Potential efficiency gains from water trading in Queensland

John Rolfe *

*Associate Professor, Faculty of Business and Law, Central Queensland University,

Address: Central Queensland University, P.O. Box 197, Emerald QLD 4720
Ph: 07 4982 8890
Fax: 07 4982 8899
Email: j.rolfe@cqu.edu.au

Abstract

Irrigation underpins approximately one-third of the value of Queensland's agricultural production. In line with the COAG reforms, water trading is being introduced to many irrigation regions, but there is often opposition from farmers, environmentalists and communities. As well as providing the economic arguments about net benefits to be gained from water trading, it is important in a political economy framework to be able to provide examples and case studies. There are three areas where net benefits may be expected from the introduction of water trading. The first involve the gains to be made from transferring water between sectors from low value use to high value use. The second involve gains from transferring water within sectors where heterogeneity between farmers create substantial differences in marginal revenues. The third involves the longer term benefits from fostering innovation and entrepreneurial attitudes among water users.

1.0 Introduction

Economic reform in the water industry in Australia is an important issue. The supplies of water have been constrained by restrictions on new dams as a consequence of environmental and political concerns, while demands have continued to increase from agricultural, urban and other users. The water industry is notable because price has rarely used as mechanism for allocating the resource, and has only been used as a partial cost-recovery mechanism. Water prices have generally been set at very low levels through the public funding of major impoundments, and the effective subsidisation of many government operated distribution systems (Smith 1998).

Over the past decade in Australia, there have been moves towards a more competitive and efficient basis for allocating water resources. These changes are being driven by the strategic framework for water sector reform adopted by the Council of Australian Governments (COAG) in 1994. Among the COAG reforms to be implemented by the year 2001 were:

- pricing based on principles of full-cost recovery and transparency,
- the development of property right systems over water,
- the deregulation and development of trading systems for water.

These reforms will essentially remove water as a factor input supplied by public institutions to being a factor input supplied by more competitive market processes. Key steps in that process include the specification of water entitlements between the environment and use purposes, the establishment of property rights to allow apportionment and trade at the farm enterprise level, and the development of appropriate regulatory and governance mechanisms. There are some differences in the ways that the state governments have set out to achieve these goals, and the reform process has not been as swift as initially set out under the COAG agenda (Whitten 2003).

Economic theory predicts that freeing up inputs to flow towards highest value use can generate substantial efficiency dividends (Easter, Dinar and Rosengrant 1998, Tsur, Roe, Doukkali and Dinar 2004). However, the moves towards competitive market pricing and allocation often meet substantial resistance. In a political sense, there is a need to not only advance theoretical economic arguments for establishing water trading mechanisms, but also give practical examples and explanations of how economic growth and regional communities are benefited by these reforms.

To counter the variety of arguments against water trading put forward by the variety of interest groups, it is useful to be able to explain and demonstrate some of the potential gains. However, it is difficult to find clear examples in Australia of gains from water trading. This is because (a) water trading is still being established in many irrigation regions in Australia, (b) the gains from water trading are difficult to identify in the short run, and (c) there are a number of other confounding factors such as weather events and macroeconomic settings that impact on economic performance in irrigation areas.

It is possible to explore the potential gains from water trading in a number of ways. One key option is to use comparative studies, where it can be shown that the use of competitive trading mechanisms in other products or locations has been advantageous. For example, a number of international case studies (Easter et al. 1998) may be appropriate for this purpose. Another key option for arguing that water trading allows new economic opportunities to develop is to demonstrate that there are large variations in opportunity costs between sectors and enterprises. An analysis of differences in gross margins is often employed by economists to emphasis the potential for inter-sector trade, but it is more difficult to capture real differences at the enterprise unit from such an analysis. For example, farmers in areas where a dominant crop such as cotton or sugarcane is grown will argue that there is little point in establishing water trading because the gross margins are relatively uniform.

One way to predict how farmers will engage in and benefit from water trading mechanisms is to employ stated preference techniques. These economic tools have been traditionally used in the environmental valuation field, but there are emerging applications in the agribusiness field (Lusk and Hudson 2004). Stated preference techniques involve some form of an experiment where farmers are asked, through a survey format, to indicate their preferred choice from different price and/or supply and demand formats.

Another tool for exploring water demand and supply issues is experimental economic procedures. The most common of these are the classroom trading exercises, such as water bank games (Crouter 2003), although other applications include field experiments with farmers or computer simulation exercises. These experimental economic procedures have useful applications in terms of designing new markets, modeling potential interactions and institutional rules, and encouraging use through learning effects (Roth 2002).

