Water options contracts to facilitate intersectoral trade

J. Byrnes[1], L. Crase[2] & B. Dollery[3]
[1]*Economist at KPMG Australia*
[2]*Associate Professor and Executive Director,*
La Trobe University, Wodonga Campus, Australia
[3]*Professor and Director of the Centre for Local Government,*
University of New England, Australia

Abstract

While much faith has been placed in the ability of market based solutions to allocate water entitlements efficiently, relatively little effort has been made in fostering trade between urban and rural sectors. One barrier has been concerns regarding the decline of rural communities following the trade of water out of rural areas. In this paper we demonstrate how the use of options contracts to facilitate temporary trade between the sectors may benefit both urban water utilities and water entitlement holders in irrigation districts.
Keywords: water options, intersectoral trade, water reform.

1 Introduction

Creating the conditions for deep and liquid markets for the trade in water entitlements has been an enduring motif in the development of Australian water resource policy for at least the last ten years (Crase et al. [4]). Yet in terms of implementation, the focus has almost solely been on trade in rural water allocations. Trade from rural to other sectors has received relatively little attention due to at least two factors. First, in some locations considerable geographic barriers necessitate elaborate engineering solutions and considerable investment. Second, politicians and some rural communities have raised objections on the grounds that access to water is the lifeblood of rural Australia (Crase et al. [4]).

www.witpress.com, ISSN 1743-3541 (on-line)
doi:10.2495/SI080091

In this paper we develop water options contracts previously proposed by Leroux and Crase [7] and Page and Hafi [12] for the temporary trade of water between rural and urban sectors without requiring the transfer of ownership over the allocation. We show that when purchased in relatively benign markets conditions, the instrument is an economically rationale alternative to purchasing permanent entitlements.

The paper itself consists of five additional parts. The background to the study area is provided in section 2 in order to give the context for this paper. In section 3 a description of the general nature of options contracts is given, and we outline the applicability of this instrument to water markets. The two existing papers to have investigated the potential for water markets in Australia are also reviewed in section 3. The methodology followed, the data analysed and the results obtained are presented in section 4. A discussion of some policy implications is given in section 5. The paper itself ends with brief concluding remarks in section 6.

2 Potential for intersectoral trade in the Murrumbidgee valley

Residential consumers in the Australian Capital Territory (ACT) have been subject to water use restrictions since 2002 (Pagan and Crase [11]), and current government policy is to make this regime a permanent feature of life for the foreseeable future (Byrnes et al. [3]). The fact that the Canberra water storage network suffers from a distinct deficit of capacity (Pagan and Crase [11]) explains why a sizable portion of its water allocation is sent down the Murrumbidgee River as environmental flow (Edwards [5]) while restrictions are simultaneously imposed on urban water use. It shouldn't surprise that the ACT government has been one of the most aggressive in investigating the gamut of solutions to solve the urban water supply 'crisis' that has prevailed in most of Australia's capital cities since the first few years of this decade. One of the 'solutions' identified was the purchase of permanent water entitlements in the Tantangara Dam, located some 100km upstream from Canberra on the Murrumbidgee River. Other options included the upgrade of existing dams, a more punative set of water restrictions and the recycling of wastewater for potable use. In comparison the 'Tantangara option' has a number of advantages. First, Tantangara represents a sizeable storage capable of meeting the water demands of Canberra in most years. Second, the capital cost of the infrastructure to allow the transfer of water from Tantangara to one of Canberra's existing water storages is relatively cheap (estimated to be $38 million). Finally, the transfer of water from Tantangara would entail beneficial environmental flows (ACTEW [2]).

Notwithstanding the advantages outlined above, the Tantangara option was rejected when first formally considered in 2005. This was essentially due to concerns surrounding less than certain property rights over allocations to be held by the ACT urban water utility, stemming from the fact that Tantangara is located in the Snowy Mountains region of NSW, and subject to the control of the

NSW government water bureaucracy (ACTEW [2]). In essence, the ACT government feared that the transfer of water from Tantangara to meet the needs of urban water consumers in Canberra would be vetoed in times of extremely low storage levels, precisely when the water would be needed (Pagan and Crase [11]).

