University of South Australia

Centre for Regulation and Market Analysis

Working Paper 2014-01

Transaction costs and agricultural water reallocation

Adam Loch*, Ron McIver* and Dustin Garrick~

*Centre for Regulation and Market Analysis,
School of Commerce, University of South Australia, Adelaide Australia.
~McMaster University, Hamilton Ontario, Canada.

University of South Australia

Centre for Regulation and Market Analysis

Formed in 2003 and comprising a multidisciplinary team of researchers, the Centre for Regulation and Market Analysis (CRMA) specialises in research that is centred on the behaviour of markets and market participants, including consumers, firms, governments and regulators. Through its research, the CRMA aims to provide policy-relevant assessments of markets that have national, regional and international applications.

The work of the CRMA spans regulatory and other applied microeconomic and macroeconomic topics in Australia, New Zealand, Asia and Europe. At the core of the CRMA's research focus is the analysis of the operation of markets. Our research examines factors affecting market competition; the regulation of markets; the protection of consumers within markets; and the legislation that shapes and influences market outcomes. A key aspect of this work is examining the institutions and policies that effect market efficiency and equity, regardless of the type of market or its location. Within this broad framework a number of key research themes are pursued by Centre members including, but not limited to, competition, regulation (macro and micro), consumer protection; water market research; and business history.

For further information regarding the CRMA, please email crma@unisa.edu.au.

Transaction costs and agricultural water reallocation

Abstract

Governments have targeted irrigated agriculture water to satisfy social demands for environmental flows to sustain river basins. The reallocation of water from agricultural to environmental managers can be achieved through various management interventions, each suited to specific river basin and political contexts. There are multiple institutional options to reallocate water - market; regulatory; and legal - which are usually combined in practice. Within any set of institutional frameworks transaction costs may impede desired changes in water allocation and use patterns. Changes to these institutional options will incur transition costs, a specific form of transaction cost associated with a shift from the status quo to a new governance arrangement. Frameworks that account for transition and other transaction costs may therefore improve selection of water reallocation intervention policies in political and competitive settings. However, the use of such transaction cost-based frameworks remains rare. This paper utilises a recently developed transaction cost analysis framework to provide a comparison of the institutional arrangements employed for water reallocation in Australia's Murray-Darling Basin. Using expert interviews with environmental water managers we identify expected magnitudes of transition and transaction costs associated with major water reallocation options. Water leasing is identified as a no-regrets option (relatively low transaction costs, and preserving future flexibility) while water infrastructure investment represents an example of policy solution at the opposite extreme (relatively high transition costs and high lock-in risk).

Keywords: agricultural water reallocation, transaction costs, transition costs, economic analysis

1. Introduction

Institutions to promote the efficient and sustainable reallocation of water resources across competing demands represent a high priority for many multi-jurisdictional river systems. This is especially so given existing climatic variability and the anticipated effects of climate change on water supply (e.g. IPCC, 2012). For such reasons there is growing international interest in principles to design effective institutional arrangements that reallocate water across human and environmental needs through markets (Garrick et al., 2011), infrastructure capital investments (Saleth et al., 2011) or multi-level river basin management (Garrick et al., 2012).[1] Australia's Murray-Darling Basin (MDB) provides an example of a large river system within a federal political context where market recovery, infrastructure investment and multi-level management arrangements constitute a set of institutional options used to encourage sustainable agricultural (e.g. irrigation) water reallocation toward social welfare and environmental sustainability gains (Loch et al., 2014). By 2024 the Australian government has committed to reallocating roughly one-quarter of MDB irrigated agricultural water use to sustain environmental flows (DSEWPC, 2012). The management and application of these environmental flows will involve institutions that promote adaptive learning over time (CEWH, 2011b).

Ideally, institutions to achieve sustainable agricultural water objectives should involve programs where targeted benefits exceed costs (NWC, 2012). Complete cost assessments should integrate transaction costs—those resources required to define, manage and transfer property rights in natural resources (McCann et al., 2005). However, traditional benefit-cost analysis typically excludes assessment of transaction costs (Thompson, 1999). This is despite many authors having identified the advantages of transaction cost assessments (TCA) in natural resource settings (e.g. Challen, 2000), and more specifically the MDB context (Loch and McIver, 2013, Garrick et al., 2012). Transaction costs may impede otherwise desired

[1] Multi-level management involves formal and/or informal arrangements between national, state and local/regional parties to provide appropriate sustainable water use objectives.

shifts in water reallocation, and their nature and sources are a substantial knowledge gap in the Australian water market literature. Consequently, TCA frameworks may assist in the identification of more suitable (i.e., cost-effective) public policy arrangements for sustainable agricultural water reallocation. In this way TCA may complement and/or supplement traditional benefit-cost analyses, in which the larger context of benefits and costs associated with water reallocation alternatives might be considered.

Garrick, *et al.* (2013b) develop a TCA framework to examine the evolution and performance of water markets and reallocation policy reforms. This framework examines the interaction of *transition* costs and other *transaction* costs across multiple phases of market-enabling policy reform. In our paper we adopt this TCA framework to address three questions on the costs of MDB sustainable agricultural water reallocation intervention approaches: i) how TCA can inform the selection of reallocation institutions; and ii) what are the likely relative magnitudes of transition and transaction costs across those alternative institutional options; and iii) what are the transaction costs associated with achieving water recovery objectives in the MDB? Accounting for and explaining transaction costs associated with potential reform alternatives improves identification of program design principles to address these barriers through comparative analysis of reallocation options within an integrated cost-benefit framework (Marshall, 2005, Marshall, 2013, McCann et al., 2005, Ofei-Mensah and Bennett, 2013, Garrick and Aylward, 2012, Garrick et al., 2013b). In our analysis all three reallocation options are analysed. However, rather than examine the benefits generated per dollar invested in each option, our evaluation examines the least-cost path to deliver each unit of water for the environment. This helps determine which option is most effective for achieving the next unit/s of water recovery as part of the ongoing reform process. Our exploratory TCA-focused analysis therefore illustrates how this outcome may be achieved to support policy evaluation by agricultural and environmental water managers, meeting calls for integrated policy/transaction cost assessment. Small-scale expert interview evidence is presented to shed light on likely relative magnitudes of static transaction cost and institutional transition cost alternatives.

