Chapter 2
Transaction Costs and Policy Design for Water Markets

Laura McCann and Dustin Garrick

Abstract This chapter synthesizes the growing empirical literature on transaction costs to identify pragmatic design recommendations for water markets and related institutions. The New Institutional Economics literature recognizes that appropriate policy choice and design will be a function of the specific characteristics of the problem. The physical and institutional determinants of both transaction costs and transformation costs should be considered in the design of water markets due to potential interactions between them. Analysts also need to incorporate the extent to which the technologies, institutional environment, governance structures, or policy designs can be changed; some factors can only be adjusted to or "designed around" while others can be designed differently. This framework highlights the importance of property rights, historic water use patterns, and path dependency since transaction costs will be incurred to obtain or retain property rights to water. The physical complexity associated with water resources increases transformation costs as well as transaction costs. Uncertainty and changing societal preferences highlight the importance of flexibility and conflict resolution mechanisms in institutional design. Sequencing of policy changes is also revealed as a key design consideration.

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L. McCann (✉)
Department of Agricultural and Applied Economics, University of Missouri,
212 Mumford Hall, Columbia, MO 65211-6200, USA
e-mail: McCannL@missouri.edu.

D. Garrick
Department of Political Science, McMaster University, 1280 Main Street West,
Kenneth Taylor Hall Room 534, Hamilton, ON L8S 4 M4, Canada

Walter G. Booth School of Engineering Practice, McMaster University, Hamilton,
ON L8S 4 M4, Canada
e-mail: dgarrick@mcmaster.ca

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2.1 Introduction

For some environmental and natural resource issues, it is difficult to model cause and effect, the problem definition may change over time, and there may not be consensus about the policy goal. Examples of these so-called "wicked" problems include climate change, nonpoint source pollution, water resource scarcity, and biodiversity conservation (Batie 2008). Water resource allocation can increasingly be viewed as a wicked problem. Population and economic growth have increased water demand across an expanding number of uses (e.g. agriculture, cities, energy and ecosystems) while supply is becoming more variable and uncertain due to climate change and deteriorating infrastructure.

Water trading and associated institutional reforms are a potentially attractive option to help manage these challenges. The potential benefits of water trading are two-fold. In terms of allocative efficiency, water trading maximizes welfare by allocating water to its highest and best use, often involving a shift from lower valued irrigation of annual crops to perennial crops, or a shift from irrigation to municipal or industrial uses. Water trading also contributes to productive efficiency by incentivizing water saving technologies since any conserved water can then be sold. However, benefits achieved depend on the design of the water markets and associated institutions. The design challenges for water markets relate principally to: (i) establishing diversion limits (the cap) and (ii) creating and/or modifying a tradable water rights system.

Design of policies and economic instruments is a relatively neglected area in applied economics according to King (2012a, b), and he has therefore encouraged applied economists to devote more attention to this task. There is relatively little literature on transaction costs[1] and design of environmental policies, but the role of transaction costs in the design of water markets has received increasing attention (Bennett 2005; Easter et al. 1998; Howitt 1994; McCann and Easter 2004; Garrido 2007; Griffin et al. 2012; Garrick et al. 2013.). Transaction costs should be a key consideration in policy design, especially for wicked problems, which are likely to entail higher transaction costs. Transaction costs ranged from 3 to 70 % of total costs in empirical studies of water markets with costs becoming a higher proportion of total costs for more complex transactions (e.g. for environmental flows) (Garrick et al. 2013).

[1]The definition of transaction costs used in this paper is that of Marshall (2013) "*Transaction costs are the costs of the resources used to (i) define, establish, maintain, use and change institutions and organizations, and (ii) define the problems that these institutions and organizations are intended to solve."* This definition expands on the definition in McCann et al. (2005) and thus is broad enough to examine the institutional environment (North 1990).

Water trading activity in Western U.S. and Australian water markets has overcome initial impediments through market-enabling policy reforms to water rights, monitoring systems and trading rules. Strategies to reduce transaction costs are an important policy design challenge as water markets emerge, as illustrated by current experiences in China and South Africa where transaction costs remain a barrier to water trading (Grafton et al. 2011). However, transaction costs reduction remains a priority even in maturing water markets. For example, the 2004 National Water Initiative of Australia identified transaction costs reduction as a policy priority to expand water trading by improving information flows, coordinating licensing systems and water rights registries, and removing interstate barriers to trade (see e.g. clauses 25 and 58 of the National Water Initiative). Bjornlund (2004) identified several factors that drive transaction costs and impede water markets, including poorly defined property rights, jurisdictional barriers, and environmental uncertainty. Reducing these costs by improving policy design is especially important given government budget deficits and large potential gains from trade across sectors and users.

The gap between the theory and practice of water markets has been the focus of a well-developed literature. Saliba and Bush (1987) identified the sources of market failure tied to public goods provision, market power, externalities and third party effects. Policy responses to these market failures have yielded insights about design that draw from the institutional economics literature. Institutional and transaction costs analysis of water markets highlight the need to account for the development (and transition costs) of market-enabling policy reform in addition to the transaction costs of reallocation. Garrick and Aylward (2012) further emphasize the need for ongoing institutional change to address unintended consequences of prior reforms and adapt to shifting water use patterns and the associated social and environmental externalities.

The objective of this chapter is to synthesize the growing theoretical and empirical literature on transaction costs in order to identify recommendations for the design of water resource policies. A broad and pragmatic approach is taken by incorporating insights from neoclassical economics, new institutional economics, and classical institutional economics to examine factors affecting both transformation costs and transaction costs of environmental and natural resource policy. Examining both types of costs is important due to potential interactions between them. Minimizing, or at least reducing, the sum of these costs for a given level of water reallocation, both in a static and dynamic sense, is the evaluation criterion used in this chapter. Transformation costs include production and abatement costs. Water conservation – defined as less water per unit of output – is an example of economizing on production costs, while costs of mitigating water pollution and other externalities are an example of abatement costs.

The appropriate choice and design of a policy instrument will depend on the nature of the water allocation problem, both the physical and socio-economic context. Design of feasible policies requires consideration of the extent to which the technologies, institutional environment, governance structures, or policy designs can be changed. Some factors can only be adjusted to or “designed around” while others can be designed differently.