However, a review of water supply options for the ACT in 2007 saw the Tantangara option revived. The plan would see high security water allocations purchased from those willing to sell (most likely irrigators from the Murrumbidgee and/or Coleambally irrigation districts) on a permanent basis. When required the water attached to the allocation would be transported to a storage dam in Canberra, either via the Murrumbidgee River (a journey of approximately 100km) or a newly constructed 20km pipeline connecting the Tantangara to the Corin Reservoir. The plan calls for the purchase of rights to approximately 20GL of water at an estimated cost of $30 million dollars (ACTEW [2]; ACT Government [1]).

Implementation appears likely to fall flat for at least two reasons. First, there are non-trivial differences between the stipulation of water allocation rights in NSW and the ACT (Pagan and Crase [11]). Second, political objections to the permanent transfer of water rights from rural to urban areas have been rapidly raised in other contexts, and seem just as likely to float to the surface in this instance (see Crase et al. [4] for a detailed discussion of this barrier to trade). Water options contracts potentially alleviate the second of these concerns.

3 The nature of options contracts and their applicability to water markets

An options contract gives the holder the right, but not the obligation, to undertake a defined action at a pre-determined future time, and at an agreed rate of exchange. When the holder of the contract opts to invoke the right, the option contract is said to have been exercised. There are two parties to an options contract: the writer and the holder. The writer of the contract is obligated to undertake an action (such as delivering an asset) in the event that the holder invokes her rights under the contract. Options contracts can be further classified into puts and calls. A call option gives the holder the right (but not the obligation) to purchase an asset, while the holder of a put option has secured the right (but not the obligation) to sell an asset (Jones et al. [6]).

Options contracts have become an efficient means of transferring risk in financial markets, and although the basic premise of an options contract holds in their application to water markets, they differ in one key respect. Ownership is not transferred upon exercise. Rather, the contract gives the right to temporary use of the water allocation. This brings two additional advantages. First, ownership remains with the writer, which may dilute some of the objections to intersectoral transfers. Second, the option can be exercised multiple times over a contract period, delivering some supply security for the urban water utility.

Given the special nature of water options contracts, Michelson and Young [8], who were the first to propose options as a means of transferring water between urban and rural sectors, identified a number of other features that must be incorporated. First, an option must take into account the possibility of allocations being varied in drought conditions and market conditions being varied by governments. Second, since ownership is not transferred, provisions must be included to allow the writer to sell her water allocation, even after having entered into an options contract.

3.1 Valuing water options contracts

There are two steps to determining whether a water options contract has value to the holder. In the first, the capital cost of obtaining the next least cost alternative supply source is compared to the cost of exercising the option. In the case that exercising the contract is the cheapest of the two alternatives, the option has economic value. In the second step the cost of purchasing the contract is compared to the value of holding the contract. Should the premium payable not extinguish the value of holding the contract, the urban water utility would benefit from purchasing the option.

3.2 Previous efforts at exploring water options in Australia

Page and Hafi [12] examined the potential for the use of options contracts to facilitate trade between irrigators in the Murrumbidgee Valley and the urban water utility in Canberra. Following the methodology of Michelson and Young [8], they found that there was net present value from holding an options contract, when compared with a range of other supply augmenting alternatives. In a similar vein, and LeRoux and Crase [7] specified an options contract following Michelsen and Young's [8] model in the context of the Victorian town of Wangaratta. They also found a net economic benefit to the urban water utility from entering into an options contract rather than purchasing permanent allocations.

4 Methodology, data and results

In this section we contribute to the literature by both estimating the Present Value Of Benefit (PVOB) to the ACT water authority from holding the option and the premium that would be required by the writer of the contract, via the Black-Scholes pricing model.

4.1 Estimation of the PVOB from holding a water option

Following Michelson and Young (1993), Crase and LeRoux (2007), Page and Hafi (2007) and Williamson et al. (2007), the PVOB from holding the option contract is estimated as follows.

$$PVOB = \sum^{T}_{t=0} [(K_{t=0}*r + M_t - B(1-P)) - (E*P)_t]d_t + [K_{t=0} - K_{t=0}(1+ a)^T]d_t \quad (1)$$

where:
PVOB = net present value of option benefits
t = year

T = contract termination year
$K_{t=0}$ = capital cost of alternative supply at the beginning of the option term
r = annual interest rate
M= annual maintenance cost of the alternative
B = price per ML of temporary water sales
E = exercise cost of option
P = annual probability of option exercise ($0 \leq P \leq 1$)
d_t = discount factor for present value, $1/(1 + r)^t$
a = annual rate of appreciation of alternative supply.