2. Transaction costs and the TCA framework

Transaction costs arise in the search, bargaining and enforcement of property rights governing natural resources (Coase, 1960). Effective and efficient reallocation of property rights is often constrained by a range of legal, social, economic and physical barriers (Bjornlund, 2004, Garrick and Aylward, 2012). Any proposed MDB water reallocation arrangements must account for the impact of current policy choices on the cost of future adjustments; that is, the risk of lock-in costs associated with diminished institutional flexibility (Marshall, 2013, Challen, 2000, Garrick et al., 2013a). This is due to the fact that MDB water reallocation options are affected by prior investments (Watson and Cummins, 2010, Harris, 2011) that reduce institutional flexibility (Challen, 2000, Crase, 2012). Therefore, a thorough TCA of proposed MDB water reallocation options may highlight important information about barriers to water reallocation, and help evaluate possible reform alternatives to address those barriers. Comparing and evaluating expected future arrangements from a transaction cost perspective may also assist water planners and managers to achieve more cost-effective and adaptive policy design.

2.1 TCA approaches

With TCA the following general proposition applies: institutional structures possessing transaction cost-economising properties will eventually displace those with greater frictions. This may not occur when economising would result in the loss of valued objectives by one of the parties to a transaction, such as political power or gain (Williamson, 1981). Such objectives are of particular interest in the context of state versus federal control under the proposed MDB Plan arrangements, and will be discussed later in our paper.

Future MDB water reallocation arrangements should ideally aim to minimise the costs incurred to achieve a given level of benefit (Crase et al., 2013, Marshall, 2013). Conceptual typologies of transaction costs (e.g. McCann et al., 2005) assist identification of relevant transition/transaction costs and associated quantitative metrics, facilitating the assessment and measurement of MDB water reallocation transaction costs (Marshall, 2013, Garrick et al., 2013b).

2.2 The TCA framework

The TCA framework (Garrick et al., 2013b) is an extension of previous initiatives to establish transaction costs typologies and theories of transaction costs and institutional change in the environmental policy context (Marshall, 2005, McCann et al., 2005, Marshall, 2013). These approaches have been adapted to a water reallocation context, establishing three broad classes of transaction costs (Challen, 2000):

a) **Institutional transition costs refer to the costs of institutional change.** For environmental water programs these would include new delivery works and measures; modification of existing works and measures; adjusting licencing systems to account for environmental water; adopting new trading rules; conducting tenders to establish acquisition prices; and developing new water accounting systems.

b) **Static transaction costs refer to the costs of implementation:** Once a program is established there will be annual costs to implement each environmental water reallocation option. These implementation costs include resources associated with identifying water acquisition targets; identifying willing sellers; conducting administrative review; conducting due diligence (including titling fees); monitoring and reporting; and dispute resolution.

c) **Institutional lock-in costs refer to constraints imposed on future adjustments.** These costs can be conceived as a loss in the quasi-option value associated with institutional flexibility.

Table 1 expands these categories for environmental policy and water reallocation purposes. The framework assesses: the relevant types of transaction costs and their interaction over time; the inter-temporal trade-offs between short-term and long-term impacts of institutional change; the distribution of transaction costs across parties and time; and long-term capacity to adapt as preferences, information etc. change (Garrick et al., 2013b). We apply the TCA framework to: identify and compare the relative magnitude of different types of transaction costs across different reallocation options; identify requirements for future investment in institutional transition or static transaction cost areas; and determine comparative differences between institutional approaches to water reallocation in the MDB.

Table 1
Categories of transaction costs (**Source**: Garrick *et al.* (2013b), used with permission)

Collective action	**Environmental policy**	**Market-based water allocation**
Institutional transition costs	Research and information	River basin development, planning and closure (cap) Hydrologic and socioeconomic studies
	Enactment or litigation	Water rights reform (adjudication, conflict resolution, rules) Establish or reform water user associations
	Design and implementation	Modification to storage and distribution Licensing systems Trading rules and registries Price discovery (auctions / tenders / brokerages) Water accounting systems
Static transaction costs	Support and administration	Transaction planning Identification of buyers / sellers Administrative review (e.g. injury analysis)
	Contracting	Water rights diligence
	Monitoring and detection	Water use accounting
	Prosecution and enforcement	Compliance monitoring and enforcement Dispute resolution
Institutional transition costs (future)	Adaptation or replacement	Revise cap; adapt water rights and water user association rules; acquire water rights for the environment if cap is revised downward

Our application of the TCA framework was implemented via expert interviews of administrators working in the area of environmental water management at various governance levels in the southern MDB. The MDB (Figure 1) offers an interesting context for the application of TCA.

Fig. 1. The Murray-Darling Basin (MDBA, 2012)

The Basin has undergone comprehensive water reform since issues of scarcity, pollution and competition became apparent, particularly since the late 1980s. New commitments to environmental sustainability coincided with prolonged drought to accelerate and deepen the reforms, particularly to return basins to sustainable levels of extraction (COAG, 2004). The full nature of historical water reform issues is beyond the scope of this paper (for a comprehensive and useful review see Crase (2012)). However, the federal government and its key river basin agency, the Murray-Darling Basin Authority (MDBA), have made significant financial investments to implement water reallocation policy, planning and institutional arrangements.

3. Expert interview methodology

The objective of the expert interviews was to establish the value of the resources (e.g. staff costs, new data management systems, etc.) associated with the design and implementation of MDB water recovery programs from environmental water managers in each of the main jurisdictions of the Basin. Delphi-based studies typically use expert feedback to obtain a reliable group opinion in order to resolve complex problems (Landeta, 2006). These initial responses offer a baseline for ongoing research that will be used to inform planned future research involving a larger sample of MDB water managers and participants. Consistent with Delphi approaches, our expert interview approach will be updated and experts' views revisited to improve their accuracy and precision as part of a longitudinal study.

3.1 Expert interviews and analysis

For expert interviews, we identified 12 expert environmental water managers associated with the MDB. These managers were drawn from a set of organisations spanning federal and state authorities and so associated with different levels of governance. The selection also ensured that the participants captured multiple management levels (junior and senior staff) in terms of their administrative roles. A direct approach was made to each expert, resulting in seven interviews. Of these, one incomplete interview response had to be discarded. However, useable responses were received from each state as well as from managers involved in federal and local environmental watering programs, providing coverage of relevant perspectives. The expert interview data was combined and qualitative comments and these responses were used to clarify drivers of opinions and issues associated with cost-estimates.

Experts provided their opinions through an electronic survey instrument. Following the TCA framework outlined above, two cost categories formed a basis for the instrument:

1. **Transition costs** reflect any new or modified institutions, works and measures required to transform existing arrangements toward the new environmental water recovery and delivery objectives.
2. **Transaction costs** reflect the subsequent expenses required annually to implement the environmental water recovery and delivery programs, both while transition toward the new arrangements takes place and following completion of the transition.

For each of these categories, experts were asked to indicate their opinion regarding the likely costs associated with: water leasing/purchasing; capital infrastructure investments; and Basin planning and management (Figure 2). These three options are detailed below.