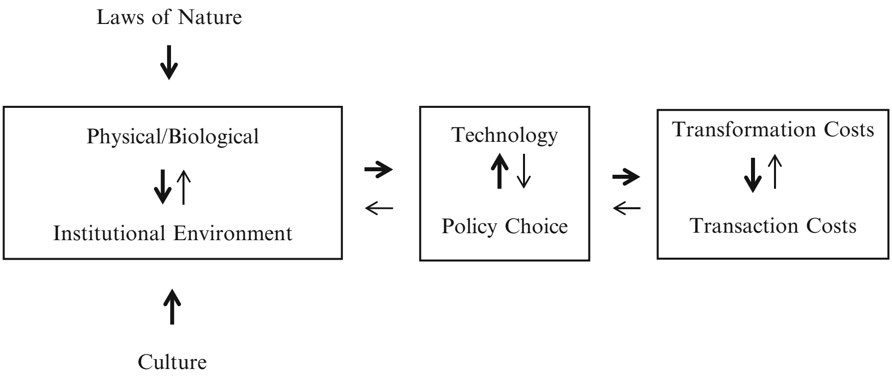

Fig. 2.1 Physical and institutional effects on transaction costs and transformation costs (Note: *Dark arrows* indicate a stronger effect and *arrows in both directions* indicate potential interactions or feedback effects)

The next section briefly summarizes the neoclassical, new institutional and classical institutional perspectives on transaction costs and their relevance for the design of water market institutions. In the third section, physical factors that affect transaction costs and transformation costs are examined, beginning with those that are least amenable to change. The fourth section examines the effect of institutions, beginning with deeper levels such as culture. Figure 2.1 presents the conceptual framework that is developed from the analysis of the physical and institutional issues, and which will be referred to throughout the chapter. It shows that some important factors are not amenable to change on the time scales addressed by policy design, i.e. laws of nature and culture. It also shows that, while discussed in separate sections, there are interactions between physical and institutional factors. The concluding section provides a synthesis of insights that is then used to develop design recommendations.

2.2 Alternative Perspectives on Transaction Costs and Water Resource Policy Design

The institutional economics literature recognizes that there are different levels of institutions and institutional analysis with more superficial levels being nested within deeper levels. Williamson's 2000 paper examines four different levels of institutional analysis: (1) informal institutions, (2) laws and policies (similar to North's institutional environment), (3) governance structures and/or policy instruments, and (4) price effects. The nested institutional framework of Williamson has been used to look at water management institutions and to inform transaction cost measurement (Easter and McCann 2010; McCann and Easter 2004) and will be used in this chapter. This section begins with the relatively superficial neoclassical treatment of transaction costs in environmental and natural resource policy analysis/design and proceeds to deeper levels of institutional analysis.

Transaction costs are increasingly being included in policy design and policy analysis, along with other costs and benefits of the policy (Krutilla and Krause 2011; McCann et al. 2005; Pujol et al. 2006; Stavins 1995). Typologies of transaction costs have been developed to facilitate measurement but they may also enable researchers to think about design more effectively (McCann et al. 2005). Garrick et al. (2013) have adapted generic transaction costs typologies across the major elements of policy design, implementation and adaptation in cap-and-trade water allocation systems.

The New Institutional Economics (NIE) literature consists of several branches including Williamson's transaction cost economics (TCE) (Williamson 1985), Coasian bargaining (Coase 1960), and collective action (Ostrom 1990). Some recent literature (e.g. Bougherara et al. 2009; Boutry 2011; Coggan et al. 2010) uses Williamson's concept of discriminating alignment to provide insights into environmental and natural resource issues. Coase's seminal paper explicitly examines the role of transaction costs in policy choice for addressing environmental impacts. Ostrom's work looks at the nature of the common pool resource and also the social context in order to develop design principles for natural resource management institutions. All three of these literatures recognize that appropriate choices, of governance structures or policies, will be a function of the specific characteristics of the problem.

Deeper levels of institutional analysis, such as studies of the institutional environment, are especially relevant for the design of solutions to wicked problems (Batie 2008). Institutional economics has examined environmental and natural resource issues (e.g. Bromley 1991; Schmid 2004; Vatn 2005). In this literature, property rights, including water rights, are an important concept affecting both the distribution and magnitudes of costs.

This brief overview and comparison of some of the literatures relating to transaction costs and institutions provides some background for readers who may not be familiar with these literatures, but a comprehensive review is beyond the scope of this chapter. The rest of the chapter incorporates useful concepts and insights from all of these literatures rather than being in the tradition of any single one of them. The next section examines a variety of physical factors that affect transaction costs as well as transformation costs.

2.3 Physical Factors Affecting Transaction Costs and Transformation Costs

Fundamental physical, biological, and technical factors will affect transformation costs and transaction costs and thus should affect the choice of policy instrument, and the design of policy. Batie (2008) indicates that wicked problems are typically interdisciplinary in nature while Schmid (2004) highlights the fundamental physical features underlying interdependencies between agents. The geographical area involved, time lags, amount of change needed, heterogeneity, internal versus external effects, measurability, economies of scale, uncertainty, asset specificity, and technology are other physical factors discussed in this section. These factors are presented in three subsections starting with those that are least amenable to change (the single dark arrow in the upper left of Fig. 2.1), followed by those that could change in a generation or two, and ending with those that could change in a few years based on changes in technology and/or institutions (the center box of Fig. 2.1). These cutoffs are somewhat arbitrary, as with the categories in Williamson (2000).

2.3.1 Physical Factors That Are Least Amenable to Change

Fundamental laws of physics and biology are examples of factors that are not amenable to change and which cannot fruitfully be the object of design. These general factors underlie many of the more specific issues addressed in this section.

2.3.1.1 Scale

The geographic scale of intervention that is needed to resolve the problem will affect policy design. Many water quality and quantity issues should be addressed on a watershed scale since both the transfer of the pollutant in space, as well as the quality of the receiving water body, matter for economic efficiency. This involves more coordination and thus higher transaction costs than would be necessary if location did not matter. This is particularly true if a water resource issue crosses political boundaries and since rivers often form boundaries of states or countries, this is quite common (Perry and Easter 2004). For example, the scale of water trading activity will affect policy design. Moving from informal, local spot markets to larger scale activity requires coordination across irrigation districts, state jurisdictions and river basin scales. It also increases the range of water uses involved. Nested governance of water institutions provides a strategy to coordinate local jurisdictions within larger and more diverse regional and national contexts (Challen 2000; Garrick et al. 2011). Grafton et al. (2011) identify the importance of river basin management for integrated assessment of water market performance. They use examples from the Murray-Darling Basin (which involves four states and one territory in Australia) where a comprehensive basin plan was used to establish sustainable diversion limits. Crase et al. (2013) discuss the transaction and transformation costs of policies to provide environmental flows in the basin. South Africa adopted catchment management authorities as part of its 1998 National Water Act, but implementation has lagged. The lack of transnational water trading is a sign of such policy design barriers, although recent reforms in the Colorado River Basin along the US-Mexico border include new provisions for international water banking (Makridis 2012).

2.3.1.2 Time Lags

In general, time lags create challenges for design of water markets. The time lag from groundwater pumping to noticeable impacts on surface water flows, and the lag between improved management (including environmental water recovery) and noticeable impacts will also have effects on transaction costs. In addition, the lag varies from region to region according to hydrogeological conditions (Skurray et al. 2012). In the Deschutes River of Central Oregon, the Oregon Water Resources Department, Deschutes River Conservancy, and irrigation districts created water banks that facilitate voluntary, compensated retirement and conversion of surface water rights into instream flow rights to offset the impact of new groundwater pumping in closed river basins. While generally perceived as successful, there are concerns with administrative capacity and enforcement provisions in part due to the time lags of groundwater pumping impacts and the associated biophysical complexity (Liberherr 2011).

