation in price. Each model produce strong results, with most variables being significant at the 0.01 level. The F value of Model 1 (47.32) is greater than that of Model 2 (40.98), which points towards accepting Model 1 over Model 2. Both models contain the same type of variables: 1) A location variable ‘Moira’ suggesting that properties in Moira are selling at lower prices than in other parts of the study area; 2) farm building value, suggesting that farm buildings are considerably undervalued by the rating and taxing valuer, 3) the water entitlement included in the transaction, and 4) land area. Model 1 includes the total area of arable land while model 2 includes two variables for land area: i) irrigated land and ii) dry arable land. The following discussion will concentrate on variables 3 and 4 as they are the key to this research.

Comparing the coefficients for the land and water variables in the two models reveals important relationships between water, land and water dependent infrastructure as was also found by Bjornlund (1999, 2001), and Bjornlund and Shanahan (2004).

Model 1 suggests that water entitlements have a value of \$719.06 per ML (with a 95% confidence interval of \$443.52 to \$994.58) and a value of arable land of \$1,294.13 per hectare. Model 2 suggests that the value of water entitlements is only \$510.68 per ML (with a 95% confidence interval of \$178.72 to 842.64), but it has two land values, dry arable land at \$787.61 per hectare and irrigated land at \$1,882.88 per hectare. The considerable difference between the two coefficients for water entitlements supports the presence of multicollinearity alluded to above and stresses the value-link between water and the land and improvements on which it is used. This is emphasized when looking at the difference in the coefficients of the land variables in the two models.

It is argued that model 2 suggests that when dry land and irrigated land are represented separately in the model, then the productive value of water dependent infrastructure is capitalized into the value of irrigated farmland, and the value ascribed to water therefore reflects the value of unused water, that is, the price at which irrigators with unused water should be willing to sell their water in the water market. Whereas model 1 suggests that when all the arable land is represented as one variable, the productive value of water-

dependent farm improvements are capitalized into the value of the water, while the value ascribed to arable land represents the value of the land being able to be irrigated, that is, the land has access to water supply infrastructure and therefore can be irrigated. In valuation terms this represents the value of commandable land. On the other hand, the value of water entitlements in this model represents the price that an irrigator should be willing to sell water for if the water is used to support water-dependent farm improvements.