1.1 Construction of individual new water storage or delivery works (e.g. new environmental works and measures)		**A** Leasing/buying environmental water	**B** Capital infrastructure investment	**C** Planning by state and basin managers
	0-$100k	☐	☐	☐
Additional comments: Click here to enter text.	$101k–$500k	☐	☐	☐
	$501k–$1m	☐	☐	☐
	$1.1–$10m	☐	☐	☐
	$11–$100m	☐	☐	☐
	$101–$250m	☐	☐	☐
	$250m+	☐	☐	☐
	Other (please comment)	☐	☐	☐

Fig. 2 Example expert survey question

3.2 MDB water reallocation options

Following numerous trials of programs to encourage MDB water reallocation to environmental uses, the ‘Millennium Drought’ between 1998/99 and 2009/10 provided significant political incentives for wider federal intervention. Intervention to reallocate water involved three major options: i) water purchasing/leasing through established markets; ii) infrastructure capital investments; and iii) river basin planning and management.[2] These reallocation options are not being trialled in isolation, but provide a basis for the alternative approaches compared in our exploratory TCA approach. TC analysis provides insight into the most effective options and the potential priorities for the next wave of water recovery which will involve around 1000 to 1500 GL given reported water reallocation achievements to 30 September 2013 (DSEWPC, 2013).

Water purchasing/leasing

Government purchasing of water rights in the MDB has accelerated proprietary and physical reallocation of water to environmental agents. For example, the *Living Murray* (TLM) program recovered approximately 786 GL of water rights between 2003/04 and 2008/09 (MDBA, 2009).[3] Subsequent federal purchasing from 2008/09 to December 2012 via *Restoring the Balance* (RtB) tenders recovered an estimated 1,117 GL of long-term average annual water yield. A barrier to further market purchasing has been political reluctance to engage in additional entitlement recovery unless it is more strategic, favouring smaller occasional market purchasing rounds instead (Australian Parliament, 2011), which have slowed the recovery process. In the interim, it has been suggested that significant environmental gains could be achieved from the occasional leasing of water to augment delivery volumes (Wheeler et al., 2013). Seasonal water leasing may provide flexible water supplies and enhanced environmental outcomes through better flow demand-supply matching (CEWH, 2011a, Connor et al., 2013, Tisdell, 2010).

Analogously, Australian agricultural water managers commonly use formal and informal water trades to manage risk positions within and across seasons (Connor and

[2] Infrastructure expenditures are transformation costs, not transaction costs, but see Hearne 1995 (as cited in Garrick et al 2013b). However, the costs incurred in policy development and implementations are the focus here.
[3] TLM programs recovered 988 GL of entitlements in total, representing 480 GL of long-term reliability water (MDBA, 2013). However, TLM recovered water does not contribute to meeting current Basin Plan sustainable diversion limit (SDL) objectives.

Kaczan, 2013). Water managers in the western U.S. (Wheeler et al., 2013, Garrick et al., 2011) and Chile (Bauer, 2004) also tend to favour seasonal water trade over permanent transfers, as the former involve relatively lower transaction costs. Seasonal water trade in the MDB would allow environmental agents to dispose of surplus water stocks, as long as sustainable objectives weren't disadvantaged by such action. Profits from such trade could support the purchase of seasonal water in dry periods and/or the recovery of additional water rights for environmental benefit (Wheeler et al., 2013). It is probable that seasonal trade of water into the market would take place after significant high-flow events when the allocation market would be well supplied, and (relatively low) prices would reflect this (Connor et al., 2013).[4]

Infrastructure capital investments

Public investment in water storage and delivery infrastructure capital forms a significant part of past and present water reallocation programs. The objective of this investment is to improve the efficiency of: existing major storage/delivery capital works (e.g. dam and head-work structures); on-farm capital works (e.g. irrigation technology and practices); and new capital works projects (e.g. improved environmental watering arrangements) to generate water savings that can then be shared among users, including the environment. Estimated water savings to date from capital works investments in the MDB (214 GL) have improved progress toward the proposed Basin Plan sustainable diversion limit (SDL) target of 2,750 GL, leaving 1,419 GL of additional water to be reallocated by 2019 (DSEWPC, 2013).[5] Although significantly more costly on a per/megalitre basis, the impetus for capital works investment may stem from a political desire to boost rural employment and economic welfare, or perceived support from irrigation groups for public subsidisation of

[4] The nature of the MDB system is such that flood events take time to pass through. Therefore, under a seasonal (allocation) trade structure there would presumably be time to identify the inflow points, relevant environmental sites to be targeted and potential sources of allocation water. Adaptive management strategies could then be utilised to evaluate how best to apply the water and match that to a purchasing agenda.

[5] The final Basin Plan sustainable diversion limit will be expanded to 3,200 GL by 2024 through the incorporation of additional funding that addresses water delivery and efficiency constraints in MDB river systems (DSEWPC, 2012).

irrigation works (Loch et al., 2014). Public subsidies have often been provided to irrigators to motivate investment in Australia (Qureshi et al., 2011, Adamson and Loch, in press). However, private surpluses from infrastructure investment (i.e. economic rents) may result if irrigator financial contributions and full-cost recovery pricing are not factored into the program (Cooper and Crase, 2013), or where reliability of supply and water entitlement market value increases are generated from environmental buyers paying inflated prices (Cox and Warner, 2009).

A particular concern associated with this approach to water recovery is lock-in costs. For example, spatial changes in rainfall or run-off patterns may also reduce the cost-effectiveness and efficiency of these projects. Further, such locked-in capital investments may be difficult to correct if the proposed/assumed environmental benefits fail to eventuate where technical efficiency or loss (e.g. seepage or evaporation) reduction expectations are not met (Quiggin, 2006). They may also reinforce the vested interests of irrigation communities who will resist necessary structural adjustments as agricultural productivity and water availability change. We expected expert interviews to reflect some of these issues, but not to take them into account when offering cost-level estimates given the mix of existing capital works upgrades/new capital works projects under consideration in the pursuit of environmental water recovery and management objectives.

Basin planning and management

Scale and scope issues associated with MDB environmental sites, diverse ecosystems and environmental outcome provision require multilateral (complex) exchanges, suggesting that central (federal government) management of MDB environmental water assets may not provide effective or cost-efficient sustainable outcomes from reallocation (Young, 2010). River planning and management arrangements arising from state legislation (e.g. the *Victorian Water Act* 1989) address some of these issues through rules-based arrangements to identify, deliver, monitor and enforce key environmental flows. However, it is often difficult to determine whether state rule-based arrangements are meeting national objectives (NWC, 2011a). Further, given the mix of regulatory, operational and commercial roles undertaken, there is potential for conflicts of interest among state and federal institutions, between the states themselves, and across intrastate institutions (Van Bueren, 2012).[6]

As a consequence of these arrangements, various state and catchment management authorities (CMAs) have been created to deliver water planning and management requirements. Devolution of environmental management between federal, state and CMA agents might provide low-cost access to environmental site information with time and place advantages, reducing delivery of environmental outcomes to less complex and costly exchanges (Garrick et al., 2012). In addition, innovative approaches to land and water management at local levels could deliver greater environmental benefits from held water entitlements (Young, 2010). As part of an integrated approach to effective water reallocation, an expansion of existing river basin planning arrangements toward more effective river basin management could provide significant environmental benefits across local, regional and national scales.