In essence, equation 1 compares the capital cost of obtaining the alternative supply and any annual costs and/or benefits associated with obtaining the alternative supply ($K_{t=0}$*r + M_t – B(1-P)), to the cost of exercising the option contract (E*P). The present value of future transactions is obtained by applying a standard discounting factor (d_t). A PVOB is estimated for each of the contracts bundled into the multiple exercise contract. Thus, in the case of a 10 year contract, ten PVOBs are estimated and summed to provide the PVOB of holding the contract over 10 years. The second term, $[K_{t=0} - K_{t=0}(1+ a)^T]d_t$, allows for inclusion of appreciation or depreciation in the value of the alternative supply, discounted to allow valuation at present value. It is important to note that the second term is only considered in the final year of the contract.

4.1.1 Data

In this example we estimate the value of contracts spanning both 5 and 10 year periods. The alternative supply to be secured is the purchase of 20 GL of high security water entitlements on the permanent market. As outlined in section 2, investigations by the ACTEW suggested the cost of this purchase would be approximately $30 million, which equates to $1,500 per ML (ACTEW, 2007). Since data regarding trades on the permanent market in the relevant district is scarce, the estimate by ACTEW was taken on face value.

The annual risk-free interest rate was arbitrarily set at 5% and left constant, however it is acknowledged that this need not be the case. The annual maintenance cost in this instance consisted of payments that would be required by the Snowy River Scheme for lost hydro electricity generation, estimated at $270 per ML. We assume that unused portions of any alternative supply could be sold into the temporary water market at $300ML, and that the probability of making temporary sales is given by (1- p).

Following Michelson and Young [8], Le Roux and Crase [8] and Williamson et al. [13], the exercise price was taken as the gross margin per ML of water consumed in the irrigation of three separate crops in the Murrumbidgee Valley: Barley, faba beans and lucerne. Data was sourced from NSW Department of Primary Industries gross margin budgets for 2007/08 (NSW DPI [10]), and acts as the 'base' scenario 1. Two further scenarios were modelled in which gross margins were deliberately increased.

The annual probability of exercise is based upon modelling by ACTEW (ACTEW [2]) that suggests water restrictions are likely to be imposed every three years out of 10. We leave the rate of appreciation at zero for the sake of simplicity.

Table 1: Gross margin assumptions.

Crop	*Gross margin: 1st scenario*	*Gross margin: 2nd scenario*	*Gross margin: 3rd scenario*
Barley	48.75	100	150
Faba beans	127	300	350
Lucerne	163	370	450

4.1.2 PVOB from holding water option contract

Table 2 presents the estimates of the PVOB to the urban water utility from holding the water options contract written by the three different irrigators, under each of the three scenarios and for contract lengths of five and 10 years.

Table 2: PVOB from holding option contract under three scenarios.

PVOB	*Barley*		*Faba Beans*		*Lucerne*	
	5yr	*10yr*	*5yr*	*10yr*	*5yr*	*10yr*
Scenario 1	$521	$929	$420	$748	$373	$665
Scenario 2	$455	$811	$195	$347	$104	$185
Scenario 3	$390	$695	$130	$232	$32	$58

A number of patterns are apparent. First, the value of holding a 10 year contract is universally higher than that of holding the 5 year contract, regardless of who the contract is purchased from. Second, the higher the exercise price of the contract, the lower the present value of holding the contract. This is intuitively appealing, since the economic principle underpinning water options is that water will move from a relatively lower value use to a higher value. Combined, the results suggest an economic benefit (in present terms) to the Canberra urban water utility of entering into either of the two contracts. This is consistent with the findings of Page and Hafi [12].

4.2 Estimation of premium payable to writer of option contract

The Black Scholes (BS) approach to determining the 'fair value' premium payable to the writer of an options contract is now almost universally employed in the pricing of financial options (Jones et al. [6]). Although the underlying nature of water prices violates a basic assumption (normality), we make use of this approach because of its general acceptance. The results are obviously limited by this modelling choice.