2.3.2 Physical Factors That Are Somewhat Amenable to Change

2.3.2.1 Magnitude of Change

A very important physical factor related to both transformation and transaction costs, is the amount of change needed to address a problem.[2] The familiar upward sloping marginal abatement cost curve indicates that as more clean-up is required, the costs will increase (e.g. Roberts et al. 2012). There are empirical studies that seem to indicate that transaction costs and abatement costs both increase as the level of abatement increases (Garrick and Aylward 2012; Krutilla and Krause 2011; Laurenceau 2012; McCann and Hafdahl 2007; Rorstad et al. 2007). This is consistent with Krutilla and Krause (2011) who argue that the higher the potential losses to firms, the higher the levels of lobbying to prevent a new environmental policy, thus increasing transaction costs. Large changes in water use may necessitate the re-structuring of irrigation districts and associated infrastructure and also affect transaction costs. As a consequence, many irrigation districts have imposed restrictions or taxes (known as ‘exit fees’) on the volume of water exiting their service areas to ensure the district retains sufficient water and associated fees to operate and maintain the irrigation canals and distribution system (Libecap 2011). This became an issue in the Murray-Darling where recent basin planning efforts

[2]This chapter’s framework takes the benefits of reallocation as given although the optimal amount of change will depend on both costs and benefits, both of which may change due to preferences and technical change. Nevertheless, in some cases the amount of change needed to solve a problem is a function of physical and biological factors.

yielded a controversial draft proposal to reduce cumulative basin-wide diversions by 27–37 % of the historic average (MDBA 2010). However, the proposed reductions were concentrated in specific sub-basins, with some regions facing even higher reductions that could bankrupt irrigation districts. The proposed step change reduction in diversion limits triggered political backlash that has substantially raised the transaction and transformation costs of policy reform (Crase et al. 2013).

2.3.2.2 Heterogeneity

An issue that is especially important for environmental and natural resource problems is heterogeneity in all its forms. Heterogeneity is a necessary condition for water markets, as there must be variation in the marginal productivity of water across different uses to allow for gains from trade. For example, Libecap (2005) notes the vast price differentials across different water uses in the Western U.S., citing the example of San Diego paying $225 per acre foot of water for which farmers paid $15.50. However, heterogeneity also poses problems in water markets when property rights are poorly specified and fail to account for different sources of water and their hydrologic interactions (Young and McColl 2009). Heterogeneity therefore becomes a problem for trading when water rights and their reliability are difficult to compare. The water markets of the Western U.S. are hamstrung by the high levels of heterogeneity in water rights. The prior appropriation doctrine, for example, requires all water rights in a region to be defined relative to each other rather than as proportional shares of the consumptive pool as is done in Australia (Ruml 2005).

2.3.2.3 External Effects

Technological externalities are transmitted through some physical medium, and enter the utility function or production function of another agent directly (physically), rather than indirectly through prices. There are often third-party effects resulting from water reallocation. Downstream water rights are often dependent on the (lagged) return flows from upstream water use. Return flows are a classic form of externality in water allocation and water markets. The buying and selling of water affects water use patterns and the ensuing return flows. Regulatory safeguards have limited the third party impacts of water trade to ensure that changes in return flows do not impair downstream users, particularly in the Western U.S. (e.g. Brown 2006); such restrictions can impose a significant barrier to trade by requiring case-by-case assessment of cropping intensity, irrigation efficiency and hydrology.

2.3.2.4 Excludability

A non-excludable good (or bad) is one for which it is not possible to exclude an additional user (or sufferer) at reasonable cost. Excluding people from such a good would involve either high costs to physically exclude potential users (e.g. irrigation headgates) or high costs of monitoring and enforcement (ditch riders and watermasters to measure and enforce water diversions). Both interventions would involve a variety of transaction costs for design and implementation. Technological changes may affect excludability, such as the construction of stream gauges and diversion weirs and associated measurement of water availability and use. Excludability is a challenge for water market design because costs of exclusion vary across multiple sources of water and are often higher for groundwater than surface water. In such cases, capping surface water use may have unintended consequences and increase pressure on groundwater reserves with costly excludability (Young and McColl 2009; Aguilera-Klink and Sanchez-Garcia 2005). Excludability also relates to the public goods characteristics of water. Environmental flows are a public good with indivisible benefits and insufficient incentives for private contributions to their provision and maintenance. As one example, overallocated basins encounter challenges due to the concentrated, private costs on irrigators (who must reduce or sell their water rights, often under duress) and the distributed, public costs and benefits of environmental restoration. The irrigation interests are therefore politically motivated to oppose reallocation, while free riding will make it comparably difficult to organize on behalf of the environment.

2.3.2.5 Measurability/Observability

Measurability and observability are somewhat related issues, and while often grouped with uncertainty, are distinct from that concept. They are also related to excludability in that activities/effects that are measurable would facilitate exclusion. In some sense, observability can be thought of as an extreme form of measurability-able to be measured with the senses. Measurability and observability have effects on transaction costs incurred by public agencies, particularly monitoring and enforcement costs, and thus affect what policies are feasible. For agri-environmental policy, the fact that measuring emissions would entail very high monitoring costs is what distinguishes nonpoint source pollution from point source pollution. Measurability may also affect the potential for new policy instruments. Bougherera et al. (2009) examined whether an environmental issue can be addressed using private property rights as a function of whether the good can be defined, defended and divested, each of which relates to measurability and excludability.

Similarly, water rights must be clearly bounded and measurable (Young and McColl 2009; Libecap 2005) for water markets to function appropriately. Monitoring requirements include water inflows, water diversions and use, and return flow impacts of water trading. Grafton et al. (2011) also identify the need to monitor public interest impacts, such as environmental flows. New regulatory and technological innovation has improved measurement and monitoring to encourage water markets. For example, Australia created its National Water Market System to streamline data collection and compatibility and ensure a consistent national registry of water rights and trading. Australia also committed 60 million AUD over 5 years as part of the 2008 Water for the Future initiative to improve data and information systems underpinning water trading.

2.3.2.6 Economies of Scale/Scope

Economies of scale that are possible are also important for policy design and to some extent this is a function of technology and industry structure as well as the magnitude of the change required. The high fixed costs of water trading have historically biased trading toward large volumes except where water banks (for an irrigation district) or infrastructure (reservoir project) exist. Reservoir projects allow the establishment of a consumptive pool of water rights that can defined as shares and traded more easily than water systems with several diversion rights.

Any policies that can exploit economies of scope would tend to be more efficient. Grolleau and McCann (2012) suggest that paying farmers near Munich to implement organic practices addressed many environmental issues at once and thus reduced transaction costs compared to a policy that addressed fertilizers, pesticides, etc., separately. In general policies should be designed to take advantage of this situation by taking advantage of the multi-purpose design of irrigation infrastructure to optimize irrigation, flood control and hydropower, as well as downstream urban water use.