Our analysis of the interview data from this institutional context considers the relative magnitude of the transition/transaction costs from the expert opinions gathered. It also analyses whether the reallocation options outlined above constitute: (cost) effective institutions; strategic investments in institutional transition cost; and institutional lock-in cost minimisation approaches. Results are discussed in the next section.

4. Results and Discussion

The contribution of the comparative analysis drawn from the interview responses lies in identifying the likely relative magnitudes of transition and transaction costs across the three

[6] An example might be the risk of institutional capture, where collusion between parties could lead to the release of water to benefit specific interests ahead of optimal environmental or social gains.

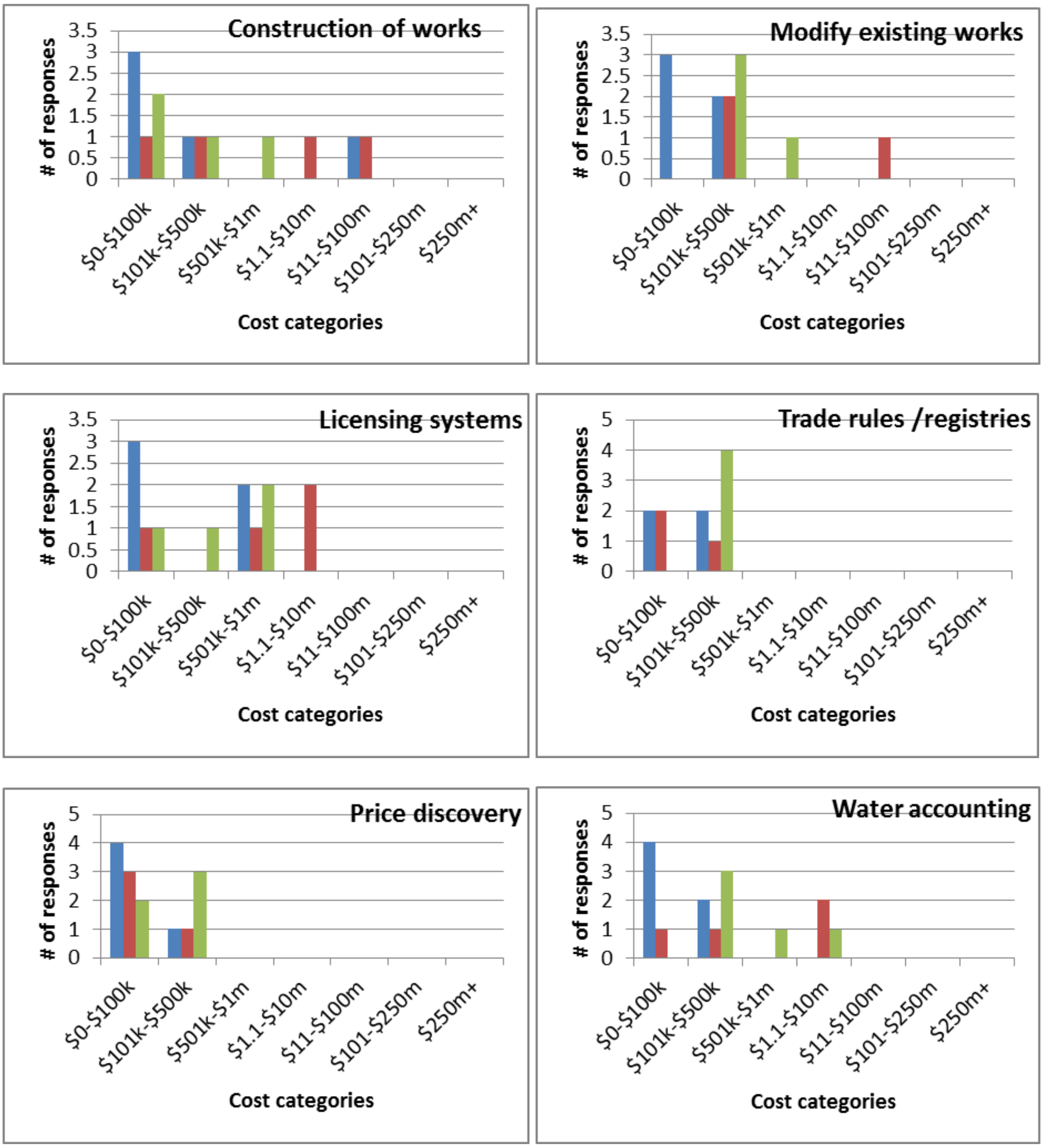
MDB reallocation options. As discussed previously, a full policy comparison would consider issues of incidence across stakeholders (e.g. Loch et al., 2012), as well as consideration of a full range of transformation costs and benefits. Instead, we hold the level of benefits constant and explore the costs incurred to achieve incremental recovery efforts in the MDB.

The summary of the interview responses presented in Figure 3 (transition costs) and Figure 4 (transaction costs) offer a useful illustration of our experts' views on the relative cost magnitudes of the programs identified in the survey. Our discussion of these results begins with consideration of the transition costs results then considers those relating to those costs categorised as transactions costs.

4.1 Transition cost results

Expert opinion about the relative magnitude of the different transition cost revealed that water purchasing/leasing requires relatively lower levels of expenditure, with successively higher costs being associated with basin management/planning and then capital investment program alternatives. However, when grouped by absolute level of cost, expert estimates of costs display a similar distribution across the three options (i.e. leasing, planning and capital). Comments received in association with the survey help to explain some of these views.

An important insight from the interview comments is that the experts find it difficult to separate costs across the different options. This reflects that they rightly view the options as interconnected approaches, rather than as mutually exclusive alternatives. Capital works greater than AUD100,000 were identified by one expert as constituting major projects for government departments, with budgets and timeframes spanning several years dependent on their scale and scope. Concerns about the accuracy of estimated water savings, externalities from increased works, and expensive reforms to rights over the longer-term could also drive costs higher.