Recent trends in the market price and implicit value of water

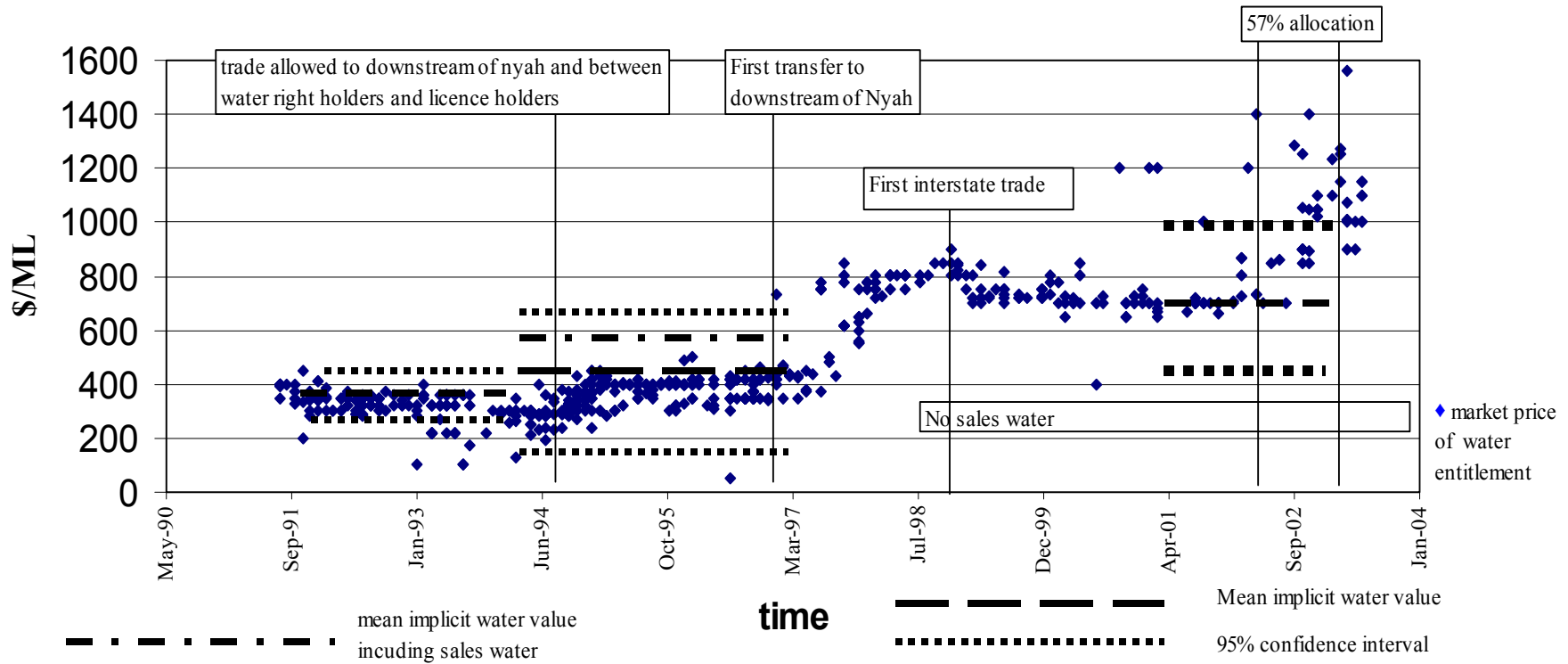
In a mature market it could be expected that the price of water entitlements being traded in the market would reflect the value of water when attached to land. When trading was first introduced, many irrigators had more water than they needed. They originally applied for and got water entitlements, but subsequently did not develop their irrigation to a level where they could utilize all the water, or they never developed their property at all. In early immature markets it could therefore be expected that such unused water would be sold first. Sellers of such water should be willing to sell at a low price since such sales would not reduce the income producing capacity of the property. As unused water is sold and markets mature, it would be expected that the price of water in the market will increase as irrigators are selling water which is actively used to support water dependent farm improvements, and that such sales therefore would reduce the income producing capacity of the property. In maturing markets it could be expected that the explicit market price for water entitlements should converge with the implicit value of water when attached to and supporting water-dependent farm improvements such as permanent plantings, irrigation and drainage infrastructure, and milking herds and equipment (Bjornlund and Shanahan (2004).

Bjornlund (1999, 2001) found that from January 1991 to December 1993, and from January 1994 until December 1996, the market price of water lagged behind the implicit value of water (See Figure 1). This was possibly due to the fact that sellers of unused water dominated the market during this period. Also, very little trading took place, the market was immature, and several trades occurred well below the mean market price. In fact, the majority of sales occurred below the mean implicit value of \$380 (Bjornlund, 1999, 2001). By June 1994, while the implicit mean value of water had increased to \$410 (Figure 1), the majority of water transfers in the market still traded in the lower end of the 95% confidence interval. When the value of sales-water was factored in, the mean implicit value of water was \$584. The level of dispersion around the mean also increased during this time.

In December 1994 new trading regulations came into force freeing up trade both spatially and between different types of water entitlements. For example, it was made possible to trade between farmers within the GMID (Goulburn-Murray Irrigation District) and farmers downstream of Nyah in Sunraysia, and also between water right holders and license holders². The lifting of spatial restrictions was expected to cause a significant shift in water from the GMID and downstream to Sunraysia as water moved from relatively

² Irrigators within the old government irrigation schemes have water entitlements in the form of water rights while irrigators who pumped their own water directly from the river had their water entitlement in the form of a diversion licence. Prior to 1994 trade between the two could not take place.