In this paper, a number of these approaches to demonstrating the potential benefits gained from water trading mechanisms are outlined, with a particular emphasis on Queensland case studies. The paper is organized in the following way. In the next section, a brief overview of background issues is outlined, including a short review of international evidence. In section three, the focus is on net economic benefits arising from flexible market systems that transfer water between sectors, including from low value agricultural crops to high value agricultural crops. In section four, the focus turns to potential gains within sectors, where heterogeneity in productivity between farmers creates substantial opportunities for specialization and trade. In section five, the focus turns to more long term effects, where it is argued that competitive trading systems might encourage more innovation and entrepreneurial behaviour. Conclusions are presented in the final section.

2. Background economic issues

Economic analysis focuses on efficiency as a key criterion for allocating water resources, where efficiency is broadly defined as a measure of the overall benefit gained from changing resource allocations. An efficient allocation occurs when the total net benefits of water use are maximized. Distributional issues are not necessarily included in economic analysis, but because they are important for equity and political reasons, are normally assessed in some sense as well. The equity impacts arising from water trading issues are discussed briefly in the next section.

The efficiency of different resource allocations is measured by estimating the consumer surplus and producer surpluses that are gained. In a competitive market framework where no market failures are present, maximum efficiency is found at a market equilibrium point where supply and demand are matched. Water prices are the signaling mechanism that match supply with demand and transfer new information about potential gains from water trades. The signaling mechanism means that water is automatically transferred from the low values users to the highest value users, generating economic surpluses.

Earlier allocation mechanisms for water resources have involved governments building supply storages and allocating water (mostly on a volumetric basis) to different sectors. Allocations to sectors have tended to remain quite fixed, so that even though demands (and by implication marginal benefits) have risen in particular sectors, allocations have not tended to change much between sectors. The classic example in Australia is where there have been few transfers of water between agricultural and industry/urban sectors, even though the marginal benefits of more water to the industry/urban sectors (as measured by willingness to pay) is probably much higher.

The standard approach to evaluating the net benefits of policy changes is use partial equilibrium analysis where only direct impacts are considered. For example, an analysis of the impacts of establishing water trading markets might involve consideration of the net returns of different production enterprises, the amount of water that might be transferred between sectors and enterprises, the increase in net production that results, and any consequent environmental impacts. A similar process would be undertaken for new water storage developments, where a cost benefit framework might be used to assess the production benefits from additional water supplies, the costs of providing the supplies, as well as any environmental and recreational impacts.

Demands for water are often calculated with the use of farm production models. The analysis occurs by identifying in a production model what the commercial returns would be from adding additional units of water to an enterprise unit. It is normal that the amount of return diminishes with increasing units, so that the derived demand function for water supplies is downward sloping. Demands across individual farmers can be summed to derive sector or regional demand functions.

Farm production models or simpler gross margin analysis models are often used as inputs in linear programming models to simulate the introduction and operation of potential water markets. Linear programming methods are often used to model water demands in the short and long term, where resource constraints, production, management and market information are combined to predict what the response of farmers would be to changes in the price and/or supply of different factors. Briggs-Clark (1986) and ONECG (2001) provide demonstrations of this type of approach.

Tsur et al. (2004) report the use of farm level analysis of derived demand to analyse water prices and returns in a number of international case studies. They also review a large number of international studies which demonstrate increasing adoption of competitive market mechanisms for water. Easter et al. (1998) provides a number of international case studies about the applications and benefits of water trading systems. For example, Archibald and Renwick (1998) estimate the gains from trade in developing water markets in California, while Hearne and Easter (1998) estimate the gains from trade in Chile's water markets. Horbulyk and Lo (1998) analyse water markets in Alberta and estimate that potential gains in consumer surplus of 56% are available from the introduction of competitive resource allocation.

Although the economic arguments in favour of competitive water markets are very strong, it is often very difficult to convince governments and stakeholders of the benefits (Easter et al. 1998). It is for this reason that it is important in the political economy sense to be able to present examples and case studies of the net benefits of water trading as well as the economic arguments. To help design these case studies, it is important to understand why stakeholders may not accept arguments about the benefits of water trading. For simplicity, resistance can be identified from four broad groups; irrigators, environmentalists, bureaucrats and communities.

Irrigators

Irrigators are often very suspicious of new water pricing mechanisms, particularly when the changes mean that water prices will rise. The COAG reform process means that there is potential for water prices to rise to farmers from four main impetuses. The first three stem from governments and the reform process, while the fourth reflects the influence of competitive pressures. The first is the requirement to recover all costs of storage and delivery. In some irrigation systems, delivery costs were highly subsidized, meaning that water charges had to rise substantially just to cover operational costs.

A second is that under the COAG reforms, account needs to be taken of the negative externalities generated by use (Beare and Heaney 2002). This may take the form of a Pigovian tax used to signal to irrigators that there may be social costs associated with water use. However, difficulties in identification and measurement mean that moves to incorporate externalities in water prices have been limited to date. In many cases, problems of negative externalities have been addressed in other ways such as volume caps, voluntary actions (eg the adoption of Best Management Plans in the cotton industry) and regulatory mechanisms (eg the requirement to establish Land and Water Management Plans for new irrigation developments in Queensland).