2.3.2.7 Number of Agents

All else equal, total transaction costs will increase with the number of agents involved. If there are many similar entities, average transaction costs may be decreasing but this effect will be reduced if agents are heterogeneous. This is related to the frequency attribute of transactions (Williamson 1985). Higher frequency results in lower transaction costs per unit due to the ability to standardize procedures, but there may be fixed costs to set up these systems so total costs need to be compared. Along these lines, Coggan et al. (2013) in the case of offset schemes, and Cacho et al. (2013) in the case of greenhouse gas offsets, recommend standardizing policies and procedures to reduce transaction costs. Water banks and water trading registry systems achieve a similar function for large numbers of buyers and sellers. In general, policies need to be designed that involve smaller numbers of agents or that enable economies of scale in development of procedures but still have the flexibility to deal with heterogeneity.

2.3.2.8 Uncertainty

To some extent factors relating to uncertainty have been discussed. Time lags, natural variability in space and time, biological diversity, heterogeneity of agents, measurement difficulties, etc. all increase uncertainty and thus pose problems for the design of environmental and natural resource policy. Risk and uncertainty reduce utility for risk-averse agents, and reduce efficiency in general, but they also increase transaction costs. Due to uncertainty, complete contracts cannot be written, resulting in increased *ex-post* transaction costs (Williamson 1985). McCann (1998) indicates that uncertainty may not be immutable; as the state of knowledge improves some types of uncertainty may be reduced. However, improving information by new research is costly so decision-makers will typically have to act in a state of imperfect knowledge (e.g. Pannell et al. 2013) and changing conditions. The high level of uncertainty regarding ecological benefits of increased water flows in the Murray-Darling Basin, together with a poorly designed consultation process, increased transaction costs and resulted in inefficient outcomes (Crase et al. 2013). As Garrick et al. (2013) and Marshall (2013) point out, even if an ideal policy were implemented at one point in time, changes in technology, preferences, etc. would mean that institutions and policies would need to be revised over time. Moreover, uncertainty about future inflows, theft by opportunistic water users and legal and institutional fragmentation all pose risks for water markets, which require informed trading decisions regarding clearly defined water rights.

2.3.2.9 Asset Specificity

Asset specificity is another interesting insight from Williamson. If a resource (such as a pipeline to a city, or distribution system for an irrigation district) is unique to a specific transacting partner, and cannot be easily redeployed for transactions with other partners, transaction costs are increased since the owner will want to ensure a return on his or her investment. The design and scale of water distribution systems thus affects asset specificity.

The heterogeneity of water rights contributes to asset specificity. Physical interactions between water sources, socioeconomic interdependencies among water users, and legal protections of return flows for downstream users can vary considerably from location to location. In the Western U.S., the prior appropriation system of water rights is based on first-in-time, first-in-right principles which establish a seniority system that is highly location specific. Market power and bilateral monopolies become an issue when the supply and demand are spatially concentrated in a given source or destination area (e.g. Libecap 2008).

2.3.3 Physical Factors That Are Amenable to Change

2.3.3.1 Technical Change

As mentioned in the previous discussion, technology is an important factor affecting transformation and transaction costs. The current state of technology, for production, conservation and monitoring, but also the potential for technological change, needs to be taken into account by policy makers. While costs and benefits are affected by technology, technological change over time is affected by policy due to changes in relative prices, a phenomenon known as induced technical innovation (Hicks 1963; Hayami and Ruttan 1971).

In theory, tradable water rights create incentives for technological innovation by establishing an opportunity cost for water use; water users can sell or lease water saved through on-farm or distribution efficiency savings and therefore may

Table 2.1 Physical factors that affect transaction and transformation costs and thus design

Factors	Attributes	Water market policy design considerations
–Least amenable to change–	Increasing physical scale of problem Longer time lags	River basin planning to establish diversion limits and coordinate water licensing systems across multiple jurisdictions Account for groundwater – surface water interactions in water rights reform
–Somewhat amenable to change–	Magnitude of change needed Increasing heterogeneity Non-excludable External effects Private/public costs aligned Measurable/Observable Potential economies of scale/scope Number of agents involved Higher uncertainty Asset specificity	Establish water rights as shares of consumptive pool (instead of fixed allocation) Robust accounting of return flows in trading rules Low-cost measurement of inflows, diversions and return flows Link trading systems to storage and distribution infrastructure when possible, to decrease heterogeneity, and asset specificity
–Amenable to change–	Technical change	Provide extension services and allow trading to promote water conservation through private irrigation efficiency improvements

invest in efficient technologies that can maintain or maximize productivity with lower water use. Australian water markets suggest that such incentives have led to farmer and irrigation district investment in efficiency savings to reduce water used in distribution systems and on the farm (NWC 2006).

This section has outlined a range of physical factors that can affect the transaction and transformation costs of water resource policies (summarized in Table 2.1). The next section presents institutional factors that affect transaction costs and transformation costs. However, there are interactions between physical and institutional factors that make them difficult to separate (shown in Fig. 2.1 as arrows going in both directions in the boxes).

2.4 Cultural and Institutional Environment Factors Affecting Transaction Costs and Transformation Costs

As highlighted in Sect. 2.2 there are nested levels of institutional analysis (Williamson 2000). These different levels of institutions affect an agent's actions simultaneously, for example price incentives and thus agents' choices at more superficial levels are fundamentally affected by the deeper levels such as property rights. Williamson also indicates that changes in prices may happen immediately while changes in governance may happen at the end of a contract. The deepest level, culture, may take hundreds of years to change and thus affects other institutions, but is not itself amenable to change. Put another way, the transaction costs of effecting change at this level would typically be prohibitively high. The following section starts with deep institutional factors that are least amenable to change, and thus must be designed around, and ends with policy instruments, which are the most likely objects of design.

2.4.1 Institutional Factors That Are Least Amenable to Change

2.4.1.1 Culture

Culture may affect how people are socialized, what choices or actions they do not consider to be in their choice set, their fundamental values, the level of trust within the society, notions of fairness and their interest in the common good, etc. (Schmid 2004; Vatn 2005). Informal institutions such as custom, folklore and religion will also affect the formal institutional environment that each country has (indicated by the single dark arrow in the lower left of Fig. 2.1). In the case of water markets, Bauer (1997) identifies cultural and psychological factors associated with water's symbolic and livelihood significance in irrigation societies in Chile. Farmers have been reluctant to separate water rights from land rights out of concern that water will be traded out of irrigation. The concerns of irrigation communities about the long-term effects of water trade on their economic and cultural viability has impeded the emergence of spot markets in the Western U.S., Canada and Chile, as well as early stages of Australia's water market reforms (as discussed by Howitt (2014) in Chap. 5, this volume, Bjornlund et al. (2014) in Chap. 12, this volume, and Hearne and Donoso (2014) in Chap. 6, this volume). In active markets of Australia, trading activity and government acquisitions of water for the environment have led to cultural arguments grounded in rural values – both economic and cultural.