In essence, the BS model prices an options contract on the likelihood that the contract will be exercised, with higher probabilities requiring relatively higher premiums. It follows that the relative values of spot and exercise prices is of crucial importance. The BS approach is specified as follows:

$$c = S_0N(d_1) - Ke^{-rT}N(d_2) \qquad (2)$$

and

$$d_1 = (\ln(S_0/K) + (r+\sigma^2/2)T)/\sigma\sqrt{T} \qquad (3)$$

$$d_2 = d_1 - \sigma\sqrt{T} \qquad (4)$$

where c is the European call price, S_0 is the stock value at time zero, N is the cumulative normal distribution, K is the strike/exercise price, r is the risk-free rate of interest, σ measures price volatility and T is the time to maturity of the option in years.

4.2.1 Data

In the case of water option contracts the stock value (S_0) is the price of temporary trades in high security water, expressed in dollars per ML. We make use of a data set supplied by the Murrumbidgee Horticultural Council (MHC, [9]) over the period 2006 to 2007. A feature of the data set is the relative lack of depth in trades and the extreme volatility from mid 2006 to late 2007. The series is presented in Figure 1, with both volume and spot price displayed.

K and r are as previously defined. Volatility in spot prices is clearly greater than 1, evident from the range of prices ($29 to $1401 per ML). Under the bold assumption that a degree of stability will return to the market as the current drought breaks we have imposed a volatility term of 0.5. As outlined above contracts of two maturities (five and ten years) are specified.

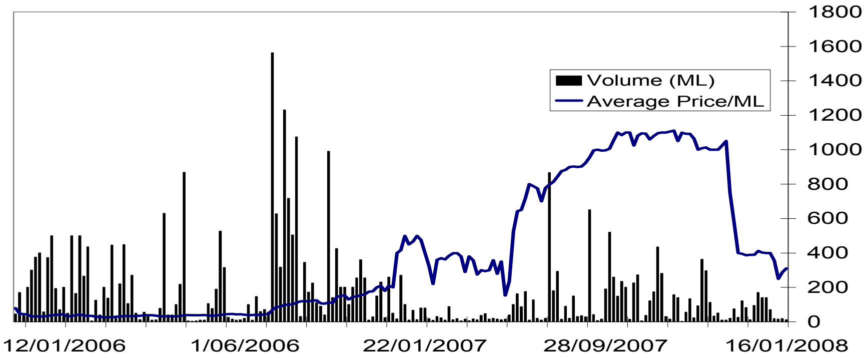

Figure 1: Average price and volume of trade in Murrumbidgee valley. (Source: Murrumbidgee Horticultural Council [9].)

If the option was in the money, (when the contract is out of the money, it is left unexercised, even though the urban water utility foregoes the premium, since water can be sourced from the spot market at a price less than the exercise price) the urban water utility would compare the value of holding the option with the cost of purchase, represented by the premium. In Table 3 the range of spot water prices at which there is still a surplus PVOB after having deducted the premium are reported. The lower value is by definition the spot price at which the contract becomes in the money. This is reported for each of the three crops and each of the three gross margin scenarios.

4.3 Results

A generally applicable principle is evident in Table 3. Those producing crops that add the least economic value per ML of water are most likely to trade with the urban water authority via an options contract. This stems from the fact these farmers require a relatively lower exercise price, resulting in relatively higher PVOB surpluses after the payment of premiums.

Table 3: Spot prices at which PVOB is greater than premium payable.

Scenario	Barley	Faba Beans	Lucerne
5 year contract			
1	$70.31 to $525	$130 to $450	$175 to $416
2	$100 to $525	Premium > PVOB	Premium > PVOB
3	$151.5 to $475	Premium > PVOB	Premium > PVOB
10 year contract			
1	$70.31 to $955	$130 to $777.50	$175 to $416
2	$100 to $843	$300 to $402.00	Premium > PVOB
3	$151.5 to $750	Premium > PVOB	Premium > PVOB

5 Policy implications

The results presented in this paper suggest it would be sensible for the urban water utility to enter into an options contract when it was not facing an immediate supply constraint due to drought, but when prices were relatively low, since the higher the spot price of water relative to the exercise price, the higher the compensation required by the writer of the contract. Thus, in periods of relatively high water prices, options contracts are less likely to be entered into by the urban water utility. The premium paid to the writer in times of supply security represents the price of obtaining future supply security well before a ‘crisis’ is encountered. Some may regard this as money well spent. The rash of expensive infrastructure projects being fast-tracked by state governments around Australia demonstrates the cost of taking a ‘just in time’ approach to urban water planning. This would also be beneficial to the farmer since she receives income from selling the option at time when the option is unlikely to be exercised.