A third potential driver of higher water prices is the potential for resource rents to be charged. While mechanisms to capture resource rents are common in the mining industry, there were no comparable mechanisms in the water industry to transfer rents to society. Typically the flow of rents was from society to the agricultural water industry. Resource rents are still to be established in the water industry, reflecting both the path-dependency nature of the reform process and the political difficulties in introducing new charges in the water industry.

The fourth potential driver of higher prices are competitive pressures. These competitive pressures may be exacerbated in some areas where water allocations need to be clawed back to meet environmental targets, although the 2004 agreement between the Commonwealth and State Governments means that governments will bear most of the costs of such clawbacks. The establishment of trading systems for water means that supply and demand intentions can be more accurately matched through the price signaling mechanism. Although these resource flows are between irrigators (rather than from irrigators to government), there is still some opposition from irrigators to competitive trading systems. This is partly because competition for water resources is likely to become more intense (water prices will increase), and because the separation of water from land titles means that land prices will be affected.

Environmentalists, bureaucrats and communities.

Environmentalists and bureaucrats are sometimes opposed to water trading mechanisms because of the perceived loss of government control when private property rights are established. For environmentalists and community groups, there is often concern that open market trading will lead to a concentration of irrigation enterprises as scale efficiencies are exploited. This is sometimes seen as being at odds with the perceived ideal that agriculture should be comprised of the smaller-scale farming enterprises. Irrigator groups and communities are sometimes concerned about water trading mechanisms when there is potential for water to be shifted away from an area to more profitable uses elsewhere.

These concerns mean that the design of new water trading mechanisms has to satisfy both economic and political criteria. Key steps in the political process are to demonstrate that there are economic gains available from water trading mechanisms, and to identify where any groups or communities may be adversely affected. For convenience, the benefits arising from water trading can be summarized into three broad groups. These are the benefits arising from shifting water between sectors, the benefits of changing production within a sector, and the benefits of fostering innovation and entrepreneurship. Each are discussed and illustrated in turn in the following sections.
\

3. The returns available from trading between sectors

The standard case that is made for net benefits from water trading mechanisms is that trade between sectors or production activities allows higher value uses to be achieved. For example, water that is taken from low value agricultural production such as rice or cereal crops and used for industry or high value agriculture should generate higher levels of economic returns. The simplest way of depicting the gains available from shifting water to higher value activities is to summarise the returns per unit or megalitre (ML) of water. This is often done for agricultural enterprises with the aid of gross margin analysis, which identifies the net return after the direct costs of growing and selling a crop have been considered, and provides a benchmark for comparing the returns for different water uses.

Case study 1. Changing Agricultural Production in the Emerald Irrigation Area

The Emerald Irrigation Area is an important irrigation district in the central Queensland region, serviced by the Fairbairn Dam, which is one of the largest water storages in Australia. The dam was completed in 1974, and was originally justified in economic terms for irrigating wheat and fodder crops to fatten sheep. Neither option have ever been commercially viable, but an important cotton industry developed in the late 1970s. ABS data indicates that by 2001, there were 24,000 hectares irrigated in the Emerald Shire, with a gross value of cotton production of $82.5M from 18,345 hectares.

A detailed gross margin exercise for cotton at Emerald is shown in Appendix One. It shows that the average cotton crop in the region has a water application rate (for flood irrigation) of 8 ML/ha, and can be expected to yield 8 bales of cotton per hectare. The return per ML of water after all operational costs have been accounted for is estimated at $165. This return is needed to cover overheads, service debt and provide a return on capital and entrepreneurship.

In the early 1990s, citrus and grape production developed at Emerald. These represent higher value crops, and substantial amounts of water have been transferred out of cotton production into these crops. An example of a gross margin analysis for citrus is shown in the table below. The analysis shows that the expected gross margin per ML of water is $2,468. By 2004, approximately 915 hectares of citrus had been established (as well as additional areas of grape production). The water that has been transferred from cotton production to those crops has generated much higher returns. After making allowances for higher security water requirements for the orchard crops, the total gross margins for citrus at Emerald is estimated at $20M, compared to $1.9M if the same water was used to grow cotton. As well, citrus and grapes require high labour inputs (pruning and harvesting), so there have been associated employment and population increases.

Table 1. Gross margin budget for citrus at Emerald.