2.4.1.2 Institutional Environment

The formal institutional environment consists of constitutions, legal systems, laws and policies (Williamson 2000). One component of the institutional environment that is least amenable to change is a constitution which provides the rules for making rules. Constitutional provisions related to water are difficult to change. In Australia, for example, Section 100 of the constitution reserves powers to state governments to regulate water use for irrigation and navigation (see Connell 2007). This has created a fragmented institutional framework that has limited interstate trade until recently (Bjornlund 2004). In addition, given the common law tradition that the U.S. inherited from Britain, previous legal decisions provide precedent for, or preclude, some policy instruments (Richards 2000; Kubasek and Silverman 1997). Common law affects water allocation by imposing norms of 'no harm' and associated regulatory safeguards to support agrarian values and protect the public trust and third parties (Schorr 2005). This highlights the issue of path dependency which is discussed at greater length below.

The system of government is typically not amenable to change. The policy-making in democracies can be quite messy (and thus involve high transaction costs). Friedman, in his book "Hot, Flat and Crowded" (2008) has a chapter entitled "China for a day" in which he suggests that, if China wanted to, it could make the hard environmental policy choices that the U.S. has been unable to make. China's recent interest in water markets and water trading illustrates this point. The government authorized and funded pilot trading activity in the Jiao River Basin, accelerating the reform process that may take decades in other regions (Grafton et al. 2011). This brings up the general concept of the capability of governments which Birner and Wittner (2004) recognize as an important constraint to environmental improvement in developing countries.

The legal system and the courts also affect the transaction costs associated with alternative policy instruments. A legal system that effectively enforces contracts enables contractual relationships that may improve economic efficiency. The governance literature based on Williamson assumes that there is a well-functioning legal system that can enforce the contracts that agents make. This is not the case everywhere (Birner and Wittner 2004). Ostrom (1990) indicates that rapid, low-cost conflict resolution mechanisms are important for successful collective action institutions. Such institutions prove important in many emerging water markets by allowing local and informal conflict management to avoid more costly and cumbersome administrative hearings and court cases. The next section includes several institutional environment issues that are more amenable to change than the legal system.

2.4.2 Institutional Factors That Are Somewhat Amenable to Change

2.4.2.1 Physical Versus Administrative Boundaries

The location of political and administrative boundaries can affect transaction costs, particularly for water management. This demonstrates the importance of considering both physical and institutional factors. Administrative boundaries that do not coincide with environmental areas of interest (e.g. counties, states or countries versus watersheds) make cooperation more difficult and increase transaction costs, particularly if small administrative units are the ones that have authority for environmental and natural resource issues (Perry and Easter 2004). Multiple agencies with responsibilities for solving a problem will also increase coordination costs (Laurenceau 2012). In some cases new umbrella organizations that can facilitate coordination across agencies or political boundaries may be helpful (e.g. the Murray-Darling Basin Authority in Australia, or the Columbia Basin Water Transactions Program in the Northwest USA). Related to this, Batie (2008) indicates that creating boundary organizations that mediate between scientists, resource managers, and stakeholders may be useful for wicked problems. While entailing transaction costs to create and operate, they may ultimately reduce transaction costs, especially in situations of conflict. Schlager and Blomquist (2008) note the difficulties of integrated river basin management because institutions are costly to develop, but that some water allocation challenges can be addressed without river basin level alignment of hydrological and political borders.

2.4.2.2 Lobbying

Krutilla and Krause (2011) argue that the transaction costs at the enactment stage, such as lobbying over a policy at both the legislative and agency (bureaucratic) levels, may be higher than the transaction costs to implement a policy. Typically these costs are ignored by economists and only the transaction costs of implementing and operating a new program are evaluated. Crase et al. (2013) argue that the consultation process in the Murray-Darling enabled lobbying by irrigators which ultimately resulted in poor policy decisions.

2.4.2.3 Property Rights

The general issue of property rights is fundamentally important both for distributional impacts but also for efficiency. Demand for changes to the bundle of property rights, which entails transaction costs, may arise due to changes in technology (Demsetz 1967) or preferences. Garrick et al. (2013) and Crase et al. (2013) provide the example of preferences for environmental flows leading to changes in water rights. Young and McColl (2009) note the importance of separating land and water rights, and also aligning water rights with hydrological interactions of groundwater, surface water and farm dams. A multi-phase legislative process has established a strong tradable permit system in Australia. The process has involved over a century of reform with strong state control, followed by state and national legislation to address environmental needs and coordinate basin-wide trade in the Murray-Darling (Tisdell (2014), Chap. 9, this volume). Bromley (1992) and Stavins (1995) point out that those who do not have the property rights (e.g. the rights to be free from pollution) are those that will incur costs to change the property rights structure. Also, when governments create brand new rights, transaction costs are incurred to obtain those rights (Krutilla and Krause 2011).

Schmid (1995, 2004) argues that because the efficient outcome assumes a particular system of property rights (e.g. you have to pay for mineral resources but not for the right to pollute) one cannot determine an efficient outcome independent of the property rights assignment. However, some parties may be able to make changes at lower cost than others and the transaction costs of regulating some groups may be lower than regulating others, as discussed earlier in the section on physical factors. Assignment of property rights thus may affect the magnitude as well as the distribution of transformation or transaction costs.

The question of where rights and responsibilities should be assigned should also consider which party has better information or is better able to use information. Furthermore, there has been an increasing need for vertical integration within nested water institutions to coordinate at the river basin level (Easter and McCann 2010; Schlager and Blomquist 2008). Nested property rights, or institutional hierarchies (Challen 2000) have developed to manage the externalities of water use and adjust private and irrigation district water rights to match the broader public interests.

2.4.2.4 Market Structure

While also discussed earlier in the section on physical factors, market structure may affect transaction costs in another way; a monopsony structure may facilitate bargaining, while bilateral monopoly can impede it. Schmid (1995) highlights the fact that when property rights were with a large cement plant in Florida, the local citrus growers did not organize to bargain with the cement plant to reduce their dust emissions. When a legal change transferred the property rights to the citrus growers (to not have their harvests diminished), the cement plant then bought property near the plant. Grolleau and McCann (2012) indicate that water utilities in Munich and New York were able to negotiate with farmers more easily than if all the individual water customers had had to do so. Irrigation districts have had a profound impact on market structure by facilitating trades within districts and impeding transfers out of districts (Carey et al. 2002; Libecap 2011).

2.4.2.5 Existing Laws and Policies

Specific legislation, such as the National Water Act in Australia, affects what policy instruments can be used, how they can be implemented, and the transaction costs of making changes. It is recognized that there are interactions between water quantity and environmental quality but the existing legislation made it very difficult to coordinate policy instruments to address both issues until the 2007 Water Act. The 2007 Act and the National Water Initiative that preceded it in 2004 have attempted to consolidate market-enabling reforms and streamline regulatory changes for water rights (Young and McColl 2009). Existing laws may also preclude consideration of some environmental effects. In the western U.S., water laws precluded consideration of instream environmental effects, although this is changing (Easter and McCann 2010; Garrick et al. 2013).