Legend: Market options; Capital options; Planning options

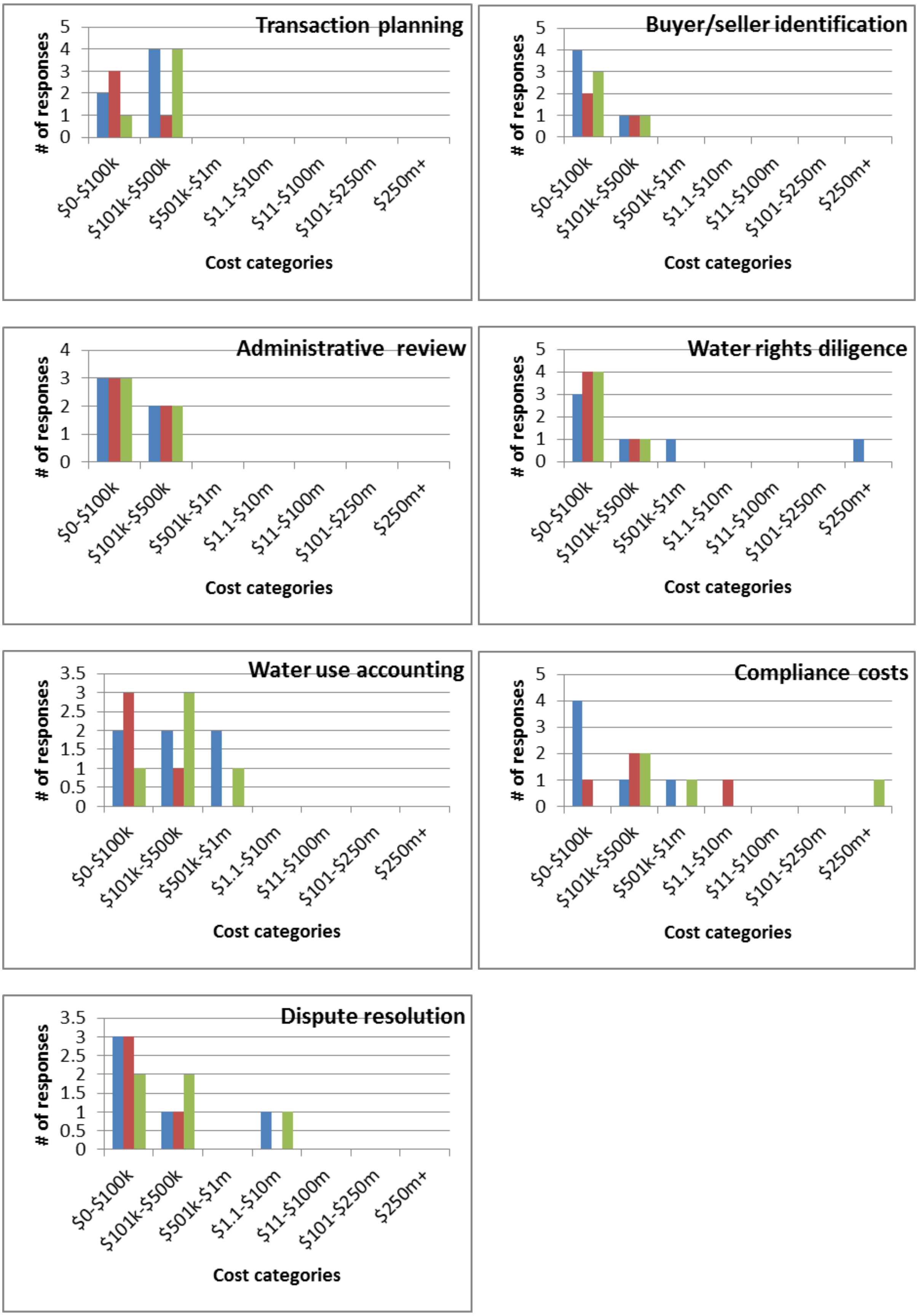
Fig. 3 Transition cost comparison across expert opinion responses

Larger transition costs might also result from efforts to identify and assess suitable capital project sites on the basis of potential savings and feasibility of implementation under diverse MDB contexts and over time. Similarly, the large (AUD11 to 100 million) transition cost reported for water markets reflects current water purchasing conducted to meet complex MDB desalination agreement requirements over a number of years.

Agricultural water user participation in seasonal trade can approximately double in some MDB trade areas during dry periods (Wheeler et al., 2009). Where this occurs, moderate transaction costs may be incurred over time though investments to assist trade registries and water accounting systems to cope with added government intervention. Illustrating this issue, license, registry and trade rule adjustments were typically reported by our experts as requiring substantial investments where existing systems are altered to accommodate current and future environmental watering objectives. While the environmental water holder would simply become a new/existing user (like any other) in the licensing and registry system, the trade of environmental water was identified as potentially driving higher transition costs in the future. This is particularly the case if a national system were to be put in place. Additionally, if a new system was instigated, planning transition costs were viewed as easily shifting into higher expenditure categories than reported here. Finally, as a relatively new requirement of the water reform process, water accounting requirements were identified by some experts as a major driver of current transition costs in the AUD500,000 to 10 million cost categories. A substantial proportion of these costs are associated with additional staffing requirements and development of new administrative procedures.

4.2 Transaction cost results

Our interview results suggest that transaction costs associated with the water market and capital works options are viewed by our sample of experts as being of relatively low magnitude (Figure 3). However, planning and management arrangements are expected to require higher levels of investment. As many of the cost areas in this category revolve around planning, administration, monitoring and review, this outcome is consistent with prior expectations.



Legend: Market options; Capital options; Planning options

Fig. 4 Transaction cost comparison across expert opinion responses

Most of the planning transaction costs were viewed by the experts as being associated with the trade of environmental water, particularly at the state government level. However, as a lot of these trade costs were yet to be experienced by some of the expert managers, they found it difficult to gauge the likely magnitude of these types of costs. Buyer/seller identification and transaction review costs were largely seen as having required relatively minor levels of expenditure by state governments to date.

Identification and review costs were also perceived to require relatively low levels of cost compared to water market and capital works program alternatives, possibly with a general expectation of diminishing costs over their expected timeframe to 2024.

Administrative review and monitoring costs might increase where oversight requirements justifying the social value of seasonal trade activity and additional expenditure on water use accounting were driven by an increased volume of water trade between different user groups. It may also be necessary to provide moderately costly support and administrative review arrangements for multi-level-programs: i) during initial contracting and water exchange arrangements; ii) during environmental watering events; and iii) following program implementation to administer incentives to identify innovative and/or flexible management options that benefit future water supply increases, or create incentive-compatible mechanisms. These may result in moderate levels of future static transaction costs, given the expenditure already enacted via the lock-in costs of MDB reforms to date.