Budget item	*Assumptions*	*Budget ($/ha)*
Sales	*$25/case for 19kg cases, 5.5 cases/tree, 384 trees/ha*	*52,800*
Total income		*52,800*
Variable costs		
Machinery operations	*Fertilizer applic, slashing, spraying*	*79*
Pruning		*557*
Fertilizer		*1034*
Herbicide		*114*
Insecticide		*79*
IPM & bait costs		*428*
Fungicide		*3106*
Irrigation and pumping	*9 ML/ha*	*1164*
Harvesting & marketing		
- labour for picking	*$1.50 per case*	*3168*
- grading, packing and cooling	*$4.10 per case*	*8659*
- bin costs	*$0.06 per case*	*127*
- degreening	*$0.04 per case*	*84*
- commission	*$2.75 per case*	*5808*
- levies	*$0.26 per case*	*549*
- freight	*$1.90 per case to Brisbane*	*4013*
Total Variable Costs		*28970*
Gross Margin		***$23,830***
Gross Margin / ML		***$2,468***

Adapted from Donaghy (1995) and Bourne et al. (1999).

A notable aspect of cotton and grape production at Emerald is that they are suited to different soils compared to cotton. Cotton is suited to the heavy clays and black soils, while citrus and grapes prefer lighter, sandy soils. When citrus and grapes were established in the region, there were no water trading mechanisms available to transfer water from the heavy soil areas to the lighter soil areas. Some citrus was grown on irrigation blocks where the lighter soils had proved uneconomic to grow cotton. In other cases, the new crops were grown on patches of poorer country on the cotton farms, or owners of multiple blocks had water rights transferred from one block where cotton was grown to another more suitable for citrus. It was fortuitous that some farms at Emerald included several soil types, and that many irrigators were large enough to own multiple blocks; otherwise water transfers may never have happened to allow citrus and grape production to start.

Case study 2.

> *A major mining company (Estrata) is developing a major new coal mine near Rolleston in central Queensland. Mine and rail construction is expected to cost approximately $600M. When the mine is commissioned in 2006, it is expected to produce 8 million tons per annum of steaming coal over a 20 year period. The mine is located in the Comet River catchment, which is a sub-catchment in the Fitzroy basin. While the coal has a low ash level and does not need to be washed before shipment, water is still needed for mine development and operations phases for items like road development and dust suppression. However, it is difficult for the mining company to gain water entitlements in the basin.*
>
> *Under the water resource planning process undertaken by the Queensland Government, total water reserves available for consumptive use in the Fitzroy basin have been capped. A number of unregulated developments have since been undertaken by landholders along the Comet River to harvest water and establish irrigation schemes, and there is now a moriatorium on any further development work or capture of overland flows in the Comet system. The Comet catchment is not included in the Fitzroy Resource Operating Plan, which means that permanent water trading is not possible. The effect is that new development proponents in the catchment can not purchase water entitlements off agricultural enterprises and establish new supply systems. The current options available are to purchase or lease agricultural enterprises and physically pump the water across.*

4. The returns available from trading within sectors

There are some irrigation areas that are dominated by similar value crops where the opportunities for trade between high and low value sectors are more limited. Many of the economic arguments about the benefits of water trading have focused on the higher returns available from transferring water to higher value uses (eg between sectors). However, there are also likely to be major benefits available from transferring water within sectors. This is because there is often substantial heterogeneity in costs at the enterprise level, which means that the more efficient operators can achieve higher returns from water inputs.

Many farm production models average revenues and costs over a number of farms, disguising the levels of heterogeneity involved. However, the difference in returns between average and more efficient producers can be substantial. For example, in the cotton industry Boyce Chartered Accountants (2001) show that the top 20% of producers perform significantly better than the average cotton producer. Across the industry, the top 20% of producers had more than double the amount of net profit in 2001 ($1042/ha) compared to the industry average ($402/ha). The more efficient producers tend to 'set' the market for factors of production such as land and water, but when water is tied to land, transfers are bulky and intermittent. In this situation, price signals about the most efficient use of water are substantially weaker than if water can be traded separately.