6 Conclusions

In this context at least, there would appear to be value for the urban water utility in the purchase of water options contracts. However, the results suggest that the transaction is likely to be with those irrigators adding relatively little value per ML of water. This is intuitively appealing, since it sits well with the basic premise of water trading: trade will move water from relatively low to higher value uses. Yet as is so often the case in water policy, options contracts do not represent a universal or perfect solution to the thorny issue of intersectoral trade. Furthermore, while the results presented here are promising, a number of important caveats must be considered. Property rights must be certain. Planning must be such that there is a high degree of certainty surrounding the proportion of the applicable resource available. Knowledge of interactions between basins and the consequences of moving allocations from one part of the system to another must be well advanced so that the parties can be reasonably certain of the quantity of water required to make the delivery.

Acknowledgements

The views and opinions expressed herein are those of the authors and do not necessarily represent the views and opinions of KPMG, an Australian partnership.

The information contained herein is of a general nature and is not intended to address the circumstances of any particular individual or entity. Although we endeavour to provide accurate and timely information, there can be no guarantee that such information is accurate as of the date it is received or that it will continue to be accurate in the future. No one should act upon such information without appropriate professional advice after a thorough examination of the particular situation.

References

[1] ACT Government (2007). 'Water supply security fact sheets.' Retrieved 21 December, 2007, from http://www.thinkwater.act.gov.au/more_information/publications.shtml#water_security.

[2] ACTEW (2007). Water security for the ACT and region: Recommendations to the ACT Government. Canberra, ACTEW.ACTEW, 2005

[3] Byrnes, J., Crase, L. and Dollery, B. (2006). 'Regulation versus pricing in urban water policy: The case of the Australian National Water Initiative', *The Australian Journal of Agricultural and Resource Economics*, Vol. 50, pp. 437–49.

[4] Crase, L., Byrnes, J. and Dollery, B. (2007). 'The Political Economy of Urban-Rural Water Trade', *Public Policy*, Vol. 2, No. 2, pp. 130–40.

[5] Edwards, G. (2007). Urban water management. Water policy in Australia: The impact of change and uncertainty. L. Crase. Washington, RFF press: 144–165.

[6] Jones, C., Shamsuddin, A, and Naumann, K. (2007). *Investments Analysis and Management*, 2nd Edition, John Wiley & Sons, China.

[7] Leroux and Crase (2007). 'Options Contracts for Managing Inter-Sectoral Water Trade: A Preliminary Investigation of the Feasibility of Urban-Irrigation Options Contracts in the Ovens Basin, Victoria, Australia', proceeding from *Australian Agricultural and Resource Economics Society Annual Conference*, February, Queenstown.

[8] Michelsen, A. and Young, R. (1993). 'Optioning agricultural water rights for urban water supplies during drought', *American Journal of Agricultural Economics* Vol. 75, 1010–1020.

[9] Murrumbidgee Horticultural Council (2007), 'High Security Water Entitlement'. Retrieved 21 January, 2008, from http://www.murrumbidgeewater.com.au/index.php?id=6&no_cache=1

[10] NSW Department of Primary Industries (2007), Farm enterprise budget series: Gross margin budgets. Retrieved 21 December, 2007, from www.agric.nsw.gov.au.

[11] Pagan, P. and Crase, L. (2008). 'Institutional Constraints and Inter-Jurisdictional Water Trade: The Case of the Australian Capital Territory and New South Wales', proceedings of *The 51st Annual Conference of the Australian Agricultural and Resource Economics Society*, February, Canberra.

[12] Page, S. and Hafi, A. (2007). *Urban Water Options Contracts: Rural to Urban Water Trade*, Australian Bureau of Agricultural and Resource Economics, Canberra.

[13] Williamson, B., Villano, R. and Fleming, E. (2007). 'Structuring Exotic Options Contracts on Water to Improve the Efficiency of Resource Allocation in the Water Spot Market', proceedings of *The 51st Annual Conference of the Australian Agricultural and Resource Economics Society*, February, Canberra.