Rights diligence costs such as the fees and charges associated with water ownership and use by environmental managers were viewed by our experts as having relatively low levels of cost, reflecting the degree of outsourcing involved. Increased requirements on due diligence may add to the static costs related to expected volumes of environmental water trade, particularly where matching seasonal trade activity to ecological outcomes is an important criterion (Australian Parliament, 2011). Federal funding for the administration of these costs via a special account was cited by one expert at AUD25.5 million for 2013-14, with growth estimated in line with growth in the projected level of the environmental water portfolio. Future cost increases were also viewed by one manager as potentially being met through increased environmental water trade (selling) activity. Conversely, one expert tipped that planning rights diligence transaction costs might actually diminish over time as processes became increasingly automated. Water saving due diligence requirements from the capital works investments undertaken—and likely underestimates of actual project costs (ACIL Tasman, 2008)—might be expected to drive experts relatively higher evaluations for static transaction costs in the capital works option.

Reported transaction costs associated with new accounting/monitoring standard requirements were of similar significance for all three environmental water options. Expenditures in these areas were reported as largely being inadequate at state levels to date, with department staffing and work across state and basin water managers being likely to impose—in some cases relatively large—costs. Compliance and enforcement costs were viewed as an essential component of better managed and organised environmental watering systems. Federal costs were estimated at AUD20 million over five years, including some capital costs in database establishment and development. Again however, a lot of the cost burden was also seen to rest with state departments and water managers being required to monitor and report compliance on specific environmental assets within their boundaries (e.g. Living Murray icon sites or specific wetland areas of international Ramsar significance). The threat of potentially breaching international (e.g. Ramsar) agreements was viewed as involving particularly high transaction costs, requiring not simply financial but also political goodwill and capital to resolve.

Increased lease trade could heighten future state tensions (e.g. premature MDB seasonal interstate trade cessation in recent years due to expanded carry-over transfers (NWC, 2011b)), requiring unexpected dispute resolution investments. However, dispute costs were typically viewed as having limited relevance to the water marketing option and higher relevance with the water planning and management option. Finally, one expert raised the issue of water delivery transaction costs, and where these might feature in the framework. These annual costs were viewed as substantial (i.e. AUD500,000 to 1 million) in their context, and included a significant planning component. We took the view that these should be treated as a capital works option cost and allocated them accordingly.

4.3 Adaptive efficiency considerations

Part of the value in using the TCA framework applied above to develop an exploratory interviews of expert managers on transition/transaction costs comes from the subsequent identification of relative cost differences between water reallocation options. That noted additional value is derived from consideration of adaptive efficiency issues surrounding the three reallocation options identified in the survey.

For instance, lock-in risks associated with the water markets option are considered to be relatively low. This is due to the opportunity to adjust ineffective decisions through further market transactions. Additionally, should future changes to environmental flow provision occur through policy and/or climate change, these requirements could also be accommodated through further (relatively) low cost transactions. Conversely, lock-in risk associated with basin planning and management arrangements arises from the possibility of inter-agency competition through rent-seeking or political point-scoring motives. The potential for lock-in risk has been identified above in the context of basin planning and the use of infrastructure investment to deliver environmental outcomes. However, there is also potential for agencies to use river management information (or its absence), inconsistencies in water rights or use rules, or conflict between stakeholder groups, as a platform to confuse and confound water management outcomes. In the absence of appropriate arrangements to limit principal/agent problems, moderate transaction costs may be incurred to address required deficiencies in management procedures.

Finally, uncertain water saving estimates from infrastructure works, being conditional on the available science, may significantly impact achievement of water reallocation toward sustainable diversion limit (SDL) targets over time. Additionally, it may be argued that infrastructure investment is at odds with the tenets of adaptive management (see Crase (2012)). Notwithstanding this, the National Water Commission argues that adaptive infrastructure approaches may be possible where investments are delayed until the last possible moment, phased-in over time, and/or provide response-time-reduction (readiness) advantages (NWC, 2012). However, where expected recovery targets are not met, the relatively inflexible (and lock-in) characteristics associated with capital works projects will increase compliance costs over time. As a consequence, any necessary future adaptations or replacement of infrastructure will be likely to require significantly higher outlays.

We suggest that water market trade alternatives constitute a no-regrets option, in light of adaptive strategy objectives in the MDB plan, given their low lock-in risk if future adaptation is required. In contrast, capital works investment may require relatively moderate to high levels of transition/transaction costs, putting infrastructure-based approaches at the opposite end of the spectrum to market arrangements, given their higher lock-in risk.

5. Discussion

Analysing the three MDB reallocation policy options via an application of the TCA framework allows several important inferences to be drawn. First, the TCA framework demonstrates potential as a tool for comparing water reallocation strategies where integrated and path-dependent themes offer constraints. Second, in conjunction with data sourced from interviews with experts, the TCA framework can aid in identifying and mapping the relative magnitude of transaction (including transition) costs associated with each option. Third, TCA may be used to highlight potential contradictions between the reallocation options selected and more economically efficient and adaptable choices.

In the MDB, water market reallocation options have been identified as generally providing relatively lower cost alternatives where transition and transaction costs are considered. This is also the case when evaluated on the basis of an adaptive efficiency choice criterion. Although dependent on market supply and demand parameters, progress toward environmental outcomes via water markets could potentially provide large reductions in future transaction costs from better site specificity between source and use locations. This is particularly where multi-level river basin planning and management is adopted in the MDB. Additional transaction benefits from reduced government intervention in water rights markets (i.e. diminished agricultural user adjustment requirements) together with the trade of water back to agricultural uses when not required for the environment (i.e. diminished disruption to economic output in regional areas) potentially increase expected welfare gains from this intervention approach.

Importantly, and as identified in the comments of our survey respondents, there are interdependencies between water market and basin planning and management options. Further, as managers they perceived water acquisition and capital works modification or construction as being largely separate expense arrangements, where the costs had already been absorbed by other programs and government departments. While it is possible that deferred static transaction (and institutional transition) costs could increase under the scenario of greater government water trade in both rights and lease markets (Tisdell, 2010), early research suggests that this impact could be minor (Connor et al., 2013). Thus, it is likely that greater transaction cost reductions could come through refinements to the reallocation of property rights between agricultural and environmental uses. This will result from an improved understanding of market procedures and delivery system constraints, allowing water resources to be placed where they can achieve site-optimised outcomes. Therefore, as both agricultural and environmental water management institutions gain experience and engage in collective action we may also expect reduced transaction costs from institutional stability over time (e.g. the learning by doing effect).

Progress toward policy reform objectives would also be advantaged by effective and efficient delivery of water to environmental sites, together with the elimination of federal prioritisation of watering applications. Over time geographically proximate government water planning and management agents could help determine how to best use allocated water, relative to their incentive structures. Within each agency there would also be significant knowledge gains from learning-by-doing, which would provide an opportunity to incorporate further efficiency improvements over time and reduce ongoing transaction costs. Additionally, potential infrastructure project reallocation option cost augmentation from strategic behaviour and rent-seeking among basin stakeholders could be mitigated by greater requirements for private financial contributions or commitments before project commencement. Each of these outcomes may result in reduced longitudinal transaction costs across MDB water reallocation options.