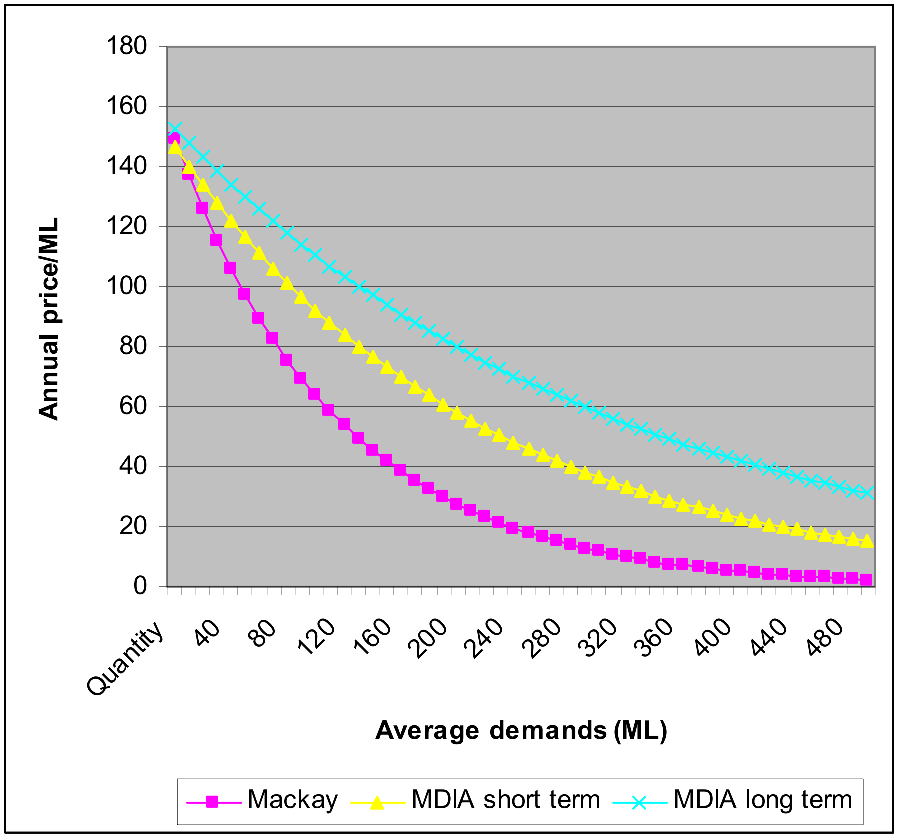
An example of an averaging approach to returns from water comes from the economic assessment of the Burnett River Dam, which is currently being constructed in Queensland. Construction of the new dam and four new or augmented weirs on the Burnett will deliver an additional 174,000 ML of water per annum (ONECG 2001). Capital costs of the project are just over $200 million, giving a capital cost of approximately $1,150/ML. In the economic analysis performed by ONECG (2001), it is assumed that the bulk of the additional water supplies are applied to existing irrigation areas to increase application rates, particularly for sugar cane. By assuming that sugar cane growers across the region would find it profitable to increase application rates by 1 – 2 ML/ha, high levels of demand from agriculture were implied. The analysis indicated that that the gross margin of irrigation water supplied to sugarcane was $156/megalitre, and this estimate was extrapolated across all sugar cane areas in the region (ONECG 2001).

In contrast, stated preference experiments conducted at a similar time but in other irrigation areas of Queensland revealed lower levels of demand that were much more sensitive to price (Rolfe 2004). The variation in responses and sensitivity to price indicates high levels of heterogeneity in water demand between growers, suggesting that substantial efficiency gains may be possible by transferring supplies between growers. Here, those experiments are reported in more detail.

Farmers in two regions were surveyed to ascertain their willingness to pay for additional water supplies. The regions surveyed were Mackay in 1998 (almost exclusively sugar cane), and the Mareeba-Dimbula Irrigation Area (MDIA) on the Atherton Tableland in 2000 (producing sugarcane, tobacco, tree crops, horticulture). Both areas have approximately 900 farms, with sugar cane as the dominant industry. In each case farmers were asked to indicate how much additional water supplies they were prepared to purchase at various price levels. At the time the surveys were conducted, (1998 and 2000), sugar prices were low, but farmers were generally optimistic about future market conditions and prepared to consider expansion. The surveys were conducted at a similar timeframe to the economic analysis of the Burnett River Dam.

The results reported in Rolfe (2004) are summarized below in Figure 1. Two key conclusions can be drawn. The first is that additional demands for water to grow sugarcane were very low at the higher prices. In contrast to the ONECG (2001) study which assumed that there would be a substantial demand for irrigation water from sugar cane at annual prices of more than $100/ML, these studies indicate that actual demands would be much lower. The second conclusion is that demands are very sensitive to price. This was largely driven by heterogeneity between farmers, where some indicated that they were prepared to take additional water supplies at higher prices, while others were not prepared to purchase any additional supplies. These results suggest that substantial efficiency gains could be available by transferring water between farmers within a single sector.

Figure 2. Average demands for selected farms in the Mackay and MDIA areas



5. The returns available from fostering innovation and entrepreneurship

The third area where gains are likely to be available from water trading mechanisms relate to the longer term impacts on innovation and entrepreneurship. The previous system of government allocations and tying water to land titles has minimized the choice constraints that face farmers. Economists expect that more competitive systems foster greater independence and innovation, leading to economic growth. One of the economic criticisms of providing subsidies is that it tends to reward poor performance, creating perverse incentives to maintain the status quo. Industries that receive subsidies tend the 'farm the government' in efforts to maintain the subsidy flow (Godden 1997).