Water prices and implicit water values - Goulburn Murray Irrigation District, Victoria



low value users with the GMID to high value horticulture and viticulture users in Sunraysia. However, the first trade from the GMID to Sunraysia did not take place until 1997, when a boom occurred in the wine grape industry (Bjornlund 2003; Bjornlund & Rossini, 2004). Figure 1 clearly shows the sharp increase in the market price of water from July 1997 to July 1999. In 1997 the price of water rose above the mean implicit value for the 1994–96 period. In September 1998 the first interstate trade took place. Shortly thereafter the market price of water declined, caused by major wineries ceasing to issue new wine grape contracts effectively barring irrigators from obtaining finance to buy additional water entitlements to expand wine grape production (Bjornlund and Rossini, 2004). In 2001 the implicit value seems to reflect the explicit price; however the equilibrium was short-lived, as the prolonged drought with no sales-water, which started in July 1998, culminated in 2002/03, when allocations only reached 56% of entitlements and caused the price of water to increase to well above the mean implicit value of water, with a large percentage of water sales falling beyond the 95% confidence interval.

The future direction of the market price can take one of two courses: either the market price of water entitlement will fall and come into line with the implicit value of water, or the market price of water entitlements will remain high, and farm prices will be bid up by purchasers taking advantage of the difference between the market price and the implicit value of water entitlements. While a difference between value and price remains, it is likely that purchasers will continue to seek to gain some of the difference, and therefore purchase land with attached entitlements, rather than purchase water entitlements in the water market. Focus groups with irrigators in the study region provided anecdotal evidence of an increasing trend that properties were sold with the intent of taking off the water entitlement and sell it in the market or transfer it to the buyer's home farm and leave the purchased property dry (Bjornlund, 2004)

Conclusions

This paper has analyzed transactions of irrigated farmland within a study area of northern Victoria to extract the implicit value of water when traded as part of an irrigated farm. This implicit value of water has then been compared with explicit prices paid for water entitlements within the study region during the study period as well as longitudinally by drawing on past research.

Two different implicit values were identified depending on how land area was included in the model. In one model the land area was included in the form of dry arable land as one variable and irrigated land as another variable. Under this specification the mean implicit value is estimated at \$511 per ML while the value of irrigated land is estimated to be \$1,883 per hectare compared to dry arable land with a value of \$788 per hectare. However, in a second model all arable land is included as one variable, in which case the value of water is estimated to be \$719 per ML while the value of land is estimated to be \$1294 per ML. Both models are highly significant and free of multicollinearity using conservative testing limits.

Given these findings it is argued that: (i) in the first model the productive value of water-dependent farm improvements is capitalized into the value of irrigated farmland, and the \$511 per ML therefore represents the price at which irrigators should be willing to sell unused water; and (ii) in the second model the productive value of water has been

capitalized into the value of the water, and the \$719 per ML therefore represents the price at which irrigators should be willing to sell water actively used to support water-dependent improvements. Under the second scenario it is argued that the ability of the land to be supplied with water is reflected in the predicted land value \$1,294 per hectare.

When separating the value of land and water for the purpose of valuing irrigation farms for rating and taxing purposes, \$719 per ML should follow the water, while the value of 1,294 should be ascribed to commandable land as part of the farm value.

During the early years of water trading the explicit price of water lagged the implicit value of water as irrigators sold unused water not supporting water dependent farm improvements. As unused water was sold, and as competition in the water market was opened up to areas with an expanding viticulture industry prices increased to match the implicit value of water. As drought conditions intensified, and after four years culminated with allocations of less than water entitlements during 2002/03, the explicit price of water soared and exceeded the implicit value of water. Under this scenario an increase has been reported in the sale of irrigation farms for the purpose of stripping off the water and selling it separately in the water market or to transferring it to the buyer's home farm.

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