6. Conclusions

Requirements for water reallocation within river basins that span different national or governance jurisdictions are common globally. However, evaluation frameworks to assist with this process are not. For MDB water reallocation the identification and evaluation of adaptively efficient intervention options is valuable given its political and social contexts. Significant policy and institutional shifts over the last five to ten years suggest unexpected turns in future MDB water reform, involving difficult choices between (or across) complex interrelated alternatives. Therefore, appropriate frameworks to compare and/or evaluate institutional water reallocation approaches need to be identified.

TCA is an economic approach that arguably has had too little impact on the contemporary water reallocation debate. Until the late 1990s many governments displayed policy preferences for market-based and other economic instruments (e.g. benefit-cost analysis, privatisation, public-private partnerships) to solve water reallocation issues, including environmental management systems. Political economy dimensions may account for current MDB reallocation policy preferences toward high lock-in transition/transaction cost and adaptation risk options such as infrastructure capital works investment, relative to water rights purchasing by the Australian government. Long-term funding requirements of market-based options to recover water rights can reduce environmental risk probabilities with relatively limited lock-in costs and immediate (albeit varying) environmental flow benefits. However, sectoral pressure from agricultural (environmental) water user groups to reduce (increase) market intervention, together with continuing uncertainty surrounding final SDL targets, serve to increase short-term political pressure.

Conversely, capital investments in water storage/delivery infrastructure and on-farm use efficiency increase agricultural water users' capacity to improve farm viability and sustainability, improve rural adjustment by creating regional job opportunities, and therefore may reduce short-term political risk. However, significant uncertainties associated with future efficiency outcomes, together with higher magnitude transaction costs and adaptive risk from the uncertainty related to those locked-in capital investments, serve to elevate the probability of environmental risk. When estimated climate change impacts of reductions in MDB runoff and shifts in rainfall distributions are factored into the equation the marginal efficiency and effectiveness of a MDB capital investment intervention policy diminishes. Yet the long-term effects of climate change constitute another low-probability political risk factor, potentially negating its impact on present policy choices.

To illustrate the potential application of TCA, we have employed a Delphi-style approach in seeking the opinion of expert environmental water managers in the MDB. Our intent has been to capture a preliminary set of data on the relative magnitude of transition/transaction costs associated with three major water reallocation options. Differences in the perceived costs based on our expert survey responses provide interesting insight into the potential cost differences between each approach, as well as useful feedback on their drivers. Although at an early stage of development, this application of the TCA/Delphi approach highlights several important issues for MDB interventions, as well as guidance for future intended research. The findings suggest considerable scope to help federal, state and catchment agencies evaluate and meet water reallocation objectives where transfers between agricultural and environmental users are required. TCA also provides increased scope to assess program realisation against social, economic and environmental requirements. Importantly, the TCA framework allows evaluation of longitudinal issues associated with some of these intervention approaches and, if required, identification of the likely magnitude of adaptive risks associated with future changes.

An important insight for MDB water managers is the perception by our surveyed experts of the interrelatedness of all three of the approaches discussed. Thus, implementation of multiple approaches may provide more effective water reallocation outcomes than the implementation of one strategy in isolation. For nations and regions that have not yet begun to work on these issues—or those not too far advanced—this paper provides an example of the application of the TCA framework in evaluating institutional program design. It also highlights the importance of TCA in developing flexible and adaptive institutions throughout the life of any water reform process.

7. References

ACIL TASMAN 2008. Australia's working rivers: The role of infrastructure and water buybacks in recovering environmental flows. Melbourne: Prepared for Crane Group Limited.

ADAMSON, D. & LOCH, A. in press. Possible negative feedbacks from 'gold-plating' irrigation infrastructure. *Agricultural Water Management*, http://dx.doi.org/10.1016/j.agwat.2013.09.022

AUSTRALIAN PARLIAMENT 2011. Of drought and flooding rains: Inquiry into the impact of the Guide to the Murray-Darling Basin Plan. Canberra: House of Representatives Standing Committee on Regional Australia.

BAUER, C. J. 2004. Results of Chilean water markets: Empirical research since 1990. *Water Resour. Res.,* 40**,** W09S06.

BJORNLUND, H. 2004. Formal and informal water markets: Drivers of sustainable rural communities? *Water Resources Research,* 40**,** W09S07.

CEWH 2011a. Commonwealth environmental water - trading arrangements: Discussion paper. Canberra: Commonwealth Environmental Water Holder.

CEWH 2011b. Restoring river health in the Murray-Darling Basin. Canberra: Commonwealth Environmental Water Holder.

CHALLEN, R. 2000. *Institutions, transaction costs, and environmental policy: institutional reform for water resources,* Northampton MA, Edward Elgar Publishers.

COAG 2004. Intergovernmental agreement on addressing water over-allocation and achieving environmental objectives in the Murray-Darling Basin. June 2004.

COASE, R. 1960. The problem of social cost. *Journal of Law & Economics,* 3**,** 1-44.

CONNOR, J., FRANKLIN, B., LOCH, A., KIRBY, M. & WHEELER, S. 2013. Trading water to improve environmental flow outcomes. *Water Resources Research,* 49**,** 4265-4276

CONNOR, J. & KACZAN, D. 2013. Principles for economically efficient and environmentally sustainable water markets: The Australian experience. *In:* SCHWABE, K., ALBIAC, J., CONNOR, J., HASSAN, R. & MEZA-GONZALEZ, L. (eds.) *Drought in Arid and Semi-Arid Environments: A Multi-Disciplinary and Cross-Country Perspective.* New York: Springer.

COOPER, B. & CRASE, L. 2013. Leading gifted horses to water: the economics of climate adaptation in government-sponsored irrigation in Victoria. Gold Coast: National Climate Change Adaptation Research Facility.

COX, J. & WARNER, R. 2009. Water trading - panacea or placebo? *Water Leaders Congress,*. Sydney Australia, 6 March: IPART, NSW.

CRASE, L. 2012. The Murray–Darling Basin Plan: An Adaptive Response to Ongoing Challenges. *Economic Papers,* 31**,** 318-326.

CRASE, L., O'KEEFE, S. & DOLLERY, B. 2013. Talk is cheap, or is it? The cost of consulting about uncertain reallocation of water in the Murray–Darling Basin, Australia. *Ecological Economics,* 88**,** 206-213.

DSEWPC 2012. Environmental water recovery strategy for the Murray-Darling Basin. Canberra: Department of Sustainability, Environment, Water, Population and Communities.