It is thus necessary to recognize that previous policy decisions can either enable or constrain the design of efficient and effective policies. Challen (2000) points out that once water rights are vested at lower levels of decision-making it is difficult (i.e. it would incur high transaction costs) to move private use rights back up the institutional hierarchy. Garrick et al. (2013) and Marshall (2013) also emphasize the importance of path dependency and lock-in in determining the costs of switching to new water resource management regimes. More generally, possible interactions among existing policies, or between existing policies and new policies, need to be considered.

2.4.3 Institutional Factors That Are Amenable to Change

Choice of governance for market transactions and choice of policy instrument for addressing environmental or natural resource problems represent a less deep level of analysis than changing the institutional environment (Williamson 2000). At this latter level the objective is typically to design new institutions (center box of Fig. 2.1) in contrast to "designing around" immutable factors. Typically the literature examines the choice of one "best" policy for the situation, e.g. water pricing or water markets. However, policies have feedback effects so choices at this level should take account of not only static effects, but also dynamic effects, especially the incentive for technological change (indicated by arrows going both ways in the center box of Fig. 2.1).

2.4.3.1 Sequencing and Timing

Sequencing of policy matters. While there is very little literature on sequencing, one would expect to have higher transaction costs to implement a draconian policy, if less restrictive, more popular policies, such as education efforts, have not been tried previously. Ervin and Graffy (1996) suggest picking the low hanging fruit first, i.e. implementing policies that have low total costs (transformation plus transaction costs). Batie (2008) indicates that adaptive management may be helpful; a policy is implemented, the results are observed and then adjustments are made. History does show that expecting companies to make immediate adjustments to regulatory changes often does not work well (e.g. lower volume toilets (Fernandez 2001), Clean Air and Water Acts (Tietenberg 2005)). Therefore having some lead time, or a gradual ratcheting up of policies, may be helpful. On the other hand, transaction costs of multiple policies are incurred if the policies subsequently need to be changed so designing policies to allow for sequencing is desirable. Crase et al. (2013) also suggest that initially requiring changes that are too small to result in observable environmental impacts may be problematic as far as support for further change is concerned. Garrick et al. (2013) note the importance of a multiphase sequencing of institutional transitions to support water trading, identifying at least three broad phases, market emergence, market strengthening, and adjustment. Sequencing matters, particularly to allow for experimentation and learning through informal trading as well as balance between security (water rights reforms and diversion limits) and flexibility (adjustment of rules to address externalities).

2.4.3.2 Intermediaries

Use of intermediaries (e.g. brokers) may reduce transaction costs, especially for infrequent transactions that require specialized knowledge (Coggan et al. 2013). This is related to the discussion of economies of scale and scope in the previous section. In the case of water markets, water banks provide a clearinghouse function to pool buyers and sellers and decrease the transaction costs of administrative review, price discovery and enforcement due to economies of scale associated with streamlined procedures for a large block of water (rather than an individual transaction) (Clifford et al. 2004). Water districts may also provide many of the same functions as water banks, or even create formal water banks, but with lower transaction costs because they are locally managed. These institutional innovations are frequently linked with economies of scale in infrastructure, such as reservoirs.

The various cultural and institutional factors affecting transaction costs are summarized in Table 2.2. Cultural factors that are least amenable to change (and thus with negligible feedback effects) are shown by a single dark arrow in the bottom left of Fig. 2.1. Those that are somewhat amenable to change are shown as the institutional environment in the leftmost box. Policies and policy instruments, the primary objects of design, are shown in the center box.

2.5 Conclusions and Design Recommendations

Water market design involves the establishment of diversion limits and tradable water rights, as well as periodic adjustments to address unintended consequences of prior reforms and changing natural conditions. Our analysis focuses on situations where property rights systems and governance allow the development of formal water markets. In these cases, where water markets are the focus of policymaking and planning efforts in water management, transaction cost analysis offers some insights about the types of physical and institutional factors that can be changed and the strategies to work around other factors to reduce transaction costs.

One of the benefits of incorporating transaction costs, as well as transformation costs, into the design of institutions and policy instruments is that it enables the analyst to bring in practical issues that are normally ignored. Transaction cost analysis also allows one to examine factors such as biophysical complexity (and associated exclusion, heterogeneity and scale issues), as well as cultural values, conflict and lobbying that are often seen as beyond the scope of economics but which are crucial to making progress on wicked problems.

Table 2.2 Cultural and institutional factors that affect transaction and transformation costs and thus design

Factors	Attributes	Water market policy design considerations
–Least amenable to change–	Culture with trust, social capital Institutional environment: Democracy Effective legal system High level of proof	Establish trust and social capital with local stakeholders through effective planning when developing diversion limits Develop information systems and water rights registries to ease burden of proof Provide extension services to navigate complex administrative procedures
–Somewhat amenable to change–	Mismatch of physical and administrative boundaries Institutions that increase lobbying Property rights assigned to those who cannot easily make changes or are hard to regulate Market structures that foster economies of scale and scope Well-designed previous legislation	Establish river basin organizations to coordinate multiple local, state and federal agencies and sectors Low cost conflict management and resolution mechanisms to limit transfer protests Identify needs of irrigation districts system-wide operations and maintenance to reduce barriers to trade out of irrigation districts Enable periodic review of diversion limits and minor adjustments in water rights as information and preferences change
–Amenable to change–	Appropriate sequencing and timing of policy interventions Use of behavioral economics concepts such as choice architecture, especially defaults Intermediaries	Use effective pilots and spot market trading before engaging in comprehensive reform Invest in extension services to inform irrigators of incentives for voluntary reallocation and private investment in conservation technology Encourage water banking and brokerages to assist in trading procedures

More generally, including transaction costs in the analysis and design of policy highlights the importance of the institutional environment, i.e. the political and legal system, as well as the specific existing policies that both enable and constrain our choices. Property rights, and conflict over property rights, which results in high costs of enactment, are revealed as fundamental determinants of transaction costs.

In addition, it helps us think about unintended consequences of policies. Previous decisions affect not only environmental quality and natural resource use, but also norms and the institutional environment, e.g. the issue of path dependence or lock-in that is raised by Challen (2000); Crase et al. (2013); Garrick et al. (2013); Libecap (2011) and Marshall (2013) to understand the difficulty of adjusting historic water use patterns as preferences and availability change. Path dependence, and the interaction between transformation costs and transaction costs implies that examination of the sequencing of policies, rather than just choice of policies may be useful.

Many physical factors affecting water market performance are difficult to change because of complex connections between different users and infrastructure systems. Hydrological interactions and time lags across different phases of the water cycle are difficult to change without inter-basin transfers and capital intensive infrastructure. Policymaking efforts can work around these constraints by establishing a nested set of diversion limits that accounts for hydrological interactions across scales and sources, e.g. groundwater and surface water. The flexibility to adjust these constraints periodically is paramount given uncertainty and changing social preferences. This has been illustrated by the recent basin planning experience in the Murray-Darling Basin of Australia.