Some evidence of the gains in innovation and entrepreneurship come from a comparison of irrigation areas in Queensland. The irrigation schemes at Emerald and the Atherton Tableland are approximately equivalent in size. Allocations from the Fairbairn Dam at Emerald are 189,000 ML/annum compared to 161,000 from the

However, while the Emerald irrigation area has about 100 water users, with approximately 30 major farmers, the Atherton Tableland region has over 1000 water users and more than 900 farmers. The Emerald Irrigation Scheme was set up nearly 100 farms, but the unviability of some crops and several downturns in the cotton market has meant that a number of original farmers were forced to sell out. Prices fell low enough for neighbours to be able to purchase additional farms, with the end result that most of the remaining farmers hold two or three farms. While the Atherton Tablelands region has also been through several slumps (especially the shrinking of the tobacco industry), there has never been the same level of consolidation.

While there are a number of differences between the regions, a key one appears to be that government support programs in the Atherton Tableland (and other sugar cane regions) have reduced incentives for restructuring to occur. The restructuring that did occur in the Emerald region allowed surviving farmers to achieve larger scale efficiencies, and has generated substantial resilience and innovation. It is also possible that the differences between the regions are partly explained by the farmer characteristics. Irrigation farming at Emerald has only developed since the 1970s, so farmers may have been well aware of other opportunities and prepared to exit the area.

Windle, Rolfe and Donaghy (2004) report a choice modeling experiment to explore the diversification choices that sugar growers might accept. Growers in the Mackay-Proserpine and Bundaberg regions were offered a series of choice sets, each containing six diversification options. The diversification options were described in terms of the level of return, cost, risk and management effort. The answers given in the choice sets were analysed with both nested and multinomial logit models to identify how the respondents traded off the different attributes.

Results showed that two-thirds of growers in the Mackay and Proserpine regions would not select any diversification options, and would rather continue growing cane. For those who were prepared to diversify, the preferred options were horticulture and small crops where it is relatively easy to move back into sugar cane if better prices return. In contrast, growers in the Bundaberg region where there is already more experience in diversification were much more likely to be prepared to select diversification options. The results indicate that familiarizing farmers with tradeoff options has a major impact on their ability to make diversification and other structural choices. This gives indirect support to the concept that engaging farmers with competitive water markets will generate more entrepreneurial behaviour. There is also a cautionary lesson that there may be slower takeup of trading opportunities in some areas where farmers are not in an entrepreneurial mindset.

6. Conclusions

Water markets are becoming more common in Australia as competitive trading systems are being introduced to various irrigation districts. The economic arguments for allocating resources through market-like mechanisms are very strong. The key advantages include an increase in net returns (surpluses) to society, better incentive structures for participants in water markets, better allocation mechanisms for scarce resources, and a transparent signaling (price) mechanism. The incentives that water markets create include better exit signals for less productive performers, as well as more flexible opportunities for new developments.

There is a range of international evidence that suggests firstly that competitive market mechanisms are being more widely applied to allocate water resources in a number of countries, and secondly that substantial efficiency gains are being recognized.

While there are no direct studies available in Queensland of the benefits of water trading, evidence can be presented about potential benefits in three main areas. The first reflect the advantages of shifting water between sectors, from low value use to high value use. This is the argument usually presented in favour of water markets. The second area reflects the opportunities to trade within sectors, where heterogeneity between farmers creates differences in marginal productivity. The third relates to longer term impacts, where the interface of farmers with competitive factor markets is more likely to generate innovation and entrepreneurial behaviour.

References.

Archibald, S.O. and Renwick, M.E. 1998 "Expected transaction costs and incentives for water market development", in K.W. Easter, M.W. Rosegrant and A. Dinar (eds) Markets for Water: Potential and Performance, Kluwer Academic Publishers, London.

Beare, S. and Heaney, A. 2002, *Water Trade and the Externalities of Water Use in Australia – Interim Report*, ABARE paper for Natural Resource Management Business Unit, AFFA, Canberra, August.

Briggs-Clark, J., Menz, K., Collins, D. and Firth, R. (1986*) A model for determining the short term demand for irrigation water*, BAE Discussion Paper 86.4, AGPS, Canberra.

Bourne, A., Ferguson, J., Johnston, W. and MacLeod, N. circa 1999, *Central Queensland Horticultural Crops Gross Margins 1997/98,* Queensland Department of Primary Industries, Central Queensland.

Boyce Chartered Accountants, 2001 *Australian Cotton Comparative Analysis*, Cotton Research and Development, Narrabri, NSW.

Crouter, J. 2003 "A water bank game with fishy externalities", *Review of Agricultural Economics*, 25(1):246-258.

Department of Natural Resources (DNR) 1998 State Water Projects Yearbook 1997-98, Brisbane.

Department of Natural Resources (DNR) 1999 State Water Projects Yearbook 1998-99, Brisbane.

Donaghy, P. 1995a "Citrus production in the Central Highlands", *Information Series QI96011*, Queensland Department of Primary Industries, Brisbane.

Easter, K.W., Rosegrant, M.W. and Dinar, A 1998 "Water markets: transaction costs and institutional options", in Easter, K.W., Rosegrant, M.W. and Dinar, A. (eds) *Markets for Water: Potential and Performance*, Kluwer Academic Publishers, London.