DSEWPC. 2013. *Progress of Water Recovery Against Proposed 2750 GL SDL Reduction* [Online]. Canberra: Department of Sustainability, Water, Environment, Population and Communities. Available: http://www.environment.gov.au/water/policy-programs/entitlement-purchasing/progress.html [Accessed 29 November 2013].

GARRICK, D. & AYLWARD, B. 2012. Transaction costs and institutional performance in market-based environmental water allocation. *Land Economics,* 88**,** 536-560.

GARRICK, D., BARK, R., CONNOR, J. & BANERJEE, O. 2012. Environmental water governance in federal rivers: opportunities and limits for subsidiarity in Australia's Murray-Darling River. *Water Policy,* 14**,** 915-936.

GARRICK, D., LANE-MILLER, C. & MCCOY, A. 2011. Institutional Innovations to Govern Environmental Water in the Western United States: Lessons for Australia's Murray-Darling Basin. *Economic Papers,* 30**,** 167-184.

GARRICK, D., MCCANN, L. & PANNELL, D. J. 2013a. Transaction costs and environmental policy: Taking stock, looking forward. *Ecological Economics,* 88**,** 182-184.

GARRICK, D., WHITTEN, S. & COGGAN, A. 2013b. Understanding the evolution and performance of market-based water allocation reforms: a transaction costs analysis framework. *Ecological Economics,* 88**,** 185-205.

HARRIS, E. 2011. The Impact of Institutional Path Dependence on Water Market Efficiency in Victoria, Australia. *Water Resources Management* 25**,** 4069-4080.

IPCC 2012. Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation: Summary for Policymakers. *In:* FIELD, C. B., BARROS, V., STOCKER, T. F., QIN, D., DOKKEN, D. J., EBI, K. L., MASTRANDREA, M. D., MACH, K. J., PLATTNER, G.-K., ALLEN, S. K., TIGNOR, M. & MIDGLEY, P. M. (eds.) *A Special Report of Working Groups I and II of the Intergovernmental Panel on Climate Change.* Cambridge, UK: Intergovernmental Panel on Climate Change.

LANDETA, J. 2006. Current validity of the Delphi method in social sciences. *Technological forecasting and social change,* 73**,** 467-482.

LOCH, A., BJORNLUND, H., WHEELER, S. & CONNOR, J. 2012. Allocation trade in Australia: a qualitative understanding of irrigator motives and behaviour. *Australian Journal of Agricultural and Resource Economics,* 56**,** 42-60.

LOCH, A. & MCIVER, R. 2013. The Murray-Darling Basin plan and public policy failure: a transaction costs analysis. *In:* BJORNLUND, H., BREBBIA, C. & WHEELER, S. (eds.) *Sustainable Irrigation and Drainage: Management, Technologies and Policies.* Southampton, UK: WITPress.

LOCH, A., WHEELER, S., BOXALL, P., HATTON-MACDONALD, D., ADAMOWICZ, W. & BJORNLUND, H. 2014. Irrigator preferences for water recovery budget expenditure in the Murray-Darling Basin. *Land Use Policy,* 36**,** 396–404.

MARSHALL, G. 2005. *Economics for Collaborative Environmental Management: Renegotiating the Commons,* London, Earthscan.

MARSHALL, G. 2013. Transaction costs, collective action and adaptation in managing complex social–ecological systems. *Ecological Economics,* 88**,** 185-194.

MCCANN, L., COLBY, B., EASTER, K. W., KASTERINE, A. & KUPERAN, K. V. 2005. Transaction cost measurement for evaluating environmental policies. *Ecological Economics,* 52**,** 527-542.

MDBA 2009. Murray-Darling Basin environmental water recovery report - as at June 30 2009. Canberra: Murray-Darling Basin Authority.

MDBA 2012. Proposed Basin Plan - A revised draft. Canberra: Murray-Darling Basin Authority.

MDBA 2013. The Living Murray Annual Environmental Watering Plan 2013–14. Canberra: Murray-Darling Basin Authority.

NWC 2011a. National water planning report card 2011. Canberra: National Water Commission.

NWC 2011b. Understanding the Victorian decision to suspend intervalley water allocation trading: 2010-11. Canberra: National Water Commission.

NWC 2012. Water policy and climate change in Australia. Canberra: National Water Commission.

OFEI-MENSAH, A. & BENNETT, J. 2013. Transaction costs of alternative greenhouse gas policies in the Australian transport energy sector. *Ecological Economics,* 88**,** 214-221.

QUIGGIN, J. 2006. Urban water supply in Australia: the option of diverting water from irrigation. *Public Policy,* 1**,** 14-22.

QURESHI, M. E., GRAFTON, Q., KIRBY, M. & HANJRA, M. 2011. Understanding irrigation water use efficiency at different scales for better policy reform: a case study of the Murray-Darling Basin, Australia. *Water Policy,* 13**,** 1-17.

SALETH, R. M., DINAR, A. & FRISBIE, A. 2011. Climate change, drought and agriculture: the role of effective institutions and infrastructure. *In:* DINAR, A. & MENDELSOHN, R. (eds.) *Handbook on agriculture and climate change.* Cheltenham, UK: Edward Elgar.

THOMPSON, D. B. 1999. Beyond benefit-cost analysis: Institutional transaction costs and regulation of water quality. *Natural Resources Journal,* 39**,** 517-541.

TISDELL, J. 2010. Impact of environmental traders on water markets: An experimental analysis. *Water Resources Research,* 46.

VAN BUEREN, M. 2012. Unfinished business in the evolution of Australian water markets. *56th annual Australian Agricultural and Resource Economics Society conference.* Freemantle WA, February 8-10

WATSON, A. & CUMMINS, T. 2010. Historical influences on irrigation and water policy in the Murray-Darling Basin. *Network: a publication of the ACCC for the Utility Regulators' Forum.* Canberra: Australian Competition and Consumer Commission.

WHEELER, S., BJORNLUND, H., SHANAHAN, M. & ZOU, A. 2009. Who trades water allocations? Evidence of the characteristics of early adopters in the Goulburn-Murray Irrigation District, Australia 1998-99. *Agricultural Economics,* 40**,** 631-643.

WHEELER, S., GARRICK, D., LOCH, A. & BJORNLUND, H. 2013. Evaluating water market products to acquire water for the environment in Australia. *Land Use Policy,* 30**,** 427-436.

WILLIAMSON, O. 1981. The economics of organisation: The transaction cost approach. *The American Journal of Sociology,* 87**,** 548-577.

YOUNG, M. 2010. Managing environmental water. *In:* BENNETT, J., KINGSFORD, R., NORRIS, R. & YOUNG, M. (eds.) *Making decisions about environmental water allocations.* Surrey Hills, Australia: Australian Farm Institute.