A range of policy design considerations can address other physical factors associated with water's biophysical complexity: heterogeneity, externalities, asset specificity and economies of scale and scope. These policy design strategies can take advantage of water rights reforms that support low-cost monitoring and conflict resolution, such as water entitlements as shares of available supplies, instead of fixed volumes.

Like physical factors, institutions and culture often prove difficult and slow to change, raising challenges for policymaking. Recognizing the factors that can be changed versus those which must be worked around can be useful in identifying design strategies and sequencing of water market reforms. Social capital, democratic institutions, the rule of law and burden of proof are characteristics of the wider society that are difficult to change. Water markets in developing regions will often struggle to move beyond informal trading because of their weak legal systems and limited social capital. In these contexts, the ability to cultivate trust among users is critical; water users associations should be included in planning and rulemaking to build on social capital. Information systems and brokerage or extension services can be useful in more formal settings where bureaucratic challenges impede progress.

Several other institutional and cultural factors are more amenable to policy changes that will reduce transaction costs, including the mismatch of physical and administrative boundaries, lobbying by affected third parties and the impacts of prior legislation. For example, river basin or catchment level organizations can harmonize diversion limits across administrative jurisdictions. Such organizations are also well positioned to work with local users to anticipate concerns and prevent lobbying or protests of transactions. One recommendation is to make use of existing institutions, policies and forms, where applicable, to reduce transaction costs. If possible, build on existing policies (water rights reforms in Australia), and/or prevent conflicts with existing policies (through national frameworks to coordinate state water allocation policy). For example, irrigation extension services can be used to expand access to incentive-based programs and to help irrigators navigate complex water trading regulations. Research on water saving technologies can create win-win options for irrigators.

In conclusion, while water market institutions that are more efficient may arise spontaneously (e.g. Demsetz 1967), in general they should be the focus of design, especially in the case of water policy issues. Applied economists have typically focused on the design of policy instruments, and to some extent technical change, but including transaction costs in the analysis means that we also should think about design in the context of the institutional environment. The effect of physical factors on transaction costs, and their interaction with institutional factors, also needs to be considered. This type of analysis implies economists and policy makers ought to consider the dynamic effects of policy choices on both technological change and institutions. Creating general policies and procedures that can be adaptable to heterogeneous and changing situations would be useful.

Ultimately, policy choice and policy design need to be matched to the specific physical and institutional characteristics of the problem. Some specific policy recommendations flow from incorporating transaction costs in water policy design. It is helpful to think of this process as a hierarchy, evaluating and trying easier solutions (e.g. the use of brokerage, licensing registries and extension services) first and then making more fundamental changes in policy, technology, or even the institutional environment (creating river basin organizations and adjusting diversion limits) if needed or when the amount of change required is large.

References

Aguilera-Klink F, Sanchez-Garcia J (2005) Water markets in Tenerife: the conflict between instrumental and ceremonial functions of the institutions. Int J Water 3(2):166–185

Batie SS (2008) Wicked problems and applied economics. Am J Agric Econ 90(5):1176–1191

Bauer CJ (1997) Bringing markets down to earth: the political economy of water rights in Chile 1975–1996. World Dev 25(5):639–659

Bennett J (2005) The evolution of markets for water. Edward Elgar Publishing, Northampton

Birner R, Wittner H (2004) On the efficient boundaries of the state: the contribution of transaction-costs economics to the analysis of decentralization and devolution in natural resource management. Environ Plann C Gov Policy 22(5):667–685

Bjornlund H (2004) What impedes water markets? Water 31(7):47–51

Bjornlund H, Zuo A, Wheeler S, Xu W (2014) Exploring the reluctance to embrace water markets in Alberta, Canada. In: Easter KW, Huang QQ (eds) Water markets for the 21st century: what have we learned? Springer, Dordrecht

Bougherara D, Grolleau G, Mzoughi N (2009) The ‘make or buy’ decision in private environmental transactions. Eur J Law Econ 27(1):79–99

Boutry O (2011) Agriculture et environnement: une analyse néo-institutionnelle de l’évolution des pratiques agricoles. Le cas de la gestion quantitative de la ressource en eau en Charente-Maritime. Ph.D. Dissertation, University of Poitiers, France

Bromley DW (1991) Environment and economy: property rights and public policy. Blackwell Publishers, Cambridge
Bromley DW (1992) Entitlements and public policy in environmental risks. In: Bromley DW, Kathleen S (eds) The social response to environmental risk: policy formulation in an age of uncertainty. Kluwer Academic Publishers, Boston
Brown T (2006) Trends in water market activity and price in the western United States. Water Resour Res 42(9):1–14
Cacho OJ, Lipper L, Moss J (2013) Transaction costs of carbon offset projects: a comparative study. Ecol Econ 88:232–243
Carey J, Sunding DL, Zilberman D (2002) Transaction costs and trading behavior in an immature water market. Environ Dev Econ 7(4):733–750
Challen R (2000) Institutions, transaction costs, and environmental policy: institutional reform for water resources. Edward Elgar, Cheltenham/England
Clifford P, Landry C, Larsen-Hayden A (2004) Analysis of water banks in the Western States. Washington Department of Ecology. Publication number 04-11-011
Coase RH (1960) The problem of social cost. J Law Econ 3:1–44
Coggan A, Whitten SM, Bennett J (2010) Influences of transaction costs in environmental policy. Ecol Econ 69(9):1777–1784
Coggan A, Buitelaar E, Whitten SM, Bennett J (2013) Factors that influence transaction costs in development offsets: who bears what and why? Ecol Econ 88:222–231
Connell D (2007) Water politics in the Murray-Darling Basin. Federation Press, Sydney
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. Ecol Econ 88:206–213
Demsetz H (1967) Toward a theory of property rights. Am Econ Rev 57(2):347–359
Easter W, McCann L (2010) Nested institutions and the need to improve international water institutions. Water Policy 12:500–516
Easter KW, Dinar A, Rosegrant WM (1998) Chap. 1, Water markets: transaction costs and institutional options. In: Easter KW, Rosegrant WM, Ariel D (eds) Water markets: potential and performance. Kluwer Academic Publishers, Boston
Ervin DE, Graffy EA (1996) Leaner environmental policies for agriculture. Choices Fourth Q 11:27–33
Fernandez F (2001) Cutting edge fixture technology: manufacturers perspective. PM Eng 7(7): 38–42
Friedman T (2008) Hot, flat and crowded: why we need a green revolution and how it can change America. Farrar, Straus & Giroux, New York
Garrick DE, Aylward B (2012) Transaction costs and institutional performance. Land Econ 88(3):536–560
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. Econ Pap 30(2):167–184
Garrick D, Whitten S, Coggan A (2013) Understanding the evolution and performance of market-based water allocation reforms: a transaction costs analysis framework. Ecol Econ 88:195–205
Garrido A (2007) Water markets design and evidence from experimental economics. Environ Resour Econ 38:311–330
Grafton RQ, Libecap G, McGlennon S, Landry C, O'Brien B (2011) An integrated assessment of water markets: a cross-country comparison. Rev Environ Econ Policy 5(2):219–239
Griffin RC, Peck DE, Maestu J (2012) Myths, principles and issues in water trading. In: Maestu J (ed) Water trading and global water scarcity: international experiences. RFF Press, New York
Grolleau G, McCann L (2012) Designing watershed programs to pay farmers for water quality services: case studies of Munich and New York City. Ecol Econ 76:87–94
Hayami Y, Ruttan VW (1971) Agricultural development: an international perspective. John Hopkins University Press, Baltimore
Hearne R, Donoso G (2014) Water markets in Chile: are they meeting needs? In: Easter KW, Huang QQ (eds) Water markets for the 21st century: what have we learned? Springer, Dordrecht