Godden, D. 1997 *Agricultural and Resource Policy: Principles and Practices*, Oxford University Press, Melbourne.

Hearne, R.R. 1998 "Institutional and Organizational Arrangements for Water Markets in Chile", in K.W. Easter, M.W. Rosegrant, and A. Dinar, (eds) 1998 *Markets for Water: Potential and Performance*, Kluwer Academic Publishers, London.

Hearne, R.R. and Easter, K.W. 1998 "Economic and financial returns from Chile's water markets", in K.W. Easter, M.W. Rosegrant, and A. Dinar, (eds) 1998 *Markets for Water: Potential and Performance*, Kluwer Academic Publishers, London.

Horbulyk, T.M. and Lo, L.J. 1998 "Welfare gains from potential water markets in Alberta, Canada", K.W. Easter, M.W. Rosegrant, and A. Dinar, (eds) 1998 *Markets for Water: Potential and Performance*, Kluwer Academic Publishers, London.
Industry Commission 1992 *Water Resources and Waste Water Disposal*, IC Report Number 26, AGPS, Canberra.

ONECG, 2001 *Indicative Economic Impacts of Additional Water Infrastructure in the Burnett Region*, Report prepared for the Burnett Water Pty Ltd, Queensland Government. Available at: http://www.burnettwater.com.au/pdf/eco_report.pdf

Rolfe, J.C. 1998 "Agricultural Demands and the Pricing of Irrigation Water", *Central Queensland Journal of Regional Development*, 5(4):38-49.

Rolfe, J.C. 2004 "Assessing demands for irrigation water in North Queensland", Agribusiness Review, Vol 12. Available at www.agrifood.info/Review/2004V12/Rolfe.htm

Roth, A.E. 2002 "The economist as engineer: game theory, experimentation and computation as tools for design economics", *Econometrica*, 70(4):1341-1378.

Smith, D.I. 1998 *Water in Australia: Resources and Management*, Oxford University Press, Melbourne.

Tsur, Y., Roe, T., Doukkali, R. and Dinar, A. 2004 *Pricing Irrigation Water: Principles and Cases from Developing Countries*, Resources for the Future, Washington DC, USA.

Whitten, S. 2003 *Water Property Rights and Water Management in the Fitzroy Basin*, report prepared for Central Queensland University and the Central Highlands Regional Resource Use Planning Cooperative, Emerald.

Windle, J., Rolfe, J. and Donaghy, P. 2004 "Diversification Choices in Agriculture: A Choice Modelling Case study of Sugarcane Growers", paper presented at the 48th Annual Conference of the Australian Agricultural and Resource Economics Society, Melbourne, 11-12th of February.

Appendix 1. Gross Margin analysis for Cotton Production in the Central Highlands, Queensland Prepared by Graham Spackman and Associates, Agricultural Consultants, in 2002.

INCOME:					$/HA
PRICE	450	$/bale (gro ss)			
less ginning cost (over & above seed return)	10	$/bale			
plus seed return	0				
less downgrading	0	$/bale			
less cartage costs:					
- module pick-up fee	60	$/module			
- no. bales/module	22				
- distance to gin	70	km			
- cartage cost	2.40	$/km			
-Total cartage cost			10.36	$/bale	
ON-FARM PRICE			430	$/bale	
YIELD	8.0	bales/ha			
GROSS INCOME					**3437**

EXPENSES: CONVENTIONAL COTTON							
Machinery operations (fuel, oil, repairs, maintenance)							
Centre-bed plough			1	@	8.00	$/ha	8.00
Triple disc hiller			1	@	8.00	$/ha	8.00
Roller			1	@	6.00	$/ha	6.00
Cultivation			1	@	6.00	$/ha	6.00
Planting			1	@	8.00	$/ha	8.00
Boomspray			1	@	6.00	$/ha	6.00
Stalk pulling/mulching			1	@	75.00	$/ha	75.00
Inter-row cultivation			2	@	6.00	$/ha	12.00
Fertilise/re-shape beds			1	@	8.00	$/ha	8.00
Rota-buck			4	@	1.00	$/ha	4.00
Seed			13	kg/ha	4.50	$/kg	58.50
Irrigation							
Water charges			8	ML/ha	25.00	$/ha	200.00
Pumping costs			0	ML/ha	12.00	$/ML	0.00
Fertiliser							
DAP			200	kg/ha	475.00	$/tonne	95.00
Muriate of potash			100	kg/ha	386.00	$/kg	38.60
Urea			400	kg/ha	440.00	$/kg	176.00
Triple 7			3	L/ha	4.00	$/L	12.00
Herbicide							
Fallow spray	100	% band	2	L/ha	5.00	$/L	10.00
Cotogard	40	% band	4.5	L/ha	11.56	$/L	20.81
Stomp	0	% band	4.5	L/ha	7.80	$/L	0.00
Cotoran	0	% band	4	L/ha	11.56	$/L	0.00
Diuron	80	% band	2	L/ha	6.37	$/L	10.19
Staple	35	% band	100	g/ha	1.17	$/g	40.95
Trifluralin	100	% band	2.3	L/ha	6.45	$/L	14.84

Other				% band	0	L/ha		$/L	0.00
Herbicide applic. cost			Aerial		0	No.	11.00	$/ha	0.00
Herbicide applic. cost			Ground		3	No.	5.00	$/ha	15.00
Insecticide									
Total insecticide	ticide		.				560.00		560.00
Growth regulant									
Pix	2	No.sprays	100	% band	0.5	L/ha	41.00	$/L	41.00
Defoliant									
Dropp WP	2	No.sprays	100	% band	50	g/ha	306.06	$/L	30.61
Prepp	2	No.sprays	100	% band	1	L/ha	19.58	$/L	39.16
DC-Tron Cotton	2	No.sprays	100	% band	2	L/ha	1.83	$/L	7.32
Salt	0	No.sprays	100	% band	17	L/ha	1.15	$/L	0.00
Other		No.sprays		% band		L/ha		$/L	0.00
TOTAL CHEMICAL COST									**775**
Insecticide/defoliant applic. cost			Ground		5	operations	11.00	$/oper'n	55.00
Insecticide/defoliant applic. cost			Aerial		7	operations	11.00	$/oper'n	77.00
Chipping							25.00	$/ha	25.00
Hail insurance							25.00	$/ha	6.00
Scouting (inc. plant mapping, exc. water scheduling)							55.00	$/ha	55.00
TOTAL PRE-HARVEST COSTS									**1714**
Interest on pre-harvest growing costs					5	mths @	9.00	% p.a.	64.27
Harvesting									
Contract harvesting							300.00	$/ha	
Own harvester (operating	costs only)						0.00	$/ha	
Percentage harvested by contractor							100.00	%	
Hire of module-maker							0.00	$/module	
Fuel					20	L/ha	0.40	$/L	8.00
Sundry - tarps etc							20.00	$/ha	20.00
TOTAL HARVESTING COSTS									**328.00**
Additional labour			200	ha grown	20	no. days	120	$/day	12.00
TOTAL VARIABLE COSTS									**2118**
GROSS MARGIN									**1319**
GROSS MARGIN $/ML									**165**

Appendix 2. Example Choice Set

Question 19a: Carefully consider each of the following 7 options. They relate to ONLY A PART of your farm. Suppose these were the ONLY options available, which would you choose?

Please indicate which option you prefer – Tick one box only

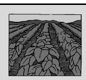
- ☐ **Option 1 – keep growing sugarcane**
- ☐ **Option 2 – beef cattle**
- ☐ **Option 3– tree crops**
- ☐ **Option 4 – horticulture (annual)**
- ☐ **Option 5 – horticulture (non-annual)**
- ☐ **Option 6 – field crops**
- ☐ **Option 7– forestry**

Option 1 – keep growing sugarcane	
Start-up costs ($/ha)	**0**
Production costs ($/ha)	**1500**
Risk (yrs at/below costs)	*2 out of 10*
Management effort	**Standard**
Net annual income ($/ha)	**700**

Option 2 – beef cattle	
Start-up costs ($/ha)	**450**
Production costs ($/ha)	**85**
Risk (yrs at/below costs)	**2 out of 10**
Management effort	**40% less**
Net annual income ($/ha)	**100**

Option 3 – tree crops	
Start-up costs ($/ha)	**20,000**
Production costs ($/ha)	**25,000**
Risk (yrs at/below costs)	**6 out of 10**
Management effort	**60% more**
Net annual income ($/ha)	**5,000**

Option 4 – horticulture (annual)	
Start-up costs ($/ha)	**1,000**
Production costs ($/ha)	**10,000**
Risk (yrs at/below costs)	**7 out of 10**
Management effort	**30% more**
Net annual income ($/ha)	**3,000**



Option 5 – horticulture (non-annual)	
Start-up costs ($/ha)	**400**
Production costs ($/ha)	**30,000**
Risk (yrs at/below costs)	**4 out of 10**
Management effort	**40% more**
Net annual income ($/ha)	**1,000**

Option 6 – field crops	
Start-up costs ($/ha)	**200**
Production costs ($/ha)	**600**
Risk (yrs at/below costs)	**6 out of 10**
Management effort	**60% more**
Net annual income ($/ha)	**400**

Option 7 – forestry	
Start-up costs ($/ha)	**2,500**
Production costs ($/ha)	**1,000**
Risk (yrs at/below costs)	**2 out of 10**
Management effort	**20% more**
Net annual income ($/ha)	**1,000**