Hicks JR (1963) The theory of wages, 2nd edn. St. Martin's Press, New York
Howitt RE (1994) Empirical analysis of water market institutions: the 1991 California water market. Resour Energy Econ 16(4):357–371
Howitt RE (2014) Are lease water markets still emerging in California? In: Easter KW, Huang QQ (eds) Water markets for the 21st century: what have we learned? Springer, Dordrecht
King RP (2012a) The science of design. Am J Agric Econ 94(2):275–284
King RP (2012b) Climate change policy and the science of design. Distinguished fellows address presented at the Australian agricultural and resource economics society annual conference, Fremantle, Western Australia, 10 February, 2012
Krutilla K, Krause R (2011) Transaction costs and environmental policy: an assessment framework and literature review. Int Rev Environ Resour Econ 4:262–354
Kubasek NK, Silverman GS (1997) Environmental law, 2nd edn. Prentice Hall, Upper Saddle River
Laurenceau M (2012) A transaction cost approach for environmental policy analysis: the case of the water framework directive in the Scheldt International river basin district. Ph.D. thesis, ENGEES, Strasbourg, France
Libecap G (2005) The problem of water. National Bureau of Economic Research working paper. Available at: http://www.aeaweb.org/annual_mtg_papers/2006/0108_1300_0702.pdf
Libecap G (2008) Chinatown revisited: Owens Valley and Los Angeles—bargaining costs and fairness perceptions of the first major water rights exchange. J Law Econ Organ 24(2):1–28
Libecap G (2011) Institutional path dependence in climate adaptation: Coman's "some unsettled problems of irrigation". Am Econ Rev 101: 1–19
Liberherr E (2011) Acceptability of the Deschutes groundwater mitigation program. Ecol Law Curr 38:25–35
Makridis C (2012) Multilateral water governance: prospects for transboundary water banking. Global Water Forum Discussion Paper
Marshall G (2013) Transaction costs, collective action and adaptation in managing complex social-ecological systems. Ecol Econ 88:185–194
McCann L (1998) Implications of a deterministic coin toss for economic modeling. Assoc Environ Resour Econ Newsl 19(1):18–19
McCann L (2013) Transaction costs and environmental policy design. Ecol Econ 88:253–262
McCann L, Easter KW (2004) A framework for estimating the transaction costs of alternative mechanisms for water exchange and allocation. Water Resour Res 40(9) July 2004. Reprinted in The economics of water quality. K. William Easter, Naomi Zeitouni (eds) Ashgate Publishing, Williston 2006
McCann L, Hafdahl A (2007) Agency perceptions of alternative salinity policies: the role of fairness. Land Econ 83(3):331–352
McCann L, Colby B, Easter KW, Kasterine A, Kuperan KV (2005) Transaction cost measurement for evaluating environmental policies. Ecol Econ 52(4):527–542
Murray-Darling Basin Authority (MDBA) (2010) Guide to the basin plan. Murray Darling Basin Authority, Canberra
National Water Commission (NWC) (2006) Investing in irrigation: achieving efficiency and sustainability. Available online at: http://archive.nwc.gov.au/data/assets/pdffile/0020/18173/Investing-in-Irrigation-PUB-0306.pdf
North DC (1990) Institutions, institutional change and economic performance. Cambridge University Press, Cambridge
Ostrom E (1990) Governing the commons: the evolution of institutions for collective action. Cambridge University Press, Cambridge
Pannell DJ, Roberts AM, Park G, Alexander J (2013) Improving environmental decisions: a transaction cost story. Ecol Econ 88:244–252
Perry J, Easter KW (2004) Resolving the scale incompatibility dilemma in river basin management. Water Resour Res 40 (2004), W08S06, doi: 10.1029/2003WR002882
Pujol J, Raggi M, Viaggi D (2006) The potential impact of markets for irrigation water in Italy and Spain: a comparison of two study areas. Aust J Agric Resour Econ 50:361–380

Richards K (2000) Framing environmental policy instrument choice. Duke Environ Law Policy Forum X(2):221–285

Roberts AM, Pannell DJ, Doole G, Vigiak O (2012) Agricultural land management strategies to reduce phosphorus loads in the Gippsland Lakes, Australia. Agr Syst 106(1):11–22

Rorstad PK, Vatn A, Kvakkestad V (2007) Why do transaction costs of agricultural policies vary? Agric Econ 36:1–11

Ruml CC (2005) The Coase theorem and western U.S. appropriative water rights. Nat Resour J 45(1):169–200

Saliba BC, Bush D (1987) Water markets in theory and practice: market transfers, water values and public policy. Westview Press, Boulder

Schlager E, Blomquist W (2008) Embracing watershed politics. University Press of Colorado, Boulder

Schmid AA (1995) The environment and property rights issues. In: Daniel WB (ed) Handbook of environmental economics. Basil Blackwell Ltd., Cambridge, MA

Schmid AA (2004) Conflict and cooperation: institutional and behavioral economics. Blackwell Publishing, Hoboken

Schorr D (2005) Appropriation as agrarianism: distributive justice in the creation of property rights. Ecol Law Q 32:3–71

Skurray JH, Roberts EJ, Pannell DJ (2012) Hydrological challenges to groundwater trading: lessons from south-west Western Australia. J Hydrol 412–413:256–268

Stavins RN (1995) Transaction costs and tradeable permits. J Environ Econ Manage 29(2):133–148

Tietenberg T (2005) Environmental and natural resource economics, 7th edn. Addison Wesley, Lebanon

Tisdell J (2014) The evolution of water Legislation in Australia. In: Easter KW, Huang QQ (eds) Water markets for the 21st century: what have we learned? Springer, Dordrecht

Vatn A (2005) Institutions and the environment. Edward Elgar Publishing, Cheltenham

Williamson OE (1985) The economic institutions of capitalism. Free Press, New York

Williamson OE (2000) The new institutional economics: taking stock, looking ahead. J Econ Lit 38(3):595–613

Young MD, McColl JC (2009) Double trouble: the importance of accounting for and defining water entitlements consistent with hydrological realities. Aust J Agric Resour Econ 53(1):19–35

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